NetApp Verified Architecture

NetApp AFX Storage Systems with NVIDIA DGX SuperPOD and NVIDIA DGX GB300 Systems

Design guide

NetApp Product and Solutions Engineering
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In collaboration with

Abstract

The NVIDIA DGX SuperPOD™ with NetApp AFX® 1K storage systems combines the world-class computing performance of NVIDIA DGX GB300 systems with NetApp cloud-connected storage systems to enable data-driven workflow for machine learning (ML), artificial intelligence (AI) and high-performance technical computing (HPC). This document describes the high-level architecture of the DGX SuperPOD solution using NetApp AFX 1K storage systems with an Ethernet storage fabric.

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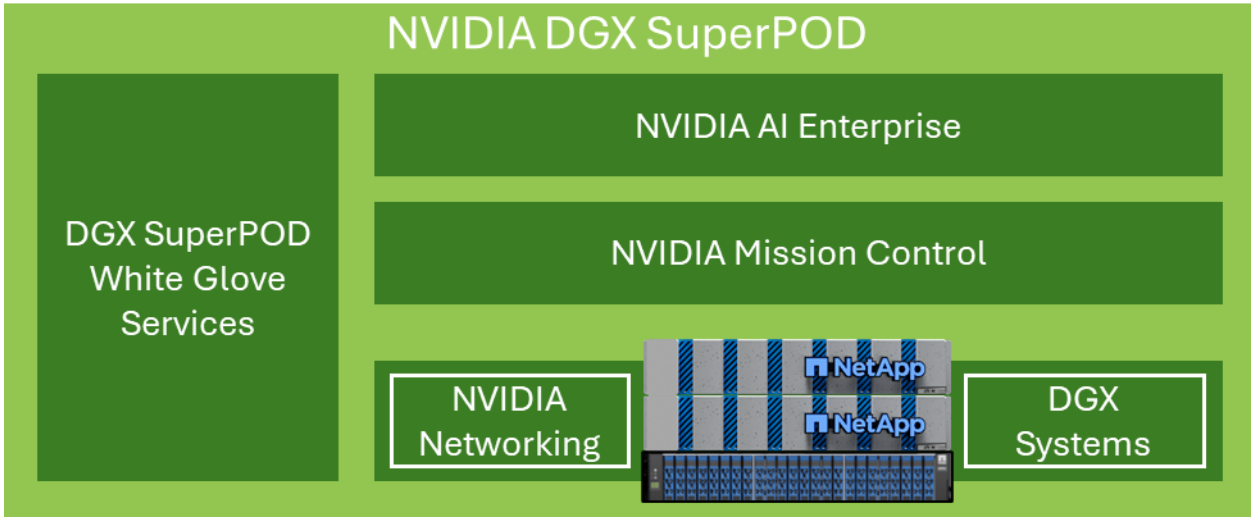
Executive summary

With the proven computing performance of NVIDIA DGX SuperPOD combined with NetApp's industry-leading data security, data governance and multi-tenancy capabilities, customers can deploy the most efficient and agile infrastructure for next-generation workloads. This document describes the high-level architecture and key features that help customers deliver faster time-to-market and return on investment for AI/ML initiatives.

Program Summary

NVIDIA DGX SuperPOD offers a turnkey AI data center solution for organizations, seamlessly delivering world-class computing, software tools, expertise, and continuous innovation. DGX SuperPOD delivers everything customers need to deploy AI/ML and HPC workloads with minimal setup time and maximum productivity. Figure 1 shows the high-level components of DGX SuperPOD.

Figure 1) NVIDIA DGX SuperPOD with NetApp AFX 1K storage systems.



DGX SuperPOD provides the following benefits:

- Proven performance for AI/ML and HPC workloads
- Integrated hardware and software stack from infrastructure management and monitoring to pre-built deep learning models and tools
- Dedicated services from installation and infrastructure management to scaling workloads and streamlining production AI

Solution overview

As organizations embrace artificial intelligence (AI) and machine learning (ML) initiatives, the demand for robust, scalable, and efficient infrastructure solutions has never been greater. At the heart of these initiatives lies the challenge of managing and training increasingly complex AI models while ensuring data security, accessibility, and resource optimization. The evolution of agentic AI and sophisticated model training requirements has created unprecedented demands for computational and storage infrastructure. Organizations must now handle massive datasets, support multiple concurrent training workloads, and maintain high-performance computing environments while ensuring data protection and regulatory compliance. Traditional infrastructure solutions often struggle to meet these demands, leading to

operational inefficiencies and delayed time-to-value for AI projects. This solution offers the following key benefits:

- **Scalability.** The NVIDIA DGX SuperPOD with NetApp AFX 1K storage systems delivers unparalleled scalability through its modular architecture and flexible expansion capabilities. Organizations can seamlessly scale their AI infrastructure by adding DGX compute nodes and AFX 1K storage systems without disrupting existing workloads or requiring complex reconfigurations.
- **Data Management and access.** The NVIDIA DGX SuperPOD with NetApp AFX 1K storage systems is based on NetApp ONTAP that excels in data management through its comprehensive suite of enterprise-grade features. Using ONTAP Snapshot copies and FlexClone, teams can instantly create space-efficient copies of datasets and vector databases for parallel development and testing. FlexCache and SnapMirror replication technologies enable streamlined, space-efficient and automated data pipelines from data sources across the entire data estate from core to edge to cloud, and multi-protocol access to data using NAS and object protocols enables new workflows optimized for ingest and data engineering tasks.
- **Security.** NetApp AFX 1K storage systems deliver enterprise-grade security through multiple layers of protection. At the infrastructure level, the solution implements robust access control mechanisms, including role-based access control (RBAC), multi-factor authentication, and detailed audit logging capabilities. The platform's comprehensive encryption framework protects data both at rest and in transit, utilizing industry-standard protocols and algorithms to safeguard intellectual property and maintain compliance with regulatory requirements. Integrated security monitoring tools provide real-time visibility into potential security threats, while automated response mechanisms help mitigate risks before they can impact operations.

Target audience

This solution is intended for organizations with HPC and AI/ML workloads that require deeper integration into broad data estates and traditional IT infrastructure tools and processes.

The target audience for the solution includes the following groups:

- IT and line of business decision makers planning for the most efficient infrastructure to deliver on AI/ML initiatives with the fastest time to market and ROI.
- Data scientists and data engineers who are interested in maximizing efficiency for critical data-focused portions of the AI/ML workflow.
- IT architects and engineers who need to deliver a reliable and secure infrastructure that enables automated data workflows and compliance with existing data and process governance standards.

Solution technology

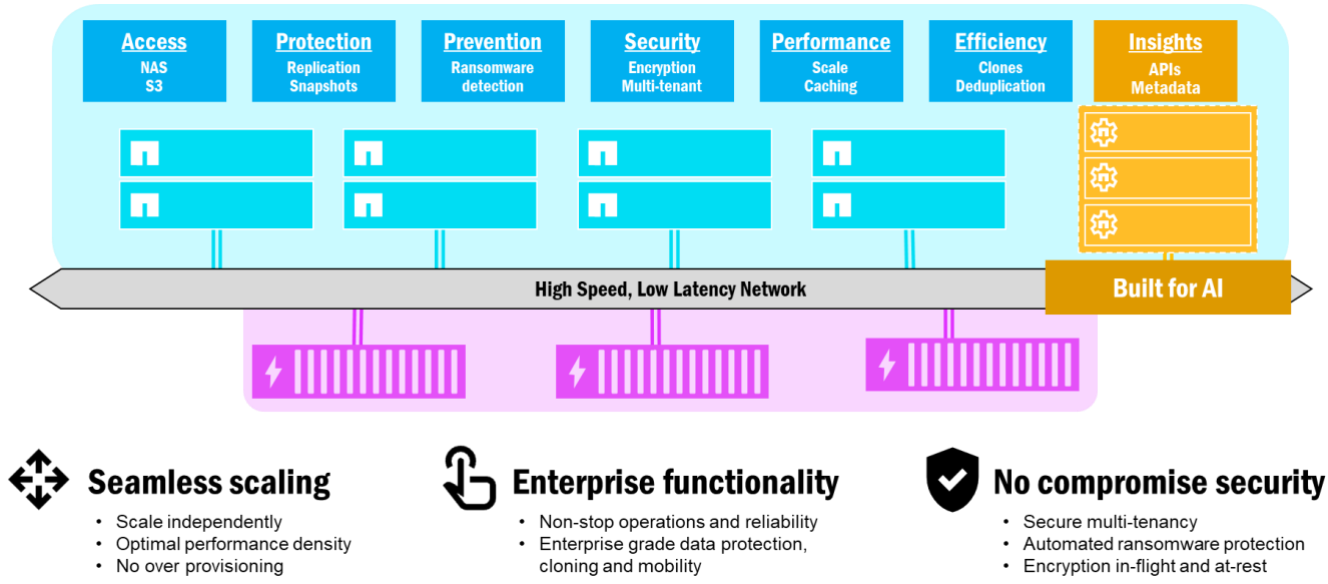
NVIDIA DGX SuperPOD includes the servers, networking and storage necessary to deliver proven performance for demanding AI workloads. NVIDIA DGX™ GB300 and NVIDIA GB300 NVL72 systems provide world-class computing power, and NVIDIA Quantum and Spectrum™ InfiniBand network switches provide ultra-low latency and industry leading network performance. With the addition of the industry-leading data management and performance capabilities of NetApp ONTAP storage, customers can deliver on AI/ML initiatives faster and with less data migration and administrative overhead. The following sections describe the storage components of the DGX SuperPOD with AFX 1K storage systems.

NetApp AFX 1K storage systems with NetApp ONTAP

The NetApp AFX 1K powered by NetApp ONTAP data management software provides built-in data protection, anti-ransomware capabilities, and the high performance, scalability and resiliency required to support the most critical business workloads. It eliminates disruptions to mission-critical operations, minimizes performance tuning, and safeguards your data from ransomware attacks. NetApp AFX 1K systems deliver- NetApp AFX also brings a new disaggregated approach to NAS and object storage to

the ONTAP family, with future potential to add on NetApp data intelligence for RAG workloads. Figure 2 is an example of the NetApp AFX disaggregated architecture.

Figure 2) NetApp AFX disaggregated architecture



NetApp AFX A1K systems with disaggregated ONTAP deliver-

- **Performance.** The AFX A1K easily manages next-generation workloads like deep learning, AI, and high-speed analytics – specifically training and inference workloads, which require both high throughput and flexibility in deployments. With features such as NFS over RDMA (including GPU direct), pNFS and session trunking, customers can achieve the high level of network performance required for next-generation applications using existing data center networking infrastructure and industry-standard protocols with no proprietary software. In addition, Advanced Capacity Balancing enables individual large files (>10GB) to be distributed across every node in the storage cluster, and when combined with pNFS, ONTAP delivers high-performance parallel access to datasets contained in a single large file when accessed by multiple clients.
- **Independent scale.** What makes the NetApp AFX 1K unique across the ONTAP portfolio is its ability to present NAS and object storage to clients while providing independent scale of storage controllers and capacity. AFX has the ability to increase node count that can provide greater CPU, network bandwidth, and RAM to workloads nondisruptively while maintaining the same capacity footprint, which reduces management overhead, disk cost, datacenter rental fees, power, cooling and more. With an increased ratio of *nodes:shelves* made possible by AFX, drive performance can now be fully utilized by nodes without leaving any available performance on the table.
- **Intelligence.** Accelerate digital transformation and eliminate data silos with an AI-ready ecosystem built on data-driven intelligence, future-proof infrastructure, and deep integrations with NVIDIA and the MLOps ecosystem. Using ONTAP Snapshot copies and FlexClone, teams can instantly create space-efficient copies of datasets for parallel development and testing. FlexCache and SnapMirror replication technologies enable streamlined, space-efficient and automated data pipelines from data sources across the enterprise. And multi-protocol access to data using NAS and object protocols enables new workflows optimized for ingest and data engineering tasks. Customers can seamlessly manage, protect, and mobilize data, at the lowest cost, across hybrid clouds with a single storage OS and the industry's richest data services suite.
- **Security.** The NVIDIA DGX SuperPOD with NetApp AFX delivers enterprise-grade security through multiple layers of protection. At the infrastructure level, the solution implements robust access control mechanisms, including role-based access control (RBAC), attribute-based access control (ABAC), multi-factor authentication, and detailed audit logging capabilities. The platform's comprehensive

encryption framework protects data both at rest and in transit, utilizing industry-standard protocols and algorithms to safeguard intellectual property and maintain compliance with regulatory requirements. Integrated security monitoring tools provide real-time visibility into potential security threats, while automated response mechanisms help mitigate risks before they can impact operations. NetApp ONTAP is the only hardened enterprise storage that's validated to store top-secret data.

- **Multitenancy**. NetApp ONTAP delivers the widest array of features to enable secure multitenant usage of storage resources. Storage Virtual Machines provide tenant-based administrative delegation with RBAC controls, comprehensive QoS controls guarantee performance for critical workloads while enabling maximum utilization, and security features such as tenant-managed keys for volume-level encryption guarantee data security on shared storage media.
- **Reliability.** NetApp eliminates disruptions to mission-critical operations through advanced reliability, availability, serviceability, and manageability (RASM) capabilities, delivering the highest uptime available. For more information see the ONTAP RASS whitepaper. In addition, system health can be optimized with AI-based predictive analytics delivered by Active IQ and Data Infrastructure Insights.
- **Simplified storage operations.** NetApp AFX simplifies storage management by presenting all capacity to all nodes in the cluster as a single pool of storage. This removes data silos (such as aggregates) and provides a unified view of all capacity available in a cluster, as well as offering automated zero-copy volume moves across node resources for better performance balancing and more even performance results across node failovers. Larger RAID groups (up to 93 data, 3 parity) with the use of RAID-TEC, offer more efficient use of disk resources and increased performance across workloads, while RAID management is all handled by the storage OS.
- **Familiarity.** NetApp AFX is "still ONTAP" at its core, despite its new architecture. All of the same commands, GUI interaction, REST APIs, reliability, and feature robustness customers have come to expect from NetApp ONTAP remains intact with AFX. In addition, migrating between AFX and unified ONTAP uses the same familiar technologies, such as SnapMirror, SVM DR, and SVM migrate. NetApp AFX delivers next-generation performance and scalability while delivering the same ONTAP experience that enterprise customers have come to rely on for every workload.

NVIDIA DGX GB300 systems

DGX GB300 systems are purpose-built to deliver extreme performance and consistent uptime for superscale generative AI training and inference workloads. Built on NVIDIA's own internal cluster designs, the full-stack resilience capabilities—available for the first time in enterprise AI infrastructure—allow enterprises to focus on innovation rather than operational complexity. With scalability up to tens of thousands of GPUs, the efficient liquid-cooled rack-scale design leverages NVIDIA Grace Blackwell Superchips to tackle the state-of-the-art AI models needed for today's advanced generative AI applications.

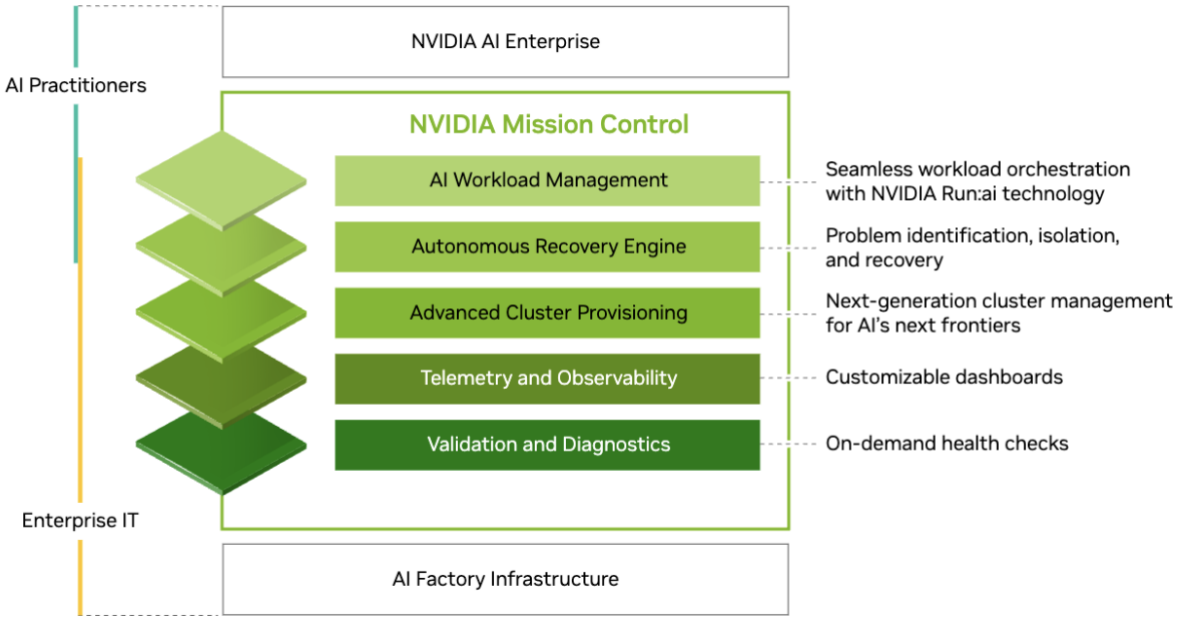
NVIDIA Spectrum SN5600 Ethernet switches

The SN5600 smart-leaf, spine, and super-spine switch offers 64 ports of 800GbE in a dense 2U form factor. The SN5600 enables both standard leaf/spine designs with top-of-rack (ToR) switches as well as end-of-row (EoR) topologies. The SN5600 offers diverse connectivity in combinations of 1 to 800GbE and boasts an industry-leading total throughput of 51.2Tb/s.

NVIDIA Mission Control software

NVIDIA Mission Control powers every aspect of AI factory operations — from developer workloads to infrastructure to facilities — with the skills of a world-class operations team delivered as software. It powers NVIDIA Blackwell and NVIDIA Rubin data centers for the newest frontiers of AI, brining instant agility to inference and training workloads and full-stack intelligence that delivers world-class infrastructure resiliency. Mission Control lets every enterprise run AI with hyperscale-grade efficiency so you can accelerate AI experimentation.

Figure 3) NVIDIA Mission Control Software.



Use case summary

NVIDIA DGX SuperPOD is designed to meet the performance requirements of the most demanding workloads at the largest scale.

This solution applies to the following use cases:

- Machine learning at massive scale using traditional analytics tools.
- Artificial intelligence model training for Large Language Models, computer vision/image classification, fraud detection and countless other use cases.
- High performance computing such as seismic analysis, computational fluid dynamics and large-scale visualization.

Solution Architecture

NVIDIA DGX SuperPOD™ provides leadership-class AI infrastructure for creating an AI factory, with agile, scalable performance for the most challenging AI training and inference workloads. It's not just a collection of hardware, but a full-stack data center platform that includes industry-leading computing, storage, networking, software, and infrastructure management optimized to work together and provide maximum performance at scale.

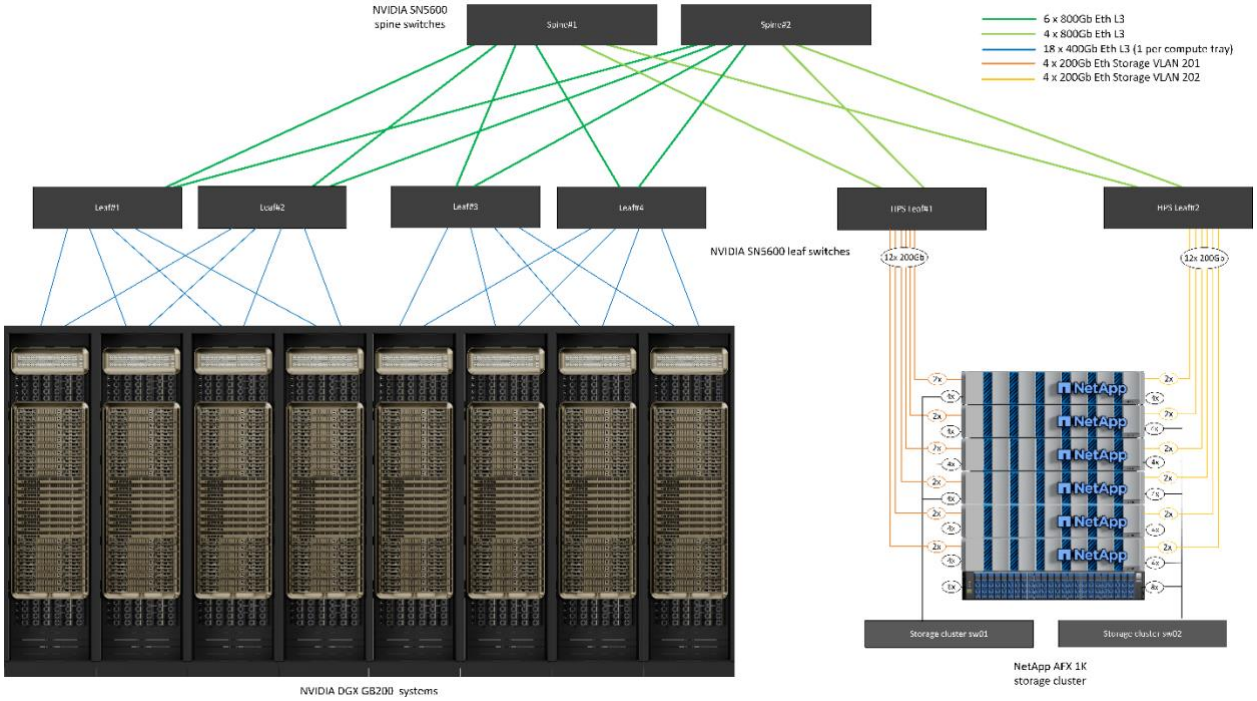
DGX SuperPOD is based on the concept of a Scalable Unit (SU) that includes 8 DGX GB300 systems and all of the other components necessary to deliver the required connectivity and eliminate any performance bottlenecks in the infrastructure. Customers can start with a single or multiple SUs and add additional SUs as needed to meet their requirements. This document describes the storage configuration for a single SU, and Table 1 shows the components needed for larger configurations.

The DGX SuperPOD reference architecture includes multiple networks, and the AFX 1K storage system is connected to several of them. For more information about DGX SuperPOD networking please refer to the NVIDIA DGX SuperPOD Reference Architecture.

For this solution the high-performance storage fabric is an Ethernet network based on the NVIDIA Spectrum SN5600 switch with 64 800GbE ports in a Spine/Leaf configuration. The In-band network provides user access for other functions such as home directories and general file shares and is also based on SN5600 switches, and the out of band (OOB) network is for device-level system administrator access using SN2201 switches.

The storage fabric is a leaf-spine architecture where the DGX systems connect to one pair of leaf switches and the storage system connects to another pair of leaf switches. Multiple 800GbE ports are used to connect each leaf switch to a pair of spine switches, creating multiple high-bandwidth paths through the network for aggregate performance and redundancy. For connectivity to the AFX 1K storage system, each 800GbE port is broken into four 200GbE ports using the appropriate copper or optical breakout cables. To support clients mounting the storage system with NFS over RDMA the storage fabric is configured for RDMA over Converged Ethernet (RoCE), which guarantees lossless packet delivery in the network. shows the storage network topology of this solution.

Figure 4) Storage fabric topology.

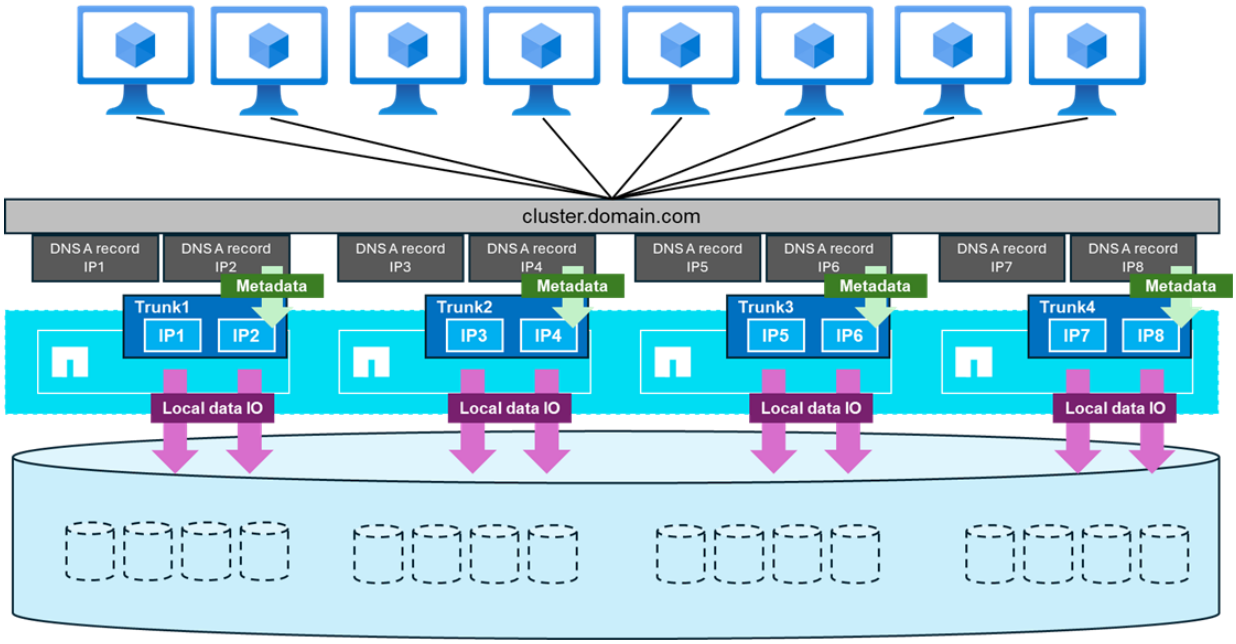


The NetApp AFX 1K storage system is a 2RU chassis containing 1 controller that pairs with another controller in the cluster for high availability (HA Pair). Each controller is connected through a back end network to external disk shelves that are shared by all controllers in the cluster. Each controller is also connected to both the SN5600 storage leaf switches using four 200Gb Ethernet connections, and there are 2 logical IP interfaces on each physical port. The storage cluster supports NFS v4.1 with Parallel NFS (pNFS) that enables clients to establish connections directly to every controller in the cluster. Additionally, session trunking combines the performance from multiple physical interfaces into a single session, enabling even single-threaded workloads to access more network bandwidth than is possible with traditional ethernet bonding. Combining all of these features with RDMA enables the AFX 1K storage system to deliver low latency and high throughput that scales linearly for workloads leveraging NVIDIA Magnum IO™ GPUDirect® Storage

For connectivity to the in-band network the AFX 1K controllers have additional 200Gb Ethernet interfaces configured in a LACP interface group providing general NFS v3 and v4 services as well as S3 access to shared filesystems if desired. All controllers and storage cluster switches are connected to the OOB network for remote administrative access.

To enable high performance and scalability, the storage controllers form a storage cluster that enables the entire performance and capacity of the cluster nodes to be combined into a single namespace called a FlexGroup with data distributed across the disks of every node in the cluster. With the new Advanced Capacity Balancing (ACB) feature released in ONTAP 9.16.1, individual files are separated and distributed across the FlexGroup to enable the highest levels of performance for single-file workloads. Figure 5 shows how pNFS and NFS session trunking work together with FlexGroup volumes and ACB to enable parallel access to large files leveraging every network interface and disk in the storage system.

Figure 5) pNFS, session trunking, FlexGroups and ACB.



This solution leverages multiple Storage Virtual Machines (SVM) to host volumes for both high-performance storage access as well as user home directories and other cluster artifacts on a management SVM. Each SVM is configured with network interfaces and FlexGroup volumes and QoS policies are implemented to ensure performance for the SVM. For more information on FlexGroup volumes, Storage Virtual Machines and ONTAP QoS capabilities please refer to the ONTAP documentation.

Hardware Requirements

Tables 1 lists the storage hardware components that are required to implement one, two, four or eight scalable units at the enhanced performance level. For detailed hardware requirements for servers and networking please see the NVIDIA DGX SuperPOD Reference Architecture.

Table 1) Hardware requirements for standard performance

SU Size	AFX 1K controllers	NX224 disk chassis	Storage Cluster Interconnect switches	Usable capacity (typical with 15TB SSD)	Max useable capacity (with 15.3TB NVMe SSD)	RU (typical)	Power (typical)
1	4	1	2	300TB	3.2PB	12	6.2
2	8	2	2	600TB	3.2PB	22	12.3
4	16	4	2	1.2PB	6.4PB	42	24.1
8	32	8	2	2.4PB	12.8PB	82	48.2

NOTE: NetApp AFX systems require 24 disks per NX224 chassis. Lower and higher capacity drives are available, and additional NX224 chassis can be added up to a maximum of 8 chassis per cluster.

Table 2) Hardware requirements for enhanced performance

SU Size	AFX 1K controllers	NX224 disk chassis	Storage Cluster Interconnect switches	Usable capacity (typical with 15TB SSD)	Max useable capacity (with 15.3TB NVMe SSD)	RU (typical)	Power (typical)
1	14	3	2	1.2PB	3.2PB	36	21.3
2	28	6	2	2.4PB	3.2PB	72	42.6
4	56	10	4	4.8PB	6.4PB	144	85.2
8	112	20	8	9.2PB	12.8PB	288	170.4

Software requirements

Table 2 lists the software components and versions that are required to integrate the AFX 1K storage system with DGX SuperPOD. DGX SuperPOD also involves other software components that are not listed here. Please refer to the DGX SuperPOD release notes for complete details.

Table 3) Software requirements.

Software	Version
NetApp ONTAP	9.18.1 or newer
NVIDIA Mission Control	2.1.0 or newer
NVIDIA DGX OS	7.2.1 or newer
NVIDIA OFED driver	MLNX_OFED_LINUX-24.10-3.2.5 LTS
NVIDIA Cumulus OS	5.11

Solution verification

This storage solution was validated in multiple stages by NetApp and NVIDIA to ensure that performance and scalability meet the requirements for NVIDIA DGX SuperPOD. The configuration was validated using

a combination of synthetic workloads and real-world ML/DL workloads to verify both maximum performance and application interoperability. Table 3 below provides examples of typical workloads and their data requirements that are commonly seen in DGX SuperPOD deployments.

Table 4) SuperPOD workload examples.

Level	Work Description	Data Set Size
Standard	Multiple concurrent LLM or fine-tuning training jobs and periodic checkpoints, where the compute requirements dominate the data I/O requirements significantly.	Most datasets can fit within the local compute systems' memory cache during training. The datasets are single modality, and models have millions of parameters.
Enhanced	Multiple concurrent multimodal training jobs and periodic checkpoints, where the data I/O performance is an important factor for end-to-end training time.	Datasets are too large to fit into local compute systems' memory cache requiring more I/O during training, not enough to obviate the need for frequent I/O. The datasets have multiple modalities and models have billions (or higher) of parameters.

Table 4 shows performance guidelines for the example workloads above. These values represent the storage throughput that can be generated by these workloads under ideal conditions. The configurations shown in this document meet or exceed the Enhanced values shown below.

Table 5) DGX SuperPOD performance guidelines.

Performance Characteristic	Standard (GBps)	Enhanced (GBps)
Single SU aggregate system read	90	280
Single SU aggregate system write	45	140
4 SU aggregate system read	360	1120
4 SU aggregate system write	180	560

Conclusion

The NVIDIA DGX SuperPOD with NetApp AFX 1K storage systems represents a significant advancement in AI infrastructure solutions. By addressing key challenges around security, data management, resource utilization, and scalability, it enables organizations to accelerate their AI initiatives while maintaining operational efficiency, data protection, and collaboration. The solution's integrated approach eliminates common bottlenecks in AI development pipelines, enabling data scientists and engineers to focus on innovation rather than infrastructure management.

Where to find additional information

To learn more about the information that is described in this document, review the following documents and/or websites:

- NVA-1175 NVIDIA DGX SuperPOD with NetApp AFF A90 Storage Systems Deployment Guide
- NVIDIA DGX B300 Datasheet
- NVIDIA DGX SuperPOD with NVIDIA DGX B200 Reference Architecture
- NVIDIA DGX SuperPOD with NVIDIA DGX H200 Reference Architecture
- NVIDIA Mission Control
- NVIDIA Spectrum SN5600 Ethernet switches
- NVIDIA DGX SuperPOD release notes
- NetApp Documentation

- NetApp AI Solutions Documentation
- NetApp ONTAP software
- NetApp Install and Maintain AFF Storage Systems
- NFS over RDMA
- What is pNFS (older doc with great pNFS info)

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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