



Concepts

Cloud Volumes ONTAP

NetApp
February 06, 2023

Table of Contents

- Concepts 1
 - Cloud Volumes ONTAP licensing 1
 - Storage 7
 - High-availability pairs 18
 - Security 23
 - Performance 24
 - License management for node-based BYOL 25
 - AutoSupport and Active IQ Digital Advisor 28
 - Default configuration for Cloud Volumes ONTAP 28

Concepts

Cloud Volumes ONTAP licensing

Several licensing options are available for Cloud Volumes ONTAP. Each option enables you to choose a consumption model that meets your needs.

Licensing overview

The following licensing options are available for new customers.

Capacity-based licensing

Pay for multiple Cloud Volumes ONTAP systems in your NetApp account by provisioned capacity. Includes the ability to purchase add-on cloud data services.

Keystone Flex Subscription

A pay-as-you-grow subscription-based service that delivers a seamless hybrid cloud experience for HA pairs.

The previous by-node licensing model remains available for existing customers who have already purchased a license or who have an active marketplace subscription.

The following sections provide more details about each of these options.

Capacity-based licensing

Capacity-based licensing packages enable you to pay for Cloud Volumes ONTAP per TiB of capacity. The license is associated with your NetApp account and enables you to charge multiple systems against the license, as long as enough capacity is available through the license.

For example, you could purchase a single 20 TiB license, deploy four Cloud Volumes ONTAP systems, and then allocate a 5 TiB volume to each system, for a total of 20 TiB. The capacity is available to the volumes on each Cloud Volumes ONTAP system deployed in that account.

Capacity-based licensing is available in the form of a *package*. When you deploy a Cloud Volumes ONTAP system, you can choose from several licensing packages based on your business needs.

Packages

The following capacity-based packages are available for Cloud Volumes ONTAP.

Freemium

Provides all Cloud Volumes ONTAP features free of charge from NetApp (cloud provider charges still apply).

- No license or contract is needed.
- Support from NetApp is not included.
- You're limited to 500 GiB of provisioned capacity per Cloud Volumes ONTAP system.
- You can use up to 10 Cloud Volumes ONTAP systems with the Freemium offering per NetApp account, in any cloud provider.

- If the provisioned capacity for a Cloud Volumes ONTAP system exceeds 500 GiB, BlueXP converts the system to the Essentials package.

As soon as a system is converted to the Essentials package, the [minimum charge](#) applies.

Any other systems that have less than 500 GiB of provisioned capacity stay on Freemium (as long as they were deployed using the Freemium offering).

Optimized

Pay for provisioned capacity and I/O operations separately.

- Cloud Volumes ONTAP single node or HA
- Charging is based on two cost components: storage and usage (I/O)

You will not be charged for I/O related to data replication (SnapMirror) or NDMP.

- Available in the Google Cloud Marketplace as a pay-as-you-go offering or as an annual contract
- Supported with selected VM types:
 - For Google Cloud: n2-standard-4, n2-standard-8
- Add on any of NetApp's cloud data services at extra cost

Essentials

Pay by capacity for Cloud Volumes ONTAP in a number of different configurations.

- Choose your Cloud Volumes ONTAP configuration:
 - A single node or HA system
 - File and block storage or secondary data for disaster recovery (DR)
- Add on any of NetApp's cloud data services at extra cost

Professional

Pay by capacity for any type of Cloud Volumes ONTAP configuration with unlimited backups.

- Provides licensing for any Cloud Volumes ONTAP configuration

Single node or HA with capacity charging for primary and secondary volumes at the same rate

- Includes unlimited volume backups using Cloud Backup, but only for Cloud Volumes ONTAP systems deployed with the Professional package
- Add on any of NetApp's cloud data services at extra cost

Edge Cache

Provides licensing for Cloud Volumes Edge Cache.

- The same capabilities as the Professional package with business continuity and data protection for a distributed enterprise
- Intelligent edge caching through a small-footprint Windows VM at each location

- One edge node with every 3 TiBs of capacity purchased
- Available in the Google Cloud Marketplace as a pay-as-you-go offering or as an annual contract

[Learn more about how Cloud Volumes Edge Cache can help your business](#)

Consumption models

Capacity-based licensing packages are available with the following consumption models:

- **BYOL**: A license purchased from NetApp that can be used to deploy Cloud Volumes ONTAP in any cloud provider.
- **PAYGO**: An hourly subscription from your cloud provider's marketplace.
- **Annual**: An annual contract from your cloud provider's marketplace.

Note the following:

- If you purchase a license from NetApp (BYOL), you also need to subscribe to the PAYGO offering from your cloud provider's marketplace.

Your license is always charged first, but you'll be charged from the hourly rate in the marketplace in these cases:

- If you exceed your licensed capacity
- If the term of your license expires
- If you have an annual contract from a marketplace, *all* Cloud Volumes ONTAP systems that you deploy are charged against that contract. You can't mix and match an annual marketplace contract with BYOL.

Changing packages

After deployment, you can change the package for a Cloud Volumes ONTAP system that uses capacity-based licensing. For example, if you deployed a Cloud Volumes ONTAP system with the Essentials package, you can change it to the Professional package if your business needs changed.

[Learn how to change charging methods.](#)

Pricing

For details about pricing, go to [NetApp BlueXP website](#).

Free trials

A 30-day free trial is available from the pay-as-you-go subscription in your cloud provider's marketplace. The free trial includes Cloud Volumes ONTAP and Cloud Backup. The trial starts when you subscribe to the offering in the marketplace.

There are no instance or capacity limitations. You can deploy as many Cloud Volumes ONTAP systems as you'd like and allocate as much capacity as needed, free of charge for 30 days. The free trial automatically converts to a paid hourly subscription after 30 days.

There are no hourly software license charges for Cloud Volumes ONTAP, but infrastructure charges from your cloud provider still apply.

You will receive a notification in BlueXP when the free trial starts, when there are 7 days left, and when there is 1 day remaining. For example:



Your Cloud Manager free trial is almost over (7 days left)

23 minutes ago | Digital Wallet

Supported configurations

Capacity-based licensing packages are available with Cloud Volumes ONTAP 9.7 and later.

Capacity limit

With this licensing model, each individual Cloud Volumes ONTAP system supports up to 2 PiB of capacity through disks and tiering to object storage.

There is no maximum capacity limitation when it comes to the license itself.

Max number of systems

With capacity-based licensing, the maximum number of Cloud Volumes ONTAP systems is limited to 20 per NetApp account. A *system* is a Cloud Volumes ONTAP HA pair, a Cloud Volumes ONTAP single node system, or any additional storage VMs that you create. The default storage VM does not count against the limit. This limit applies to all licensing models.

For example, let's say you have three working environments:

- A single node Cloud Volumes ONTAP system with one storage VM (this is the default storage VM that's created when you deploy Cloud Volumes ONTAP)

This working environment counts as one system.

- A single node Cloud Volumes ONTAP system with two storage VMs (the default storage VM, plus one additional storage VM that you created)

This working environment counts as two systems: one for the single node system and one for the additional storage VM.

- A Cloud Volumes ONTAP HA pair with three storage VMs (the default storage VM, plus two additional storage VMs that you created)

This working environment counts as three systems: one for the HA pair and two for the additional storage VMs.

That's six systems in total. You would then have room for an additional 14 systems in your account.

If you have a large deployment that requires more than 20 systems, contact your account rep or sales team.

[Learn more about NetApp accounts.](#)

Notes about charging

The following details can help you understand how charging works with capacity-based licensing.

Minimum charge

There is a 4 TiB minimum charge for each data-serving storage VM that has at least one primary (read-write) volume. If the sum of the primary volumes is less than 4 TiB, then BlueXP applies the 4 TiB minimum charge to that storage VM.

If you haven't provisioned any volumes yet, then the minimum charge doesn't apply.

The 4 TiB minimum capacity charge doesn't apply to storage VMs that contain secondary (data protection) volumes only. For example, if you have a storage VM with 1 TiB of secondary data, then you're charged just for that 1 TiB of data.

Overages

If you exceed your BYOL capacity or if your license expires, you'll be charged for overages at the hourly rate based on your marketplace subscription.

Essentials package

With the Essentials package, you're billed by the deployment type (HA or single node) and the volume type (primary or secondary). For example, *Essentials HA* has different pricing than *Essentials Secondary HA*.

If you purchased an Essentials license from NetApp (BYOL) and you exceed the licensed capacity for that deployment and volume type, the Digital Wallet charges overages against a higher priced Essentials license (if you have one). This happens because we first use the available capacity that you've already purchased as prepaid capacity before charging against the marketplace. Charging to the marketplace would add costs to your monthly bill.

Here's an example. Let's say you have the following licenses for the Essentials package:

- A 500 TiB *Essentials Secondary HA* license that has 500 TiB of committed capacity
- A 500 TiB *Essentials Single Node* license that only has 100 TiB of committed capacity

Another 50 TiB is provisioned on an HA pair with secondary volumes. Instead of charging that 50 TiB to PAYGO, the Digital Wallet charges the 50 TiB overage against the *Essentials Single Node* license. That license is priced higher than *Essentials Secondary HA*, but it's cheaper than the PAYGO rate.

In the Digital Wallet, that 50 TiB will be shown as charged against the *Essentials Single Node* license.

Storage VMs

- There are no extra licensing costs for additional data-serving storage VMs (SVMs), but there is a 4 TiB minimum capacity charge per data-serving SVM.
- Disaster recovery SVMs are charged according to the provisioned capacity.

HA pairs

For HA pairs, you're only charged for the provisioned capacity on a node. You aren't charged for data that is synchronously mirrored to the partner node.

FlexClone and FlexCache volumes

- You won't be charged for the capacity used by FlexClone volumes.
- Source and destination FlexCache volumes are considered primary data and charged according to the provisioned space.

How to get started

Learn how to get started with capacity-based licensing:

- [Set up licensing for Cloud Volumes ONTAP in Google Cloud](#)

Keystone Flex Subscription

A pay-as-you-grow subscription-based service that delivers a seamless hybrid cloud experience for those preferring OpEx consumption models to upfront CapEx or leasing.

Charging is based on the size of your committed capacity for one or more Cloud Volumes ONTAP HA pairs in your Keystone Flex Subscription.

The provisioned capacity for each volume is aggregated and compared to the committed capacity on your Keystone Flex Subscription periodically, and any overages are charged as burst on your Keystone Flex Subscription.

[Learn more about Keystone Flex Subscriptions.](#)

Supported configurations

Keystone Flex Subscriptions are supported with HA pairs. This licensing option isn't supported with single node systems at this time.

Capacity limit

Each individual Cloud Volumes ONTAP system supports up to 2 PiB of capacity through disks and tiering to object storage.

How to get started

Learn how to get started with a Keystone Flex Subscription:

- [Set up licensing for Cloud Volumes ONTAP in Google Cloud](#)

Node-based licensing

Node-based licensing is the previous generation licensing model that enabled you to license Cloud Volumes ONTAP by node. This licensing model is not available for new customers and no free trials are available. By-node charging has been replaced with the by-capacity charging methods described above.

Node-based licensing is still available for existing customers:

- If you have an active license, BYOL is available for license renewals only.
- If you have an active marketplace subscription, charging is still available through that subscription.

License conversions

Converting an existing Cloud Volumes ONTAP system to another licensing method isn't supported. The three current licensing methods are capacity-based licensing, Keystone Flex Subscriptions, and node-based licensing. For example, you can't convert a system from node-based licensing to capacity-based licensing (and vice versa).

If you want to transition to another licensing method, you can purchase a license, deploy a new Cloud Volumes ONTAP system using that license, and then replicate the data to that new system.

Note that converting a system from PAYGO by-node licensing to BYOL by-node licensing (and vice versa) isn't supported. You need to deploy a new system and then replicate data to that system. [Learn how to change between PAYGO and BYOL.](#)

Storage

Client protocols

Cloud Volumes ONTAP supports the iSCSI, NFS, SMB, NVMe-TCP, and S3 client protocols.

iSCSI

iSCSI is a block protocol that can run on standard Ethernet networks. Most client operating systems offer a software initiator that runs over a standard Ethernet port.

NFS

NFS is the traditional file access protocol for UNIX and LINUX systems. Clients can access files in ONTAP volumes using the NFSv3, NFSv4, and NFSv4.1 protocols. You can control file access using UNIX-style permissions, NTFS-style permissions, or a mix of both.

Clients can access the same files using both NFS and SMB protocols.

SMB

SMB is the traditional file access protocol for Windows systems. Clients can access files in ONTAP volumes using the SMB 2.0, SMB 2.1, SMB 3.0, and SMB 3.1.1 protocols. Just like with NFS, a mix of permission styles are supported.

S3

Cloud Volumes ONTAP supports S3 as an option for scale-out storage. S3 protocol support enables you to configure S3 client access to objects contained in a bucket in a storage VM (SVM).

[Learn how to configure and manage S3 object storage services in ONTAP.](#)

NVMe-TCP

NVMe-TCP is supported for cloud providers if you are using Cloud Volumes ONTAP version 9.12.1 or newer. BlueXP does not provide any management capabilities for NVMe-TCP.

For more information on configuring NVMe through ONTAP, see [Configure a storage VM for NVMe.](#)

Disks and aggregates

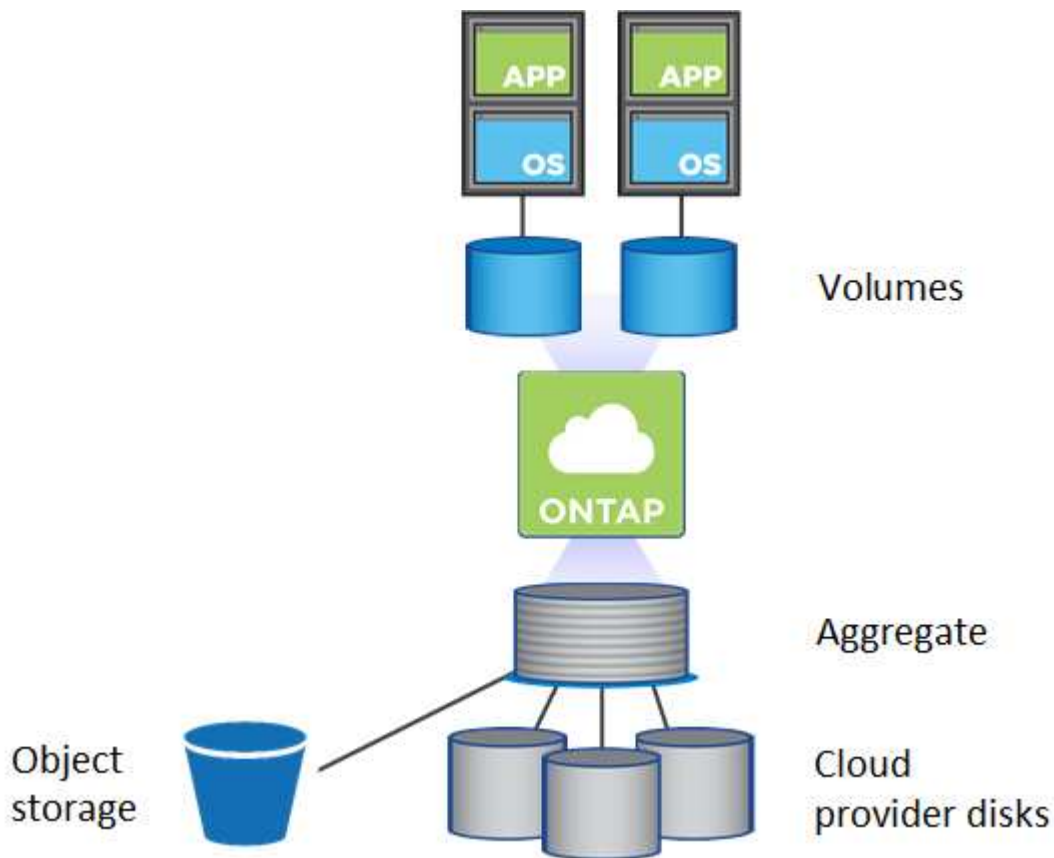
Understanding how Cloud Volumes ONTAP uses cloud storage can help you understand your storage costs.



All disks and aggregates must be created and deleted directly from BlueXP. You should not perform these actions from another management tool. Doing so can impact system stability, hamper the ability to add disks in the future, and potentially generate redundant cloud provider fees.

Overview

Cloud Volumes ONTAP uses cloud provider storage as disks and groups them into one or more aggregates. Aggregates provide storage to one or more volumes.



Several types of cloud disks are supported. You choose the disk type when you create a volume and the default disk size when you deploy Cloud Volumes ONTAP.



The total amount of storage purchased from a cloud provider is the *raw capacity*. The *usable capacity* is less because approximately 12 to 14 percent is overhead that is reserved for Cloud Volumes ONTAP use. For example, if BlueXP creates a 500 GiB aggregate, the usable capacity is 442.94 GiB.

Google Cloud storage

In Google Cloud, an aggregate can contain up to 6 disks that are all the same size. The maximum disk size is 64 TiB.

The disk type can be either *Zonal SSD persistent disks*, *Zonal Balanced persistent disks*, or *Zonal standard persistent disks*. You can pair persistent disks with a Google Storage bucket to [tier inactive data to low-cost object storage](#).

Related links

- [Google Cloud documentation: Storage Options](#)
- [Review storage limits for Cloud Volumes ONTAP in Google Cloud](#)

RAID type

The RAID type for each Cloud Volumes ONTAP aggregate is RAID0 (striping). Cloud Volumes ONTAP relies on the cloud provider for disk availability and durability. No other RAID types are supported.

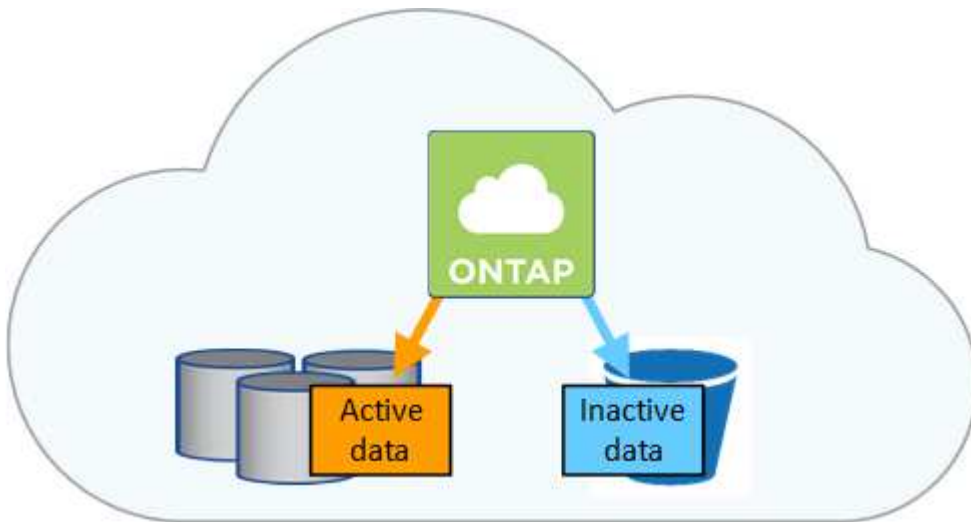
Hot spares

RAID0 doesn't support the use of hot spares for redundancy.

Creating unused disks (hot spares) attached to a Cloud Volumes ONTAP instance is an unnecessary expense and may prevent provisioning additional space as needed. Therefore, it's not recommended.

Data tiering overview

Reduce your storage costs by enabling automated tiering of inactive data to low-cost object storage. Active data remains in high-performance SSDs or HDDs, while inactive data is tiered to low-cost object storage. This enables you to reclaim space on your primary storage and shrink secondary storage.



Data tiering is powered by FabricPool technology.



You don't need to install a feature license to enable data tiering (FabricPool).

Data tiering in Google Cloud

When you enable data tiering in Google Cloud, Cloud Volumes ONTAP uses persistent disks as a performance tier for hot data and a Google Cloud Storage bucket as a capacity tier for inactive data.

Performance tier

The performance tier can be either SSD persistent disks, balanced persistent disks, or standard persistent disks.

Capacity tier

A Cloud Volumes ONTAP system tiers inactive data to a single Google Cloud Storage bucket.

BlueXP creates a bucket for each working environment and names it *fabric-pool-cluster unique identifier*. A different bucket is not created for each volume.

When BlueXP creates the bucket, it uses the following default settings:

- Location type: Region
- Storage class: Standard
- Public access: Subject to object ACLs
- Access control: Fine-grained
- Protection: None
- Data encryption: Google-managed key

Storage classes

The default storage class for tiered data is the *Standard Storage* class. If the data is infrequently accessed, you can reduce your storage costs by changing to *Nearline Storage* or *Coldline Storage*. When you change the storage class, inactive data starts in the Standard Storage class and transitions to the storage class that you selected, if the data is not accessed after 30 days.

The access costs are higher if you do access the data, so take that into consideration before you change the storage class. [Learn more about storage classes for Google Cloud Storage](#).

You can select a storage tier when you create the working environment and you can change it any time after. For details about changing the storage class, see [Tiering inactive data to low-cost object storage](#).

The storage class for data tiering is system wide—it's not per volume.

Data tiering and capacity limits

If you enable data tiering, a system's capacity limit stays the same. The limit is spread across the performance tier and the capacity tier.

Volume tiering policies

To enable data tiering, you must select a volume tiering policy when you create, modify, or replicate a volume. You can select a different policy for each volume.

Some tiering policies have an associated minimum cooling period, which sets the time that user data in a volume must remain inactive for the data to be considered "cold" and moved to the capacity tier. The cooling period starts when data is written to the aggregate.



You can change the minimum cooling period and default aggregate threshold of 50% (more on that below). [Learn how to change the cooling period](#) and [learn how to change the threshold](#).

BlueXP enables you to choose from the following volume tiering policies when you create or modify a volume:

Snapshot Only

After an aggregate has reached 50% capacity, Cloud Volumes ONTAP tiers cold user data of Snapshot copies that are not associated with the active file system to the capacity tier. The cooling period is approximately 2 days.

If read, cold data blocks on the capacity tier become hot and are moved to the performance tier.

All

All data (not including metadata) is immediately marked as cold and tiered to object storage as soon as possible. There is no need to wait 48 hours for new blocks in a volume to become cold. Note that blocks located in the volume prior to the All policy being set require 48 hours to become cold.

If read, cold data blocks on the cloud tier stay cold and are not written back to the performance tier. This policy is available starting with ONTAP 9.6.

Auto

After an aggregate has reached 50% capacity, Cloud Volumes ONTAP tiers cold data blocks in a volume to a capacity tier. The cold data includes not just Snapshot copies but also cold user data from the active file system. The cooling period is approximately 31 days.

This policy is supported starting with Cloud Volumes ONTAP 9.4.

If read by random reads, the cold data blocks in the capacity tier become hot and move to the performance tier. If read by sequential reads, such as those associated with index and antivirus scans, the cold data blocks stay cold and do not move to the performance tier.

None

Keeps data of a volume in the performance tier, preventing it from being moved to the capacity tier.

When you replicate a volume, you can choose whether to tier the data to object storage. If you do, BlueXP applies the **Backup** policy to the data protection volume. Starting with Cloud Volumes ONTAP 9.6, the **All** tiering policy replaces the backup policy.

Turning off Cloud Volumes ONTAP impacts the cooling period

Data blocks are cooled by cooling scans. During this process, blocks that haven't been used have their block temperature moved (cooled) to the next lower value. The default cooling time depends on the volume tiering policy:

- Auto: 31 days
- Snapshot Only: 2 days

Cloud Volumes ONTAP must be running for the cooling scan to work. If Cloud Volumes ONTAP is turned off, cooling will stop, as well. As a result, you can experience longer cooling times.



When Cloud Volumes ONTAP is turned off, the temperature of each block is preserved until you restart the system. For example, if the temperature of a block is 5 when you turn the system off, the temp is still 5 when you turn the system back on.

Setting up data tiering

For instructions and a list of supported configurations, see [Tiering inactive data to low-cost object storage](#).

Storage management

BlueXP (formerly Cloud Manager) provides simplified and advanced management of Cloud Volumes ONTAP storage.



All disks and aggregates must be created and deleted directly from BlueXP. You should not perform these actions from another management tool. Doing so can impact system stability, hamper the ability to add disks in the future, and potentially generate redundant cloud provider fees.

Storage provisioning

BlueXP makes storage provisioning for Cloud Volumes ONTAP easy by purchasing disks and managing aggregates for you. You simply need to create volumes. You can use an advanced allocation option to provision aggregates yourself, if desired.

Simplified provisioning

Aggregates provide cloud storage to volumes. BlueXP creates aggregates for you when you launch an instance, and when you provision additional volumes.

When you create a volume, BlueXP does one of three things:

- It places the volume on an existing aggregate that has sufficient free space.
- It places the volume on an existing aggregate by purchasing more disks for that aggregate.
- It purchases disks for a new aggregate and places the volume on that aggregate.

BlueXP determines where to place a new volume by looking at several factors: an aggregate's maximum size, whether thin provisioning is enabled, and free space thresholds for aggregates.



The Account Admin can modify free space thresholds from the **Settings** page.

Advanced allocation

Rather than let BlueXP manage aggregates for you, you can do it yourself. [From the Advanced allocation page](#), you can create new aggregates that include a specific number of disks, add disks to an existing aggregate, and create volumes in specific aggregates.

Capacity management

The Account Admin can choose whether BlueXP notifies you of storage capacity decisions or whether BlueXP automatically manages capacity requirements for you.

This behavior is determined by the *Capacity Management Mode* on a Connector. The Capacity Management Mode affects all Cloud Volumes ONTAP systems managed by that Connector. If you have another Connector, it can be configured differently.

Automatic capacity management

The Capacity Management Mode is set to automatic by default. In this mode, BlueXP automatically purchases new disks for Cloud Volumes ONTAP instances when more capacity is needed, deletes unused collections of disks (aggregates), moves volumes between aggregates when needed, and attempts to unfail disks.

The following examples illustrate how this mode works:

- If an aggregate reaches the capacity threshold and it has room for more disks, BlueXP automatically purchases new disks for that aggregate so volumes can continue to grow.

BlueXP checks the free space ratio every 15 minutes to determine if it needs to purchase additional disks.

- If an aggregate reaches the capacity threshold and it can't support any additional disks, BlueXP automatically moves a volume from that aggregate to an aggregate with available capacity or to a new aggregate.

If BlueXP creates a new aggregate for the volume, it chooses a disk size that accommodates the size of that volume.

Note that free space is now available on the original aggregate. Existing volumes or new volumes can use that space. The space can't be returned to the cloud provider in this scenario.

- If an aggregate contains no volumes for more than 12 hours, BlueXP deletes it.

Management of LUNs with automatic capacity management

BlueXP's automatic capacity management doesn't apply to LUNs. When BlueXP creates a LUN, it disables the autogrow feature.

Manual capacity management

If the Account Admin set the Capacity Management Mode to manual, BlueXP displays Action Required messages when capacity decisions must be made. The same examples described in the automatic mode apply to the manual mode, but it is up to you to accept the actions.

Learn more

[Learn how to modify the capacity management mode.](#)

Write speed

BlueXP enables you to choose normal or high write speed for most Cloud Volumes ONTAP configurations. Before you choose a write speed, you should understand the differences between the normal and high settings and risks and recommendations when using high write speed.

Normal write speed

When you choose normal write speed, data is written directly to disk. When data is written directly to disk, reduces the likelihood of data loss in the event of an unplanned system outage, or a cascading failure involving an unplanned system outage (HA pairs only).

Normal write speed is the default option.

High write speed

When you choose high write speed, data is buffered in memory before it is written to disk, which provides faster write performance. Due to this caching, there is the potential for data loss if an unplanned system outage occurs.

The amount of data that can be lost in the event of an unplanned system outage is the span of the last two consistency points. A consistency point is the act of writing buffered data to disk. A consistency point occurs when the write log is full or after 10 seconds (whichever comes first). However, the performance of the storage provided by your cloud provider can affect consistency point processing time.

When to use high write speed

High write speed is a good choice if fast write performance is required for your workload and you can withstand the risk of data loss in the event of an unplanned system outage, or a cascading failure involving an unplanned system outage (HA pairs only).

Recommendations when using high write speed

If you enable high write speed, you should ensure write protection at the application layer, or that the applications can tolerate data loss, if it occurs.

Configurations that support high write speed

Not all Cloud Volumes ONTAP configurations support high write speed. Those configurations use normal write speed by default.

Google Cloud

If you use a single node system, Cloud Volumes ONTAP supports high write speed with all machine types.

Cloud Volumes ONTAP doesn't support high write speed with HA pairs in Google Cloud.

[Learn more about the Google Cloud machine types that Cloud Volumes ONTAP supports.](#)

How to select a write speed

You can choose a write speed when you create a new working environment and you can [change the write speed for an existing system](#).

What to expect if data loss occurs

If data loss occurs due to high write speed, the Event Management System (EMS) reports the following two events:

- Cloud Volumes ONTAP 9.12.1 or later

```
NOTICE nv.data.loss.possible: An unexpected shutdown occurred while in high write speed mode, which possibly caused a loss of data.
```

- Cloud Volumes ONTAP 9.11.0 to 9.11.1

```
DEBUG nv.check.failed: NVRAM check failed with error "NVRAM disabled due to dirty shutdown with High Write Speed mode"
```



```
ERROR wafl.root.content.changed: Contents of the root volume '' might have changed. Verify that all recent configuration changes are still in effect..
```

- Cloud Volumes ONTAP 9.8 to 9.10.1

```
DEBUG nv.check.failed: NVRAM check failed with error "NVRAM disabled due to dirty shutdown"
```

```
ERROR wafl.root.content.changed: Contents of the root volume '' might have changed. Verify that all recent configuration changes are still in effect..
```

When this happens, Cloud Volumes ONTAP should be able to boot up and continue to serve data without user intervention.

How to stop data access if data loss occurs

If you are concerned about data loss, want the applications to stop running upon data loss, and the data access to be resumed after the data loss issue is properly addressed, you can use the NVFAIL option from the CLI to achieve that goal.

To enable the NVFAIL option

```
vol modify -volume <vol-name> -nvfail on
```

To check NVFAIL settings

```
vol show -volume <vol-name> -fields nvfail
```

To disable the NVFAIL option

```
vol modify -volume <vol-name> -nvfail off
```

When data loss occurs, an NFS or iSCSI volume with NVFAIL enabled should stop serving data (there's no impact to CIFS which is a stateless protocol). For more details, refer to [How NVFAIL impacts access to NFS volumes or LUNs](#).

To check the NVFAIL state

```
vol show -fields in-nvfailed-state
```

After the data loss issue is properly addressed, you can clear the NVFAIL state and the volume will be available for data access.

To clear the NVFAIL state

```
vol modify -volume <vol-name> -in-nvfailed-state false
```

Flash Cache

Some Cloud Volumes ONTAP configurations include local NVMe storage, which Cloud Volumes ONTAP uses as *Flash Cache* for better performance.

What's Flash Cache?

Flash Cache speeds access to data through real-time intelligent caching of recently read user data and NetApp metadata. It's effective for random read-intensive workloads, including databases, email, and file services.

Supported configurations

Flash Cache is supported with specific Cloud Volumes ONTAP configurations. View supported configurations in the [Cloud Volumes ONTAP Release Notes](#)

Limitations

- Compression must be disabled on all volumes to take advantage of the Flash Cache performance improvements.

Choose no storage efficiency when creating a volume from BlueXP, or create a volume and then [disable data compression by using the CLI](#).

- Cache rewarming after a reboot is not supported with Cloud Volumes ONTAP.

WORM storage

You can activate write once, read many (WORM) storage on a Cloud Volumes ONTAP system to retain files in unmodified form for a specified retention period. Cloud WORM storage is powered by SnapLock technology, which means WORM files are protected at the file level.

How WORM storage works

Once a file has been committed to WORM storage, it can't be modified, even after the retention period has expired. A tamper-proof clock determines when the retention period for a WORM file has elapsed.

After the retention period has elapsed, you are responsible for deleting any files that you no longer need.

Activating WORM storage

How you activate WORM storage depends on the Cloud Volumes ONTAP version that you're using.

Version 9.10.1 and later

Starting with Cloud Volumes ONTAP 9.10.1, you have the option to enable or disable WORM at the volume level. How you choose to enable WORM depends on your needs.

When you create a new Cloud Volumes ONTAP working environment, you're prompted to enable or disable WORM storage:

- If you enable WORM storage when creating a working environment, every volume that you create from BlueXP has WORM enabled. But you can use System Manager or the CLI to create volumes that have

WORM disabled.

This option is a good choice if you want to create a dedicated system for WORM storage.

- If you disable WORM storage when creating a working environment, every volume that you create from BlueXP has WORM disabled. But you can use System Manager or the CLI to create volumes with WORM enabled.

This option is a good choice if you want to mix different types of volumes on the same system.

With either option, you should [understand how charging works](#).

Version 9.10.0 and earlier

You can activate WORM storage on a Cloud Volumes ONTAP system when you create a new working environment. You can't activate WORM storage on individual volumes—WORM must be activated at the system level. It can be activated only when you create the working environment.

Charging

Charging for WORM storage is hourly, according to the total provisioned capacity of WORM volumes.

You should understand the following charging behavior with Cloud Volumes ONTAP 9.10.1 and later:

- Beginning with ONTAP 9.10.1, WORM volumes and non-WORM volumes can exist on the same aggregate.
- If you enable WORM when you create a Cloud Volumes ONTAP working environment, every volume that you create from BlueXP has WORM enabled. However, you can use the ONTAP CLI or System Manager to create volumes that have WORM disabled. Those volumes are not charged at the WORM rate.
- If you don't enable WORM when you create a working environment, every volume that you create from BlueXP has WORM disabled. You are not charged at the WORM rate for those volumes. However, you can use the ONTAP CLI or System Manager to create WORM-enabled volumes. Those volumes will be charged at the WORM rate.

[Learn about pricing for WORM storage](#)

Committing files to WORM

You can use an application to commit files to WORM over NFS or CIFS, or use the ONTAP CLI to autocommit files to WORM automatically. You can also use a WORM appendable file to retain data that is written incrementally, like log information.

After you activate WORM storage on a Cloud Volumes ONTAP system, you must use the ONTAP CLI for all management of WORM storage. For instructions, refer to [ONTAP documentation](#).

WORM and data tiering

When you create a new Cloud Volumes ONTAP 9.8 system or later, you can enable both data tiering and WORM storage together. Enabling data tiering with WORM storage allows you to tier the data to an object store in the cloud.

You should understand the following about enabling both data tiering and WORM storage:

- Data that is tiered to object storage doesn't include the ONTAP WORM functionality. To ensure end-to-end

WORM capability, you'll need to set up the bucket permissions correctly.

- The data that is tiered to object storage doesn't carry the WORM functionality, which means technically anyone with full access to buckets and containers can go and delete the objects tiered by ONTAP.
- Reverting or downgrading to Cloud Volumes ONTAP 9.8 is blocked after enabling WORM and tiering.

Limitations

- WORM storage in Cloud Volumes ONTAP operates under a "trusted storage administrator" model. While WORM files are protected from alteration or modification, volumes can be deleted by a cluster administrator even if those volumes contain unexpired WORM data.
- In addition to the trusted storage administrator model, WORM storage in Cloud Volumes ONTAP also implicitly operates under a "trusted cloud administrator" model. A cloud administrator could delete WORM data before its expiry date by removing or editing cloud storage directly from the cloud provider.

High-availability pairs

High-availability pairs in Google Cloud

A Cloud Volumes ONTAP high availability (HA) configuration provides nondisruptive operations and fault tolerance. In Google Cloud, data is synchronously mirrored between the two nodes.

HA components

Cloud Volumes ONTAP HA configurations in Google Cloud include the following components:

- Two Cloud Volumes ONTAP nodes whose data is synchronously mirrored between each other.
- A mediator instance that provides a communication channel between the nodes to assist in storage takeover and giveback processes.
- One zone or three zones (recommended).

If you choose three zones, the two nodes and mediator are in separate Google Cloud zones.

- Four Virtual Private Clouds (VPCs).

The configuration uses four VPCs because GCP requires that each network interface resides in a separate VPC network.

- Four Google Cloud internal load balancers (TCP/UDP) that manage incoming traffic to the Cloud Volumes ONTAP HA pair.

[Learn about networking requirements](#), including more details about load balancers, VPCs, internal IP addresses, subnets, and more.

The following conceptual image shows a Cloud Volumes ONTAP HA pair and its components:



Mediator

Here are some key details about the mediator instance in Google Cloud:

Instance type

e2-micro (an f1-micro instance was previously used)

Disks

Two standard persistent disks that are 10 GiB each

Operating system

Debian 11



For Cloud Volumes ONTAP 9.10.0 and earlier, Debian 10 was installed on the mediator.

Upgrades

When you upgrade Cloud Volumes ONTAP, BlueXP also updates the mediator instance as needed.

Access to the instance

For Debian, the default cloud user is `admin`. Google Cloud creates and adds a certificate for the `admin` user when SSH access is requested through the Google Cloud console or `gcloud` command line. You can specify `sudo` to gain root privileges.

Third-party agents

Third-party agents or VM extensions are not supported on the mediator instance.

Storage takeover and giveback

If a node goes down, the other node can serve data for its partner to provide continued data service. Clients can access the same data from the partner node because the data was synchronously mirrored to the partner.

After the node reboots, the partner must resync data before it can return the storage. The time that it takes to resync data depends on how much data was changed while the node was down.

Storage takeover, resync, and giveback are all automatic by default. No user action is required.

RPO and RTO

An HA configuration maintains high availability of your data as follows:

- The recovery point objective (RPO) is 0 seconds.

Your data is transactionally consistent with no data loss.

- The recovery time objective (RTO) is 60 seconds.

In the event of an outage, data should be available in 60 seconds or less.

HA deployment models

You can ensure the high availability of your data by deploying an HA configuration in multiple zones or in a single zone.

Multiple zones (recommended)

Deploying an HA configuration across three zones ensures continuous data availability if a failure occurs within a zone. Note that write performance is slightly lower compared to using a single zone, but it's minimal.

Single zone

When deployed in a single zone, a Cloud Volumes ONTAP HA configuration uses a spread placement policy. This policy ensures that an HA configuration is protected from a single point of failure within the zone, without having to use separate zones to achieve fault isolation.

This deployment model does lower your costs because there are no data egress charges between zones.

How storage works in an HA pair

Unlike an ONTAP cluster, storage in a Cloud Volumes ONTAP HA pair in GCP is not shared between nodes. Instead, data is synchronously mirrored between the nodes so that the data is available in the event of failure.

Storage allocation

When you create a new volume and additional disks are required, BlueXP allocates the same number of disks to both nodes, creates a mirrored aggregate, and then creates the new volume. For example, if two disks are required for the volume, BlueXP allocates two disks per node for a total of four disks.

Storage configurations

You can use an HA pair as an active-active configuration, in which both nodes serve data to clients, or as an active-passive configuration, in which the passive node responds to data requests only if it has taken over storage for the active node.

Performance expectations for an HA configuration

A Cloud Volumes ONTAP HA configuration synchronously replicates data between nodes, which consumes network bandwidth. As a result, you can expect the following performance in comparison to a single-node Cloud Volumes ONTAP configuration:

- For HA configurations that serve data from only one node, read performance is comparable to the read performance of a single-node configuration, whereas write performance is lower.
- For HA configurations that serve data from both nodes, read performance is higher than the read performance of a single-node configuration, and write performance is the same or higher.

For more details about Cloud Volumes ONTAP performance, see [Performance](#).

Client access to storage

Clients should access NFS and CIFS volumes by using the data IP address of the node on which the volume resides. If NAS clients access a volume by using the IP address of the partner node, traffic goes between both nodes, which reduces performance.



If you move a volume between nodes in an HA pair, you should remount the volume by using the IP address of the other node. Otherwise, you can experience reduced performance. If clients support NFSv4 referrals or folder redirection for CIFS, you can enable those features on the Cloud Volumes ONTAP systems to avoid remounting the volume. For details, see ONTAP documentation.

You can easily identify the correct IP address from BlueXP:

Volumes

2 Volumes | 0.22 TB Allocated | < 0.01 TB Used (0 TB in S3)



Related links

- [Learn about networking requirements](#)
- [Learn how to get started in GCP](#)

Actions unavailable during takeover

When a node in an HA pair isn't available, the other node serves data for its partner to provide continued data service. This is called *storage takeover*. Several actions are unavailable until in storage giveback is complete.



When a node in an HA pair is unavailable, the state of the working environment in BlueXP is *Degraded*.

The following actions are unavailable from BlueXP storage takeover:

- Support registration
- License changes
- Instance or VM type changes
- Write speed changes
- CIFS setup
- Changing the location of configuration backups
- Setting the cluster password
- Managing disks and aggregates (advanced allocation)

These actions are available again after storage giveback completes and the state of the working environment changes back to normal.

Security

Cloud Volumes ONTAP supports data encryption and provides protection against viruses and ransomware.

Encryption of data at rest

Cloud Volumes ONTAP supports the following encryption technologies:

- NetApp encryption solutions (NVE and NAE)
- Google Cloud Platform default encryption

You can use NetApp encryption solutions with native encryption from your cloud provider, which encrypts data at the hypervisor level. Doing so would provide double encryption, which might be desired for very sensitive data. When the encrypted data is accessed, it's unencrypted twice—once at the hypervisor-level (using keys from the cloud provider) and then again using NetApp encryption solutions (using keys from an external key manager).

NetApp encryption solutions (NVE and NAE)

Cloud Volumes ONTAP supports [NetApp Volume Encryption \(NVE\)](#) and [NetApp Aggregate Encryption \(NAE\)](#). NVE and NAE are software-based solutions that enable (FIPS) 140-2-compliant data-at-rest encryption of volumes. Both NVE and NAE use AES 256-bit encryption.

- NVE encrypts data at rest one volume at a time. Each data volume has its own unique encryption key.
- NAE is an extension of NVE—it encrypts data for each volume, and the volumes share a key across the aggregate. NAE also allows common blocks across all volumes in the aggregate to be deduplicated.

Both NVE and NAE are supported with an external key manager.

If you use NVE, you have the option to use your cloud provider's key vault to protect ONTAP encryption keys:

- Google Cloud Key Management Service

New aggregates have NetApp Aggregate Encryption (NAE) enabled by default after you set up an external key manager. New volumes that aren't part of an NAE aggregate will have NetApp Volume Encryption (NVE) enabled by default (for example, if you have existing aggregates that were created before setting up an external key manager).

Setting up a supported key manager is the only required step. For set up instructions, refer to [Encrypting volumes with NetApp encryption solutions](#).

Google Cloud Platform default encryption

[Google Cloud Platform data-at-rest encryption](#) is enabled by default for Cloud Volumes ONTAP. No setup is required.

While Google Cloud Storage always encrypts your data before it's written to disk, you can use BlueXP APIs to create a Cloud Volumes ONTAP system that uses *customer-managed encryption keys*. These are keys that you generate and manage in GCP using the Cloud Key Management Service. [Learn more](#).

ONTAP virus scanning

You can use integrated antivirus functionality on ONTAP systems to protect data from being compromised by viruses or other malicious code.

ONTAP virus scanning, called *Vscan*, combines best-in-class third-party antivirus software with ONTAP features that give you the flexibility you need to control which files get scanned and when.

For information about the vendors, software, and versions supported by Vscan, see the [NetApp Interoperability Matrix](#).

For information about how to configure and manage the antivirus functionality on ONTAP systems, see the [ONTAP 9 Antivirus Configuration Guide](#).

Ransomware protection

Ransomware attacks can cost a business time, resources, and reputation. BlueXP enables you to implement the NetApp solution for ransomware, which provides effective tools for visibility, detection, and remediation.

- BlueXP identifies volumes that are not protected by a Snapshot policy and enables you to activate the default Snapshot policy on those volumes.

Snapshot copies are read-only, which prevents ransomware corruption. They can also provide the granularity to create images of a single file copy or a complete disaster recovery solution.

- BlueXP also enables you to block common ransomware file extensions by enabling ONTAP's FPolicy solution.

Ransomware Protection

Ransomware attacks can cost a business time, resources, and reputation. The NetApp solution for ransomware provides effective tools for visibility, detection, and remediation. [Learn More](#)

1 Enable Snapshot Copy Protection ⓘ



50 %
Protection

1 Volumes without a Snapshot Policy

To protect your data, activate the default Snapshot policy for these volumes ⓘ

Activate Snapshot Policy

2 Block Ransomware File Extensions ⓘ



ONTAP's native FPolicy configuration monitors and blocks file operations based on a file's extension.

View Denied File Names ⓘ

Activate FPolicy

[Learn how to implement the NetApp solution for ransomware.](#)

Performance

You can review performance results to help you decide which workloads are appropriate for Cloud Volumes ONTAP.

Performance technical reports

- Cloud Volumes ONTAP for Google Cloud

[NetApp Technical Report 4816: Performance Characterization of Cloud Volumes ONTAP for Google Cloud](#)

CPU performance

Cloud Volumes ONTAP nodes show as highly utilized (over 90%) from your cloud provider's monitoring tools. This is because ONTAP reserves all vCPUs presented to the virtual machine so that they are available when needed.

For help, see the [NetApp knowledgebase article about how to monitor ONTAP CPU utilization using the CLI](#)

License management for node-based BYOL

Each Cloud Volumes ONTAP system that has a node-based BYOL must have a system license installed with an active subscription. BlueXP simplifies the process by managing licenses for you and by displaying a warning before they expire.



A node-based license is the previous generation BYOL for Cloud Volumes ONTAP. A node-based license is available for license renewals only.

[Learn more about Cloud Volumes ONTAP licensing options.](#)

BYOL system licenses

A node-based license provides up to 368 TiB of capacity for a single node or HA pair.

You can purchase multiple licenses for a Cloud Volumes ONTAP BYOL system to allocate more than 368 TiB of capacity. For example, you might purchase two licenses to allocate up to 736 TiB of capacity to Cloud Volumes ONTAP. Or you could purchase four licenses to get up to 1.4 PiB.

The number of licenses that you can purchase for a single node system or HA pair is unlimited.



Some on-premises ONTAP storage systems that you purchased may have included a free Cloud Volumes ONTAP license. You can use the license to create a new Cloud Volumes ONTAP system, or you can apply the license to an existing Cloud Volumes ONTAP system to expand the capacity. [See if you have any available licenses to use.](#)

Be aware that disk limits can prevent you from reaching the capacity limit by using disks alone. You can go beyond the disk limit by [tiering inactive data to object storage](#). For information about disk limits, refer to [storage limits in the Cloud Volumes ONTAP Release Notes](#).

License management for a new system

When you create a node-based BYOL system, BlueXP prompts you for the serial number of your license and your NetApp Support Site account. BlueXP uses the account to download the license file from NetApp and to install it on the Cloud Volumes ONTAP system.

[Learn how to add NetApp Support Site accounts to BlueXP.](#)

If BlueXP can't access the license file over the secure internet connection, you can [obtain the file yourself and then manually upload the file to BlueXP](#).

License expiration

BlueXP displays a warning 30 days before a node-based license is due to expire and again when the license expires. The following image shows a 30-day expiration warning that appears in the user interface:



You can select the working environment to review the message.

BlueXP includes a license expiration warning in the Cloud Volumes ONTAP report that's emailed to you, if you are an Account Admin and you enabled the option:



The emailed report includes the license expiration warning every 2 weeks.

If you don't renew the license in time, the Cloud Volumes ONTAP system shuts itself down. If you restart it, it shuts itself down again.

License renewal

When you renew a node-based BYOL subscription by contacting a NetApp representative, BlueXP automatically obtains the new license from NetApp and installs it on the Cloud Volumes ONTAP system.

If BlueXP can't access the license file over the secure internet connection, you can [obtain the file yourself and then manually upload the file to BlueXP](#).

License transfer to a new system

A node-based BYOL license is transferable between Cloud Volumes ONTAP systems when you delete an existing system and then create a new one using the same license.

For example, you might want to delete an existing licensed system and then use the license with a new BYOL system in a different VPC/VNet or cloud provider. Note that only *cloud-agnostic* serial numbers work in any cloud provider. Cloud-agnostic serial numbers start with the *908xxxx* prefix.

It's important to note that your BYOL license is tied to your company and a specific set of NetApp Support Site credentials.

AutoSupport and Active IQ Digital Advisor

The AutoSupport component of ONTAP collects telemetry and sends it for analysis. Active IQ Digital Advisor analyzes the data from AutoSupport and provides proactive care and optimization. Using artificial intelligence, Active IQ can identify potential problems and help you resolve them before they impact your business.

Active IQ enables you to optimize your data infrastructure across your global hybrid cloud by delivering actionable predictive analytics and proactive support through a cloud-based portal and mobile app. Data-driven insights and recommendations from Active IQ are available to all NetApp customers with an active SupportEdge contract (features vary by product and support tier).

Here are some things you can do with Active IQ:

- Plan upgrades.

Active IQ identifies issues in your environment that can be resolved by upgrading to a newer version of ONTAP and the Upgrade Advisor component helps you plan for a successful upgrade.

- View system wellness.

Your Active IQ dashboard reports any issues with wellness and helps you correct those issues. Monitor system capacity to make sure you never run out of storage space. View support cases for your system.

- Manage performance.

Active IQ shows system performance over a longer period than you can see in ONTAP System Manager. Identify configuration and system issues that are impacting your performance. Maximize efficiency. View storage efficiency metrics and identify ways to store more data in less space.

- View inventory and configuration.

Active IQ displays complete inventory and software and hardware configuration information. See when service contracts are expiring and renew them to ensure you remain supported.

Related information

- [NetApp Documentation: Active IQ Digital Advisor](#)
- [Launch Active IQ](#)
- [SupportEdge Services](#)

Default configuration for Cloud Volumes ONTAP

Understanding how Cloud Volumes ONTAP is configured by default can help you set up and administer your systems, especially if you are familiar with ONTAP because the

default setup for Cloud Volumes ONTAP is different than ONTAP.

Default setup

- BlueXP creates one data-serving storage VM when it deploys Cloud Volumes ONTAP. Some configurations support additional storage VMs. [Learn more about managing storage VMs.](#)

Starting with the BlueXP 3.9.5 release, logical space reporting is enabled on the initial storage VM. When space is reported logically, ONTAP reports the volume space such that all the physical space saved by the storage efficiency features are also reported as used.

- BlueXP automatically installs the following ONTAP feature licenses on Cloud Volumes ONTAP:

- CIFS
- FlexCache
- FlexClone
- iSCSI
- NetApp Volume Encryption (only for BYOL or registered PAYGO systems)
- NFS
- SnapMirror
- SnapRestore
- SnapVault

- Several network interfaces are created by default:

- A cluster management LIF
- An intercluster LIF
- An SVM management LIF on HA systems in Google Cloud
- A node management LIF

In Google Cloud, this LIF is combined with the intercluster LIF.

- An iSCSI data LIF
- A CIFS and NFS data LIF



LIF failover is disabled by default for Cloud Volumes ONTAP due to cloud provider requirements. Migrating a LIF to a different port breaks the external mapping between IP addresses and network interfaces on the instance, making the LIF inaccessible.

- Cloud Volumes ONTAP sends configuration backups to the Connector using HTTPS.

The backups are accessible from <https://ipaddress/occm/offboxconfig/> where *ipaddress* is the IP address of the Connector host.

- BlueXP sets a few volume attributes differently than other management tools (System Manager or the CLI, for example).

The following table lists the volume attributes that BlueXP sets differently from the defaults:

Attribute	Value set by BlueXP
Autosize mode	grow
Maximum autosize	1,000 percent <div>  The Account Admin can modify this value from the Settings page. </div>
Security style	NTFS for CIFS volumes UNIX for NFS volumes
Space guarantee style	none
UNIX permissions (NFS only)	777

See the [ONTAP *volume create* man page](#) for information about these attributes.

Internal disks for system data

In addition to the storage for user data, BlueXP also purchases cloud storage for system data.

Google Cloud (single node)

- One 10 GiB SSD persistent disk for boot data
- One 64 GiB SSD persistent disk for root data
- One 500 GiB SSD persistent disk for NVRAM
- One 315 GiB Standard persistent disk for saving cores
- Snapshots for boot and root data
- Boot and root disks are encrypted by default.

Google Cloud (HA pair)

- Two 10 GiB SSD persistent disks for boot data
- Four 64 GiB SSD persistent disk for root data
- Two 500 GiB SSD persistent disk for NVRAM
- Two 315 GiB Standard persistent disk for saving cores
- One 10 GiB Standard persistent disk for mediator data
- One 10 GiB Standard persistent disk for mediator boot data
- Snapshots for boot and root data
- Boot and root disks are encrypted by default.

Where the disks reside

BlueXP lays out the storage as follows:

- Boot data resides on a disk attached to the instance or virtual machine.

This disk, which contains the boot image, is not available to Cloud Volumes ONTAP.

- Root data, which contains the system configuration and logs, resides in aggr0.
- The storage virtual machine (SVM) root volume resides in aggr1.
- Data volumes also reside in aggr1.

Copyright information

Copyright © 2023 NetApp, Inc. All Rights Reserved. Printed in the U.S. No part of this document covered by copyright may be reproduced in any form or by any means—graphic, electronic, or mechanical, including photocopying, recording, taping, or storage in an electronic retrieval system—without prior written permission of the copyright owner.

Software derived from copyrighted NetApp material is subject to the following license and disclaimer:

THIS SOFTWARE IS PROVIDED BY NETAPP “AS IS” AND WITHOUT ANY EXPRESS OR IMPLIED WARRANTIES, INCLUDING, BUT NOT LIMITED TO, THE IMPLIED WARRANTIES OF MERCHANTABILITY AND FITNESS FOR A PARTICULAR PURPOSE, WHICH ARE HEREBY DISCLAIMED. IN NO EVENT SHALL NETAPP BE LIABLE FOR ANY DIRECT, INDIRECT, INCIDENTAL, SPECIAL, EXEMPLARY, OR CONSEQUENTIAL DAMAGES (INCLUDING, BUT NOT LIMITED TO, PROCUREMENT OF SUBSTITUTE GOODS OR SERVICES; LOSS OF USE, DATA, OR PROFITS; OR BUSINESS INTERRUPTION) HOWEVER CAUSED AND ON ANY THEORY OF LIABILITY, WHETHER IN CONTRACT, STRICT LIABILITY, OR TORT (INCLUDING NEGLIGENCE OR OTHERWISE) ARISING IN ANY WAY OUT OF THE USE OF THIS SOFTWARE, EVEN IF ADVISED OF THE POSSIBILITY OF SUCH DAMAGE.

NetApp reserves the right to change any products described herein at any time, and without notice. NetApp assumes no responsibility or liability arising from the use of products described herein, except as expressly agreed to in writing by NetApp. The use or purchase of this product does not convey a license under any patent rights, trademark rights, or any other intellectual property rights of NetApp.

The product described in this manual may be protected by one or more U.S. patents, foreign patents, or pending applications.

LIMITED RIGHTS LEGEND: Use, duplication, or disclosure by the government is subject to restrictions as set forth in subparagraph (b)(3) of the Rights in Technical Data -Noncommercial Items at DFARS 252.227-7013 (FEB 2014) and FAR 52.227-19 (DEC 2007).

Data contained herein pertains to a commercial product and/or commercial service (as defined in FAR 2.101) and is proprietary to NetApp, Inc. All NetApp technical data and computer software provided under this Agreement is commercial in nature and developed solely at private expense. The U.S. Government has a non-exclusive, non-transferrable, nonsublicensable, worldwide, limited irrevocable license to use the Data only in connection with and in support of the U.S. Government contract under which the Data was delivered. Except as provided herein, the Data may not be used, disclosed, reproduced, modified, performed, or displayed without the prior written approval of NetApp, Inc. United States Government license rights for the Department of Defense are limited to those rights identified in DFARS clause 252.227-7015(b) (FEB 2014).

Trademark information

NETAPP, the NETAPP logo, and the marks listed at <http://www.netapp.com/TM> are trademarks of NetApp, Inc. Other company and product names may be trademarks of their respective owners.