



Manage storage with Element software

Element Software

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Manage storage with Element software

Use Element software to set up SolidFire storage, monitor cluster capacity and performance, and manage storage activity across a multi-tenant infrastructure.

Element is the storage operating system at the heart of a SolidFire cluster. Element software runs independently on all nodes in the cluster and enables the nodes of the cluster to combine resources and present as a single storage system to external clients. Element software is responsible for all cluster coordination, scale and management of the system as a whole.

The software interface is built upon the Element API.

- [Access the Element software user interface](#)
- [Configure SolidFire system options after deployment](#)
- [Upgrade storage system components](#)
- [Use basic options in the Element software UI](#)
- [Manage accounts](#)
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- [Manage volumes and virtual volumes](#)
- [Protect your data](#)
- [Troubleshoot your system](#)

Find more information

- [SolidFire and Element Software Documentation](#)
- [NetApp Element Plug-in for vCenter Server](#)

Access the Element software user interface

You can access the Element UI by using the management virtual IP (MVIP) address of the primary cluster node.

You must ensure that popup blockers and NoScript settings are disabled in your browser.

You can access the UI using IPv4 or IPv6 addressing, depending on configuration during cluster creation.

1. Choose one of the following:

- IPv6: Enter `https://[IPv6 MVIP address]` For example:

```
https://[fd20:8b1e:b256:45a::1234]/
```

- IPv4: Enter `https://[IPv4 MVIP address]` For example:

```
https://10.123.456.789/
```

2. For DNS, enter the host name.
3. Click through any authentication certificate messages.

Find more information

- [SolidFire and Element Software Documentation](#)
- [NetApp Element Plug-in for vCenter Server](#)

Configure SolidFire system options after deployment

After you set up your SolidFire system, you might want to perform some optional tasks.

If you change credentials in the system, you might want to know the impact on other components.

Additionally, you can configure settings for multi-factor authentication, external key management, and Federal Information Processing Standards (FIPS) security. You should also look at updating passwords when needed.

Find more information

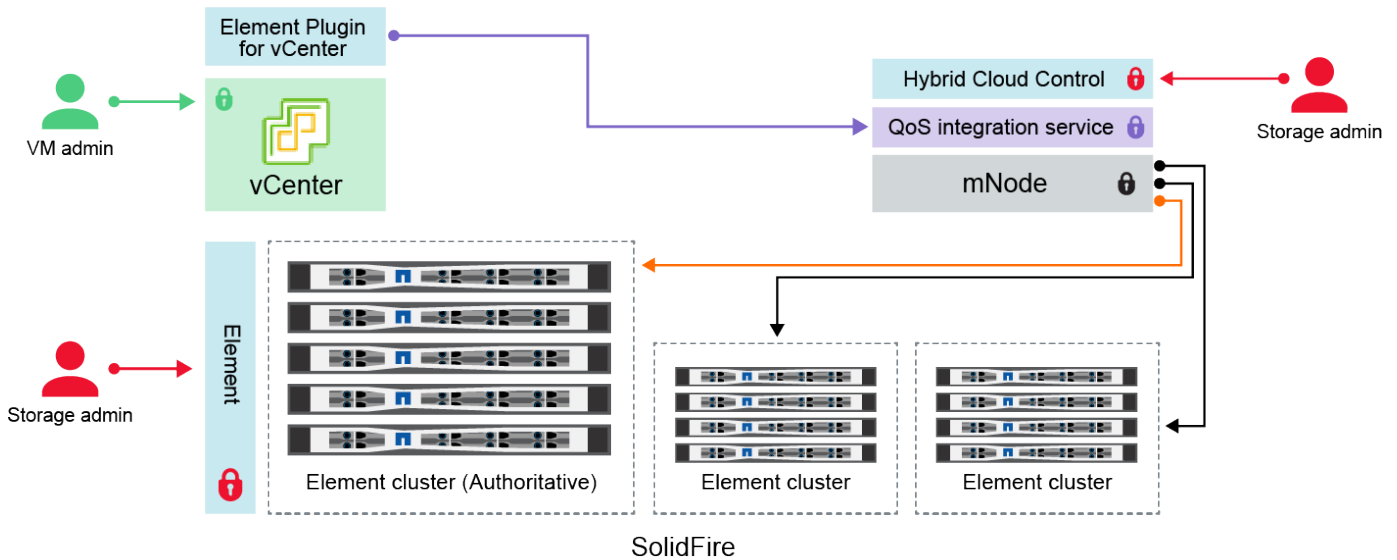
- [Change credentials in NetApp HCI and NetApp SolidFire](#)
- [Change the Element software default SSL certificate](#)
- [Change the IPMI password for nodes](#)
- [Enable multi-factor authentication](#)
- [Get started with external key management](#)
- [Create a cluster supporting FIPS drives](#)

Change credentials in NetApp HCI and NetApp SolidFire


Depending on the security policies in the organization that deployed NetApp HCI or NetApp SolidFire, changing credentials or passwords is commonly part of the security practices. Before you change passwords, you should be aware of the impact on other software components in the deployment.




If you change credentials for one component of a NetApp HCI or NetApp SolidFire deployment, the following table provides guidance as to the impact on other components.




NetApp SolidFire component interactions:



- Administrator uses administrative Element storage credentials to log into Element UI and Hybrid Cloud Control
- Element Plugin for VMware vCenter uses password to communicate with QoS service on mNode
- mNode and services use Element certificates to communicate with authoritative storage cluster
- mNode and services use Element administrative credentials for additional storage clusters
- Administrators use VMware vSphere Single Sign-on credentials to log into vCenter

Credential Type and Icon	Usage by Admin	See these instructions
Element credentials 	<p>Applies to: NetApp HCI and SolidFire</p> <p>Admins use these credentials to log into:</p> <ul style="list-style-type: none"> • Element user interface on the Element storage cluster • Hybrid Cloud Control on the management node (mnode) <p>When Hybrid Cloud Control manages multiple storage clusters, it accepts only the admin credentials for the storage clusters, known as the <i>authoritative cluster</i> that the mnode was initially set up for. For storage clusters later added to Hybrid Cloud Control, the mnode securely stores admin credentials. If credentials for subsequently added storage clusters are changed, the credentials must also be updated in the mnode using the mnode API.</p>	<ul style="list-style-type: none"> • Update the storage cluster admin passwords. • Update the storage cluster admin credentials in the mnode using the modifyclusteradmin API.

Credential Type and Icon	Usage by Admin	See these instructions
vSphere Single Sign-on credentials 	<p>Applies to: NetApp HCI only</p> <p>Admins use these credentials to log into the VMware vSphere Client. When vCenter is part of the NetApp HCI installation, credentials are configured in the NetApp Deployment Engine as the following:</p> <ul style="list-style-type: none"> • username@vsphere.local with the specified password, and • administrator@vsphere.local with the specified password. When an existing vCenter is used to deploy NetApp HCI, the vSphere Single Sign-on credentials are managed by the IT VMware admins. 	<p>Update vCenter and ESXi credentials.</p>
Baseboard management controller (BMC) credentials 	<p>Applies to: NetApp HCI only</p> <p>Administrators use these credentials to log in to the BMC of the NetApp compute nodes in a NetApp HCI deployment. The BMC provides basic hardware monitoring and virtual console capabilities.</p> <p>BMC (sometimes referred to as <i>IPMI</i>) credentials for each NetApp compute node are stored securely on the mnode in NetApp HCI deployments. NetApp Hybrid Cloud Control uses BMC credentials in a service account capacity to communicate with the BMC in the compute nodes during compute node firmware upgrades.</p> <p>When the BMC credentials are changed, the credentials for the respective compute nodes must be updated also on the mnode to retain all Hybrid Cloud Control functionality.</p>	<ul style="list-style-type: none"> • Configure IPMI for each node on NetApp HCI. • For H410C, H610C, and H615C nodes, change default IPMI password. • For H410S and H610S nodes, change default IPM password. • Change BMC credentials on the management node.
ESXi credentials 	<p>Applies to: NetApp HCI only</p> <p>Admins can log into ESXi hosts using either SSH or the local DCUI with a local root account. In NetApp HCI deployments, the username is 'root' and the password was specified during the initial installation of that compute node in NetApp Deployment Engine.</p> <p>ESXi root credentials for each NetApp compute node are stored securely on the mnode in NetApp HCI deployments. NetApp Hybrid Cloud Control uses the credentials in a service account capacity to communicate with ESXi hosts directly during compute node firmware upgrades and health checks.</p> <p>When the ESXi root credentials are changed by a VMware admin, the credentials for the respective compute nodes must be updated on the mnode to retain Hybrid Cloud Control functionality.</p>	<p>Update credentials for vCenter and ESXi hosts.</p>

Credential Type and Icon	Usage by Admin	See these instructions
<p>QoS integration password</p> 	<p>Applies to: NetApp HCI and optional in SolidFire</p> <p>Not used for interactive logins by admins.</p> <p>The QoS integration between VMware vSphere and Element Software is enabled via:</p> <ul style="list-style-type: none"> • Element Plug-in for vCenter Server, and • QoS service on the mnode. <p>For authentication, the QoS service uses a password that is exclusively used in this context. The QoS password is specified during the initial installation of the Element Plug-in for vCenter Server, or auto-generated during NetApp HCI deployment.</p> <p>No impact on other components.</p>	<p>Update QoSSIOC credentials in the NetApp Element Plug-in for vCenter Server.</p> <p>The NetApp Element Plug-in for vCenter Server SIOC password is also known as the <i>QoSSIOC password</i>.</p> <p>Review the Element Plug-in for vCenter Server KB article.</p>
<p>vCenter Service Appliance credentials</p> 	<p>Applies to: NetApp HCI only if set up by NetApp Deployment Engine</p> <p>Admins can log into the vCenter Server appliance virtual machines. In NetApp HCI deployments, the username is 'root' and the password was specified during the initial installation of that compute node in the NetApp Deployment Engine. Depending on the VMware vSphere version deployed, certain admins in the vSphere Single Sign-on domain can also log in to the appliance.</p> <p>No impact on other components.</p>	<p>No changes needed.</p>
<p>NetApp Management Node admin credentials</p> 	<p>Applies to: NetApp HCI and optional in SolidFire</p> <p>Admins can log into the NetApp management node virtual machines for advanced configuration and troubleshooting. Depending on the management node version deployed, login via SSH is not enabled by default.</p> <p>In NetApp HCI deployments, the username and password was specified by the user during the initial installation of that compute node in NetApp Deployment Engine.</p> <p>No impact on other components.</p>	<p>No changes needed.</p>

Find more information

- [Change the Element software default SSL certificate](#)
- [Change the IPMI password for nodes](#)
- [Enable multi-factor authentication](#)

- [Get started with external key management](#)
- [Create a cluster supporting FIPS drives](#)

Change the Element software default SSL certificate

You can change the default SSL certificate and private key of the storage node in the cluster using the NetApp Element API.

When a NetApp Element software cluster is created, the cluster creates a unique self-signed Secure Sockets Layer (SSL) certificate and private key that is used for all HTTPS communication via the Element UI, per-node UI, or APIs. Element software supports self-signed certificates as well as certificates that are issued and verified by a trusted Certificate Authority (CA).

You can use the following API methods to get more information about the default SSL certificate and make changes.

- **GetSSLCertificate**

You can use the [GetSSLCertificate method](#) to retrieve information about the currently installed SSL certificate including all certificate details.

- **SetSSLCertificate**

You can use the [SetSSLCertificate method](#) to set the cluster and per-node SSL certificates to the certificate and private key you supply. The system validates the certificate and private key to prevent an invalid certificate from being applied.

- **RemoveSSLCertificate**

The [RemoveSSLCertificate method](#) removes the currently installed SSL certificate and private key. The cluster then generates a new self-signed certificate and private key.



The cluster SSL certificate is automatically applied to all new nodes added to the cluster. Any node removed from the cluster reverts to a self-signed certificate and all user-defined certificate and key information is removed from the node.

Find more information

- [Change the management node default SSL certificate](#)
- [What are the requirements around setting custom SSL certificates in Element Software?](#)
- [SolidFire and Element Software Documentation](#)
- [NetApp Element Plug-in for vCenter Server](#)

Change default IPMI password for nodes

You can change the default Intelligent Platform Management Interface (IPMI) administrator password as soon as you have remote IPMI access to the node. You might want to do this if there were any installation updates.

For details about configuring IPM access for nodes, see [Configure IPMI for each node](#).

You can change the IPM password for these nodes:

- H410S nodes
- H610S nodes

Change the default IPMI password for H410S nodes

You should change the default password for the IPMI administrator account on each storage node as soon as you configure the IPMI network port.

What you'll need

You should have configured the IPMI IP address for each storage node.

Steps

1. Open a web browser on a computer that can reach the IPMI network and browse to the IPMI IP address for the node.
2. Enter the user name `ADMIN` and password `ADMIN` in the login prompt.
3. Upon logging in, click the **Configuration** tab.
4. Click **Users**.
5. Select the `ADMIN` user and click **Modify User**.
6. Select the **Change Password** check box.
7. Enter a new password in the **Password** and **Confirm Password** fields.
8. Click **Modify**, and then click **OK**.
9. Repeat this procedure for any other H410S nodes with default IPMI passwords.

Change the default IPMI password for H610S nodes

You should change the default password for the IPMI administrator account on each storage node as soon as you configure the IPMI network port.

What you'll need

You should have configured the IPMI IP address for each storage node.

Steps

1. Open a web browser on a computer that can reach the IPMI network and browse to the IPMI IP address for the node.
2. Enter the user name `root` and password `calvin` in the login prompt.
3. Upon logging in, click the menu navigation icon at the top left of the page to open the sidebar drawer.
4. Click **Settings**.
5. Click **User Management**.
6. Select the **Administrator** user from the list.
7. Enable the **Change Password** check box.
8. Enter a new, strong password in the **Password** and **Confirm Password** fields.
9. Click **Save** at the bottom of the page.
10. Repeat this procedure for any other H610S nodes with default IPMI passwords.

Find more information

- [SolidFire and Element Software Documentation](#)
- [NetApp Element Plug-in for vCenter Server](#)

Use basic options in the Element software UI

The NetApp Element software web user interface (Element UI) enables you to monitor and perform common tasks on your SolidFire system.

Basic options include viewing API commands activated by UI activity and providing feedback.

- [View API activity](#)
- [Icons in the Element interface](#)
- [Provide feedback](#)

For more information

- [SolidFire and Element Software Documentation](#)
- [NetApp Element Plug-in for vCenter Server](#)

View API activity

The Element system uses the NetApp Element API as the foundation for its features and functionality. The Element UI enables you to view various types of real-time API activity on the system as you use the interface. With the API log, you can view user-initiated and background system API activity, as well as API calls made on the page you are currently viewing.

You can use the API log to identify what API methods are used for certain tasks, and see how to use the API methods and objects to build custom applications.

For information about each method, see [Element Software API reference](#).

1. From the Element UI navigation bar, click **API Log**.
2. To modify the type of API activity displayed in the API Log window, perform the following steps:
 - a. Select **Requests** to display API request traffic.
 - b. Select **Responses** to display API response traffic.
 - c. Filter the types of API traffic by selecting one of the following:
 - **User Initiated**: API traffic by your activities during this web UI session.
 - **Background Polling**: API traffic generated by background system activity.
 - **Current Page**: API traffic generated by tasks on the page you are currently viewing.

Find more information

- [Managing storage with the Element API](#)

- [SolidFire and Element Software Documentation](#)
- [NetApp Element Plug-in for vCenter Server](#)

Interface refresh rate impacted by cluster load

Depending on API response times, the cluster might automatically adjust the data refresh interval for certain portions of the NetApp Element software page you are viewing.








The refresh interval is reset to the default when you reload the page in your browser. You can see the current refresh interval by clicking the cluster name in the upper-right of the page. Note that the interval controls how often API requests are made, not how quickly the data comes back from the server.






When a cluster is under heavy load, it might queue API requests from the Element UI. In rare circumstances, when system response is significantly delayed, such as a slow network connection combined with a busy cluster, you might be logged out of the Element UI if the system does not respond to queued API requests quickly enough. If you are redirected to the logout screen, you can log in again after dismissing any initial browser authentication prompt. Upon returning to the overview page, you might be prompted for cluster credentials if they are not saved by your browser.

Icons in the Element interface

The NetApp Element software interface displays icons to represent actions you can take on system resources.

The following table provides a quick reference:

Icon	Description
	Actions
	Backup to
	Clone or copy
	Delete or purge
	Edit
	Filter
	Pair

	Refresh
	Restore
	Restore from
	Rollback
	Snapshot

Provide feedback

You can help improve the Element software web user interface and address any UI issues by using the feedback form that is accessible throughout the UI.

1. From any page in the Element UI, click the **Feedback** button.
2. Enter relevant information in the Summary and Description fields.
3. Attach any helpful screenshots.
4. Enter a name and email address.
5. Select the check box to include data about your current environment.
6. Click **Submit**.

Find more information

- [SolidFire and Element Software Documentation](#)
- [NetApp Element Plug-in for vCenter Server](#)

Manage accounts

In SolidFire storage systems, tenants can use accounts to enable clients to connect to volumes on a cluster. When you create a volume, it is assigned to a specific account. You can also manage cluster administrator accounts for a SolidFire storage system.

- [Work with accounts using CHAP](#)
- [Manage cluster administrator user accounts](#)

For more information

- [SolidFire and Element Software Documentation](#)
- [NetApp Element Plug-in for vCenter Server](#)

Work with accounts using CHAP

In SolidFire storage systems, tenants can use accounts to enable clients to connect to volumes on a cluster. An account contains the Challenge-Handshake Authentication Protocol (CHAP) authentication required to access the volumes assigned to it. When you create a volume, it is assigned to a specific account.

An account can have up to two-thousand volumes assigned to it, but a volume can belong to only one account.

Create an account

You can create an account to allow access to volumes.

Each account name in the system must be unique.

1. Select **Management > Accounts**.
2. Click **Create Account**.
3. Enter a **Username**.
4. In the **CHAP Settings** section, enter the following information:



Leave the credential fields blank to auto-generate either password.

- **Initiator Secret** for CHAP node session authentication.
 - **Target Secret** for CHAP node session authentication.
5. Click **Create Account**.

View account details

You can view performance activity for individual accounts in a graphical format.

The graph information provides I/O and throughput information for the account. The Average and Peak activity levels are shown in increments of 10-second reporting periods. These statistics include activity for all volumes assigned to the account.

1. Select **Management > Accounts**.
2. Click the Actions icon for an account.
3. Click **View Details**.

Here are some of the details:

- **Status:** The status of the account. Possible values:
 - active: An active account.
 - locked: A locked account.
 - removed: An account that has been deleted and purged.
- **Active Volumes:** The number of active volumes assigned to the account.
- **Compression:** The compression efficiency score for the volumes assigned to the account.
- **Deduplication:** The deduplication efficiency score for the volumes assigned to the account.

- **Thin Provisioning:** The thin provisioning efficiency score for the volumes assigned to the account.
- **Overall Efficiency:** The overall efficiency score for the volumes assigned to the account.

Edit an account

You can edit an account to change the status, change the CHAP secrets, or modify the account name.

Modifying CHAP settings in an account or removing initiators or volumes from an access group can cause initiators to lose access to volumes unexpectedly. To verify that volume access will not be lost unexpectedly, always log out iSCSI sessions that will be affected by an account or access group change, and verify that initiators can reconnect to volumes after any changes to initiator settings and cluster settings have been completed.



Persistent volumes that are associated with management services are assigned to a new account that is created during installation or upgrade. If you are using persistent volumes, do not modify or delete their associated account.

1. Select **Management > Accounts**.
2. Click the Actions icon for an account.
3. In the resulting menu, select **Edit**.
4. **Optional:** Edit the **Username**.
5. **Optional:** Click the **Status** drop-down list and select a different status.



Changing the status to **locked** terminates all iSCSI connections to the account, and the account is no longer accessible. Volumes associated with the account are maintained; however, the volumes are not iSCSI discoverable.

6. **Optional:** Under **CHAP Settings**, edit the **Initiator Secret** and **Target Secret** credentials used for node session authentication.



If you do not change the **CHAP Settings** credentials, they remain the same. If you make the credentials fields blank, the system generates new passwords.

7. Click **Save Changes**.

Delete an account

You can delete an account when it is no longer needed.

Delete and purge any volumes associated with the account before you delete the account.



Persistent volumes that are associated with management services are assigned to a new account that is created during installation or upgrade. If you are using persistent volumes, do not modify or delete their associated account.

1. Select **Management > Accounts**.
2. Click the Actions icon for the account you want to delete.
3. In the resulting menu, select **Delete**.
4. Confirm the action.

Find more information

- [SolidFire and Element Software Documentation](#)
- [NetApp Element Plug-in for vCenter Server](#)

Manage cluster administrator user accounts

You can manage cluster administrator accounts for a SolidFire storage system by creating, deleting, and editing cluster administrator accounts, changing the cluster administrator password, and configuring LDAP settings to manage system access for users.

Storage cluster administrator account types

There are two types of administrator accounts that can exist in a storage cluster running NetApp Element software: the primary cluster administrator account and a cluster administrator account.

- **Primary cluster administrator account**

This administrator account is created when the cluster is created. This account is the primary administrative account with the highest level of access to the cluster. This account is analogous to a root user in a Linux system. You can change the password for this administrator account.

- **Cluster administrator account**

You can give a cluster administrator account a limited range of administrative access to perform specific tasks within a cluster. The credentials assigned to each cluster administrator account are used to authenticate API and Element UI requests within the storage system.



A local (non-LDAP) cluster administrator account is required to access active nodes in a cluster via the per-node UI. Account credentials are not required to access a node that is not yet part of a cluster.

View cluster admin details

1. To create a cluster-wide (non-LDAP) cluster administrator account, perform the following actions:
 - a. Click **Users > Cluster Admins**.
2. On the Cluster Admins page of the Users tab, you can view the following information.
 - **ID**: Sequential number assigned to the cluster administrator account.
 - **Username**: The name given to the cluster administrator account when it was created.
 - **Access**: The user permissions assigned to the user account. Possible values:
 - read
 - reporting
 - nodes
 - drives
 - volumes

- accounts
- clusterAdmins
- administrator



All permissions are available to the administrator access type.

- **Type:** The type of cluster administrator. Possible values:
 - Cluster
 - Ldap
- **Attributes:** If the cluster administrator account was created using the Element API, this column shows any name-value pairs that were set using that method.

See [NetApp Element Software API Reference](#).

Create a cluster administrator account

You can create new cluster administrator accounts with permissions to allow or restrict access to specific areas of the storage system. When you set cluster administrator account permissions, the system grants read-only rights for any permissions you do not assign to the cluster administrator.

If you want to create an LDAP cluster administrator account, ensure that LDAP is configured on the cluster before you begin.

[Enable LDAP authentication with the Element user interface](#)

You can later change cluster administrator account privileges for reporting, nodes, drives, volumes, accounts, and cluster-level access. When you enable a permission, the system assigns write access for that level. The system grants the administrator user read-only access for the levels that you do not select.

You can also later remove any cluster administrator user account created by a system administrator. You cannot remove the primary cluster administrator account that was created when the cluster was created.

1. To create a cluster-wide (non-LDAP) cluster administrator account, perform the following actions:
 - a. Click **Users > Cluster Admins**.
 - b. Click **Create Cluster Admin**.
 - c. Select the **Cluster** user type.
 - d. Enter a user name and password for the account and confirm password.
 - e. Select user permissions to apply to the account.
 - f. Select the check box to agree to the End User License Agreement.
 - g. Click **Create Cluster Admin**.
2. To create a cluster administrator account in the LDAP directory, perform the following actions:
 - a. Click **Cluster > LDAP**.
 - b. Ensure that LDAP Authentication is enabled.
 - c. Click **Test User Authentication** and copy the distinguished name that appears for the user or one of the groups of which the user is a member so that you can paste it later.
 - d. Click **Users > Cluster Admins**.

- e. Click **Create Cluster Admin**.
- f. Select the LDAP user type.
- g. In the Distinguished Name field, follow the example in the text box to enter a full distinguished name for the user or group. Alternatively, paste it from the distinguished name you copied earlier.

If the distinguished name is part of a group, then any user that is a member of that group on the LDAP server will have permissions of this admin account.

To add LDAP Cluster Admin users or groups the general format of the username is “LDAP:<Full Distinguished Name>”.

- h. Select user permissions to apply to the account.
- i. Select the check box to agree to the End User License Agreement.
- j. Click **Create Cluster Admin**.

Edit cluster administrator permissions

You can change cluster administrator account privileges for reporting, nodes, drives, volumes, accounts, and cluster-level access. When you enable a permission, the system assigns write access for that level. The system grants the administrator user read-only access for the levels that you do not select.

1. Click **Users > Cluster Admins**.
2. Click the Actions icon for the cluster administrator you want to edit.
3. Click **Edit**.
4. Select user permissions to apply to the account.
5. Click **Save Changes**.

Change passwords for cluster administrator accounts

You can use the Element UI to change cluster administrator passwords.

1. Click **Users > Cluster Admins**.
2. Click the Actions icon for the cluster administrator you want to edit.
3. Click **Edit**.
4. In the Change Password field, enter a new password and confirm it.
5. Click **Save Changes**.

Find more information

- [Enable LDAP authentication with the Element user interface](#)
- [Disable LDAP](#)
- [SolidFire and Element Software Documentation](#)
- [NetApp Element Plug-in for vCenter Server](#)

Manage LDAP

You can set up the Lightweight Directory Access Protocol (LDAP) to enable secure,

directory-based login functionality to SolidFire storage. You can configure LDAP at the cluster level and authorize LDAP users and groups.

Managing LDAP involves setting up LDAP authentication to a SolidFire cluster using an existing Microsoft Active Directory environment and testing the configuration.



You can use both IPv4 and IPv6 addresses.

Enabling LDAP involves the following high-level steps, described in detail:

1. **Complete pre-configuration steps for LDAP support.** Validate that you have all of the details required to configure LDAP authentication.
2. **Enable LDAP authentication.** Use either the Element UI or the Element API.
3. **Validate the LDAP configuration.** Optionally, check that the cluster is configured with the correct values by running the `GetLdapConfiguration` API method or by checking the LDAP configuration using the Element UI.
4. **Test the LDAP authentication** (with the `readonly` user). Test that the LDAP configuration is correct either by running the `TestLdapAuthentication` API method or by using the Element UI. For this initial test, use the username “sAMAccountName” of the `readonly` user. This will validate that your cluster is configured correctly for LDAP authentication and also validate that the `readonly` credentials and access are correct. If this step fails, repeat steps 1 through 3.
5. **Test the LDAP authentication** (with a user account that you want to add). Repeat step 4 with a user account that you want to add as an Element cluster admin. Copy the distinguished name (DN) or the user (or the group). This DN will be used in step 6.
6. **Add the LDAP cluster admin** (copy and paste the DN from the Test LDAP authentication step). Using either the Element UI or the `AddLdapClusterAdmin` API method, create a new cluster admin user with the appropriate access level. For the username, paste in the full DN you copied in Step 5. This assures that the DN is formatted correctly.
7. **Test the cluster admin access.** Log in to the cluster using the newly created LDAP cluster admin user. If you added an LDAP group, you can log in as any user in that group.

Complete pre-configuration steps for LDAP support

Before you enable LDAP support in Element, you should set up a Windows Active Directory Server and perform other pre-configuration tasks.

Steps

1. Set up a Windows Active Directory Server.
2. **Optional:** Enable LDAPS support.
3. Create users and groups.
4. Create a read-only service account (such as “sfireadonly”) to be used for searching the LDAP directory.

Enable LDAP authentication with the Element user interface

You can configure storage system integration with an existing LDAP server. This enables LDAP administrators to centrally manage storage system access for users.

You can configure LDAP with either the Element user interface or the Element API. This procedure describes how to configure LDAP using the Element UI.

This example shows how to configure LDAP authentication on SolidFire and it uses SearchAndBind as the authentication type. The example uses a single Windows Server 2012 R2 Active Directory Server.

Steps

1. Click **Cluster > LDAP**.
2. Click **Yes** to enable LDAP authentication.
3. Click **Add a Server**.
4. Enter the **Host Name/IP Address**.



An optional custom port number can also be entered.

For example, to add a custom port number, enter <host name or ip address>:<port number>

5. **Optional:** Select **Use LDAPS Protocol**.
6. Enter the required information in **General Settings**.

LDAP Servers

Host Name/IP Address	<input type="text" value="192.168.9.99"/>	Remove
	<input type="checkbox"/> Use LDAPS Protocol	

[Add a Server](#)

General Settings

Auth Type	<input type="text" value="Search and Bind"/>	
Search Bind DN	<input type="text" value="msmyth@thesmyths.ca"/>	
Search Bind Password	<input type="text" value="e.g. password"/>	<input type="checkbox"/> Show password
User Search Base DN	<input type="text" value="OU=Home users,DC=thesmyths,DC=ca"/>	
User Search Filter	<input type="text" value="(&(objectClass=person)) (sAMAccountName=%USER"/>	
Group Search Type	<input type="text" value="Active Directory"/>	
Group Search Base DN	<input type="text" value="OU=Home users,DC=thesmyths,DC=ca"/>	

[Save Changes](#)

7. Click **Enable LDAP**.
8. Click **Test User Authentication** if you want to test the server access for a user.

9. Copy the distinguished name and user group information that appears for use later when creating cluster administrators.
10. Click **Save Changes** to save any new settings.
11. To create a user in this group so that anyone can log in, complete the following:
 - a. Click **User > View**.

Create a New Cluster Admin ✕

Select User Type

Cluster LDAP

Enter User Details

Distinguished Name

CN=StorageAdmins,OU=Home
users,DC=thesmyths,DC=ca

Select User Permissions

- | | |
|------------------------------------|--|
| <input type="checkbox"/> Reporting | <input type="checkbox"/> Volumes |
| <input type="checkbox"/> Nodes | <input type="checkbox"/> Accounts |
| <input type="checkbox"/> Drives | <input type="checkbox"/> Cluster Admin |

Accept the Following End User License Agreement

- b. For the new user, click **LDAP** for the User Type, and paste the group you copied to the Distinguished Name field.
- c. Select the permissions, typically all permissions.
- d. Scroll down to the End User License Agreement and click **I accept**.
- e. Click **Create Cluster Admin**.

Now you have a user with the value of an Active Directory group.

To test this, log out of the Element UI and log back in as a user in that group.

Enable LDAP authentication with the Element API

You can configure storage system integration with an existing LDAP server. This enables LDAP administrators to centrally manage storage system access for users.

You can configure LDAP with either the Element user interface or the Element API. This procedure describes how to configure LDAP using the Element API.

To leverage LDAP authentication on a SolidFire cluster, you enable LDAP authentication first on the cluster using the `EnableLdapAuthentication` API method.

Steps

1. Enable LDAP authentication first on the cluster using the `EnableLdapAuthentication` API method.
2. Enter the required information.

```
{
  "method": "EnableLdapAuthentication",
  "params": {
    "authType": "SearchAndBind",
    "groupSearchBaseDN": "dc=prodtest,dc=solidfire,dc=net",
    "groupSearchType": "ActiveDirectory",
    "searchBindDN": "SFReadOnly@prodtest.solidfire.net",
    "searchBindPassword": "ReadOnlyPW",
    "userSearchBaseDN": "dc=prodtest,dc=solidfire,dc=net ",
    "userSearchFilter":
    " (& (objectClass=person) (sAMAccountName=%USERNAME%)) "
    "serverURIs": [
      "ldap://172.27.1.189",
    ]
  },
  "id": "1"
}
```

3. Change the values of the following parameters:

Parameters used	Description
authType: SearchAndBind	Dictates that the cluster will use the readonly service account to first search for the user being authenticated and subsequently bind that user if found and authenticated.
groupSearchBaseDN: dc=prodtest,dc=solidfire,dc=net	Specifies the location in the LDAP tree to begin searching for groups. For this example, we've used the root of our tree. If your LDAP tree is very large, you might want to set this to a more granular sub-tree to decrease search times.

Parameters used	Description
<p>userSearchBaseDN: dc=prodtest,dc=solidfire,dc=net</p>	<p>Specifies the location in the LDAP tree to begin searching for users. For this example, we've used the root of our tree. If your LDAP tree is very large, you might want to set this to a more granular subtree to decrease search times.</p>
<p>groupSearchType: ActiveDirectory</p>	<p>Uses the Windows Active Directory server as the LDAP server.</p>
<pre> userSearchFilter: " (& (objectClass=person) (sAMAccountName=%USERNAME%)) " </pre> <p>To use the userPrincipalName (email address for login) you could change the userSearchFilter to:</p> <pre> " (& (objectClass=person) (userPrincipalName=%USERNAME%)) " </pre> <p>Or, to search both userPrincipalName and sAMAccountName, you can use the following userSearchFilter:</p> <pre> " (& (objectClass=person) (</pre>	<pre> (sAMAccountName=%USERNAME%)(userPrincipalName=%USERNAME%))" ---- </pre>
<p>Leverages the sAMAccountName as our username for logging in to the SolidFire cluster. These settings tell LDAP to search for the username specified during login in the sAMAccountName attribute and also limit the search to entries that have "person" as a value in the objectClass attribute.</p>	<p>searchBindDN</p>
<p>This is the distinguished name of readonly user that will be used to search the LDAP directory. For active directory it's usually easiest to use the userPrincipalName (email address format) for the user.</p>	<p>searchBindPassword</p>

To test this, log out of the Element UI and log back in as a user in that group.

View LDAP details

View LDAP information on the LDAP page on the Cluster tab.



You must enable LDAP to view these LDAP configuration settings.

1. To view LDAP details with the Element UI, click **Cluster > LDAP**.

- **Host Name/IP Address:** Address of an LDAP or LDAPS directory server.
- **Auth Type:** The user authentication method. Possible values:
 - Direct Bind
 - Search And Bind
- **Search Bind DN:** A fully qualified DN to log in with to perform an LDAP search for the user (needs bind-level access to the LDAP directory).
- **Search Bind Password:** Password used to authenticate access to the LDAP server.
- **User Search Base DN:** The base DN of the tree used to start the user search. The system searches the subtree from the specified location.
- **User Search Filter:** Enter the following using your domain name:

```
( & (objectClass=person) ( | (sAMAccountName=%USERNAME%) (userPrincipalName=%USERN
AME%) ) )
```

- **Group Search Type:** Type of search that controls the default group search filter used. Possible values:
 - Active Directory: Nested membership of all of a user’s LDAP groups.
 - No Groups: No group support.
 - Member DN: Member DN-style groups (single-level).
- **Group Search Base DN:** The base DN of the tree used to start the group search. The system searches the subtree from the specified location.
- **Test User Authentication:** After LDAP is configured, use this to test the user name and password authentication for the LDAP server. Enter an account that already exists to test this. The distinguished name and user group information appears, which you can copy for later use when creating cluster administrators.

Test the LDAP configuration

After configuring LDAP, you should test it by using either the Element UI or the Element API `TestLdapAuthentication` method.

Steps

1. To test the LDAP configuration with the Element UI, do the following:
 - a. Click **Cluster > LDAP**.
 - b. Click **Test LDAP Authentication**.
 - c. Resolve any issues by using the information in the table below:

Error message	Description
xLDAPUserNotFound	<ul style="list-style-type: none"> • The user being tested was not found in the configured <code>userSearchBaseDN</code> subtree. • The <code>userSearchFilter</code> is configured incorrectly.

Error message	Description
xLDAPBindFailed (Error: Invalid credentials)	<ul style="list-style-type: none"> The username being tested is a valid LDAP user, but the password provided is incorrect. The username being tested is a valid LDAP user, but the account is currently disabled.
xLDAPSearchBindFailed (Error: Can't contact LDAP server)	The LDAP server URI is incorrect.
xLDAPSearchBindFailed (Error: Invalid credentials)	The read-only username or password is configured incorrectly.
xLDAPSearchFailed (Error: No such object)	The userSearchBaseDN is not a valid location within the LDAP tree.
xLDAPSearchFailed (Error: Referral)	<ul style="list-style-type: none"> The userSearchBaseDN is not a valid location within the LDAP tree. The userSearchBaseDN and groupSearchBaseDN are in a nested OU. This can cause permission issues. The workaround is to include the OU in the user and group base DN entries, (for example: ou=storage, cn=company, cn=com)

2. To test the LDAP configuration with the Element API, do the following:

a. Call the TestLdapAuthentication method.

```
{
  "method": "TestLdapAuthentication",
  "params": {
    "username": "admin1",
    "password": "admin1PASS"
  },
  "id": 1
}
```

b. Review the results. If the API call is successful, the results include the specified user's distinguished name and a list of groups in which the user is a member.


```
{
  "id": 1
  "result": {
    "groups": [
      "CN=StorageMgmt,OU=PTUsers,DC=prodtest,DC=solidfire,DC=net"
    ],
    "userDN": "CN=Admin1
Jones,OU=PTUsers,DC=prodtest,DC=solidfire,DC=net"
  }
}
```

Disable LDAP

You can disable LDAP integration using the Element UI.

Before you begin, you should note all the configuration settings, because disabling LDAP erases all settings.

Steps

1. Click **Cluster > LDAP**.
2. Click **No**.
3. Click **Disable LDAP**.

Find more information

- [SolidFire and Element Software Documentation](#)
- [NetApp Element Plug-in for vCenter Server](#)

Manage your system

You can manage your system in the Element UI. This includes enabling multi-factor authentication, managing cluster settings, supporting Federal Information Processing Standards (FIPS), and using external key management.

- [Enable multi-factor authentication](#)
- [Configure cluster settings](#)
- [Create a cluster supporting FIPS drives](#)
- [Get started with external key management](#)

For more information

- [SolidFire and Element Software Documentation](#)
- [NetApp Element Plug-in for vCenter Server](#)

Enable multi-factor authentication

Multi-factor authentication (MFA) uses a third-party Identity Provider (IdP) via the Security Assertion Markup Language (SAML) to manage user sessions. MFA enables administrators to configure additional factors of authentication as required, such as password and text message, and password and email message.

Set up multi-factor authentication

You can use these basic steps via the Element API to set up your cluster to use multi-factor authentication.

Details of each API method can be found in the [Element API Reference](#).

1. Create a new third-party Identity Provider (IdP) configuration for the cluster by calling the following API method and passing the IdP metadata in JSON format: `CreateIdpConfiguration`

IdP metadata, in plain text format, is retrieved from the third-party IdP. This metadata needs to be validated to ensure that it is correctly formatted in JSON. There are numerous JSON formatter applications available that you can use, for example: <https://freeformatter.com/json-escape.html>.

2. Retrieve cluster metadata, via `spMetadataUrl`, to copy to the third-party IdP by calling the following API method: `ListIdpConfigurations`

`spMetadataUrl` is a URL used to retrieve service provider metadata from the cluster for the IdP in order to establish a trust relationship.

3. Configure SAML assertions on the third-party IdP to include the “NameID” attribute to uniquely identify a user for audit logging and for Single Logout to function properly.
4. Create one or more cluster administrator user accounts authenticated by a third-party IdP for authorization by calling the following API method: `AddIdpClusterAdmin`



The username for the IdP cluster Administrator should match the SAML attribute Name/Value mapping for the desired effect, as shown in the following examples:

- `email=bob@company.com` — where the IdP is configured to release an email address in the SAML attributes.
- `group=cluster-administrator` - where the IdP is configured to release a group property in which all users should have access. Note that the SAML attribute Name/Value pairing is case-sensitive for security purposes.

5. Enable MFA for the cluster by calling the following API method: `EnableIdpAuthentication`

Find more information

- [SolidFire and Element Software Documentation](#)
- [NetApp Element Plug-in for vCenter Server](#)

Additional information for multi-factor authentication

You should be aware of the following caveats in relation to multi-factor authentication.

- In order to refresh IdP certificates that are no longer valid, you will need to use a non-IdP admin user to call the following API method: `UpdateIdpConfiguration`
- MFA is incompatible with certificates that are less than 2048 bits in length. By default, a 2048-bit SSL certificate is created on the cluster. You should avoid setting a smaller sized certificate when calling the API method: `SetSSLCertificate`



If the cluster is using a certificate that is less than 2048 bits pre-upgrade, the cluster certificate must be updated with a 2048-bit or greater certificate after upgrade to Element 12.0 or later.

- IdP admin users cannot be used to make API calls directly (for example, via SDKs or Postman) or used for other integrations (for example, OpenStack Cinder or vCenter Plug-in). Add either LDAP cluster admin users or local cluster admin users if you need to create users that have these abilities.

Find more information

- [Managing storage with the Element API](#)
- [SolidFire and Element Software Documentation](#)
- [NetApp Element Plug-in for vCenter Server](#)

Configure cluster settings

You can view and change cluster-wide settings and perform cluster-specific tasks from the Cluster tab of the Element UI.

You can configure settings such as cluster fullness threshold, support access, encryption at rest, virtual volumes, SnapMirror, and NTP broadcast client.

Options

- [Work with virtual volumes](#)
- [Use SnapMirror replication between Element and ONTAP clusters](#)
- [Set the cluster full threshold](#)
- [Enable and disable support access](#)
- [How are the blockSpace thresholds calculated for Element](#)
- [Enable and disable encryption for a cluster](#)
- [Manage the Terms of Use banner](#)
- [Configure Network Time Protocol servers for the cluster to query](#)
- [Manage SNMP](#)
- [Manage drives](#)
- [Manage nodes](#)
- [Manage virtual networks](#)
- [View Fibre Channel ports details](#)

Find more information

- [SolidFire and Element Software Documentation](#)

- [NetApp Element Plug-in for vCenter Server](#)

Enable and disable encryption at rest for a cluster

With SolidFire clusters, you can encrypt all at-rest data stored on cluster drives. You can enable cluster-wide protection of self-encrypting drives (SED) using either [hardware or software-based encryption at rest](#).

You can enable hardware encryption at rest using the Element UI or API. Enabling the hardware encryption at rest feature does not affect performance or efficiency on the cluster. You can enable software encryption at rest using the Element API only.

Hardware-based encryption at rest is not enabled by default during cluster creation and can be enabled and disabled from the Element UI.



For SolidFire all-flash storage clusters, software encryption at rest must be enabled during cluster creation and cannot be disabled after the cluster has been created.

What you'll need

- You have cluster administrator privileges to enable or change encryption settings.
- For hardware-based encryption at rest, you have ensured that the cluster is in a healthy state before changing encryption settings.
- If you are disabling encryption, two nodes must be participating in a cluster to access the key to disable encryption on a drive.

Check encryption at rest status

To see the current status of encryption at rest and/or software encryption at rest on the cluster, use the [GetClusterInfo](#) method. You can use the [GetSoftwareEncryptionAtRestInfo](#) method to get information the cluster uses to encrypt data at rest.



The Element software UI dashboard at <https://<MVIP>/> currently only shows encryption at rest status for hardware-based encryption.

Options

- [Enable hardware-based encryption at rest](#)
- [Enable software-based encryption at rest](#)
- [Disable hardware-based encryption at rest](#)

Enable hardware-based encryption at rest



To enable encryption at rest using an external key management configuration, you must enable encryption at rest via the [API](#). Enabling using the existing Element UI button will revert to using internally generated keys.

1. From the Element UI, select **Cluster > Settings**.
2. Select **Enable Encryption at Rest**.

Enable software-based encryption at rest



Software encryption at rest cannot be disabled after it is enabled on the cluster.

1. During cluster creation, run the [create cluster method](#) with `enableSoftwareEncryptionAtRest` set to `true`.

Disable hardware-based encryption at rest

1. From the Element UI, select **Cluster > Settings**.
2. Select **Disable Encryption at Rest**.

Find more information

- [SolidFire and Element Software Documentation](#)
- [Documentation for earlier versions of NetApp SolidFire and Element products](#)

Set the cluster full threshold

You can change the level at which the system generates a block cluster fullness warning using the steps below. In addition, you can use the `ModifyClusterFullThreshold` API method to change the level at which the system generates a block or metadata warning.

What you'll need

You must have cluster administrator privileges.

Steps

1. Click **Cluster > Settings**.
2. In the Cluster Full Settings section, enter a percentage in **Raise a warning alert when `_`% capacity remains before Helix could not recover from a node failure**.
3. Click **Save Changes**.

Find more information

[How are the blockSpace thresholds calculated for Element](#)

Enable and disable support access

You can enable support access to temporarily allow NetApp support personnel access to storage nodes via SSH for troubleshooting.

You must have cluster admin privileges to change support access.

1. Click **Cluster > Settings**.
2. In the Enable / Disable Support Access section, enter the duration (in hours) that you want to allow support to have access.
3. Click **Enable Support Access**.
4. **Optional:** To disable support access, click **Disable Support Access**.

Manage the Terms of Use banner

You can enable, edit, or configure a banner that contains a message for the user.

Options

[Enable the Terms of Use banner](#) [Edit the Terms of Use banner](#) [Disable the Terms of Use banner](#)

Enable the Terms of Use banner

You can enable a Terms of Use banner that appears when a user logs in to the Element UI. When the user clicks on the banner, a text dialog box appears containing the message you have configured for the cluster. The banner can be dismissed at any time.

You must have cluster administrator privileges to enable Terms of Use functionality.

1. Click **Users > Terms of Use**.
2. In the **Terms of Use** form, enter the text to be displayed for the Terms of Use dialog box.



Do not exceed 4096 characters.

3. Click **Enable**.

Edit the Terms of Use banner

You can edit the text that a user sees when they select the Terms of Use login banner.

What you'll need

- You must have cluster administrator privileges to configure Terms of Use.
- Ensure that the Terms of Use feature is enabled.

Steps

1. Click **Users > Terms of Use**.
2. In the **Terms of Use** dialog box, edit the text that you want to appear.



Do not exceed 4096 characters.

3. Click **Save Changes**.

Disable the Terms of Use banner

You can disable the Terms of Use banner. With the banner disabled, the user is no longer requested to accept the terms of use when using the Element UI.

What you'll need

- You must have cluster administrator privileges to configure Terms of Use.
- Ensure that Terms of Use is enabled.

Steps

1. Click **Users > Terms of Use**.
2. Click **Disable**.

Set the Network Time Protocol

Setting up the Network Time Protocol (NTP) can be achieved in one of two ways: either instruct each node in a cluster to listen for broadcasts or or instruct each node to query an NTP server for updates.

The NTP is used to synchronize clocks over a network. Connection to an internal or external NTP server should be part of the initial cluster setup.

Configure Network Time Protocol servers for the cluster to query

You can instruct each node in a cluster to query a Network Time Protocol (NTP) server for updates. The cluster contacts only configured servers and requests NTP information from them.

Configure NTP on the cluster to point to a local NTP server. You can use the IP address or the FQDN host name. The default NTP server at cluster creation time is set to `us.pool.ntp.org`; however, a connection to this site cannot always be made depending on the physical location of the SolidFire cluster.

Using the FQDN depends on whether the individual storage node's DNS settings are in place and operational. To do so, configure the DNS servers on every storage node and ensure that the ports are open by reviewing the Network Port Requirements page.

You can enter up to five different NTP servers.



You can use both IPv4 and IPv6 addresses.

What you'll need

You must have cluster administrator privileges to configure this setting.

Steps

1. Configure a list of IPs and/or FQDNs in the server settings.
2. Ensure that the DNS is set properly on the nodes.
3. Click **Cluster > Settings**.
4. Under Network Time Protocol Settings, select **No**, which uses the standard NTP configuration.
5. Click **Save Changes**.

Find more information

- [SolidFire and Element Software Documentation](#)
- [NetApp Element Plug-in for vCenter Server](#)

Configure the cluster to listen for NTP broadcasts

By using the broadcast mode, you can instruct each node in a cluster to listen on the network for Network Time Protocol (NTP) broadcast messages from a particular server.

What you'll need

- You must have cluster administrator privileges to configure this setting.

- You must configure an NTP server on your network as a broadcast server.

Steps

1. Click **Cluster > Settings**.
2. Enter the NTP server or servers that are using broadcast mode into the server list.
3. Under Network Time Protocol Settings, select **Yes** to use a broadcast client.
4. To set the broadcast client, in the **Server** field, enter the NTP server you configured in broadcast mode.
5. Click **Save Changes**.

Find more information

- [SolidFire and Element Software Documentation](#)
- [NetApp Element Plug-in for vCenter Server](#)

Manage SNMP

You can configure Simple Network Management Protocol (SNMP) in your cluster.

You can select an SNMP requestor, select which version of SNMP to use, identify the SNMP User-based Security Model (USM) user, and configure traps to monitor the SolidFire cluster. You can also view and access management information base files.



You can use both IPv4 and IPv6 addresses.

SNMP details

On the SNMP page of the Cluster tab, you can view the following information.

- **SNMP MIBs**

The MIB files that are available for you to view or download.

- **General SNMP Settings**

You can enable or disable SNMP. After you enable SNMP, you can choose which version to use. If using version 2, you can add requestors, and if using version 3, you can set up USM users.

- **SNMP Trap Settings**

You can identify which traps you want to capture. You can set the host, port, and community string for each trap recipient.

Configure an SNMP requestor

When SNMP version 2 is enabled, you can enable or disable a requestor, and configure requestors to receive authorized SNMP requests.

1. Click **Cluster > SNMP**.
2. Under **General SNMP Settings**, click **Yes** to enable SNMP.

3. From the **Version** list, select **Version 2**.
4. In the **Requestors** section, enter the **Community String** and **Network** information.



By default, the community string is public, and the network is localhost. You can change these default settings.

5. **Optional:** To add another requestor, click **Add a Requestor** and enter the **Community String** and **Network** information.
6. Click **Save Changes**.

Find more information

- [Configure SNMP traps](#)
- [View managed object data using management information base files](#)

Configure an SNMP USM user

When you enable SNMP version 3, you need to configure a USM user to receive authorized SNMP requests.

1. Click **Cluster > SNMP**.
2. Under **General SNMP Settings**, click **Yes** to enable SNMP.
3. From the **Version** list, select **Version 3**.
4. In the **USM Users** section, enter the name, password, and passphrase.
5. **Optional:** To add another USM user, click **Add a USM User** and enter the name, password, and passphrase.
6. Click **Save Changes**.

Configure SNMP traps

System administrators can use SNMP traps, also referred to as notifications, to monitor the health of the SolidFire cluster.

When SNMP traps are enabled, the SolidFire cluster generates traps associated with event log entries and system alerts. To receive SNMP notifications, you need to choose the traps that should be generated and identify the recipients of the trap information. By default, no traps are generated.

1. Click **Cluster > SNMP**.
2. Select one or more types of traps in the **SNMP Trap Settings** section that the system should generate:
 - Cluster Fault Traps
 - Cluster Resolved Fault Traps
 - Cluster Event Traps
3. In the **Trap Recipients** section, enter the host, port, and community string information for a recipient.
4. **Optional:** To add another trap recipient, click **Add a Trap Recipient** and enter host, port, and community string information.
5. Click **Save Changes**.

View managed object data using management information base files

You can view and download the management information base (MIB) files used to define each of the managed objects. The SNMP feature supports read-only access to those objects defined in the SolidFire-StorageCluster-MIB.

The statistical data provided in the MIB shows system activity for the following:

- Cluster statistics
- Volume statistics
- Volumes by account statistics
- Node statistics
- Other data such as reports, errors, and system events

The system also supports access to the MIB file containing the upper level access points (OIDs) to SF-Series products.

Steps

1. Click **Cluster > SNMP**.
2. Under **SNMP MIBs**, click the MIB file you want to download.
3. In the resulting download window, open or save the MIB file.

Manage drives

Each node contains one or more physical drives that are used to store a portion of the data for the cluster. The cluster utilizes the capacity and performance of the drive after the drive has been successfully added to a cluster. You can use the Element UI to manage drives.

For more information

- [SolidFire and Element Software Documentation](#)
- [NetApp Element Plug-in for vCenter Server](#)

Drives details

The Drives page on the Cluster tab provides a list of the active drives in the cluster. You can filter the page by selecting from the Active, Available, Removing, Erasing, and Failed tabs.

When you first initialize a cluster, the active drives list is empty. You can add drives that are unassigned to a cluster and listed in the Available tab after a new SolidFire cluster is created.

The following elements appear in the list of active drives.

- **Drive ID**

The sequential number assigned to the drive.

- **Node ID**

The node number assigned when the node is added to the cluster.

- **Node Name**

The name of the node that houses the drive.

- **Slot**

The slot number where the drive is physically located.

- **Capacity**

The size of the drive, in GB.

- **Serial**

The serial number of the drive.

- **Wear Remaining**

The wear level indicator.

The storage system reports the approximate amount of wear available on each solid-state drive (SSD) for writing and erasing data. A drive that has consumed 5 percent of its designed write and erase cycles reports 95 percent wear remaining. The system does not refresh drive wear information automatically; you can refresh or close and reload the page to refresh the information.

- **Type**

The type of drive. The type can be either block or metadata.

Manage nodes

You can manage SolidFire storage and Fibre Channel nodes from the Nodes page of the Cluster tab.

If a newly added node accounts for more than 50 percent of the total cluster capacity, some of the capacity of this node is made unusable ("stranded"), so that it complies with the capacity rule. This remains the case until more storage is added. If a very large node is added that also disobeys the capacity rule, the previously stranded node will no longer be stranded, while the newly added node becomes stranded. Capacity should always be added in pairs to avoid this happening. When a node becomes stranded, an appropriate cluster fault is thrown.

Find more information

[Add a node to a cluster](#)

Add a node to a cluster

You can add nodes to a cluster when more storage is needed or after cluster creation. Nodes require initial configuration when they are first powered on. After the node is configured, it appears in the list of pending nodes and you can add it to a cluster.

The software version on each node in a cluster must be compatible. When you add a node to a cluster, the cluster installs the cluster version of NetApp Element software on the new node as needed.

You can add nodes of smaller or larger capacities to an existing cluster. You can add larger node capacities to a cluster to allow for capacity growth. Larger nodes added to a cluster with smaller nodes must be added in pairs. This allows for sufficient space for Double Helix to move the data should one of the larger nodes fail. You can add smaller node capacities to a larger node cluster to improve performance.



If a newly added node accounts for more than 50 percent of the total cluster capacity, some of the capacity of this node is made unusable ("stranded"), so that it complies with the capacity rule. This remains the case until more storage is added. If a very large node is added that also disobeys the capacity rule, the previously stranded node will no longer be stranded, while the newly added node becomes stranded. Capacity should always be added in pairs to avoid this happening. When a node becomes stranded, the strandedCapacity cluster fault is thrown.

[NetApp video: Scale on Your Terms: Expanding a SolidFire Cluster](#)

You can add nodes to NetApp HCI appliances.

Steps

1. Select **Cluster > Nodes**.
2. Click **Pending** to view the list of pending nodes.

When the process for adding nodes is complete, they appear in the Active nodes list. Until then, pending nodes appear in the Pending Active list.

SolidFire installs the Element software version of the cluster on the pending nodes when you add them to a cluster. This might take a few minutes.

3. Do one of the following:
 - To add individual nodes, click the **Actions** icon for the node you want to add.
 - To add multiple nodes, select the check box of the nodes to add, and then **Bulk Actions**. **Note:** If the node you are adding has a different version of Element software than the version running on the cluster, the cluster asynchronously updates the node to the version of Element software running on the cluster master. After the node is updated, it automatically adds itself to the cluster. During this asynchronous process, the node will be in a pendingActive state.
4. Click **Add**.

The node appears in the list of active nodes.

Find more information

[Node versioning and compatibility](#)

Node versioning and compatibility

Node compatibility is based on the Element software version installed on a node. Element software-based storage clusters automatically image a node to the Element software version on the cluster if the node and cluster are not at compatible versions.

The following list describes the software release significance levels that make up the Element software version

number:

- **Major**

The first number designates a software release. A node with one major component number cannot be added to a cluster containing nodes of a different major-patch number, nor can a cluster be created with nodes of mixed major versions.

- **Minor**

The second number designates smaller software features or enhancements to existing software features that have been added to a major release. This component is incremented within a major version component to indicate that this incremental release is not compatible with any other Element software incremental releases with a different minor component. For example, 11.0 is not compatible with 11.1, and 11.1 is not compatible with 11.2.

- **Micro**

The third number designates a compatible patch (incremental release) to the Element software version represented by the major.minor components. For example, 11.0.1 is compatible with 11.0.2, and 11.0.2 is compatible with 11.0.3.

Major and minor version numbers must match for compatibility. Micro numbers do not have to match for compatibility.

Cluster capacity in a mixed node environment

You can mix different types of nodes in a cluster. The SF-Series 2405, 3010, 4805, 6010, 9605, 9010, 19210, 38410 and the H-Series can coexist in a cluster.

The H-Series consists of H610S-1, H610S-2, H610S-4, and H410S nodes. These nodes are both 10GbE and 25GbE capable.

It is best to not intermix non-encrypted and encrypted nodes. In a mixed node cluster, no node can be larger than 33 percent of the total cluster capacity. For instance, in a cluster with four SF-Series 4805 nodes, the largest node that can be added alone is an SF-Series 9605. The cluster capacity threshold is calculated based on the potential loss of the largest node in this situation.

Beginning with Element 12.0, the following SF-series storage nodes are not supported:

- SF3010
- SF6010
- SF9010

If you upgrade one of these storage nodes to Element 12.0, you will see an error stating that this node is not supported by Element 12.0.

View node details

You can view details for individual nodes such as service tags, drive details, and graphics for utilization and drive statistics. The Nodes page of the Cluster tab provides the Version column where you can view the software version of each node.

Steps

1. Click **Cluster > Nodes**.
2. To view the details for a specific node, click the **Actions** icon for a node.
3. Click **View Details**.
4. Review the node details:
 - **Node ID**: The system-generated ID for the node.
 - **Node Name**: The host name for the node.
 - **Available 4k IOPS**: The IOPS configured for the node.
 - **Node Role**: The role that the node has in the cluster. Possible values:
 - **Cluster Master**: The node that performs cluster-wide administrative tasks and contains the MVIP and SVIP.
 - **Ensemble Node**: A node that participates in the cluster. There are either 3 or 5 ensemble nodes depending on cluster size.
 - **Fibre Channel**: A node in the cluster.
 - **Node Type**: The model type of the node.
 - **Active Drives**: The number of active drives in the node.
 - **Management IP**: The management IP (MIP) address assigned to node for 1GbE or 10GbE network admin tasks.
 - **Cluster IP**: The cluster IP (CIP) address assigned to the node used for the communication between nodes in the same cluster.
 - **Storage IP**: The storage IP (SIP) address assigned to the node used for iSCSI network discovery and all data network traffic.
 - **Management VLAN ID**: The virtual ID for the management local area network.
 - **Storage VLAN ID**: The virtual ID for the storage local area network.
 - **Version**: The version of software running on each node.
 - **Replication Port**: The port used on nodes for remote replication.
 - **Service Tag**: The unique service tag number assigned to the node.

View Fibre Channel ports details

You can view details of Fibre Channel ports such as its status, name, and port address from the FC Ports page.

View information about the Fibre Channel ports that are connected to the cluster.

Steps

1. Click **Cluster > FC Ports**.
2. To filter information on this page, click **Filter**.
3. Review the details:
 - **Node ID**: The node hosting the session for the connection.
 - **Node Name**: System-generated node name.
 - **Slot**: Slot number where the Fibre Channel port is located.

- **HBA Port:** Physical port on the Fibre Channel host bus adapter (HBA).
- **WWNN:** The world wide node name.
- **WWPN:** The target world wide port name.
- **Switch WWN:** World wide name of the Fibre Channel switch.
- **Port State:** Current state of the port.
- **nPort ID:** The node port ID on the Fibre Channel fabric.
- **Speed:** The negotiated Fibre Channel speed. Possible values are as follows:
 - 4Gbps
 - 8Gbps
 - 16Gbps

Find more information

- [SolidFire and Element Software Documentation](#)
- [NetApp Element Plug-in for vCenter Server](#)

Manage virtual networks

Virtual networking in SolidFire storage enables traffic between multiple clients that are on separate logical networks to be connected to one cluster. Connections to the cluster are segregated in the networking stack through the use of VLAN tagging.

Find more information

- [Add a virtual network](#)
- [Enable virtual routing and forwarding](#)
- [Edit a virtual network](#)
- [Edit VRF VLANs](#)
- [Delete a virtual network](#)

Add a virtual network

You can add a new virtual network to a cluster configuration to enable a multi-tenant environment connection to a cluster running Element software.

What you'll need

- Identify the block of IP addresses that will be assigned to the virtual networks on the cluster nodes.
- Identify a storage network IP (SVIP) address that will be used as an endpoint for all NetApp Element storage traffic.



You must consider the following criteria for this configuration:

- VLANs that are not VRF-enabled require initiators to be in the same subnet as the SVIP.
- VLANs that are VRF-enabled do not require initiators to be in the same subnet as the SVIP, and routing is supported.

- The default SVIP does not require initiators to be in the same subnet as the SVIP, and routing is supported.

When a virtual network is added, an interface for each node is created and each requires a virtual network IP address. The number of IP addresses you specify when creating a new virtual network must be equal to or greater than the number of nodes in the cluster. Virtual network addresses are bulk provisioned by and assigned to individual nodes automatically. You do not need to manually assign virtual network addresses to the nodes in the cluster.

Steps

1. Click **Cluster > Network**.
2. Click **Create VLAN**.
3. In the **Create a New VLAN** dialog box, enter values in the following fields:
 - **VLAN Name**
 - **VLAN Tag**
 - **SVIP**
 - **Netmask**
 - (Optional) **Description**
4. Enter the **Starting IP** address for the range of IP addresses in **IP Address Blocks**.
5. Enter the **Size** of the IP range as the number of IP addresses to include in the block.
6. Click **Add a Block** to add a non-continuous block of IP addresses for this VLAN.
7. Click **Create VLAN**.

View virtual network details

Steps

1. Click **Cluster > Network**.
2. Review the details.
 - **ID**: Unique ID of the VLAN network, which is assigned by the system.
 - **Name**: Unique user-assigned name for the VLAN network.
 - **VLAN Tag**: VLAN tag assigned when the virtual network was created.
 - **SVIP**: Storage virtual IP address assigned to the virtual network.
 - **Netmask**: Netmask for this virtual network.
 - **Gateway**: Unique IP address of a virtual network gateway. VRF must be enabled.
 - **VRF Enabled**: Indication of whether virtual routing and forwarding is enabled or not.
 - **IPs Used**: The range of virtual network IP addresses used for the virtual network.

Enable virtual routing and forwarding

You can enable virtual routing and forwarding (VRF), which allows multiple instances of a routing table to exist in a router and work simultaneously. This functionality is available for storage networks only.

You can enable VRF only at the time of creating a VLAN. If you want to switch back to non-VRF, you must delete and re-create the VLAN.

1. Click **Cluster > Network**.
2. To enable VRF on a new VLAN, select **Create VLAN**.
 - a. Enter relevant information for the new VRF/VLAN. See Adding a virtual network.
 - b. Select the **Enable VRF** check box.
 - c. **Optional**: Enter a gateway.
3. Click **Create VLAN**.

Find more information

[Add a virtual network](#)

Edit a virtual network

You can change VLAN attributes, such as VLAN name, netmask, and size of the IP address blocks. The VLAN tag and SVIP cannot be modified for a VLAN. The gateway attribute is not a valid parameter for non-VRF VLANs.

If any iSCSI, remote replication, or other network sessions exist, the modification might fail.

When managing the size of VLAN IP address ranges, you should note the following limitations:

- You can only remove IP addresses from the initial IP address range assigned at the time the VLAN was created.
- You can remove an IP address block that was added after the initial IP address range, but you cannot resize an IP block by removing IP addresses.
- When you try to remove IP addresses, from either the initial IP address range or in an IP block, that are in use by nodes in the cluster, the operation might fail.
- You cannot reassign specific in-use IP addresses to other nodes in the cluster.

You can add an IP address block by using the following procedure:

1. Select **Cluster > Network**.
2. Select the Actions icon for the VLAN you want to edit.
3. Select **Edit**.
4. In the **Edit VLAN** dialog box, enter the new attributes for the VLAN.
5. Select **Add a Block** to add a non-continuous block of IP addresses for the virtual network.
6. Select **Save Changes**.

Link to troubleshooting KB articles

Link to the Knowledge Base articles for help with troubleshooting issues with managing your VLAN IP address ranges.

- [Duplicate IP warning after adding a storage node in VLAN on Element cluster](#)
- [How to determine which VLAN IP's are in use and which nodes those IP's are assigned to in Element](#)

Edit VRF VLANs

You can change VRF VLAN attributes, such as VLAN name, netmask, gateway, and IP address blocks.

1. Click **Cluster > Network**.
2. Click the Actions icon for the VLAN you want to edit.
3. Click **Edit**.
4. Enter the new attributes for the VRF VLAN in the **Edit VLAN** dialog box.
5. Click **Save Changes**.

Delete a virtual network

You can remove a virtual network object. You must add the address blocks to another virtual network before you remove a virtual network.

1. Click **Cluster > Network**.
2. Click the Actions icon for the VLAN you want to delete.
3. Click **Delete**.
4. Confirm the message.

Find more information

[Edit a virtual network](#)

Create a cluster supporting FIPS drives

Security is becoming increasingly critical for the deployment of solutions in many customer environments. Federal Information Processing Standards (FIPS) are standards for computer security and interoperability. FIPS 140-2 certified encryption for data at rest is a component of the overall security solution.

- [Avoid mixing nodes for FIPS drives](#)
- [Enable encryption at rest](#)
- [Identify whether nodes are ready for the FIPS drives feature](#)
- [Enable the FIPS drives feature](#)
- [Check the FIPS drive status](#)
- [Troubleshoot the FIPS drive feature](#)

Avoid mixing nodes for FIPS drives

To prepare for enabling the FIPS drives feature, you should avoid mixing nodes where some are FIPS drives capable and some are not.

A cluster is considered FIPS drives compliant based on the following conditions:

- All drives are certified as FIPS drives.

- All nodes are FIPS drives nodes.
- Encryption at Rest (EAR) is enabled.
- The FIPS drives feature is enabled. All drives and nodes must be FIPS capable and Encryption at Rest must be enabled in order to enable the FIPS drive feature.

Enable encryption at rest

You can enable and disable cluster-wide encryption at rest. This feature is not enabled by default. To support FIPS drives, you must enable encryption at rest.

1. In the NetApp Element software UI, click **Cluster > Settings**.
2. Click **Enable Encryption at Rest**.

Find more information

- [Enable and disable encryption for a cluster](#)
- [SolidFire and Element Software Documentation](#)
- [NetApp Element Plug-in for vCenter Server](#)

Identify whether nodes are ready for the FIPS drives feature

You should check to see if all nodes in the storage cluster are ready to support FIPS drives by using the NetApp Element software GetFipsReport API method.

The resulting report shows one of the following statuses:

- None: Node is not capable of supporting the FIPS drives feature.
- Partial: Node is FIPS capable, but not all drives are FIPS drives.
- Ready: Node is FIPS capable and all drives are FIPS drives or no drives are present.

Steps

1. Using the Element API, check to see if the nodes and drives in the storage cluster are capable of FIPS drives by entering:

```
GetFipsReport
```

2. Review the results, noting any nodes that did not display a status of Ready.
3. For any nodes that did not display a Ready status, check to see if the drive is capable of supporting the FIPS drives feature:
 - Using the Element API, enter: `GetHardwareList`
 - Note the value of the **DriveEncryptionCapabilityType**. If it is "fips," the hardware can support the FIPS drives feature.

See details about `GetFipsReport` or `ListDriveHardware` in the [Element API Reference](#).

4. If the drive cannot support the FIPS drives feature, replace the hardware with FIPS hardware (either node or drives).

Find more information

- [SolidFire and Element Software Documentation](#)
- [NetApp Element Plug-in for vCenter Server](#)

Enable the FIPS drives feature

You can enable the FIPS drives feature by using the NetApp Element software `EnableFeature` API method.

Encryption at Rest must be enabled on the cluster and all nodes and drives must be FIPS capable, as indicated when the `GetFipsReport` displays a Ready status for all nodes.

Step

1. Using the Element API, enable FIPS on all drives by entering:

```
EnableFeature params: FipsDrives
```

Find more information

- [Manage storage with the Element API](#)
- [SolidFire and Element Software Documentation](#)
- [NetApp Element Plug-in for vCenter Server](#)

Check the FIPS drive status

You can check whether the FIPS drives feature is enabled on the cluster by using the NetApp Element software `GetFeatureStatus` API method, which shows whether the FIPS Drives Enabled Status is true or false.

1. Using the Element API, check the FIPS drives feature on the cluster by entering:

```
GetFeatureStatus
```

2. Review the results of the `GetFeatureStatus` API call. If the FIPS Drives enabled value is True, the FIPS drives feature is enabled.

```
{"enabled": true,  
 "feature": "FipsDrives"  
}
```

Find more information

- [Manage storage with the Element API](#)
- [SolidFire and Element Software Documentation](#)
- [NetApp Element Plug-in for vCenter Server](#)

Troubleshoot the FIPS drive feature

Using the NetApp Element software UI, you can view alerts for information about cluster faults or errors in the system related to the FIPS drives feature.

1. Using the Element UI, select **Reporting > Alerts**.
2. Look for cluster faults including:
 - FIPS drives mismatched
 - FIPS drives out of compliance
3. For resolution suggestions, see Cluster Fault code information.

Find more information

- [Cluster fault codes](#)
- [Manage storage with the Element API](#)
- [SolidFire and Element Software Documentation](#)
- [NetApp Element Plug-in for vCenter Server](#)

Enable FIPS 140-2 for HTTPS on your cluster

You can use the EnableFeature API method to enable the FIPS 140-2 operating mode for HTTPS communications.

With NetApp Element software, you can choose to enable Federal Information Processing Standards (FIPS) 140-2 operating mode on your cluster. Enabling this mode activates the NetApp Cryptographic Security Module (NCSM) and leverages FIPS 140-2 Level 1 certified encryption for all communication via HTTPS to the Netapp Element UI and API.



After you enable FIPS 140-2 mode, it cannot be disabled. When FIPS 140-2 mode is enabled, each node in the cluster reboots and runs through a self-test ensuring that the NCSM is correctly enabled and operating in the FIPS 140-2 certified mode. This causes an interruption to both management and storage connections on the cluster. You should plan carefully and only enable this mode if your environment needs the encryption mechanism it offers.

For more information, see the Element API information.

The following is an example of the API request to enable FIPS:

```
{
  "method": "EnableFeature",
  "params": {
    "feature" : "fips"
  },
  "id": 1
}
```

After this operating mode is enabled, all HTTPS communication uses the FIPS 140-2 approved ciphers.

Find more information

- [SSL ciphers](#)
- [Manage storage with the Element API](#)
- [SolidFire and Element Software Documentation](#)
- [NetApp Element Plug-in for vCenter Server](#)

SSL ciphers

SSL ciphers are encryption algorithms used by hosts to establish a secure communication. There are standard ciphers that Element software supports and non-standard ones when FIPS 140-2 mode is enabled.

The following lists provide the standard Secure Socket Layer (SSL) ciphers supported by Element software and the SSL ciphers supported when FIPS 140-2 mode is enabled:

- **FIPS 140-2 disabled**

TLS_DHE_RSA_WITH_AES_128_CBC_SHA256 (dh 2048) - A
TLS_DHE_RSA_WITH_AES_128_GCM_SHA256 (dh 2048) - A
TLS_DHE_RSA_WITH_AES_256_CBC_SHA256 (dh 2048) - A
TLS_DHE_RSA_WITH_AES_256_GCM_SHA384 (dh 2048) - A
TLS_ECDHE_RSA_WITH_AES_128_CBC_SHA256 (secp256r1) - A
TLS_ECDHE_RSA_WITH_AES_128_GCM_SHA256 (secp256r1) - A
TLS_ECDHE_RSA_WITH_AES_256_CBC_SHA384 (secp256r1) - A
TLS_ECDHE_RSA_WITH_AES_256_GCM_SHA384 (secp256r1) - A
TLS_RSA_WITH_3DES_EDE_CBC_SHA (rsa 2048) - C
TLS_RSA_WITH_AES_128_CBC_SHA (rsa 2048) - A
TLS_RSA_WITH_AES_128_CBC_SHA256 (rsa 2048) - A
TLS_RSA_WITH_AES_128_GCM_SHA256 (rsa 2048) - A
TLS_RSA_WITH_AES_256_CBC_SHA (rsa 2048) - A
TLS_RSA_WITH_AES_256_CBC_SHA256 (rsa 2048) - A
TLS_RSA_WITH_AES_256_GCM_SHA384 (rsa 2048) - A
TLS_RSA_WITH_CAMELLIA_128_CBC_SHA (rsa 2048) - A
TLS_RSA_WITH_CAMELLIA_256_CBC_SHA (rsa 2048) - A
TLS_RSA_WITH_IDEA_CBC_SHA (rsa 2048) - A

TLS_RSA_WITH_RC4_128_MD5 (rsa 2048) - C

TLS_RSA_WITH_RC4_128_SHA (rsa 2048) - C

TLS_RSA_WITH_SEED_CBC_SHA (rsa 2048) - A

- **FIPS 140-2 enabled**

TLS_DHE_RSA_WITH_AES_128_CBC_SHA256 (dh 2048) - A

TLS_DHE_RSA_WITH_AES_128_GCM_SHA256 (dh 2048) - A

TLS_DHE_RSA_WITH_AES_256_CBC_SHA256 (dh 2048) - A

TLS_DHE_RSA_WITH_AES_256_GCM_SHA384 (dh 2048) - A

TLS_ECDHE_RSA_WITH_AES_128_CBC_SHA256 (sect571r1) - A

TLS_ECDHE_RSA_WITH_AES_128_CBC_SHA256 (secp256r1) - A

TLS_ECDHE_RSA_WITH_AES_128_GCM_SHA256 (secp256r1) - A

TLS_ECDHE_RSA_WITH_AES_128_GCM_SHA256 (sect571r1) - A

TLS_ECDHE_RSA_WITH_AES_256_CBC_SHA384 (sect571r1) - A

TLS_ECDHE_RSA_WITH_AES_256_CBC_SHA384 (secp256r1) - A

TLS_ECDHE_RSA_WITH_AES_256_GCM_SHA384 (secp256r1) - A

TLS_ECDHE_RSA_WITH_AES_256_GCM_SHA384 (sect571r1) - A

TLS_RSA_WITH_3DES_EDE_CBC_SHA (rsa 2048) - C

TLS_RSA_WITH_AES_128_CBC_SHA (rsa 2048) - A

TLS_RSA_WITH_AES_128_CBC_SHA256 (rsa 2048) - A

TLS_RSA_WITH_AES_128_GCM_SHA256 (rsa 2048) - A

TLS_RSA_WITH_AES_256_CBC_SHA (rsa 2048) - A

TLS_RSA_WITH_AES_256_CBC_SHA256 (rsa 2048) - A

TLS_RSA_WITH_AES_256_GCM_SHA384 (rsa 2048) - A

Find more information

[Enable FIPS 140-2 for HTTPS on your cluster](#)

Get started with external key management

External key management (EKM) provides secure Authentication Key (AK) management in conjunction with an off-cluster external key server (EKS). The AKs are used to lock and unlock Self Encrypting Drives (SEDs) when [encryption at rest](#) is enabled on the cluster.

The EKS provides secure generation and storage of the AKs. The cluster utilizes the Key Management Interoperability Protocol (KMIP), an OASIS defined standard protocol, to communicate with the EKS.

- [Set up external management](#)
- [Rekey software encryption at rest master key](#)
- [Recover inaccessible or invalid authentication keys](#)
- [External key management API commands](#)

Find more information

- [CreateCluster API that can be used to enable software encryption at rest](#)
- [SolidFire and Element Software Documentation](#)
- [Documentation for earlier versions of NetApp SolidFire and Element products](#)

Set up external key management

You can follow these steps and use the Element API methods listed to set up your external key management feature.

What you'll need

- If you are setting up external key management in combination with software encryption at rest, you have enabled software encryption at rest using the [CreateCluster](#) method on a new cluster that does not contain volumes.

Steps

1. Establish a trust relationship with the External Key Server (EKS).
 - a. Create a public/private key pair for the Element cluster that is used to establish a trust relationship with the key server by calling the following API method: [CreatePublicPrivateKeyPair](#)
 - b. Get the certificate sign request (CSR) which the Certification Authority needs to sign. The CSR enables the key server to verify that the Element cluster that will be accessing the keys is authenticated as the Element cluster. Call the following API method: [GetClientCertificateSignRequest](#)
 - c. Use the EKS/Certificate Authority to sign the retrieved CSR. See third-party documentation for more information.
2. Create a server and provider on the cluster to communicate with the EKS. A key provider defines where a key should be obtained, and a server defines the specific attributes of the EKS that will be communicated with.
 - a. Create a key provider where the key server details will reside by calling the following API method: [CreateKeyProviderKmip](#)
 - b. Create a key server providing the signed certificate and the public key certificate of the Certification Authority by calling the following API methods: [CreateKeyServerKmip](#) [TestKeyServerKmip](#)

If the test fails, verify your server connectivity and configuration. Then repeat the test.

 - c. Add the key server into the key provider container by calling the following API methods: [AddKeyServerToProviderKmip](#) [TestKeyProviderKmip](#)

If the test fails, verify your server connectivity and configuration. Then repeat the test.

3. Do one of the following as a next step for encryption at rest:

- a. (For hardware encryption at rest) Enable [hardware encryption at rest](#) by providing the ID of the key provider that contains the key server used for storing the keys by calling the [EnableEncryptionAtRest](#) API method.



You must enable encryption at rest via the [API](#). Enabling encryption at rest using the existing Element UI button will cause the feature to revert to using internally generated keys.

- b. (For software encryption at rest) In order for [software encryption at rest](#) to utilize the newly created key provider, pass the key provider ID to the [RekeySoftwareEncryptionAtRestMasterKey](#) API method.

Find more information

- [Enable and disable encryption for a cluster](#)
- [SolidFire and Element Software Documentation](#)
- [Documentation for earlier versions of NetApp SolidFire and Element products](#)

Rekey software encryption at rest master key

You can use the Element API to rekey an existing key. This process creates a new replacement master key for your external key management server. Master keys are always replaced by new master keys and never duplicated or overwritten.

You might need to rekey as part of one of the following procedures:

- Create a new key as part of a change from internal key management to external key management.
- Create a new key as a reaction to or as protection against a security-related event.



This process is asynchronous and returns a response before the rekey operation is complete. You can use the [GetAsyncResult](#) method to poll the system to see when the process has completed.

What you'll need

- You have enabled software encryption at rest using the [CreateCluster](#) method on a new cluster that does not contain volumes and has no I/O. Use [GetSoftwareEncryptionatRestInfo](#) to confirm that the state is enabled before proceeding.
- You have [established a trust relationship](#) between the SolidFire cluster and an External Key Server (EKS). Run the [TestKeyProviderKmpip](#) method to verify that a connection to the key provider is established.

Steps

1. Run the [ListKeyProvidersKmpip](#) command and copy the key provider ID (`keyProviderID`).
2. Run the [RekeySoftwareEncryptionAtRestMasterKey](#) with the `keyManagementType` parameter as `external` and `keyProviderID` as the ID number of the key provider from the previous step:

```

{
  "method": "rekeysoftwareencryptionatrestmasterkey",
  "params": {
    "keyManagementType": "external",
    "keyProviderID": "<ID number>"
  }
}

```

3. Copy the `asyncHandle` value from the `RekeySoftwareEncryptionAtRestMasterKey` command response.
4. Run the [GetAsyncResult](#) command with the `asyncHandle` value from the previous step to confirm the change in configuration. From the command response, you should see that the older master key configuration has been updated with new key information. Copy the new key provider ID for use in a later step.

```

{
  "id": null,
  "result": {
    "createTime": "2021-01-01T22:29:18Z",
    "lastUpdateTime": "2021-01-01T22:45:51Z",
    "result": {
      "keyToDecommission": {
        "keyID": "<value>",
        "keyManagementType": "internal"
      },
      "newKey": {
        "keyID": "<value>",
        "keyManagementType": "external",
        "keyProviderID": <value>
      },
      "operation": "Rekeying Master Key. Master Key management being transferred from Internal Key Management to External Key Management with keyProviderID=<value>",
      "state": "Ready"
    },
    "resultType": "RekeySoftwareEncryptionAtRestMasterKey",
    "status": "complete"
  }
}

```

5. Run the `GetSoftwareEncryptionatRestInfo` command to confirm that new key details, including the `keyProviderID`, have been updated.

```

{
  "id": null,
  "result": {
    "masterKeyInfo": {
      "keyCreatedTime": "2021-01-01T22:29:18Z",
      "keyID": "<updated value>",
      "keyManagementType": "external",
      "keyProviderID": <value>
    },
    "rekeyMasterKeyAsyncResultID": <value>
    "status": "enabled",
    "version": 1
  },
}

```

Find more information

- [Manage storage with the Element API](#)
- [SolidFire and Element Software Documentation](#)
- [Documentation for earlier versions of NetApp SolidFire and Element products](#)

Recover inaccessible or invalid authentication keys

Occasionally, an error can occur that requires user intervention. In the event of an error, a cluster fault (referred to as a cluster fault code) will be generated. The two most likely cases are described here.

The cluster is unable to unlock the drives due to a `KmipServerFault` cluster fault.

This can occur when the cluster first boots up and the key server is inaccessible or the required key is unavailable.

1. Follow the recovery steps in the cluster fault codes (if any).

A `sliceServiceUnhealthy` fault might be set because the metadata drives have been marked as failed and placed into the "Available" state.

Steps to clear:

1. Add the drives again.
2. After 3 to 4 minutes, check that the `sliceServiceUnhealthy` fault has cleared.

See [cluster fault codes](#) for more information.

External key management API commands

List of all of the APIs available for managing and configuring EKM.

Used for establishing a trust relationship between the cluster and external customer-owned servers:

- `CreatePublicPrivateKeyPair`
- `GetClientCertificateSignRequest`

Used for defining the specific details of external customer-owned servers:

- `CreateKeyServerKmp`
- `ModifyKeyServerKmp`
- `DeleteKeyServerKmp`
- `GetKeyServerKmp`
- `ListKeyServersKmp`
- `TestKeyServerKmp`

Used for creating and maintaining key providers which manage external key servers:

- `CreateKeyProviderKmp`
- `DeleteKeyProviderKmp`
- `AddKeyServerToProviderKmp`
- `RemoveKeyServerFromProviderKmp`
- `GetKeyProviderKmp`
- `ListKeyProvidersKmp`
- `RekeySoftwareEncryptionAtRestMasterKey`
- `TestKeyProviderKmp`

For information about the API methods, see [API reference information](#).

Manage volumes and virtual volumes

You can manage the data in a cluster running Element software from the Management tab in the Element UI. Available cluster management functions include creating and managing data volumes, volume access groups, initiators, and Quality of Service (QoS) policies.

- [Work with volumes](#)
- [Work with virtual volumes](#)
- [Work with volume access groups and initiators](#)

For more information

- [SolidFire and Element Software Documentation](#)
- [NetApp Element Plug-in for vCenter Server](#)

Work with volumes

The SolidFire system provisions storage using volumes. Volumes are block devices accessed over the network by iSCSI or Fibre Channel clients. From the Volumes page on the Management tab, you can create, modify, clone, and delete volumes on a node. You can also view statistics about volume bandwidth and I/O usage.

Find more information

- [Manage Quality of Service policies](#)
- [Create a volume](#)
- [View individual volume performance details](#)
- [Edit active volumes](#)
- [Delete a volume](#)
- [Restore a deleted volume](#)
- [Purge a volume](#)
- [Clone a volume](#)
- [Assign LUNs to Fibre Channel volumes](#)
- [Apply a QoS policy to volumes](#)
- [Remove the QoS policy association of a volume](#)

Manage Quality of Service policies

A Quality of Service (QoS) policy enables you to create and save a standardized quality of service setting that can be applied to many volumes. You can create, edit, and delete QoS policies from the QoS Policies page on the Management tab.



If you are using QoS policies, do not use custom QoS on a volume. Custom QoS will override and adjust QoS policy values for volume QoS settings.

[NetApp video: SolidFire Quality of Service Policies](#)

See [Performance and quality of service](#).

- [Create a QoS policy](#)
- [Edit a QoS policy](#)
- [Delete a QoS policy](#)

Create a QoS policy

You can create QoS policies and apply them when creating volumes.

1. Select **Management > QoS Policies**.
2. Click **Create QoS Policy**.
3. Enter the **Policy Name**.

4. Enter the **Min IOPS**, **Max IOPS**, and **Burst IOPS** values.
5. Click **Create QoS Policy**.

Edit a QoS policy

You can change the name of an existing QoS policy or edit the values associated with the policy. Changing a QoS policy affects all volumes associated with the policy.

1. Select **Management > QoS Policies**.
2. Click the Actions icon for the QoS policy you want to edit.
3. In the resulting menu, select **Edit**.
4. In the **Edit QoS Policy** dialog box, modify the following properties as required:
 - Policy Name
 - Min IOPS
 - Max IOPS
 - Burst IOPS
5. Click **Save Changes**.

Delete a QoS policy

You can delete a QoS policy if it is no longer needed. When you delete a QoS policy, all volumes associated with the policy maintain the QoS settings but become unassociated with a policy.



If you are trying instead to disassociate a volume from a QoS policy, you can change the QoS settings for that volume to custom.

1. Select **Management > QoS Policies**.
2. Click the Actions icon for the QoS policy you want to delete.
3. In the resulting menu, select **Delete**.
4. Confirm the action.

Find more information

- [Remove the QoS policy association of a volume](#)
- [SolidFire and Element Software Documentation](#)
- [NetApp Element Plug-in for vCenter Server](#)

Manage volumes

The SolidFire system provisions storage using volumes. Volumes are block devices accessed over the network by iSCSI or Fibre Channel clients.

From the Volumes page on the Management tab, you can create, modify, clone, and delete volumes on a node.

Create a volume

You can create a volume and associate the volume with a given account. Every volume must be associated with an account. This association gives the account access to the volume through the iSCSI initiators using the CHAP credentials.

You can specify QoS settings for a volume during creation.

1. Select **Management > Volumes**.
2. Click **Create Volume**.
3. In the **Create a New Volume** dialog box, enter the **Volume Name**.
4. Enter the total size of the volume.



The default volume size selection is in GB. You can create volumes using sizes measured in GB or GiB:

- 1GB = 1 000 000 000 bytes
- 1GiB = 1 073 741 824 bytes

5. Select a **Block Size** for the volume.
6. Click the **Account** drop-down list and select the account that should have access to the volume.

If an account does not exist, click the **Create Account** link, enter a new account name, and click **Create**. The account is created and associated with the new volume.



If there are more than 50 accounts, the list does not appear. Begin typing and the auto-complete function displays possible values for you to choose.

7. To set the **Quality of Service**, do one of the following:
 - a. Under **Policy**, you can select an existing QoS policy, if available.
 - b. Under **Custom Settings**, set customized minimum, maximum, and burst values for IOPS or use the default QoS values.

Volumes that have a Max or Burst IOPS value greater than 20,000 IOPS might require high queue depth or multiple sessions to achieve this level of IOPS on a single volume.

8. Click **Create Volume**.

View volume details

1. Select **Management > Volumes**.
2. Review the details.
 - **ID**: The system-generated ID for the volume.
 - **Name**: The name given to the volume when it was created.
 - **Account**: The name of the account assigned to the volume.
 - **Access Groups**: The name of the volume access group or groups to which the volume belongs.
 - **Access**: The type of access assigned to the volume when it was created. Possible values:
 - Read / Write: All reads and writes are accepted.

- Read Only: All read activity allowed; no writes allowed.
- Locked: Only Administrator access allowed.
- ReplicationTarget: Designated as a target volume in a replicated volume pair.
- **Used**: The percentage of used space in the volume.
- **Size**: The total size (in GB) of the volume.
- **Snapshots**: The number of snapshots created for the volume.
- **QoS Policy**: The name and link to the user-defined QoS policy.
- **Min IOPS**: The minimum number of IOPS guaranteed for the volume.
- **Max IOPS**: The maximum number of IOPS allowed for the volume.
- **Burst IOPS**: The maximum number of IOPS allowed over a short period of time for the volume. Default = 15,000.
- **Attributes**: Attributes that have been assigned to the volume as a key/value pair through an API method.
- **512e**: Indication of whether 512e is enabled on a volume. Possible values:
 - Yes
 - No
- **Created On**: The date and time that the volume was created.

View individual volume details

You can view performance statistics for individual volumes.

1. Select **Reporting > Volume Performance**.
2. In the volume list, click the Actions icon for a volume.
3. Click **View Details**.

A tray appears at the bottom of the page containing general information about the volume.

4. To see more detailed information about the volume, click **See More Details**.

The system displays detailed information as well as performance graphs for the volume.

Edit active volumes

You can modify volume attributes such as QoS values, volume size, and the unit of measurement in which byte values are calculated. You can also modify account access for replication usage or to restrict access to the volume.

You can resize a volume when there is sufficient space on the cluster under the following conditions:

- Normal operating conditions.
- Volume errors or failures are being reported.
- The volume is being cloned.
- The volume is being resynced.

Steps

1. Select **Management > Volumes**.
2. In the **Active** window, click the Actions icon for the volume you want to edit.
3. Click **Edit**.
4. **Optional:** Change the total size of the volume.
 - You can increase, but not decrease, the size of the volume. You can only resize one volume in a single resizing operation. Garbage collection operations and software upgrades do not interrupt the resizing operation.
 - If you are adjusting volume size for replication, you should first increase the size of the volume assigned as the replication target. Then you can resize the source volume. The target volume can be greater or equal in size to the source volume, but it cannot be smaller.

The default volume size selection is in GB. You can create volumes using sizes measured in GB or GiB:

- 1GB = 1 000 000 000 bytes
- 1GiB = 1 073 741 824 bytes

5. **Optional:** Select a different account access level of one of the following:
 - Read Only
 - Read/Write
 - Locked
 - Replication Target
6. **Optional:** Select the account that should have access to the volume.

If the account does not exist, click the **Create Account** link, enter a new account name, and click **Create**. The account is created and associated with the volume.



If there are more than 50 accounts, the list does not appear. Begin typing and the auto-complete function displays possible values for you to choose.

7. **Optional:** To change the selection in **Quality of Service**, do one of the following:
 - a. Under **Policy**, you can select an existing QoS policy, if available.
 - b. Under **Custom Settings**, set customized minimum, maximum, and burst values for IOPS or use the default QoS values.



If you are using QoS policies on a volume, you can set custom QoS to remove the QoS policy affiliation with the volume. Custom QoS will override and adjust QoS policy values for volume QoS settings.



When you change IOPS values, you should increment in tens or hundreds. Input values require valid whole numbers.



Configure volumes with an extremely high burst value. This allows the system to process occasional large block sequential workloads more quickly, while still constraining the sustained IOPS for a volume.

8. Click **Save Changes**.

Delete a volume

You can delete one or more volumes from an Element storage cluster.

The system does not immediately purge a deleted volume; the volume remains available for approximately eight hours. If you restore a volume before the system purges it, the volume comes back online and iSCSI connections are restored.

If a volume used to create a snapshot is deleted, its associated snapshots become inactive. When the deleted source volumes are purged, the associated inactive snapshots are also removed from the system.



Persistent volumes that are associated with management services are created and assigned to a new account during installation or upgrade. If you are using persistent volumes, do not modify or delete the volumes or their associated account.

Steps

1. Select **Management > Volumes**.
2. To delete a single volume, perform the following steps:
 - a. Click the Actions icon for the volume you want to delete.
 - b. In the resulting menu, click **Delete**.
 - c. Confirm the action.

The system moves the volume to the **Deleted** area on the **Volumes** page.

3. To delete multiple volumes, perform the following steps:
 - a. In the list of volumes, check the box next to any volumes you want to delete.
 - b. Click **Bulk Actions**.
 - c. In the resulting menu, click **Delete**.
 - d. Confirm the action.

The system moves the volumes to the **Deleted** area on the **Volumes** page.

Restore a deleted volume

You can restore a volume in the system if it has been deleted but not yet purged. The system automatically purges a volume approximately eight hours after it has been deleted. If the system has purged the volume, you cannot restore it.

1. Select **Management > Volumes**.
2. Click the **Deleted** tab to view the list of deleted volumes.
3. Click the Actions icon for the volume you want to restore.
4. In the resulting menu, click **Restore**.
5. Confirm the action.

The volume is placed in the **Active** volumes list and iSCSI connections to the volume are restored.

Purge a volume

When a volume is purged, it is permanently removed from the system. All data in the volume is lost.

The system automatically purges deleted volumes eight hours after deletion. However, if you want to purge a volume before the scheduled time, you can do so.

1. Select **Management > Volumes**.
2. Click the **Deleted** button.
3. Perform the steps to purge a single volume or multiple volumes.

Option	Steps
Purge a single volume	<ol style="list-style-type: none">a. Click the Actions icon for the volume you want to purge.b. Click Purge.c. Confirm the action.
Purge multiple volumes	<ol style="list-style-type: none">a. Select the volumes you want to purge.b. Click Bulk Actions.c. In the resulting menu, select Purge.d. Confirm the action.

Clone a volume

You can create a clone of a single volume or multiple volumes to make a point-in-time copy of the data. When you clone a volume, the system creates a snapshot of the volume and then creates a copy of the data referenced by the snapshot. This is an asynchronous process, and the amount of time the process requires depends on the size of the volume you are cloning and the current cluster load.

The cluster supports up to two running clone requests per volume at a time and up to eight active volume clone operations at a time. Requests beyond these limits are queued for later processing.



Operating systems differ in how they treat cloned volumes. VMware ESXi will treat a cloned volume as a volume copy or snapshot volume. The volume will be an available device to use to create a new datastore. For more information on mounting clone volumes and handling snapshot LUNs, see VMware documentation on [mounting a VMFS datastore copy](#) and [managing duplicate VMFS datastores](#).



Before you truncate a cloned volume by cloning to a smaller size, ensure that you prepare the partitions so that they fit into the smaller volume.

Steps

1. Select **Management > Volumes**.
2. To clone a single volume, perform the following steps:
 - a. In the list of volumes on the **Active** page, click the Actions icon for the volume you want to clone.
 - b. In the resulting menu, click **Clone**.
 - c. In the **Clone Volume** window, enter a volume name for the newly cloned volume.

d. Select a size and measurement for the volume using the **Volume Size** spin box and list.



The default volume size selection is in GB. You can create volumes using sizes measured in GB or GiB:

- 1GB = 1 000 000 000 bytes
- 1GiB = 1 073 741 824 bytes

e. Select the type of access for the newly cloned volume.

f. Select an account to associate with the newly cloned volume from the **Account** list.



You can create an account during this step if you click the **Create Account** link, enter an account name, and click **Create**. The system automatically adds the account to the **Account** list after you create it.

3. To clone multiple volumes, perform the following steps:

a. In the list of volumes on the **Active** page, check the box next to any volumes you want to clone.

b. Click **Bulk Actions**.

c. In the resulting menu, select **Clone**.

d. In the **Clone Multiple Volumes** dialog box, enter a prefix for the cloned volumes in the **New Volume Name Prefix** field.

e. Select an account to associate with the cloned volumes from the **Account** list.

f. Select the type of access for the cloned volumes.

4. Click **Start Cloning**.



Increasing the volume size of a clone results in a new volume with additional free space at the end of the volume. Depending on how you use the volume, you might need to extend partitions or create new partitions in the free space to make use of it.

For more information

- [SolidFire and Element Software Documentation](#)
- [NetApp Element Plug-in for vCenter Server](#)

Assign LUNs to Fibre Channel volumes

You can change the LUN assignment for a Fibre Channel volume in a volume access group. You can also make Fibre Channel volume LUN assignments when you create a volume access group.

Assigning new Fibre Channel LUNs is an advanced function and could have unknown consequences on the connecting host. For example, the new LUN ID might not be automatically discovered on the host, and the host might require a rescan to discover the new LUN ID.

1. Select **Management > Access Groups**.
2. Click the Actions icon for the access group you want to edit.
3. In the resulting menu, select **Edit**.

4. Under **Assign LUN IDs** in the **Edit Volume Access Group** dialog box, click the arrow on the **LUN Assignments** list.
5. For each volume in the list that you want to assign a LUN to, enter a new value in the corresponding **LUN** field.
6. Click **Save Changes**.

Apply a QoS policy to volumes

You can bulk apply an existing QoS policy to one or more volumes.

The QoS policy you want to bulk apply must exist.

1. Select **Management > Volumes**.
2. In the list of volumes, check the box next to any volumes you want to apply the QoS policy to.
3. Click **Bulk Actions**.
4. In the resulting menu, click **Apply QoS Policy**.
5. Select the QoS policy from the drop-down list.
6. Click **Apply**.

Find more information

[Quality of Service policies](#)

Remove the QoS policy association of a volume

You can remove a QoS policy association from a volume by selecting custom QoS settings.

The volume you want to modify should be associated with a QoS policy.

1. Select **Management > Volumes**.
2. Click the Actions icon for a volume that contains a QoS policy you want to modify.
3. Click **Edit**.
4. In the resulting menu under **Quality of Service**, click **Custom Settings**.
5. Modify **Min IOPS**, **Max IOPS**, and **Burst IOPS**, or keep the default settings.
6. Click **Save Changes**.

Find more information

[Delete a QoS policy](#)

Work with virtual volumes

You can view information and perform tasks for virtual volumes and their associated storage containers, protocol endpoints, bindings, and hosts using the Element UI.

The NetApp Element software storage system ships with the Virtual Volumes (VVols) feature disabled. You must perform a one-time task of manually enabling vSphere VVol functionality through the Element UI.

After you enable the VVol functionality, a VVols tab appears in the user interface that offers VVols-related monitoring and limited management options. Additionally, a storage-side software component known as the VASA Provider acts as a storage awareness service for vSphere. Most VVols commands, such as VVol creation, cloning, and editing, are initiated by a vCenter Server or ESXi host and translated by the VASA Provider to Element APIs for the Element software storage system. Commands to create, delete, and manage storage containers and delete virtual volumes can be initiated using the Element UI.

The majority of configurations necessary for using Virtual Volumes functionality with Element software storage systems are made in vSphere. See the *VMware vSphere Virtual Volumes for SolidFire Storage Configuration Guide* to register the VASA Provider in vCenter, create and manage VVol datastores, and manage storage based on policies.



Do not register more than one NetApp Element VASA provider to a single vCenter instance. Where a second NetApp Element VASA provider is added, this renders all VVOL datastores inaccessible.



VASA support for multiple vCenters is available as an upgrade patch if you have already registered a VASA provider with your vCenter. To install, download the VASA39 .tar.gz file from the [NetApp Software Downloads](#) site and follow the directions in the manifest. The NetApp Element VASA provider uses a NetApp certificate. With this patch, the certificate is used unmodified by vCenter to support multiple vCenters for VASA and VVols use. Do not modify the certificate. Custom SSL certificates are not supported by VASA.

Find more information

- [Enable virtual volumes](#)
- [View virtual volume details](#)
- [Delete a virtual volume](#)
- [Create a storage container](#)
- [Edit a storage container](#)
- [Delete a storage container](#)
- [Protocol endpoints](#)
- [Bindings](#)
- [Host details](#)

Enable virtual volumes

You must manually enable vSphere Virtual Volumes (VVols) functionality through the NetApp Element software. The Element software system comes with VVols functionality disabled by default, and it is not automatically enabled as part of a new installation or upgrade. Enabling the VVols feature is a one-time configuration task.

What you'll need

- The cluster must be running Element 9.0 or later.
- The cluster must be connected to an ESXi 6.0 or later environment that is compatible with VVols.
- If you are using Element 11.3 or later, the cluster must be connected to an ESXi 6.0 update 3 or later environment.



Enabling vSphere Virtual Volumes functionality permanently changes the Element software configuration. You should only enable VVols functionality if your cluster is connected to a VMware ESXi VVols-compatible environment. You can disable the VVols feature and restore the default settings only by returning the cluster to the factory image, which deletes all data on the system.

Steps

1. Select **Clusters > Settings**.
2. Find the cluster-specific settings for Virtual Volumes.
3. Click **Enable Virtual Volumes**.
4. Click **Yes** to confirm the Virtual Volumes configuration change.

The **VVols** tab appears in the Element UI.



When VVols functionality is enabled, the SolidFire cluster starts the VASA Provider, opens port 8444 for VASA traffic, and creates protocol endpoints that can be discovered by vCenter and all ESXi hosts.

5. Copy the VASA Provider URL from the Virtual Volumes (VVols) settings in **Clusters > Settings**. You will use this URL to register the VASA Provider in vCenter.
6. Create a storage container in **VVols > Storage Containers**.



You must create at least one storage container so that VMs can be provisioned to a VVol datastore.

7. Select **VVols > Protocol Endpoints**.
8. Verify that a protocol endpoint has been created for each node in the cluster.



Additional configuration tasks are required in vSphere. See the *VMware vSphere Virtual Volumes for SolidFire Storage Configuration Guide* to register the VASA Provider in vCenter, create and manage VVol datastores, and manage storage based on policies.

Find more information

[VMware vSphere Virtual Volumes for SolidFire Storage Configuration Guide](#)

View virtual volume details

You can review virtual volume information for all active virtual volumes on the cluster in the Element UI. You can also view performance activity for each virtual volume, including input, output, throughput, latency, queue depth, and volume information.

What you'll need

- You should have enabled VVols functionality in the Element UI for the cluster.
- You should have created an associated storage container.
- You should have configured your vSphere cluster to use Element software VVols functionality.
- You should have created at least one VM in vSphere.

Steps

1. Click **VVols > Virtual Volumes**.

The information for all active virtual volumes is displayed.

2. Click the **Actions** icon for the virtual volume you want to review.
3. In the resulting menu, select **View Details**.

Details

The Virtual Volumes page of the VVols tab provides information about each active virtual volume on the cluster, such as volume ID, snapshot ID, parent virtual volume ID, and virtual volume ID.

- **Volume ID:** The ID of the underlying volume.
- **Snapshot ID:** The ID of the underlying volume snapshot. The value is 0 if the virtual volume does not represent a SolidFire snapshot.
- **Parent Virtual Volume ID:** The virtual volume ID of the parent virtual volume. If the ID is all zeros, the virtual volume is independent with no link to a parent.
- **Virtual Volume ID:** The UUID of the virtual volume.
- **Name:** The name assigned to the virtual volume.
- **Storage Container:** The storage container that owns the virtual volume.
- **Guest OS Type:** Operating system associated with the virtual volume.
- **Virtual Volume Type:** The virtual volume type: Config, Data, Memory, Swap, or Other.
- **Access:** The read-write permissions assigned to the virtual volume.
- **Size:** The size of the virtual volume in GB or GiB.
- **Snapshots:** The number of associated snapshots. Click the number to link to snapshot details.
- **Min IOPS:** The minimum IOPS QoS setting of the virtual volume.
- **Max IOPS:** The maximum IOPS QoS setting of the virtual volume.
- **Burst IOPS:** The maximum burst QoS setting of the virtual volume.
- **VMW_VmID:** Information in fields prefaced with "VMW_" are defined by VMware.
- **Create Time:** The time the virtual volume creation task was completed.

Individual virtual volume details

The Virtual Volumes page on the VVols tab provides the following virtual volume information when you select an individual virtual volume and view its details.

- **VMW_XXX:** Information in fields prefaced with "VMW_" are defined by VMware.
- **Parent Virtual Volume ID:** The virtual volume ID of the parent virtual volume. If the ID is all zeros, the virtual volume is independent with no link to a parent.
- **Virtual Volume ID:** The UUID of the virtual volume.
- **Virtual Volume Type:** The virtual volume type: Config, Data, Memory, Swap, or Other.
- **Volume ID:** The ID of the underlying volume.
- **Access:** The read-write permissions assigned to the virtual volume.

- **Account Name:** Name of the account containing the volume.
- **Access Groups:** Associated volume access groups.
- **Total Volume Size:** Total provisioned capacity in bytes.
- **Non-Zero Blocks:** Total number of 4KiB blocks with data after the last garbage collection operation has completed.
- **Zero Blocks:** Total number of 4KiB blocks without data after the last round of garbage collection operation has completed.
- **Snapshots:** The number of associated snapshots. Click the number to link to snapshot details.
- **Min IOPS:** The minimum IOPS QoS setting of the virtual volume.
- **Max IOPS:** The maximum IOPS QoS setting of the virtual volume.
- **Burst IOPS:** The maximum burst QoS setting of the virtual volume.
- **Enable 512:** Because virtual volumes always use 512-byte block size emulation, the value is always yes.
- **Volumes Paired:** Indicates if a volume is paired.
- **Create Time:** The time the virtual volume creation task was completed.
- **Blocks Size:** Size of the blocks on the volume.
- **Unaligned Writes:** For 512e volumes, the number of write operations that were not on a 4k sector boundary. High numbers of unaligned writes might indicate improper partition alignment.
- **Unaligned Reads:** For 512e volumes, the number of read operations that were not on a 4k sector boundary. High numbers of unaligned reads might indicate improper partition alignment.
- **scsiEUIDeviceID:** Globally unique SCSI device identifier for the volume in EUI-64 based 16-byte format.
- **scsiNAADeviceID:** Globally unique SCSI device identifier for the volume in NAA IEEE Registered Extended format.
- **Attributes:** List of name-value pairs in JSON object format.

Delete a virtual volume

Although virtual volumes should always be deleted from the VMware Management Layer, the functionality for you to delete virtual volumes is enabled from the Element UI. You should only delete a virtual volume from the Element UI when absolutely necessary, such as when vSphere fails to clean up virtual volumes on SolidFire storage.

1. Select **VVols > Virtual Volumes**.
2. Click the Actions icon for the virtual volume you want to delete.
3. In the resulting menu, select **Delete**.



You should delete a virtual volume from the VMware Management Layer to ensure that the virtual volume is properly unbound before deletion. You should only delete a virtual volume from the Element UI when absolutely necessary, such as when vSphere fails to clean up virtual volumes on SolidFire storage. If you delete a virtual volume from the Element UI, the volume will be purged immediately.

4. Confirm the action.
5. Refresh the list of virtual volumes to confirm that the virtual volume has been removed.

6. **Optional:** Select **Reporting > Event Log** to confirm that the purge has been successful.

Manage storage containers

A storage container is a vSphere datastore representation created on a cluster running Element software.

Storage containers are created and tied to NetApp Element accounts. A storage container created on Element storage appears as a vSphere datastore in vCenter and ESXi. Storage containers do not allocate any space on Element storage. They are simply used to logically associate virtual volumes.

A maximum of four storage containers per cluster is supported. A minimum of one storage container is required to enable VVols functionality.

Create a storage container

You can create storage containers in the Element UI and discover them in vCenter. You must create at least one storage container to begin provisioning VVol-backed virtual machines.

Before you begin, enable VVols functionality in the Element UI for the cluster.

Steps

1. Select **VVols > Storage Containers**.
2. Click the **Create Storage Containers** button.
3. Enter storage container information in the **Create a New Storage Container** dialog box:
 - a. Enter a name for the storage container.
 - b. Configure initiator and target secrets for CHAP.



Leave the CHAP Settings fields blank to automatically generate secrets.

- c. Click the **Create Storage Container** button.
4. Verify that the new storage container appears in the list in the **Storage Containers** sub-tab.



Because a NetApp Element account ID is created automatically and assigned to the storage container, it is not necessary to manually create an account.

View storage container details

On the Storage Containers page of the VVols tab, you can view information for all active storage containers on the cluster.

- **Account ID:** The ID of the Netapp Element account associated with the storage container.
- **Name:** The name of the storage container.
- **Status:** The status of the storage container. Possible values:
 - Active: The storage container is in use.
 - Locked: The storage container is locked.
- **PE Type:** The protocol endpoint type (SCSI is the only available protocol for Element software).

- **Storage Container ID:** The UUID of the virtual volume storage container.
- **Active Virtual Volumes:** The number of active virtual volumes associated with the storage container.

View individual storage container details

You can view the storage container information for an individual storage container by selecting it from the Storage Containers page on the VVols tab.

- **Account ID:** The ID of the NetApp Element account associated with the storage container.
- **Name:** The name of the storage container.
- **Status:** The status of the storage container. Possible values:
 - Active: The storage container is in use.
 - Locked: The storage container is locked.
- **Chap Initiator Secret:** The unique CHAP secret for the initiator.
- **Chap Target Secret:** The unique CHAP secret for the target.
- **Storage Container ID:** The UUID of the virtual volume storage container.
- **Protocol Endpoint Type:** Indicates the protocol endpoint type (SCSI is the only available protocol).

Edit a storage container

You can modify storage container CHAP authentication in the Element UI.

1. Select **VVols > Storage Containers**.
2. Click the **Actions** icon for the storage container you want to edit.
3. In the resulting menu, select **Edit**.
4. Under CHAP Settings, edit the Initiator Secret and Target Secret credentials used for authentication.



If you do not change the CHAP Settings credentials, they remain the same. If you make the credentials fields blank, the system automatically generates new secrets.

5. Click **Save Changes**.

Delete a storage container

You can delete storage containers from the Element UI.

What you'll need

Ensure that all virtual machines have been removed from the VVol datastore.

Steps

1. Select **VVols > Storage Containers**.
2. Click the **Actions** icon for the storage container you want to delete.
3. In the resulting menu, select **Delete**.
4. Confirm the action.
5. Refresh the list of storage containers in the **Storage Containers** sub-tab to confirm that the storage container has been removed.

Protocol endpoints

Protocol endpoints are access points used by a host to address storage on a cluster running NetApp Element software. Protocol endpoints cannot be deleted or modified by a user, are not associated with an account, and cannot be added to a volume access group.

A cluster running Element software automatically creates one protocol endpoint per storage node in the cluster. For example, a six-node storage cluster has six protocol endpoints that are mapped to each ESXi host. Protocol endpoints are dynamically managed by Element software and are created, moved, or removed as needed without any intervention. Protocol endpoints are the target for multi-pathing and act as an I/O proxy for subsidiary LUNs. Each protocol endpoint consumes an available SCSI address, just like a standard iSCSI target. Protocol endpoints appear as a single-block (512-byte) storage device in the vSphere client, but this storage device is not available to be formatted or used as storage.

iSCSI is the only supported protocol. Fibre Channel protocol is not supported.

Protocol endpoints details

The Protocol Endpoints page on the VVols tab provides protocol endpoint information.

- **Primary Provider ID**

The ID of the primary protocol endpoint provider.

- **Secondary Provider ID**

The ID of the secondary protocol endpoint provider.

- **Protocol Endpoint ID**

The UUID of the protocol endpoint.

- **Protocol Endpoint State**

The status of the protocol endpoint. Possible values are as follows:

- Active: The protocol endpoint is in use.
- Start: The protocol endpoint is starting.
- Failover: The protocol endpoint has failed over.
- Reserved: The protocol endpoint is reserved.

- **Provider Type**

The type of the protocol endpoint's provider. Possible values are as follows:

- Primary
- Secondary

- **SCSI NAA Device ID**

The globally unique SCSI device identifier for the protocol endpoint in NAA IEEE Registered Extended Format.

Bindings

To perform I/O operations with a virtual volume, an ESXi host must first bind the virtual volume.

The SolidFire cluster chooses an optimal protocol endpoint, creates a binding that associates the ESXi host and virtual volume with the protocol endpoint, and returns the binding to the ESXi host. After it is bound, the ESXi host can perform I/O operations with the bound virtual volume.

Bindings details

The Bindings page on the VVols tab provides binding information about each virtual volume.

The following information is displayed:

- **Host ID**

The UUID for the ESXi host that hosts virtual volumes and is known to the cluster.

- **Protocol Endpoint ID**

Protocol endpoint IDs that correspond to each node in the SolidFire cluster.

- **Protocol Endpoint in Band ID**

The SCSI NAA device ID of the protocol endpoint.

- **Protocol Endpoint Type**

The protocol endpoint type.

- **VVol Binding ID**

The binding UUID of the virtual volume.

- **VVol ID**

The universally unique identifier (UUID) of the virtual volume.

- **VVol Secondary ID**

The secondary ID of the virtual volume that is a SCSI second level LUN ID.

Host details

The Hosts page on the VVols tab provides information about VMware ESXi hosts that host virtual volumes.

The following information is displayed:

- **Host ID**

The UUID for the ESXi host that hosts virtual volumes and is known to the cluster.

- **Host Address**

The IP address or DNS name for the ESXi host.

- **Bindings**

Binding IDs for all virtual volumes bound by the ESXi host.

- **ESX Cluster ID**

The vSphere host cluster ID or vCenter GUID.

- **Initiator IQNs**

Initiator IQNs for the virtual volume host.

- **SolidFire Protocol Endpoint IDs**

The protocol endpoints that are currently visible to the ESXi host.

Work with volume access groups and initiators

You can use iSCSI initiators or Fibre Channel initiators to access the volumes defined within volume access groups.

You can create access groups by mapping iSCSI initiator IQNs or Fibre Channel WWPNs in a collection of volumes. Each IQN that you add to an access group can access each volume in the group without requiring CHAP authentication.

There are two types of CHAP authentication methods:

- Account-level CHAP authentication: You can assign CHAP authentication for the account.
- Initiator-level CHAP authentication: You can assign unique CHAP target and secrets for specific initiators without being bound to single CHAP across a single account. This Initiator-level CHAP authentication replaces account level credentials.

Optionally, with per-initiator CHAP, you can enforce initiator authorization and per-initiator CHAP authentication. These options can be defined on a per-initiator basis and an access group can contain a mix of initiators with different options.

Each WWPN that you add to an access group enables Fibre Channel network access to the volumes in the access group.



Volume access groups have the following limits:

- A maximum of 64 IQNs or WWPNs are allowed in an access group.
- An access group can be made up of a maximum of 2000 volumes.
- An IQN or WWPN can belong to only one access group.
- A single volume can belong to a maximum of four access groups.

Find more information

- [Create a volume access group](#)
- [Add volumes to an access group](#)
- [Remove volumes from an access group](#)
- [Create an initiator](#)
- [Edit an initiator](#)
- [Add a single initiator to a volume access group](#)
- [Add multiple initiators to a volume access group](#)
- [Remove initiators from an access group](#)
- [Delete an access group](#)
- [Delete an initiator](#)


Create a volume access group


You can create volume access groups by mapping initiators to a collection of volumes for secured access. You can then grant access to the volumes in the group with an account CHAP initiator secret and target secret.

If you use initiator-based CHAP, you can add CHAP credentials for a single initiator in a volume access group, providing more security. This enables you to apply this option for volume access groups that already exist.

Steps

1. Click **Management > Access Groups**.
2. Click **Create Access Group**.
3. Enter a name for the volume access group in the **Name** field.
4. Add an initiator to the volume access group in one of the following ways:

Option	Description
Adding a Fibre Channel initiator	<p>a. Under Add Initiators, select an existing Fibre Channel initiator from the Unbound Fibre Channel Initiators list.</p> <p>b. Click Add FC Initiator.</p> <p> You can create an initiator during this step if you click the Create Initiator link, enter an initiator name, and click Create. The system automatically adds the initiator to the Initiators list after you create it.</p> <p>A sample of the format is as follows:</p> <pre>5f:47:ac:c0:5c:74:d4:02</pre>

Option	Description
Adding an iSCSI initiator	<p data-bbox="513 153 1481 289">Under Add Initiators, select an existing initiator from the Initiators list. Note: You can create an initiator during this step if you click the Create Initiator link, enter an initiator name, and click Create. The system automatically adds the initiator to the Initiators list after you create it.</p> <p data-bbox="513 321 956 352">A sample of the format is as follows:</p> <div data-bbox="513 394 1481 489" style="border: 1px solid #ccc; padding: 5px; margin: 10px 0;"> <pre data-bbox="540 422 1437 453">iqn.2010-01.com.solidfire:c2r9.fc0.2100000e1e09bb8b</pre> </div> <div data-bbox="540 552 597 611" style="float: left; margin-right: 10px;">  </div> <p data-bbox="659 531 1455 632">You can find the initiator IQN for each volume by selecting View Details in the Actions menu for the volume on the Management > Volumes > Active list.</p> <p data-bbox="513 678 1455 779">When you modify an initiator, you can toggle the requiredCHAP attribute to True, which enables you to set the target initiator secret. For details, see API information about the ModifyInitiator API method.</p> <p data-bbox="513 810 979 842">Manage storage with the Element API</p>

5. **Optional:** Add more initiators as needed.
6. Under Add Volumes, select a volume from the **Volumes** list.

The volume appears in the **Attached Volumes** list.

7. **Optional:** Add more volumes as needed.
8. Click **Create Access Group**.

Find more information

[Add volumes to an access group](#)

View individual access group details

You can view details for an individual access group, such as attached volumes and initiators, in a graphical format.

1. Click **Management > Access Groups**.
2. Click the Actions icon for an access group.
3. Click **View Details**.

Volume access group details

The Access Groups page on the Management tab provides information about volume access groups.

The following information is displayed:

- **ID:** The system-generated ID for the access group.

- **Name:** The name given to the access group when it was created.
- **Active Volumes:** The number of active volumes in the access group.
- **Compression:** The compression efficiency score for the access group.
- **Deduplication:** The deduplication efficiency score for the access group.
- **Thin Provisioning:** The thin provisioning efficiency score for the access group.
- **Overall Efficiency:** The overall efficiency score for the access group.
- **Initiators:** The number of initiators connected to the access group.

Add volumes to an access group

You can add volumes to a volume access group. Each volume can belong to more than one volume access group; you can see the groups that each volume belongs to on the **Active** volumes page.

You can also use this procedure to add volumes to a Fibre Channel volume access group.

1. Click **Management > Access Groups**.
2. Click the Actions icon for the access group you want to add volumes to.
3. Click the **Edit** button.
4. Under Add Volumes, select a volume from the **Volumes** list.

You can add more volumes by repeating this step.

5. Click **Save Changes**.

Remove volumes from an access group

When you remove a volume from an access group, the group no longer has access to that volume.

Modifying CHAP settings in an account or removing initiators or volumes from an access group can cause initiators to lose access to volumes unexpectedly. To verify that volume access will not be lost unexpectedly, always logout iSCSI sessions that will be affected by an account or access group change, and verify that initiators can reconnect to volumes after any changes to initiator settings and cluster settings have been completed.

1. Click **Management > Access Groups**.
2. Click the Actions icon for the access group you want to remove volumes from.
3. Click **Edit**.
4. Under Add Volumes in the **Edit Volume Access Group** dialog box, click the arrow on the **Attached Volumes** list.
5. Select the volume you want to remove from the list and click the **x** icon to remove the volume from the list.

You can remove more volumes by repeating this step.

6. Click **Save Changes**.

Create an initiator

You can create iSCSI or Fibre Channel initiators and optionally assign them aliases.

You can also assign initiator-based CHAP attributes by using an API call. To add a CHAP account name and credentials per initiator, you must use the `CreateInitiator` API call to remove and add CHAP access and attributes. Initiator access can be restricted to one or more VLANs by specifying one or more `virtualNetworkIDs` via the `CreateInitiators` and `ModifyInitiators` API calls. If no virtual networks are specified, the initiator can access all networks.

For details, see the API reference information. [Manage storage with the Element API](#)

Steps

1. Click **Management > Initiators**.
2. Click **Create Initiator**.
3. Perform the steps to create a single initiator or multiple initiators:

Option	Steps
Create a single initiator	<ol style="list-style-type: none">a. Click Create a Single Initiator.b. Enter the IQN or WWPN for the initiator in the IQN/WWPN field.c. Enter a friendly name for the initiator in the Alias field.d. Click Create Initiator.
Create multiple initiators	<ol style="list-style-type: none">a. Click Bulk Create Initiators.b. Enter a list of IQNs or WWPNs in the text box.c. Click Add Initiators.d. Choose an initiator from the resulting list and click the corresponding Add icon in the Alias column to add an alias for the initiator.e. Click the check mark to confirm the new alias.f. Click Create Initiators.

Edit an initiator

You can change the alias of an existing initiator or add an alias if one does not already exist.

To add a CHAP account name and credentials per initiator, you must use the `ModifyInitiator` API call to remove and add CHAP access and attributes.

See [Manage storage with the Element API](#).

Steps

1. Click **Management > Initiators**.
2. Click the Actions icon for the initiator you want to edit.
3. Click **Edit**.

4. Enter a new alias for the initiator in the **Alias** field.
5. Click **Save Changes**.

Add a single initiator to a volume access group

You can add an initiator to an existing volume access group.

When you add an initiator to a volume access group, the initiator has access to all volumes in that volume access group.



You can find the initiator for each volume by clicking the Actions icon and then selecting **View Details** for the volume in the active volumes list.

If you use initiator-based CHAP, you can add CHAP credentials for a single initiator in a volume access group, providing more security. This enables you to apply this option for volume access groups that already exist.

Steps

1. Click **Management > Access Groups**.
2. Click the **Actions** icon for the access group you want to edit.
3. Click **Edit**.
4. To add a Fibre Channel initiator to the volume access group, perform the following steps:
 - a. Under Add Initiators, select an existing Fibre Channel initiator from the **Unbound Fibre Channel Initiators** list.
 - b. Click **Add FC Initiator**.



You can create an initiator during this step if you click the **Create Initiator** link, enter an initiator name, and click **Create**. The system automatically adds the initiator to the **Initiators** list after you create it.

A sample of the format is as follows:

```
5f:47:ac:c0:5c:74:d4:02
```

5. To add an iSCSI initiator to the volume access group, under Add Initiators, select an existing initiator from the **Initiators** list.



You can create an initiator during this step if you click the **Create Initiator** link, enter an initiator name, and click **Create**. The system automatically adds the initiator to the **Initiators** list after you create it.

The accepted format of an initiator IQN is as follows: iqn.yyyy-mm, in which y and m are digits, followed by text which must only contain digits, lower-case alphabetic characters, a period (.), colon (:), or dash (-).

A sample of the format is as follows:

```
iqn.2010-01.com.solidfire:c2r9.fc0.2100000e1e09bb8b
```



You can find the initiator IQN for each volume from the **Management > Volumes Active Volumes** page by clicking the Actions icon and then selecting **View Details** for the volume.

6. Click **Save Changes**.

Add multiple initiators to a volume access group

You can add multiple initiators to an existing volume access group to allow access to volumes in the volume access group with or without requiring CHAP authentication..

When you add initiators to a volume access group, the initiators have access to all volumes in that volume access group.



You can find the initiator for each volume by clicking the Actions icon and then **View Details** for the volume in the active volumes list.

You can add multiple initiators to an existing volume access group to enable access to volumes and assign unique CHAP credentials for each initiator within that volume access group. This enables you to apply this option for volume access groups that already exist.

You can assign initiator-based CHAP attributes by using an API call. To add a CHAP account name and credentials per initiator, you must use the ModifyInitiator API call to remove and add CHAP access and attributes.

For details, see [Manage storage with the Element API](#).

Steps

1. Click **Management > Initiators**.
2. Select the initiators you want to add to an access group.
3. Click the **Bulk Actions** button.
4. Click **Add to Volume Access Group**.
5. In the Add to Volume Access Group dialog box, select an access group from the **Volume Access Group** list.
6. Click **Add**.

Remove initiators from an access group

When you remove an initiator from an access group, it can no longer access the volumes in that volume access group. Normal account access to the volume is not disrupted.

Modifying CHAP settings in an account or removing initiators or volumes from an access group can cause initiators to lose access to volumes unexpectedly. To verify that volume access will not be lost unexpectedly, always logout iSCSI sessions that will be affected by an account or access group change, and verify that initiators can reconnect to volumes after any changes to initiator settings and cluster settings have been completed.

Steps

1. Click **Management > Access Groups**.
2. Click the **Actions** icon for the access group you want to remove.

3. In the resulting menu, select **Edit**.
4. Under Add Initiators in the **Edit Volume Access Group** dialog box, click the arrow on the **Initiators** list.
5. Select the x icon for each initiator you want to remove from the access group.
6. Click **Save Changes**.

Delete an access group

You can delete an access group when it is no longer needed. You do not need to delete Initiator IDs and Volume IDs from the volume access group before deleting the group. After you delete the access group, group access to the volumes is discontinued.

1. Click **Management > Access Groups**.
2. Click the **Actions** icon for the access group you want to delete.
3. In the resulting menu, click **Delete**.
4. To also delete the initiators associated with this access group, select the **Delete initiators in this access group** check box.
5. Confirm the action.

Delete an initiator

You can delete an initiator after it is no longer needed. When you delete an initiator, the system removes it from any associated volume access group. Any connections using the initiator remain valid until the connection is reset.

Steps

1. Click **Management > Initiators**.
2. Perform the steps to delete a single initiator or multiple initiators:

Option	Steps
Delete single initiator	<ol style="list-style-type: none"> a. Click the Actions icon for the initiator you want to delete. b. Click Delete. c. Confirm the action.
Delete multiple initiators	<ol style="list-style-type: none"> a. Select the check boxes next to the initiators you want to delete. b. Click the Bulk Actions button. c. In the resulting menu, select Delete. d. Confirm the action.

Protect your data

NetApp Element software enables you to protect your data in a variety of ways with capabilities such as snapshots for individual volumes or groups of volumes, replication between clusters and volumes running on Element, and replication to ONTAP systems.

- **Snapshots**

Snapshot-only data protection replicates changed data at specific points of time to a remote cluster. Only those snapshots that are created on the source cluster are replicated. Active writes from the source volume are not.

[Use volume snapshots for data protection](#)

- **Remote replication between clusters and volumes running on Element**

You can replicate volume data synchronously or asynchronously from either cluster in a cluster pair both running on running on Element for failover and failback scenarios.

[Perform remote replication between clusters running NetApp Element software](#)

- **Replication between Element and ONTAP clusters using SnapMirror technology**

With NetApp SnapMirror technology, you can replicate snapshots that were taken using Element to ONTAP for disaster recovery purposes. In a SnapMirror relationship, Element is one endpoint and ONTAP is the other.

[Use SnapMirror replication between Element and ONTAP clusters](#)

- **Back up to and restore volumes from SolidFire, S3 or Swift object stores**

You can back up and restore volumes to other SolidFire storage, as well as secondary object stores that are compatible with Amazon S3 or OpenStack Swift.

[Back up and restore volumes to SolidFire, S3, or Swift object stores](#)

For more information

- [SolidFire and Element Software Documentation](#)
- [NetApp Element Plug-in for vCenter Server](#)

Use volume snapshots for data protection

A volume snapshot is a point-in-time copy of a volume. You can take a snapshot of a volume and use the snapshot later if you need to roll a volume back to the state it was in at the time the snapshot was created.

Snapshots are similar to volume clones. However, snapshots are simply replicas of volume metadata, so you cannot mount or write to them. Creating a volume snapshot also takes only a small amount of system resources and space, which makes snapshot creation faster than cloning.

You can take a snapshot of an individual volume or a set of volumes.

Optionally, replicate snapshots to a remote cluster and use them as a backup copy of the volume. This enables you to roll back a volume to a specific point in time by using the replicated snapshot. Alternatively, you can create a clone of a volume from a replicated snapshot.

Find more information

- [Use individual volume snapshots for data protection](#)
- [Using group snapshots for data protection task](#)
- [Scheduling a snapshot](#)

Use individual volume snapshots for data protection

A volume snapshot is a point-in-time copy of a volume. You can use an individual volume rather than a group of volumes for the snapshot.

Find more information

- [Create a volume snapshot](#)
- [Edit snapshot retention](#)
- [Deleting a snapshot](#)
- [Cloning a volume from a snapshot](#)
- [Rolling back a volume to a snapshot](#)
- [Backing up a volume snapshot to an Amazon S3 object store](#)
- [Backing up a volume snapshot to an OpenStack Swift object store](#)
- [Backing up a volume snapshot to a SolidFire cluster](#)

Create a volume snapshot

You can create a snapshot of an active volume to preserve the volume image at any point in time. You can create up to 32 snapshots for a single volume.

1. Click **Management > Volumes**.
2. Click the **Actions** icon for the volume you want to use for the snapshot.
3. In the resulting menu, select **Snapshot**.
4. In the **Create Snapshot of Volume** dialog box, enter the new snapshot name.
5. **Optional:** Select the **Include Snapshot in Replication When Paired** check box to ensure that the snapshot is captured in replication when the parent volume is paired.
6. To set the retention for the snapshot, select from one of the following options:
 - Click **Keep Forever** to retain the snapshot on the system indefinitely.
 - Click **Set Retention Period** and use the date spin boxes to choose a length of time for the system to retain the snapshot.
7. To take a single, immediate snapshot, perform the following steps:
 - a. Click **Take Snapshot Now**.
 - b. Click **Create Snapshot**.
8. To schedule the snapshot to run at a future time, perform the following steps:
 - a. Click **Create Snapshot Schedule**.
 - b. Enter a **New Schedule Name**.

- c. Choose a **Schedule Type** from the list.
- d. **Optional:** Select the **Recurring Schedule** check box to repeat the scheduled snapshot periodically.
- e. Click **Create Schedule**.

Find more information

[Schedule a snapshot](#)

Edit snapshot retention

You can change the retention period for a snapshot to control when or if the system deletes snapshots. The retention period you specify begins when you enter the new interval. When you set a retention period, you can select a period that begins at the current time (retention is not calculated from the snapshot creation time). You can specify intervals in minutes, hours, and days.

Steps

1. Click **Data Protection > Snapshots**.
2. Click the **Actions** icon for the snapshot you want to edit.
3. In the resulting menu, click **Edit**.
4. **Optional:** Select the **Include Snapshot in Replication When Paired** check box to ensure that the snapshot is captured in replication when the parent volume is paired.
5. **Optional:** Select a retention option for the snapshot:
 - Click **Keep Forever** to retain the snapshot on the system indefinitely.
 - Click **Set Retention Period** and use the date spin boxes to select a length of time for the system to retain the snapshot.
6. Click **Save Changes**.

Delete a snapshot

You can delete a volume snapshot from a storage cluster running Element software. When you delete a snapshot, the system immediately removes it.

You can delete snapshots that are being replicated from the source cluster. If a snapshot is syncing to the target cluster when you delete it, the sync replication completes and the snapshot is deleted from the source cluster. The snapshot is not deleted from the target cluster.

You can also delete snapshots that have been replicated to the target from the target cluster. The deleted snapshot is kept in a list of deleted snapshots on the target until the system detects that you have deleted the snapshot on the source cluster. When the target detects that you have deleted the source snapshot, the target stops replication of the snapshot.

When you delete a snapshot from the source cluster, the target cluster snapshot is not affected (the reverse is also true).

1. Click **Data Protection > Snapshots**.
2. Click the **Actions** icon for the snapshot you want to delete.
3. In the resulting menu, select **Delete**.

4. Confirm the action.

Clone a volume from a snapshot

You can create a new volume from a snapshot of a volume. When you do this, the system uses the snapshot information to clone a new volume using the data contained on the volume at the time the snapshot was created. This process stores information about other snapshots of the volume in the newly created volume.

1. Click **Data Protection > Snapshots**.
2. Click the **Actions** icon for the snapshot you want to use for the volume clone.
3. In the resulting menu, click **Clone Volume From Snapshot**.
4. Enter a **Volume Name** in the **Clone Volume From Snapshot** dialog box.
5. Select a **Total Size** and size units for the new volume.
6. Select an **Access** type for the volume.
7. Select an **Account** from the list to associate with the new volume.
8. Click **Start Cloning**.

Roll back a volume to a snapshot

You can roll back a volume to a previous snapshot at any time. This reverts any changes made to the volume since the snapshot was created.

Steps

1. Click **Data Protection > Snapshots**.
2. Click the **Actions** icon for the snapshot you want to use for the volume rollback.
3. In the resulting menu, select **Rollback Volume To Snapshot**.
4. **Optional:** To save the current state of the volume before rolling back to the snapshot:
 - a. In the **Rollback To Snapshot** dialog box, select **Save volume's current state as a snapshot**.
 - b. Enter a name for the new snapshot.
5. Click **Rollback Snapshot**.

Back up a volume snapshot

You can use the integrated backup feature to back up a volume snapshot. You can back up snapshots from a SolidFire cluster to an external object store, or to another SolidFire cluster. When you back up a snapshot to an external object store, you must have a connection to the object store that allows read/write operations.

- [Back up a volume snapshot to an Amazon S3 object store](#)
- [Back up a volume snapshot to an OpenStack Swift object store](#)
- [Back up a volume snapshot to a SolidFire cluster](#)

Back up a volume snapshot to an Amazon S3 object store

You can back up SolidFire snapshots to external object stores that are compatible with Amazon S3.

1. Click **Data Protection > Snapshots**.
2. Click the **Actions** icon for the snapshot you want to back up.
3. In the resulting menu, click **Backup to**.
4. In the **Integrated Backup** dialog box under **Backup to**, select **S3**.
5. Select an option under **Data Format**:
 - **Native**: A compressed format readable only by SolidFire storage systems.
 - **Uncompressed**: An uncompressed format compatible with other systems.
6. Enter a hostname to use to access the object store in the **Hostname** field.
7. Enter an access key ID for the account in the **Access Key ID** field.
8. Enter the secret access key for the account in the **Secret Access Key** field.
9. Enter the S3 bucket in which to store the backup in the **S3 Bucket** field.
10. **Optional**: Enter a nametag to append to the prefix in the **Nametag** field.
11. Click **Start Read**.

Back up a volume snapshot to an OpenStack Swift object store

You can back up SolidFire snapshots to secondary object stores that are compatible with OpenStack Swift.

1. Click **Data Protection > Snapshots**.
2. Click the **Actions** icon for the snapshot you want to back up.
3. In the resulting menu, click **Backup to**.
4. In the **Integrated Backup** dialog box, under **Backup to**, select **Swift**.
5. Select an option under **Data Format**:
 - **Native**: A compressed format readable only by SolidFire storage systems.
 - **Uncompressed**: An uncompressed format compatible with other systems.
6. Enter a **URL** to use to access the object store.
7. Enter a **Username** for the account.
8. Enter the **Authentication Key** for the account.
9. Enter the **Container** in which to store the backup.
10. **Optional**: Enter a **Nametag**.
11. Click **Start Read**.

Back up a volume snapshot to a SolidFire cluster

You can back up volume snapshots residing on a SolidFire cluster to a remote SolidFire cluster.

Ensure that the source and target clusters are paired.

When backing up or restoring from one cluster to another, the system generates a key to be used as authentication between the clusters. This bulk volume write key allows the source cluster to authenticate with the destination cluster, providing a level of security when writing to the destination volume. As part of the backup or restore process, you need to generate a bulk volume write key from the destination volume before starting the operation.

1. On the destination cluster, click **Management > Volumes**.
2. Click the **Actions** icon for the destination volume.
3. In the resulting menu, click **Restore from**.
4. In the **Integrated Restore** dialog box under **Restore from**, select **SolidFire**.
5. Select a data format under **Data Format**:
 - **Native**: A compressed format readable only by SolidFire storage systems.
 - **Uncompressed**: An uncompressed format compatible with other systems.
6. Click **Generate Key**.
7. Copy the key from the **Bulk Volume Write Key** box to your clipboard.
8. On the source cluster, click **Data Protection > Snapshots**.
9. Click the Actions icon for the snapshot you want to use for the backup.
10. In the resulting menu, click **Backup to**.
11. In the **Integrated Backup** dialog box under **Backup to**, select **SolidFire**.
12. Select the same data format you selected earlier in the **Data Format** field.
13. Enter the management virtual IP address of the destination volume's cluster in the **Remote Cluster MVIP** field.
14. Enter the remote cluster user name in the **Remote Cluster Username** field.
15. Enter the remote cluster password in the **Remote Cluster Password** field.
16. In the **Bulk Volume Write Key** field, paste the key you generated on the destination cluster earlier.
17. Click **Start Read**.

Using group snapshots for data protection task

You can create a group snapshot of a related set of volumes to preserve a point-in-time copy of the metadata for each volume. You can use the group snapshot in the future as a backup or rollback to restore the state of the group of volumes to a previous state.

Find more information

- [Create a group snapshot](#)
- [Edit group snapshots](#)
- [Edit members of group snapshot](#)
- [Delete a group snapshot](#)
- [Roll back volumes to a group snapshot](#)
- [Clone multiple volumes](#)

- [Clone multiple volumes from a group snapshot](#)

Group snapshot details

The Group Snapshots page on the Data Protection tab provides information about the group snapshots.

- **ID**

The system-generated ID for the group snapshot.

- **UUID**

The unique ID of the group snapshot.

- **Name**

User-defined name for the group snapshot.

- **Create Time**

The time at which the group snapshot was created.

- **Status**

The current status of the snapshot. Possible values:

- Preparing: The snapshot is being prepared for use and is not yet writable.
- Done: This snapshot has finished preparation and is now usable.
- Active: The snapshot is the active branch.

- **# Volumes**

The number of volumes in the group.

- **Retain Until**

The day and time the snapshot will be deleted.

- **Remote Replication**

Indication of whether or not the snapshot is enabled for replication to a remote SolidFire cluster. Possible values:

- Enabled: The snapshot is enabled for remote replication.
- Disabled: The snapshot is not enabled for remote replication.

Creating a group snapshot

You can create a snapshot of a group of volumes, and you can also create a group snapshot schedule to automate group snapshots. A single group snapshot can consistently snapshot up to 32 volumes at one time.

Steps

1. Click **Management > Volumes**.
2. Use the check boxes to select multiple volumes for a group of volumes.
3. Click **Bulk Actions**.
4. Click **Group Snapshot**.
5. Enter a new group snapshot name in the Create Group Snapshot of Volumes dialog box.
6. **Optional:** Select the **Include Each Group Snapshot Member in Replication When Paired** check box to ensure that each snapshot is captured in replication when the parent volume is paired.
7. Select a retention option for the group snapshot:
 - Click **Keep Forever** to retain the snapshot on the system indefinitely.
 - Click **Set Retention Period** and use the date spin boxes to choose a length of time for the system to retain the snapshot.
8. To take a single, immediate snapshot, perform the following steps:
 - a. Click **Take Group Snapshot Now**.
 - b. Click **Create Group Snapshot**.
9. To schedule the snapshot to run at a future time, perform the following steps:
 - a. Click **Create Group Snapshot Schedule**.
 - b. Enter a **New Schedule Name**.
 - c. Select a **Schedule Type** from the list.
 - d. **Optional:** Select the **Recurring Schedule** check box to repeat the scheduled snapshot periodically.
 - e. Click **Create Schedule**.

Editing group snapshots

You can edit the replication and retention settings for existing group snapshots.

1. Click **Data Protection > Group Snapshots**.
2. Click the Actions icon for the group snapshot you want to edit.
3. In the resulting menu, select **Edit**.
4. **Optional:** To change the replication setting for the group snapshot:
 - a. Click **Edit** next to **Current Replication**.
 - b. Select the **Include Each Group Snapshot Member in Replication When Paired** check box to ensure that each snapshot is captured in replication when the parent volume is paired.
5. **Optional:** To change the retention setting for the group snapshot, select from the following options:
 - a. Click **Edit** next to **Current Retention**.
 - b. Select a retention option for the group snapshot:
 - Click **Keep Forever** to retain the snapshot on the system indefinitely.
 - Click **Set Retention Period** and use the date spin boxes to choose a length of time for the system to retain the snapshot.
6. Click **Save Changes**.

Deleting a group snapshot

You can delete a group snapshot from the system. When you delete the group snapshot, you can choose whether all snapshots associated with the group are deleted or retained as individual snapshots.

If you delete a volume or snapshot that is a member of a group snapshot, you can no longer roll back to the group snapshot. However, you can roll back each volume individually.

1. Click **Data Protection > Group Snapshots**.
2. Click the Actions icon for the snapshot you want to delete.
3. In the resulting menu, click **Delete**.
4. Select from one of the following options in the confirmation dialog box:
 - Click **Delete group snapshot AND all group snapshot members** to delete the group snapshot and all member snapshots.
 - Click **Retain group snapshot members as individual snapshots** to delete the group snapshot but keep all member snapshots.
5. Confirm the action.

Roll back volumes to a group snapshot

You can roll back a group of volumes at any time to a group snapshot.

When you roll back a group of volumes, all volumes in the group are restored to the state they were in at the time the group snapshot was created. Rolling back also restores volume sizes to the size recorded in the original snapshot. If the system has purged a volume, all snapshots of that volume were also deleted at the time of the purge; the system does not restore any deleted volume snapshots.

1. Click **Data Protection > Group Snapshots**.
2. Click the Actions icon for the group snapshot you want to use for the volume rollback.
3. In the resulting menu, select **Rollback Volumes To Group Snapshot**.
4. **Optional:** To save the current state of the volumes before rolling back to the snapshot:
 - a. In the **Rollback To Snapshot** dialog box, select **Save volumes' current state as a group snapshot**.
 - b. Enter a name for the new snapshot.
5. Click **Rollback Group Snapshot**.

Editing members of group snapshot

You can edit the retention settings for members of an existing group snapshot.

1. Click **Data Protection > Snapshots**.
2. Click the **Members** tab.
3. Click the Actions icon for the group snapshot member you want to edit.
4. In the resulting menu, select **Edit**.
5. To change the replication setting for the snapshot, select from the following options:
 - Click **Keep Forever** to retain the snapshot on the system indefinitely.

- Click **Set Retention Period** and use the date spin boxes to choose a length of time for the system to retain the snapshot.

6. Click **Save Changes**.

Clone multiple volumes

You can create multiple volume clones in a single operation to create a point-in-time copy of the data on a group of volumes.

When you clone a volume, the system creates a snapshot of the volume and then creates a new volume from the data in the snapshot. You can mount and write to the new volume clone. Cloning multiple volumes is an asynchronous process and takes a variable amount of time depending on the size and number of the volumes being cloned.

Volume size and current cluster load affect the time needed to complete a cloning operation.

Steps

1. Click **Management > Volumes**.
2. Click the **Active** tab.
3. Use the check boxes to select multiple volumes, creating a group of volumes.
4. Click **Bulk Actions**.
5. Click **Clone** in the resulting menu.
6. Enter a **New Volume Name Prefix** in the **Clone Multiple Volumes** dialog box.

The prefix is applied to all volumes in the group.

7. **Optional:** Select a different account to which the clone will belong.

If you do not select an account, the system assigns the new volumes to the current volume account.

8. **Optional:** Select a different access method for the volumes in the clone.

If you do not select an access method, the system uses the current volume access.

9. Click **Start Cloning**.

Cloning multiple volumes from a group snapshot

You can clone a group of volumes from a point-in-time group snapshot. This operation requires that a group snapshot of the volumes already exist, because the group snapshot is used as the basis to create the volumes. After you create the volumes, you can use them like any other volume in the system.

Volume size and current cluster load affect the time needed to complete a cloning operation.

1. Click **Data Protection > Group Snapshots**.
2. Click the Actions icon for the group snapshot you want to use for the volume clones.
3. In the resulting menu, select **Clone Volumes From Group Snapshot**.
4. Enter a **New Volume Name Prefix** in the **Clone Volumes From Group Snapshot** dialog box.

The prefix is applied to all volumes created from the group snapshot.

5. **Optional:** Select a different account to which the clone will belong.

If you do not select an account, the system assigns the new volumes to the current volume account.

6. **Optional:** Select a different access method for the volumes in the clone.

If you do not select an access method, the system uses the current volume access.

7. Click **Start Cloning**.

Schedule a snapshot

You can protect data on a volume or a group of volumes by scheduling volume snapshots to occur at specified intervals. You can schedule either single volume snapshots or group snapshots to run automatically.

When you configure a snapshot schedule, you can choose from time intervals based on days of the week or days of the month. You can also specify the days, hours, and minutes before the next snapshot occurs. You can store the resulting snapshots on a remote storage system if the volume is being replicated.

Find more information

- [Create a snapshot schedule](#)
- [Edit a snapshot schedule](#)
- [Delete a snapshot schedule](#)
- [Copy a snapshot schedule](#)

Snapshot schedule details

On the Data Protection > Schedules page, you can view the following information in the list of snapshot schedules.

- **ID**

The system-generated ID for the snapshot.

- **Type**

The type of schedule. Snapshot is currently the only type supported.

- **Name**

The name given to the schedule when it was created. Snapshot schedule names can be up to 223 characters in length and contain a-z, 0-9, and dash (-) characters.

- **Frequency**

The frequency at which the schedule is run. The frequency can be set in hours and minutes, weeks, or months.

- **Recurring**

Indication of whether the schedule is to run only once or at regular intervals.

- **Manually Paused**

Indication of whether or not the schedule has been manually paused.

- **Volume IDs**

The ID of the volume the schedule will use when the schedule is run.

- **Last Run**

The last time the schedule was run.

- **Last Run Status**

The outcome of the last schedule execution. Possible values:

- Success
- Failure

Create a snapshot schedule

You can schedule a snapshot of a volume or volumes to automatically occur at specified intervals.

When you configure a snapshot schedule, you can choose from time intervals based on days of the week or days of the month. You can also create a recurring schedule and specify the days, hours, and minutes before the next snapshot occurs.

If you schedule a snapshot to run at a time period that is not divisible by 5 minutes, the snapshot will run at the next time period that is divisible by 5 minutes. For example, if you schedule a snapshot to run at 12:42:00 UTC, it will run at 12:45:00 UTC. You cannot schedule a snapshot to run at intervals of less than 5 minutes.

Steps

1. Click **Data Protection > Schedules**.
2. Click **Create Schedule**.
3. In the **Volume IDs CSV** field, enter a single volume ID or a comma-separated list of volume IDs to include in the snapshot operation.
4. Enter a new schedule name.
5. Select a schedule type and set the schedule from the options provided.
6. **Optional:** Select **Recurring Schedule** to repeat the snapshot schedule indefinitely.
7. **Optional:** Enter a name for the new snapshot in the **New Snapshot Name** field.

If you leave the field blank, the system uses the time and date of the snapshot's creation as the name.

8. **Optional:** Select the **Include Snapshots in Replication When Paired** check box to ensure that the snapshots are captured in replication when the parent volume is paired.
9. To set the retention for the snapshot, select from the following options:
 - Click **Keep Forever** to retain the snapshot on the system indefinitely.

- Click **Set Retention Period** and use the date spin boxes to choose a length of time for the system to retain the snapshot.

10. Click **Create Schedule**.

Edit a snapshot schedule

You can modify existing snapshot schedules. After modification, the next time the schedule runs it uses the updated attributes. Any snapshots created by the original schedule remain on the storage system.

Steps

1. Click **Data Protection > Schedules**.
2. Click the **Actions** icon for the schedule you want to change.
3. In the resulting menu, click **Edit**.
4. In the **Volume IDs CSV** field, modify the single volume ID or comma-separated list of volume IDs currently included in the snapshot operation.
5. To pause or resume the schedule, select from the following options:
 - To pause an active schedule, select **Yes** from the **Manually Pause Schedule** list.
 - To resume a paused schedule, select **No** from the **Manually Pause Schedule** list.
6. Enter a different name for the schedule in the **New Schedule Name** field if desired.
7. To change the schedule to run on different days of the week or month, select **Schedule Type** and change the schedule from the options provided.
8. **Optional:** Select **Recurring Schedule** to repeat the snapshot schedule indefinitely.
9. **Optional:** Enter or modify the name for the new snapshot in the **New Snapshot Name** field.

If you leave the field blank, the system uses the time and date of the snapshot's creation as the name.

10. **Optional:** Select the **Include Snapshots in Replication When Paired** check box to ensure that the snapshots are captured in replication when the parent volume is paired.
11. To change the retention setting, select from the following options:
 - Click **Keep Forever** to retain the snapshot on the system indefinitely.
 - Click **Set Retention Period** and use the date spin boxes to select a length of time for the system to retain the snapshot.
12. Click **Save Changes**.

Copy a snapshot schedule

You can copy a schedule and maintain its current attributes.

1. Click **Data Protection > Schedules**.
2. Click the **Actions** icon for the schedule you want to copy.
3. In the resulting menu, click **Make a Copy**.

The **Create Schedule** dialog box appears, populated with the current attributes of the schedule.

4. **Optional:** Enter a name and updated attributes for the new schedule.

5. Click **Create Schedule**.

Delete a snapshot schedule

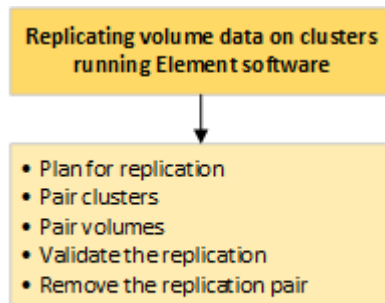
You can delete a snapshot schedule. After you delete the schedule, it does not run any future scheduled snapshots. Any snapshots that were created by the schedule remain on the storage system.

1. Click **Data Protection > Schedules**.
2. Click the **Actions** icon for the schedule you want to delete.
3. In the resulting menu, click **Delete**.
4. Confirm the action.

Perform remote replication between clusters running NetApp Element software

For clusters running Element software, real-time replication enables the quick creation of remote copies of volume data. You can pair a storage cluster with up to four other storage clusters. You can replicate volume data synchronously or asynchronously from either cluster in a cluster pair for failover and failback scenarios.

The replication process includes these steps:



- [Plan cluster and volume pairing for real-time replication](#)
- [Pair clusters for replication](#)
- [Pair volumes](#)
- [Validate volume replication](#)
- [Delete a volume relationship after replication](#)
- [Manage volume relationships](#)

Plan cluster and volume pairing for real-time replication

Real-time remote replication requires that you pair two storage clusters running Element software, pair volumes on each cluster, and validate replication. After replication completes, you should delete the volume relationship.

What you'll need

- You must have cluster administrator privileges to one or both clusters being paired.
- All node IP addresses on both management and storage networks for paired clusters are routed to each other.
- MTU of all paired nodes must be the same and be supported end-to-end between clusters.
- Both storage clusters should have unique cluster names, MVIPs, SVIPs., and all node IP addresses.
- The difference between Element software versions on the clusters is no greater than one major version. If the difference is greater, one of the clusters must be upgraded to perform data replication.



WAN Accelerator appliances have not been qualified by NetApp for use when replicating data. These appliances can interfere with compression and deduplication if deployed between two clusters that are replicating data. Be sure to fully qualify the effects of any WAN Accelerator appliance before you deploy it in a production environment.

Find more information

- [Pair clusters for replication](#)
- [Pair volumes](#)
- [Assign a replication source and target to paired volumes](#)

Pair clusters for replication

You must pair two clusters as a first step to using real-time replication functionality. After you pair and connect two clusters, you can configure active volumes on one cluster to be continuously replicated to a second cluster, providing continuous data protection (CDP).

What you'll need

- You must have cluster administrator privileges to one or both clusters being paired.
- All node MIPs and SIPs are routed to each other.
- Less than 2000 ms of round-trip latency between clusters.
- Both storage clusters should have unique cluster names, MVIPs, SVIPs, and all node IP addresses.
- The difference between Element software versions on the clusters is no greater than one major version. If the difference is greater, one of the clusters must be upgraded to perform data replication.



Cluster pairing requires full connectivity between nodes on the management network. Replication requires connectivity between the individual nodes on the storage cluster network.

You can pair one cluster with up to four other clusters for replicating volumes. You can also pair clusters within the cluster group with each other.

Find more information

[Network port requirements](#)

Pair clusters using MVIP or a pairing key

You can pair a source and target cluster using the MVIP of the target cluster if there is cluster administrator access to both clusters. If cluster administrator access is only

available on one cluster in a cluster pair, a pairing key can be used on the target cluster to complete the cluster pairing.

1. Select one of the following methods to pair clusters:
 - Pair clusters using MVIP: Use this method if there is cluster administrator access to both clusters. This method uses the MVIP of the remote cluster to pair two clusters.
 - Pair clusters using a pairing key: Use this method if there is cluster administrator access to only one of the clusters. This method generates a pairing key that can be used on the target cluster to complete the cluster pairing.

Find more information

- [Pair clusters using MVIP](#)
- [Pair clusters using a pairing key](#)

Pair clusters using MVIP

You can pair two clusters for real-time replication by using the MVIP of one cluster to establish a connection with the other cluster. Cluster administrator access on both of clusters is required to use this method. The cluster administrator user name and password is used to authenticate cluster access before the clusters can be paired.

1. On the local cluster, select **Data Protection > Cluster Pairs**.
2. Click **Pair Cluster**.
3. Click **Start Pairing** and click **Yes** to indicate that you have access to the remote cluster.
4. Enter the remote cluster MVIP address.
5. Click **Complete pairing on remote cluster**.

In the **Authentication Required** window, enter the cluster administrator user name and password of the remote cluster.

6. On the remote cluster, select **Data Protection > Cluster Pairs**.
7. Click **Pair Cluster**.
8. Click **Complete Pairing**.
9. Click the **Complete Pairing** button.

Find more information

- [Pair clusters using a pairing key](#)
- [Pairing clusters using MVIP \(video\)](#)

Pair clusters using a pairing key

If you have cluster administrator access to a local cluster but not the remote cluster, you can pair the clusters using a pairing key. A pairing key is generated on a local cluster and then sent securely to a cluster administrator at a remote site to establish a connection and complete the cluster pairing for real-time replication.

1. On the local cluster, select **Data Protection > Cluster Pairs**.
2. Click **Pair Cluster**.
3. Click **Start Pairing** and click **No** to indicate that you do not have access to the remote cluster.
4. Click **Generate Key**.



This action generates a text key for pairing and creates an unconfigured cluster pair on the local cluster. If you do not complete the procedure, you will need to manually delete the cluster pair.

5. Copy the cluster pairing key to your clipboard.
6. Make the pairing key accessible to the cluster administrator at the remote cluster site.



The cluster pairing key contains a version of the MVIP, user name, password, and database information to permit volume connections for remote replication. This key should be treated in a secure manner and not stored in a way that would allow accidental or unsecured access to the user name or password.



Do not modify any of the characters in the pairing key. The key becomes invalid if it is modified.

7. On the remote cluster, select **Data Protection > Cluster Pairs**.
8. Click **Pair Cluster**.
9. Click **Complete Pairing** and enter the pairing key in the **Pairing Key** field (paste is the recommended method).
10. Click **Complete Pairing**.

Find more information

- [Pair clusters using MVIP](#)
- [Pairing clusters using a cluster pairing key \(video\)](#)

Validate the cluster pair connection

After the cluster pairing has completed, you might want to verify the cluster pair connection to ensure replication success.

1. On the local cluster, select **Data Protection > Cluster Pairs**.
2. In the **Cluster Pairs** window, verify that the cluster pair is connected.
3. **Optional:** Navigate back to the local cluster and the **Cluster Pairs** window and verify that the cluster pair is connected.

Pair volumes

After you have established a connection between clusters in a cluster pair, you can pair a volume on one cluster with a volume on the other cluster in the pair. When a volume pairing relationship is established, you must identify which volume is the replication target.

You can pair two volumes for real-time replication that are stored on different storage clusters in a connected cluster pair. After you pair two clusters, you can configure active volumes on one cluster to be continuously replicated to a second cluster, providing continuous data protection (CDP). You can also assign either volume to be the source or target of the replication.

Volume pairings are always one-to-one. After a volume is part of a pairing with a volume on another cluster, you cannot pair it again with any other volume.

What you'll need

- You have established a connection between clusters in a cluster pair.
- You have cluster administrator privileges to one or both clusters being paired.

Steps

1. [Create a target volume with read or write access](#)
2. [Pair volumes using a volume ID or pairing key](#)
3. [Assign a replication source and target to paired volumes](#)

Create a target volume with read or write access

The replication process involves two endpoints: the source and the target volume. When you create the target volume, the volume is automatically set to read/write mode to accept the data during the replication.

1. Select **Management > Volumes**.
2. Click **Create Volume**.
3. In the Create a New Volume dialog box, enter the Volume Name.
4. Enter the total size of the volume, select a block size for the volume, and select the account that should have access to the volume.
5. Click **Create Volume**.
6. In the Active window, click the Actions icon for the volume.
7. Click **Edit**.
8. Change the account access level to Replication Target.
9. Click **Save Changes**.

Pair volumes using a volume ID or pairing key

The pairing process involves pairing two volumes by using either a volume ID or a pairing key.

1. Pair volumes by selecting one of the following methods:
 - Using a volume ID: Use this method if you have cluster administrator access to both clusters on which volumes are to be paired. This method uses the volume ID of the volume on the remote cluster to initiate a connection.
 - Using a pairing Key: Use this method if you have cluster administrator access to only the source cluster. This method generates a pairing key that can be used on the remote cluster to complete the volume pair.



The volume pairing key contains an encrypted version of the volume information and might contain sensitive information. Only share this key in a secure manner.

Find more information

- [Pair volumes using a volume ID](#)
- [Pair volumes using a pairing key](#)

Pair volumes using a volume ID

You can pair a volume with another volume on a remote cluster if you have cluster administrator credentials for the remote cluster.

What you'll need

- Ensure that the clusters containing the volumes are paired.
- Create a new volume on the remote cluster.



You can assign a replication source and target after the pairing process. A replication source or target can be either volume in a volume pair. You should create a target volume that contains no data and has the exact characteristics of the source volume, such as size, block size setting for the volumes (either 512e or 4k), and QoS configuration. If you assign an existing volume as the replication target, the data on that volume will be overwritten. The target volume can be greater or equal in size to the source volume, but it cannot be smaller.

- Know the target Volume ID.

Steps

1. Select **Management > Volumes**.
2. Click the **Actions** icon for the volume you want to pair.
3. Click **Pair**.
4. In the **Pair Volume** dialog box, select **Start Pairing**.
5. Select **I Do** to indicate that you have access to the remote cluster.
6. Select a **Replication Mode** from the list:
 - **Real-time (Asynchronous)**: Writes are acknowledged to the client after they are committed on the source cluster.
 - **Real-time (Synchronous)**: Writes are acknowledged to the client after they are committed on both the source and target clusters.
 - **Snapshots Only**: Only snapshots created on the source cluster are replicated. Active writes from the source volume are not replicated.
7. Select a remote cluster from the list.
8. Choose a remote volume ID.
9. Click **Start Pairing**.

The system opens a web browser tab that connects to the Element UI of the remote cluster. You might be required to log on to the remote cluster with cluster administrator credentials.

10. In the Element UI of the remote cluster, select **Complete Pairing**.
11. Confirm the details in **Confirm Volume Pairing**.
12. Click **Complete Pairing**.

After you confirm the pairing, the two clusters begin the process of connecting the volumes for pairing. During the pairing process, you can see messages in the **Volume Status** column of the **Volume Pairs** window. The volume pair displays `PausedMisconfigured` until the volume pair source and target are assigned.

After you successfully complete the pairing, you should refresh the Volumes table to remove the **Pair** option from the **Actions** list for the paired volume. If you do not refresh the table, the **Pair** option remains available for selection. If you select the **Pair** option again, a new tab opens and because the volume is already paired, the system reports a `StartVolumePairing Failed: xVolumeAlreadyPaired` error message in the **Pair Volume** window of the Element UI page.

Find more information

- [Volume pairing messages](#)
- [Volume pairing warnings](#)
- [Assign a replication source and target to paired volumes](#)

Pair volumes using a pairing key

If you do not have cluster admin credentials for a remote cluster, you can pair a volume with another volume on a remote cluster using a pairing key.

What you'll need

- Ensure that the clusters containing the volumes are paired.
- Ensure that there is a volume on the remote cluster to use for the pairing.



You can assign a replication source and target after the pairing process. A replication source or target can be either volume in a volume pair. You should create a target volume that contains no data and has the exact characteristics of the source volume, such as size, block size setting for the volumes (either 512e or 4k), and QoS configuration. If you assign an existing volume as the replication target, the data on that volume will be overwritten. The target volume can be greater or equal in size to the source volume, but it cannot be smaller.

Steps

1. Select **Management > Volumes**.
2. Click **Actions** icon for the volume you want to pair.
3. Click **Pair**.
4. In the **Pair Volume** dialog box, select **Start Pairing**.
5. Select **I Do Not** to indicate that you do not have access to the remote cluster.
6. Select a **Replication Mode** from the list:
 - **Real-time (Asynchronous)**: Writes are acknowledged to the client after they are committed on the source cluster.

- **Real-time (Synchronous):** Writes are acknowledged to the client after they are committed on both the source and target clusters.
- **Snapshots Only:** Only snapshots created on the source cluster are replicated. Active writes from the source volume are not replicated.

7. Click **Generate Key**.



This action generates a text key for pairing and creates an unconfigured volume pair on the local cluster. If you do not complete the procedure, you will need to manually delete the volume pair.

8. Copy the pairing key to your computer's clipboard.

9. Make the pairing key accessible to the cluster admin at the remote cluster site.



The volume pairing key should be treated in a secure manner and not used in a way that would allow accidental or unsecured access.



Do not modify any of the characters in the pairing key. The key becomes invalid if it is modified.

10. In the remote cluster Element UI, select **Management > Volumes**.

11. Click the Actions icon for the volume you want to pair.

12. Click **Pair**.

13. In the **Pair Volume** dialog box, select **Complete Pairing**.

14. Paste the pairing key from the other cluster into the **Pairing Key** box.

15. Click **Complete Pairing**.

After you confirm the pairing, the two clusters begin the process of connecting the volumes for pairing. During the pairing process, you can see messages in the **Volume Status** column of the **Volume Pairs** window. The volume pair displays `PausedMisconfigured` until the volume pair source and target are assigned.

After you successfully complete the pairing, you should refresh the Volumes table to remove the **Pair** option from the **Actions** list for the paired volume. If you do not refresh the table, the **Pair** option remains available for selection. If you select the **Pair** option again, a new tab opens and because the volume is already paired, the system reports a `StartVolumePairing Failed: xVolumeAlreadyPaired` error message in the **Pair Volume** window of the Element UI page.

Find more information

- [Volume pairing messages](#)
- [Volume pairing warnings](#)
- [Assign a replication source and target to paired volumes](#)

Assign a replication source and target to paired volumes

After volumes are paired, you must assign a source volume and its replication target volume. A replication source or target can be either volume in a volume pair. You can also

use this procedure to redirect data sent to a source volume to a remote target volume should the source volume become unavailable.

What you'll need

You have access to the clusters containing the source and target volumes.

Steps

1. Prepare the source volume:
 - a. From the cluster that contains the volume you want to assign as source, select **Management > Volumes**.
 - b. Click the **Actions** icon for the volume you want to assign as source and click **Edit**.
 - c. In the **Access** drop-down list, select **Read/Write**.



If you are reversing source and target assignment, this action will cause the volume pair to display the following message until a new replication target is assigned:
PausedMisconfigured

Changing access pauses volume replication and causes the transmission of data to cease. Be sure that you have coordinated these changes at both sites.

- d. Click **Save Changes**.
2. Prepare the target volume:
 - a. From the cluster that contains the volume you want to assign as target, select **Management > Volumes**.
 - b. Click the Actions icon for the volume you want to assign as target and click **Edit**.
 - c. In the **Access** drop-down list, select **Replication Target**.



If you assign an existing volume as the replication target, the data on that volume will be overwritten. You should use a new target volume that contains no data and has the exact characteristics of the source volume, such as size, 512e setting, and QoS configuration. The target volume can be greater or equal in size to the source volume, but it cannot be smaller.

- d. Click **Save Changes**.

Find more information

- [Pair volumes using a volume ID](#)
- [Pair volumes using a pairing key](#)

Validate volume replication

After a volume is replicated, you should ensure that the source and target volumes are active. When in an active state, volumes are paired, data is being sent from the source to the target volume, and the data is in sync.

1. From both clusters, select **Data Protection > Volume Pairs**.
2. Verify that the volume status is Active.

Find more information

[Volume pairing warnings](#)

Delete a volume relationship after replication

After replication completes and you no longer need the volume pair relationship, you can delete the volume relationship.

1. Select **Data Protection > Volume Pairs**.
2. Click the **Actions** icon for the volume pair you want to delete.
3. Click **Delete**.
4. Confirm the message.

Manage volume relationships

You can manage volume relationships in many ways, such as pausing replication, reversing volume pairing, changing the mode of replication, deleting a volume pair, or deleting a cluster pair.

Find more information

- [Pause replication](#)
- [Change the mode of replication](#)
- [Delete volume pairs](#)

Pause replication

You can manually pause replication if you need to stop I/O processing for a short time. You might want to pause replication if there is a surge in I/O processing and you want to reduce the processing load.

1. Select **Data Protection > Volume Pairs**.
2. Click the Actions icon for the volume pair.
3. Click **Edit**.
4. In the **Edit Volume Pair** pane, manually pause the replication process.



Pausing or resuming volume replication manually causes the transmission of data to cease or resume. Be sure that you have coordinated these changes at both sites.

5. Click **Save Changes**.

Change the mode of replication

You can edit volume pair properties to change the replication mode of the volume pair relationship.

1. Select **Data Protection > Volume Pairs**.

2. Click the Actions icon for the volume pair.
3. Click **Edit**.
4. In the **Edit Volume Pair** pane, select a new replication mode:
 - **Real-time (Asynchronous)**: Writes are acknowledged to the client after they are committed on the source cluster.
 - **Real-time (Synchronous)**: Writes are acknowledged to the client after they are committed on both the source and target clusters.
 - **Snapshots Only**: Only snapshots created on the source cluster are replicated. Active writes from the source volume are not replicated. **Attention**: Changing the mode of replication changes the mode immediately. Be sure that you have coordinated these changes at both sites.
5. Click **Save Changes**.

Delete volume pairs

You can delete a volume pair if you want to remove a pair association between two volumes.

1. Select **Data Protection > Volume Pairs**.
2. Click the Actions icon for the volume pair you want to delete.
3. Click **Delete**.
4. Confirm the message.

Delete a cluster pair

You can delete a cluster pair from the Element UI of either of the clusters in the pair.

1. Click **Data Protection > Cluster Pairs**.
2. Click the Actions icon for a cluster pair.
3. In the resulting menu, click **Delete**.
4. Confirm the action.
5. Perform the steps again from the second cluster in the cluster pairing.

Cluster pair details

The Cluster Pairs page on the Data Protection tab provides information about clusters that have been paired or are in the process of being paired. The system displays pairing and progress messages in the Status column.

- **ID**

A system-generated ID given to each cluster pair.

- **Remote Cluster Name**

The name of the other cluster in the pair.

- **Remote MVIP**

The management virtual IP address of the other cluster in the pair.

- **Status**

Replication status of the remote cluster

- **Replicating Volumes**

The number of volumes contained by the cluster that are paired for replication.

- **UUID**

A unique ID given to each cluster in the pair.

Volume pair details

The Volume Pairs page on the Data Protection tab provides information about volumes that have been paired or are in the process of being paired. The system displays pairing and progress messages in the Volume Status column.

- **ID**

System-generated ID for the volume.

- **Name**

The name given to the volume when it was created. Volume names can be up to 223 characters and contain a-z, 0-9, and dash (-).

- **Account**

Name of the account assigned to the volume.

- **Volume Status**

Replication status of the volume

- **Snapshot Status**

Status of the snapshot volume.

- **Mode**

The client write replication method. Possible values are as follows:

- Async
- Snapshot-Only
- Sync

- **Direction**

The direction of the volume data:

- Source volume icon (➔) indicates data is being written to a target outside the cluster.
- Target volume icon (←) indicates data is being written to the local volume from an outside source.

- **Async Delay**

Length of time since the volume was last synced with the remote cluster. If the volume is not paired, the value is null.

- **Remote Cluster**

Name of the remote cluster on which the volume resides.

- **Remote Volume ID**

Volume ID of the volume on the remote cluster.

- **Remote Volume Name**

Name given to the remote volume when it was created.

Volume pairing messages

You can view volume pairing messages during the initial pairing process from the Volume Pairs page under the Data Protection tab. These messages can display on both source and target ends of the pair in the Replicating Volumes list view.

- **PausedDisconnected**

Source replication or sync RPCs timed out. Connection to the remote cluster has been lost. Check network connections to the cluster.

- **ResumingConnected**

The remote replication sync is now active. Beginning the sync process and waiting for data.

- **ResumingRRSync**

A single helix copy of the volume metadata is being made to the paired cluster.

- **ResumingLocalSync**

A double helix copy of the volume metadata is being made to the paired cluster.

- **ResumingDataTransfer**

Data transfer has resumed.

- **Active**

Volumes are paired and data is being sent from the source to the target volume and the data is in sync.

- **Idle**

No replication activity is occurring.

Volume pairing warnings

The Volume Pairs page on the Data Protection tab provides these messages after you pair volumes. These messages can display on both source and target ends of the pair (unless otherwise indicated) in the Replicating Volumes list view.

- **PausedClusterFull**

Because the target cluster is full, source replication and bulk data transfer cannot proceed. The message displays on the source end of the pair only.

- **PausedExceededMaxSnapshotCount**

The target volume already has the maximum number of snapshots and cannot replicate additional snapshots.

- **PausedManual**

Local volume has been manually paused. It must be unpaused before replication resumes.

- **PausedManualRemote**

Remote volume is in manual paused mode. Manual intervention required to unpause the remote volume before replication resumes.

- **PausedMisconfigured**

Waiting for an active source and target. Manual intervention required to resume replication.

- **PausedQoS**

Target QoS could not sustain incoming IO. Replication auto-resumes. The message displays on the source end of the pair only.

- **PausedSlowLink**

Slow link detected and stopped replication. Replication auto-resumes. The message displays on the source end of the pair only.

- **PausedVolumeSizeMismatch**

Target volume is not the same size as the source volume.

- **PausedXCopy**

A SCSI XCOPY command is being issued to a source volume. The command must complete before replication can resume. The message displays on the source end of the pair only.

- **StoppedMisconfigured**

A permanent configuration error has been detected. The remote volume has been purged or unpaired. No corrective action is possible; a new pairing must be established.

Use SnapMirror replication between Element and ONTAP clusters

You can create SnapMirror relationships from the Data Protection tab in the Netapp Element UI. SnapMirror functionality must be enabled to see this in the user interface.

IPv6 is not supported for SnapMirror replication between NetApp Element software and ONTAP clusters.

[NetApp video: SnapMirror for NetApp HCI and Element Software](#)

Systems running NetApp Element software support SnapMirror functionality to copy and restore Snapshot copies with NetApp ONTAP systems. The primary reason for using this technology is disaster recovery of NetApp HCI to ONTAP. Endpoints include ONTAP, ONTAP Select, and Cloud Volumes ONTAP. See TR-4641 NetApp HCI Data Protection.

[NetApp Technical Report 4641: NetApp HCI Data Protection](#)

Find more information

- [Building your Data Fabric with NetApp HCI, ONTAP, and Converged Infrastructure](#)
- [Replication between NetApp Element Software and ONTAP](#)

SnapMirror overview

Systems running NetApp Element software support SnapMirror functionality to copy and restore snapshots with NetApp ONTAP systems.

Systems running Element can communicate directly with SnapMirror on ONTAP systems 9.3 or higher. The Netapp Element API provides methods to enable SnapMirror functionality on clusters, volumes, and snapshots. Additionally, the Element UI includes all necessary functionality to manage SnapMirror relationships between Element software and ONTAP systems.

You can replicate ONTAP originated volumes to Element volumes in specific use cases with limited functionality. For more information, see ONTAP documentation.

Find more information

[Replication between Element software and ONTAP](#)

Enable SnapMirror on the cluster

You must manually enable SnapMirror functionality at the cluster level through the Netapp Element UI. The system comes with SnapMirror functionality disabled by default, and it is not automatically enabled as part of a new installation or upgrade. Enabling the SnapMirror feature is a one-time configuration task.

SnapMirror can only be enabled for clusters running Element software used in conjunction with volumes on a NetApp ONTAP system. You should enable SnapMirror functionality only if your cluster is connected for use with NetApp ONTAP volumes.

What you'll need

The storage cluster must be running NetApp Element software.

Steps

1. Click **Clusters > Settings**.
2. Find the cluster-specific settings for SnapMirror.
3. Click **Enable SnapMirror**.



Enabling SnapMirror functionality permanently changes the Element software configuration. You can disable the SnapMirror feature and restore the default settings only by returning the cluster to the factory image.

4. Click **Yes** to confirm the SnapMirror configuration change.

Enable SnapMirror on the volume

You must enable SnapMirror on the volume in the Element UI. This allows replication of data to specified ONTAP volumes. This is permission from the administrator of the cluster running NetApp Element software for SnapMirror to control a volume.

What you'll need

- You have enabled SnapMirror in the Element UI for the cluster.
- A SnapMirror endpoint is available.
- The volume must be 512e block size.
- The volume is not participating in remote replication.
- The volume access type is not Replication Target.



You can also set this property when creating or cloning a volume.

Steps

1. Click **Management > Volumes**.
2. Click the **Actions** icon for the volume you want to enable SnapMirror for.
3. In the resulting menu, select **Edit**.
4. In the **Edit Volume** dialog box, select the check box **Enable SnapMirror**.
5. Click **Save Changes**.

Create a SnapMirror endpoint

You must create a SnapMirror endpoint in the Netapp Element UI before you can create a relationship.

A SnapMirror endpoint is an ONTAP cluster that serves as a replication target for a cluster running Element software. Before you create a SnapMirror relationship, you first create a SnapMirror endpoint.

You can create and manage up to four SnapMirror endpoints on a storage cluster running Element software.



If an existing endpoint was originally created using the API and credentials were not saved, you can see the endpoint in the Element UI and verify its existence, but it cannot be managed using the Element UI. This endpoint can then only be managed using the Element API.

For details about API methods, see [Manage storage with the Element API](#).

What you'll need

- You should have enabled SnapMirror in the Element UI for the storage cluster.
- You know the ONTAP credentials for the endpoint.

Steps

1. Click **Data Protection > SnapMirror Endpoints**.
2. Click **Create Endpoint**.
3. In the **Create a New Endpoint** dialog box, enter the cluster management IP address of the ONTAP system.
4. Enter the ONTAP administrator credentials associated with the endpoint.
5. Review additional details:
 - LIFs: Lists the ONTAP intercluster logical interfaces used to communicate with Element.
 - Status: Shows the current status of the SnapMirror endpoint. Possible values are: connected, disconnected, and unmanaged.
6. Click **Create Endpoint**.

Create a SnapMirror relationship

You must create a SnapMirror relationship in the Netapp Element UI.



When a volume is not yet enabled for SnapMirror and you select to create a relationship from the Element UI, SnapMirror is automatically enabled on that volume.

What you'll need

SnapMirror is enabled on the volume.

Steps

1. Click **Management > Volumes**.
2. Click the **Actions** icon for the volume that is to be a part of the relationship.
3. Click **Create a SnapMirror Relationship**.
4. In the **Create a SnapMirror Relationship** dialog box, select an endpoint from the **Endpoint** list.
5. Select if the relationship will be created using a new ONTAP volume or an existing ONTAP volume.
6. To create a new ONTAP volume in the Element UI, click **Create new volume**.
 - a. Select the **Storage Virtual Machine** for this relationship.
 - b. Select the **Aggregate** from the drop-down list.
 - c. In the **Volume Name Suffix** field, enter a suffix.



The system detects the source volume name and copies it to the **Volume Name** field. The suffix you enter appends the name.

- d. Click **Create Destination Volume**.
7. To use an existing ONTAP volume, click **Use existing volume**.
 - a. Select the **Storage Virtual Machine** for this relationship.

- b. Select the volume that is the destination for this new relationship.
8. In the **Relationship Details** section, select a policy. If the selected policy has keep rules, the Rules table displays the rules and associated labels.
9. **Optional:** Select a schedule.

This determines how often the relationship creates copies.

10. **Optional:** In the **Limit Bandwidth to** field, enter the maximum amount of bandwidth that can be consumed by data transfers associated with this relationship.
11. Review additional details:
 - **State:** Current relationship state of the destination volume. Possible values are:
 - uninitialized: The destination volume has not been initialized.
 - snapmirrored: The destination volume has been initialized and is ready to receive SnapMirror updates.
 - broken-off: The destination volume is read/write and snapshots are present.
 - **Status:** Current status of the relationship. Possible values are idle, transferring, checking, quiescing, quiesced, queued, preparing, finalizing, aborting, and breaking.
 - **Lag Time:** The amount of time in seconds that the destination system lags behind the source system. The lag time must be no more than the transfer schedule interval.
 - **Bandwidth Limit:** The maximum amount of bandwidth that can be consumed by data transfers associated with this relationship.
 - **Last Transferred:** Timestamp of the last transferred snapshot. Click for further information.
 - **Policy Name:** The name of the ONTAP SnapMirror policy for the relationship.
 - **Policy Type:** Type of ONTAP SnapMirror policy selected for the relationship. Possible values are:
 - async_mirror
 - mirror_vault
 - **Schedule Name:** Name of the pre-existing schedule on the ONTAP system selected for this relationship.
12. To not initialize at this time, ensure that the **Initialize** check box is not selected.



Initialization can be time-consuming. You might want to run this during off-peak hours. Initialization performs a baseline transfer; it makes a snapshot copy of the source volume, then transfers that copy and all the data blocks it references to the destination volume. You can initialize manually or use a schedule to start the initialization process (and subsequent updates) according to the schedule.

13. Click **Create Relationship**.
14. Click **Data Protection > SnapMirror Relationships** to view this new SnapMirror relationship.

SnapMirror relationship actions

You can configure a relationship from the SnapMirror Relationships page of the Data Protection tab. The options from the Actions icon are described here.

- **Edit:** Edits the policy used or schedule for the relationship.

- **Delete:** Deletes the SnapMirror relationship. This function does not delete the destination volume.
- **Initialize:** Performs the first initial baseline transfer of data to establish a new relationship.
- **Update:** Performs an on-demand update of the relationship, replicating any new data and Snapshot copies included since the last update to the destination.
- **Quiesce:** Prevents any further updates for a relationship.
- **Resume:** Resumes a relationship that is quiesced.
- **Break:** Makes the destination volume read-write and stops all current and future transfers. Determine that clients are not using the original source volume, because the reverse resync operation makes the original source volume read-only.
- **Resync:** Reestablishes a broken relationship in the same direction before the break occurred.
- **Reverse Resync:** Automates the necessary steps to create and initialize a new relationship in the opposite direction. This can be done only if the existing relationship is in a broken state. This operation will not delete the current relationship. The original source volume reverts to the most recent common Snapshot copy and resynchronizes with the destination. Any changes that are made to the original source volume since the last successful SnapMirror update are lost. Any changes that were made to, or new data written into the current destination volume is sent back to the original source volume.
- **Abort:** Cancels a current transfer in progress. If a SnapMirror update is issued for an aborted relationship, the relationship continues with the last transfer from the last restart checkpoint that was created before the abort occurred.

SnapMirror labels

A SnapMirror label serves as a marker for transferring a specified snapshot according to the retention rules of the relationship.

Applying a label to a snapshot marks it as a target for SnapMirror replication. The role of the relationship is to enforce the rules upon data transfer by selecting the matching labeled snapshot, copying it to the destination volume, and ensuring the correct number of copies are kept. It refers to the policy to determine the keep count and the retention period. The policy can have any number of rules and each rule has a unique label. This label serves as the link between the snapshot and the retention rule.

It is the SnapMirror label that indicates which rule is applied for the selected snapshot, group snapshot, or schedule.

Add SnapMirror labels to snapshots

SnapMirror labels specify the snapshot retention policy on the SnapMirror endpoint. You can add labels to snapshots and group snapshots.

You can view available labels from an existing SnapMirror relationship dialog box or the NetApp ONTAP System Manager.



When you add a label to a group snapshot, any existing labels to individual snapshots are overwritten.

What you'll need

- SnapMirror is enabled on the cluster.
- The label you want to add already exists in ONTAP.

Steps

1. Click **Data Protection > Snapshots** or **Group Snapshots** page.
2. Click the **Actions** icon for the snapshot or group snapshot you want to add a SnapMirror label to.
3. In the **Edit Snapshot** dialog box, enter text in the **SnapMirror Label** field. The label must match a rule label in the policy applied to the SnapMirror relationship.
4. Click **Save Changes**.

Add SnapMirror labels to snapshot schedules

You can add SnapMirror labels to snapshot schedules to ensure that a SnapMirror policy is applied. You can view available labels from an existing SnapMirror relationship dialog box or the NetApp ONTAP System Manager.

What you'll need

- SnapMirror must be enabled at the cluster level.
- The label you want to add already exists in ONTAP.

Steps

1. Click **Data Protection > Schedules**.
2. Add a SnapMirror label to a schedule in one of the following ways:

Option	Steps
Creating a new schedule	<ol style="list-style-type: none">a. Select Create Schedule.b. Enter all other relevant details.c. Select Create Schedule.
Modifying existing schedule	<ol style="list-style-type: none">a. Click the Actions icon for the schedule you want to add a label to and select Edit.b. In the resulting dialog box, enter text in the SnapMirror Label field.c. Select Save Changes.

Find more information

[Create a snapshot schedule](#)

Disaster recovery using SnapMirror

In the event of a problem with a volume or cluster running NetApp Element software, use the SnapMirror functionality to break the relationship and failover to the destination volume.



If the original cluster has completely failed or is non-existent, contact NetApp Support for further assistance.

Perform a failover from an Element cluster

You can perform a failover from the Element cluster to make the destination volume read/write and accessible to hosts on the destination side. Before you perform a failover from the Element cluster, you must break the SnapMirror relationship.

Use the NetApp Element UI to perform the failover. If the Element UI is not available, you can also use ONTAP System Manager or ONTAP CLI to issue the break relationship command.

What you'll need

- A SnapMirror relationship exists and has at least one valid snapshot on the destination volume.
- You have a need to failover to the destination volume due to unplanned outage or planned event at the primary site.

Steps

1. In the Element UI, click **Data Protection > SnapMirror Relationships**.
2. Find the relationship with the source volume that you want to failover.
3. Click the **Actions** icon.
4. Click **Break**.
5. Confirm the action.

The volume on the destination cluster now has read-write access and can be mounted to the application hosts to resume production workloads. All SnapMirror replication is halted as a result of this action. The relationship shows a state of broken-off.

Perform a failback to Element

When the issue on the primary side has been mitigated, you must resynchronize the original source volume and fail back to NetApp Element software. The steps you perform vary depending on whether the original source volume still exists or whether you need to failback to a newly created volume.

Find more information

- [Perform a failback when source volume still exists](#)
- [Perform a failback when source volume no longer exists](#)
- [SnapMirror failback scenarios](#)

SnapMirror failback scenarios

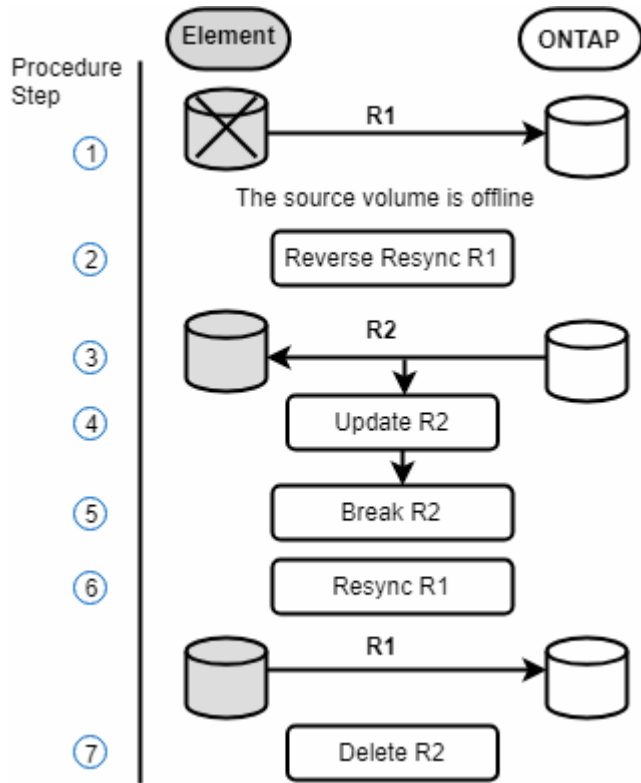
The SnapMirror disaster recovery functionality is illustrated in two failback scenarios. These assume the original relationship has been failed over (broken).

The steps from the corresponding procedures are added for reference.

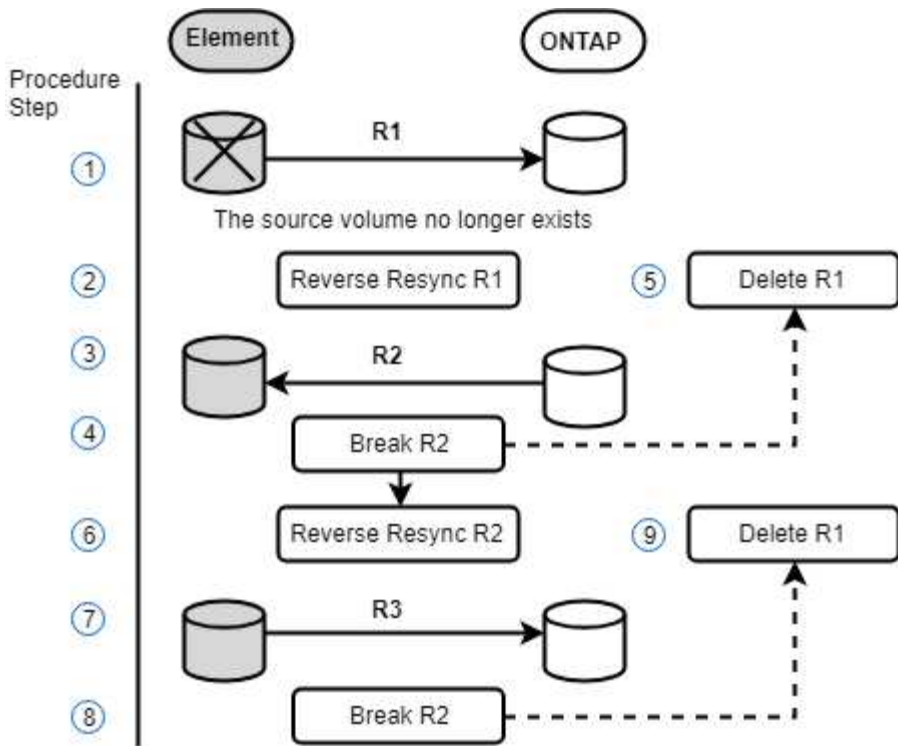


In the examples here, R1 = the original relationship in which the cluster running NetApp Element software is the original source volume (Element) and ONTAP is the original destination volume (ONTAP). R2 and R3 represent the inverse relationships created through the reverse resync operation.

The following image shows the failback scenario when the source volume still exists:



The following image shows the failback scenario when the source volume no longer exists:



Find more information

- [Perform a failback when source volume still exists](#)
- [Perform a failback when source volume no longer exists](#)

Perform a failback when source volume still exists

You can resynchronize the original source volume and fail back using the Netapp Element UI. This procedure applies to scenarios where the original source volume still exists.

1. In the Element UI, find the relationship that you broke to perform the failover.
2. Click the Actions icon and click **Reverse Resync**.
3. Confirm the action.



The Reverse Resync operation creates a new relationship in which the roles of the original source and destination volumes are reversed (this results in two relationships as the original relationship persists). Any new data from the original destination volume is transferred to the original source volume as part of the reverse resync operation. You can continue to access and write data to the active volume on the destination side, but you will need to disconnect all hosts to the source volume and perform a SnapMirror update before redirecting back to the original primary.

4. Click the Actions icon of the inverse relationship that you just created and click **Update**.

Now that you have completed the reverse resync and ensured that there are no active sessions connected to the volume on the destination side and that the latest data is on the original primary volume, you can perform the following steps to complete the failback and reactivate the original primary volume:

5. Click the Actions icon of the inverse relationship and click **Break**.
6. Click the Actions icon of the original relationship and click **Resync**.



The original primary volume can now be mounted to resume production workloads on the original primary volume. The original SnapMirror replication resumes based on the policy and schedule configured for the relationship.

7. After you confirm that the original relationship status is “snapmirrored”, click the Actions icon of the inverse relationship and click **Delete**.

Find more information

[SnapMirror failback scenarios](#)

Perform a failback when source volume no longer exists

You can resynchronize the original source volume and fail back using the Netapp Element UI. This section applies to scenarios in which the original source volume has been lost but the original cluster is still intact. For instructions about how to restore to a new cluster, see the documentation on the NetApp Support Site.

What you'll need

- You have a broken-off replication relationship between Element and ONTAP volumes.
- The Element volume is irretrievably lost.
- The original volume name shows as NOT FOUND.

Steps

1. In the Element UI, find the relationship that you broke to perform the failover.

Best Practice: Make note of the SnapMirror policy and schedule details of the original broken-off relationship. This information will be required when recreating the relationship.

2. Click the **Actions** icon and click **Reverse Resync**.
3. Confirm the action.



The Reverse Resync operation creates a new relationship in which the roles of the original source volume and the destination volume are reversed (this results in two relationships as the original relationship persists). Because the original volume no longer exists, the system creates a new Element volume with the same volume name and volume size as the original source volume. The new volume is assigned a default QoS policy called sm-recovery and is associated with a default account called sm-recovery. You will want to manually edit the account and QoS policy for all volumes that are created by SnapMirror to replace the original source volumes that were destroyed.

Data from the latest snapshot is transferred to the new volume as part of the reverse resync operation. You can continue to access and write data to the active volume on the destination side, but you will need to disconnect all hosts to the active volume and perform a SnapMirror update before reinstating the original primary relationship in a later step. After you complete the reverse resync and ensure that there are no active sessions connected to the volume on the destination side and that the latest data is on the original primary volume, continue with the following steps to complete the failback and reactivate the original

primary volume:

4. Click the **Actions** icon of the inverse relationship that was created during the Reverse Resync operation and click **Break**.
5. Click the **Actions** icon of the original relationship, in which the source volume does not exist, and click **Delete**.
6. Click the **Actions** icon of the inverse relationship, which you broke in step 4, and click **Reverse Resync**.
7. This reverses the source and destination and results in a relationship with the same volume source and volume destination as the original relationship.
8. Click the **Actions** icon and **Edit** to update this relationship with the original QoS policy and schedule settings you took note of.
9. Now it is safe to delete the inverse relationship that you reverse resynced in step 6.

Find more information

[SnapMirror failback scenarios](#)

Perform a transfer or one-time migration from ONTAP to Element

Typically, when you use SnapMirror for disaster recovery from a SolidFire storage cluster running NetApp Element software to ONTAP software, Element is the source and ONTAP the destination. However, in some cases the ONTAP storage system can serve as the source and Element as the destination.

- Two scenarios exist:
 - No previous disaster recovery relationship exists. Follow all the steps in this procedure.
 - Previous disaster recovery relationship does exist, but not between the volumes being used for this mitigation. In this case, follow only steps 3 and 4 below.

What you'll need

- The Element destination node must have been made accessible to ONTAP.
- The Element volume must have been enabled for SnapMirror replication.

You must specify the Element destination path in the form `hostip:/lun/<id_number>`, where `lun` is the actual string "lun" and `id_number` is the ID of the Element volume.

Steps

1. Using ONTAP, create the relationship with the Element cluster:

```
snapmirror create -source-path SVM:volume|cluster://SVM/volume
-destination-path hostip:/lun/name -type XDP -schedule schedule -policy
policy
```

```
cluster_dst::> snapmirror create -source-path svm_1:volA_dst
-destination-path 10.0.0.11:/lun/0005 -type XDP -schedule my_daily
-policy MirrorLatest
```

2. Verify that the SnapMirror relationship was created by using the ONTAP `snapmirror show` command.

See information about creating a replication relationship in the ONTAP documentation and for complete command syntax, see the ONTAP man page.

3. Using the `ElementCreateVolume` API, create the target volume and set the target volume access mode to SnapMirror:

Create an Element volume using the Element API

```
{
  "method": "CreateVolume",
  "params": {
    "name": "SMTargetVolumeTest2",
    "accountID": 1,
    "totalSize": 100000000000,
    "enable512e": true,
    "attributes": {},
    "qosPolicyID": 1,
    "enableSnapMirrorReplication": true,
    "access": "snapMirrorTarget"
  },
  "id": 1
}
```

4. Initialize the replication relationship using the ONTAP `snapmirror initialize` command:

```
snapmirror initialize -source-path hostip:/lun/name
-destination-path SVM:volume|cluster://SVM/volume
```

Back up and restore volumes

You can back up and restore volumes to other SolidFire storage, as well as secondary object stores that are compatible with Amazon S3 or OpenStack Swift.

When you restore volumes from OpenStack Swift or Amazon S3, you need manifest information from the original backup process. If you are restoring a volume that was backed up on a SolidFire storage system, no manifest information is required.

Find more information

- [Back up a volume to an Amazon S3 object store](#)
- [Back up a volume to an OpenStack Swift object store](#)
- [Back up a volume to a SolidFire storage cluster](#)
- [Restore a volume from backup on an Amazon S3 object store](#)
- [Restore a volume from backup on an OpenStack Swift object store](#)
- [Restore a volume from backup on a SolidFire storage cluster](#)

Back up a volume to an Amazon S3 object store

You can back up volumes to external object stores that are compatible with Amazon S3.

1. Click **Management** > **Volumes**.
2. Click the Actions icon for the volume you want to back up.
3. In the resulting menu, click **Backup to**.
4. In the **Integrated Backup** dialog box under **Backup to**, select **S3**.
5. Select an option under **Data Format**:
 - **Native**: A compressed format readable only by SolidFire storage systems.
 - **Uncompressed**: An uncompressed format compatible with other systems.
6. Enter a hostname to use to access the object store in the **Hostname** field.
7. Enter an access key ID for the account in the **Access Key ID** field.
8. Enter the secret access key for the account in the **Secret Access Key** field.
9. Enter the S3 bucket in which to store the backup in the **S3 Bucket** field.
10. Enter a nametag to append to the prefix in the **Nametag** field.
11. Click **Start Read**.

Back up a volume to an OpenStack Swift object store

You can back up volumes to external object stores that are compatible with OpenStack Swift.

1. Click **Management** > **Volumes**.
2. Click the Actions icon for the volume to back up.
3. In the resulting menu, click **Backup to**.
4. In the **Integrated Backup** dialog box under **Backup to**, select **Swift**.
5. Select a data format under **Data Format**:
 - **Native**: A compressed format readable only by SolidFire storage systems.
 - **Uncompressed**: An uncompressed format compatible with other systems.
6. Enter a URL to use to access the object store in the **URL** field.
7. Enter a user name for the account in the **Username** field.
8. Enter the authentication key for the account in the **Authentication Key** field.

9. Enter the container in which to store the backup in the **Container** field.
10. **Optional:** Enter a name tag to append to the prefix in the **Nametag** field.
11. Click **Start Read**.

Back up a volume to a SolidFire storage cluster

You can back up volumes residing on a cluster to a remote cluster for storage clusters running Element software.

Ensure that the source and target clusters are paired.

See [Pair clusters for replication](#).

When backing up or restoring from one cluster to another, the system generates a key to be used as authentication between the clusters. This bulk volume write key allows the source cluster to authenticate with the destination cluster, providing a level of security when writing to the destination volume. As part of the backup or restore process, you need to generate a bulk volume write key from the destination volume before starting the operation.

1. On the destination cluster, **Management > Volumes**.
2. Click the Actions icon for the destination volume.
3. In the resulting menu, click **Restore from**.
4. In the **Integrated Restore** dialog box, under **Restore from**, select **SolidFire**.
5. Select an option under **Data Format**:
 - **Native:** A compressed format readable only by SolidFire storage systems.
 - **Uncompressed:** An uncompressed format compatible with other systems.
6. Click **Generate Key**.
7. Copy the key from the **Bulk Volume Write Key** box to your clipboard.
8. On the source cluster, go to **Management > Volumes**.
9. Click the Actions icon for the volume to back up.
10. In the resulting menu, click **Backup to**.
11. In the **Integrated Backup** dialog box under **Backup to**, select **SolidFire**.
12. Select the same option you selected earlier in the **Data Format** field.
13. Enter the management virtual IP address of the destination volume's cluster in the **Remote Cluster MVIP** field.
14. Enter the remote cluster user name in the **Remote Cluster Username** field.
15. Enter the remote cluster password in the **Remote Cluster Password** field.
16. In the **Bulk Volume Write Key** field, paste the key you generated on the destination cluster earlier.
17. Click **Start Read**.

Restore a volume from backup on an Amazon S3 object store

You can restore a volume from a backup on an Amazon S3 object store.

1. Click **Reporting > Event Log**.
2. Locate the backup event that created the backup you need to restore.
3. In the **Details** column for the event, click **Show Details**.
4. Copy the manifest information to your clipboard.
5. Click **Management > Volumes**.
6. Click the Actions icon for the volume you want to restore.
7. In the resulting menu, click **Restore from**.
8. In the **Integrated Restore** dialog box under **Restore from**, select **S3**.
9. Select the option that matches the backup under **Data Format**:
 - **Native**: A compressed format readable only by SolidFire storage systems.
 - **Uncompressed**: An uncompressed format compatible with other systems.
10. Enter a hostname to use to access the object store in the **Hostname** field.
11. Enter an access key ID for the account in the **Access Key ID** field.
12. Enter the secret access key for the account in the **Secret Access Key** field.
13. Enter the S3 bucket in which to store the backup in the **S3 Bucket** field.
14. Paste the manifest information into the **Manifest** field.
15. Click **Start Write**.

Restore a volume from backup on an OpenStack Swift object store

You can restore a volume from a backup on an OpenStack Swift object store.

1. Click **Reporting > Event Log**.
2. Locate the backup event that created the backup you need to restore.
3. In the **Details** column for the event, click **Show Details**.
4. Copy the manifest information to your clipboard.
5. Click **Management > Volumes**.
6. Click the Actions icon for the volume you want to restore.
7. In the resulting menu, click **Restore from**.
8. In the **Integrated Restore** dialog box under **Restore from**, select **Swift**.
9. Select the option that matches the backup under **Data Format**:
 - **Native**: A compressed format readable only by SolidFire storage systems.
 - **Uncompressed**: An uncompressed format compatible with other systems.
10. Enter a URL to use to access the object store in the **URL** field.
11. Enter a user name for the account in the **Username** field.
12. Enter the authentication key for the account in the **Authentication Key** field.
13. Enter the name of the container in which the backup is stored in the **Container** field.
14. Paste the manifest information into the **Manifest** field.
15. Click **Start Write**.

Restore a volume from backup on a SolidFire storage cluster

You can restore a volume from a backup on a SolidFire storage cluster.

When backing up or restoring from one cluster to another, the system generates a key to be used as authentication between the clusters. This bulk volume write key allows the source cluster to authenticate with the destination cluster, providing a level of security when writing to the destination volume. As part of the backup or restore process, you need to generate a bulk volume write key from the destination volume before starting the operation.

1. On the destination cluster, click **Management > Volumes**.
2. Click the Actions icon for the volume you want to restore.
3. In the resulting menu, click **Restore from**.
4. In the **Integrated Restore** dialog box, under **Restore from**, select **SolidFire**.
5. Select the option that matches the backup under **Data Format**:
 - **Native**: A compressed format readable only by SolidFire storage systems.
 - **Uncompressed**: An uncompressed format compatible with other systems.
6. Click **Generate Key**.
7. Copy the **Bulk Volume Write Key** information to the clipboard.
8. On the source cluster, click **Management > Volumes**.
9. Click the Actions icon for the volume you want to use for the restore.
10. In the resulting menu, click **Backup to**.
11. In the **Integrated Backup** dialog box, select **SolidFire** under **Backup to**.
12. Select the option that matches the backup under **Data Format**.
13. Enter the management virtual IP address of the destination volume's cluster in the **Remote Cluster MVIP** field.
14. Enter the remote cluster user name in the **Remote Cluster Username** field.
15. Enter the remote cluster password in the **Remote Cluster Password** field.
16. Paste the key from your clipboard into the **Bulk Volume Write Key** field.
17. Click **Start Read**.

Troubleshoot your system

You must monitor the system for diagnostic purposes and to get information about performance trends and statuses of various system operations. You might need to replace nodes or SSDs for maintenance purposes.

- [View information about system events](#)
- [View status of running tasks](#)
- [View system alerts](#)
- [View node performance activity](#)
- [View volume performance](#)

- [View iSCSI sessions](#)
- [View Fibre Channel sessions](#)
- [Troubleshoot drives](#)
- [Troubleshoot nodes](#)
- [Work with per-node utilities for storage nodes](#)
- [Work with the management node](#)
- [Understand cluster fullness levels](#)

For more information

- [SolidFire and Element Software Documentation](#)
- [NetApp Element Plug-in for vCenter Server](#)

View information about system events

You can view information about various events detected in the system. The system refreshes the event messages every 30 seconds. The event log displays key events for the cluster.

1. In the Element UI, select **Reporting > Event Log**.

For every event, you see the following information:

Item	Description
ID	Unique ID associated with each event.
Event Type	The type of event being logged, for example, API events or clone events.
Message	Message associated with the event.
Details	Information that helps identify why the event occurred.
Service ID	The service that reported the event (if applicable).
Node	The node that reported the event (if applicable).
Drive ID	The drive that reported the event (if applicable).
Event Time	The time the event occurred.

Find more information

[Event types](#)

Event types

The system reports multiple types of events; each event is an operation that the system has completed. Events can be routine, normal events or events that require administrator attention. The Event Types column on the Event Log page indicates in which part of the system the event occurred.



The system does not log read-only API commands in the event log.

The following list describes the types of events that appear in the event log:

- **apiEvent**

Events initiated by a user through an API or web UI that modify settings.

- **binAssignmentsEvent**

Events related to the assignment of data bins. Bins are essentially containers that hold data and are mapped across the cluster.

- **binSyncEvent**

System events related to a reassignment of data among block services.

- **bsCheckEvent**

System events related to block service checks.

- **bsKillEvent**

System events related to block service terminations.

- **bulkOpEvent**

Events related to operations performed on an entire volume, such as a backup, restore, snapshot, or clone.

- **cloneEvent**

Events related to volume cloning.

- **clusterMasterEvent**

Events appearing upon cluster initialization or upon configuration changes to the cluster, such as adding or removing nodes.

- **csumEvent**

Events related to invalid data checksums on the disk.

- **dataEvent**

Events related to reading and writing data.

- **dbEvent**

Events related to the global database maintained by ensemble nodes in the cluster.

- **driveEvent**

Events related to drive operations.

- **encryptionAtRestEvent**

Events related to the process of encryption on a cluster.

- **ensembleEvent**

Events related to increasing or decreasing the number of nodes in an ensemble.

- **fibreChannelEvent**

Events related to the configuration of and connections to the nodes.

- **gcEvent**

Events related to processes run every 60 minutes to reclaim storage on block drives. This process is also known as garbage collection.

- **ieEvent**

Internal system error.

- **installEvent**

Automatic software installation events. Software is being automatically installed on a pending node.

- **iSCSIEvent**

Events related to iSCSI issues in the system.

- **limitEvent**

Events related to the number of volumes or virtual volumes in an account or in the cluster nearing the maximum allowed.

- **maintenanceModeEvent**

Events related to the node maintenance mode, such as disabling the node.

- **networkEvent**

Events related to the status of virtual networking.

- **platformHardwareEvent**

Events related to issues detected on hardware devices.

- **remoteClusterEvent**

Events related to remote cluster pairing.

- **schedulerEvent**

Events related to scheduled snapshots.

- **serviceEvent**

Events related to system service status.

- **sliceEvent**

Events related to the Slice Server, such as removing a metadata drive or volume.

There are three types of slice reassignment events, which include information about the service where a volume is assigned:

- flipping: changing the primary service to a new primary service

```
sliceID oldPrimaryServiceID->newPrimaryServiceID
```

- moving: changing the secondary service to a new secondary service

```
sliceID {oldSecondaryServiceID(s)}->{newSecondaryServiceID(s)}
```

- pruning: removing a volume from a set of services

```
sliceID {oldSecondaryServiceID(s)}
```

- **snmpTrapEvent**

Events related to SNMP traps.

- **statEvent**

Events related to system statistics.

- **tsEvent**

Events related to the system transport service.

- **unexpectedException**

Events related to unexpected system exceptions.

- **ureEvent**

Events related to Unrecoverable Read Errors that occur while reading from the storage device.

- **vasaProviderEvent**

Events related to a VASA (vSphere APIs for Storage Awareness) Provider.

View status of running tasks

You can view the progress and completion status of running tasks in the web UI that are being reported by the ListSyncJobs and ListBulkVolumeJobs API methods. You can access the Running Tasks page from the Reporting tab of the Element UI.

If there are a large number of tasks, the system might queue them and run them in batches. The Running Tasks page displays the services currently being synchronized. When a task is complete, it is replaced by the next queued synchronizing task. Synchronizing tasks might continue to appear on the Running Tasks page until there are no more tasks to complete.



You can see replication synchronizations data for volumes undergoing replication on the Running Tasks page of the cluster containing the target volume.

View system alerts

You can view alerts for information about cluster faults or errors in the system. Alerts can be information, warnings, or errors and are a good indicator of how well the cluster is running. Most errors resolve themselves automatically.

You can use the ListClusterFaults API method to automate alert monitoring. This enables you to be notified about all alerts that occur.

1. In the Element UI, select **Reporting > Alerts**.

The system refreshes the alerts on the page every 30 seconds.

For every event, you see the following information:

Item	Description
ID	Unique ID associated with a cluster alert.

Severity	The degree of importance of the alert. Possible values: <ul style="list-style-type: none"> • warning: A minor issue that might soon require attention. System upgrades are still allowed. • error: A failure that might cause performance degradation or loss of high availability (HA). Errors generally should not affect service otherwise. • critical: A serious failure that affects service. The system is unable to serve API or client I/O requests. Operating in this state could lead to potential loss of data. • bestPractice: A recommended system configuration best practice is not being used.
Type	The component that the fault affects. Can be node, drive, cluster, service, or volume.
Node	Node ID for the node that this fault refers to. Included for node and drive faults, otherwise set to - (dash).
Drive ID	Drive ID for the drive that this fault refers to. Included for drive faults, otherwise set to - (dash).
Error Code	A descriptive code that indicates what caused the fault.
Details	A description of the fault with additional details.
Date	The date and time the fault was logged.

2. Click **Show Details** for an individual alert to view information about the alert.
3. To view the details of all alerts on the page, click the Details column.

After the system resolves an alert, all information about the alert including the date it was resolved is moved to the Resolved area.

Find more information

- [Cluster fault codes](#)
- [Manage storage with the Element API](#)

Cluster fault codes

The system reports an error or a state that might be of interest by generating a fault code, which is listed on the Alerts page. These codes help you determine what component of

the system experienced the alert and why the alert was generated.

The following list outlines the different types of codes:

- **authenticationServiceFault**

The Authentication Service on one or more cluster nodes is not functioning as expected.

Contact NetApp Support for assistance.

- **availableVirtualNetworkIPAddressesLow**

The number of virtual network addresses in the block of IP addresses is low.

To resolve this fault, add more IP addresses to the block of virtual network addresses.

- **blockClusterFull**

There is not enough free block storage space to support a single node loss. See the `GetClusterFullThreshold` API method for details on cluster fullness levels. This cluster fault indicates one of the following conditions:

- `stage3Low` (Warning): User-defined threshold was crossed. Adjust Cluster Full settings or add more nodes.
- `stage4Critical` (Error): There is not enough space to recover from a 1-node failure. Creation of volumes, snapshots, and clones is not allowed.
- `stage5CompletelyConsumed` (Critical)¹; No writes or new iSCSI connections are allowed. Current iSCSI connections will be maintained. Writes will fail until more capacity is added to the cluster. To resolve this fault, purge or delete volumes or add another storage node to the storage cluster.

- **blocksDegraded**

Block data is no longer fully replicated due to a failure.

Severity	Description
Warning	Only two complete copies of the block data are accessible.
Error	Only a single complete copy of the block data is accessible.
Critical	No complete copies of the block data are accessible.

Note: The warning status can only occur on a Triple Helix system.

To resolve this fault, restore any offline nodes or block services, or contact NetApp Support for assistance.

- **blockServiceTooFull**

A block service is using too much space.

To resolve this fault, add more provisioned capacity.

- **blockServiceUnhealthy**

A block service has been detected as unhealthy:

- Severity = Warning: No action is taken. This warning period will expire in `cTimeUntilBSIsKilledMSec=330000` milliseconds.
- Severity = Error: The system is automatically decommissioning data and re-replicating its data to other healthy drives.
- Severity = Critical: There are failed block services on several nodes greater than or equal to the replication count (2 for double helix). Data is unavailable and bin syncing will not finish. Check for network connectivity issues and hardware errors. There will be other faults if specific hardware components have failed. The fault will clear when the block service is accessible or when the service has been decommissioned.

- **clockSkewExceedsFaultThreshold**

Time skew between the Cluster master and the node which is presenting a token exceeds the recommended threshold. Storage cluster cannot correct the time skew between the nodes automatically.

To resolve this fault, use NTP servers that are internal to your network, rather than the installation defaults. If you are using an internal NTP server, contact NetApp Support for assistance.

- **clusterCannotSync**

There is an out-of-space condition and data on the offline block storage drives cannot be synced to drives that are still active.

To resolve this fault, add more storage.

- **clusterFull**

There is no more free storage space in the storage cluster.

To resolve this fault, add more storage.

- **clusterIOPSAreOverProvisioned**

Cluster IOPS are over provisioned. The sum of all minimum QoS IOPS is greater than the expected IOPS of the cluster. Minimum QoS cannot be maintained for all volumes simultaneously.

To resolve this issue, lower the minimum QoS IOPS settings for volumes.

- **disableDriveSecurityFailed**

The cluster is not configured to enable drive security (Encryption at Rest), but at least one drive has drive security enabled, meaning that disabling drive security on those drives failed. This fault is logged with "Warning" severity.

To resolve this fault, check the fault details for the reason why drive security could not be disabled. Possible reasons are:

- The encryption key could not be acquired, investigate the problem with access to the key or the external key server.

- The disable operation failed on the drive, determine whether the wrong key could possibly have been acquired. If neither of these are the reason for the fault, the drive might need to be replaced.

You can attempt to recover a drive that does not successfully disable security even when the correct authentication key is provided. To perform this operation, remove the drive(s) from the system by moving it to Available, perform a secure erase on the drive and move it back to Active.

- **disconnectedClusterPair**

A cluster pair is disconnected or configured incorrectly. Check network connectivity between the clusters.

- **disconnectedRemoteNode**

A remote node is either disconnected or configured incorrectly. Check network connectivity between the nodes.

- **disconnectedSnapMirrorEndpoint**

A remote SnapMirror endpoint is disconnected or configured incorrectly. Check network connectivity between the cluster and the remote SnapMirrorEndpoint.

- **driveAvailable**

One or more drives are available in the cluster. In general, all clusters should have all drives added and none in the available state. If this fault appears unexpectedly, contact NetApp Support.

To resolve this fault, add any available drives to the storage cluster.

- **driveFailed**

The cluster returns this fault when one or more drives have failed, indicating one of the following conditions:

- The drive manager cannot access the drive.
- The slice or block service has failed too many times, presumably because of drive read or write failures, and cannot restart.
- The drive is missing.
- The master service for the node is inaccessible (all drives in the node are considered missing/failed).
- The drive is locked and the authentication key for the drive cannot be acquired.
- The drive is locked and the unlock operation fails. To resolve this issue:
- Check network connectivity for the node.
- Replace the drive.
- Ensure that the authentication key is available.

- **driveHealthFault**

A drive has failed the SMART health check and as a result, the drive's functions are diminished. There is a Critical severity level for this fault:

- Drive with serial: <serial number> in slot: <node slot><drive slot> has failed the SMART overall health check. To resolve this fault, replace the drive.

- **driveWearFault**

A drive's remaining life has dropped below thresholds, but it is still functioning. There are two possible severity levels for this fault: Critical and Warning:

- Drive with serial: <serial number> in slot: <node slot><drive slot> has critical wear levels.
- Drive with serial: <serial number> in slot: <node slot><drive slot> has low wear reserves. To resolve this fault, replace the drive soon.

- **duplicateClusterMasterCandidates**

More than one storage cluster master candidate has been detected. Contact NetApp Support for assistance.

- **enableDriveSecurityFailed**

The cluster is configured to require drive security (Encryption at Rest), but drive security could not be enabled on at least one drive. This fault is logged with "Warning" severity.

To resolve this fault, check the fault details for the reason why drive security could not be enabled. Possible reasons are:

- The encryption key could not be acquired, investigate the problem with access to the key or the external key server.
- The enable operation failed on the drive, determine whether the wrong key could possibly have been acquired. If neither of these are the reason for the fault, the drive might need to be replaced.

You can attempt to recover a drive that does not successfully enable security even when the correct authentication key is provided. To perform this operation, remove the drive(s) from the system by moving it to Available, perform a secure erase on the drive and move it back to Active.

- **ensembleDegraded**

Network connectivity or power has been lost to one or more of the ensemble nodes.

To resolve this fault, restore network connectivity or power.

- **exception**

A fault reported that is other than a routine fault. These faults are not automatically cleared from the fault queue. Contact NetApp Support for assistance.

- **failedSpaceTooFull**

A block service is not responding to data write requests. This causes the slice service to run out of space to store failed writes.

To resolve this fault, restore block services functionality to allow writes to continue normally and failed space to be flushed from the slice service.

- **fanSensor**

A fan sensor has failed or is missing.

To resolve this fault, replace any failed hardware.

- **fibreChannelAccessDegraded**

A Fibre Channel node is not responding to other nodes in the storage cluster over its storage IP for a period of time. In this state, the node will then be considered unresponsive and generate a cluster fault. Check network connectivity.

- **fibreChannelAccessUnavailable**

All Fibre Channel nodes are unresponsive. The node IDs are displayed. Check network connectivity.

- **fibreChannelActiveIxl**

The IxL Nexus count is approaching the supported limit of 8000 active sessions per Fibre Channel node.

- Best practice limit is 5500.
- Warning limit is 7500.
- Maximum limit (not enforced) is 8192. To resolve this fault, reduce the IxL Nexus count below the best practice limit of 5500.

- **fibreChannelConfig**

This cluster fault indicates one of the following conditions:

- There is an unexpected Fibre Channel port on a PCI slot.
- There is an unexpected Fibre Channel HBA model.
- There is a problem with the firmware of a Fibre Channel HBA.
- A Fibre Channel port is not online.
- There is a persistent issue configuring Fibre Channel passthrough. Contact NetApp Support for assistance.

- **fibreChannelIOPS**

The total IOPS count is approaching the IOPS limit for Fibre Channel nodes in the cluster. The limits are:

- FC0025: 450K IOPS limit at 4K block size per Fibre Channel node.
- FCN001: 625K OPS limit at 4K block size per Fibre Channel node. To resolve this fault, balance the load across all available Fibre Channel nodes.

- **fibreChannelStaticIxl**

The IxL Nexus count is approaching the supported limit of 16000 static sessions per Fibre Channel node.

- Best practice limit is 11000.
- Warning limit is 15000.
- Maximum limit (enforced) is 16384. To resolve this fault, reduce the IxL Nexus count below the best practice limit of 11000.

- **fileSystemCapacityLow**

There is insufficient space on one of the filesystems.

To resolve this fault, add more capacity to the filesystem.

- **fipsDrivesMismatch**

A non-FIPS drive has been physically inserted into a FIPS capable storage node or a FIPS drive has been

physically inserted into a non-FIPS storage node. A single fault is generated per node and lists all drives affected.

To resolve this fault, remove or replace the mismatched drive or drives in question.

- **fipsDrivesOutOfCompliance**

The system has detected that Encryption at Rest was disabled after the FIPS Drives feature was enabled. This fault is also generated when the FIPS Drives feature is enabled and a non-FIPS drive or node is present in the storage cluster.

To resolve this fault, enable Encryption at Rest or remove the non-FIPS hardware from the storage cluster.

- **fipsSelfTestFailure**

The FIPS subsystem has detected a failure during the self test.

Contact NetApp Support for assistance.

- **hardwareConfigMismatch**

This cluster fault indicates one of the following conditions:

- The configuration does not match the node definition.
- There is an incorrect drive size for this type of node.
- An unsupported drive has been detected. A possible reason is that the installed Element version does not recognize this drive. Recommend updating the Element software on this node.
- There is a drive firmware mismatch.
- The drive encryption capable state does not match the node. Contact NetApp Support for assistance.

- **idPCertificateExpiration**

The cluster's service provider SSL certificate for use with a third-party identity provider (IdP) is nearing expiration or has already expired. This fault uses the following severities based on urgency:

Severity	Description
Warning	Certificate expires within 30 days.
Error	Certificate expires within 7 days.
Critical	Certificate expires within 3 days or has already expired.

To resolve this fault, update the SSL certificate before it expires. Use the UpdateIdpConfiguration API method with `refreshCertificateExpirationTime=true` to provide the updated SSL certificate.

- **inconsistentBondModes**

The bond modes on the VLAN device are missing. This fault will display the expected bond mode and the bond mode currently in use.

- **inconsistentInterfaceConfiguration**

The interface configuration is inconsistent.

To resolve this fault, ensure the node interfaces in the storage cluster are consistently configured.

- **inconsistentMtus**

This cluster fault indicates one of the following conditions:

- Bond1G mismatch: Inconsistent MTUs have been detected on Bond1G interfaces.
- Bond10G mismatch: Inconsistent MTUs have been detected on Bond10G interfaces. This fault displays the node or nodes in question along with the associated MTU value.

- **inconsistentRoutingRules**

The routing rules for this interface are inconsistent.

- **inconsistentSubnetMasks**

The network mask on the VLAN device does not match the internally recorded network mask for the VLAN. This fault displays the expected network mask and the network mask currently in use.

- **incorrectBondPortCount**

The number of bond ports is incorrect.

- **invalidConfiguredFibreChannelNodeCount**

One of the two expected Fibre Channel node connections is degraded. This fault appears when only one Fibre Channel node is connected.

To resolve this fault, check the cluster network connectivity and network cabling, and check for failed services. If there are no network or service problems, contact NetApp Support for a Fibre Channel node replacement.

- **irqBalanceFailed**

An exception occurred while attempting to balance interrupts.

Contact NetApp Support for assistance.

- **kmipCertificateFault**

- Root Certification Authority (CA) certificate is nearing expiration.

To resolve this fault, acquire a new certificate from the root CA with expiration date at least 30 days out and use `ModifyKeyServerK mip` to provide the updated root CA certificate.

- Client certificate is nearing expiration.

To resolve this fault, create a new CSR using `GetClientCertificateSigningRequest`, have it signed ensuring the new expiration date is at least 30 days out, and use `ModifyKeyServerK mip` to replace the expiring KMIP client certificate with the new certificate.

- Root Certification Authority (CA) certificate has expired.

To resolve this fault, acquire a new certificate from the root CA with expiration date at least 30 days out and use `ModifyKeyServerKmpip` to provide the updated root CA certificate.

- Client certificate has expired.

To resolve this fault, create a new CSR using `GetClientCertificateSigningRequest`, have it signed ensuring the new expiration date is at least 30 days out, and use `ModifyKeyServerKmpip` to replace the expired KMIP client certificate with the new certificate.

- Root Certification Authority (CA) certificate error.

To resolve this fault, check that the correct certificate was provided, and, if needed, reacquire the certificate from the root CA. Use `ModifyKeyServerKmpip` to install the correct KMIP client certificate.

- Client certificate error.

To resolve this fault, check that the correct KMIP client certificate is installed. The root CA of the client certificate should be installed on the EKS. Use `ModifyKeyServerKmpip` to install the correct KMIP client certificate.

- **kmipServerFault**

- Connection failure

To resolve this fault, check that the External Key Server is alive and reachable via the network. Use `TestKeyServerKimp` and `TestKeyProviderKmpip` to test your connection.

- Authentication failure

To resolve this fault, check that the correct root CA and KMIP client certificates are being used, and that the private key and the KMIP client certificate match.

- Server error

To resolve this fault, check the details for the error. Troubleshooting on the External Key Server might be necessary based on the error returned.

- **memoryEccThreshold**

A large number of correctable or uncorrectable ECC errors have been detected. This fault uses the following severities based on urgency:

Event	Severity	Description
A single DIMM <code>cErrorCount</code> reaches <code>cDimmCorrectableErrWarnThreshold</code> .	Warning	Correctable ECC memory errors above threshold on DIMM: <Processor> <DIMM Slot>
A single DIMM <code>cErrorCount</code> stays above <code>cDimmCorrectableErrWarnThreshold</code> until <code>cErrorFaultTimer</code> expires for the DIMM.	Error	Correctable ECC memory errors above threshold on DIMM: <Processor> <DIMM>

A memory controller reports cErrorCount above cMemCtlrCorrectableErrWarnThreshold, and cMemCtlrCorrectableErrWarnDuration is specified.	Warning	Correctable ECC memory errors above threshold on memory controller: <Processor> <Memory Controller>
A memory controller reports cErrorCount above cMemCtlrCorrectableErrWarnThreshold until cErrorFaultTimer expires for the memory controller.	Error	Correctable ECC memory errors above threshold on DIMM: <Processor> <DIMM>
A single DIMM reports a uErrorCount above zero, but less than cDimmUncorrectableErrFaultThreshold.	Warning	Uncorrectable ECC memory error(s) detected on DIMM: <Processor> <DIMM Slot>
A single DIMM reports a uErrorCount of at least cDimmUncorrectableErrFaultThreshold.	Error	Uncorrectable ECC memory error(s) detected on DIMM: <Processor> <DIMM Slot>
A memory controller reports a uErrorCount above zero, but less than cMemCtlrUncorrectableErrFaultThreshold.	Warning	Uncorrectable ECC memory error(s) detected on memory controller: <Processor> <Memory Controller>
A memory controller reports a uErrorCount of at least cMemCtlrUncorrectableErrFaultThreshold.	Error	Uncorrectable ECC memory error(s) detected on memory controller: <Processor> <Memory Controller>

To resolve this fault, contact NetApp Support for assistance.

- **memoryUsageThreshold**

Memory usage is above normal. This fault uses the following severities based on urgency:



See the **Details** heading in the error fault for more detailed information on the type of fault.

Severity	Description
Warning	System memory is low.
Error	System memory is very low.

Critical	System memory is completely consumed.
----------	---------------------------------------

To resolve this fault, contact NetApp Support for assistance.

- **metadataClusterFull**

There is not enough free metadata storage space to support a single node loss. See the `GetClusterFullThreshold` API method for details on cluster fullness levels. This cluster fault indicates one of the following conditions:

- `stage3Low` (Warning): User-defined threshold was crossed. Adjust Cluster Full settings or add more nodes.
- `stage4Critical` (Error): There is not enough space to recover from a 1-node failure. Creation of volumes, snapshots, and clones is not allowed.
- `stage5CompletelyConsumed` (Critical)¹; No writes or new iSCSI connections are allowed. Current iSCSI connections will be maintained. Writes will fail until more capacity is added to the cluster. Purge or delete data or add more nodes. To resolve this fault, purge or delete volumes or add another storage node to the storage cluster.

- **mtuCheckFailure**

A network device is not configured for the proper MTU size.

To resolve this fault, ensure that all network interfaces and switch ports are configured for jumbo frames (MTUs up to 9000 bytes in size).

- **networkConfig**

This cluster fault indicates one of the following conditions:

- An expected interface is not present.
- A duplicate interface is present.
- A configured interface is down.
- A network restart is required. Contact NetApp Support for assistance.

- **noAvailableVirtualNetworkIPAddresses**

There are no available virtual network addresses in the block of IP addresses.

- `virtualNetworkID # TAG(#)` has no available storage IP addresses. Additional nodes cannot be added to the cluster. To resolve this fault, add more IP addresses to the block of virtual network addresses.

- **nodeHardwareFault (Network interface <name> is down or cable is unplugged)**

A network interface is either down or the cable is unplugged.

To resolve this fault, check network connectivity for the node or nodes.

- **nodeHardwareFault (Drive encryption capable state mismatches node's encryption capable state for the drive in slot <node slot><drive slot>)**

A drive does not match encryption capabilities with the storage node it is installed in.

- **nodeHardwareFault (Incorrect <drive type> drive size <actual size> for the drive in slot <node slot><drive slot> for this node type - expected <expected size>)**

A storage node contains a drive that is the incorrect size for this node.

- **nodeHardwareFault (Unsupported drive detected in slot <node slot><drive slot>; drive statistics and health information will be unavailable)**

A storage node contains a drive it does not support.

- **nodeHardwareFault (The drive in slot <node slot><drive slot> should be using firmware version <expected version>, but is using unsupported version <actual version>)**

A storage node contains a drive running an unsupported firmware version.

- **nodeMaintenanceMode**

A node has been placed in maintenance mode. This fault uses the following severities based on urgency:

Severity	Description
Warning	Indicates that the node is still in maintenance mode.
Error	Indicates that maintenance mode has failed to disable, most likely due to failed or active standbys.

To resolve this fault, disable maintenance mode once maintenance completes. If the Error level fault persists, contact NetApp Support for assistance.

- **nodeOffline**

Element software cannot communicate with the specified node. Check network connectivity.

- **notUsingLACPBondMode**

LACP bonding mode is not configured.

To resolve this fault, use LACP bonding when deploying storage nodes; clients might experience performance issues if LACP is not enabled and properly configured.

- **ntpServerUnreachable**

The storage cluster cannot communicate with the specified NTP server or servers.

To resolve this fault, check the configuration for the NTP server, network, and firewall.

- **ntpTimeNotInSync**

The difference between storage cluster time and the specified NTP server time is too large. The storage cluster cannot correct the difference automatically.

To resolve this fault, use NTP servers that are internal to your network, rather than the installation defaults. If you are using internal NTP servers and the issue persists, contact NetApp Support for assistance.

- **nvrAmDeviceStatus**

An NVRAM device has an error, is failing, or has failed. This fault has the following severities:

Severity	Description
Warning	<p>A warning has been detected by the hardware. This condition may be transitory, such as a temperature warning.</p> <ul style="list-style-type: none"> • nvmLifetimeError • nvmLifetimeStatus • energySourceLifetimeStatus • energySourceTemperatureStatus • warningThresholdExceeded
Error	<p>An Error or Critical status has been detected by the hardware. The cluster master attempts to remove the slice drive from operation (this generates a drive removal event). If secondary slice services are not available the drive will not be removed. Errors returned in addition to the Warning level errors:</p> <ul style="list-style-type: none"> • NVRAM device mount point doesn't exist. • NVRAM device partition doesn't exist. • NVRAM device partition exists, but not mounted.
Critical	<p>An Error or Critical status has been detected by the hardware. The cluster master attempts to remove the slice drive from operation (this generates a drive removal event). If secondary slice services are not available the drive will not be removed.</p> <ul style="list-style-type: none"> • persistenceLost • armStatusSaveNArmed • csaveStatusError

Replace any failed hardware in the node. If this does not resolve the issue, contact NetApp Support for assistance.

- **powerSupplyError**

This cluster fault indicates one of the following conditions:

- A power supply is not present.
- A power supply has failed.
- A power supply input is missing or out of range. To resolve this fault, verify that redundant power is supplied to all nodes. Contact NetApp Support for assistance.

- **provisionedSpaceTooFull**

The overall provisioned capacity of the cluster is too full.

To resolve this fault, add more provisioned space, or delete and purge volumes.

- **remoteRepAsyncDelayExceeded**

The configured asynchronous delay for replication has been exceeded. Check network connectivity between clusters.

- **remoteRepClusterFull**

The volumes have paused remote replication because the target storage cluster is too full.

To resolve this fault, free up some space on the target storage cluster.

- **remoteRepSnapshotClusterFull**

The volumes have paused remote replication of snapshots because the target storage cluster is too full.

To resolve this fault, free up some space on the target storage cluster.

- **remoteRepSnapshotsExceededLimit**

The volumes have paused remote replication of snapshots because the target storage cluster volume has exceeded its snapshot limit.

To resolve this fault, increase the snapshot limit on the target storage cluster.

- **scheduleActionError**

One or more of the scheduled activities ran, but failed.

The fault clears if the scheduled activity runs again and succeeds, if the scheduled activity is deleted, or if the activity is paused and resumed.

- **sensorReadingFailed**

The Baseboard Management Controller (BMC) self-test failed or a sensor could not communicate with the BMC.

Contact NetApp Support for assistance.

- **serviceNotRunning**

A required service is not running.

Contact NetApp Support for assistance.

- **sliceServiceTooFull**

A slice service has too little provisioned capacity assigned to it.

To resolve this fault, add more provisioned capacity.

- **sliceServiceUnhealthy**

The system has detected that a slice service is unhealthy and is automatically decommissioning it.

- Severity = Warning: No action is taken. This warning period will expire in 6 minutes.
- Severity = Error: The system is automatically decommissioning data and re-replicating its data to other healthy drives. Check for network connectivity issues and hardware errors. There will be other faults if specific hardware components have failed. The fault will clear when the slice service is accessible or when the service has been decommissioned.

- **sshEnabled**

The SSH service is enabled on one or more nodes in the storage cluster.

To resolve this fault, disable the SSH service on the appropriate node or nodes or contact NetApp Support for assistance.

- **sslCertificateExpiration**

The SSL certificate associated with this node is nearing expiration or has expired. This fault uses the following severities based on urgency:

Severity	Description
Warning	Certificate expires within 30 days.
Error	Certificate expires within 7 days.
Critical	Certificate expires within 3 days or has already expired.

To resolve this fault, renew the SSL certificate. If needed, contact NetApp Support for assistance.

- **strandedCapacity**

A single node accounts for more than half of the storage cluster capacity.

In order to maintain data redundancy, the system reduces the capacity of the largest node so that some of its block capacity is stranded (not used).

To resolve this fault, add more drives to existing storage nodes or add storage nodes to the cluster.

- **tempSensor**

A temperature sensor is reporting higher than normal temperatures. This fault can be triggered in conjunction with powerSupplyError or fanSensor faults.

To resolve this fault, check for airflow obstructions near the storage cluster. If needed, contact NetApp Support for assistance.

- **upgrade**

An upgrade has been in progress for more than 24 hours.

to resolve this fault, resume the upgrade or contact NetApp Support for assistance.

- **unresponsiveService**

A service has become unresponsive.

Contact NetApp Support for assistance.

- **virtualNetworkConfig**

This cluster fault indicates one of the following conditions:

- An interface is not present.
- There is an incorrect namespace on an interface.
- There is an incorrect netmask.
- There is an incorrect IP address.
- An interface is not up and running.
- There is a superfluous interface on a node. Contact NetApp Support for assistance.

- **volumesDegraded**

Secondary volumes have not finished replicating and synchronizing. The message is cleared when the synchronizing is complete.

- **volumesOffline**

One or more volumes in the storage cluster are offline. The **volumeDegraded** fault will also be present.

Contact NetApp Support for assistance.

View node performance activity

You can view performance activity for each node in a graphical format. This information provides real-time statistics for CPU and read/write I/O operations per second (IOPS) for each drive the node. The utilization graph is updated every five seconds, and the drive statistics graph updates every ten seconds.

1. Click **Cluster > Nodes**.
2. Click **Actions** for the node you want to view.
3. Click **View Details**.



You can see specific points in time on the line and bar graphs by positioning your cursor over the line or bar.

View volume performance

You can view detailed performance information for all volumes in the cluster. You can sort the information by volume ID or by any of the performance columns. You can also use filter the information by certain criteria.

You can change how often the system refreshes performance information on the page by clicking the **Refresh every** list, and choosing a different value. The default refresh interval is 10 seconds if the cluster has less than 1000 volumes; otherwise, the default is 60 seconds. If you choose a value of Never, automatic page refreshing is disabled.

You can reenable automatic refreshing by clicking **Turn on auto-refresh**.

1. In the Element UI, select **Reporting > Volume Performance**.
2. In the volume list, click the Actions icon for a volume.
3. Click **View Details**.

A tray is displayed at the bottom of the page containing general information about the volume.

4. To see more detailed information about the volume, click **See More Details**.

The system displays detailed information as well as performance graphs for the volume.

Find more information

[Volume performance details](#)

Volume performance details

You can view performance statistics of volumes from the Volume Performance page of the Reporting tab in the Element UI.

The following list describes the details that are available to you:

- **ID**

The system-generated ID for the volume.

- **Name**

The name given to the volume when it was created.

- **Account**

The name of the account assigned to the volume.

- **Access Groups**

The name of the volume access group or groups to which the volume belongs.

- **Volume Utilization**

A percentage value that describes how much the client is using the volume.

Possible values:

- 0 = Client is not using the volume
- 100 = Client is using the max
- >100 = Client is using the burst

- **Total IOPS**

The total number of IOPS (read and write) currently being executed against the volume.

- **Read IOPS**

The total number of read IOPS currently being executed against the volume.

- **Write IOPS**

The total number of write IOPS currently being executed against the volume.

- **Total Throughput**

The total amount of throughput (read and write) currently being executed against the volume.

- **Read Throughput**

The total amount of read throughput currently being executed against the volume.

- **Write Throughput**

The total amount of write throughput currently being executed against the volume.

- **Total Latency**

The average time, in microseconds, to complete read and write operations to a volume.

- **Read Latency**

The average time, in microseconds, to complete read operations to the volume in the last 500 milliseconds.

- **Write Latency**

The average time, in microseconds, to complete write operations to a volume in the last 500 milliseconds.

- **Queue Depth**

The number of outstanding read and write operations to the volume.

- **Average IO Size**

Average size in bytes of recent I/O to the volume in the last 500 milliseconds.

View iSCSI sessions

You can view the iSCSI sessions that are connected to the cluster. You can filter the information to include only the desired sessions.

1. In the Element UI, select **Reporting > iSCSI Sessions**.
2. To see the filter criteria fields, click **Filter**.

Find more information

[iSCSI session details](#)

iSCSI session details

You can view information about the iSCSI sessions that are connected to the cluster.

The following list describes the information that you can find about the iSCSI sessions:

- **Node**

The node hosting the primary metadata partition for the volume.

- **Account**

The name of the account that owns the volume. If value is blank, a dash (-) is displayed.

- **Volume**

The volume name identified on the node.

- **Volume ID**

ID of the volume associated with the Target IQN.

- **Initiator ID**

A system-generated ID for the initiator.

- **Initiator Alias**

An optional name for the initiator that makes finding the initiator easier when in a long list.

- **Initiator IP**

The IP address of the endpoint that initiates the session.

- **Initiator IQN**

The IQN of the endpoint that initiates the session.

- **Target IP**

The IP address of the node hosting the volume.

- **Target IQN**

The IQN of the volume.

- **Created On**

Date the session was established.

View Fibre Channel sessions

You can view the Fibre Channel (FC) sessions that are connected to the cluster. You can filter information to include only those connections you want displayed in the window.

1. In the Element UI, select **Reporting > FC Sessions**.
2. To see the filter criteria fields, click **Filter**.

Find more information

[Fibre Channel session details](#)

Fibre Channel session details

You can find information about the active Fibre Channel (FC) sessions that are connected to the cluster.

The following list describes the information you can find about the FC sessions connected to the cluster:

- **Node ID**

The node hosting the session for the connection.

- **Node Name**

System-generated node name.

- **Initiator ID**

A system-generated ID for the initiator.

- **Initiator WWPN**

The initiating worldwide port name.

- **Initiator Alias**

An optional name for the initiator that makes finding the initiator easier when in a long list.

- **Target WWPN**

The target worldwide port name.

- **Volume Access Group**

Name of the volume access group that the session belongs to.

- **Volume Access Group ID**

System-generated ID for the access group.

Troubleshoot drives

You can replace a failed solid-state drive (SSD) with a replacement drive. SSDs for SolidFire storage nodes are hot-swappable. If you suspect an SSD has failed, contact NetApp Support to verify the failure and walk you through the proper resolution procedure. NetApp Support also works with you to get a replacement drive according to your service-level agreement.

How-swappable in this case means that you can remove a failed drive from an active node and replace it with a new SSD drive from NetApp. It is not recommended that you should remove non-failed drives on an active cluster.

You should maintain on-site spares suggested by NetApp Support to allow for immediate replacement of the drive if it fails.



For testing purposes, if you are simulating a drive failure by pulling a drive from a node, you must wait 30 seconds before inserting the drive back into the drive slot.

If a drive fails, Double Helix redistributes the data on the drive across the nodes remaining on the cluster. Multiple drive failures on the same node are not an issue since Element software protects against two copies of data residing on the same node. A failed drive results in the following events:

- Data is migrated off of the drive.
- Overall cluster capacity is reduced by the capacity of the drive.
- Double Helix data protection ensures that there are two valid copies of the data.



SolidFire storage systems do not support removal of a drive if it results in an insufficient amount of storage to migrate data.

For more information

- [Remove failed drives from the cluster](#)
- [Basic MDSS drive troubleshooting](#)
- [Remove MDSS drives](#)
- [Replacing drives for SolidFire storage nodes](#)
- [Replacing drives for H600S series storage nodes](#)
- [H410S and H610S hardware information](#)
- [SF-series hardware information](#)

Remove failed drives from the cluster

The SolidFire system puts a drive in a failed state if the drive's self-diagnostics tells the node it has failed or if communication with the drive stops for five and a half minutes or longer. The system displays a list of the failed drives. You must remove a failed drive from the failed drive list in NetApp Element software.

Drives in the **Alerts** list show as **blockServiceUnhealthy** when a node is offline. When restarting the node, if the node and its drives come back online within five and a half minutes, the drives automatically update and

continue as active drives in the cluster.

1. In the Element UI, select **Cluster > Drives**.
2. Click **Failed** to view the list of failed drives.
3. Note the slot number of the failed drive.

You need this information to locate the failed drive in the chassis.

4. Remove the failed drives using one of the following methods:

Option	Steps
To remove individual drives	<ol style="list-style-type: none">a. Click Actions for the drive you want to remove.b. Click Remove.
To remove multiple drives	<ol style="list-style-type: none">a. Select all the drives you want to remove, and click Bulk Actions.b. Click Remove.

Basic MDSS drive troubleshooting

You can recover metadata (or slice) drives by adding them back to the cluster in the event that one or both metadata drives fail. You can perform the recovery operation in the NetApp Element UI if the MDSS feature is already enabled on the node.

If either or both of the metadata drives in a node experiences a failure, the slice service will shut down and data from both drives will be backed up to different drives in the node.

The following scenarios outline possible failure scenarios, and provide basic recommendations to correct the issue:

System slice drive fails

- In this scenario, the slot 2 is verified and returned to an available state.
- The system slice drive must be repopulated before the slice service can be brought back online.
- You should replace the system slice drive, when the system slice drive becomes available, add the drive and the slot 2 drive at the same time.



You cannot add the drive in slot 2 by itself as a metadata drive. You must add both drives back to the node at the same time.

Slot 2 fails

- In this scenario, the system slice drive is verified and returned to an available state.
- You should replace slot 2 with a spare, when slot 2 becomes available, add the system slice drive and the slot 2 drive at the same time.

System slice drive and slot 2 fails

- You should replace both system slice drive and slot 2 with a spare drive. When both drives become available, add the system slice drive and the slot 2 drive at the same time.

Order of operations

- Replace the failed hardware drive with a spare drive (replace both drives if both have failed).
- Add drives back to the cluster when they have been repopulated and are in an available state.

Verify operations

- Verify that the drives in slot 0 (or internal) and slot 2 are identified as metadata drives in the Active Drives list.
- Verify that all slice balancing has completed (there are no further moving slices messages in the event log for at least 30 minutes).

For more information

[Add MDSS drives](#)

Add MDSS drives

You can add a second metadata drive on a SolidFire node by converting the block drive in slot 2 to a slice drive. This is accomplished by enabling the multi-drive slice service (MDSS) feature. To enable this feature, you must contact NetApp Support.

Getting a slice drive into an available state might require replacing a failed drive with a new or spare drive. You must add the system slice drive at the same time you add the drive for slot 2. If you try to add the slot 2 slice drive alone or before you add the system slice drive, the system will generate an error.

1. Click **Cluster > Drives**.
2. Click **Available** to view the list of available drives.
3. Select the slice drives to add.
4. Click **Bulk Actions**.
5. Click **Add**.
6. Confirm from the **Active Drives** tab that the drives have been added.

Remove MDSS drives

You can remove the multi-drive slice service (MDSS) drives. This procedure applies only if the node has multiple slice drives.



If the system slice drive and the slot 2 drive fail, the system will shutdown slice services and remove the drives. If there is no failure and you remove the drives, both drives must be removed at the same time.

1. Click **Cluster > Drives**.
2. From the **Available** drives tab, click the check box for the slice drives being removed.

3. Click **Bulk Actions**.
4. Click **Remove**.
5. Confirm the action.

Troubleshoot nodes

You can remove nodes from a cluster for maintenance or replacement. You should use the NetApp Element UI or API to remove nodes before taking them offline.

An overview of the procedure to remove storage nodes is as follows:

- Ensure that there is sufficient capacity in the cluster to create a copy of the data on the node.
- Remove drives from the cluster by using the UI or the RemoveDrives API method.

This results in the system migrating data from the node's drives to other drives in the cluster. The time this process takes is dependent on how much data must be migrated.

- Remove the node from the cluster.

Keep the following considerations in mind before you power down or power up a node:

- Powering down nodes and clusters involves risks if not performed properly.

Powering down a node should be done under the direction of NetApp Support.

- If a node has been down longer than 5.5 minutes under any type of shutdown condition, Double Helix data protection begins the task of writing single replicated blocks to another node to replicate the data. In this case, contact NetApp Support for help with analyzing the failed node.
- To safely reboot or power down a node, you can use the Shutdown API command.
- If a node is in a down, or in an off state, you must contact NetApp Support before bringing it back online.
- After a node is brought back online, you must add the drives back to the cluster, depending on how long it has been out of service.

For more information

[Replacing a failed SolidFire chassis](#)

[Replacing a failed H600S series node](#)

Power down a cluster

Perform the following procedure to power down an entire cluster.

Steps

1. (Optional) Contact NetApp Support for assistance with completing the preliminary steps.
2. Verify that all I/O has stopped.
3. Disconnect all iSCSI sessions:
 - a. Navigate to the management virtual IP (MVIP) address on the cluster to open the Element UI.
 - b. Note the nodes listed in the Nodes list.

- c. Run the Shutdown API method with the halt option specified on each Node ID in the cluster.

When you restart the cluster, you must follow certain steps to verify that all nodes come online:



1. Verify that all Critical severity and `volumesOffline` cluster faults have been resolved.
2. Wait for 10 to 15 minutes for the cluster to settle.
3. Start bringing up the hosts to access the data.

If you want to allow more time when powering on nodes and verifying that they are healthy after maintenance, contact technical support for assistance with delaying data synchronization to prevent unnecessary bin syncing.

Find more information

[How to gracefully shut down and power on a NetApp Solidfire/HCI storage cluster](#)

Work with per-node utilities for storage nodes

You can use the per-node utilities to troubleshoot network problems if the standard monitoring tools in the NetApp Element software UI do not give you enough information for troubleshooting. Per-node utilities provide specific information and tools that can help you troubleshoot network problems between nodes or with the management node.

Find more information

- [Access per-node settings using the per-node UI](#)
- [Network settings details from the per-node UI](#)
- [Cluster settings details from the per-node UI](#)
- [Run system tests using the per-node UI](#)
- [Run system utilities using the per-node UI](#)

Access per-node settings using the per-node UI

You can access network settings, cluster settings, and system tests and utilities in the per-node user interface after you enter the management node IP and authenticate.

If you want to modify settings of a node in an Active state that is part of a cluster, you must log in as a cluster administrator user.



You should configure or modify one node at a time. You should ensure that the network settings specified are having the expected effect, and that the network is stable and performing well before you make modifications to another node.

1. Open the per-node UI using one of the following methods:
 - Enter the management IP address followed by `:442` in a browser window, and log in using an admin user name and password.
 - In the Element UI, select **Cluster > Nodes**, and click the management IP address link for the node you want to configure or modify. In the browser window that opens, you can edit the settings of the node.



Node01

NETWORK SETTINGS CLUSTER SETTINGS SYSTEM TESTS SYSTEM UTILITIES

Network Settings

Bond1G Bond10G [Reset Changes](#)

Method	Link Speed
<input type="text" value="static"/>	<input type="text" value="1000"/>
IPv4 Address	IPv4 Subnet Mask
<input type="text"/>	<input type="text" value="255.255.255.0"/>
IPv4 Gateway Address	IPv6 Address
<input type="text"/>	<input type="text"/>
IPv6 Gateway Address	MTU
<input type="text"/>	<input type="text" value="1500"/>
DNS Servers	
<input type="text"/>	
Search Domains	
<input type="text"/>	

Bond Mode Status

Network settings details from the per-node UI

You can change the storage node network settings to give the node a new set of network attributes.

You can see the network settings for a storage node on the **Network Settings** page when you log in to the node (<https://<node IP>:442/hcc/node/network-settings>). You can select either **Bond1G** (management) or **Bond10G** (storage) settings. The following list describes the settings that you can modify when a storage node is in Available, Pending, or Active state:

- **Method**

The method used to configure the interface. Possible methods:

- loopback: Used to define the IPv4 loopback interface.
- manual: Used to define interfaces for which no configuration is done by default.
- dhcp: Used to obtain an IP address via DHCP.
- static: Used to define Ethernet interfaces with statically allocated IPv4 addresses.

- **Link Speed**

The speed negotiated by the virtual NIC.

- **IPv4 Address**

The IPv4 address for the eth0 network.

- **IPv4 Subnet Mask**

Address subdivisions of the IPv4 network.

- **IPv4 Gateway Address**

Router network address to send packets out of the local network.

- **IPv6 Address**

The IPv6 address for the eth0 network.

- **IPv6 Gateway Address**

Router network address to send packets out of the local network.

- **MTU**

Largest packet size that a network protocol can transmit. Must be greater than or equal to 1500. If you add a second storage NIC, the value should be 9000.

- **DNS Servers**

Network interface used for cluster communication.

- **Search Domains**

Search for additional MAC addresses available to the system.

- **Bond Mode**

Can be one of the following modes:

- ActivePassive (default)
- ALB
- LACP

- **Status**

Possible values:

- UpAndRunning
- Down
- Up

- **Virtual Network Tag**

Tag assigned when the virtual network was created.

- **Routes**

Static routes to specific hosts or networks via the associated interface the routes are configured to use.

Cluster settings details from the per-node UI

You can verify cluster settings for a storage node after cluster configuration and modify the node hostname.

The following list describes the cluster settings for a storage node indicated from the **Cluster Settings** page of the per-node UI (<https://<node IP>:442/hcc/node/cluster-settings>).

- **Role**

Role the node has in the cluster. Possible values:

- Storage: Storage or Fibre Channel node.
- Management: Node is a management node.

- **Hostname**

Name of the node.

- **Cluster**

Name of the cluster.

- **Cluster Membership**

State of the node. Possible values:

- Available: The node has no associated cluster name and is not yet part of a cluster.
- Pending: The node is configured and can be added to a designated cluster. Authentication is not required to access the node.
- PendingActive: The system is in the process of installing compatible software on the node. When complete, the node will move to the Active state.
- Active: The node is participating in a cluster. Authentication is required to modify the node.

- **Version**

Version of the Element software running on the node.

- **Ensemble**

Nodes that are part of the database ensemble.

- **Node ID**

ID assigned when a node is added to the cluster.

- **Cluster Interface**

Network interface used for cluster communication.

- **Management Interface**

Management network interface. This defaults to Bond1G but can also use Bond10G.

- **Storage Interface**

Storage network interface using Bond10G.

- **Encryption Capable**

Indicates whether or not the node supports drive encryption.

Run system tests using the per-node UI

You can test changes to the network settings after you commit them to the network configuration. You can run the tests to ensure that the storage node is stable and can be brought online without any issues.

You have logged in to the per-node UI for the storage node.

1. Click **System Tests**.
2. Click **Run Test** next to the test you want to run or select **Run All Tests**.



Running all test operations can be time consuming and should be done only at the direction of NetApp Support.

- **Test Connected Ensemble**

Tests and verifies the connectivity to a database ensemble. By default, the test uses the ensemble for the cluster the node is associated with. Alternatively you can provide a different ensemble to test connectivity.

- **Test Connect Mvip**

Pings the specified management virtual IP (MVIP) address and then executes a simple API call to the MVIP to verify connectivity. By default, the test uses the MVIP for the cluster the node is associated with.

- **Test Connect Svip**

Pings the specified storage virtual IP (SVIP) address using Internet Control Message Protocol (ICMP) packets that match the Maximum Transmission Unit (MTU) size set on the network adapter. It then connects to the SVIP as an iSCSI initiator. By default, the test uses the SVIP for the cluster the node is associated with.

- **Test Hardware Config**

Tests that all hardware configurations are correct, validates firmware versions are correct, and confirms all drives are installed and running properly. This is the same as factory testing.



This test is resource intensive and should only be run if requested by NetApp Support.

- **Test Local Connectivity**

Tests the connectivity to all of the other nodes in the cluster by pinging the cluster IP (CIP) on each node. This test will only be displayed on a node if the node is part of an active cluster.

- **Test Locate Cluster**

Validates that the node can locate the cluster specified in the cluster configuration.

- **Test Network Config**

Verifies that the configured network settings match the network settings being used on the system. This test is not intended to detect hardware failures when a node is actively participating in a cluster.

- **Test Ping**

Pings a specified list of hosts or, if none are specified, dynamically builds a list of all registered nodes in the cluster and pings each for simple connectivity.

- **Test Remote Connectivity**

Tests the connectivity to all nodes in remotely paired clusters by pinging the cluster IP (CIP) on each node. This test will only be displayed on a node if the node is part of an active cluster.

Run system utilities using the per-node UI

You can use the per-node UI for the storage node to create or delete support bundles, reset configuration settings for drives, and restart network or cluster services.

You have logged in to the per-node UI for the storage node.

1. Click **System Utilities**.
2. Click the button for the system utility that you want to run.

- **Control Power**

Reboots, power cycles, or shuts down the node.



This operation causes temporary loss of networking connectivity.

Specify the following parameters:

- Action: Options include Restart and Halt (power off).
- Wakeup Delay: Any additional time before the node comes back online.

- **Collect Node Logs**

Creates a support bundle under the node's /tmp/bundles directory.

Specify the following parameters:

- **Bundle Name:** Unique name for each support bundle created. If no name is provided, then "supportbundle" and the node name are used as the file name.
- **Extra Args:** This parameter is fed to the sf_make_support_bundle script. This parameter should be used only at the request of NetApp Support.
- **Timeout Sec:** Specify the number of seconds to wait for each individual ping response.

◦ **Delete Node Logs**

Deletes any current support bundles on the node that were created using **Create Cluster Support Bundle** or the CreateSupportBundle API method.

◦ **Reset Drives**

Initializes drives and removes all data currently residing on the drive. You can reuse the drive in an existing node or in an upgraded node.

Specify the following parameter:

- **Drives:** List of device names (not driveIDs) to reset.

◦ **Reset Network Config**

Helps resolve network configuration issues for an individual node and resets an individual node's network configuration to the factory default settings.

◦ **Reset Node**

Resets a node to the factory settings. All data is removed but network settings for the node are preserved during this operation. Nodes can only be reset if they are unassigned to a cluster and in Available state.



All data, packages (software upgrades), configurations, and log files are deleted from the node when you use this option.

◦ **Restart Networking**

Restarts all networking services on a node.



This operation can cause temporary loss of network connectivity.

◦ **Restart Services**

Restarts Element software services on a node.



This operation can cause temporary node service interruption. You should perform this operation only at the direction of NetApp Support.

Specify the following parameters:

- **Service:** Service name to be restarted.

- Action: Action to perform on the service. Options include start, stop and restart.

Work with the management node

You can use the management node (mNode) to upgrade system services, manage cluster assets and settings, run system tests and utilities, configure Active IQ for system monitoring, and enable NetApp Support access for troubleshooting.



As a best practice, only associate one management node with one VMware vCenter instance, and avoid defining the same storage and compute resources or vCenter instances in multiple management nodes.

See [management node documentation](#) for more information.

Understand cluster fullness levels

The cluster running Element software generates cluster faults to warn the storage administrator when the cluster is running out of capacity. There are three levels of cluster fullness, all of which are displayed in the NetApp Element UI: warning, error, and critical.

The system uses the BlockClusterFull error code to warn about cluster block storage fullness. You can view the cluster fullness severity levels from the Alerts tab of the Element UI.

The following list includes information about the BlockClusterFull severity levels:

- **Warning**

This is a customer-configurable warning that appears when the cluster's block capacity is approaching the error severity level. By default, this level is set at three percent under the error level and can be tuned via the Element UI and API. You must add more capacity, or free up capacity as soon as possible.

- **Error**

When the cluster is in this state, if a node is lost, there will not be enough capacity in the cluster to rebuild Double Helix data protection. New volume creation, clones, and snapshots are all blocked while the cluster is in this state. This is not a safe or recommended state for any cluster to be in. You must add more capacity, or free up capacity immediately.

- **Critical**

This critical error has occurred because the cluster is 100 percent consumed. It is in a read-only state and no new iSCSI connections can be made to the cluster. When this stage is reached, you must free up or add more capacity immediately.

The system uses the MetadataClusterFull error code to warn about cluster metadata storage fullness. You can view the cluster metadata storage fullness from the Cluster Capacity section on the Overview page of the Reporting tab in the Element UI.

The following list includes information about the MetadataClusterFull severity levels:

- **Warning**

This is a customer-configurable warning that appears when the cluster's metadata capacity is approaching

the error severity level. By default, this level is set at three percent under the error level and can be tuned via the Element API. You must add more capacity, or free up capacity as soon as possible.

- **Error**

When the cluster is in this state, if a node is lost, there will not be enough capacity in the cluster to rebuild Double Helix data protection. New volume creation, clones, and snapshots are all blocked while the cluster is in this state. This is not a safe or recommended state for any cluster to be in. You must add more capacity, or free up capacity immediately.

- **Critical**

This critical error has occurred because the cluster is 100 percent consumed. It is in a read-only state and no new iSCSI connections can be made to the cluster. When this stage is reached, you must free up or add more capacity immediately.



The following applies to two-node cluster thresholds:

- Metadata fullness error is 20% below critical.
- Block fullness error is 1 block drive (including stranded capacity) below critical; meaning that it is two block drives worth of capacity below critical.

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