



White Paper

**Why your SAN needs NetApp for  
public cloud and Kubernetes**  
NetApp Cloud for cloud-native services

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# 1. Executive summary

According to [Statista](#), about half of all corporate data now resides in the cloud, and that share is expected to continue to increase rapidly. IDC expects spending on compute and storage cloud infrastructure to have a compound annual growth rate of 11.3% over the 2021-2025 forecast period, reaching \$112.9 billion in 2025 and accounting for 66.1% of total compute and storage infrastructure spend.

In a recent Coldago Research end-user survey, cloud storage is the #1 technology considered for projects in 2021. Customers are migrating their infrastructure to cloud-native architectures with containerized management tools like Kubernetes that automate the deployment and management of these new applications. Gartner predicts that by 2022, 75% of global organizations will be running containerized applications in production.

## Cloud-native storage services

Public cloud adoption continues to grow, so the types of workloads running on public cloud infrastructure now include advanced enterprise databases and applications. The availability of traditional virtual machines and modern containers on AWS, Microsoft Azure, Google Cloud, and other public clouds is facilitating this migration. However, the storage services of public cloud providers often lack essential enterprise functionality, so businesses look to enterprise storage providers for alternatives.

Examples include:

- Business continuity through remote clustering
- Disaster recovery through synchronous replication
- Performance management through adaptive quality of service
- Storage efficiency through data reduction
- Resilience through high-availability controller pairs

Conversely, the storage systems of the major providers of infrastructure for on-premises data centers (for example, Dell EMC) lack essential public cloud functionality. Examples include:

- Self-service consumption from public cloud marketplaces
- Flexible subscription options with no long-term commitments
- Storage deployments ready to use within minutes

For example, Dell EMC APEX Cloud Services offer near-cloud (not cloud-native) storage and can take up to 14 days to deploy. Also, these and other providers offer no options for cloud-native storage, which limits the use of their enterprise storage in a hybrid multicloud environment.

NetApp brings enterprise storage functionality to public cloud service offerings. These services provide the robust functionality that businesses require to build hybrid multicloud environments. They support the migration of workloads across multiple on-premises, and public clouds locations. These cloud-native storage services include:

- Azure NetApp Files
- Amazon FSx for NetApp ONTAP
- NetApp® Cloud Volumes Service for Google Cloud
- NetApp Cloud Volumes ONTAP®

## Hybrid multicloud management and analytics services

Many virtualized workloads start in private cloud environments (on-premises data centers), while many containerized workloads start in public cloud environments. When businesses move virtualized and containerized workloads across private and public clouds, they create hybrid multicloud environments. A common set of data analytics and management services that support both virtualized and containerized application topologies and are available on both on-premises systems and public cloud services is essential for hybrid multiclouds. Common analytics and management tools allow smooth operation regardless of where workloads, storage, and data are located. However, the relevant tools from the public cloud and other enterprise storage providers support only their proprietary infrastructure.

Most storage system vendors, including Dell EMC, remain focused on developing storage systems for on-premises environments with limited capabilities relevant to the public cloud. Generally, their public cloud support consists of backup offerings using a software-as-a-service (SaaS) approach. However, the services required to complete a hybrid multicloud workload environment are lacking. Examples of relevant services include:

- Hybrid multicloud control, orchestration, and management
- Data caching, synchronization, tiering, discovery, mapping, and classification
- Storage alerting, monitoring, troubleshooting, and optimization

NetApp offers many cloud-based services for analytics and management that support infrastructure, workloads, and data across entire hybrid multiclouds.

### CLOUD CONTROLS



Cloud Manager. Centralized management, monitoring, and automation for Cloud Central services.



Astra™ Control. Application-aware control plane with orchestration and management for Kubernetes.



Virtual Desktop Service. Global control plane for virtual desktop management that functions as an extension of the cloud.

### CLOUD SERVICES AND ANALYTICS



Cloud Insights. Alerting, monitoring, troubleshooting, and optimization for the hybrid multicloud.



Cloud Sync. Rapid and secure copying, moving, and synchronizing for file and object data.



Cloud Data Sense. Automatic discovery, mapping, and classification for hybrid multicloud data.



Cloud Tiering. Policy-based tiering of inactive (cold) data to hybrid cloud object storage.



Cloud Backup. Data protection with secure backup and recovery of ONTAP based storage.



Global File Cache. Real-time distributed file sharing of active data for distributed workforces.

### COMPUTE OPERATIONS



Spot Cloud Analyzer by NetApp. Cloud infrastructure management solution that uses advanced analytics to provide visibility and insight into cloud costs.



Spot Eco by NetApp. Automated optimization for AWS Savings Plans and Reserved Instances that eliminates the risk of unused resources.



Spot Ocean by NetApp. Automated serverless infrastructure engine that continuously analyses and automatically scales resources to maximize utilization and availability.



Spot Elastigroup by NetApp. Runs mission-critical workloads on cloud infrastructure spot instances with guaranteed availability backed by an enterprise-grade service level agreement.



Spot PC by NetApp. Fully managed, continuously optimized cloud desktops as a service with Azure Virtual Desktops and Windows 365.

Table 1) NetApp Cloud Central services.

### Hybrid multicloud storage infrastructure

AWS, Microsoft Azure, and Google Cloud focus on providing public cloud infrastructure, including storage, but they also offer some private cloud infrastructure. Dell EMC focuses on providing private cloud storage but offers some public cloud infrastructure. NetApp specializes in delivering complete solutions for hybrid multicloud, including on-premises private cloud and off-premises public cloud storage.

Dell EMC PowerMax and PowerStore offer on-premises enterprise storage that can be used for private cloud environments, for example. However, they each use different software that is not cross-compatible and runs on Dell EMC storage systems only. This means that neither storage system software runs on AWS, Microsoft Azure, or Google Cloud infrastructure, so there is no public cloud storage complement for PowerMax or PowerStore. This lack of Dell EMC public cloud storage restricts the use of PowerMax and PowerStore in hybrid multicloud environments.

Compared to private cloud-focused storage systems providers like Dell EMC and public cloud focused storage services providers like AWS, Microsoft Azure, and Google Cloud, NetApp offers the private cloud and public cloud storage services required to build hybrid multicloud environments. These NetApp products and services include:

- **Hybrid multicloud.** Combinations of the following NetApp public and private cloud services and products.
- **Public cloud.** AWS FSx for NetApp ONTAP, Azure NetApp Files, NetApp Cloud Volumes Service, and NetApp Cloud Volumes ONTAP®.
- **Private cloud.** NetApp Keystone™, NetApp AFF, NetApp AFF All SAN Array (ASA), NetApp FAS, and NetApp ONTAP Select.

## 2. What differentiates cloud storage?

### Introduction

For most of the past decade, customer data environments have been on an incredible growth path, with steady migration to the cloud. Organizations are looking for cost-effective ways to manage their IT investments, improve the resilience of data and applications, and support the transition to an increasingly mobile and virtual workforce.

Customers' cloud selection criteria include the following considerations:

- **Realizing economic efficiencies**
  - Cost containment of the IT infrastructure, including management burden
  - Flexibility, with a consumption-based model for both private and public cloud IT infrastructure
- **Meeting service level objectives**
  - Data accessibility, with the ability to deliver to the desired quality of service for workloads
  - Elasticity, to scale compute and storage on demand to meet the needs of the business
- **Delivering data protection and security**
  - Reliable data protection, delivering bullet-proof disaster recovery
  - Comprehensive resilience against cybersecurity threats, including malware and ransomware

### Cloud-native storage services: Comparing NetApp and Dell EMC

Cloud-native storage services (storage that is fully integrated with public clouds) is the ideal choice for workloads running on Amazon, Microsoft Azure, and Google Cloud infrastructures. Public cloud providers offer default cloud-native storage services, but there are many possible reasons to prefer alternatives, including better functionality, higher performance, and lower expenses. Some businesses prefer alternatives because the default storage services of public cloud providers are too different from the enterprise storage they use elsewhere. Whatever the reasons to seek alternatives, Table 2 compares the availability of NetApp and Dell EMC cloud-native storage.

NetApp	Cloud-native storage	Dell EMC
AWS FSx for NetApp ONTAP, Cloud Volumes ONTAP	Block and file storage	None
Azure NetApp Files, Cloud Volumes Service for Google Cloud	File storage	None

Table 2) Comparison of NetApp and Dell EMC cloud-native storage.

## NetApp: The clear winner for hybrid multicloud management and analytics services

Having a place to store the structured and unstructured data of private, public, and hybrid cloud workloads is a minimal requirement. Real-world requirements, whether mandatory or desirable, often include:

- Cloud orchestration (analytics and optimization)
- Storage administration (management and monitoring)
- Storage optimization (caching and tiering)
- Data movement (synchronization and replication)
- Data protection (backup and recovery)
- Data security (encryption and analytics)

The challenge of meeting these and other requirements is greater for hybrid multicloud environments with storage and data across private and public cloud locations. Table 3 compares the cloud-native services of NetApp and Dell EMC for management and analytics.

NetApp	Hybrid multicloud management and analytics services	Dell EMC
Cloud Manager	Control, orchestration, and data management for hybrid cloud	None
Astra Control	Kubernetes storage provisioning and data management	None
Virtual Desktop Service	Global control plane for virtual desktop management	None
Cloud Insights	Monitoring, optimization, and security for cloud workloads	Cloud IQ
Cloud Sync	Automated cloud replication and synchronization for file data	None
Cloud Data Sense	Data discovery, mapping, and classification for hybrid cloud	None
Cloud Tiering	Data growth management for hybrid cloud	None
Cloud Backup	Storage backup and restore to multiple public clouds	None
Global File Cache	Global file sharing for distributed workforces	None
Cloud Analyzer	Advanced analytics to provide visibility and insight into cloud costs	None
Eco	Automated optimization for AWS Savings Plans and Reserved Instances	None
Ocean	Automated serverless engine that continuously analyses and automatically scales resources	None
Elastigroup	Runs mission-critical workloads on cloud infrastructure spot instances with availability SLA	None
Spot PC	Fully managed, continuously optimized cloud desktops as a service with Azure Virtual Desktops and Windows 365.	None

Table 3) Comparison of NetApp and Dell EMC hybrid multicloud management and analytics services.

## Comparison of hybrid multicloud storage infrastructures

Digital transformation, emerging technology, and economic changes are accelerating the adoption of hybrid multicloud environments. Established businesses that have spent decades designing, developing, and managing data centers to meet their past IT needs now face challenges that extend across multiple public clouds. Emerging businesses may have started with a cloud-first approach that leverages a public cloud infrastructure but now face similar challenges to incorporate multiple private clouds. All businesses will eventually face the challenges of hybrid multicloud.

Hybrid multicloud inherently has two major hurdles to overcome:

- The “hybrid” challenge, which involves the integration of private cloud and public cloud infrastructure.
- The “multi” challenge, which involves the integration of different locations distributed across (potentially numerous) private cloud and public cloud locations.

NetApp ONTAP storage software, with its products and services for hybrid multicloud storage, overcomes these challenges, while Dell EMC storage hardware and software do not, as shown in Table 4.

NetApp	Hybrid multicloud storage	Dell EMC
<p><b>NetApp ONTAP storage</b> (any mix of the following)</p> <p><u>Private Cloud</u> NetApp ASA, AFF, FAS, NetApp ONTAP Select</p> <p><u>Public Cloud</u> AWS FSx for NetApp ONTAP, Azure NetApp Files, Cloud Volumes Service for Google Cloud, and Cloud Volumes ONTAP</p>	High-end SAN and NAS storage	PowerMax + PowerMax in VMware Cloud on AWS (not cloud native, hosted by MSP)
	Midrange SAN and NAS storage	PowerStore + PowerStore in VMware Cloud on AWS (not cloud native, hosted by MSP)
	Entry-level SAN and NAS storage	None
	Unified SAN, NAS, S3 storage	None
	SAN-only storage	None
NAS-only storage	PowerScale + PowerScale for Google Cloud (not cloud native, hosted by MSP)	

Table 4) Comparison of NetApp and Dell EMC hybrid multicloud storage.

## Summary

The demand for cloud storage is growing rapidly, with more than half of all corporate data now residing in the cloud. NetApp hybrid multicloud solutions make it simple to run more containerized applications in production and to use more public cloud infrastructure. NetApp hybrid multicloud solutions include the following categories of services and products:

- Cloud-native storage services
- Hybrid multicloud management and analytics services
- Hybrid multicloud storage infrastructure

NetApp ONTAP storage makes hybrid multicloud feasible for every business through cloud-native storage services and software products for the public clouds of AWS, Microsoft Azure, and Google Cloud. Also, the comparison tables in this section show that Dell EMC offers:

- Storage systems that address fewer hybrid multicloud environments.
- One public cloud option for PowerMax, PowerStore, and PowerScale.
- No cloud-native storage services or products.
- Very few hybrid multicloud management and analytics services.

With NetApp, the investments that businesses make in private and public cloud are extensible to hybrid multicloud. To learn more, read all about the NetApp hybrid multicloud experience.

## 3. Public cloud workloads

### Introduction

The original concept of cloud has evolved to include disparate infrastructures (for example, on premises, remote site, and public cloud) at different locations (for example, edge, core, and cloud) operating as cloud platforms. This concept is now referred to as hybrid multicloud. Multicloud functionality includes data movement, monitoring, and management. Forecasts emphasize the need for a hybrid multicloud strategy that gives businesses the freedom to use the most appropriate public cloud for each workload.

[IDC](#) reports that by 2022, more than 90% of enterprises will be using a mix of on-premises private clouds and off-premises public clouds, driving heightened value in a hybrid model. A recent [Gartner](#) survey found that 81% of respondents who use public clouds are using two or more public cloud providers.

The growing popularity of running workloads on public cloud infrastructure, and the evolution of private cloud infrastructure to hybrid cloud, makes public cloud capabilities relevant to SAN storage. Examples include SAN storage cloud tiering and cloud backup to significantly improve the total cost of ownership (TCO) and return on investment (ROI).

Many of the world's largest cloud infrastructure and managed services providers, including —IBM Cloud, Microsoft Azure, Google Cloud, Amazon, and SAP Cloud, trust NetApp storage for their public cloud customers. NetApp storage for public cloud workloads is based on the ONTAP storage platform including the following services and products:

- **Hybrid multicloud.** Combinations of the following NetApp public and private cloud services and products.
- **Public cloud.** AWS FSx for NetApp ONTAP, Azure NetApp Files, NetApp Cloud Volumes Service, and NetApp Cloud Volumes ONTAP.
- **Private Cloud** – NetApp Keystone, NetApp ASA, NetApp AFF, NetApp FAS, and NetApp ONTAP Select.

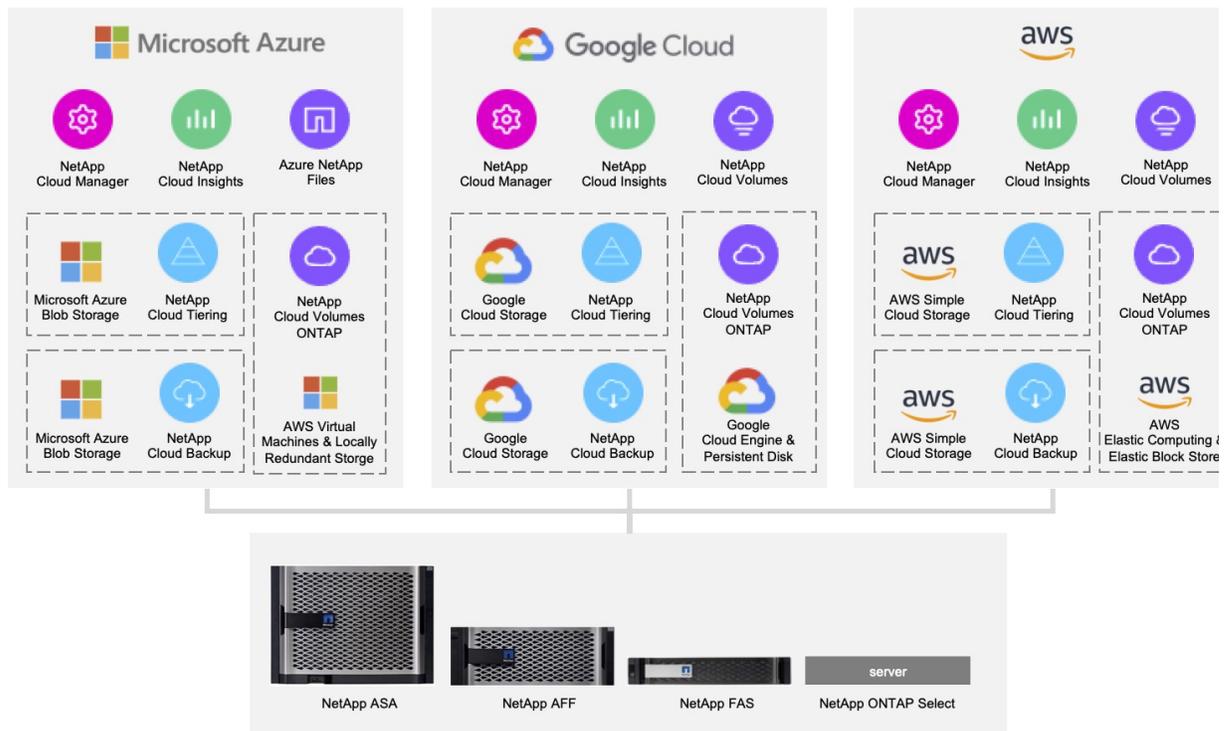


Figure 1) NetApp Cloud Services for Microsoft Azure, Google Cloud, and AWS.

### NetApp cloud-native storage complements SAN storage

The term *cloud native* describes applications developed to run on public cloud infrastructure, so *cloud-native storage* refers to storage that runs exclusively on public cloud infrastructure. NetApp cloud-native storage complements SAN storage on premises to run cloud-native workloads in a single public cloud or across multiple public clouds at the same time. Options include:

- Azure NetApp Files
- AWS FSx for NetApp ONTAP
- Cloud Volumes Service for Google Cloud
- Cloud Volumes ONTAP

These NetApp services allow customers to run cloud-native and other applications on the infrastructure of multiple public clouds and to move public cloud data across multiple public clouds. NetApp cloud services run on public cloud infrastructure and are accessed online on a subscription basis. NetApp offers enterprise-class cloud services for storage and data management that complement NetApp SAN storage, as described in Table 1.

The NetApp cloud-native services give customers the ability to increase IT productivity and reduce the cost of managing storage while providing greater protection and availability of data assets. Customers can accelerate performance by intelligently and automatically placing data on the storage that offers the ideal mix of functionality, performance, and cost to meet service level objectives across hybrid multicloud environments.

<b>Specifications</b>	<b>Azure NetApp Files</b>	<b>NetApp Cloud Volumes Service for Google Cloud</b>
Architecture	Cloud native	
Infrastructure	Public cloud	
Capacity	100GiB to 100TiB per volume	
Standard tier performance	4k IOPS & 16MiB/s per TiB	16 or 32MiB/s per TiB
Premium tier performance	16k IOPS & 64MiB/s per TiB	64MiB/s per TiB
Ultra/Extreme tier performance	32k IOPS & 128MiB/s per TiB (Ultra)	128MiB/s per TiB (Extreme)
Service level agreements	Performance, availability, and downtime	
Protocols	NFSv3 and NFSv4.1, SMB 2.1, 3.0, and 3.1.1	

Table 5) Specifications for NetApp cloud-native storage.

AWS FSx for NetApp ONTAP, Azure NetApp Files, and Cloud Volumes Service for Google Cloud offer many data management capabilities, including high availability, snapshot copies and restores, rapid clones, and data-at-rest encryption. NetApp Cloud Volumes services add advanced enterprise capabilities, including cloud-based storage infrastructure management, AI-driven application insights, cloud workload orchestration, automated data synchronization, and privacy controls for compliance.

<b>Specifications</b>	<b>AWS FSx for NetApp ONTAP</b>
Architecture	Cloud native
Infrastructure	Public cloud (AWS)
Capacity	Up to 188TB primary, unlimited secondary (IA)
Performance	Up to 2GB/s
Service level agreements	Performance, availability, and durability
Protocols	iSCSI, NFSv3 and NFSv4.1, SMB 2.1 and 3.1.1

Table 6) Specifications for AWS FSx for NetApp ONTAP.

Amazon FSx for NetApp ONTAP combines the rich data management capabilities of NetApp ONTAP with the agility and scalability of a native AWS service. It is a fully managed AWS service that allows customers to launch and run file storage with multiprotocol support for Linux, Windows, and iSCSI workloads powered by ONTAP data management software natively in the AWS Cloud. Amazon FSx is a service that makes it easy and cost effective to run popular file systems in AWS. It offers fully managed, feature-rich, highly performant file storage built on the latest AWS compute, disk, and networking technologies. It provides proven, enterprise-grade features, performance, capabilities, and APIs that customers use on premises, with the agility, scalability, security, and simplicity of a native AWS service. AWS FSx for NetApp ONTAP offers a frictionless path for enterprise customers to extend their applications from on premises to Amazon.

### **Software-defined storage for public, private, and hybrid multicloud**

Software-defined storage (SDS) is a system of abstracting data storage by using specialized software and standardized infrastructure so that the provisioning and management of storage are separated from the underlying hardware.

NetApp Cloud Volumes ONTAP for Amazon, Microsoft Azure, and Google Cloud are SDS offerings that provide cloud-based data management services using public infrastructure. NetApp ONTAP Select is an SDS product (a software appliance) that is deployed with an on-premises infrastructure, such as open-standard x86 servers, and IBM Cloud infrastructure. Businesses can deploy hybrid multicloud unified SAN and NAS storage that spans private and public cloud infrastructure for workloads at the edge, core, and cloud. Furthermore, NetApp hybrid cloud storage transforms to hybrid multicloud storage with the addition of NetApp SDS on Microsoft Azure, AWS, Google Cloud, and IBM Cloud.

Customers can choose to deploy a highly flexible, software-defined NetApp SAN storage solution running on:

- Public infrastructure with NetApp Cloud Volumes ONTAP
- Private infrastructure with NetApp ONTAP Select
- Hybrid infrastructure with both of these NetApp products

[Gartner](#) predicts that 40% of enterprise information technology operations will use hybrid cloud storage by 2025, up from 15% in 2021. NetApp is well positioned to address this market shift with a product portfolio that includes services, software, and systems to make it easy to deploy a hybrid multicloud storage solution. The public cloud portion can include NetApp Cloud Volumes ONTAP software running on Azure, AWS, and Google Cloud plus NetApp ONTAP Select software running on IBM Cloud. The private cloud portion can include systems like NetApp ASA, NetApp AFF, and NetApp FAS plus software like NetApp ONTAP Select or storage as a service under NetApp Keystone. The flexibility and reach of NetApp hybrid multicloud SAN storage are unrivaled.

Specifications	NetApp Cloud Volumes ONTAP on AWS, Azure, and Google Cloud	NetApp ONTAP Select on IBM Cloud	NetApp ONTAP Select on premises
Architecture	Software defined		
Infrastructure	Public cloud		Private cloud
Capacity (raw)	Up to 368TiB per volume	Up to 12TiB per volume	Up to 400TiB per node
Performance (read)	Up to 800MiB/s per volume	Up to 48k IOPS per volume	Up to 950MiB/s per node
Protocols	iSCSI, NFSv3 and NFSv4.1, SMB 2.1, 3.0, and 3.1.1	iSCSI, NFSv3 and NFSv4.1, SMB 2.1, 3.0, and 3.1.1	iSCSI, NFSv3 and NFSv4.1, SMB 2.1, 3.0, and 3.1.1

Table 7) Specifications of NetApp storage software for hybrid multicloud SAN storage.

NetApp software-defined solutions extend beyond SAN storage to include sophisticated capabilities for business continuity like stretched, high-availability, active-active metro clustering across multiple kilometer distances using NetApp ONTAP MetroCluster SDS. Cloud Volumes ONTAP and ONTAP Select offer many enterprise-class data management capabilities such as high availability to improve service levels, data replication for disaster recovery, data reduction for efficient resource utilization, snapshot copies and restores for data protection, immutable snapshot copies for ransomware protection, data tiering to object storage to minimize storage expenses, rapid clones for development and testing, and data-at-rest encryption for data security. The capabilities of NetApp Cloud Volumes ONTAP and NetApp ONTAP Select are enhanced even further when NetApp Cloud Central services are added.

### Summary

NetApp delivers a comprehensive set of cloud storage and data management capabilities for cloud-native workloads.

NetApp ONTAP Select for SAN and NAS storage plus ONTAP MetroCluster SDS for high-availability metro clustering deliver comprehensive enterprise-grade capabilities for business continuity and disaster recovery. Amazon FSx for NetApp ONTAP, Azure NetApp Files, NetApp Cloud Volumes Service for Google Cloud, and NetApp Cloud Volumes ONTAP for AWS, Microsoft Azure, and Google Cloud deliver cloud-native SAN and NAS storage services directly from the marketplaces of multiple public clouds. NetApp Cloud Manager offers cloud-native data management services, compute optimization, infrastructure and application insights, data tiering, data recovery, cloud-native application mobility, and compliance. Other storage vendors lack NetApp's comprehensive functionality of cloud-native storage and data management services.

Competitive alternatives from Dell EMC don't offer cloud-native storage services like NetApp Cloud Volumes or cloud-native data management services like NetApp Cloud Tiering. PowerStore and Unity XT support SAN and NAS storage using on-premises systems only, which eliminates the possibility of hybrid multicloud support, including native-cloud storage. For example, Dell EMC Unity Cloud Edition software for VMware Cloud on AWS infrastructure doesn't support SAN but offers NFS and SMB file storage at capacities of 10, 25, or 50TB only. Surprisingly, Dell EMC PowerStore and Unity XT don't support synchronous active-active replication over metro distances (high-availability metro clustering) for SAN and NAS storage. That's true even when using optional Dell EMC PowerStore metro node appliances that support block storage over Fibre Channel only, excluding block storage over iSCSI and all file storage over any protocols.

## 4. Kubernetes container workloads

### Introduction

Containers are an important way to launch new applications because they provide a lightweight, isolated environment that makes apps easier to develop, deploy, and manage. [Gartner forecasts](#) that the adoption of cloud-native applications and infrastructure will drive more than 75% of global organizations to run containerized workloads in production by 2022. Also, [Gartner predicts](#) that by 2025, 75% of enterprise-generated data will be created and processed at the container-friendly edge rather than at the core or in the cloud. This suggests tremendous growth in container workloads during the first decade of Kubernetes, which was launched in 2014.

Container images, or containers, are packages that include all of the software needed to deliver the same functionality wherever they are run. Complex solutions can be constructed from multiple containers. Kubernetes (K8s) is open-source orchestration software for building, testing, implementing, managing, and scaling containers. Containers decouple databases, applications, and services (microservices) from underlying hosts, while Kubernetes automates dynamic resource provisioning to meet demand, so both are well suited for environments with diverse infrastructure like multiple public clouds.

NetApp facilitates container workloads with a platform that is agnostic to Kubernetes distributions and includes the following services and products:

- **NetApp Astra Control** cloud service for Kubernetes workload management
- **Astra Trident** container storage interface storage orchestrator
- **NetApp Cloud Manager** cloud service for storage management
- **NetApp Cloud Volumes** for data management
- **Amazon FSx for NetApp ONTAP, Azure NetApp Files, and NetApp Cloud Volumes Service** for public cloud file storage
- **NetApp Cloud Volumes ONTAP** for public cloud block, file, and object storage
- **NetApp Keystone** for private cloud block, file, and object storage as a service
- **NetApp AFF, NetApp FAS, and NetApp ONTAP Select** for private cloud block, file, and object storage

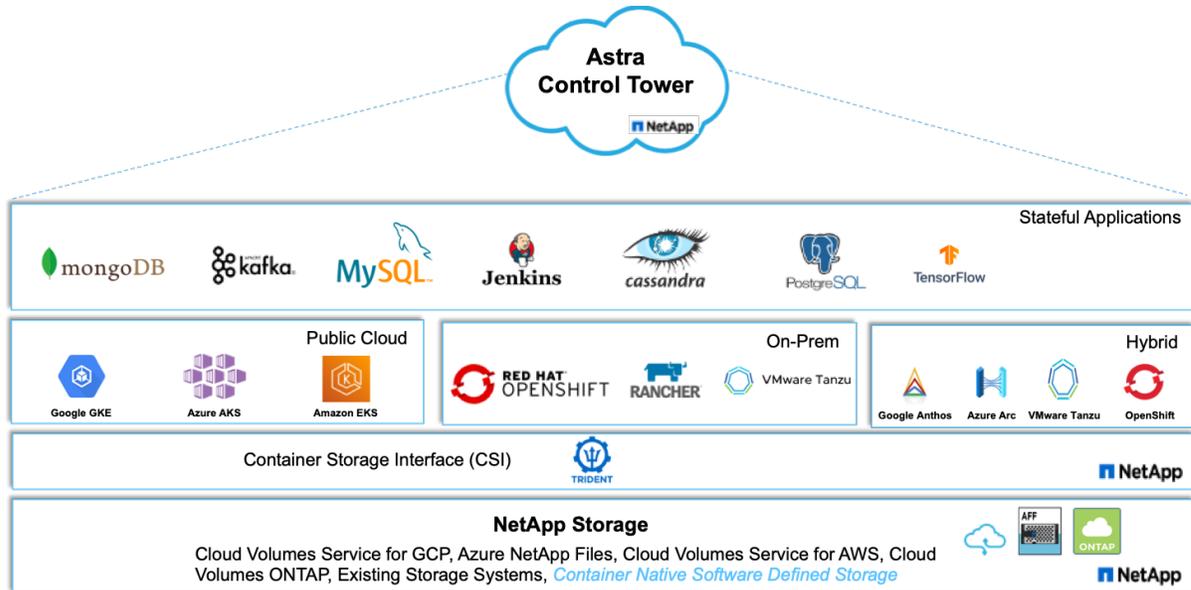


Figure 2) NetApp solution for Kubernetes containers workloads.

### Application-aware data management for Kubernetes

Stateful container workloads, such as databases, must use persistent storage to protect data against loss between container sessions, which can be complex to set up and manage. Kubernetes provides a convenient mechanism for persistent storage, called a persistent volume, which allows the use of storage units, such as storage volumes, by pods within nodes. NetApp Astra Trident makes file- and block-level persistent storage easy to manage. Astra Trident works across multiple public clouds by leveraging container-ready storage, including NetApp Cloud Volumes ONTAP and AWS FSx for NetApp ONTAP, and across multiple private clouds with storage systems like NetApp AFF.

NetApp Astra Control is an application-aware data management service that manages, protects, and moves data-rich Kubernetes workloads in both public clouds and on-premises data centers. Astra Control automatically discovers applications in Kubernetes clusters and protects data in containers by using application-aware snapshot copies, backups and restores, and clones. Entire applications and their data can be moved between clusters with Astra Control, regardless of cluster locations.

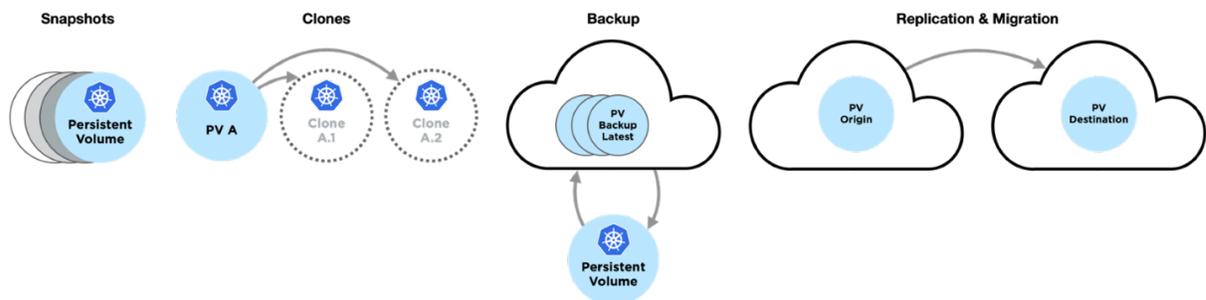


Figure 3) NetApp application-aware data management for Kubernetes containers workloads.

NetApp Astra Control is built on the foundational technology of NetApp Astra Trident. It uses Cloud Volumes Service for Google Cloud storage services as back-end storage for persistent volumes when using Google Kubernetes Engine and Azure NetApp Files when using Azure Kubernetes Service. Astra Trident supports on-premises Kubernetes clusters with Astra Control Center. Soon, Astra Control will support AWS FSx for NetApp ONTAP, AWS Elastic Kubernetes Service, and AWS Red Hat OpenShift on AWS, and NetApp software-defined storage when using an on-premises Kubernetes infrastructure.

### Simple consumption of Kubernetes storage for enhanced productivity

With Kubernetes, administrators make persistent volumes available for developers to claim and use as they create and destroy numerous Kubernetes containers when using methodologies like DevOps or practices like continuous integration and continuous deployment (CI/CD). Therefore, it's vital to keep container infrastructure consumption simple. Astra Trident uses the Kubernetes Container Storage Interface to allow developers to define storage classes by using desired attributes, such as features and specifications, and then dynamically provisions persistent volumes from NetApp storage by using storage classes. This ability eliminates the need for developers to involve administrators when working with Kubernetes containers.

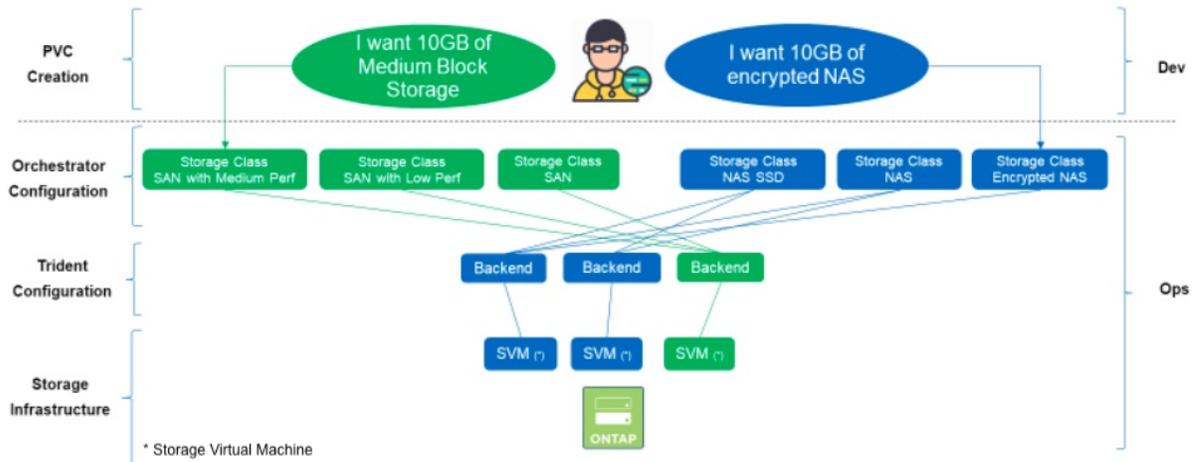


Figure 4) NetApp Trident storage consumption for Kubernetes containers.

### Container-ready storage for application-persistent volumes

Kubernetes is inherently a cloud-native platform designed by Google and maintained by the Cloud Native Computing Foundation. Therefore, persistent volumes running on cloud-native storage are ideal for Kubernetes container workloads running on a public cloud infrastructure. NetApp offers many cloud-native storage options for persistent volumes that are available on multiple public clouds from Microsoft Azure, Google Cloud, AWS, and IBM Cloud. For example:

- NetApp Cloud Volumes ONTAP for block and file storage
- Amazon FSx for NetApp ONTAP for block and file storage
- Azure NetApp Files for file storage
- NetApp Cloud Volumes Service on Google Cloud for file storage
- NetApp ONTAP Select on IBM Cloud for block and file storage
- NetApp Cloud Central including Astra Control for Kubernetes orchestration



Figure 5) NetApp Cloud Volumes with cloud-native storage and services.

Kubernetes container workloads need more than persistent storage alone, so NetApp offers cloud-native Cloud Insights for monitoring and reporting, Cloud Manager for API-driven management, and Spot Ocean for cloud automation of containers. Other NetApp cloud-native services are offered for provisioning, migration, access, protection, classification, and optimization.

## On-premises storage for container persistent volumes

The use of Kubernetes container workloads is increasing in private clouds running on premises in data centers. However, the needs of container workloads differ from those of virtualized and traditional workloads. According to IDC Innovators, Containerized Application Storage Platforms, 2020, traditional storage technologies aren't well suited to the needs of containerized environments, which are denser, more dynamic, and require higher scalability. With NetApp, all of the diverse block, file, and object storage requirements of mixed container, virtual, and traditional workloads on premises can be met with a single storage system (see Table 8).

Specifications	NetApp ASA	NetApp AFF	NetApp FAS
Architecture	Storage system	Storage system or cluster	
Infrastructure	Hybrid multicloud		
Capacity (raw)	Up to 5.3PiB per system	Up to 140PiB per cluster	Up to 176PiB per cluster
Performance (read)		Up to 300GiB/s per cluster	
Protocols	Fibre Channel, iSCSI	NVMe over Fibre Channel, Fibre Channel, iSCSI, NFSv3, NFSv4.1 and parallel NFS, SMB 2.1, 3.0, and 3.1.1, S3	NVMe over Fibre Channel, Fibre Channel, iSCSI, NFSv3, NFSv4.1 and parallel NFS, SMB 2.1, 3.0, and 3.1.1, S3

Table 8) Specifications of NetApp storage systems for hybrid multicloud SAN storage.

NetApp ASA offers an on-premises solution that delivers a simplified and dedicated SAN-only experience when workloads are limited to block storage only. NetApp AFF offers an all-flash (SSD-only) solution, and NetApp FAS offers a hybrid (SSD-accelerated HDD) solution that delivers block, file, and object storage. This solution has the ability to scale out to a cluster with up to 24 nodes (using 12 high-availability controller pairs) and up to 5,760 drives (up to 1,440 drives with NetApp FAS). All three NetApp storage systems integrate with Microsoft Azure, AWS, and Google Cloud to create a hybrid multicloud storage solution.

## Summary

NetApp delivers more cloud-native storage, data, and Kubernetes services for container workloads than Dell EMC.

Kubernetes administrators and developers can best apply Gartner's *Best Practices for Running Containers and Kubernetes in Production* by using NetApp services and products for a wide variety of use cases. Here are some examples:

- File storage is available directly from the cloud marketplaces of Microsoft Azure (Azure NetApp Files), AWS (AWS FSx for NetApp ONTAP), and Google Cloud (NetApp Cloud Volumes Service for Google Cloud).
- Unified block and file storage are available directly from public cloud marketplaces as NetApp Cloud Volumes ONTAP SDS software running on the public cloud infrastructure of Microsoft Azure, Google Cloud, and AWS.
- Unified block and file storage are available directly from IBM Cloud, which runs the NetApp ONTAP Select SDS software.
- NetApp ASA, AFF, and FAS systems offer on-premises block, file, and object storage for mixed workloads, including containers.
- NetApp Cloud Central offers a collection of cloud-native services for provisioning, migration, access, protection, classification, and optimization to complement NetApp cloud-native storage services. These services include Astra Control, which discovers applications in Kubernetes clusters and protects data in containers by using application-aware snapshot copies, backups, restores, and clones.

Other storage vendors fail to offer similar cloud-native services to support Kubernetes container workloads. Dell EMC doesn't offer anything like NetApp Cloud Central services, including NetApp Astra Control for Kubernetes container storage and application-aware data management. Also, Dell EMC doesn't offer cloud-native storage for Kubernetes container workloads that are directly available from the public cloud marketplaces of Microsoft Azure, Google Cloud, and AWS.

## 5. Conclusions

IT organizations face the daunting challenge of cost-effectively managing the massive growth of data that needs to be accessed, stored, and securely protected while meeting the service level objectives of higher and higher levels of performance and availability.

This situation has led many enterprises to turn to the public cloud. But a growing number of organizations are coupling the compelling value of public cloud with private cloud to address the wide range of workloads (containerized, virtualized, bare metal) and multiple data types (block, file, object) to create an efficient hybrid cloud architecture. Dependence on access to data everywhere, from edge to core to cloud, has resulted in the need for advanced management tools to address a new wave of applications for a hybrid IT strategy.

Customers who invest in hybrid cloud demand that the end-to-end solution can deliver the following capabilities.

- **Intelligent management.** Monitor all IT infrastructure from a single pane of glass with AI-based insights tools to troubleshoot and address the service level objectives for required performance and uptime.
- **Performance guarantees.** Manage lifecycles so that data is on the optimal tier of storage across on-premises data centers and public cloud environments.
- **Data protection.** Secure backup and restore capabilities address disaster recovery, business continuity, and cybersecurity requirements while meeting corporate governance and retention strategies for data everywhere in the hybrid cloud infrastructure.

NetApp offers the private cloud and public cloud storage required to build hybrid multicloud environments. Compared to private cloud-focused storage system providers like Dell EMC or public cloud-focused storage services providers like AWS, Microsoft Azure, and Google Cloud, NetApp is the clear choice. These NetApp products and services include:

- **Hybrid multicloud.** Combinations of the following NetApp public and private cloud services and products.
- **Public cloud.** Amazon FSx for NetApp ONTAP, Azure NetApp Files, NetApp Cloud Volumes Service, and NetApp Cloud Volumes ONTAP.
- **Private cloud.** NetApp Keystone, ASA, AFF, FAS, and ONTAP Select.

When it comes to cloud storage, you have a choice. Box yourself in with a Dell data center migration or get more out of your data with NetApp across the hybrid multicloud cloud. Visit us at [NetApp.com](https://www.netapp.com) to learn why you should [think twice and migrate once](#).

## APPENDIX: NETAPP SERVICES AND PRODUCTS

### NetApp Cloud native Storage Solutions

#### AWS FSx for NetApp ONTAP

Combines the rich data management capabilities of NetApp ONTAP with the agility and scalability of a native AWS service.

#### Azure NetApp Files

File storage solution co-developed by Microsoft and NetApp and directly available from Azure marketplace.

#### NetApp Cloud Volumes Service

File storage solution that is directly available from the AWS and Google Cloud marketplaces.

### NetApp Software-defined Storage Solutions

#### NetApp Cloud Volumes ONTAP

Block and file storage solution that integrates with Microsoft Azure, AWS, and Google Cloud.

#### NetApp ONTAP Select for On-premises

Block and file storage solution that integrates with private cloud virtualized servers and bare metal servers.

#### NetApp ONTAP Select for IBM Cloud

Block and file storage solution that is directly available from the IBM Cloud marketplace as a public cloud service.

### NetApp Cloud Central Services

#### NetApp Cloud Manager

A centralized control plane to manage, monitor, and automate NetApp Cloud Central services, Azure NetApp Files, NetApp Cloud Volumes Services, and NetApp Cloud Volumes ONTAP in hybrid multicloud environments.

#### NetApp File Cache

Allows distributed enterprises to securely consolidate silos of file servers into one cohesive global storage footprint in the public cloud, which streamlines overall IT management, significantly cuts costs, and boosts business productivity on a global scale.

### **NetApp Astra Control**

A fully managed application-aware data management service that manages, protects, and moves data-rich Kubernetes workloads in both public clouds and on-premises. It enables data protection, disaster recovery, and migration for Kubernetes workloads leveraging NetApp data management technology for snapshots, backups, replication, and cloning.

### **NetApp Cloud Insights**

Provides visibility into infrastructure and applications with alerting, monitoring, troubleshooting, and optimization of all resources and applications on-premises and in the hybrid multicloud. Supports early detection of ransomware events, powerful Kubernetes monitoring, and machine learning.

### **NetApp Cloud Sync**

A cloud-based service for rapidly and securely copying, moving, and synchronizing data across NFS or CIFS file and object storage across private, public, and hybrid cloud locations. Object support includes NetApp StorageGRID, AWS S3, Azure Blob, and IBM Cloud Object Storage.

### **NetApp Cloud Data Sense**

Provides automated controls for data privacy regulations such as the GDPR and CCPA that help businesses to get databases and applications privacy ready – whether their data is on-premises and in multiple public clouds.

### **NetApp Cloud Tiering**

Uses NetApp FabricPool technology for policy-based tiering of inactive (cold) data from NetApp storage systems to object storage on-premises or in the Microsoft Azure, AWS, and Google Cloud public clouds.

### **NetApp Cloud Backup**

An add-on service for NetApp Cloud Volumes and NetApp storage systems that deliver backup and restore capabilities for protection, and long-term archive of data.

### **NetApp Virtual Desktop Service**

A global control plane for virtual desktop management that functions as an extension of the cloud. With Virtual Desktop Service, businesses anywhere in the world can deploy a validated solution to address the challenges and inefficiencies facing most organizations when managing legacy virtual desktop solutions.

### **Spot Cloud Analyzer**

A cloud infrastructure management solution that uses advanced analytics to provide visibility and insights into your cloud costs, shows you where you can optimize those costs, and lets you implement that optimization using Spot's portfolio of continuous optimization products in just a few clicks.

### **Spot Eco**

Eco eliminates risk by identifying and off-loading unused Reserved Instances and Savings Plans. As your needs change Eco updates your portfolio so you can enjoy the benefits of long-term pricing without financial lock-in.

### **Spot Ocean**

Ocean automates cloud infrastructure for containers. It continuously analyzes how your containers are using infrastructure, automatically scaling compute resources to maximize utilization and availability utilizing the optimal blend of spot, reserved and on-demand compute instances.

### **Spot Elastigroup**

Elastigroup's predictive autoscaling simplifies the process of defining scaling policies, identifying peak times and automatically scaling to ensure the right capacity in advance. Machine learning algorithms predict the future load of your application and proactively scale the cluster in order to accommodate peak traffic.

### **Spot PC**

Spot PC allows you to provide on-demand, secure, cost-effective cloud desktops for Azure Virtual Desktop and Windows 365, built and operated by the desktop, infrastructure and cloud experts at Spot by NetApp.

## NetApp Storage Infrastructure Solutions

### NetApp ASA

All SAN Array (ASA) solution equivalent to NetApp AFF configured to deliver a simplified and dedicated SAN-only experience with support for system scale-up and cluster scale-out.

### NetApp AFF

All-Flash FAS (AFF) block, file, and object storage solution with solid-state drives (SSDs) and support for system scale-up and cluster scale-out.

### NetApp FAS

Fabric Attached Storage (FAS) block, file, and object storage solution with hard-disk drives and QLC flash for storage, SSDs for acceleration, and support for system scale-up and cluster scale-out.

### FlexPod

Converged infrastructure platforms including NetApp storage and Cisco servers and fabrics spot ecoand available in almost 200 pre-validated designs for enterprise workloads across the edge, core, and cloud.

Refer to the [Interoperability Matrix Tool \(IMT\)](#) on the NetApp Support site to validate that the exact product and feature versions described in this document are supported for your specific environment. The NetApp IMT defines the product components and versions that can be used to construct configurations that are supported by NetApp. Specific results depend on each customer's installation in accordance with published specifications.

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