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IBM Storage FlashSystem 9500 Product Guide: Updated for IBM Storage Virtualize 8.7

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IBM Storage FlashSystem 9500 Product Guide

This IBM® Redpaper Product Guide describes the IBM Storage FlashSystem 9500 (IBM FlashSystem 9500) solution, which is a next-generation IBM FlashSystem® control enclosure. Leveraging IBM FlashCore® technology and Non-Volatile Memory Express (NVMe) architecture, it delivers high performance, reliability, and data protection. Ideal for AI, big data analytics, and cloud environments, the 9500 helps enterprises overcome resource constraints and maximize existing investments.

The IBM FlashSystem 9500 also provides a rich set of software-defined storage (SDS) features that are delivered by IBM Storage Virtualize, including the following features:

- Data reduction and deduplication
- Dynamic tiering
- Thin provisioning
- Snapshots
- Cloning
- Data copy services
- Transparent Cloud Tiering
- Policy-based replication and policy-based high availability (policy-based HA)
- Ransomware Threat Detection

Scale-out and scale-up configurations further enhance capacity and throughput for better availability.

Note: This guide explores the IBM FlashSystem 9500's hardware features and the new features offered by IBM Storage Virtualize 8.7. For more information on IBM Storage Virtualize 8.7 features refer to IBM Storage Virtualize for SAN Volume Controller and FlashSystem Family Getting Started Guide.

Benefits

The IBM FlashSystem 9500 delivers a powerful combination of performance, security, and cost-efficiency for modern businesses. The following are its key benefits:

- **High performance:** NVMe technology and IBM FlashCore Modules provide exceptional speed, enabling faster application response times and smoother data processing. This translates to quicker task completion and improved user experience.
- **Enhanced security:** The FlashSystem 9500 prioritizes data protection.

Features like IBM Safeguarded Snapshot safeguard your valuable information from cyberattacks and ransomware threats by creating isolated, immutable copies. This ensures data integrity and minimizes downtime in case of breaches.

- **Cost-effectiveness:** Data reduction technologies like built-in hardware data compression and data tiering pools significantly reduce storage requirements. This translates to lower storage costs without sacrificing performance. Additionally, the FlashSystem 9500 offers flexible capacity options, allowing you to scale storage as your needs evolve.
- **Simplified management:** Built on IBM Storage Virtualize software, the FlashSystem 9500 offers centralized management for all your storage systems. AI-driven automation streamlines data tiering and simplifies storage administration, freeing up IT resources for other tasks.
- **Hybrid cloud ready:** The FlashSystem 9500 seamlessly integrates with hybrid cloud environments. This allows you to manage data across on-premises and cloud storage, providing greater flexibility and scalability for your IT infrastructure.

Placing your IBM FlashSystem 9500 in your infrastructure

Various possible use cases are available for the IBM FlashSystem 9500. All of which can address many technical or business requirements. In addition, the FlashSystem 9500 can be used to simplify the overall storage architecture.

The FlashSystem 9500 can be used in the following scenarios:

- First tier storage repository for production data.
- Primary or target system for data replication or disaster recovery (DR).
- HA storage within a policy-based high availability configuration (where two FlashSystem 9500s are in a synchronous replication relationship).
- Externally virtualizing IBM or non-IBM storage by using IBM Storage Virtualize, which extends advanced functions (such as data reduction, encryption, and replication) to those storage subsystems.
- Data migration from IBM or non-IBM storage with IBM Storage Virtualize.
- Hybrid cloud storage by:
  - Enabling communication between an on-premises deployment of IBM Storage Virtualize and IBM Storage Virtualize for Public Cloud.
  - Deploying the Container Storage Interface (CSI) driver for Red Hat OpenShift Container Platform to provide persistent storage for on-premises or cloud-based containerized applications.
  - Using transparent cloud tiering to convert data into an object store for back up to certain available cloud instances.
- Support and interoperability within the IBM Storage Software Suite, including:
  - IBM Storage Scale where the FlashSystem 9500 can be used as the back-end storage repository for metadata, primary data, or in initial microprogram load (IML) processing.
  - IBM Storage Protect and IBM Storage Protect Plus where the FlashSystem 9500 can be used as cache or data repository.
- IBM Copy Data Management where the FlashSystem 9500 can be used as cache or a copy services target.

Figure 1 shows an IBM FlashSystem 9500 that is fully deployed in a hybrid multicloud environment in which it is also externally virtualizing various on-premises storage subsystems.

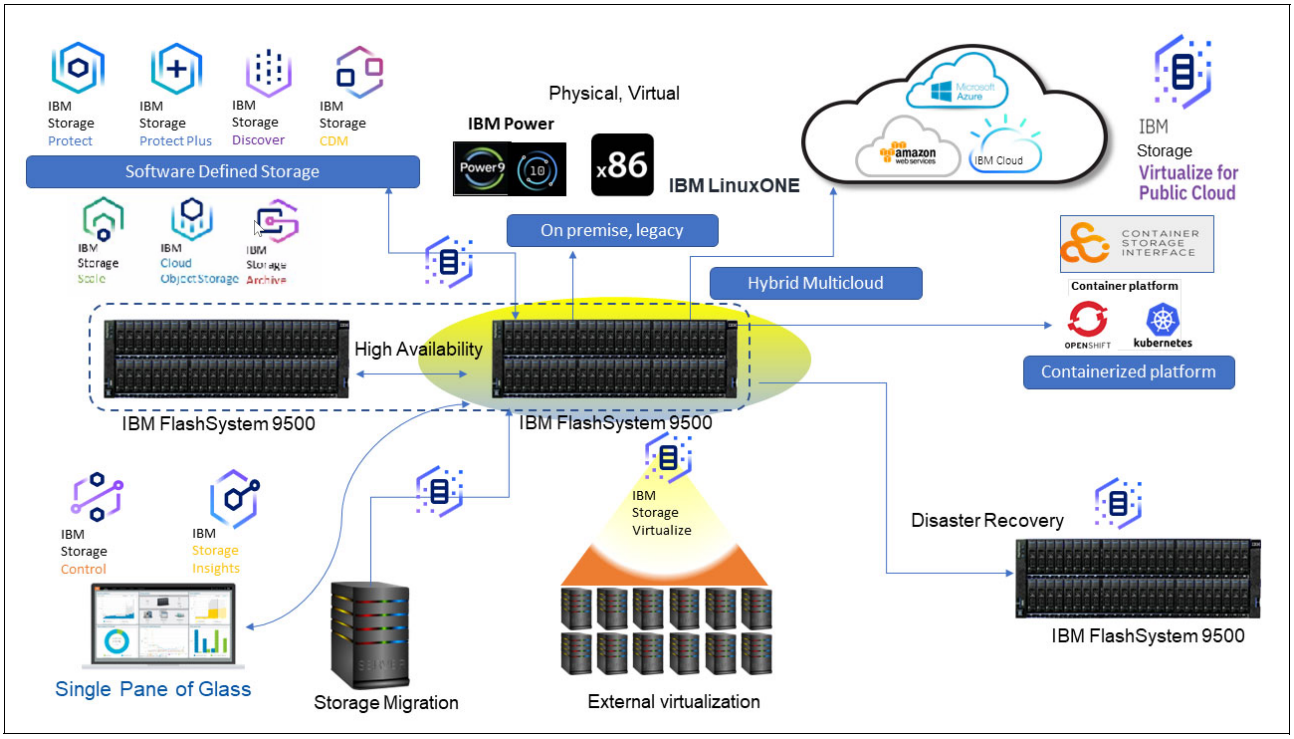

Figure 1 Fully deployed IBM FlashSystem 9500 sample scenario

The IBM FlashSystem 9500 can support multiple Open System hosts and interoperability with all of the software from the IBM Storage Suite of products.

In this scenario, the IBM FlashSystem 9500 provides the following benefits:

- Investment protection of established storage by using IBM Storage Virtualize to migrate from older storage subsystems and externally virtualize existing heterogeneous storage.
- A hybrid multicloud architecture by connecting to IBM Storage Virtualize for Public Cloud, which is available in Amazon S3, OpenStack Swift, Microsoft Azure, and IBM Cloud.
- Data protection by extending HA and DR to heterogeneous storage that is externally virtualized.
- Support for containerized workloads by interfacing with Red Hat OpenShift and Kubernetes for on-premises and off-premises infrastructures.
- Ease of management and seamless integration with the IBM Storage Insights and all the products in the IBM Storage Software Suit.

IBM FlashSystem 9500 enclosures overview

The IBM FlashSystem 9500 system features the following types of enclosures:

- A *control enclosure* manages your storage systems, communicates with the host, and manages interfaces. In addition, it can house up to 48 NVMe-capable flash drives.

These drives can be industry-standard NVMe types or the exclusive IBM FlashCore Module (FCM) NVMe type or up to 12 optional Storage Class Memory (SCM) type drives. A control enclosure contains 2 node canisters which form an *I/O group*.

- An *expansion enclosure* increases the available capacity of an IBM FlashSystem 9500 cluster. It communicates with the control enclosure through a dual pair of 12 Gbps serial-attached SCSI (SAS) connections. This enclosure can house many of the flash (SSDs) SAS type drives, depending on which model of enclosure is ordered. FCM's are not permitted in any of the SAS Expansion Enclosures.

Figure 2 shows the IBM FlashSystem 9500 control enclosure front view where you can see the 48 NVMe drives in two rows of 24 drives.

Note: There are new rules for the plugging of the NVMe drives in the control enclosure. See “IBM FlashSystem 9500 NVMe drive options” on page 24.

Figure 2 IBM FlashSystem 9500 control enclosure front view

Control enclosures

Each control enclosure can have multiple attached expansion enclosures, which expand the available capacity of the entire system. The IBM FlashSystem 9500 solution supports up to two control enclosures and up to two chains of SAS expansion enclosures per control enclosure.

Note: At the time of writing, there was a change in the machine type (MT) and model numbers because of the implementation of Expert Care. MT 4666 is still available through restricted ordering.

The IBM FlashSystem 9500 control enclosure supports up to 48 NVMe-capable flash drives in a 4U high form factor and consists of the following machine types and models:

- 4666-AH8: IBM FlashSystem 9500 control enclosure
- 4983-AH8: IBM FlashSystem 9500 control enclosure with Expert Care
- 4666-UH8: IBM FlashSystem 9500 control enclosure utility model

Notes:

- IBM Storage FlashSystem 9500, MT 4666, requires IBM Storage Virtualize Software for IBM Storage FlashSystem 9500 8.5.0, or later, for operation. Use of the software is entitled through the acquisition of IBM Storage Virtualize software licenses. IBM Storage FlashSystem 9500 system function capabilities are provided through IBM Storage Virtualize software. The software is licensed through IBM Storage Virtualize Software for FlashSystem 9500 (SW PID 5639- 011) for control enclosures and IBM Storage Virtualize Software for FlashSystem 9000 Expansions (SW PID 5639-EB2) for expansion enclosures. A three-month registration for software maintenance (SWMA) for 5639-012 is required if IBM Storage Expert Care is not ordered with the system.
- The 4666 UH8 model is an IBM FlashSystem 9500 solution with a 1-year warranty, optional Storage Expert Care service offerings, and is a 4666 offered in the Storage Utility Offering space. This model is physically and functionally identical to the IBM FlashSystem 4666 AH8 model, except for target configurations and variable capacity billing.
- The variable capacity billing uses IBM Storage Control or IBM Storage Insights to monitor the system usage, which allows allocated storage usage above a base subscription rate to be billed per terabyte per month. Allocated storage is storage that is allocated to a specific host and unusable to other hosts, whether or not data is written. For thin-provisioning, the data that is written is considered used. For thick-provisioning, the total allocated volume space is considered used.
- IBM Storage FlashSystem 9500, MT 4983, requires IBM Storage Virtualize Software for IBM Storage FlashSystem 9500 8.7.0, or later, for operation. Because the 4983 uses Licensed Internal Code (LIC), all licenses are included except encryption and external virtualization.

Each IBM FlashSystem 9500 control enclosure includes the following features:

- Two node canisters, each with two 24-core processors and options for up to 1.5 GB memory to deliver a system total of 3 TB memory.
- Up to 12 (six per canister) I/O adapter cages to add PCIe adapter features:
  - Four-port 32 Gbps FC-NVMe card
  - Four-port 64 Gbps FC-NVMe card (only 3 adapters per canister supported)
  - Two-port 25 Gbps Ethernet iSCSI or iSCSI Extensions for RDMA
  - Two-port 25 Gbps Ethernet iSCSI and policy-based high availability over iWARP (RPQ only) card
  - Two-port 100 Gbps Ethernet iSCSI and NVMe RDMA card
  - 12 Gbps SAS ports for expansion enclosure attachment
- Support for up to 48 NVMe flash or FCM drive options.
- Hot-swappable batteries, boot drives, and AC power supplies.
- 4U, 19-inch rack mounted enclosure.

Expansion enclosures

The IBM FlashSystem 9000 expansion enclosures consist of the following machine types and models:

- 4666 model AFF small form factor (SFF)
- 4983 model AFF small form factor (SFF)
- 4666 model A9F large form factor (LFF)
- 4983 model A9F large form factor (LFF)

The new SAS-based SFF and LFF expansion enclosures support flash SSDs as MDisks in a storage pool, which can be used for IBM Easy Tier. The following expansion enclosure models are available:

- IBM FlashSystem 9000 SFF Expansion Enclosure Model AFF offers drive options with up to 24 2.5-inch SSD flash drives. Up to 72 drives in three AFF SAS expansion enclosures are supported per IBM FlashSystem 9500 per SAS chain. The AFF expansion enclosure is 2U high.
- IBM FlashSystem 9000 LFF Expansion Enclosure Model A9F offers drive options with up to 92 3.5-inch (and 2.5-inch drives in carriers) SSD flash drives. The model A9F SAS expansion enclosure supports up to 92 drives per IBM FlashSystem 9500 Expansion enclosure per SAS chain.

SAS chain limitations

When you attach expansion enclosures to the control enclosure, you are not limited by the type of the enclosure. The only limitation for each of the two SAS chains is its chain weight. The IBM FlashSystem 9500 supports a maximum SAS chain weight of 3. Each type of enclosure has its own chain weight:

- IBM FlashSystem 9000 Expansion Enclosure Model AFF has a chain weight of 1.
- IBM FlashSystem 9000 Expansion Enclosure Model A9F has a chain weight of 2.5.

For example, with the IBM FlashSystem 9500, you can have three IBM FlashSystem 9000 Expansion Enclosure Model AFF, or you can have one IBM FlashSystem 9000 Expansion Enclosure Model A9F expansion per SAS chain.

Note: A 5U expansion enclosure cannot be mixed with 2U expansion enclosures on the same chain.

For more information about Enclosures, see Enclosures.

For more information about configuration limits, see V8.7.0.x Configuration Limits for IBM FlashSystem 9500.

IBM FlashSystem 9500R rack

The FlashSystem 9500R rack offering is a product that is preassembled, installed, and configured by IBM that contains the following components:

- A pair of clustered IBM FlashSystem 9500 Control Enclosures Models AH8, which can be specified by ordering a IBM FlashSystem 9502R.
- Two 32G Gbps FC switches for dedicated FC clustered network.

Other components, such as IBM FlashSystem 9000 Expansion Enclosure Models AFF and A9F, can be added to the rack after delivery to meet the growing needs of the business.

Figure 3 shows the legend that is used to denote the component placement and mandatory gaps for the figures that show the configurations.

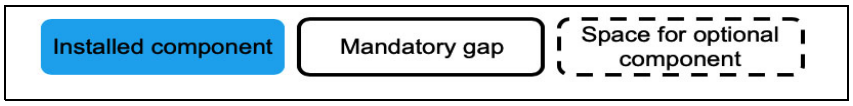

Figure 3 9500R component placement legend

Figure 4 shows the layout of the components in the IBM FlashSystem 9500R rack enclosure and the positions that are assigned for the option expansion enclosures.

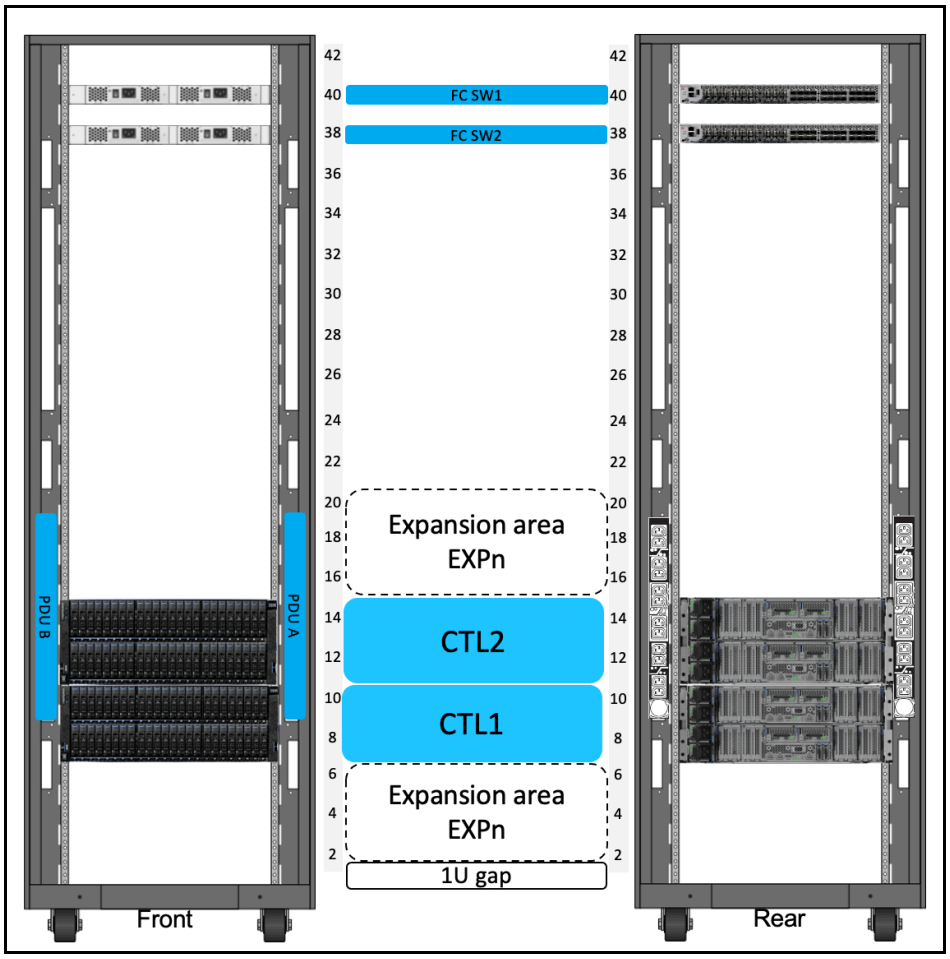

Figure 4 IBM FlashSystem 9500R rack enclosure

Features of IBM FlashSystem 9500

IBM Storage Virtualize 8.7 delivers support for IBM FlashSystem 9500 machine type 4666-AH8, the new 4983-AH8 and utility model 4666-UH8.

This release provides the advanced software functions of IBM Storage Virtualize software to FlashSystem 9500. and includes the following features:

- Control enclosure support for SSDs, including up to 48 industry 2.5-inch SFF standard NVMe drives and IBM FlashCore Modules and up to 12 SCM drives.

  The following NVMe drives are supported:

  - 2.5-inch SFF 4.8 TB, 9.6 TB, 19.2 TB, or 38.4 TB IBM FlashCore Module NVMe drives
  - 1.92 TB, 3.84 TB, 7.68 TB, 15.36 TB, or 30.72 TB industry-standard drives
  - A mixture of both
  - Storage Class Memory drives of 1.6 TB
- Autonomic tiering through Easy Tier, which enables workload data to be placed on the most suitable storage media (various classes of NVMe for the control enclosure and HDDs and commodity SSDs for the expansion enclosures and externally virtualized storage).
- Hardware-based data reduction and encryption from the IBM FlashCore Modules with negligible impact on system performance.
- Scale-out capacity options with the 12 Gbps SAS-attached model A9F and AFF expansion enclosures.
- Software-based AES-256 data-at-rest encryption and key management through IBM Security® Guardium® Key Lifecycle Manager or USB key encryption. Up to four IBM Security Guardium Key Lifecycle Manager key servers are supported.
- Remote support assistance (RSA), which enables IBM support personnel to access the system to complete troubleshooting tasks.
- High availability (HA) solutions such as policy-based HA.
- Cyber resiliency with Safeguarded Snapshot, which provides rapid ransomware recovery by using immutable, untouchable snapshots that are based on FlashCopy technology.
- Multiple management modes by using a graphical user interface (GUI) or a Linux-based command-line interface (CLI).
- Performance throttling that allows control of used resources when the system is processing host I/O, advanced functions, or copy services.
- Transparent cloud tiering (TCT), which enables a FlashCopy volume that can be backed up to an S3 object store, such as AWS or IBM Cloud.
- Support for 32 / 64 Gbps FC and 10 or 25 Gbps Ethernet or 100 Gbps Ethernet iSCSI and NVMe RDMA connectivity. The ability to intermix these port options is also supported.
- Simplified connectivity by using portsets, which enable host connectivity ports to be grouped for more effective zoning and management.
- Easier access and compatibility with IBM Storage Insights, which offers advanced performance monitoring for one or more IBM FlashSystem 9500 storage systems.
- Additional access security by using multi-factor authentication.

In addition to the base warranty, the IBM FlashSystem 9500 offers IBM Storage Expert Care with two levels of support options. Either IBM Storage Expert Care Advanced 1-5 years or IBM Storage Expert Care Premium 1-5 years.

For more information on IBM Storage Virtualize features refer to IBM Storage Virtualize for SAN Volume Controller and FlashSystem Family Getting Started Guide.

Also, refer to the IBM Redbooks *Unleash the Power of Flash: Getting Started with IBM Storage Virtualize Version 8.7 on IBM Storage FlashSystem and IBM SAN Volume Controller*, SG24-8561.

What is new with IBM Storage Virtualize 8.7.0

In this section we discuss several important features that are available with IBM Storage Virtualize 8.7.0. For a complete list of the new features see IBM Documentation What's new in Version 8.7.

Policy-based high availability for IBM FlashSystem 9500

Policy-based HA for IBM FlashSystem 9500 is available with IBM Storage Virtualize 8.7.0 and later. This ensures continuous application data access even in case of primary storage system failures. Policy-based HA maintains synchronized data copies on a peer system, allowing applications to access data from either system. This active/active solution enables simultaneous I/O to both copies while maintaining data synchronization. Synchronous replication guarantees data consistency between production volumes. Volume groups manage consistency across application-dependent volumes. Storage partitions facilitate easy management of highly available resources by grouping related volume groups, hosts, and mappings. To prevent conflicts, IP Quorum determines the active management system. You can flexibly add or modify volumes, volume groups, hosts, and mappings within existing partitions or create new ones. See Figure 5.

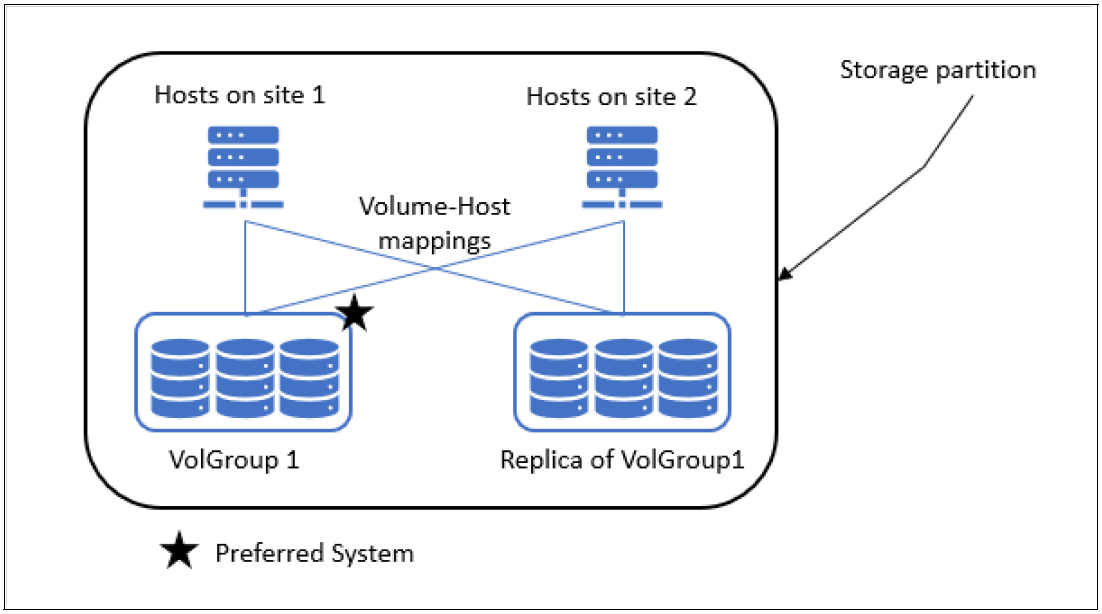

Figure 5 Storage partitions

Storage partitions simplify HA management by automating host mapping to volume group replicas across both systems. Hosts seamlessly access volumes with identical UIDs. To maintain consistency, HA replicates not only data but also storage partition configurations, including host definitions and mappings. Configuration changes are typically managed on the preferred system and synchronized to both. The preferred system is usually the system where the partition is managed and remains accessible during disconnections.

Hosts can access volumes through the preferred system or, if host locations are set, directly from the local storage system. Volume groups, storage partitions, and policies are centrally managed on the active management system, which can fail over in case of an outage. Local hosts automatically switch to the remote system using ALUA multipathing during local site failures.

For more information on policy-based HA refer to *Ensuring Business Continuity: A Practical Guide to Policy-Based Replication and Policy-Based High Availability for IBM Storage Virtualize Systems,* SG24-8569.

IBM Flash Grid

IBM Storage Virtualize, with storage partitions and volume groups, separates business continuity requirements like HA and replication from hardware systems, enabling multiple software-defined virtual storage systems within a single FlashSystem deployment. Flash Grid empowers users to create federated, scalable clusters of independent storage devices, surpassing traditional scale-out limitations. It offers linear performance, capacity, and resource growth with up to eight systems.

Unlike previous "per I/O group" clustering, Flash Grid focuses on system-level scale-out, simplifying management and reducing hardware compatibility constraints. This approach enables easier hardware replacement, capacity balancing, and non-disruptive application data migration through storage partition migration. Clients can aggregate IBM FlashSystem or SVC systems into a single, highly available, manageable storage grid.

Once storage partitions are configured, they can easily be moved from a system to another, manually balanced by users over several systems and sites. They can also be stretched over two sites for high availability. See Figure 6. At the time of this writing, Flash Grid features (partitions mobility) are manageable with IBM Storage Insights Pro only.

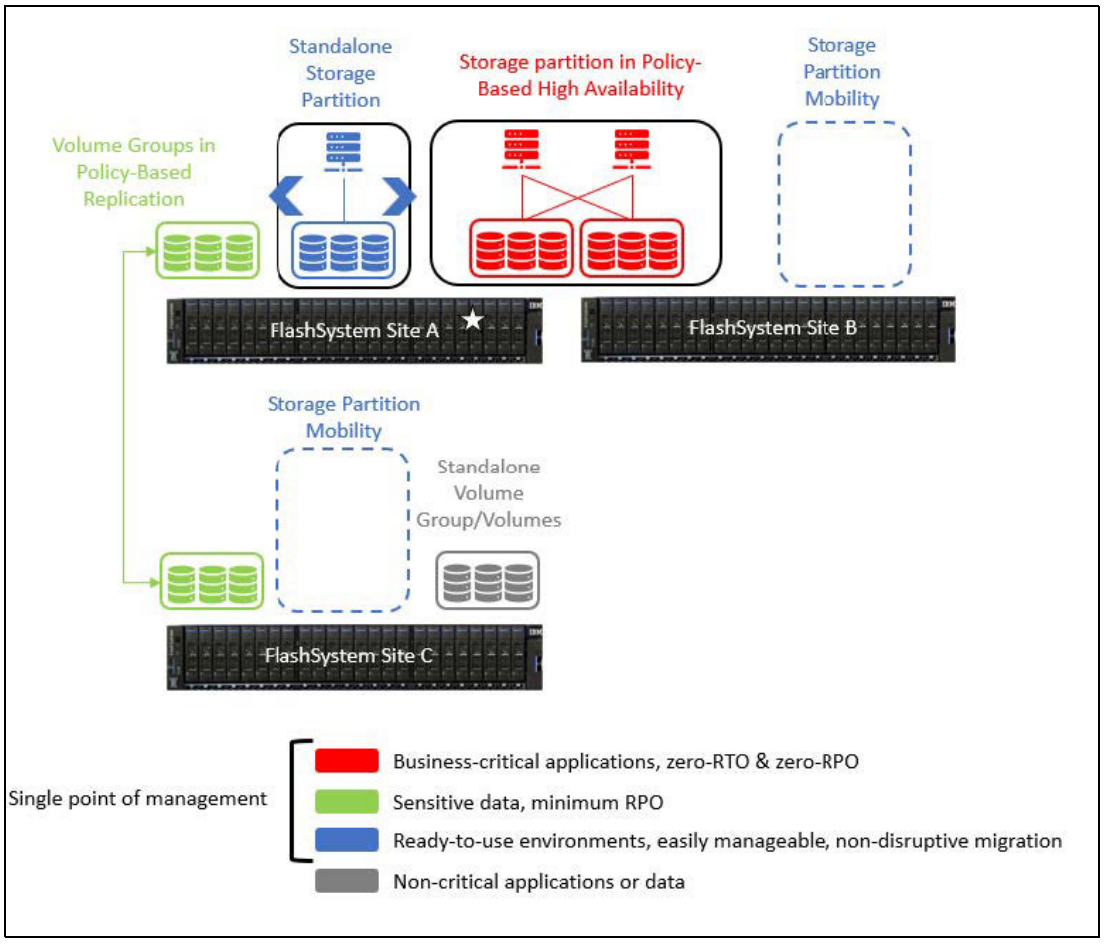

Figure 6 IBM Flash Grid concept

It is possible to use the CLI to create a Flash Grid and add or remove systems in a Flash Grid.

Safeguarded Snapshot

IBM Safeguarded Snapshot (previously called Safeguarded Copy) regularly creates isolated, separated from server, immutable snapshots of data to help protect against cyberattacks, malware, acts of disgruntled employees, and other data corruption. Because Safeguarded snapshots are on the same FlashSystem storage as operational data, recovery is faster than restoring from copies stored separately.

For more information about Safeguarded Snapshot, see *Data Resiliency Designs: A Deep Dive into IBM Storage Safeguarded Snapshots*, REDP-5737.

As described in Cyber Resilience, you can combine the power of IBM Storage Defender and IBM Storage FlashSystem to fight ransomware and implement a more resilient data storage environment.

Here is an example of how our cyber security features can help you minimize downtime after an attack. Figure 7 illustrates the time it takes to recover all your data without the Cyber Resilience function.

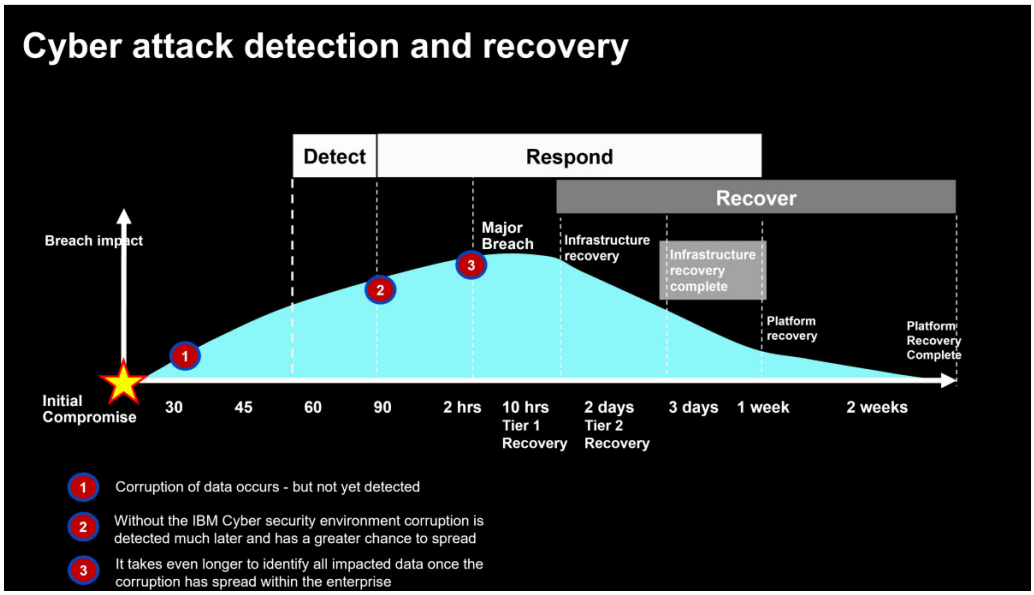

Figure 7 Cyber attack detection and recovery without cyber security functions

Figure 8 on page 12 shows you how long it takes to recover after an attack with Cyber Resilience function.

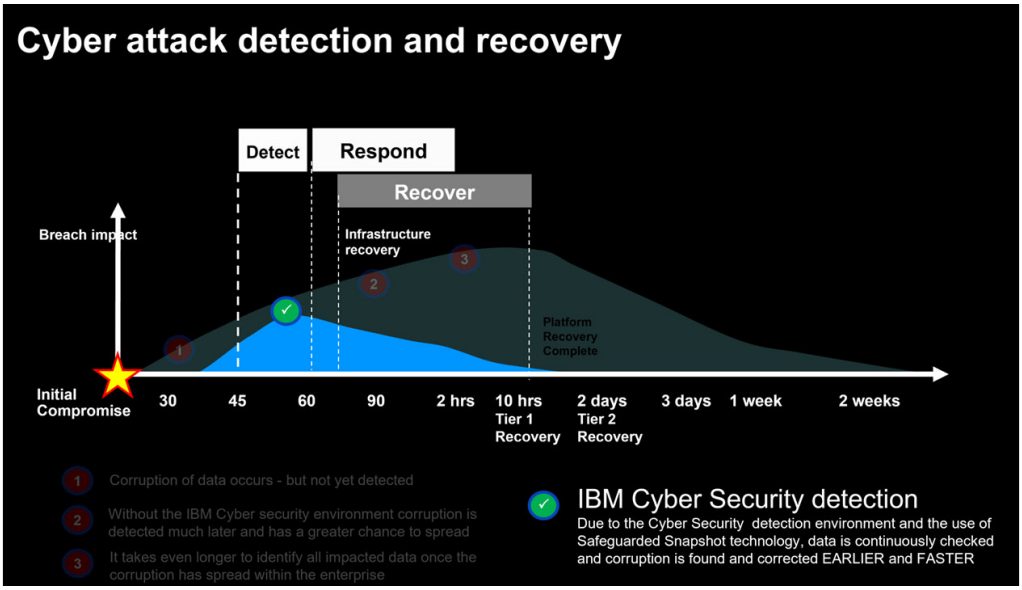

Figure 8 Cyber attack detection and recovery with Cyber security functions

How to assess your business cyber resilience: You can take the two part cyber resilience evaluation to learn how prepared your organization is for cyber threats.

IBM FlashCore technology

When IBM FlashCore Module (FCM) flash drives are installed and configured in the IBM FlashSystem 9500, the combination of FCMs and the IBM FlashSystem 9500 provide the following benefits:

- Hardware-accelerated architecture that is engineered for flash, with a hardware-only data path.
- A modified dynamic GZIP algorithm for IBM FlashSystem data compression and decompression. Because the algorithm is implemented completely in hardware, no processor intervention is required.
- Design for low latency, density, and reliability.
- IBM Advanced Flash Management, which improves flash endurance over standard implementations without increasing latency.
- Capability to run a maximum of 48 FCM drives in a single control enclosure.

Figure 9 on page 13 shows IBM FlashCore technology. For more information about IBM FlashCore technology, see What is flash storage? or the IBM Redpaper *IBM FlashCore Module (FCM) Product Guide: Features the newly available FCM4 with AI-powered ransomware detection*, REDP-5725.

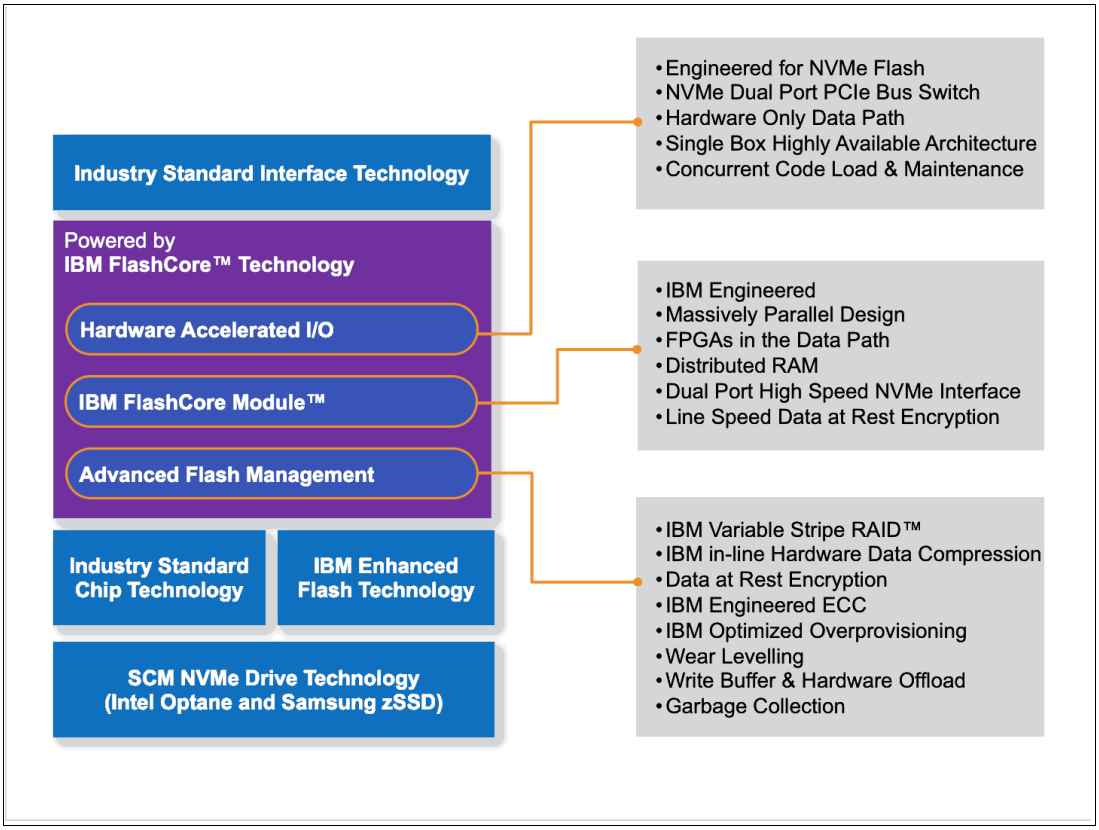

Figure 9 IBM FlashCore technology

Storage Class Memory

Storage Class Memory (SCM) is another way to describe nonvolatile memory devices that perform faster at approximately 10 µs than traditional NAND SSDs, which perform at 100 µs. Both are slower than dynamic random access memory (DRAM), which has response times of approximately 100 ns.

The typical cost for SCMs is between the costs for DRAM and traditional NAND. The price for SCMs is significantly more expensive than traditional NAND drives.

The IBM FlashSystem 9500 system supports the new low-latency, high-speed SCM drives in any of the slots of the control enclosure. The control enclosure can contain up to 12 x 1.6 TB 2.5-Inch NVMe Storage Class Memory Drives.

Note: SCM and other NVM Express (NVMe) drive types can be installed in any drive slot. However, the highest capacity drives must be installed in the lowest available drive slots.

SCM and Easy Tier

Because of their faster speed, SCM drives are placed in a new top tier of Easy Tier. This new tier is ranked higher than the existing tier0_flash that is used for NVMe NAND drives that are supported today. The following Easy Tier levels are available:

Storage Class Memory tier

Exists when the pool contains drives that use persistent memory technologies that improve the endurance and speed of current flash storage device technologies.

Tier 0 flash

Exists when the pool contains high-performance flash drives.

Tier 1 flash

Exists when the pool contains tier 1 flash drives. Tier 1 flash drives typically offer larger capacities, but slightly slower performance and lower write endurance characteristics.

Enterprise tier

Exists when the pool contains enterprise-class MDisks, which are disk drives that are optimized for performance.

Nearline tier

Exists when the pool contains nearline-class MDisks, which are disk drives that are optimized for capacity.

Hot data is placed in the SCM tier when Easy Tier is enabled. Extent allocation for data reduction pools (DRPs) and Volume Groups (VGs) is tuned to use SCM drives, especially for metadata (directory volume lookups). This use case is one of the main use cases for SCM drives with an IBM FlashSystem 9500 system.

SCM and RAID configurations

SCM drives feature the following rules concerning RAID supported configurations:

- Distributed RAID 1 (DRAID 1) with two drives (including distributed spare capacity) or more and is the best practice recommendation and configuration.
- Distributed RAID 6 (DRAID 6) with six drives (including distributed spare capacity) or more is supported.
- SCM drives have their own SCM technology type and drive class.
- SCM and Standard NVMe (or SAS) cannot intermix in the same array.
- Easy Tier tier_scm arrays can take lower tech types as spare drives when no tier_scm drives are available.
- Lower tier arrays can accept tier_scm drives as superior drives.

Note: DRAID 5 and traditional RAID are not supported by FS9500.

SCM drive formatting and UNMAPS

Because of its media technology, SCM drive formats can take 15 minutes, which is typically more time than is needed for formatting an NVMe drive.

SCM drive formats occur when one of the following conditions exists:

- A drive is replaced.
- An enclosure is managed.
- An array or MDisk is removed.

Note: Intel Optane drives do not support UNMAPs because it is not beneficial for these drives. Instead, the system writes zeros to deallocate drive sectors.

IBM Storage Expert Care

IBM FlashSystem 9500 is a client-installed product and is being released with a one-year warranty with the option to include IBM Storage Expert Care Advanced or IBM Storage Expert Care Premium.

Note: IBM FlashSystem 9500 does not include Basic Expert Care. A three-month software maintenance (SWMA) offering is defaulted when no IBM Storage Expert Care Service and Support option is selected.

Figure 10 shows IBM Storage Expert Care levels.

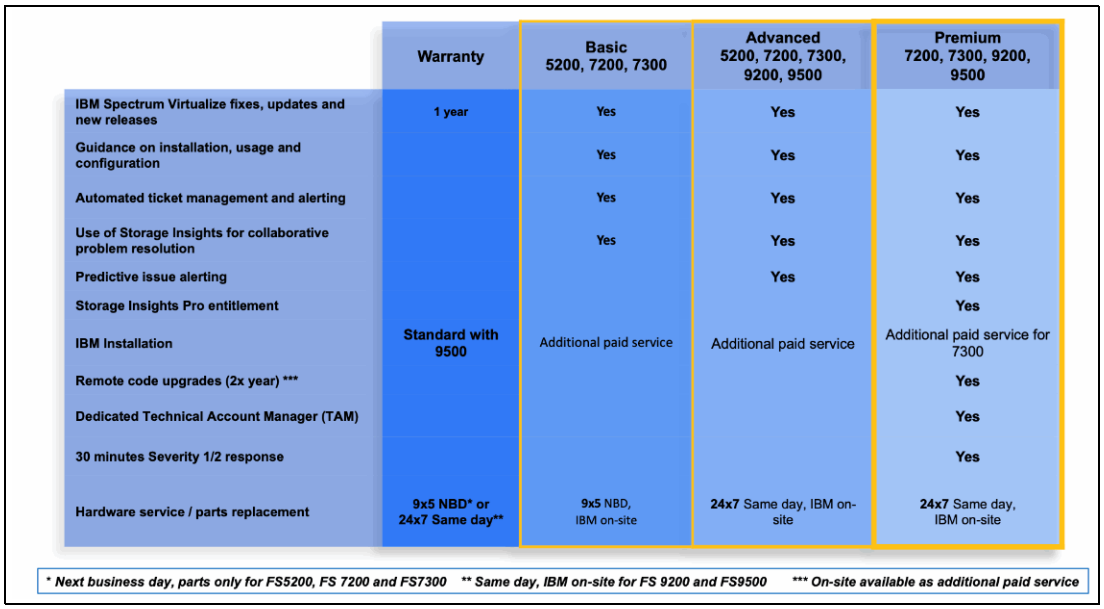

Figure 10 IBM Storage Expert Care levels

IBM Storage Expert Care options

The following are the IBM Storage Expert Care options for IBM FlashSystem 9500.

IBM Storage Expert Care Advanced

The following support features are included with the IBM Storage Expert Care Advanced option:

- Available in 3–5 years duration.
- IBM onsite repair coverage includes 24x7, same-day support that is based on the duration that is chosen.
- IBM Software Maintenance (SWMA) software support and services agreement.
- IBM Storage Expert Care services:
  - Installation, usage, and configuration support line
  - Proactive issue resolution
  - Predictive alerting
  - Automated ticket management

IBM Storage Expert Care Premium

The following support features come with the IBM Storage Expert Care Premium option:

- Available in 3–5 years duration.
- IBM onsite repair coverage includes 24x7, same-day support that is based on the duration that is chosen.
- Enhanced response time for defect support:
  - *Response time* is defined as the elapsed time between technical support receipt of the customer problem submission and the acknowledgment of the submission.
  - 30-minute targeted response time objectives for Severity 1 and Severity 2 problem reports.
- IBM Storage Expert Care services:
  - Installation, usage, and configuration support line
  - Proactive issue resolution
  - Predictive alerting
- Automated ticket management
- IBM Storage Insights Pro with more detailed reports and planning
- Remote Code Load:
  - Code upgrades are provided by IBM remote support representatives up to twice per year to keep your systems updated.
  - On-site code load services that are available through feature code #AHY2 - Remote code load exception when required.
- Technical Account Manager to serve as the key client interface.

Note: A Technical Account Manager serves as the key client interface for in-scope hardware and software, delivering partnership and consultancy, and direct engagement on high-priority support cases.

Storage Assurance

IBM Storage Assurance Perpetual offers a subscription model for IBM FlashSystem that ensures consistent modernization, budget predictability, and premium support. This option includes full-system refreshes, eliminating lifecycle challenges like terminal code levels, end-of-support concerns, disruptive migrations, and procurement hurdles. Available as a 4 or 8-year contract, it simplifies storage management and reduces costs.

Table 1 Overview of the available IBM Storage Assurance features

Years	Upfront	Annual	Quarterly	Monthly
1	ALF0	ALF8	ALFG	ALFO
2	ALF1	ALF9	ALFH	ALFP
3	ALF2	ALFA	ALFI	ALFQ
4	ALF3	ALFB	ALFJ	ALFR
5	ALF4	ALFC	ALFK	ALFS
6	ALF5	ALFD	ALFL	ALFT

Years	Upfront	Annual	Quarterly	Monthly
7	ALF6	ALFE	ALFM	ALFU
8	ALF7	ALFF	ALFN	ALFV

Note: Availability varies depending on country offering.

The Perpetual Model offers transparent, flat-rate pricing for budget predictability. It ensures access to cutting-edge technology, boosting operational agility. With a future-proof all-flash platform, continuous innovation is unlocked. Enjoy flexible payment options (upfront, annual, quarterly, or monthly) on 4 or 8-year contracts, backed by premium ExpertCare support, comprehensive software licensing, and automatic hardware refreshes aligned with SLAs:

- Refresh if the system is not meeting your performance or energy efficiency needs.
- Refresh if your system is no longer compatible with the latest SW release or if your system has reached its end-of-support (EOS) date.
- Refresh if your system cannot add more capacity.
- Refresh at least once during an 8-year contract.

IBM Storage Assurance Perpetual delivers continuous innovation, budget predictability, and simplified management for IBM FlashSystem. Enjoy AI-powered data management, ransomware protection, and seamless upgrades while optimizing storage efficiency, performance, and resilience across hybrid cloud environments.

Note: IBM Storage Assurance program comes with the following guarantees:

- Non-disruptive system-to-system migrations guarantee.
- Price protection guarantee.
- Workload performance guarantee.
- End of service guarantee.
- Energy efficiency guarantee.
- Eight-year contract full-system guarantee.
- Terminal code level guarantee.
- Capacity upgrade eligibility guarantee.

This program is available for FlashSystem 5300, FlashSystem 7300 and FlashSystem 9500 and their all flash-expansions. For high-level contract term details and country availability, see IBM Storage Assurance Perpetual Contract Details and Country Availability.

For more information, see IBM Storage Assurance.

Optional guarantees

Several optional guarantees are available to enhance your IBM FlashSystem 9500 investment. Contact your IBM Storage representative for more details.

60-second cyber recovery guarantee

Once configured by IBM Expert Labs, the FlashSystem 60-second cyber recovery guarantee states that immutable snapshots from Safeguarded Snapshot can be recovered in just 60 seconds. This offering includes FlashSystem implementation, Safeguarded Snapshot configuration and recovery validation.

The scope of work also enhances security options such as Two Person Integrity and Multi-Factor authentication. This guarantee also includes capabilities such as the ransomware threat detection capabilities as part of the tools to detect an attack.

3:1 data compression guarantee

IBM offers a 3:1 data compression guarantee to give organizations peace of mind when they acquire a specific amount of raw capacity for their workloads. Organizations will benefit from the hardware-assisted data reduction technology on IBM FlashCore Modules (FCMs). FCMs are a unique computational storage platform that due to advanced hardware assistance delivers a great compression ratio on the business's workloads without any performance impact.

Sustainability guarantee

Because of the innovative IBM FlashCore Modules, the FlashSystem devices are able to guarantee that they will not exceed a certain energy efficiency (W/TB) amount across all FlashCore Module drive configurations, reducing carbon emissions. This improves client's environmental impact from their data storage with some configurations guaranteed as low as a 1.7 W/TB maximum, supporting green IT initiatives.

IBM FlashSystem 9500 GUI

Because IBM FlashSystem 9500 control enclosures cluster to form a system, a single management interface is used for IBM FlashSystem 9500 control enclosures. Each IBM FlashSystem 9500 node canister is an individual server in an IBM FlashSystem 9500 clustered system on which the IBM Storage Virtualize software runs.

You can access the GUI by opening any supported web browser and entering the management IP addresses. You can connect from any workstation that can communicate with the IBM FlashSystem 9500 system. The IBM FlashSystem 9500 control enclosure is delivered in a 4U 19-inch rack-mount enclosure. The IBM FlashSystem 9500 system features an IBM Service Support Representative (SSR) installation as part of the product offering.

Figure 11 on page 19 shows the IBM FlashSystem 9500 GUI dashboard.

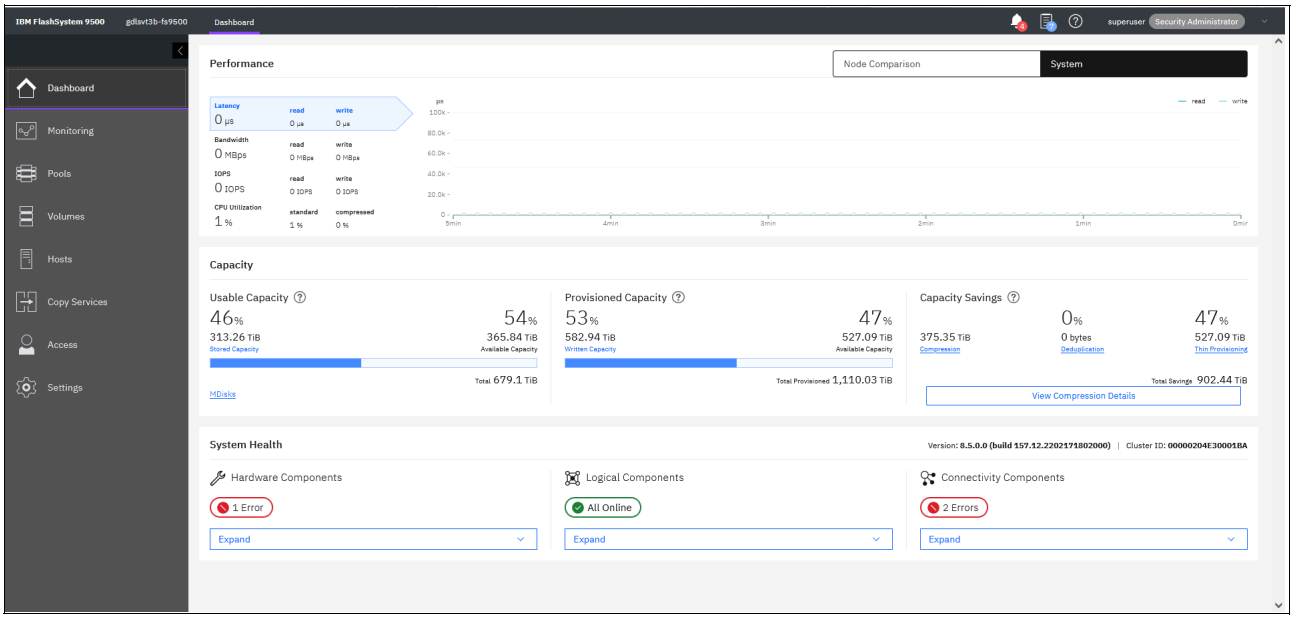

Figure 11 IBM FlashSystem 9500 GUI showing the dashboard

Figure 12 shows the Control Enclosure 1 window. You can open this window by selecting **Monitoring** → **System Hardware** from the left panel.

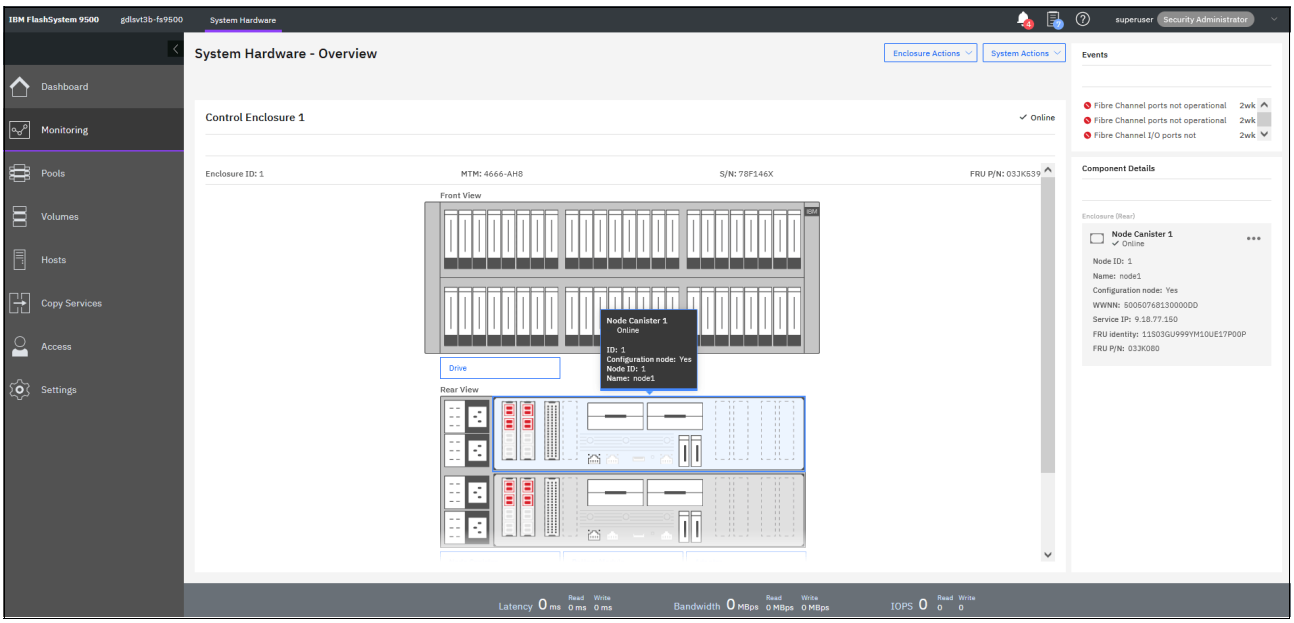

Figure 12 IBM FlashSystem 9500 system overview of the control enclosure

The IBM FlashSystem 9500 system includes a CLI, which is useful for scripting, and an intuitive GUI for simple and familiar management of the product. The IBM FlashSystem 9500 system supports SNMP email forwarding that uses Simple Mail Transfer Protocol (SMTP), and syslog redirection for complete enterprise management access.

By using the GUI, you can quickly deploy and manage storage. The GUI runs on the IBM FlashSystem 9500 control enclosure; therefore, a separate console is not needed. When you enter the system IP address in a web browser, you can manage all of the expansion enclosures from one place.

The IBM FlashSystem 9500 control enclosure node canisters are configured for active-active redundancy. The node canisters run a highly customized Linux based operating system that coordinates and monitors all significant functions in the system.

The node canisters provide a web interface, Secure Shell (SSH) access, and SNMP connectivity through external Ethernet interfaces. By using the web and SSH interfaces, administrators can monitor system performance and health metrics, configure storage, and collect support data, among other features.

The storage configuration includes defining logical units with capacities, access policies, and other parameters. No software must be installed on host computers to administer the IBM FlashSystem 9500 system beyond a web browser or a standard SSH client.

IBM Storage Insights

IBM Storage Insights is an IBM Cloud Software as a Service offering that can help you monitor and optimize the storage resources in the system and across your data center.

IBM strongly recommends that all customers install and use this no-charge, cloud-based application because it provides a single dashboard that gives you a clear view of all your IBM block storage. You can make better decisions by seeing trends in performance and capacity.

For more information about the architecture and design overview of IBM Storage Insights, see IBM Redbooks *Unleash the Power of Flash: Getting Started with IBM Storage Virtualize Version 8.7 on IBM Storage FlashSystem and IBM SAN Volume Controller*, SG24-8561.

IBM Storage Control

IBM Storage Control consolidates a range of IBM storage provisioning, virtualization, cloud, automation, and monitoring solutions through a unified server platform. IBM Storage Control provides insight and awareness about the configuration capabilities, storage health, and events of a storage system regarding VMware and vSphere. With this capability, VMware administrators can independently and centrally manage their storage resources on IBM storage systems. For more information, see IBM Storage Control.

Supported platforms

The IBM FlashSystem 9500 system features extensive interoperability with support for a wide range of operating systems that includes Microsoft Windows Server, Linux, and IBM AIX® and IBM i. Supported hardware includes IBM Power Systems and x86 & x86_64 servers, host bus adapters (HBAs), and SAN fabrics. For more information, see V8.7.0.x Configuration Limits and Restrictions for IBM FlashSystem 9500 and IBM System Storage Interoperation Center.

IBM FlashSystem 9500 hardware component overview

The IBM FlashSystem 9500 control enclosure is a 4U rack-mounted NVMe flash memory enclosure that is based on IBM flash technology. It provides the primary management interface (GUI) and the host interface configuration. The IBM FlashSystem 9500 control enclosure supports FC Protocol (FCP and FC-NVMe) and iSCSI interfaces.

For iSCSI, the RoCE and iWARP protocols are supported. Figure 13 shows the front view of the IBM FlashSystem 9500 control enclosure.

Figure 13 IBM FlashSystem 9500 control enclosure front view

Note: There are new rules for the plugging of the NVMe drives in the control enclosure. See the “IBM FlashSystem 9500 NVMe drive options” on page 24.

The IBM FlashSystem provides the following NVMe technologies:

- Supports:
  - Unique world class IBM FCM drives with inline compression
  - Industry-standard NVMe drives
  - Industry-standard NVMe drives with up to 1.47 PB of maximum raw capacity
- Option for SCM type drives
- Macroefficiency with up to 5.52 PB of raw maximum protected capacity with inline hardware data compression ratio of up to 3:1 if you use IBM FCM drives
- Latency measured in microseconds with IBM FCMs
- Optional expansion enclosures that provide tiering options with SSD flash drives

The IBM FlashSystem 9500 system is offered as three models:

1. 4666 model AH8: IBM FlashSystem 9500 NVMe control enclosure
2. 4666 model UH8: IBM FlashSystem 9500 NVMe control enclosure utility model
3. 4983 model AH8: IBM FlashSystem 9500 NVMe control enclosure

Note: The 4666-UH8 utility-based model features fixed configurations because they are Capacity on Demand (CoD)-based offerings.

A newer machine type 4983 model AH8 being introduced is physically identical to the 4666 except it is sold with LIC, which is in line with the other products in the IBM FlashSystem product line. This ensures that all features are included in the product price except for encryption.

The IBM FlashSystem 9500 configuration can consist of the following components:

- A total of 1–2 IBM FlashSystem 9500 control enclosures
- A total of 1–6 IBM FlashSystem 9000 SFF expansion enclosures
- A total of 1–2 IBM FlashSystem 9000 LFF High Density (HD) expansion enclosures

The following machine warranties are offered for the IBM FlashSystem 9500 system:

- Machine type 4666-AH8 with a 12-month, parts-only
- Machine type 4666-UH8 with a 12-month, parts-only
- Machine type 4983-AH8 with a 12 month, parts only

All models are offered with optional Storage Expert care to enhance the service from IBM with various levels of cover and duration. For more information, see “IBM Storage Expert Care” on page 15.

The IBM FlashSystem 9500 control enclosure includes integrated AC power supplies (PSU) and battery units inside each of the canisters. These batteries supply power to the control enclosure during a sudden power loss or failure so that the system can correctly commit all transactions to the storage medium.

The IBM FlashSystem 9500 control enclosure includes the following features:

- Control enclosure:
  - Two canisters that are placed one on top of the other
  - 48 NVMe drive slots
- Full internal redundancy:
  - Redundant and hot-swappable:
    - Canisters
    - Batteries within each canister
    - Power supplies and boot drives
  - Hot-swappable PCI Express (PCIe) adapters
  - Concurrently replaceable DIMMs and fans
- Each canister contains the following components and quantities:
  - CPU (2)
  - DIMM Slots (24)
  - Battery (2)
  - Canister Fans (5)
  - Power Supply PSU (2)
  - PCIe adapters cages (4)
  - PCIe adapter cards (0-6)
  - PCIe Compression QAT card (1)
  - PCIe adapter blanking plates (0-6)l

Figure 14 on page 23 shows a top-down view of the IBM FlashSystem 9500 enclosure. Highlighted are the various components of the control enclosure and the two canisters.

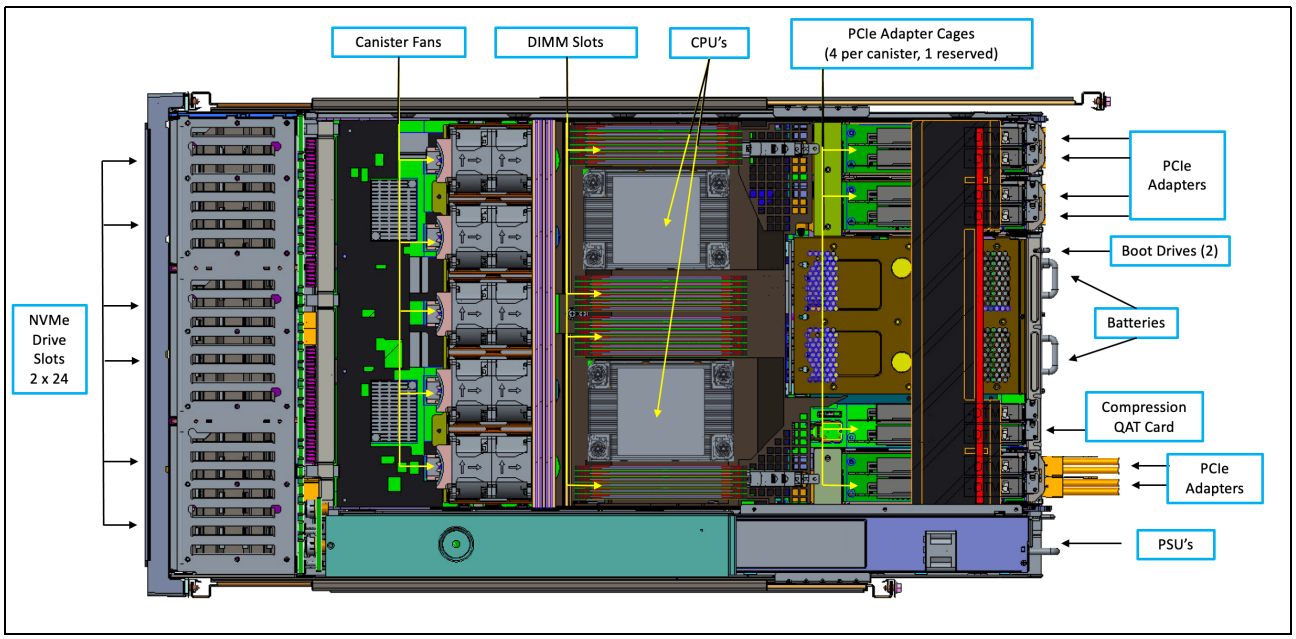

Figure 14 Top view of the IBM FlashSystem 9500 enclosure

Figure 15 shows the rear view of the IBM FlashSystem 9500 control enclosure. All components are concurrently maintainable, except for the passive midplanes. All external connections are from the rear of the system.

Figure 15 Rear view of IBM FlashSystem 9500 control enclosure

Figure 16 shows a more detailed view of the rear of a canister.

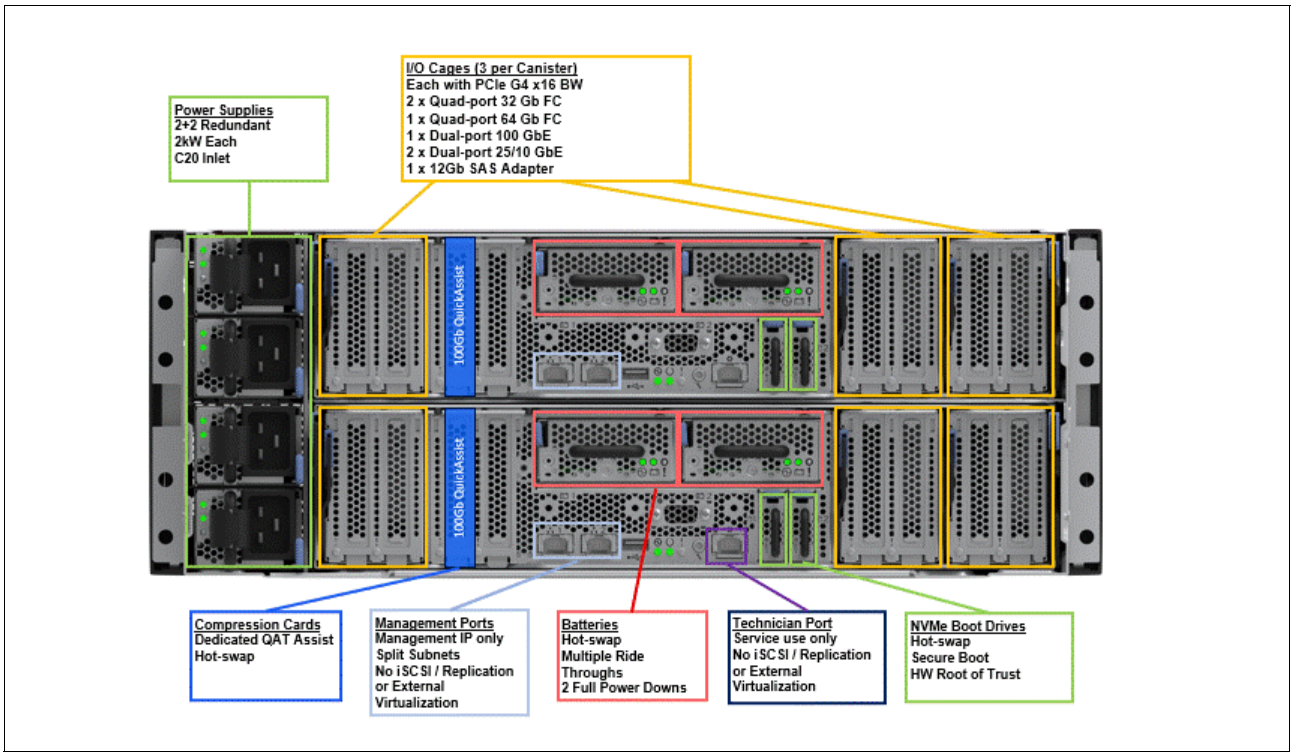

Figure 16 IBM FlashSystem 9500 enclosure detailed rear view

Figure 16 shows the two canisters, which are located one above the other three PCIe G4 interface cages, four power supply units (PSU), the two batteries and boot drives per canister and the USB and management Ethernet ports.

The PCIe adapters plug into the adapter cages and any unused PCIe adapter slots include a blanking plate assembly in place to ensure and maintain the correct air flow for cooling through the canister. A dedicated compression QAT card is also included in each canister.

IBM FlashSystem 9500 NVMe drive options

The IBM FlashSystem 9500 control enclosure supports up to 48 NVMe 2.5-inch drives, which can be the IBM FlashCore Module NVMe type drives or the industry-standard NVMe drives.

With partially populated control enclosures, we have some drive slot plugging rules that must be adhered to, ensuring the best possible operating conditions for the drives.

Figure 17 on page 25 shows the logical NMVe drive placement, starting from the center of the enclosure (slot 12) on the upper 24 slots. Any slots that do not have an NVMe drive present must have a blank filler installed.

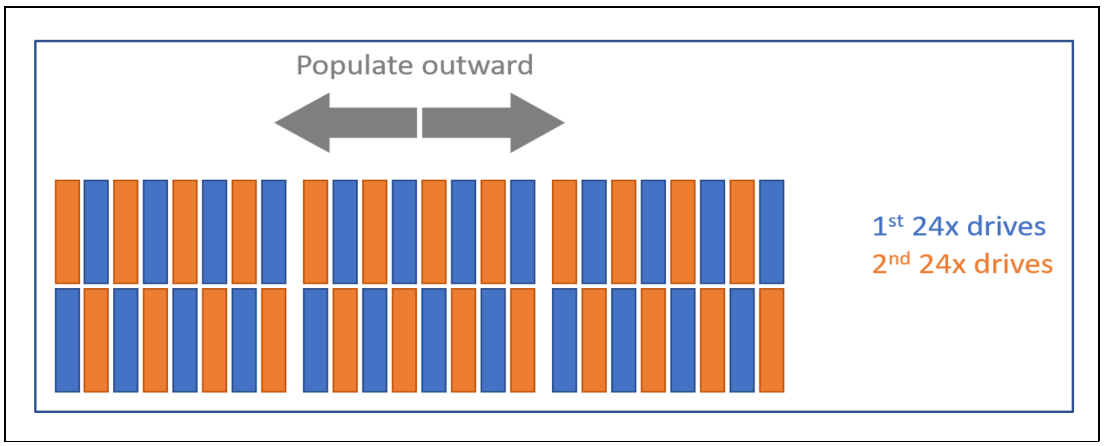

Figure 17 Logical NMVe drive placement

Figure 18 shows the actual drive population with numbering. This shows how the drives are populated from center out, and then distributing them from top and bottom, as the number of drives increase over time.

Note: The layout in Figure 18 has been split at slots 12 and 13 for better clarity on this page, but in reality slots 1 to 24 and slots 25 to 48 are contiguous.

Slot 1	Slot 2	Slot 3	Slot 4	Slot 5	Slot 6	Slot 7	Slot 8	Slot 9	Slot 10	Slot 11	Slot 12
36	11	34	9	32	7	30	5	28	3	26	1
Slot 25	Slot 26	Slot 27	Slot 28	Slot 29	Slot 30	Slot 31	Slot 32	Slot 33	Slot 34	Slot 35	Slot 36
24	47	22	45	20	43	18	41	16	39	14	37
Slot 13	Slot 14	Slot 15	Slot 16	Slot 17	Slot 18	Slot 19	Slot 20	Slot 21	Slot 22	Slot 23	Slot 24
25	2	27	4	29	6	31	8	33	10	35	12
Slot 37	Slot 38	Slot 39	Slot 40	Slot 41	Slot 42	Slot 43	Slot 44	Slot 45	Slot 46	Slot 47	Slot 48
13	38	15	40	17	42	19	44	21	46	23	48

Figure 18 NVMe drive population with numbering

Supported drive types

The following 2.5-inch (SFF) IBM FlashCore Module NVMe types are supported in IBM FlashSystem 9500 control enclosures:

- 4.8 TB 2.5-inch NVMe FlashCore Module
- 9.6 TB 2.5-inch NVMe FlashCore Module
- 19.2 TB 2.5-inch NVMe FlashCore Module
- 38.4 TB 2.5-inch NVMe FlashCore Module

The following 2.5-inch (SFF) NVMe industry-standard flash drives are supported in IBM FlashSystem 9500 control enclosures:

- 1.92 TB 2.5-inch
- 3.84 TB 2.5-inch
- 7.68 TB 2.5-inch
- 15.36 TB 2.5-inch
- 30.72 TB 2.5-inch

It also supports up to 12 1.6 TB NVMe SCM drives.

The following DRAID rules must be observed:

- DRAID 1 is recommended for array configurations of 3–5 drives.
- DRAID 1 and DRAID 6 are recommended for array configurations of six drives, depending on capacity and performance requirements.
- DRAID 6 is recommended for array configurations with seven or more drives.
- All flash modules must be the same type and capacity within the same DRAID array.

The following DRAID guidelines are recommended:

- FlashCore Modules:
  - DRAID 6 (6 drives minimum; 48 drives maximum)
  - DRAID 1 (2 drives minimum; 16 drives maximum)
  - It is a best practice that all drives in a single array be of the same type, technology, and size.
- Industry standard NVMe drives:
  - DRAID 6 (6 drives minimum; 128 drives maximum)
  - DRAID 1 (2 drives minimum; 16 drives maximum)
  - It is a best practice that all drives in a single array be of the same type, technology, and size.
- Storage-class memory drives:
  - DRAID 6 (6 drives minimum; 12 drives maximum).
  - DRAID 1 (2 drives minimum; 12 drives maximum).
  - Storage Class Memory drives in the same RAID array must be of the same capacity.

All drive slots must be filled regardless of the number of drive modules. If a slot does not have a drive module that is installed, a filler must be used to ensure correct air flow through the enclosure. All drives are dual-port and hot-swappable.

Drives of the same form factor and connector type can be intermixed within an enclosure. All flash modules must be the same type and capacity within the same DRAID array.

Consider the following points:

- Each IBM FCM contains IBM enhanced flash chips, FPGA chips, an IBM PowerPC® processor, and DRAM devices that are connected to the flash controllers and processor.
- Cache options from 1.0 TB (512 GB per canister) to 3.0 TB (1.5 TB per canister) per control enclosure.
- Four 1 Gbps Ethernet ports standard for management and technician connectivity only.
- 32 Gbps / 64 Gbps FC, 25 Gbps Ethernet, and 100 Gbps Ethernet ports are available for FC and iSCSI connectivity through the use of a PCIe adapter.

- 12 Gbps SAS ports for expansion enclosure attachments are available by using a PCIe adapter.

The IBM FlashSystem 9500 control enclosure supports FCP with point to point (FC-P2P), arbitrated loop (FC-AL), and switched fabric (FC-SW) topologies. FC interfaces can be configured as N_port or NL_port types.

The FC port is configured in NPIV mode; therefore, the user must check that this configuration is defined for their installation. If not, this configuration must be changed from the default when the SAN infrastructure is set up. Full active-active multipathing across all interfaces also is supported, although host software support for this function can vary.

The IBM FlashSystem 9500 control enclosure also includes the following expansion features:

- Capability for adding into clustered systems with one more IBM FlashSystem 9500 control enclosure.
- Up to six SAS attached expansion enclosures are supported per IBM FlashSystem 9500 controller pair, which provides up to 144 SSDs with IBM FlashSystem 9000 Expansion Model AFF.
- Up to two IBM FlashSystem 9000 LFF HD model A9F expansion enclosures are supported per IBM FlashSystem 9500 control enclosure pair, which provides up to 184 SSD drives.

For more information about mixing expansion enclosures and the maximum configurations that are allowed, see V8.7.0.x Configuration Limits and Restrictions for IBM FlashSystem 9500.

IBM FlashSystem 9500 utility model UH8

IBM FlashSystem 9500 utility models UH8 provide a variable capacity storage offering. These models also offer a fixed capacity, with a base subscription of approximately 35% of the total capacity.

IBM Storage Insights monitors the system and capacity that is used. The amount that is billed is based on the capacity-used basis. With this billing structure, you can increase or decrease usage, and pay for the configured capacity only.

IBM FlashSystem utility models are provided for customers who can benefit from a variable capacity system, where billing is based on provisioned space only. The hardware is leased through IBM Global Finance on a three-year lease. Leased hardware entitles the customer to use approximately 30—40% of the total system capacity at no extra cost depending on the specific terms of the contract. If storage must increase beyond that initial capacity, the extra usage is billed based on the average daily provisioned capacity per terabyte per month on a quarterly basis.

Example: A total system capacity of 115 TB

A customer has an IBM FlashSystem 9500 utility model with 12 9.6 TB NVMe drives for a total system capacity of 115 TB. The base subscription for such a system is 40.25 TB. No extra billing occurs during the months where the average daily usage is less than 40.25 TB.

The system monitors daily provisioned capacity and averages those daily usage rates over the month. The result is the average daily usage for the month.

If a customer uses 45 TB, 42.5 TB, and 50 TB in three consecutive months, IBM Storage Insights calculates the overage (see Table 2), rounding to the nearest terabyte.

Table 2 Billing calculations based on customer usage

Average daily	Base	Overage	To be billed
45 TB	40.25 TB	4.75 TB	5 TB
42.5 TB	40.25 TB	2.25 TB	2 TB
50 TB	40.25 TB	9.75 TB	10 TB

The total capacity that is billed at the end of the quarter is 17 TB per quarter in this example.

Flash drive expansions can be ordered with the system in all supported configurations. Table 3 lists the feature codes that are associated with the UH6 utility model billing.

Table 3 9500 UH8 utility model billing feature codes

Feature code	Description
#AE00	Variable Usage 1 TB/month
#AE01	Variable Usage 10 TB/month
#AE02	Variable Usage 100 TB/month

These features are used to purchase the variable capacity that is used in the utility models. The features #AE00, #AE01, and #AE02 provide terabytes of capacity beyond the base subscription on the system. Usage is based on the average capacity that is used per month. The total of the prior three months' usage is totaled, and the corresponding number of #AE00, #AE01, and #AE02 features ordered quarterly.

Billing

The local project office compiles the usage information from IBM Storage Insights on a quarterly basis. This data is compared to the base system capacity subscription. Any provisioned capacity beyond that base subscription is billed per terabyte, per month on a quarterly basis.

The calculated usage is based on the average use over a month. In a highly variable environment, such as managed or cloud service providers, this subscription enables the system to be used only as much as is necessary during any month. Usage can increase or decrease, and is billed.

Provisioned capacity is considered capacity that is reserved by the system. In thick-provisioned environments, this capacity is the capacity that is allocated to a host, whether it has data that is written.

For thin-provisioned environments, the data that is written is used because of the different ways in which thick-provisioning and thin-provisioning use flash drive space.

IBM FlashSystem 9500 supported expansion enclosures

This section describes the supported expansion enclosures of the IBM FlashSystem 9500.

IBM FlashSystem 9000 SFF Expansion Enclosure Model AFF

IBM FlashSystem 9000 Expansion Enclosure Model AFF holds up to 24 2.5-inch SAS flash drives in a 2U 19-inch rack mount enclosure. An intermix of capacity drives is allowed in any drive slot, and up to three AFF enclosures can be attached to the control enclosure to a total of 72 drives maximum.

Figure 19 shows the front view of the IBM FlashSystem 9000 Expansion Enclosure Model AFF.

Figure 19 IBM FlashSystem 9000 Expansion Enclosure Model AFF

Figure 20 shows the rear view of IBM FlashSystem 9000 SFF Expansion Enclosure Model AFF.

Figure 20 Rear view of IBM FlashSystem 9000 Expansion Enclosure Model AFF

Model AFF: Supports up to 24 SFF SSD 2.5-inch drives that can be formatted as DRAID 1or DRAID 6. It supports the following drive types:

- 1.92 TB 2.5-inch flash drive
- 3.84 TB 2.5-inch flash drive
- 7.68 TB 2.5-inch flash drive
- 15.36 TB 2.5-inch flash drive
- 30.72 TB 2.5-inch flash drive

The AFF model of IBM FlashSystem 9000 SFF Expansion Enclosure includes the following features:

- Up to 24 2.5-inch flash SSDs or HDDs
- Two expansion canisters
- 12 Gbps SAS ports for attachment to the IBM FlashSystem 9500 control enclosures
- 2U 19-inch rack-mount enclosure with AC power supplies

IBM FlashSystem 9000 LFF Expansion Enclosure Model A9F

IBM FlashSystem 9500 LFF Expansion Enclosure Model A9F includes the following features:

- Up to 92 3.5-inch drives that are top-loaded into drive slots of the expansion enclosure
- 5U 19-inch rack-mount enclosure with slide rail and cable management assembly

- High-performance SSD support, which is available in 1.92 TB, 3.84 TB, 7.66 TB, 15.36 TB, and 30.72 TB capacity versions
- Redundant 200–240 V AC power supplies (new C19/C20 PDU power cord required)

Figure 21 shows the front view of the IBM FlashSystem 9000 Expansion Enclosure Model A9F.

Figure 21 IBM FlashSystem 9000 Expansion Enclosure Model A9F

Model A9F: Supports up to 92 LFF 2.5-inch SSDs in a 3.5-inch carrier. It can be formatted as DRAID 1 or DRAID 6 and supports the following drive types:

- 1.92 TB 12 Gbps SAS flash drive (2.5-inch and 3.5-inch form factor features)
- 3.84 TB 12 Gbps SAS flash drive (2.5-inch and 3.5-inch form factor features)
- 7.68 TB 12 Gbps SAS flash drive (2.5-inch and 3.5-inch form factor features)
- 15.36 TB 12 Gbps SAS flash drive (2.5-inch and 3.5-inch form factor features)
- 30.72 TB 12 Gbps SAS flash drive (2.5-inch and 3.5-inch form factor features)

Figure 22 shows the rear view of IBM FlashSystem 9000 LFF Model A9F Expansion Enclosure.

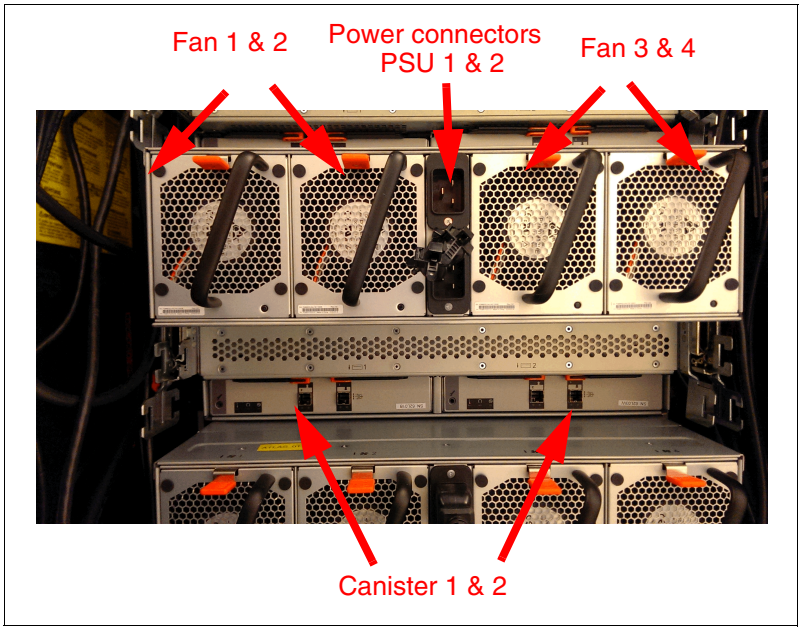

Figure 22 Rear view of IBM FlashSystem 9000 LFF Model A9F Expansion Enclosure

Scalability and performance

Multiple expansion enclosures are supported for each IBM FlashSystem 9500 control enclosure, which provides up to 72 drives with Expansion Enclosure Model AFF and up to 92 drives with Expansion Enclosure Model A9F.

On each SAS chain, the system can support up to a SAS chain weight of three:

- Each 4666-A9F expansion enclosure adds a value of 2.5 to the SAS chain weight.
- Each 4666-AFF expansion enclosure adds a value of 1 to the SAS chain weight.

For example, each of the following expansion enclosure configurations has a total SAS weight of three:

- Three 4666-AFF expansion enclosures per SAS chain.
- One 4666-A9F expansion enclosure per SAS chain.

The IBM FlashSystem 9500 system includes the following scalability and performance features:

- Up to 1.84 PB usable and 5.52 PB effective flash capacity in only 4U with 3:1 data reduction.
- Up to 3.68 PB usable and 18.4 PB maximum flash capacity in only 8U with 5:1 data reduction.
- Extra scalability through Expansion Enclosures Models AFF and A9F, and increased raw capacity of up to a maximum of 32 PB.

- The IBM FlashSystem 9500 system can deliver up to 6.3 million IOPS, with latency down to 50 microseconds (µs) and bandwidth up to 65 GBps from a single system.
- A clustered IBM FlashSystem 9500 system (including the IBM FlashSystem 9500R system) can scale linearly and deliver 12.6 million IOPS and 130 GBps on a fully configured IBM FlashSystem 9500 cluster with two enclosures.

Scaling up and scaling out

The IBM FlashSystem 9500 system's scalable architecture enables flash capacity to be added (scaled up) to support multiple applications by adding expansion enclosures. Scale out expands NVMe capacity, with the processing power to use that capacity to linearly scale IOPS and bandwidth. As a result, your organization can gain a competitive advantage through a more flexible, responsive, and efficient storage environment.

The IBM FlashSystem 9500 system has the following flexible scalability configuration options:

- Base configuration
- Scale out: Add Control Enclosures and capacity
- Scale up: Add capacity

As previously mentioned, each IBM FlashSystem 9500 system has two canisters (sometimes also known as *nodes* or *controllers*). Each canister contains the CPUs, cache memory, PCIe cards, and other hardware to communicate to the NVMe drives and connected host systems. These two canisters are housed in a chassis that is known as a *control enclosure*. The pair of canisters in a control enclosure is also called an I/O group.

It is possible to connect up to a maximum of two control enclosures of the same machine type to form a cluster.

Note: The FS9500 now has two machine types: the 4666 and the new 4983. If you are going to cluster these types of systems, then the machine types *must* match. You cannot cluster a 4666 with a 4983 and vice versa.

Table 4 lists the values of the CPUs, cache memory, raw NVMe drive size, and PCIe adapters cards for each number of control enclosures.

Table 4 Maximum values for each canister and control enclosure

Element Description	Number of CPUs	Maximum cache memory (GB)	Max NVMe 48 drive capacity raw (TB)	Inclusive Onboard Ethernet ports	Max PCIe ports (FC, Ethernet)
One Canister	2	1536	N/A	2	24
One Enclosure	4	3072	922	4	48
Two Enclosures	8	6144	1844	8	96

A basic configuration of an IBM FlashSystem 9500 storage platform consists of one IBM FlashSystem 9500 control enclosure. For a balanced increase of performance and scale, up to two IBM FlashSystem 9500 control enclosures can be clustered into a single storage system, which multiplies performance and capacity with each addition.

IBM is also offering a pre-configured clustered system, which is known as the IBM FlashSystem 9500R system. This configuration features two IBM FlashSystem 9500 control enclosures, FC switches, and optional expansion enclosures in a rack that are approved by IBM and ready for the IBM Engineer and Lab Services to install and start.

Note: For more information about the FS 9500R rack mount offering, see “IBM FlashSystem 9500R rack” on page 6.

The clustered IBM FlashSystem 9500 system can include dedicated internal FC switches for internal communications. However, other methods are available to configure the switches and ports to provide performance improvements.

For more information about how to restrict the FC ports for control enclosure inter-node connections and host connections, see Fibre Channel port masking.

With the scalable IBM FlashSystem 9500 configurations, you can add IBM FlashSystem 9500 control enclosures to the storage system. If 1.84 TB usable capacity and up to 9.21 PB maximum effective capacity from two control enclosures is not enough, capacity can be increased by adding SAS expansion enclosures with SSDs.

The IBM FlashSystem 9500 system is expandable up to the architectural limit of IBM Storage Virtualize of 32 PB by using SSDs in expansion enclosures.

Maximum capacity configurations

Table 5 lists the maximum raw capacity, usable capacity, and maximum effective capacity for scalable configurations that are built on the IBM FlashSystem 9500 control enclosures.

Table 5 IBM FlashSystem 9500 maximum usable and effective capacity.

Number of control enclosures	Maximum usable capacity by using DRAID 6 with 48 drives (terabytes)	Maximum effective capacity (terabytes) with inline IBM FlashCore Modules Drive compression @ 3:1 ratio	Maximum effective capacity (terabytes) with software data reduction @ 5:1 ratio
One control enclosure	1834	5502	9216
Two control enclosures	3668	11004	18432

Note: IBM FlashCore Module inline compression is hardware-based and operates at line speed, which has no effect on performance.

Capacity expansion through expansion enclosures

The IBM FlashSystem 9500 system supports the addition of expansion enclosures to extend capacity.

For more information about the available drive module options that can be installed in expansion enclosures, see “IBM FlashSystem 9500 hardware component overview” on page 20.

Expansion Enclosure Model A9F

HD Enclosure Model A9F accepts only SAS SSDs. With this tiering option, 1 expansion enclosure can be used per control enclosure with a maximum capacity of 2.82 PB when using 30.72 TB flash drives.

Note: To support SAS-attached expansion enclosures, an AHBA - SAS Enclosure Attachment adapter must be installed in the control enclosure of the IBM FlashSystem 9500 system.

Expansion Enclosure Model AFF

IBM FlashSystem 9000 SFF Expansion Enclosure Model AFF offers new tiering options with flash drives. Each SFF Expansion Enclosure supports up to 24 2.5-inch flash drives.

Up to 3 expansion enclosures are supported per IBM FlashSystem 9500 control enclosure, which provides up to 72 drives with up to 2.21 PB of SAS SSD capacity.

Note: The IBM Storage Virtualize maximum storage limit is 32 PB.

RAID types

The IBM FlashSystem 9500 system supports the following DRAID levels:

- DRAID 6 for all drive types - SCM Class drives, FCMs, and Industry-standard flash drives.

- DRAID 1 arrays contain 2–6 drives initially, and can be expanded up to 16 drives of the same capacity.
- It is a best practice that all drives in a single array be of the same type, technology, and size.
- Only one DRAID array per pool.

The IBM FlashSystem 9500 does not support traditional RAID.

For more information about the types of supported RAID configurations, see Planning for array configurations.

Encryption

Like its predecessors, IBM FlashSystem 9500 data encryption is based on the industry standard AES-XTS 256 encryption, as defined in the IEEE 1619-2007 standard and NIST Special Publication 800-38E as XTS-AES-256.

The data encryption key is protected by a 256-bit AES key wrap of a key that is derived from the access key that is stored on the USB flash drive. The wrapped key is stored in the system in nonvolatile form.

For more detailed information on IBM FlashSystem 95300 data encryption refer to *Chapter 18- Security* in IBM Storage Virtualize for SAN Volume Controller and FlashSystem Family Getting Started Guide.

Reliability, availability, and serviceability

IBM FlashSystem 9500 delivers the following enterprise-class reliability features, much like its predecessors:

- IBM FlashSystem 9500 control enclosures support concurrent code load. Onsite and remote code upgrades are supported. However, an extra feature Remote Code Load (RCL) support #AHY2 must be purchased for remote code loads, which include code loads to the FCM drives. The RCL support #AHY2 feature is available with Expert Care support.
- The components of the IBM FlashSystem 9500 are one of the following types:
  - Hot-swappable: All system functions remain the same.
  - Concurrently replaceable: All functions remain, but elements might be offline, so performance or availability might be affected.

  The IBM FlashSystem 9500 control enclosure features the following clustered node canisters that contain hot-swappable and concurrently replaceable components:
  - Hot-swappable:
    - Secure boot drives
    - Batteries
    - PSUs (2 per canister)
    - NVMe or FCM drives
  - Concurrently replaceable:
    - Fan modules
    - Memory DIMMs
    - Trusted Platform Module (TPM)
    - PCIe adapters
    - Node canister

If an IBM FlashCore Module failure occurs, critical customer applications can remain online while the defective module is replaced because a spare module is available.

- IBM enhanced technology in the SCM drives for higher storage density and improved performance can coexist with FCM4 drives in the IBM FlashSystem 9500 for even more demanding workloads.
- By using 3-site data copies, with synchronous and asynchronous data copies, greater flexibility exists in creating DR and HA solutions.

Options and feature codes

This section describes the options and feature codes of the IBM FlashSystem 9500 control enclosure.

Memory options

Table 6 lists the following memory options by feature code:

Table 6 IBM FlashSystem 9500 memory options per control enclosure / two node canisters.

Base Memory (GB)	#ACGN Plant or Field Upgrade (GB)	#ACGP Plant or Field Upgrade (GB)	Total Memory (GB)
1024	N/A	N/A	1024
1024	1024	N/A	2048
1024	1024	1024	3096

- (#ACGN): 1024 GB Cache upgrade

  This feature indicates that the base machine is configured with 1024 GB (512 GB for each node canister). Selecting this feature determines the cache upgrade paths that the machine uses.
- (#ACGP): 1024 GB Cache upgrade

  This feature provides another 1024 GB of cache (512 GB for each node canister) to increase the total system cache by 1024 GB to the total memory of 3096 GB.

Host I/O connectivity and expansion enclosure adapters

This section includes discussion of a single canister.

Remember: An IBM FlashSystem 9500 enclosure consists of *two* node canisters. The canisters have identical configurations.

Six PCIe slots are available for port expansions in the IBM FlashSystem 9500 node canister. Each canister has six PCIe adapter slots and both canisters must have the same configuration. The PCIe adapter feature codes offer a pair of adapters to ensure that they are supplied symmetrically in each canister.

The node canister can be configured with six I/O adapter features to provide up to twenty-four 32 Gbps FC ports or up to ten 10/25 Gbps Ethernet ports and six 100 Gbps

Ethernet. The node canister includes two 1 Gbps Ethernet ports for system management. A feature code is also available to include the SAS Expansion card if the user wants to use optional expansion enclosures.

Figure 23 shows the connectivity options for the different adapters at time of this writing.

Adapter	Supported Protocols	Supported Optics	Ports
32/64 Gb Fibre Channel	Fibre Channel FC-NVMe	32Gb / 64Gb SW SFP 32Gb / 64Gb LW SFP	4
12G SAS	SAS Expansion	mini-HD	2
25Gb iWARP Ethernet	iSCSI Cluster/hyperswap over iWARP (RPQ only)	10Gb RJ45 SFP+ SFP28 and more*	2
25Gb RoCE Ethernet	iSCSI NVMe/RDMA	10Gb RJ45 SFP+ SFP28 and more*	2
100Gb RoCE Ethernet	NVMe/RDMA iSCSI**	QSFP28 MPO QSFP28 LC 100Gb DAC and more*	2

Figure 23 Connectivity options

For more information about the limits and rules for adapter placement to ensure correct best practices, see IBM FlashSystems & SAN Volume Controller FAQ.

Table 7 lists the maximum host port count per building block configuration in a clustered configuration. At the time of writing, 2 control enclosures is the maximum number that can be clustered.

Table 7 Maximum host port count per control enclosure

Number of control enclosures	32 Gbps FC	64 Gbps FC	100 Gbps iSCSI (RoCE)	10 / 25 Gbps iSCSI (RoCE)	10 / 25 Gbps iSCSI (iWARP)
One	48	24	12	20	20
Two	96	48	24	40	40

Note: All connectivity ports are NVMe-oF compatible.

Table 8 lists the current features for host and connectivity for the IBM FlashSystem 9500 Control Enclosure 4666-AH8, 4666-UH8 and 4983-AH8 machine types.

Table 8 Supported expansion enclosure and interface components MTMs 4666*-AH8, 4666-UH8 and 4983-AH8*

Item	Feature code	Description	Ports
100 Gbps Ethernet (RoCE) adapters (Pair)	#AHB8	This feature provides two I/O adapters, each with two 100 Gbps Ethernet ports. It is used to add 100 Gbps Ethernet connectivity to the FlashSystem 9500 control enclosure and supports RDMA with RoCE 2.	Each adapter has two 100 Gbps Ethernet ports. Supplied without optics or cables.
SAS Expansion Enclosure Attach Card (Pair)	#AHBA	This feature provides two 4-port 12 Gbps SAS Expansion Enclosure attachment adapters. This feature is used to attach up to 3 AFF or 1 A9F Expansion Enclosure.	Each adapter has 2 active SAS ports.
32 Gbps FC 4-Port adapter pair	#AHBB	This feature provides two I/O adapters. It is used to add 32 Gbps FC connectivity.	Each adapter has four 32 Gbps FC ports and shortwave SFP transceivers.
10/25 Gbps Ethernet (RoCE) adapter pair	#AHBH	This feature provides two I/O adapters. It is used to add 10/25 Gbps Ethernet connectivity and supports RoCE V2.	Each adapter has two 25 Gbps Ethernet ports. Supplied without optics or cables.
10/25 Gbps Ethernet (iWARP) adapter pair	#AHBJ	This feature provides two I/O adapters. It is used to add 10/25 Gbps Ethernet connectivity. and supports RDMA with iWARP.	Each adapter has two 25 Gbps Ethernet ports. Supplied without optics or cables.
64 Gbps FC 4-Port adapter pair	#AHBK	This feature provides two I/O adapters. It is used to add 64 Gbps FC connectivity.	Each adapter has four 64 Gbps FC ports and shortwave SFP transceivers.
25 Gbps Ethernet InfoSphere® MDM Server Workbench SFP28 Transceivers (Four)	#ACHP	This feature provides four 25 Gbps shortwave SFP28 transceivers to populate a pair of 25/10 Gbps Ethernet host interface cards. These transceivers are used to set the card ports to 25 Gbps.	Requires feature AHBH, AHBJ, or AHB8.
10 Gbps Ethernet InfoSphere MDM Server Workbench SFP+ Transceivers (Four)	#ACHQ	This feature provides four 10 Gbps shortwave SFP+ transceivers to populate a pair of 25/10 Gbps Ethernet host interface cards. These transceivers are used to set the card ports to 10 Gbps.	Requires feature AHBH, AHBJ, or AHB8.
32 Gbps FC LW SFP Transceivers (Pair)	#ACHV	This feature provides two 32 Gbps longwave SFP transceivers for use with 32 Gbps FC I/O ports.	#AHBB is a prerequisite. The maximum allowed is four for each instance of #AHBB.
100 Gbps Ethernet QSFP28 SR4 Transceivers (Four)	#ACHX	This feature provides four 100 Gbps Ethernet QSFP28 transceivers to populate a pair of 100 Gbps Ethernet host interface cards.	Requires feature AHB8.

Cables

The following cable feature codes are available:

- (#ACSQ): 1 m OM3 Fiber Cable (LC)
- (#ACSU): 2 m OM3 Fiber Cable (LC)
- (#ACSR): 5 m OM3 Fiber Cable (LC)
- (#ACSS): 10 m OM3 Fiber Cable (LC)
- (#ACST): 25 m OM3 Fiber Cable (LC)

Cables that must be ordered with the expansion enclosure

The following cable feature codes are available with the expansion enclosures only:

- (#ACUA): 0.6 m 12 Gbps SAS Cable only for SFF Expansion (mSAS HD)
- (#ACUB): 1.5 m 12 Gbps SAS Cable only for SFF Expansion (mSAS HD)
- (#ACUC): 3 m 12 Gbps SAS Cable SFF/HD LFF Expansion (mSAS HD)
- (#ACUD): 6 m 12 Gbps SAS Cable SFF/HD LFF Expansion (mSAS HD)

IBM Storage Class Memory, FlashCore Modules, and industry-standard NVMe drive options

The IBM FlashSystem 9500 system supports Storage Class Memory (SCM) drives, IBM FlashCore Modules, industry-standard flash drives, and an intermix of all three.

IBM FlashCore Modules combine IBM MicroLatency technology, advanced flash management, and reliability into a 2.5-inch SFF NVMe with built-in hardware compression and encryption that do not affect performance.

For improved flexibility, IBM FlashSystem 9500 systems also support various industry-standard, self-encrypting NVMe flash drives.

The following NVMe flash drive feature codes are available:

- (#AHS9): 4.8 TB NVMe FlashCore Module 3
- (#AHSA): 9.6 TB NVMe FlashCore Module 3
- (#AHSB): 19.2 TB NVMe FlashCore Module 3
- (#AHSC): 38.4 TB NVMe FlashCore Module 3
- (#AHSE): 4.8 TB NVMe FlashCore Module 4
- (#AHSF): 9.6 TB NVMe FlashCore Module 4
- (#AHSG): 19.2 TB NVMe FlashCore Module 4
- (#AHSH): 38.4 TB NVMe FlashCore Module 4
- (#AHTH): 1.92 TB NVMe Flash Drive
- (#AHTI): 3.84 TB NVMe Flash Drive
- (#AHTJ): 7.68 TB NVMe Flash Drive
- (#AHTK): 15.36 TB NVMe Flash Drive
- (#AHTL): 30.72 TB NVMe Flash Drive
- (#AHTM): 1.6 TB NVMe SCM Drive

Consider the following points about limitations and drives:

- IBM FlashCore Modules:
  - DRAID 6 (recommended with a minimum of 6, and a maximum of 48)
  - DRAID 1 (minimum of 2, maximum of 16)
  - IBM FlashCore Modules in the same RAID array must be of the same capacity

Important: FCM2 cannot work together with FCM3 and FCM4 in the same RAID array. It you plan to upgrade or expand your FCM2 system you have to create a separate new RAID array with either FCM3 or FCM4 and upgrade your system onto a supported software level. Note that FCM2 and FCM3 are already withdrawn.

FCM3 and FCM4 can work together in the same RAID array, but the FCM4 drives will work like FCM3 drives without the enhanced Ransomware Detection features.

To benefit from all the new Ransomware Detection features, you need all drives to be FCM4 and your IBM Storage Virtualize code level to be at least 8.6.3.

- Industry-standard NVMe drives:
  - DRAID 6 (minimum of 6; maximum of 128)
  - DRAID 1 (minimum of 2; maximum of 16)
  - Industry-standard NVMe drives in the same RAID array must be of the same capacity
- SCM NVMe drives:
  - DRAID 6 (minimum of 6, maximum of 12)
  - DRAID 1 (minimum of 2, maximum of 12)
  - SCM NVMe drives in the same RAID array must be of the same capacity

IBM FlashSystem 9000 Expansion Enclosure options for models AFF and A9F

The following feature codes are available for SAS flash drives:

- Supported on Model AFF only (maximum of 24):
  - (#AH2A) 1.92 TB 12 Gbps SAS 2.5-inch flash drive
  - (#AH2B) 3.84 TB 12 Gbps SAS 2.5-inch flash drive
  - (#AH2C) 7.68 TB 12 Gbps SAS 2.5-inch flash drive
  - (#AH2D) 15.36 TB 12 Gbps SAS 2.5-inch flash drive
  - (#AH2E) 30.72 TB 2 Gbps SAS 2.5-inch flash drive
- Supported on Model A9F only (maximum of 92):
  - (#AH7J) 1.92 TB 12 Gbps SAS 3.5-inch flash drive
  - (#AH7K) 3.84 TB 12 Gbps SAS 3.5-inch flash drive
  - (#AH7L) 7.68 TB 12 Gbps SAS 3.5-inch flash drive
  - (#AH7M) 15.36 TB 12 Gbps SAS 3.5-inch flash drive
  - (#AH7N) 30.72 TB 12 Gbps SAS 3.5-inch flash drive (requires EOS 8.0)

Physical and electrical specifications

This section describes the specifications for the 9500 FlashSystem control and expansion enclosures.

IBM FlashSystem 9500 Control Enclosure for 4666 AH8 / 4666 UH8 / 4983 AH8

The control enclosure features the following specifications:

- Physical specifications:
  - Height: 17.43 cm (6.8 in.)

  - Width: 44.6 cm (17.6 in.)
  - Depth: 82.6 cm (32.6 in.)
  - Approximate weight:
    - Empty: 25.18 kg (55.51 lb.)
    - Fully configured: 69.31 kg (152.82 lb.)
- Air temperature:
  - Operating: 5–35° C (41–95° F) 0–3048 m (0–10,000 ft.). Above 900 m, the allowable maximum air temperature decreases by 1° C per 300 m.
  - Nonoperating: 1–45° C (34–113° F).
- Relative humidity:
  - Operating: 8%–80% noncondensing
  - Nonoperating: 8%–80% noncondensing
- Electrical power:
  - Voltage range: 200–240 V AC
  - Frequency: 50–60 Hz
  - Maximum power: 3300 W (power usage varies with configuration and system usage)
  - Heat dissipation (BTU per hour): 11258 Btu/h
  - Acoustical noise emission: 8.2 bels (idling), 8.8 bels (operating)

IBM FlashSystem 9000 SFF Expansion Enclosure for 4666 and 4983 Model AFF

The Expansion Enclosure AFF features the following specifications:

- Physical specifications:
  - Height: 8.7 cm (3.4 in.)
  - Width: 48.3 cm (19.0 in.)
  - Depth: 55.6 cm (21.9 in.)
  - Approximate weight:
    - Empty: 16.7 kg (36.8 lb)
    - Fully configured: 25.0 kg (55.1 lb)
- Air temperature:
  - Operating: 5–35° C (41–95° F) 0–3048 m (0–10,000 ft). Above 900 m, the allowable maximum air temperature decreases by 1° C per 300 m.
  - Nonoperating: 1–50° C (34–122° F).
- Relative humidity:
  - Operating: 8%–80% noncondensing
  - Nonoperating: 8%–80% noncondensing
- Electrical power:
  - Voltage range: 100–240 V AC
  - Frequency: 50–60 Hz
  - Power: 800 W
  - Heat dissipation (BTU per hour): 1,037
  - Acoustical noise emission: 6.2 bels (idling), 6.2 bels (operating)

IBM FlashSystem 9000 LFF High-Density Expansion Enclosure for 4666 and 4983 Model A9F

The High-Density Expansion Enclosure A9F features the following specifications:

- Physical specifications:
- Height: 22.2 cm (8.75 in.)
- Width: 48.3 cm (19.0 in.)
- Depth: 96.8 cm (38.1 in.)
- Approximate weight:
  - Empty: 67.0 kg (147.7 lb)
  - Fully configured: 135.0 kg (297.0 lb)
- Air temperature:
  - Operating: 5–35° C (41–95° F) 0–3048 m (0–10,000 ft). Above 900 m, the allowable maximum air temperature decreases by 1° C per 300 m.
  - Nonoperating: 1–50° C (34–122 degrees F).
- Relative humidity:
  - Operating: 8%–80% noncondensing
  - Nonoperating: 8%–80% noncondensing
- Electrical power:
  - Voltage range: 180–264 V AC
  - Frequency: 47–63 Hz
  - Power: 2400 W
  - Heat dissipation (BTU per hour): 8,189
  - Acoustical noise emission: 8.5 bels (idling), 8.5 bels (operating)

Note: All noise emission levels are the declared upper limit sound power level in bels for a random sample of machines. All measurements are made in accordance with ISO 7779 and reported in conformance with ISO 9296.

Software and licensing

All IBM FlashSystem 9500 and IBM FlashSystem 9500R systems include preinstalled IBM Storage Virtualize Software V8.7 or later. The following product numbers are for the base licenses for each model of the IBM FlashSystem 9500 system:

- IBM Storage Virtualize Software for IBM FlashSystem 9500 Controller (5639-011) requires at least one IBM FlashSystem 9500 Control Enclosure 4666-AH8 or 4666-UH8 for installation.
- IBM FlashSystem 9500 Control Enclosure 4983-AH8 is LIC, and does not require a separate IBM Storage Virtualize Software license

All features are inclusive except for encryption, which is a feature code that is enabled for those countries that allow it, and external virtualization. Any connected storage that is not an IBM FlashSystem 9500 control enclosure requires the External Virtualization license per storage capacity unit (SCU) that is based on the tier of storage that is available on the external storage system. In addition, if you use FlashCopy and Remote Mirroring on an external storage system, you must purchase a per-tebibyte license to use these functions.

Consider the following points:

- FlashSystem 9500 control enclosures support external storage virtualization. Use of the external virtualization capability is entitled through the acquisition of IBM Storage Virtualize Software for SAN Volume Controller (PID 5641-VC8 in AAS and PID 5725-M19 in Passport Advantage®). These licenses are the same licenses as for IBM SAN Volume Controller. Therefore, IBM SAN Volume Controller licenses can be used for the IBM FlashSystem 9500 system for these features.
- With the IBM FlashSystem 9500 system, a license exists for the hardware-assisted encryption if it is purchased (Encryption Enablement Pack [#ACE9 and #ACEE]). This feature code is needed if you want to use USB-Key encryption, IBM Security Guardium Key Lifecycle Manager-based encryption, or both on the control enclosure.
- As a best practice, use the Encryption USB Drive Pack feature (#ACEA). This feature provides four USB flash drives for storing the encryption master access key. A total of three USB flash drives are required per FlashSystem cluster when encryption is enabled in the cluster, regardless of the number of systems in the cluster.

  If encryption is to be used in a cluster, this feature must be ordered on one IBM FlashSystem, which results in a shipment of four USB flash drives.
- A storage system that is used only as a quorum device does not need a software license.

To set these licenses, use the Licensed Function page in the System Setup wizard.

If you are adding these licenses to a system, select **Settings** → **System** → **Licensed Function** in the management GUI. You can also use the **`chlicense`** CLI command to update current license settings on the system.

For more information about IBM Storage Virtualize licensing, see Licensed functions.

IBM Storage Virtualize external licensing

The IBM FlashSystem 9500 system supports differential, capacity, and key-based licensing. For example, with external virtualization, differential licensing charges different rates for different types of storage. This difference provides cost-effective management of capacity across multiple tiers of storage. Licensing for these functions is based on the number of SCUs that is purchased.

With other functions, such as remote mirroring and FlashCopy, the license grants a specific number of terabytes of capacity for that function.

Key-based licenses, such as encryption, require an authorization code and key to be downloaded to the system before the function can be used.

Note: SCUs are needed for only virtualized storage that does not have the 5639-011 base license.

The SCU is defined in terms of the category of the storage capacity, as listed in Table 9.

Note: Any storage use case that is not listed in Table 9 is classified as Category 1.

Table 9 SCU category definitions

License	Drive class	SCU Ratio
SCM	Storage Class Memory (SCM) devices	SCU equates to 1.00 TB of usable of Category 1 storage.
Flash	All flash devices, other than SCM drives	SCU equates to 1.18 TB of usable of Category 1 storage.
Enterprise	10 K or 15 K RPM drives	SCU equates to 2 TB of usable of Category 2 storage.
Nearline	Nearline SATA drives	SCU equates to 4.00 TB of usable of Category 3 storage.

Table 10 shows an example of calculating SCUs (storage capacity unit). The example is a customer who virtualizes external disk arrays with 5 TB SCM devices, 30 TB SSD flash drives, 400 TB Enterprise drives, and 800 TB Nearline capacity.

Table 10 Example of calculating SCUs

Category	Type	Capacity (TB)	TB per SCU	# of SCUs
Category 1	SCM	5	1.00	5
Category 1	SSD	30	1.18	26
Category 2	Enterprise	400	2.00	200
Category 3	Nearline	800	4.00	200
Total		**1235**		**431**

A total of 431 SCUs are required for the example that is shown in Table 10. When you calculate the number of SCUs per category, fractions must be rounded up to the next higher integer number.

For more information about IBM Storage Virtualize Differential Licensing, see Licensed functions.

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Ordering information

For more information about ordering IBM FlashSystem 9500 expansions, see “Scaling up and scaling out” on page 32.

For more information about ordering hardware features, see “Options and feature codes” on page 36.

For more information about ordering software licenses, see “Software and licensing” on page 42.

Related information

For more information, see the following resources:

- IBM Documentation for IBM FlashSystem:

  https://www.ibm.com/docs/en/flashsystem-7x00/8.7.x
- IBM FlashSystem Family FAQ

  Overview of the IBM FlashSystem family with guidance on how to select the product that is right for you:

  https://www.ibm.com/downloads/cas/9OGKVW2R
- IBM FlashSystems & SAN Volume Controller FAQ

  https://www.ibm.com/downloads/cas/2DWAMWRB
- IBM FlashSystem 9500 product page:

  https://www.ibm.com/products/flashsystem-9500
- IBM Offering Information page (announcement letters and sales manuals):

  http://www.ibm.com/common/ssi/index.wss?request_locale=en
- IBM Storage Virtualize FAQ

  Details about the IBM Storage Virtualize products, covering the IBM FlashSystem family and SAN Volume Controller:

  https://www.ibm.com/downloads/cas/2DWAMWRB

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