Introduction to APEX File Storage for AWS

Architecture and Performance Guidelines

May 2023

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White Paper

Abstract

This white paper provides an introduction to APEX File Storage for AWS, including architecture, supported cluster configurations, and performance considerations.

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Executive summary

Overview

In this white paper, we present an architecture overview of APEX File Storage for AWS and delve into the performance considerations of clusters, including cluster size, EC2 instance type, and EBS volume type. The paper also showcases the results of performance tests[1] conducted on various example cluster configurations. For detailed OneFS information, see the APEX File Storage for AWS Getting Started Guide available on the Dell Support website.

Revisions

Date	Part number/ revision	Description
May 2023	H19642	Initial release

We value your feedback

Dell Technologies and the authors of this document welcome your feedback on this document. Contact the Dell Technologies team by email.

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Note: For links to other documentation for this topic, see the PowerScale Info Hub.

[1] Benchmark results depend on workload, specific application requirements, and system design and implementation. Relative system performance varies based on these and other factors. The benchmarking results should not be used as a substitute for a specific customer application benchmark when critical capacity planning or product evaluation decisions are made. All performance data contained in this report was obtained in a rigorously controlled environment. Results obtained in other operating environments may vary significantly. Dell Technologies does not warrant or represent that a user can or will achieve similar performance results.

Benefits of running OneFS in the cloud

Dell PowerScale OneFS is a highly scalable and flexible file system designed to meet the demanding storage needs of data-intensive workloads. It serves as the underlying software platform that powers Dell PowerScale appliance nodes, enabling them to function as a unified distributed file system. APEX File Storage for AWS introduces the OneFS distributed file system software into the public cloud, enabling users to enjoy the same management experience in the cloud as with their on-premises PowerScale appliance.

By leveraging APEX File Storage for AWS, you can effortlessly deploy and manage file storage on AWS without the need for hardware administration. This service provides a flexible and elastic storage infrastructure that can expand or shrink according to your business requirements.

Key features and benefits of APEX File Storage for AWS include:

- **Simplified journey to hybrid cloud:** With the increasing adoption of hybrid cloud environments, organizations often face the challenge of seamlessly moving data between on-premises and cloud-based environments. APEX File Storage for AWS simplifies this transition by enabling effortless data mobility through native replication and provides a consistent data management platform across both environments. Once in the cloud, you can take advantage of the enterprise-class features of OneFS, including multiprotocol support, CloudPools, Data Reduction, Snapshots, to run your workloads in a manner consistent with your on-premises operations. APEX File Storage for AWS can use CloudPools to tier cold or infrequently accessed data to cost-effective cloud storage services such as AWS S3 object storage. CloudPools extends OneFS namespace to the private/public cloud and allows you to store much more data than the usable cluster capacity.
- **Scalability:** Because the APEX File Storage for AWS leverages the OneFS distributed file system, you have the flexibility to begin with a compact OneFS cluster and gradually expand it as your data storage needs increase. The capacity can be dynamically scaled up to a maximum cluster capacity of 1 PiB. This allows you to scale your storage infrastructure as needed, avoiding excessive provisioning and reducing upfront capital expenses.
- **Data management:** APEX File Storage for AWS offers powerful data management capabilities, including snapshot, data replication, and backup and restore. These features enable you to protect critical data, ensure high availability, and streamline data management. The uniformity of OneFS features across both cloud and on-premises environments allows organizations to simplify operations, reduce the complexity of management, and maintain a consistent user experience.
- **High performance:** APEX File Storage for AWS offers exceptional file storage performance with low-latency access to data, ensuring that you can access data quickly and efficiently.

APEX File Storage for AWS architecture and use cases

Architecture

APEX File Storage for AWS is a software-defined cloud file storage service that combines the power of OneFS distributed file system with the flexibility and scalability of cloud infrastructure. It is a fully customer-managed service that is designed to meet the needs of enterprise-scale file workloads running on AWS. The architecture of APEX File Storage for AWS is built on the OneFS distributed file system. This architecture uses multiple cluster nodes to establish a single global namespace. Each cluster node operates as an instance of the OneFS software, running on an AWS EC2 instance to deliver storage capacity and compute resources. It is worth noting that the network bandwidth limit at the EC2 instance level is shared between the cluster internal network and the external network.

APEX File Storage for AWS uses cloud-native technologies and leverages the elasticity of cloud infrastructure, so that you can easily scale the storage infrastructure as your business requirements grow. It can dynamically scale storage capacity and performance to meet changing demands by adding additional cluster nodes without disruption, enabling the storage infrastructure to scale in a more cost-effective and efficient manner. To guarantee the durability and resiliency of data, APEX File Storage for AWS distributes data across multiple nodes within the cluster. It also uses advanced data protection techniques such as erasure coding and provides features such as SyncIQ to ensure that data is available. Even in the event of one or more node failures, the data remains accessible from the remaining cluster nodes.

Figure 1 shows the technical architecture of APEX File Storage for AWS.

- **Availability zone:** APEX File Storage for AWS is designed to run in a single AWS availability zone to get the best performance.
- **Virtual Private Cloud (VPC):** APEX File Storage for AWS requires an AWS VPC to provide network connectivity.
- **OneFS cluster internal subnet:** The cluster nodes communicate with each other through the internal subnet. The internal subnet must be isolated from instances that are not in the cluster. Therefore, a dedicated subnet is required for the internal network interfaces of cluster nodes that do not share the internal subnets with other EC2 instances.
- **OneFS cluster external subnet:** The cluster nodes communicate with clients through the external subnet by using different protocols, such as NFS, SMB, and S3.
- **OneFS cluster internal network interfaces:** Network interfaces are in the internal subnet.
- **OneFS cluster external network interfaces:** Network interfaces are in the external subnet.
- **OneFS cluster internal security group:** The internal security group applies to the cluster internal network interfaces, which allows all traffic only between the cluster nodes' internal network interfaces.
- **OneFS cluster external security group:** The external security group applies to the cluster external network interfaces, which allows specific ingress traffic from clients.

- **Elastic Compute Cloud (EC2) instance nodes:** The EC2 instance nodes are cluster nodes that run the OneFS file system backed by Elastic Block Store (EBS) volumes and provide network bandwidth. All nodes in a cluster are placed in a spread strategy placement group, so that all nodes are placed on distinct hardware to ensure high availability. See the AWS Placement groups documentation for more details.

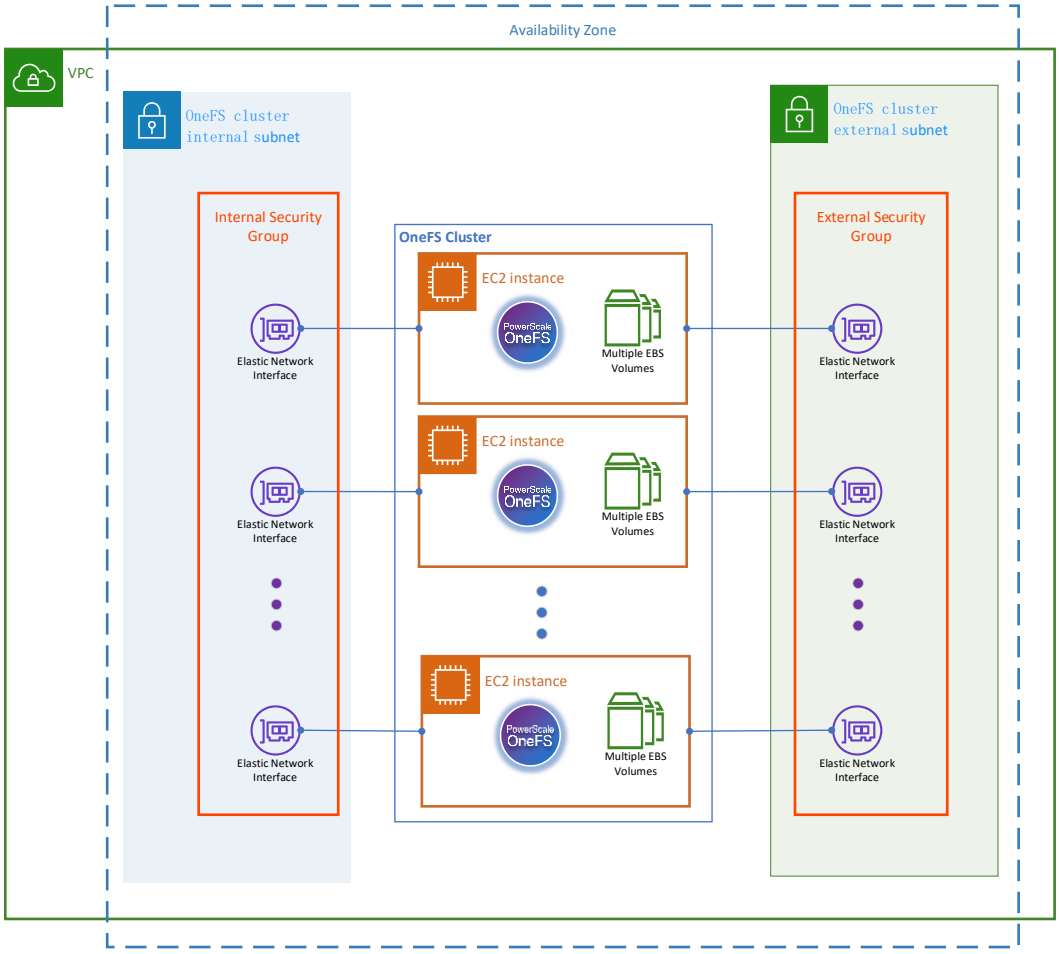

Figure 1. APEX File Storage for AWS architecture

Overall, APEX File Storage for AWS offers a powerful and flexible scale-out file storage solution that can help you improve data management, optimize costs, and achieve scalability and security in a cloud-based environment.

Use cases

APEX File Storage for AWS provides a range of use cases, including data mobility, cloud burst, disaster recovery to cloud, and streamlined management.

Data mobility

APEX File Storage for AWS provides data mobility capability through OneFS SyncIQ. Traditional IT workloads such as File Share, Home Directories, and Archive benefit the most here.

- **Snapshots integration:** To provide point-in-time data protection, when a SyncIQ job starts, it automatically generates a snapshot of the dataset stored on-premises and moves them to the cloud for backup and disaster recovery purposes. This ensures that data is available if an outage or other disruption occurs.
- **Data synchronization:** APEX File Storage for AWS provides synchronization capabilities, enabling organizations to keep data synchronized between different AWS cloud regions clusters, or between on-premises clusters and cloud clusters. This ensures that data is up-to-date and available across multiple locations.
- **Data Migration:** With support for data replication to and from cloud clusters, APEX File Storage for AWS enables seamless data migration between different environments. This enhances flexibility and scalability, enabling organizations to optimize their storage and cloud infrastructure.

Cloud burst

APEX File Storage for AWS provides a flexible and scalable solution for cloud burst scenarios. It allows organizations to rapidly allocate additional storage compute and capacity in the cloud, eliminating the requirement for upfront hardware investment. Cloud burst scenarios can arise for various reasons, such as in industry-specific workflows like video rendering in Media and Entertainment, seasonal peaks in demand, unforeseen workload surges, or sudden business growth. Additionally, compute-intensive workloads such as AI/ML and analytics can also be efficiently executed within this environment.

Streamlined management

APEX File Storage for AWS provides the same storage management interfaces and data access interfaces as an on-premises PowerScale appliance. This eliminates the need for application refactoring during the migration from on-premises to cloud and minimizes the need to retrain storage administrators.

Supported cluster configurations

When setting up a new cluster, it is important to consider the type of storage configuration that is supported. Different configurations fulfill different requirements, depending on the intended use and the amount of data that needs to be stored. In general, a supported cluster configuration should be reliable, performant, and offer enough storage capacity to meet your needs.

APEX File Storage for AWS provides two types of cluster configuration:

- **Solid State Drive (SSD) cluster:** APEX File Storage for AWS supports clusters backed by General Purpose SSD (gp3) EBS volumes with up to 1 PiB cluster raw capacity. The gp3 EBS volumes are the latest generation of General Purpose SSD volumes, and the lowest cost SSD volume offered by AWS EBS. They balance price and performance for a wide variety of workloads. See Table 1 for the supported configuration.

- **Hard Disk Drive (HDD) cluster:** APEX File Storage for AWS supports clusters backed by Throughput Optimized HDD (st1) EBS volumes with up to 360 TiB cluster raw capacity. The st1 EBS volumes provide low-cost magnetic storage that defines performance in terms of throughput rather than IOPS. This volume type is a good fit for large, sequential workloads. See Table 2 for the supported configuration.

For a single cluster of APEX File Storage for AWS, all nodes in the cluster must use the same configuration, including EC2 instance type and size, EBS volume type, and EBS volume size.

SSD cluster

Table 1 shows the supported configuration for an SSD cluster.

Table 1. Supported configuration for an SSD cluster

Configuration items	Supported options
Cluster size	4 to 6 nodes
EC2 instance type	All nodes in a cluster must be same instance size. The supported instance sizes are m5dn.8xlarge, m5dn.12xlarge, m5dn.16xlarge, or m5dn.24xlarge. See Amazon EC2 m5 instances for more details.
EBS volume (disk) type	gp3
EBS volume (disk) counts per node	5, 6, 10, 12, 15, 18, or 20
Single EBS volume sizes	1 TiB–16 TiB
Cluster raw capacity	24 TiB–1 PiB
Cluster protection level	+2n

Note: all criteria in this table must be met. Therefore, **not all combinations of cluster size, volume count, and single volume size are supported.** For some combinations of cluster size, volume account, and single volume size, the total cluster raw capacity may fall outside the maximum supported cluster raw capacity. For example, for a 6-node cluster, if each node contains 20 volumes, and each volume size is 16 TiB, the final total cluster raw capacity is 1,920 TiB, which exceeds the maximum supported raw capacity. Therefore, this combination is not supported.

See Appendix A: supported cluster configuration details for all supported combinations.

HDD cluster

Table 2 shows the supported configuration for an HDD cluster.

Table 2. Supported configuration for an HDD cluster

Configuration items	Supported options
Cluster size	4 to 6 nodes
EC2 instance type	All nodes in a cluster must be same instance size. The supported instance sizes are m5dn.8xlarge, m5dn.12xlarge, m5dn.16xlarge, or m5dn.24xlarge. See Amazon EC2 m5 instances for more details.
EBS volume (disk) type	st1

Configuration items	Supported options
EBS volume (disk) counts per node	5 or 6
Single EBS volume sizes	4 TiB or 10 TiB
Cluster raw capacity	80 TiB–360 TiB
Cluster protection level	+2n

Data protection

File system journal

OneFS file system journal, which stores information about changes to the file system, is designed to enable fast consistent recoveries after system failures or crashes. The file system replays the journal entries after a node or cluster recovers from an outage.

Each m5dn EC2 cluster node contains local NVMe-based SSD storage, which is physically connected to the host server. This is also known as EC2 instance store. OneFS leverages one of the local NVMe-based SSD as the journal target storage for protecting uncommitted writes to the file system. When a node boots up, it checks its journal and selectively replays transactions to disk where the journaling system deems it necessary.

OneFS protection level

The OneFS cluster is designed to withstand one or more simultaneous component failures while continuing to serve data. To achieve this, OneFS protects files with either erasure code-based protection, using Reed-Solomon error correction (N+M protection), or a mirroring system. Data protection is applied in software at the file level, enabling the system to focus on recovering only those files that are compromised by a failure, rather than having to check and repair an entire file set or volume. OneFS metadata and inodes are always protected by mirroring, rather than Reed-Solomon coding, and with at least the level of protection as the data they reference. For more technical details about OneFS protection levels, refer to OneFS Data Protection.

APEX File Storage for AWS supports the protection level of +2n, which can tolerate the failure of two drives or two nodes. The reason we choose +2n for the APEX File Storage for AWS over the previous default of +2d:1n is to ensure high availability and reliability in the cloud environment. The overhead due to protection varies with cluster size. Table 3 shows the protection overhead of APEX File Storage for AWS with different cluster sizes:

Table 3. Protection overhead

Cluster size	Protection level	Erasure code	Protection overhead	Efficiency
4 nodes	+2n	2+2 (2 data blocks + 2 protection blocks)	50%	50%
5 nodes	+2n	3+2 (3 data blocks + 2 protection blocks)	40%	60%
6 nodes	+2n	4+2 (4 data blocks + 2 protection blocks)	33%	67%

File system efficiency increases as the cluster size grows. Therefore, when capacity is your major requirement, deploying a cluster with more nodes to get a higher usable cluster capacity is recommended. “Usable cluster capacity” means the capacity available

to store data after protection overhead. For example, if you are planning to provision 500 TiB total raw cluster capacity, you can achieve nearly 335 TiB usable cluster capacity on a 6-node cluster and only 250 TiB usable cluster capacity on a 4-node cluster.

Note: The final usable capacity of a OneFS cluster depends on the characteristics of the data and on file system features in use. For example, OneFS provides inline data reduction and small file efficiency features to help save storage capacity. Data capacity savings due to inline data reduction and small file efficiency are highly dependent on the data and can vary considerably. This variance means that accurate rates of savings are not predictable without comprehensive analysis of the dataset. The preceding usable cluster capacity estimation is for guidance only when implementing APEX File Storage for AWS. For more details about storage efficiency, see the white paper Dell PowerScale OneFS: Data Reduction and Storage Efficiency.

AWS infrastructure considerations

Cluster EC2 instance size

The m5dn instance type is designed for general-purpose workloads that require a balance of compute, memory, and network resources. Table 4 provides details of the supported instance sizes for APEX File Storage for AWS.

Table 4. Supported EC2 instance size

Instance size	vCPU	Memory (GiB)	Network bandwidth (Gbps)	EBS bandwidth (Mbps)
m5dn.8xlarge	32	128	25	6800
m5dn.12xlarge	48	192	50	9500
m5dn.16xlarge	64	256	75	13600
m5dn.24xlarge	96	384	100	19000

Different EC2 instance sizes provide different compute, memory, storage, and network capabilities. Choose an instance size based on the requirements of your workload. Here are some guidelines to consider:

- The network bandwidth limit in Table 4 is an instance level limit, which means that all network interface traffic shares the same bandwidth. Therefore, for each cluster node, the network bandwidth limit is shared by both the internal network and the external network.
- The EBS bandwidth limit in Table 4 is also an instance level limit, which means that the total throughput of all attached EBS volumes cannot exceed the limit. Therefore, to maximize an instance performance, the available throughput from all EBS volumes and the instance-level EBS bandwidth limit should either be equal or roughly the same.
- Metadata-intensive workloads typically require more CPU resources. In these cases, it is important to consider whether the chosen EC2 instance size provides enough vCPU resources.

Cluster EBS type

APEX File Storage for AWS supports both gp3 EBS volumes for an SSD cluster and st1 EBS volumes for an HDD cluster. These two volume types have different performance characteristics.

gp3 EBS volume

The gp3 volume provides a balance of price and performance. It is designed to support a broad range of workloads. By default, a single gp3 volume delivers a consistent baseline throughput performance of 125 MiB/s and IOPS performance of 3000 IOPS. At extra cost, you can provision additional throughput up to 1,000 MiB/s and additional IOPS up to 16,000 IOPS on one gp3 volume independently. This means that you can provision the necessary IOPS or throughput performance without the need for extra capacity. See the AWS documentation General Purpose SSD volumes for more details.

When sizing a cluster, to make the aggregated EBS volume throughput match the instance level EBS bandwidth limit, you have the option to either increase the number of volumes allocated per node with lower throughput performance per volume or decrease the number of volumes allocated per node while increasing the throughput performance per volume. Table 5 shows two examples of an m5dn.12xlarge node configuration by using different gp3 volume configurations.

Table 5. Examples of gp3 configuration per node

AWS Instance EBS bandwidth limit	Volume counts per node	Single volume size	Single volume provisioned throughput and IOPS	Aggregated provisioned volume throughput per node	AWS EBS hourly cost per node
1187.5 MB/s	10	1 TiB	125 MiB/s 3000 IOPS	1250 MiB/s	1.12 USD
1187.5 MB/s	5	2 TiB	250 MiB/s 3000 IOPS	1250 MiB/s	1.16 USD

Note: the AWS EBS hourly cost is calculated with AWS Pricing Calculator, and assumes the region is us-east-1 for comparison purposes. The cost is the AWS list price and may change.

From the preceding comparison, with the same total raw node capacity, provisioning more volumes with the default EBS volume throughput and IOPS configuration is more cost-effective. In terms of cost, it is advisable to use the default volume throughput and IOPS configuration along with a greater number of volumes when setting up clusters backed by gp3 volumes and having the same capacity and aggregated volume throughput.

st1 EBS volume

The st1 volumes are designed for throughput-intensive workloads such as large, sequential datasets or big data analytics. They consist of magnetic storage that defines performance in terms of throughput rather than IOPS and provides high throughput at a low cost per gigabyte. st1 volumes can also be used for backup and disaster recovery purposes.

St1 volumes use a burst bucket model for performance. Volume size determines both the baseline throughput and burst throughput of your volume. See the AWS documentation

Throughput Optimized HDD volumes for more details. When sizing a cluster, to make the aggregated EBS volume throughput match the instance level EBS bandwidth limit, you need to provision sufficient capacity per node.

Performance

Test methodology

To understand the performance characteristics of APEX File Storage for AWS, we used a standard benchmark tool for sequential read and sequential write tests with NFS version 3. We tested sequential read workloads with a request size of 128 KiB and sequential write workloads with a request size of 512 KiB.

Regarding the sequential read/write tests, here are a few specifics:

- In our tests, the OneFS access pattern “streaming” has been applied to the top-level test directory and any child objects of that directory. For more information about OneFS data access patterns, see PowerScale OneFS Best Practices.
- Sequential writes (100% writes) are done to large test files. Each write thread writes to a unique large test file. We used 30 GiB files for sequential writes.
- Sequential reads (100% reads) are done from existing large test files. Each read thread reads from a unique large test file. We used 30 GiB files for sequential reads.

OneFS inline compression and inline dedupe features are kept enabled during all tests. The benchmark workload specified 0% compressible or duplicated data blocks.

We used 12 m5n.16xlarge clients to push workloads to the OneFS clusters during each test. Each client instance contains 64 vCPU cores and 256 GiB memory, and the network bandwidth is 75 Gbps. Our clients are powerful enough to complete the performance tests. For each test, we followed the rule of ensuring that the aggregated EBS bandwidth exceeded the instance-level EBS bandwidth.

All performance tests in this document are performed in the US East (N. Virginia) Region (us-east-1), in the same Availability Zone.

Test results

Maximum throughput performance achieved

APEX File Storage for AWS can deliver exceptionally superior performance. A single cluster can deliver a total of 10,305 MB/sec sequential read throughput, and 3,930 MB/sec sequential write throughput.

The Table 6 shows a configuration example of the cluster that achieved the maximum sequential read and write throughput performance.

Table 6. Cluster configuration of maximum throughput performance

Cluster item	Configuration
Cluster size	6 nodes
EC2 instance type	m5dn.12xlarge
EBS volume type	gp3

Cluster item	Configuration
EBS volumes per node	12x 1 TiB
Cluster raw capacity	72 TiB
Cluster protection level	+2n

Performance factors

In this section, we have introduced the performance impact of the four key factors when designing a OneFS cluster of APEX File Storage for AWS. These four key factors are:

- Instance type
- Node count
- EBS volume settings (volume count per node and volume performance)
- EBS volume type

Instance type

Our tests show that scaling up the instance type from m5dn.8xlarge to m5dn.12xlarge, provided scaling performance. Figure 2 and Figure 3 show the performance impact when changing the instance type on clusters using gp3 volumes.

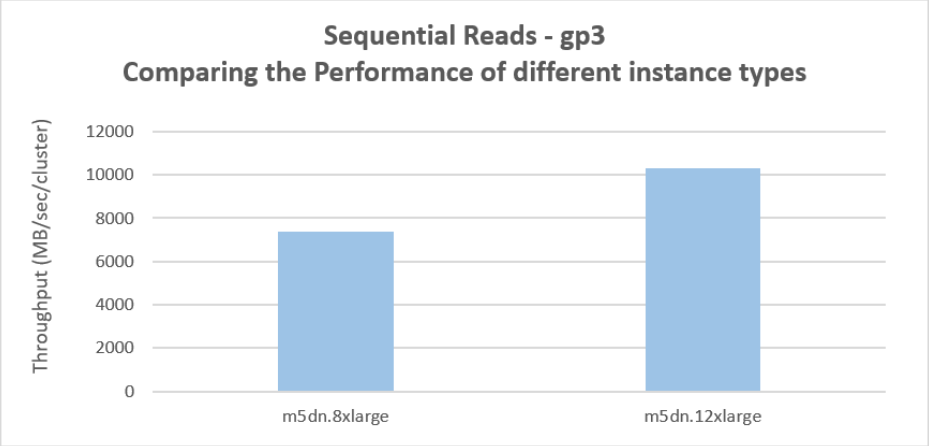

Figure 2. Sequential read throughput of gp3/SSD cluster

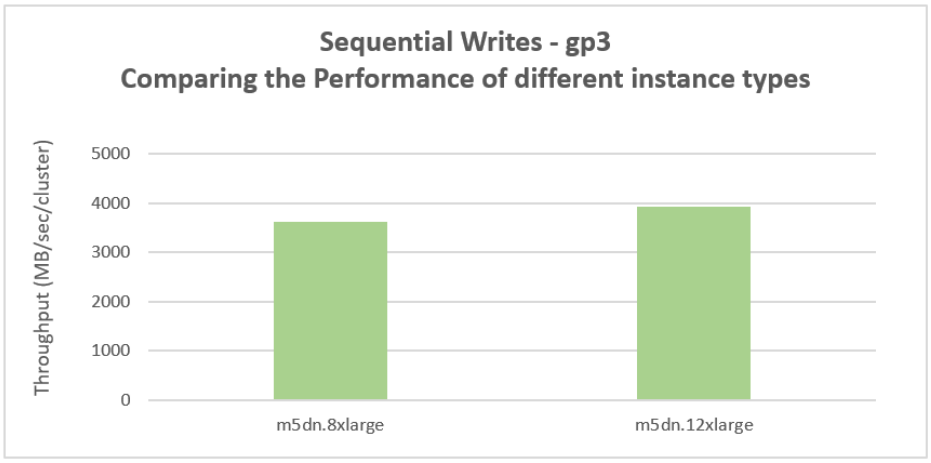

Figure 3. Sequential write throughput of gp3/SSD cluster

The only difference between these two tests is the node instance type. Other important specific configurations of the clusters are:

- **Volume type**: gp3
- **Node count**: 6
- **Volumes per node**: 12 x 1 TiB

Figure 4 and Figure 5 show the instance type impact on st1 volume clusters.

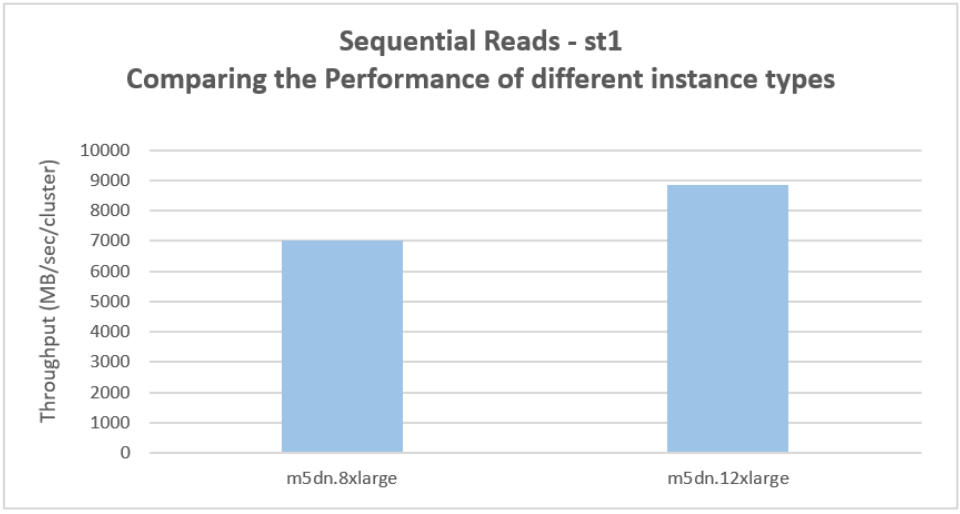

Figure 4. Sequential read throughput of st1/HDD cluster

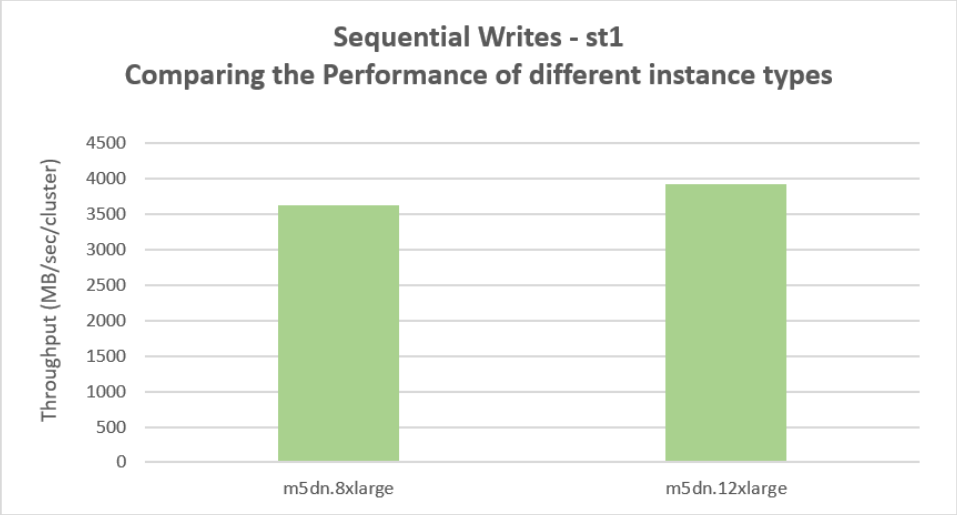

Figure 5. Sequential write throughput of st1/HDD cluster

The only difference between the tests is the node instance type. Other important specific configurations of the clusters are:

- **Volume type**: st1
- **Node count**: 6
- **Volumes per node**: 6x 8 TiB

Note: For st1 clusters, we conduct internal performance testing using 8 TiB data volumes for measuring performance only. In all above tests, we followed the rule of ensuring that the aggregated EBS bandwidth exceeded the instance-level EBS bandwidth

Node count

APEX File Storage for AWS has shown good scalability while adding new nodes to the cluster. Figure 6 and Figure 7 show the performance impact when using different nodes on gp3 clusters. Figure 8 and Figure 9 show the performance impact when using different nodes on st1 clusters.

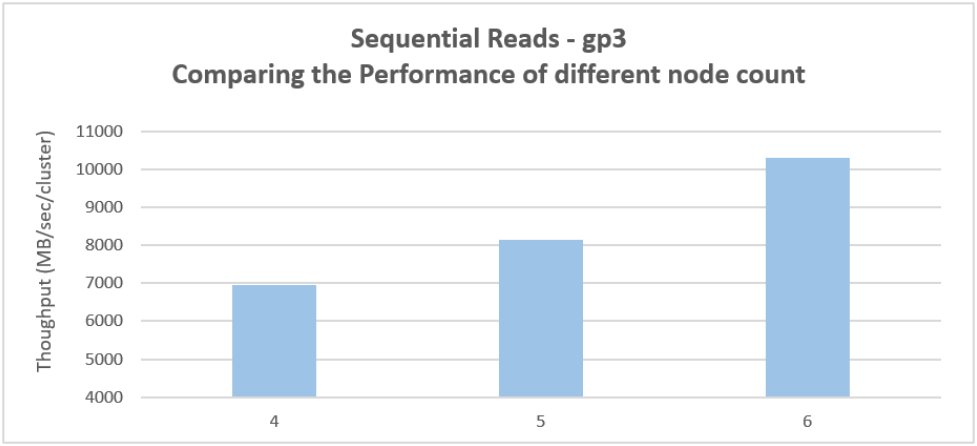

Figure 6. Sequential Read Scale-out performance testing for gp3/SSD cluster

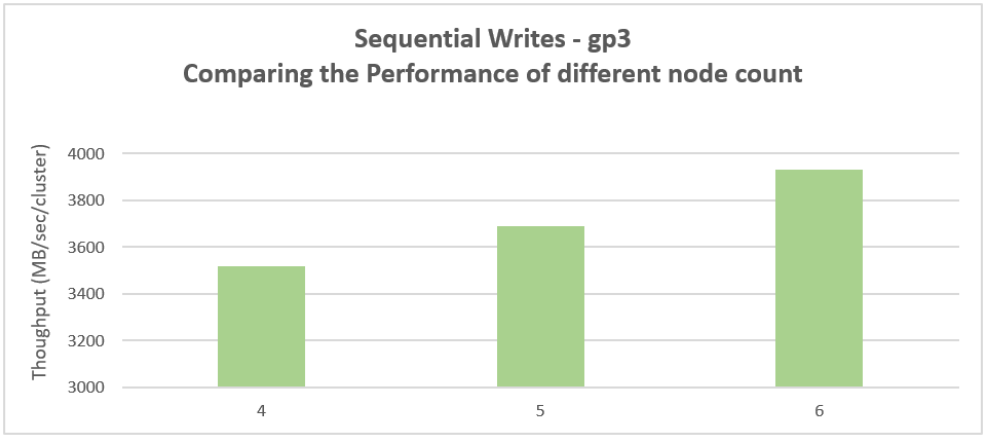

Figure 7. Sequential Write Scale-out performance testing for gp3/SSD cluster

In the gp3/SSD cluster scale-out tests, other specific configurations are:

- **Instance type**: m5dn.12xlarge
- **Volume type**: gp3
- **Volumes per node**: 12x 1 TiB

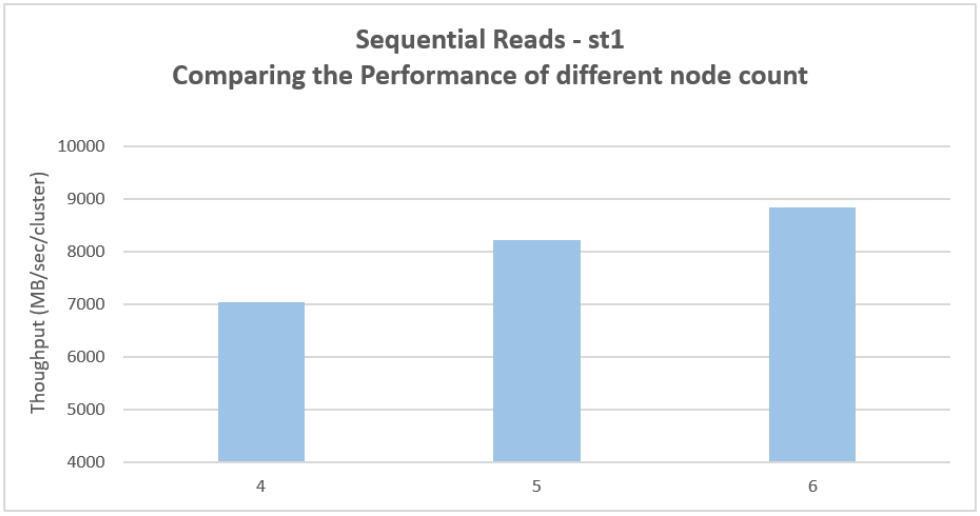

Figure 8. Sequential Read Scale-out performance testing for st1/HDD cluster

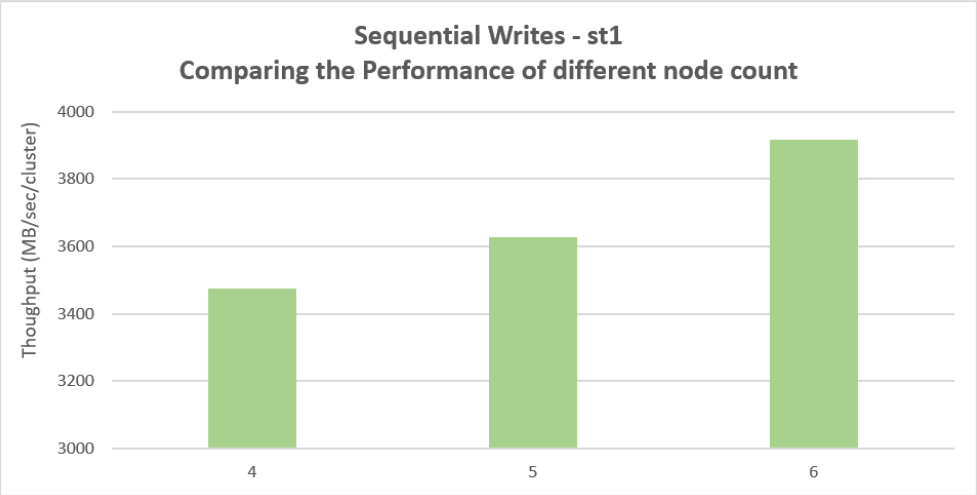

Figure 9. Sequential Write Scale-out performance testing for st1/HDD cluster

In the st1/HDD cluster scale-out tests, other specific configurations are:

- **Instance type**: m5dn.12xlarge
- **Volume type**: st1
- **Volumes per node**: 6 x 8 TiB

Note: For st1 clusters, we conducted internal performance testing using 8 TiB data volumes. In all above tests, we followed the rule of ensuring that the aggregated EBS bandwidth exceeded the instance-level EBS bandwidth.

EBS volume settings

When setting up the cluster, users can choose the supported volume size and volume count in each node. For example, gp3 clusters support 5, 6, 10, 12, 15, 18, or 20 volumes per node. The performance profile of gp3 volumes can vary from 3,000 IOPS, 125 MiB/sec to 16,000 IOPS, 1,000 MiB/sec. St1 volume performance limit scales linearly, at the rate of 40 MiB/sec per TiB.

Performance tests show that when aggregated EBS available throughput (volume count * per-volume throughput) is the same or greater than instance EBS bandwidth limit, there will be no significant performance difference in the sequential read and write workloads.

Table 7 provides an example of test details.

Table 7. Aggregated EBS volume throughput per node performance impact

Cluster Configuration	Aggregated EBS available bandwidth per node	Instance EBS bandwidth limit	Sequential throughput performance per cluster
• Instance size: m5dn.12xlarge • Volumes type: gp3 • Cluster size: 6 nodes • Volumes per node: 12 • Single volume: 145 MiB/s	1,740 MiB/sec	1,187.5 MB/sec	Sequential Read: 10,305.6 MB/sec Sequential Write: 3,930.0 MB/sec
• Instance size: m5dn.12xlarge • Volumes type: gp3 • Cluster size: 6 nodes • Volumes per node: 6 • Single volume: 300 MiB/s	1,800 MiB/sec	1,187.5 MB/sec	Sequential Read: 10,089.0 MB/sec Sequential Write: 3,955.2 MB/sec

EBS volume type

For sequential read and sequential write workloads, gp3/SSD cluster and st1/HDD cluster achieve similar performance. This does not mean that st1 cluster performance can be compared to gp3 clusters in other workloads. For example, gp3 cluster can achieve much better performance with lower latency in a classic metadata intensive workload.

Findings summary

Overall, our performance testing revealed several areas that you need to consider before deploying OneFS clusters of APEX File Storage for AWS, so that the clusters can meet your organization's performance requirements. The following are the key findings:

- **Instance type:** For sequential read and write workloads, scaling up the instance size from m5dn.8xlarge to m5dn.12xlarge, provides you scaling performance.
- **Cluster size:** Clusters with more nodes can serve higher throughput workloads. Throughput performance grows when adding nodes to the cluster.
- **Aggregated EBS volume throughput per node:** When determining the specific configuration of a cluster, if the aggregated EBS bandwidth is the same as the instance-level EBS bandwidth limit, then from a performance perspective, we can consider that the combination of the corresponding number of volumes and volume throughput is the same. The instance aggregated EBS bandwidth is calculated using the following formula:

  Aggregated EBS bandwidth = (Number of volumes) * (Defined throughput per volume)

- **Cluster volume type:** gp3 cluster can effectively balance performance and cost for both sequential reads/writes and metadata intensive workloads. While st1 cluster can effectively balance storage capacity and cost, it is suitable for archive and sequential reads/writes workloads.

Appendix A: supported cluster configuration details

SSD cluster of gp3

The following table shows the available combinations of cluster size, volume count, and single volume size for an SSD cluster of gp3.

Table 8. Supported combinations of gp3 cluster

Cluster size	EBS volume count per node	Single EBS volume size (TiB)		Cluster raw capacity (TiB)		Approximate usable capacity percentage
		Minimum	Maximum	Minimum	Maximum	
4	5	1	16	20	320	50%
5	5	1	16	25	400	60%
6	5	1	16	30	480	67%
4	6	1	16	24	384	50%
5	6	1	16	30	480	60%
6	6	1	16	36	576	67%
4	10	1	16	40	640	50%
5	10	1	16	50	800	60%
6	10	1	16	60	960	67%
4	12	1	16	48	768	50%
5	12	1	16	60	960	60%
6	12	1	14.2	72	1022.4	67%
4	15	1	16	60	960	50%
5	15	1	13.6	75	1020	60%
6	15	1	11.3	90	1017	67%
4	18	1	14.2	72	1022.4	50%
5	18	1	11.3	90	1017	60%
6	18	1	9.4	108	1015.2	67%
4	20	1	12.8	80	1024	50%
5	20	1	10.2	100	1020	60%
6	20	1	8.5	120	1020	67%

HDD cluster of st1

The following table shows the available combinations of cluster size, volume count, and single volume size for an HDD cluster of st1.

Table 9. Supported combinations of st1 cluster

Cluster size	EBS volume count per node	Single EBS volume size (TiB)	Cluster raw capacity (TiB)	Approximate usable capacity percentage
4	5	4 or 10	80 or 200	50%
5	5	4 or 10	100 or 250	60%
6	5	4 or 10	120 or 300	67%
4	6	4 or 10	96 or 240	50%
5	6	4 or 10	120 or 300	60%
6	6	4 or 10	144 or 360	67%

References

Dell Technologies documentation

The following resources provide information related to this document. Access to documents depends on your login credentials. If you do not have access to a document, contact your Dell Technologies representative.

- APEX File Storage for AWS product page
- APEX File Storage for AWS Deployment Guide
- APEX File Storage for AWS Getting Started Guide on Dell Support
- PowerScale OneFS Technical Overview—Data protection

AWS documentation

The following AWS documentation provides additional information related to this document:

- AWS EC2 instance types
- AWS EBS volume types
- AWS EBS–optimized instances