

# IBM FlashSystem 9200 Product Guide

Jon Herd



Storage





## IBM FlashSystem 9200 Product Guide

This IBM® Redbooks® Product Guide publication describes the IBM FlashSystem® 9200 solution, which is a comprehensive, all-flash, and NVMe-enabled enterprise storage solution that delivers the full capabilities of IBM FlashCore® technology. In addition, it provides a rich set of software-defined storage (SDS) features, including data reduction and de-duplication, dynamic tiering, thin-provisioning, snapshots, cloning, replication, data copy services, and IBM HyperSwap® for high availability (HA). Scale-out and scale-up configurations further enhance capacity and throughput for better availability.

The success or failure of businesses often depend on how well they use their data assets for competitive advantage. Deeper insights from data require better information technology. As organizations modernize their IT infrastructure to boost innovation, they need a data storage system that can keep pace with highly virtualized environments, cloud computing, mobile and social systems of engagement, and in-depth and real-time analytics.

Making the correct decision about storage investment is critical. Organizations must have enough storage performance and agility to innovate because they must implement cloud-based IT services, deploy a virtual desktop infrastructure (VDI), enhance fraud detection, and use new analytics capabilities. Concurrently, future storage investments must lower IT infrastructure costs while helping organizations derive the greatest possible value from their data assets.

IBM FlashSystem storage solutions can accelerate the transformation of modern organizations into an IBM Cognitive Business®. IBM FlashSystem all-flash storage arrays support the organization's active data sets. IBM FlashSystem solutions offer a broad range of industry-leading storage virtualization and data management features that can provide improved storage system performance, efficiency, and reliability. IBM FlashSystem solutions can be less expensive than conventional enterprise storage solutions.

With the release of IBM FlashSystem 9200 Software V8.4.0, extra functions and features are available, including support for new larger IBM FlashCore Modules Non-Volatile Memory Express (NVMe) type drives within the Control Enclosure and the optional storage-class memory (SCM) drives. New software features include GUI enhancements, a new dashboard, remote support assistance (RSA), data de-duplication, and an IBM Storage Insights configuration.

## Flash for less than the cost of disk

Integral to the IBM FlashSystem 9200 solution is the IBM FlashCore technology. The recent evolution of this technology saw the introduction of inline hardware compression and decompression with the IBM FlashSystem model AE3 enclosure.

The IBM FlashSystem 9200 system with IBM FlashCore Modules NVMe type drives features built-in hardware data compression as standard, and this data reduction is “always on”. This compression is implemented in hardware by using field-programmable gate arrays (FPGAs) within each module and a modified dynamic GZIP algorithm. With this approach, the solution can deliver the level of performance that you expect without compression, with the added benefit of better utilization of the physical storage.

Compression and decompression are transparent above the IBM FlashCore Modules except for management of space. Performance is not affected and scales linearly with the number of instances.

IBM FlashSystem 9200 Control Enclosure Data Reduction Pool compression can increase the effective capacity of your flash memory up to 5x, decreasing the cost for effective capacity up to 80%. Data Reduction Pool supports active data, unlike other data reduction solutions. The IBM FlashSystem 9200 Control Enclosure offers several features for Data Reduction Pool compression workloads. These features include 16 Intel core processors with up to 768 GB of memory per node, and a built-in compression accelerator for hardware-assisted compression. In addition, the IBM FlashSystem 9200 system with IBM FlashCore Modules NVMe-type drives applies compression to any data that is not already compressed.

The IBM FlashSystem 9200 system also supports the new SCM type drives. SCM is a new storage media technology that offers high endurance, high IOPS, and ultra-low latencies. For more information, see “Storage-class memory” on page 13.

## Agile integration

The IBM FlashSystem 9200 system has the following agile characteristics:

- ▶ Fully integrated system management
- ▶ Application-aware data services
- ▶ Advanced Encryption Standard (AES), data at rest encryption with all NVMe type drives, and IBM FlashCore Modules drives with FIPS 140-2.
- ▶ In-line hardware compression with IBM FlashCore Module type drives
- ▶ Tiering or mirroring to existing storage
- ▶ Mixed workload consolidation
- ▶ Nondisruptive data migrations
- ▶ Concurrent code load

By accelerating applications, both physical and virtual, the IBM FlashSystem 9200 system can help organizations reduce costs, increase revenue, and improve customer satisfaction for all types of applications, including the following categories:

- ▶ Transactional
- ▶ Enterprise resource planning (ERP) and supply chain management
- ▶ Big data and analytics

- ▶ Server and desktop virtualization
- ▶ Cloud

## AI-empowered

The IBM FlashSystem 9200 system has the following AI-empowered characteristics:

- ▶ AI-empowered storage analytics, storage resource management, and a support platform.
- ▶ AI-based data placement for optimal data center performance and zero-downtime data migration.
- ▶ IBM Storage Insights: AI-empowered predictive analytics, storage resource management, and a support platform delivered over the cloud.

## Multicloud enabled

With IBM Spectrum® Virtualize on premises, IBM Spectrum Virtualize for Public Cloud V8.4.0 can enable clients to migrate data to and from supported public cloud providers, including IBM Cloud™ and Amazon Web Services (AWS). Clients can create hybrid multicloud solutions for their traditional block data and workloads by using built-in IP replication capabilities.

IBM Spectrum Virtualize for Public Cloud is deployed on a cloud infrastructure as a service (IaaS) from IBM Cloud or AWS, either on bare metal servers in IBM Cloud or on Amazon Elastic Compute Cloud (Amazon EC2) instances on AWS, and virtualized AWS Amazon Elastic Block Store (EBS) storage. This setup enables clients to create clustered configurations like on premises while bringing the optimization and virtualization capabilities of IBM Spectrum Virtualize to public cloud infrastructures. These capabilities include most of the key features of IBM Spectrum Virtualize, such as IBM FlashCopy®, Transparent Cloud Tiering (TCT), thin provisioning, Global Mirror, Metro Mirror, Global Mirror with change volumes, and IBM Easy Tier® to public cloud IaaS.

IBM Spectrum Virtualize on premises and IBM Spectrum Virtualize for Public Cloud together enable a hybrid multicloud deployment with a single data management layer between on premises systems and the cloud across heterogeneous storage pools that might exist in the data center. IBM Spectrum Virtualize provides the following functions:

- ▶ Storage pooling and automated allocation with thin provisioning
- ▶ Easy Tier automated tiering
- ▶ Deduplication and compression to reduce cloud storage costs
- ▶ FlashCopy and remote mirror for local snapshots and remote replication
- ▶ Support for virtualized and containerized server environments including:
  - VMware
  - MicrosoftHyper-V
  - IBM PowerVM®
  - Red Hat OpenShift
  - CRI-O
  - Kubernetes

For more information about IBM FlashSystem systems and Hybrid Multicloud, see [IBM FlashSystems and Hybrid Multicloud](#).

## Advanced Data Services

The IBM FlashSystem 9200 system provides these advanced data services:

- ▶ Business continuity with replication services
- ▶ Data protection with IBM FlashCopy services
- ▶ Higher storage efficiency with thin provisioning
- ▶ Data reduction pools that provide compression with deduplication
- ▶ IBM Easy Tier
- ▶ External virtualization
- ▶ IP quorum support
- ▶ N\_Port ID Virtualization (NPIV) support
- ▶ VMware vSphere Virtual Volume (VVOL) support and space-efficient copies
- ▶ TCT

## IBM FlashSystem 9200 enclosures overview

The IBM FlashSystem 9200 system has two different types of enclosures: Control Enclosures and Expansion Enclosures.

- ▶ A Control Enclosure manages your storage systems, communicates with the host, and manages interfaces. In addition, it can also house up to 24 NVMe-capable flash drives. These drives can be either industry-standard NVMe types or the exclusive IBM FlashCore Module NVMe type and up to 12 optional SCM class drives.
- ▶ An Expansion Enclosure increases the available capacity of an IBM FlashSystem 9200 cluster. It communicates with the Control Enclosure through a dual pair of 12 Gbps serial-attached SCSI (SAS) connections. These Expansion Enclosures can house many of flash (solid-state drive (SSD)) SAS type drives, depending on which model of enclosure is ordered.

Figure 1 shows the IBM FlashSystem 9200 Control Enclosure front view with an NVMe drive partially removed



Figure 1 IBM FlashSystem 9200 Control Enclosure with one NVMe drive partially removed

## Control Enclosures

Each Control Enclosure can have multiple attached Expansion Enclosures, which expand the available capacity of the entire system. The IBM FlashSystem 9200 solution supports up to four Control Enclosures and up to two chains of SAS Expansion Enclosures per Control Enclosure.

The IBM FlashSystem 9200 Control Enclosure supports up to 24 NVMe-capable flash drives in a 2U high form factor and consists of the following machine types:

- ▶ The 9846 has one model: AG8
- ▶ The 9848 has two models: AG8 and UG8

**Note:** The 9848-UG8 model is an IBM FlashSystem 9200 solution with a 3-year warranty, and is offered in the Storage Utility Offering space. This model is physically and functionally identical to the IBM FlashSystem 9848-AG8 model, except for target configurations and variable capacity billing.

The variable capacity billing uses IBM Spectrum 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 identified as storage that is allocated to a specific host (and unusable to other hosts), whether data is written or not. For thin-provisioning, the data that is written is considered used. For thick-provisioning, the total allocated volume space is considered used.

## Expansion Enclosures

The IBM FlashSystem 9000 Expansion Enclosure consists of the following machine types:

- ▶ The 9846 has two models: AFF and A9F
- ▶ The 9848 has two models: AFF and A9F

New SAS-based small form factor (SFF) and large form factor (LFF) Expansion Enclosures support flash-only MDisks in a storage pool, which can be used for IBM Easy Tier. Consider the following points:

- ▶ IBM FlashSystem 9000 SFF Expansion Enclosure Model AFF offers drive options with SSD flash drives. Up to 480 drives of SAS expansions are supported per IBM FlashSystem 9200 Control Enclosure. The Expansion Enclosure is 2U high.
- ▶ IBM FlashSystem 9000 LFF Expansion Enclosure Model A9F offers drive options with SSD flash drives. Up to 784 drives of SAS expansions are supported per IBM FlashSystem 9200 Control Enclosure. The Expansion Enclosure is 5U high.

The IBM FlashSystem 9200 Control Enclosure can be recognized by the nomenclature “IBM FlashSystem 9200” on the left side of the bezel cover, which covers the rack-mounting screws.

Figure 2 on page 8 shows the IBM FlashSystem 9200 bezel and NVMe drive description.



Figure 2 IBM FlashSystem 9200 bezel and IBM FlashCore Module description

Labeling on the NVMe drive provides the drive type, capacity, and FRU number. The example that is shown in Figure 2 is the IBM FlashCore Module NVMe 19.2 TB type.

## IBM FlashSystem 9200R overview

The IBM FlashSystem 9200R system provides a way of ordering a clustered IBM FlashSystem 9200 system with a dedicated Fibre Channel (FC) network and optional Expansion Enclosures, which are delivered ready-assembled in a rack.

The IBM FlashSystem 9200R system can be ordered with 2, 3, or 4 IBM FlashSystem 9200 model AG8 controller enclosures. These different configurations are referred to as IBM FlashSystem 9202R, IBM FlashSystem 9203R, and IBM FlashSystem 9204R, with the last number denoting the number of AG8 controller enclosures in the rack.

Each rack features a pair of 16-port FC switches with all ports enabled. This configuration allows a redundant, dedicated FC network to be created to allow inter-cluster traffic to flow between the canisters in the AG8 controller enclosures. By having this dedicated network, cluster traffic is prevented from interfering with host or copy service traffic and provides reliable, consistent communications.



For customers that want extra storage, a single 2U 24 drive model AFF or 5U 92 drive model A9F Expansion Enclosure can be added to each model AG8. To allow the expansion to be attached to the model AG8, a 12Gb SAS card is required in one of the IO card slots, which reduces the number of slots that are available for host and clustering connectivity.

## Compatibility

Although the IBM FlashSystem 9200R system is a separately orderable product, it remains equivalent to a clustered IBM FlashSystem 9200 system.

Therefore, all of the functionality that is available through IBM Spectrum Virtualize (such as data reduction, copy services, and distributed array [DRAID]) is available in the IBM FlashSystem 9200R system. Indeed, the GUI shows the system as a clustered IBM FlashSystem 9200 system.

The IBM FlashSystem 9200R system has the same licensing scheme as the IBM FlashSystem 9200 system. That is, all-inclusive licensing for all functions except encryption, which is a country limited feature code, and external virtualization.

The configuration rules and best practices that are associated with the IBM FlashSystem 9200 system are also the same. Other considerations are involved when clustered IBM FlashSystem products are used, but these considerations differ when the IBM FlashSystem 9200 system is supplied in the IBM FlashSystem 9200R rack form. Any limitations (such as number of volumes and number of RC partnerships) also match the limitations for the IBM FlashSystem 9200 system.

Interoperability is the same as the IBM FlashSystem 9200 system, and can be referenced as an IBM FlashSystem 9200 system in the [IBM System Storage™ Interoperability Center](#).

For more information, see the IBM FlashSystem 9200R Rack Solution Product Guide.

## Did you know

The IBM FlashSystem 9200 system runs IBM Spectrum Virtualize V8.4.0, which provides the following functionality:

- ▶ Supports the IBM FlashCore Module NVMe type drives with IBM enhanced flash technology.
- ▶ The IBM FlashSystem 9200 Control Enclosure supports up to 24 ultra-low latency 2.5-inch (SFF) 4.8 TB, 9.6 TB, 19.2 TB, or 38.4 TB IBM FlashCore Module NVMe types or up to 24 NVMe 800 GB, 1.92 TB, 3.84 TB, 7.68 TB, or 15.36 TB industry-standard drives, or a mixture of both.
- ▶ Supports up to 12 NVMe SCM Drives in capacities 375 GB, 750 GB, 800 GB, and 1.6 TB.
- ▶ IBM FlashCore Module NVMe types provide automatic data compression and encryption without affecting the system performance.
- ▶ The model A9F and AFF SAS Expansion Enclosures can be used with the IBM FlashSystem 9200 control expansion.
- ▶ The IBM FlashSystem 9200 system can use IBM Security Key Lifecycle Manager or USB key encryption. Up to four IBM Security Key Lifecycle Manager key servers are supported. Offers hardware-based AES 256 data-at-rest encryption by using USB key and IBM Security Key Lifecycle Manager key server-based encryption, with no performance impact.

- ▶ RSA enables IBM support personnel to access the system to complete troubleshooting tasks.
- ▶ Consistency protection for Global Mirror and Metro Mirror replication.
- ▶ Management GUI support for host clusters, including private and shared volume mappings.
- ▶ Throttling allows customers to control resources that are used when the system is processing I/Os on hosts, host clusters, volumes, copy offload operations, and storage pools.
- ▶ TCT is a function of IBM Spectrum Virtualize that uses IBM FlashCopy mechanisms to produce a point-in-time snapshot of the data.
- ▶ Provides flexible interface types, including FC and Ethernet (iWARP and RDMA over Converged Ethernet [RoCE] protocols) to easily integrate into existing SAN and iSCSI network environments.
- ▶ IBM Storage Insights offers some key capabilities that helps clients meet the demands that are put on IT by helping to build the connective fabric between IBM, storage, and the user. IBM Storage Insights provides advanced customer service and monitors the performance, capacity, and health of each device.

## Current release functions

This section describes several new functions and features that are available in the current IBM FlashSystem 9200 release.

### New in IBM FlashSystem 9200 Software V8.4.0

The following functions are included in IBM FlashSystem 9200 Software V8.4.0:

- ▶ 3 Site Data Replication for HyperSwap. 3 Site Data Replication for HyperSwap supports the following use cases:
  - Disaster scenarios
  - Site maintenance
  - Link failure cases
- ▶ Security updates:
  - IBM is releasing a new set of options to allow a security administrator to create policies for passwords, account lockout, session time-out.
  - Create a single system-wide policy that applies to all local accounts (session time-outs also apply to remote accounts).
  - Configurable CLI time-out.
  - HTTP proxy server for cloud callhome and Storage Replication Adapter (SRA) log upload.
  - NVMe drive security updates (new events and sense data to better identify and resolve NVMe drive encryption errors) and secure data deletion.
- ▶ UI modernization updates:
  - Modernized syslog servers panel.
  - New host dialog.

- New Add Storage experience.
- Modernized remote copy experience (2-site and 3-site).
- ▶ DRAID-1:
  - 2 member drives per array (0 rebuild area)
  - 3 - 16 member drives per array (1 rebuild area)
  - System recommendation is to create DRAID-1 in arrays up to 6 drives
- ▶ Data reduction child pools:
  - User can create child pools in data reduction parent pools
  - Data reduction child pools are created without a quota and can consume entire parent capacity
- ▶ DRP
  - Redirect-on-write for DRP snapshots adds a redirect-on-write (RoW) alternative to the existing copy-on-write (CoW) capabilities.
  - Comprestimator always on.
  - RAID Reconstruct Read (3R) leveraging RAID capabilities, DRP asks for a specific data block reconstruction when detecting a potential corruption.
- ▶ Miscellaneous:
  - Updates to max configuration limits.
  - 8.4.0 mirrored vDisks fast format enhancements.
  - 8.4.0 FC-NVMe enhancements.
  - 8.4.0 improved handling of memory errors.
  - SCM restrictions lifted. See “Storage-class memory” on page 13.
  - As of Spectrum Virtualize 8.4.0.2 and SI/ Spectrum Control 5.3.7 or later data collection can be done with Monitor (least privileged) role. As each node writes a statistics file it will automatically be uploaded to the config node.
  - 8.4.0 DNS support enhancements.

## IBM FlashSystem 9200 Software V8.3.1

The following functions are included in IBM FlashSystem 9200 Software V8.3.1:

- ▶ Support for IBM FlashSystem 9200 enclosures with new larger NVMe drives.
- ▶ RSA provides a secure connection for remote support with audit logging.
- ▶ Management GUI enhancements.
- ▶ Ownership groups: An ownership group defines a subset of users and objects within the system. You can create ownership groups to further restrict access to specific resources that are defined in the ownership group.
- ▶ Priority flow control (PFC): PFC is an Ethernet protocol that supports the ability to select the priority of different types of traffic within the network.
- ▶ Support for expanding DRAID.
- ▶ Support for pool-level volume protection: Volume protection prevents active volumes or host mappings from being deleted inadvertently if the system detects recent I/O activity.
- ▶ Support for Simple Network Management Protocol (SNMP) protocol version 3 enhanced security features.

- ▶ Support for enhanced auditing features for syslog servers.
- ▶ Enhanced password security: The user must change the default password to a different password on first login/system setup.
- ▶ Improvements to the terms and definitions that relate to capacity were updated.
- ▶ Support for the new SCM technology with implementation that uses new drives from Intel and Samsung, which can enchain workload throughput, with or without that uses of Easy Tier.
- ▶ 3-site replication: This replication provides enhanced disaster tolerance for IBM Spectrum Virtualize systems, which allows coordination of data between three disparate sites for failover and failback.  

At the time of this announcement, 3-site replication requires the submission of a request through the SCORE system to help manage and ensure that the requirements and configuration details are met.
- ▶ Secure Drive Erase: The ability to completely erase any customer data from a NVMe or SAS SSD, before it is removed from the control or Expansion Enclosure.

## IBM FlashCore technology

At the heart of the IBM FlashSystem 9200 system is IBM FlashCore technology (if the IBM FlashCore Module NVMe type drives are ordered), which consists of the following key elements:

- ▶ Hardware-accelerated architecture that is engineered for flash, with a hardware-only data path.
- ▶ The IBM FlashSystem data compression and decompression algorithm is a Modified dynamic GZIP algorithm. It is implemented completely in hardware; no processor intervention is required.
- ▶ IBM FlashCore Modules, which are designed for low latency, density, and reliability.
- ▶ IBM Advanced Flash Management, which improves flash endurance over standard implementations without sacrificing latency.

Figure 3 on page 13 shows IBM FlashCore technology.

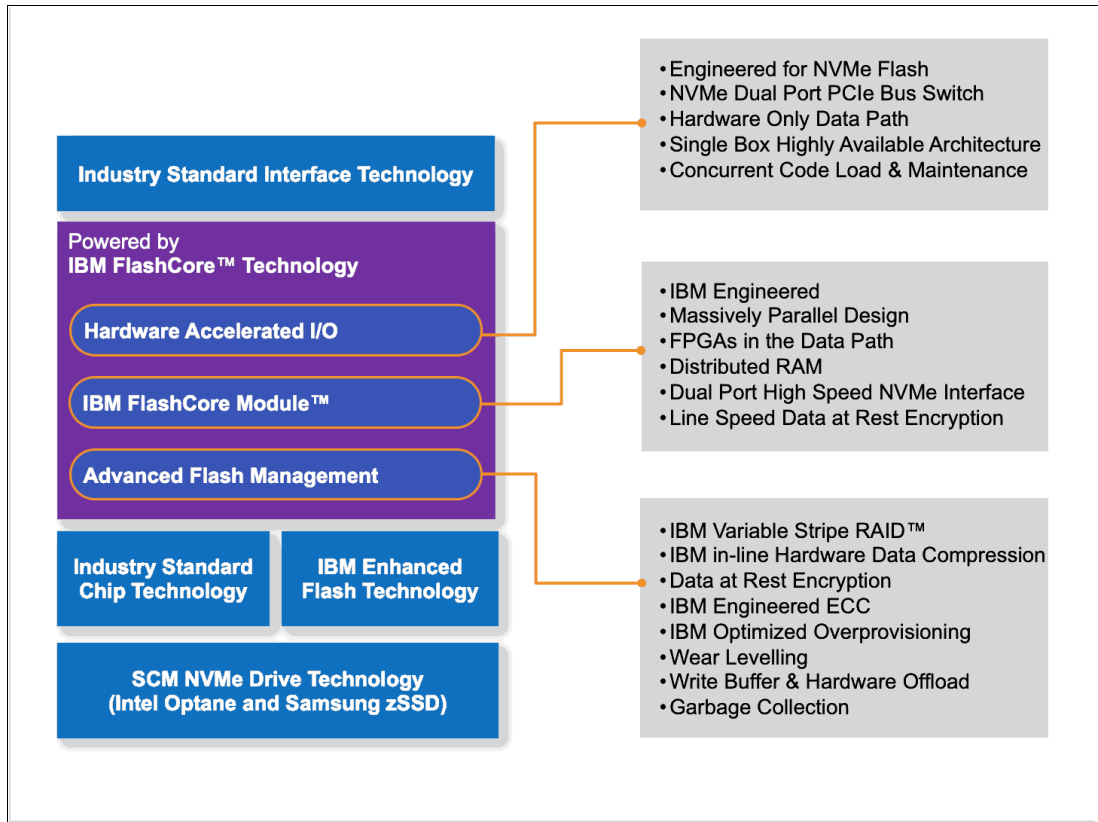


Figure 3 IBM FlashCore technology

For more information about IBM FlashCore technology, see [IBM FlashSystem 900 - Overview](#).

## Storage-class memory

SCM is an industry-wide buzz word for non-volatile memory devices that perform faster (~10µs) than traditional NAND SSDs(100µs), but slower than dynamic random access memory (DRAM) (100ns).

The technology pricing sits between DRAM and traditional NAND. Price is significantly more expensive than traditional NAND drives.

At the time of this writing, the following vendors are most prevalent in the marketplace:

- ▶ Intel (3D Xpoint memory technology in Optane drives)
- ▶ Samsung (zNAND memory technology in zSSDs)

The IBM FlashSystem 9200 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 SCM drives.

**Note:** Storage Class Memory (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 Easy tier levels are:

- ▶ Storage Class Memory
  - Storage Class Memory tier exists when the pool contains drives that use persistent memory technologies that improve endurance and speed of current flash storage device technologies.
- ▶ Tier 0 flash
  - Tier 0 flash tier exists when the pool contains high performance flash drives.
- ▶ Tier 1 flash
  - Tier 1 flash tier exists when the pool contains tier 1 flash drives. Tier 1 flash drives typically offer larger capacities, but slightly lower performance and write endurance characteristics.
- ▶ Enterprise tier
  - Enterprise tier exists when the pool contains enterprise-class MDisks, which are disk drives that are optimized for performance.
- ▶ Nearline tier
  - 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. DRP and VG extent allocation was tuned to use SCM drives, specially for metadata (directory volume lookups). This is one of the main use cases for SCM drives in an IBM FlashSystem 9200 system.

## SCM and RAID configurations

SCM Drives feature the following rules concerning RAID supported configurations:

- ▶ Distributed DRAID 1 with two drives (including distributed spare capacity) or more and is the best practice recommendation and configuration.
- ▶ Distributed DRAID 5 with four drives (including distributed spare capacity) or more is supported
- ▶ Distributed DRAID 6 with six drives (including distributed spare capacity) or more is supported
- ▶ Traditional TRAIID 1 and 10 with two drives is supported; however, no spare is available, and performance might be limited.
- ▶ 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.

## SCM drive formatting and UNMAPS

Because of its media technology, SCM drive formats take much longer to format a drive than a typical NVMe drive. The drive formats can take up to 15 minutes, so the user must be patient and wait until the process completes.

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

- ▶ A drive is replaced
- ▶ An enclosure is managed
- ▶ An array/mdisk is removed

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

## IBM FlashWatch overview

IBM FlashWatch is a new offering from IBM to compliment the purchase of the IBM FlashSystem 9200 system. It provides the following features that are included in the purchase of the product:

- ▶ Acquisition:
  - HA Guarantee:
    - Proven 99.9999% availability
    - Optional 100% commitment when HyperSwap is used
  - Data Reduction Guarantee:
    - 2:1 self-certified
    - Up to 5:1 with workload profiling
  - All-inclusive Licensing
    - All storage function included in licensing cost for internal storage
- ▶ Operation:
  - Comprehensive Care
    - Up to 7 years of 24x7 support, with 3 years Technical Advisor, enhanced response times, and managed code upgrades
  - Cloud Analytics
    - Storage Insights included at no extra cost to proactively manage your environment
  - Flash Endurance Guarantee
    - Flash media is covered for all workloads while under warranty or maintenance
- ▶ Migration:
  - IBM Flash Momentum - Storage Upgrade Program
    - Replace your controller and storage every 3 years with full flexibility
  - Cloud-like Pricing
    - Storage Utility pricing has monthly payments for only the storage that you use
  - No Cost Migration
    - 90 day, no-cost data migration from over 500 storage controllers (IBM and non-IBM)

For more information about the IBM FlashWatch offering, see the [IBM FlashWatch FAQ](#).

The IBM FlashWatch offering is applicable across the IBM Spectrum Virtualize family. The Product Matrix in the FAQ describes which elements are applicable against which product.

## IBM Storage Insights

IBM Storage Insights is another part of the monitoring capability of the IBM FlashSystem 9200 system and supplements the views that are available in the GUI.

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

With storage health information, you can focus on areas that need attention, and when IBM support is needed, IBM Storage Insights simplifies uploading logs, speeds resolution with online configuration data, and provides an overview of open tickets all in one place.

IBM Storage Insights includes the following features:

- ▶ A unified view of IBM systems:
  - Provides a single view to see all your system's characteristics
  - Displays all of your IBM storage inventory
  - Provides a live event feed so that you know in real time what is going on with your storage so that you can act quickly
- ▶ IBM Storage Insights collects telemetry data and Call Home data, and provides real-time system reporting of capacity and performance
- ▶ Overall storage monitoring, which provides the following information:
  - The overall health of the system
  - Monitoring of the configuration to see whether it meets preferred practices
  - System resource management to determine which system is overtaxed and provides proactive recommendations to fix it
- ▶ IBM Storage Insights provides advanced customer service with an event filter that you can use to accomplish the following tasks:
  - You and IBM Support can view support tickets, open and close them, and track trends.
  - You can use the autolog collection capability to collect the logs and send them to IBM before IBM Support looks in to the problem. This capability can save as much as 50% of the time to resolve the case.

In addition to the no-charge version of IBM Storage Insights, IBM also offers IBM Storage Insights Pro, which is a subscription service that provides longer historical views of data, more reporting and optimization options, and supports IBM file and block storage with EMC VNX and VMAX.

### Customer dashboard

Figure 4 on page 17 shows a view of the IBM Storage Insights main dashboard and the systems that it monitors.



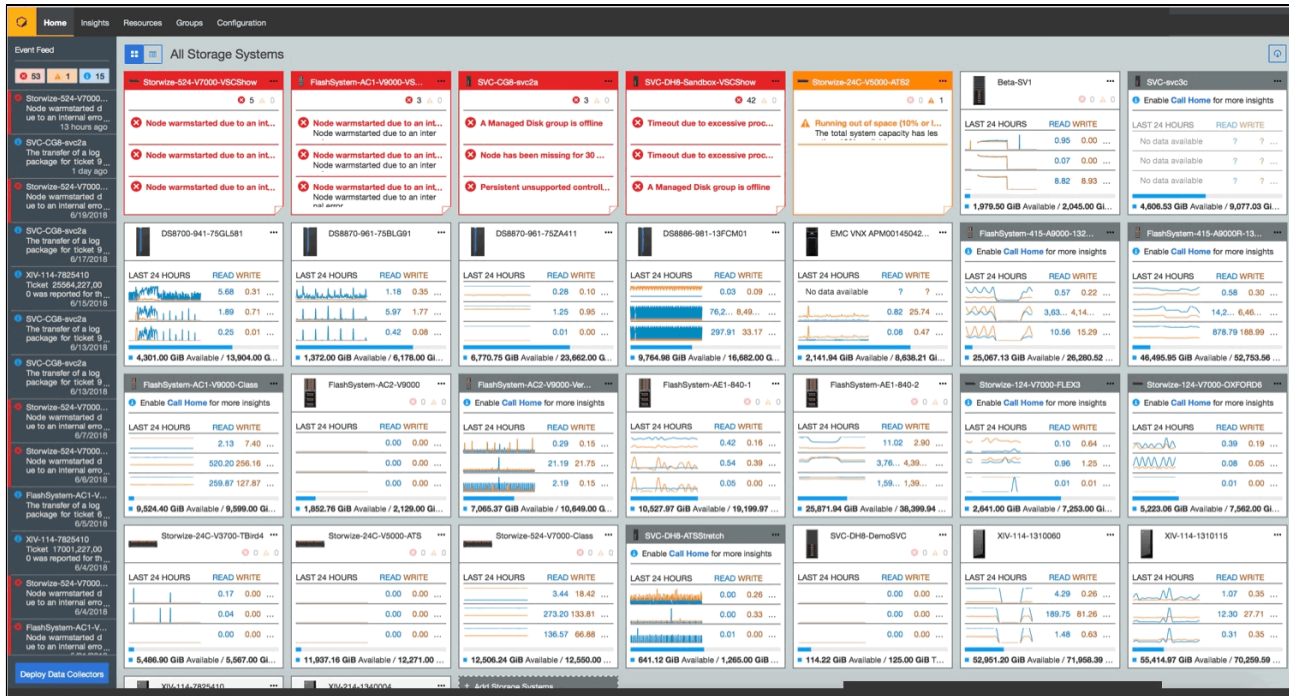


Figure 4 IBM Storage Insights dashboard

For more information about dashboard displays, see “IBM Storage Insights: Information and registration” on page 17.

For more information about the architecture and design overview of IBM Storage Insights, see *IBM FlashSystem 9100 Architecture, Performance, and Implementation*, [SG24-8425](#).

### IBM Storage Insights: Information and registration

For more information about IBM Storage Insights, see the following web pages:

- ▶ [Fact Sheet](#)
- ▶ [Demonstration](#)
- ▶ [IBM Knowledge Center](#)
- ▶ [Registration](#)

## IBM Spectrum Control Connect

IBM FlashSystem 9200 Software V8.4.0 supports integration of VMware APIs for Storage Awareness (VASA) and vStorage API for Array Integration (VAAI) by using IBM Spectrum Control Connect V3.2.5 (formally known as IBM Spectrum Control Base) or later. This centralized server system consolidates a range of IBM storage provisioning, virtualization, cloud, automation, and monitoring solutions through a unified server platform. For more information about this feature, see [IBM Knowledge Center](#).

IBM Spectrum Control Connect 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.

## IBM Enterprise Class Support

IBM Enterprise Class Support (ECS) is available for only the IBM FlashSystem 9200 systems that are purchased with a 3-year warranty (see Table 1).

*Table 1 Machine types that qualify for Enterprise Class Support*

Component	Machine type model
IBM FlashSystem 9200 Control Enclosure	9848-AG8 9848-UG8
IBM FlashSystem 9000 Expansion Enclosure	9848-AFF 9848-A9F

The ECS offering provides the following key enhancements to the product base 3-year warranty terms and conditions:

- ▶ IBM Technical Advisor to proactively improve problem management and communication
- ▶ Software and product installation
- ▶ Configuration support
- ▶ Onsite and remote software updates, with up to six times during the warranty period
- ▶ Enhanced response times for high severity problems

During the warranty period, and with a current active software maintenance agreement, the client is entitled to enhanced response times for severity 1 problems. IBM also provides an IBM Service Support Representative (IBM SSR) to perform onsite product setup and installation. In addition, the IBM SSR or IBM Remote Support Center performs up to six software updates during the warranty period.

IBM Technical Advisor support is provided during the warranty period. This support enhances end-to-end support for the client's complex IT solutions. IBM Technical Advisor uses an integrated approach for coordinated, cross-team support to enable clients to maximize IT availability.

IBM Technical Advisor works with clients, sales teams, and IBM Business Partners to ensure that the Technical Delivery Assessment (TDA) checklist and site planning steps are complete. Also, with the 3-year warranty, IBM Technical Advisor proactively plans the software updates, which ensure that workstation, network access, user ID, and software download steps are complete before deploying the IBM SR or IBM Remote Support Center to perform the software update.

## IBM FlashSystem 9200 GUI

Because IBM FlashSystem 9200 Control Enclosures cluster to form a system, a single management interface is used for IBM FlashSystem 9200 Control Enclosures. Each IBM FlashSystem 9200 node canister is an individual server in an IBM FlashSystem 9200 clustered system, on which the IBM FlashSystem 9200 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 9200 system. The IBM FlashSystem 9200 Control Enclosure is delivered in a 2U 19-inch rack-mount enclosure. The IBM FlashSystem 9200 system features IBM engineer (SSR) installation as part of the product offering.

Figure 5 shows the IBM FlashSystem 9200 GUI dashboard.

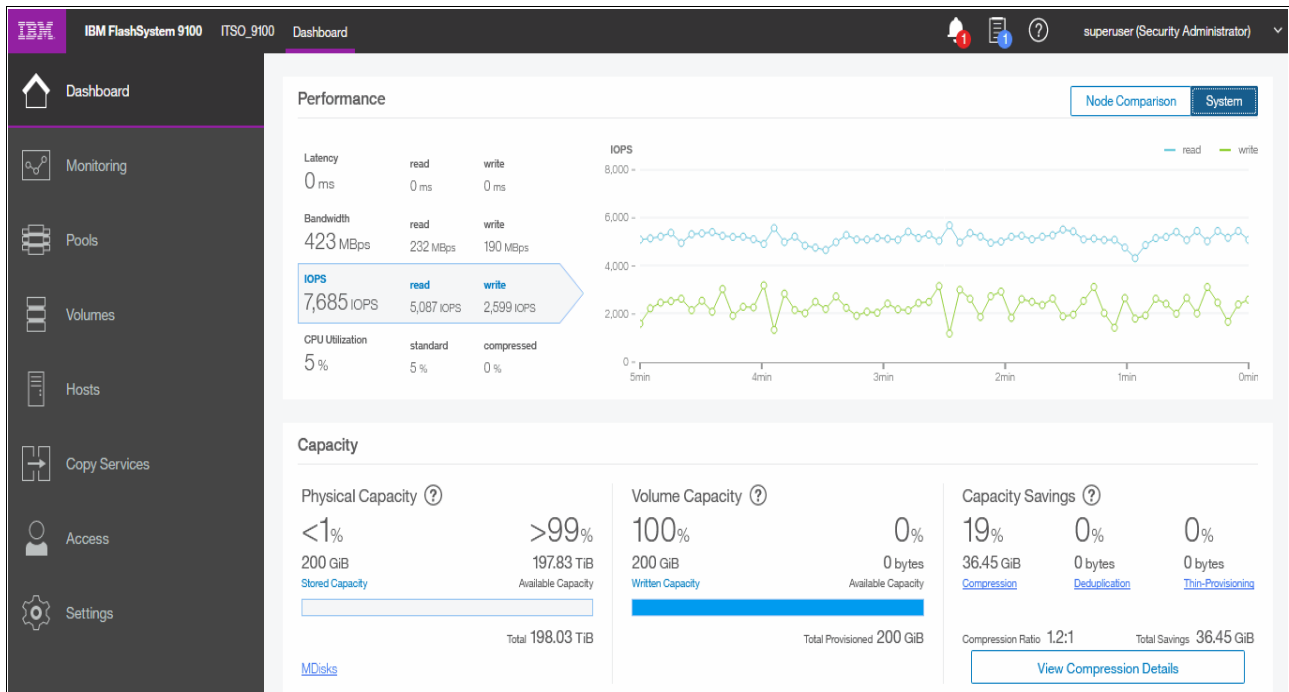


Figure 5 IBM FlashSystem 9200 GUI showing the dashboard

Figure 6 shows the Control Enclosure window. You can open this window by selecting **Monitoring** → **System Overview** from the left graphical menu.

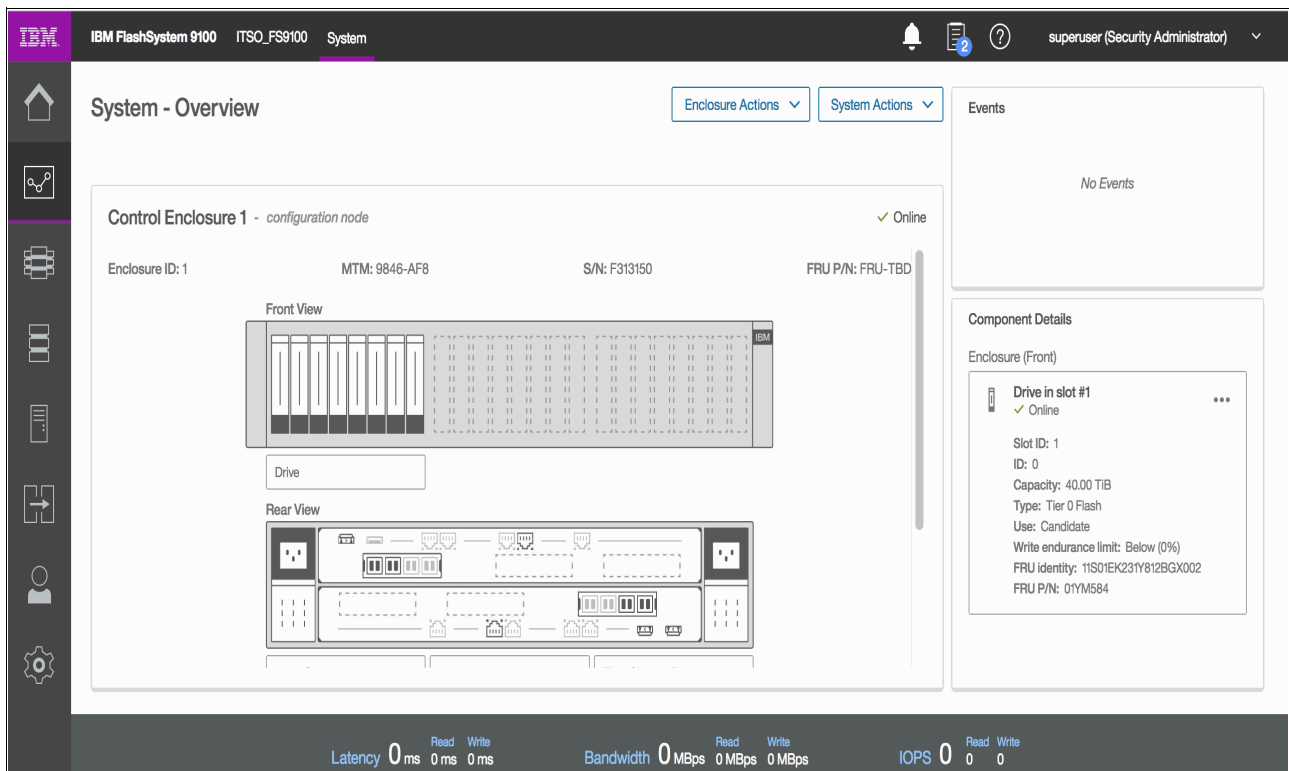


Figure 6 IBM FlashSystem 9200 system overview of the Control Enclosure

The IBM FlashSystem 9200 system includes a command-line interface (CLI), which is useful for scripting, and an intuitive GUI for simple and familiar management of the product. The IBM FlashSystem 9200 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 storage and manage it efficiently. The GUI runs on the IBM FlashSystem 9200 Control Enclosure; therefore, a separate console is not needed. Point your web browser to the system IP address, and you can manage all of the Expansion Enclosures from one place.

The IBM FlashSystem 9200 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 9200 system beyond a web browser or a standard SSH client.

## Supported platforms

The IBM FlashSystem 9200 system has extensive interoperability with support for a wide range of operating systems (Microsoft Windows Server 2008 and 2012, Linux, and IBM AIX®, and IBM i), hardware platforms (IBM System x, IBM Power Systems, and x86 servers that are not from IBM), host bus adapters (HBAs), and SAN fabrics. For more information, see the [IBM System Storage Interoperation Center \(SSIC\)](#).

## IBM FlashSystem 9200 hardware component overview

The IBM FlashSystem 9200 Control Enclosure is a 2U rack-mounted NVMe flash memory enclosure that is based on IBM flash technology that provides the primary management interface (GUI) and the host interface configuration. The IBM FlashSystem 9200 Control Enclosures support FC Protocol (FCP and NVMeOF on FC) and iSCSI interfaces. For iSCSI, the RoCE and iWARP protocols are supported.

The IBM FlashSystem provides the following NVMe technologies:

- ▶ Supports unique world class IBM FlashCore Module drives with inline compression.
- ▶ Supports industry-standard NVMe drives.
- ▶ Option for Intel Optane or Samsung zSSD SCM type drives.
- ▶ NVMe-oF on FC.
- ▶ IBM FlashSystem 9200 system is offered as two models:
  - Model AG8: IBM FlashSystem 9200 SFF NVMe Control Enclosure
  - Model UG8: IBM FlashSystem 9200 SFF NVMe Control Enclosure

**Note:** The UG8 utility-based model features fixed configurations because they are Capacity on Demand (CoD) based offerings.

- ▶ Macroefficiency with up to 920 TB of raw maximum protected capacity with inline hardware data compression if you use IBM FlashCore Module NVMe types.
- ▶ Support for industry-standard NVMe drives with up to 368 TB of maximum raw capacity.
- ▶ Extreme performance with IBM MicroLatency® FlashCore Modules.
- ▶ Optional Expansion Enclosures provide tiering options with SSD flash drives.

The IBM FlashSystem 9200 configuration consists of the following components:

- ▶ A total of 1 - 4 IBM FlashSystem 9200 Control Enclosures
- ▶ A total of 1 - 20 IBM FlashSystem 9000 SFF Expansion Enclosures
- ▶ A total of 1 - 8 IBM FlashSystem 9000 LFF High Density (HD) Expansion Enclosures

The following machine types are offered for the IBM FlashSystem 9200 system:

- ▶ Machine type 9846 with a 12-month warranty
- ▶ Machine type 9848 with a 36-month warranty

Machine type 9848 also features ECS support (including IBM Technical Advisor coverage) during the warranty period.

The Control Enclosure includes integrated AC power supplies and battery units inside each of the node 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 9200 Control Enclosure includes the following features:

- ▶ Full internal redundancy:
  - Redundant and hot-swappable node canisters.
  - Redundant and hot-swappable batteries within each node canister.
  - Hot-swappable PCI Express (PCIe) adapters.
  - Redundant and hot-swappable power supplies, DIMMs, and fans.
- ▶ The Control Enclosure support up to 24 NVMe 2.5-inch drives, which can be the IBM FlashCore Module NVMe type drives or the industry-standard NVMe drives.

The following 2.5-inch (SFF) IBM FlashCore Module NVMe types are supported in IBM FlashSystem 9200 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

Distributed RAID 6 (recommended), Distributed RAID 5 (supported)

The following 2.5-inch (SFF) NVMe industry-standard drives are supported in IBM FlashSystem 9200 Control Enclosures:

- 800 GB 2.5-inch NVMe flash drive
- 1.92 TB 2.5-inch NVMe flash drive
- 3.84 TB 2.5-inch NVMe flash drive
- 7.68 TB 2.5-inch NVMe flash drive
- 15.36 TB 2.5-inch NVMe flash drive

Traditional RAID 10 and Distributed RAID 6 (recommended), Distributed RAID 5 (supported)

It also supports up to 12 NVMe SCM Drives in capacities:

- 375 GB NVMe SCM Drive

- 750 GB NVMe SCM Drive
- 800 GB NVMe SCM Drive
- 1.6 TB NVMe SCM Drive

Distributed RAID 5, or TRAIID 1 or 10 with fewer than four drives:

- 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 6 array.

Each IBM flash memory module 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 256 GB (128 GB per canister) to 1.5 TB (768 GB per canister).
- ▶ Eight 10 Gb Ethernet ports standard for iSCSI connectivity.
- ▶ 32 Gb and 16 Gb FC, 25 Gb Ethernet, and 10 Gb Ethernet ports for FC and iSCSI connectivity.
- ▶ 12 Gb SAS ports for Expansion Enclosure attachment.

The IBM FlashSystem 9200 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 ports come configured in NPIV mode, so the user must check that this configuration is preferred for their installation. If not, this configuration must be changed from the default when you set up the SAN infrastructure. Full active-active multipathing across all interfaces also is supported, although host software support for this function can vary.

Figure 7 shows the front view of the IBM FlashSystem 9200 Control Enclosure.



Figure 7 IBM FlashSystem 9200 Control Enclosure front view

The IBM FlashSystem 9200 Control Enclosure also includes the following expansion features:

- ▶ Capability for adding into clustered systems with more IBM FlashSystem 9200 Control Enclosures or IBM V7000 Gen 2 or Gen 3 controllers.
- ▶ Up to 20 SAS attached Expansion Enclosures are supported per IBM FlashSystem 9200 controller pair, which provides up to 480 SSDs with expansion Model AFF.
- ▶ Up to eight LFF HD A9F expansion controllers are supported per IBM FlashSystem 9200 Control Enclosure pair, which provides up to 736 SSD flash drives of Tier 1 capacity.

Figure 8 on page 23 shows the components of the IBM FlashSystem 9200 Control Enclosure from the rear. You can see the interface cards, power supply units, and the various USB and Ethernet ports. All components are concurrently maintainable, except for the passive midplane and power interposer board. All external connections are from the rear of the system.

**Note:** The upper node canister is mounted upside down in the Expansion Enclosure. Therefore, the port numbering must be read *right to left*.

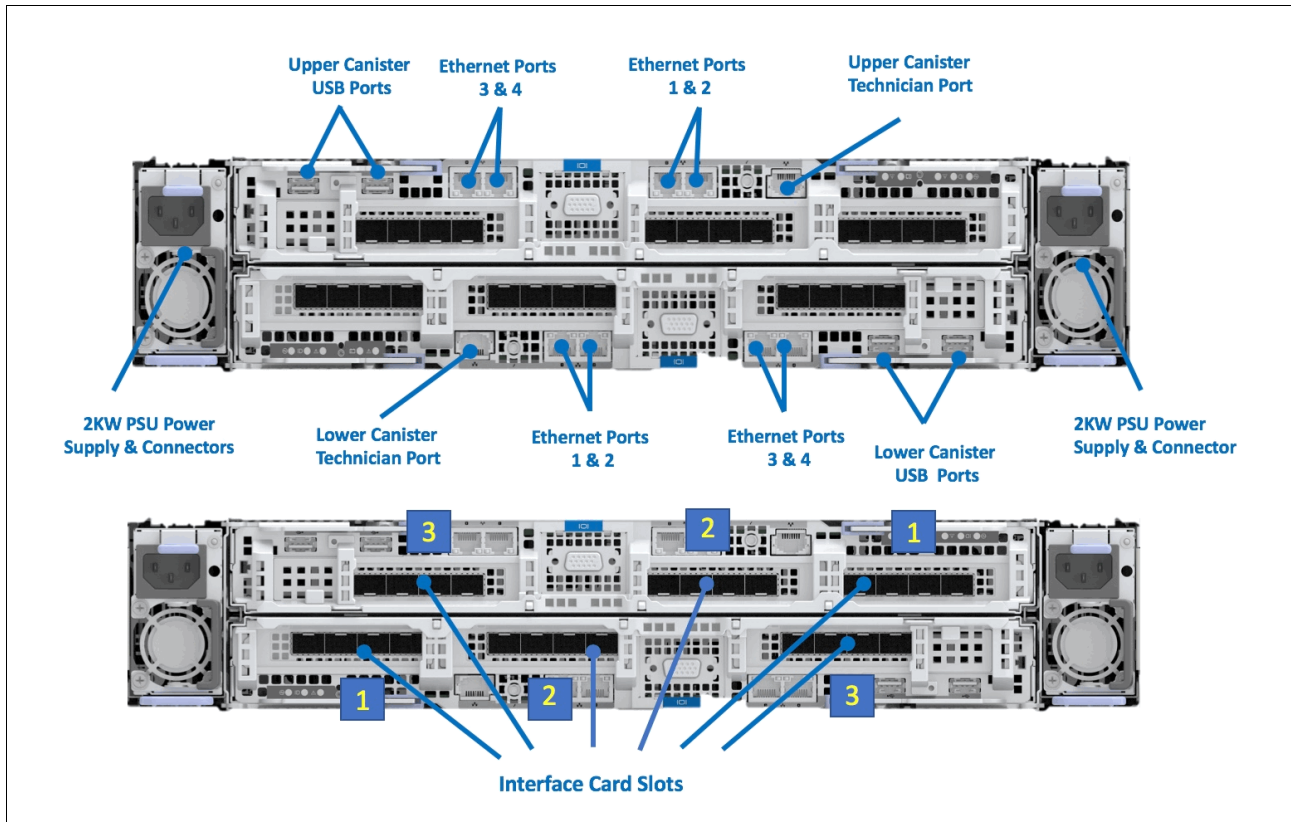


Figure 8 Rear view of IBM FlashSystem 9200 Control Enclosure

### IBM FlashSystem 9200 Utility Model UG8

IBM FlashSystem 9200 Utility Models UG8 provide a variable capacity storage offering. These models also offer a fixed capacity, with a base subscription of around 35% of the total capacity.

IBM Storage Insights is used to monitor system usage, and capacity that is used. This usage is billed on the capacity-used basis. With this billing structure, you can grow or shrink usage, and pay only for the configured capacity.

IBM FlashSystem utility models are provided for customers who can benefit from a variable capacity system, where billing is based only on provisioned space. The hardware is leased through IBM Global Finance on a three-year lease, which entitles the customer to use approximately 30 - 40% of the total system capacity at no extra cost (customer individual contract dependant). If storage needs to increase beyond that initial capacity, 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 9200 utility model with 4.8 TB NVMe drives for a total system capacity of 115 TB. The base subscription for such a system is 40.25 TB. During the months where the average daily usage is below 40.25 TB, no extra billing occurs.

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 month 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 UG 8 utility model billing.

Table 3 9200 UG8 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 should be 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- and thin-provisioning use flash drive space.



Figure 9 shows a summary of the IBM FlashSystem 9200 machine types and models.

Machine Type Model	9846-AG8	9848-AG8 / UG8
Mktg Name	FlashSystem 9200	FlashSystem 9200
Warranty	1 Year; 24x7	3 Year; 24x7
Install	IBM Engineer (SSR)	
Services	Optional priced service offerings	ECS including TA support
Expansion Enclosures	AFF, A9F	AFF, A9F
Misc	All Flash	

Figure 9 IBM FlashSystem 9200 machine type and models

## IBM FlashSystem 9000 Expansion Enclosures

IBM FlashSystem 9000 Expansion Enclosures are 2U or 5U rack-mounted units. The Expansion Enclosures are offered in the following models with four drive features:

- ▶ Model AFF: Supports up to 24 SFF 2.5-inch drives that can be formatted as RAID 5 or DRAID 6.
- ▶ Model A9F: Supports up to 92 LFF 2.5-inch HD Drives in a 3.5-inch carrier, and can be formatted as RAID 5 or DRAID 6.
- ▶ The following 12 Gb SAS industry-standard drives are supported in IBM FlashSystem 9000 Expansion Enclosures, all in 2.5-inch and 3.5-inch form factor features:
  - 1.92 TB 12 Gb SAS flash drive
  - 3.84 TB 12 Gb SAS flash drive
  - 7.68 TB 12 Gb SAS flash drive
  - 15.36 TB 12 Gb SAS flash drive

Multiple Expansion Enclosures are supported per IBM FlashSystem 9200 controller pair, which provides up to 480 drives with Expansion Enclosure Model AFF, and up to 736 drives with Expansion Enclosure Model A9F.

On each SAS chain, the systems can support up to a SAS chain weight of 10:

- ▶ Each 9846-A9F or 9848-A9F Expansion Enclosure adds a value of 2.5 to the SAS chain weight.
- ▶ Each 9846-AFF or 9848-A9F 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 10:

- ▶ Four 9846-A9F enclosures per SAS chain
- ▶ Two 9848-A9F enclosures and five 9848-AFF enclosures per SAS chain

Figure 10 shows the front view of the IBM FlashSystem 9000 Expansion Enclosure Model AFF.



Figure 10 Front view of the IBM FlashSystem 9000 SFF Expansion Enclosure Model AFF

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

- ▶ Two expansion canisters
- ▶ 12 Gb SAS ports for attachment to the IBM FlashSystem 9200 Control Enclosures
- ▶ 2U 19-inch rack-mount enclosure with AC power supplies

Figure 11 shows the rear view of IBM FlashSystem 9000 SFF Expansion Enclosure model AFF.



Figure 11 Rear view of IBM FlashSystem 9000 SFF Expansion Enclosure Model AFF

IBM FlashSystem 9000 LFF Expansion Enclosure Model A9F delivers the following features:

- ▶ Up to 92 drives 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, and 15.36 TB capacity versions.
- ▶ Redundant 200 - 240 V AC power supplies (new PDU power cord required).

Figure 12 shows the front view of IBM FlashSystem 9000 LFF model A9F Expansion Enclosure.

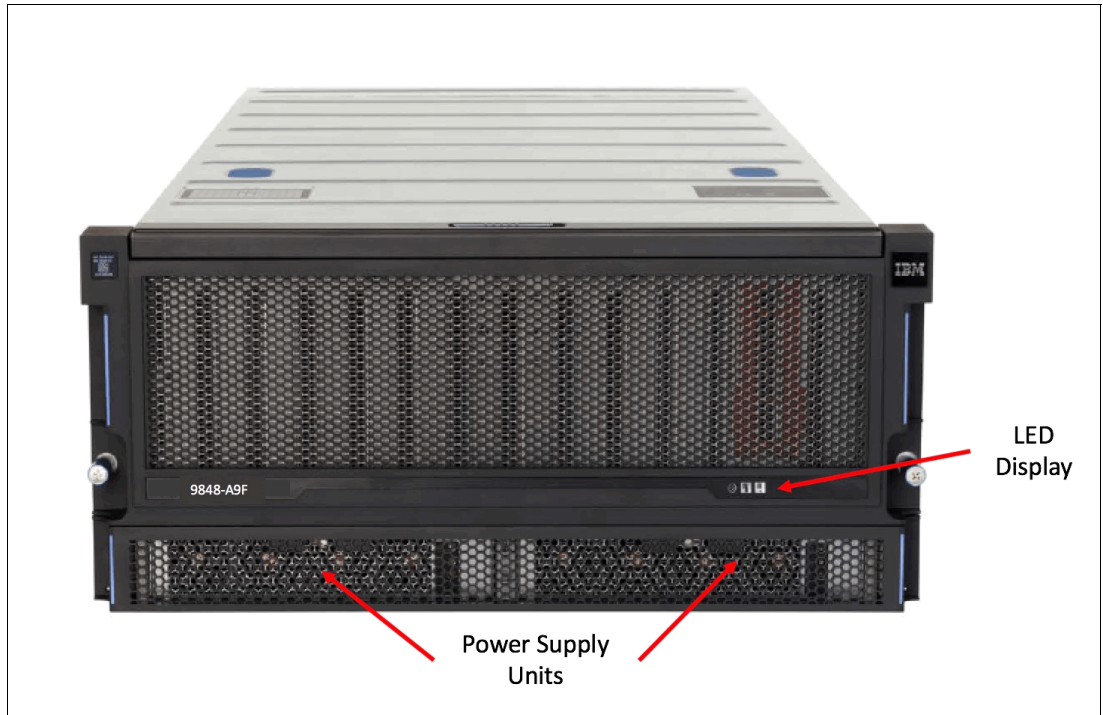


Figure 12 Front view of IBM FlashSystem 9000 LFF model A9F Expansion Enclosure

Figure 13 shows the rear view of IBM FlashSystem 9000 LFF model A9F Expansion Enclosure.

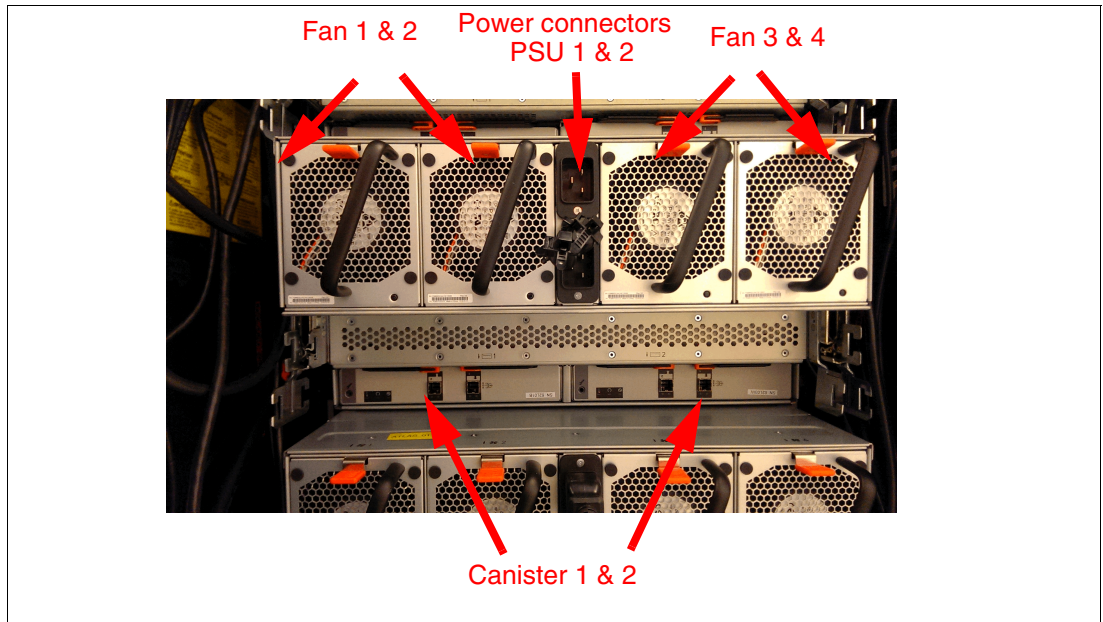


Figure 13 Rear view of IBM FlashSystem 9000 LFF model A9F Expansion Enclosure

## Scalability and performance

The IBM FlashSystem 9200 system has the following scalability and performance features:

- ▶ Up to 806 TB usable and 1.62 PB effective flash capacity in only 2U with 2:1 compression.
- ▶ Up to 3.2 PB usable and 15.8 PB maximum flash capacity in only 8U with 5:1 compression.
- ▶ Extra scalability through Expansion Enclosures models AFF and A9F, and increased raw capacity of up to a maximum of 32 PB.
- ▶ The IBM FlashSystem 9200 system can deliver up to 4.5 million IOPS, with latency down to 70µs and bandwidth up to 45GBps from a single system.
- ▶ A clustered IBM FlashSystem 9200 system, including the IBM FlashSystem 9200R system can scale linearly and delivers 18 million IOPS and 180GBps on a fully configured 4x IBM FlashSystem 9200 cluster.

## Advanced functions

The IBM FlashSystem 9200 system provides the following advanced functions:

- ▶ HyperSwap for the IBM FlashSystem 9200 system
- ▶ NVMeoF - NVMe over Fabrics
- ▶ IP quorum base support
- ▶ Data reduction tools
- ▶ N\_Port ID Virtualization support
- ▶ VMware integration
- ▶ RAID types
- ▶ External Virtualization
- ▶ Manageability and security

These advanced functions are described next.

### HyperSwap for the IBM FlashSystem 9200 system

HyperSwap is available with IBM FlashSystem 9200 Software V8.3.1 and later. You can use HyperSwap to present each volume to two I/O groups. The configuration tolerates combinations of node and site failures by using the same flexible choices of host multipathing driver interoperability as are currently available for the IBM FlashSystem 9200 system. The use of FlashCopy helps maintain a *golden image* during automatic resynchronization.

**Important:** Because remote mirroring is used to support the HyperSwap capability, remote mirroring licensing is a requirement for using HyperSwap. For more information, see “Software and licensing” on page 49.

IBM FlashSystem 9200 Software V8.4.0 includes remote mirroring of Control Enclosures and Expansion Enclosures. IBM Spectrum Virtualize is used to provide functions for externally virtualized storage.

The HyperSwap function uses a *HyperSwap topology* to spread the nodes of the system across two sites, with storage at a third site that acts as a tie-breaking quorum device.

Consider the following points:

- ▶ The HyperSwap topology locates both nodes of an I/O group in the same site. Therefore, at least two I/O groups are required to get a volume that is resiliently stored on both sites.
- ▶ The HyperSwap topology uses extra system resources to support a fully independent cache at each site. This configuration provides full performance, even if one site is lost. In some environments, a HyperSwap topology provides better performance than a *stretched topology*.
- ▶ The HyperSwap function can now be configured through a new CLI that greatly simplifies the setup process to a handful of commands. The HyperSwap function also adds the ability to configure and manage local HyperSwap through the GUI for simpler configuration and operation.
- ▶ Hosts, IBM FlashSystem 9200 Control Enclosures, and IBM FlashSystem 9000 Expansion Enclosures are in one of two failure domains or sites.
- ▶ Volumes are visible as a single object across both sites (I/O groups).

Figure 14 shows how the HyperSwap function works.

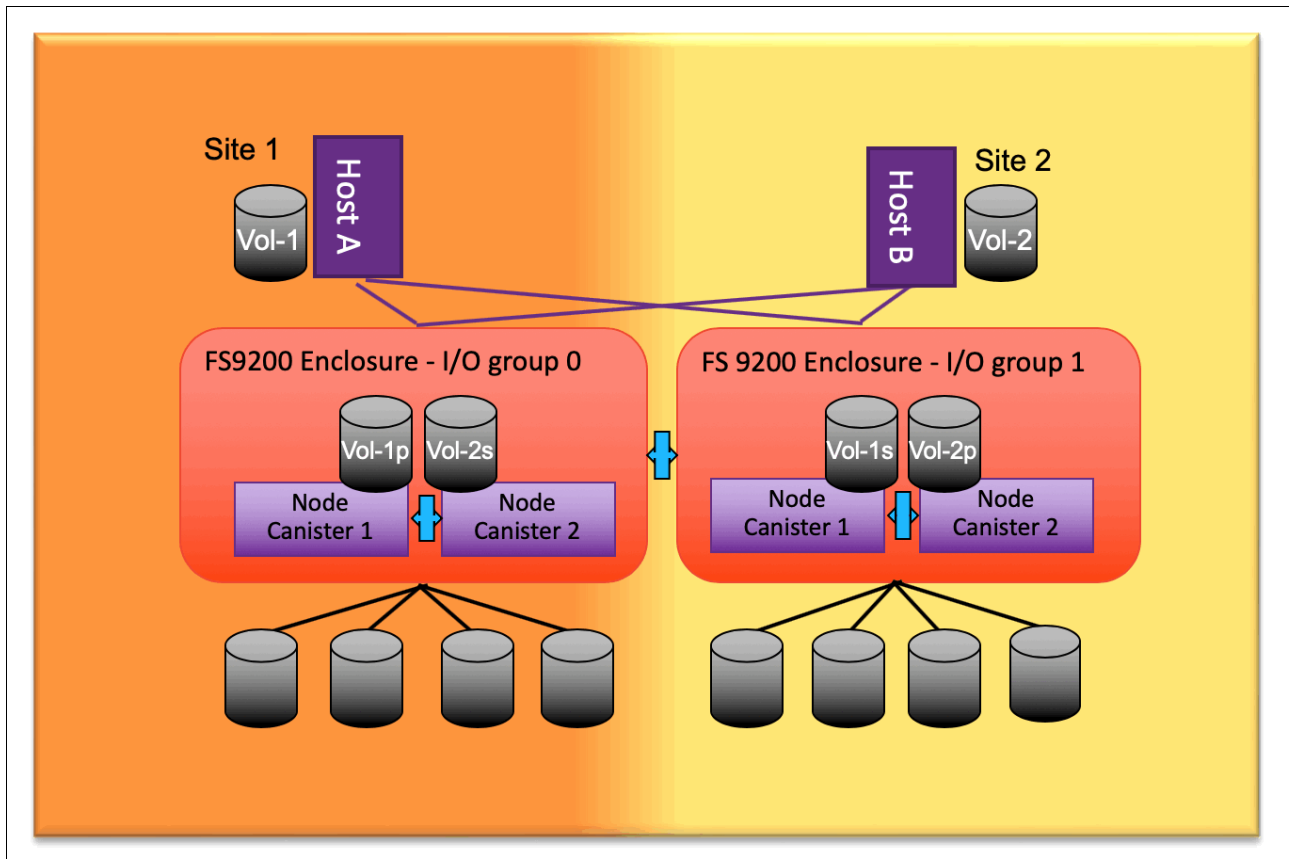


Figure 14 HyperSwap function

Each primary volume (P) has a secondary volume (S) on the opposite I/O group. The secondary volumes are not mapped to the hosts. The dual-write to the secondary volumes is handled by the IBM FlashSystem 9200 HyperSwap function, and is transparent to the hosts.

HyperSwap features the following characteristics:

- ▶ The HyperSwap function is available on IBM FlashSystem 9200 Software V8.3.1 and later, and with two or more I/O groups.

- ▶ You can do a multiple-step CLI-based configuration on a single system by performing simple object creation through the GUI and CLI.
- ▶ Data is stored on two sites in parallel.
- ▶ The maximum distance between sites is 300 kilometers (km).
- ▶ Two independent copies of data are maintained (four if you use another volume mirroring to two pools in each site).
- ▶ HyperSwap uses a standard host multipathing driver.
- ▶ Cache data is retained if only one site is online.
- ▶ Automatically synchronizes and resynchronizes copies.
- ▶ Automatic host-to-storage-system path optimization, based on the host site (requires Asymmetric Logical Unit Access (ALUA) and Target Port Groups Support (TPGS) support from the multipathing driver).
- ▶ Consistent state data is retained during resynchronization for DR.
- ▶ The maximum number of highly available volumes is 1250.
- ▶ Requires a remote mirroring license for volumes. Exact license requirements can vary by product.

## NVMe over Fabrics

The NVMe protocol is an open collection of standards and interfaces that fully uses the benefits of non-volatile memory in all types of computing environments, from mobile to data center. It is designed to deliver high bandwidth and low latency storage access. This section describes the NVMe protocol and interface as it relates particularly to flash-based architectures.

The NVMe protocol is an interface specification for communicating with storage devices and it is functionally the same as other protocols, such as Serial ATA (SATA) and SAS. However, the NVMe interface was designed from the ground up for extremely fast storage media, such as flash-based SSDs and low-latency non-volatile storage technologies.

NVMe storage devices are typically directly attached to a host system over a PCIe bus and the NVMe controller is contained in the storage device, which alleviates the need for another I/O controller between the CPU and the storage device. This architecture results in lower latency, throughput scalability, and simpler system designs.

This design is implemented in the IBM FlashSystem 9200 system, with its dual ported PCIe based NVMe drives.

However, the PCIe bus limits the number of NVMe drives that can be attached to a host over the bus to a few tens of devices. Because the maximum length of PCIe cabling is also only a few meters, the flexibility of deploying PCIe NVMe drives outside the host server is severely limited and data center level scalability is not feasible.

NVMe over Fabrics (NVMe-oF) overcomes the limitations of the SCSI protocol and the limited number of concurrent queues by extending the benefits of low latency and high efficiency of the NVMe technology across network fabrics to support sharing of NVMe storage at a large scale (100s or 1000s of devices) and over distance.

Figure 15 on page 31 shows that the NVMe architecture supports many different network fabric technologies.

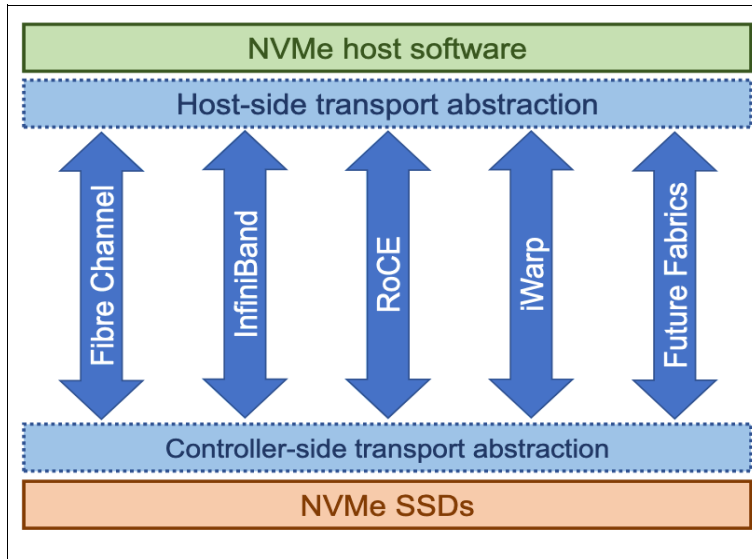


Figure 15 NVMe technology support options

The NVMe transport layer can be mapped to different network fabric technologies.

Currently, the NVMe transport layer supports NVMe over Fabrics using FC, which is referred to as FC-NVMe or NVMeFC.

FC-NVMe uses the Fibre Channel Protocol (FCP) as its transport mechanism, which puts the data transfer in control of the target and transfers data direct from host memory, similar to RDMA. In addition, FC-NVMe allows for a host to send commands and data together (first burst), which eliminates the first data “read” by the target and provides better performance at distances.

The NVMe over Fabrics interface uses the same model of submission and completion queues as PCIe NVMe. As such, it maintains the same asynchronous submission and completion model and achieves similar benefits in terms of latency, efficiency, and scalability as the NVMe technology because of the shortened code paths and lockless concurrency in multi-core environments.

The IBM FlashSystem 9200 system supports NVMe protocols by way of the various PCIe cards that can be ordered and installed in the Control Enclosure. For more information about these options, see “Host I/O connectivity and Expansion Enclosure adapters” on page 45.

For more information about NVMeoF protocols and architecture, see *IBM Storage and the NVM Express Revolution*, [REDP-5437](#).

## IP quorum base support

For lower implementation and operation costs for a HA solution, you can use IP quorum base support to use lower-cost IP network-attached hosts as a quorum disk. HyperSwap implementations require FC storage on a third site to cope with tie-breaker situations if the intersite link fails, and when connectivity between sites 1 and 2 is lost.

In a HyperSwap setup, a quorum disk at the third site is needed. The quorum disk on the third site must be the active quorum disk. Only the active quorum disk acts as a tie-breaker.

A quorum device is also used to store a backup copy of important system configuration data. Just over 256 MB is reserved for this purpose on each quorum device.

A system can have only one active quorum device that is used for a tie-break situation. However, the system uses up to three quorum devices to record a backup of system configuration data to be used if a disaster occurs. The system automatically selects one quorum device to be the active quorum device.

For more information about configuring quorum disks within two or three sites, see [IBM Knowledge Center](#).

**Note:** Fibre Channel over IP (FCIP) connectivity is not supported between nodes when a HyperSwap system is configured without the use of inter-switch links (ISLs).

## Data reduction tools

Compression and de-duplication is a key part of the IBM FlashSystem 9200 system. IBM Comprestimator and Data Reduction Estimator Tool (DRET) is the key sizing tool to estimate how much capacity savings that a client can expect. IBM Comprestimator and DRET can recognize the patterns of the actual client data, and estimate the compressibility of data per volume.

IBM FlashSystem models are supported by the IBM Comprestimator (available as a stand-alone tool and also found in the IBM FlashSystem 9200 GUI) and also the stand-alone DRET. This DRET tool is a host-based application that the user uses to estimate the amount of compression and de-duplication on the IBM FlashSystem 9200 system for specific workloads.

Figure 16 shows how to start the Estimate Compression Saving option from the GUI.

From the main menu, click **Volumes** → **Volumes** and select one volume; then, right-click to see the pop-up menu. From this menu, select **Capacity Savings** → **Estimate Compression Saving**.

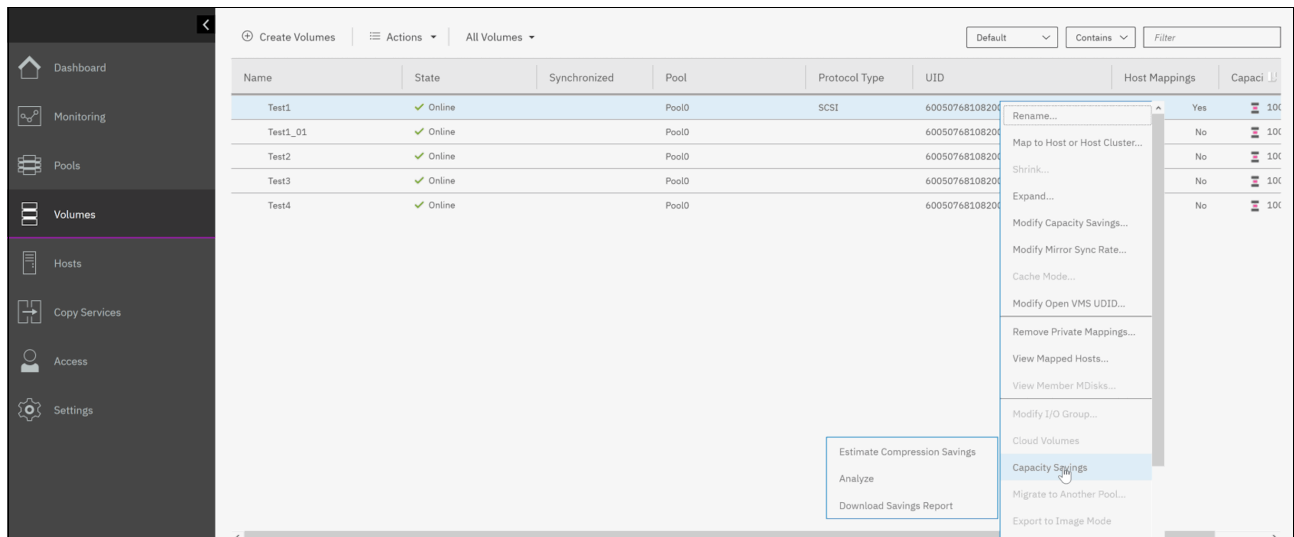


Figure 16 Estimate Compression Saving from the GUI

Choose your data reduction approach and use the tools to estimate the amount of usable storage that is required by reviewing the following tools:

- ▶ IBM FlashCore Module - IBM FlashCore Module Compression:
  - Use the FCM option.



- Do not use the Estimate Compression Saving option in the GUI to calculate the IBM FlashCore Module savings.
- ▶ Data Reduction Pool compression:
  - Use the DRP option.
  - Workloads that are on any IBM Spectrum Virtualize platforms can use the Estimate Compression Saving option in the GUI.
- ▶ Data Reduction Pool compression and deduplication:
  - IBM Comprestimator and DRET shows the savings for thin-provisioning, compression, and deduplication.
  - IBM Comprestimator and DRET reads entire volumes to identify de-duplicated data, so it takes longer to run.

For more information about data reduction pool compression and setup, see *Introduction and Implementation of Data Reduction Pools and Deduplication*, [SG24-8430](#).

## N\_Port ID Virtualization support

Starting with V8.3.1, IBM FlashSystem 9200 Software offers NPIV support. Use NPIV to virtualize WWPNs, which increases redundancy during firmware updates and scheduled maintenance where WWPNs transparently move to the controller that is not being maintained. As a consequence, FC-attached hosts experience zero path reduction during controller outages.

**Important:** The IBM FlashSystem 9200 system has NPIV enabled by default; therefore, if the customer does not want to use it, they must turn it off before configuring FC ports for host communications.

## VMware integration

IBM FlashSystem 9200 Software V8.3.1 and higher includes the following features, which enable tight integration with VMware:

- ▶ vCenter plug-in
  - Enables monitoring and self-service provisioning of the system from within VMware vCenter.
- ▶ VAAI support
  - This function supports hardware-accelerated virtual machine (VM) copy and migration and hardware-accelerated VM initiation, and accelerates VMware Virtual Machine File System (VMFS).
- ▶ Microsoft Windows System Resource Manager (SRM) for VMware Site Recovery Manager
  - Supports automated storage and host failover, failover testing, and failback.
- ▶ VVOL integration for better usability
  - The migration of space-efficient volumes between storage containers maintains the space efficiency of volumes. Cloning a VM achieves a full independent set of VVOLs, and resiliency is improved for VMs if volumes start running out of space.

Before the availability of VVOLs, a VM in a VMware environment was presented as a VMware Virtual Machine Disk (VMDK) file. This file represented a physical disk to the VM, which was accessed by the operating system that is installed on the VM in the same way that a physical volume on a regular server was presented.

The VMDK file was placed in a file system that is called VMFS, which is hosted by a standard volume (LUN). For example, it might be implemented on an external storage system, such as the IBM FlashSystem 9200 system. With the availability of the VVOL technology, each VM disk can now be mapped to an external storage volume (for example, an IBM FlashSystem 9200 volume).

With VVOL, the IBM FlashSystem 9200 solution is “aware” of individual VMDK files. Therefore, data operations, such as snapshot and replication, can be performed directly by the IBM FlashSystem 9200 system at the VMDK level rather than the entire VMFS data store.

**Note:** The integration of VVOL with the IBM FlashSystem 9200 system is based on the VASA. IBM support for VASA is delivered as part of IBM Spectrum Control. VASA V2 is required to use the VVOL capability.

## Scaling up and scaling out

The IBM FlashSystem 9200 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 9200 system has the following flexible scalability configuration options:

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

Each IBM FlashSystem 9200 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 hosts systems. These two canisters are housed in a chassis that is known as a Control Enclosure.

It is possible to connect up to a maximum of four Control Enclosures to form a cluster.

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 24 drive capacity raw (TB)	Inclusive Onboard Ethernet ports	Max PCIe ports (FC, Ethernet)
One Canister	2	768	N/A	4	12
One Enclosure	4	1536	922	8	24
Two Enclosures	8	3072	1844	16	48
Three Enclosures	12	4608	2766	24	72

Element Description	Number of CPUs	Maximum cache memory (GB)	Max NVMe 24 drive capacity raw (TB)	Inclusive Onboard Ethernet ports	Max PCIe ports (FC, Ethernet)
Four Enclosures	16	6144	3688	32	96

A basic configuration of an IBM FlashSystem 9200 storage platform consists of one IBM FlashSystem 9200 Control Enclosure. For a balanced increase of performance and scale, up to four IBM FlashSystem 9200 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 9200R system. This configuration features with two or more IBM FlashSystem 9200 Control Enclosures, FC switches, and optional Expansion Enclosures in a rack that is approved by IBM and ready for the IBM Engineer and Lab Services to install and start.

**Note:** For more information about the new FS9200R rack mount offering, see “IBM FlashSystem 9200R overview” on page 8.

The clustered IBM FlashSystem 9200 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 the [IBM Knowledge Center](#).

With the scalable IBM FlashSystem 9200 configurations, you can add up to three IBM FlashSystem 9200 Control Enclosures to the storage system. If 379 TB usable and up to 1.6 PB maximum from four Control Enclosures is not enough capacity, you can add capacity by adding SAS Expansion Enclosures with SSDs.

In total, an IBM FlashSystem 9200 system can contain a maximum of four IBM FlashSystem 9200 Control Enclosures. This configuration offers a potential storage capacity of 3.2 PB usable and up to 6.4 PB effective capacity, assuming 2:1 or better hardware compression, when the IBM FlashCore Modules type drives are used.

With software-based data reduction, you can scale to 16.0 PB effective, assuming 5:1 data reduction that uses compression and de-duplication.

The IBM FlashSystem 9200 system is expandable to 32 PB by using SSDs in Expansion Enclosures as tier 1 capacity.

## 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 9200 Control Enclosures.

Table 5 IBM FlashSystem 9200 maximum usable and effective capacity.

Number of Control Enclosures	Maximum usable capacity by using DRAID 6 with 24 drives (terabytes)	Maximum effective capacity (terabytes) with inline IBM FlashCore Modules Drive compression @ 2:1 ratio	Maximum effective capacity (terabytes) with software data reduction @ 5:1 ratio
One Control Enclosure	806	1612	4030
Two Control Enclosures	1612	3224	8060
Three Control Enclosures	2418	4836	12090
Four Control Enclosures	3224	6448	16120

Consider the following points:

- ▶ IBM FlashCore Module NVMe types drives:
  - Six drive minimum.
  - DRAID 6 (recommended) and DRAID 5 (supported).
  - IBM FlashCore Modules in the same RAID array must have the same capacity.
- ▶ Industry-standard NVMe drives:
  - Two drive minimum (varies by RAID type).
  - Traditional RAID 10 and DRAID 6 (recommended) and DRAID 5 (supported).
  - Industry-standard NVMe drives in the same RAID array must have the same capacity.
- ▶ SCM drives:
  - Two drive minimum with up to 12 drives of the same type and capacity.
  - Distributed RAID 5, or TRAIID 1 or 10 with fewer than four drives.

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

## Expansion Enclosures

With IBM FlashSystem 9200 Software V8.4.0, the IBM FlashSystem 9200 system supports the addition of Expansion Enclosures.

HD Enclosure Model A9F accepts only SAS SSDs. With this tiering option, you can have eight enclosures per Control Enclosure with a maximum capacity of 1350 TB each.

**Note:** To support SAS-attached Expansion Enclosures, an AHBA - SAS Enclosure Attachment adapter must be installed in the Control Enclosure of the IBM FlashSystem 9200 system.

Figure 17 shows the maximum enclosure configuration with A9F expansions.

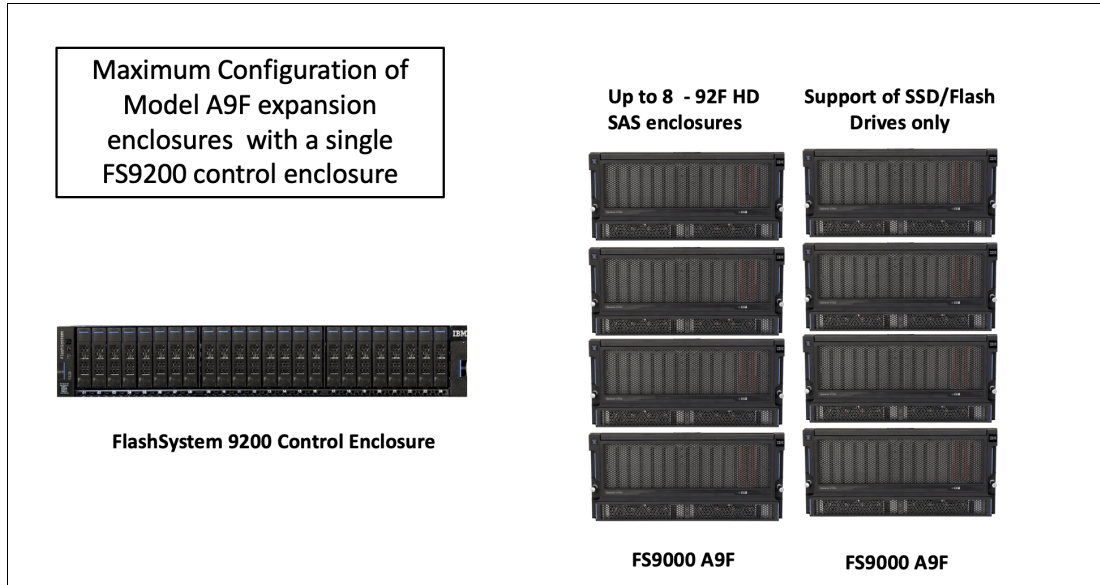


Figure 17 Maximum configuration for model A9F enclosures

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 20 Expansion Enclosures are supported per IBM FlashSystem 9200 Control Enclosure, which provides up to 480 drives with up to 1.9 PB of SAS SSD capacity.

Figure 18 shows the maximum configuration of 20 Expansion Enclosures in the AFF models.

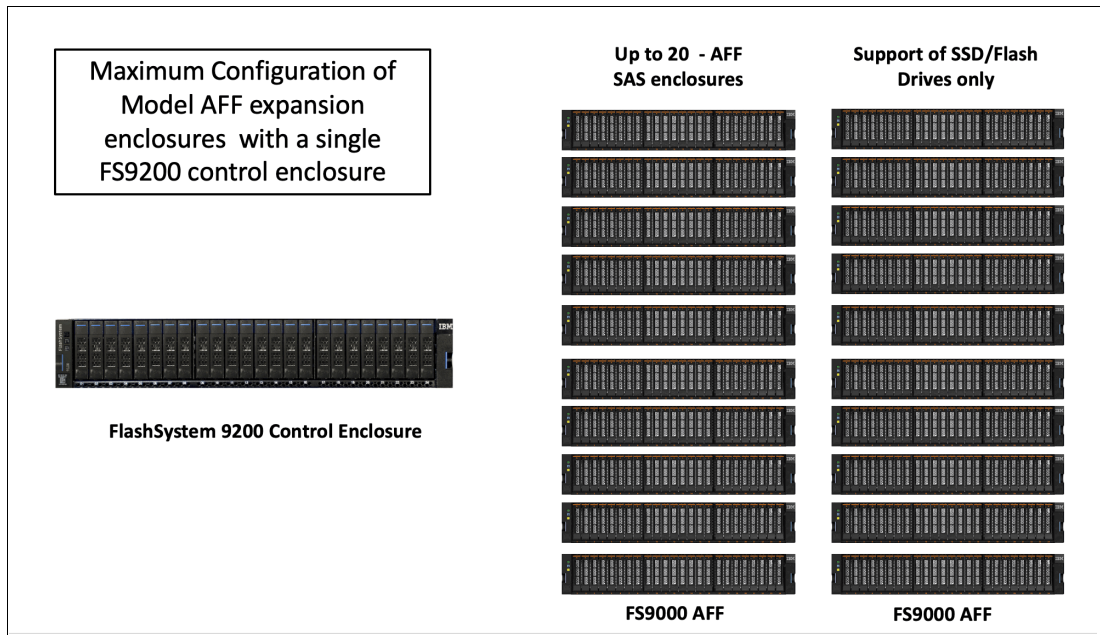


Figure 18 Maximum configuration for model AFF enclosures

## Expansion Enclosure drive offerings

The SFF Expansion Enclosure Model AFF and LFF HD Expansion Enclosure Model A9F deliver increased storage density and capacity for the IBM FlashSystem 9200 system with cost-efficiency while maintaining its highly flexible and intuitive characteristics.

Both models of the Expansion Enclosure support a complete range of 2.5-inch SAS SSDs (in 3.5-inch carriers on Model A9F) to easily increase storage capacity and density in a flexible and affordable manner. SAS SSD flash drives are offered in 1.92 TB, 3.84 TB, 7.68 TB, and 15.36 TB sizes.

These SSD flash drive options are available for the IBM FlashSystem 9200 solution with a maximum of 32 PB combined NVMe flash and SAS capacity that is configured on four IBM FlashSystem 9200 Control Enclosures.

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

## RAID types

The IBM FlashSystem 9200 system supports the following main DRAID types and optional traditional RAID types:

- ▶ IBM FlashCore Modules:
  - Six drive minimum.
  - Distributed DRAID 6 (recommended) and DRAID5 (supported).
  - IBM FlashCore Modules in the same RAID array must be of the same capacity.
- ▶ Industry-standard NVMe drives:
  - Two drive minimum (varies by RAID type).
  - Traditional TRAIID 10 and DRAID 6 (recommended) and DRAID 5 (supported).
  - Industry-standard NVMe drives in the same RAID array must be of the same capacity.
- ▶ SCM NVMe drives
  - Two drive minimum with up to 12 drives of the same type and capacity.
  - Distributed DRAID 5, or traditional TRAIID 1 or 10 with fewer than 4 drives.
  - Can occupy any slots in the control enclosure.
  - SCM NVMe drives in the same RAID array must be of the same capacity.

**Note:** SCM NVMe drives will be available on the FS9100 range of machines, with support from code 8.3.1 or higher

- ▶ IBM FlashSystem 9200 Expansion Enclosure
  - SAS SSD flash drives: RAID 0, 1, and 10 and DRAID 6 (recommended), and DRAID 5 (supported).

The additional SAS attached Expansion Enclosures can be configured with various RAID options. DRAID (DRAID 5 and DRAID 6) offers improved RAID rebuild times and performance. DRAID 6 is preferred for Expansion Enclosures because of the drive sizes that are used.

## Summary of supported array types and RAID levels

IBM FlashSystem 9200 systems support IBM FlashCore Module NVMe drives, industry-standard NVMe drives, and SAS drives that are within Expansion Enclosures. The type and level of arrays varies, depending on the type of drives in the I/O group.

Table 6 lists the supported drives, array types, and RAID levels. For all types of drives, DRAID 6 is recommended except for SCM drives.

The IBM FlashSystem 9200 system does *not* support mixing SAS drives in an array with NVMe drives or mixing IBM FlashCore Modules in an array with industry-standard NVMe drives.

Table 6 Summary of supported drives, array types, and RAID levels

Supported drives	TRAID					DRAID		
	RAID 0	RAID 1	RAID 5	RAID 6	RAID 10	RAID 1	RAID 5	RAID 6
Industry-standard NVMe drives	X	X			X	X	X	X
IBM FlashCore Module NVMe drives					X <sup>a</sup>	X	X	X
SCM NVMe drives		X			X	X	X	X
SAS SSDs (Expansion Enclosure)	X	X			X	X	X	X

a. except for 38.4 TB FCM Drives

**Note:** DRAID6 is recommended for all types of drives, except for SCM drives. Some of the RAID type arrays can be created by using only the CLI, not the GUI.

For more information about the types of supported RAID configurations, see [IBM Knowledge Center](#).

## External Virtualization

The IBM FlashSystem 9200 system offers external virtualization technology that helps you manage other IBM or third-party storage arrays with thin-provisioning, space-efficient copies, and DR tools, such as data replication. External virtualization also makes the migration of data from one storage device to another easier.

You can use the IBM FlashSystem 9200 system to manage the capacity of other disk systems with external storage virtualization. When the IBM FlashSystem 9200 system virtualizes a storage system, its capacity becomes part of the IBM FlashSystem 9200 system and is managed in the same manner as the capacity on internal flash modules within the IBM FlashSystem 9200 system. Capacity in external storage systems inherits all the rich functions and ease of use of the IBM FlashSystem 9200 system.

You can use the IBM FlashSystem 9200 system to preserve your investments in storage, centralize management, and make storage migrations easier with storage virtualization, and Easy Tier. The IBM FlashSystem 9200 system provides non-disruptive operations because of storage virtualization.

Virtualization also helps insulate applications from changes that are made to the physical storage infrastructure. When you add storage capacity or a new tier of storage, for example, the changes are transparent to applications; therefore, you have minimal downtime.

Any externally virtualized storage needs extra licenses to be purchased and are charged on a capacity basis of the storage that is added.

## Manageability and security

The IBM FlashSystem 9200 system offers the following manageability and security features:

- ▶ Advanced security for data at rest with hardware-accelerated AES-XTS 256 encryption.
- ▶ IBM obtained FIPS 140-2 Level 1 certification for IBM FlashCore Modules in the IBM FlashSystem 9100.

At the time of this writing, the newer IBM FlashCore Modules in the IBM FlashSystem 9200 system are undergoing a FIPS validation process.

- ▶ A GUI to manage the IBM FlashSystem 9200 Control Enclosures and the IBM FlashSystem 9200 Expansion Enclosures. The GUI is available in any supported browser. Included in the GUI is the IBM FlashSystem 9200 CLI, which support a collection of commands that you can use to manage the IBM FlashSystem 9200 system.
- ▶ Representational State Transfer (REST) application programming interface (API)

The IBM FlashSystem 9200 system that is running IBM Spectrum Virtualize 8.4.0 software supports the REST model API. The REST-API consists of command targets that are used to retrieve system information and to create, modify, and delete system resources.

- ▶ RSA provides secure connection for IBM Remote Support, which can perform remote troubleshooting and code load, and obtain diagnostic logs.
- ▶ Email alerts.
- ▶ SNMP alerts.
- ▶ Syslog redirect to send system log messages to another host.

## Reliability, availability, and serviceability

The IBM FlashSystem 9200 system delivers the following enterprise-class reliability features:

- ▶ Concurrent code load enables customer applications to remain online during firmware upgrades to all components, including the flash drives.
- ▶ Redundant hot-swappable components

The IBM FlashSystem 9200 Control Enclosure has two clustered, hot-swappable node canisters that contain hot-swappable fan modules, memory DIMMs, batteries, Trusted Platform Module (TPM), and PCIe adapters. The enclosure also houses two AC power supplies that are N+1 redundant and hot-swappable.

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 Variable Stripe RAID is a patented IBM technology that provides an intra-module RAID stripe within each flash module. Variable Stripe RAID technology helps reduce downtime, and maintains performance and capacity during partial or full flash chip failures.

- ▶ IBM enhanced technology in the SCM drives for higher storage density and improved performance.
- ▶ IBM FlashSystem 9200 Control Enclosures support concurrent code load. Both onsite and remote code upgrades are supported.



# Encryption

IBM FlashSystem 9200 data encryption is based on the AES algorithm, which uses a 256-bit symmetric encryption key in XTS mode, 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 non-volatile form.

Encryption on the IBM FlashSystem 9200 system requires the following feature codes:

- ▶ Encryption Enablement (#ACE6)

This feature enables the encryption function. A single instance of this feature enables the function on the entire IBM FlashSystem 9200 system (IBM FlashSystem 9200 Control Enclosure and all attached IBM FlashSystem 9200 Expansion Enclosures) and on externally virtualized storage subsystems.

USB flash drives (#ACEA) or IBM Security Key Lifecycle Manager are required for encryption key management.

- ▶ Encryption USB Flash Drives (Four Pack) Optional (#ACEA)

This feature provides four USB flash drives for storing the encryption master access key.

Unless IBM Security Key Lifecycle Manager is used for encryption keys management, a total of three USB flash drives are required per IBM FlashSystem 9200 cluster when encryption is enabled in the cluster, regardless of the number of systems in the cluster. If encryption is used in a cluster, this feature should be ordered on one IBM FlashSystem 9200 system, which results in a shipment of four USB flash drives.

Encryption can be applied to virtualized storage arrays, even if the virtualized array does not have encryption capabilities. In this scenario, the encryption is done by using IBM Spectrum Virtualize software. Encrypted volumes are transparent to applications, which eases implementation and operation. In addition, the IBM FlashSystem 9200 system has the following functions:

- ▶ Encryption Activation: Adding an encryption license to a system is not concurrent and must be done at array initialization time.
- ▶ Encryption Deactivation: Removing encryption is also non-concurrent and destroys any data on the array.
- ▶ Encryption Rekey: Changing the encryption key on a previously initialized system is concurrent and can be done while array is in use.

These operations require that you purchase Encryption Enablement Pack (#ACE6).

## Self-encrypting drives

The IBM FlashCore Modules and NVMe IBM FlashCore Modules type drives, including the SCMs, in the IBM FlashSystem 9200 Control Enclosure are self-encrypting drives (SEDs). With SEDs, you can encrypt the data on the drive within the hardware.

These types of flash drives include the following features:

- ▶ Encryption of data is done in the electrical circuit of the drive, so it is not affected by performance issues from software encryption.
- ▶ Data Encryption Keys never leave the confines of the SED, and are never loaded into CPU or memory.
- ▶ You can perform a fast cryptographic erasure of a SED by using a single CLI command to replace the DEK or revert the entire device to factory settings.

- ▶ Supports a security feature that is called *auto-lock*, which protects against someone plugging your drive into another system and accessing your data.
- ▶ Drives automatically lock themselves on power loss and require an access key at start time to unlock and allow I/O operations.
- ▶ If an SED drive is taken from a system with encryption and placed in another system, the drive data is not readable. The systems posts an error message saying it is locked. The only way to use the drive is to format it. This formatting also performs a cryptographic erase by removing any encryption keys; therefore, all of the data on the drive is destroyed.

### **Combining system encryption with self-encrypting drives**

For Control Enclosures that support NVMe architecture, NVMe-attached drives are self-encrypting and self-compressing. With SEDs that use NVMe architecture, data encryption is completed in the drive. Data encryption keys remain on the drive without being stored in system memory.

In addition, the system supports automatic locks of encrypted drives when the system or drive is powered down. When the drive or system restarts, a master key is required to unlock the drive and continue I/O operations.

Because the encryption of data is done in the electrical circuit of the drive, it is not affected by any potential performance issues from software encryption. If SEDs are encrypting the data, why do you need to enable system encryption in IBM Spectrum Virtualize?

The answer is that you can use SEDs without enabling encryption on the system, but SEDs are unlocked by default at start time, unless configured with extra protection. System level encryption in IBM Spectrum Virtualize allows you to use USB flash drives or IBM Security Key Lifecycle Manager to manage access to encrypted objects on the system. This feature ensures that when a system is powered, this extra encryption key is required to read the data on the drives.

Consider the following points:

- ▶ SEDs are always encrypting, and you cannot stop them from being encrypted.
- ▶ You can use SEDs without enabling encryption on the system, but SEDs are unlocked by default unless they are configured with extra protection.
- ▶ With system encryption in IBM Spectrum Virtualize, you can use USB flash drives or IBM Security Key Lifecycle Manager to manage access to encrypted objects on the system.
- ▶ Software in the operating system is required to manage an access key that can be used to lock and unlock the SEDs and bring them online for I/O.

Therefore, the best solution is to use the SEDs with the Encryption Enablement Pack and USB or IBM Security Key Lifecycle Manager type encryption, or a mixture of both. This configuration ensures the maximum level of encrypting for your data that is on the system.

### **Transparent Cloud Tiering and encryption**

TCT is a licensed function that enables volume data to be copied and transferred to cloud storage. The system supports creating connections to cloud service providers to store copies of volume data in private or public cloud storage.

With TCT, administrators can move older data to cloud storage to free up capacity on the system. Point-in-time snapshots of data can be created on the system and then copied and stored on cloud storage.

An external cloud service provider manages the cloud storage, which reduces storage costs for the system. At the time of this writing, IBM supports the OpenStack Swift and Amazon S3 cloud service providers.

The following considerations apply to TCT and encryption:

- ▶ When a cloud account is created, it must continue to use the same encryption type throughout the life of the data in that cloud account. Even if the cloud account object is removed and remade on the system, the encryption type for that cloud account might not be changed while backup data for that system exists in the cloud provider.
- ▶ When performing rekeying operations on a system that has an encryption-enabled cloud account, perform the commit operation immediately after the prepare operation. Retain the previous system master key (on a USB or in the keyserver) because this key might be needed to retrieve your cloud backup data when performing a T4 recovery or an import.
- ▶ The `restore_uid` option should not be used when the backup is imported to a new cluster.
- ▶ Importing TCT data is supported only from systems whose backup data was created at V7.8.0.1 or later.
- ▶ TCT uses Sig V2 when connecting to Amazon regions, and does not currently support regions that require Sig V4.

For more information, search for 9200 TCT at [IBM Knowledge Center](#).

### Secure Drive Erasure Process

The IBM FlashSystem 9200 system running IBM Spectrum Virtualize V8.3.1 or higher provides methods to securely erase data from a drive or boot drive when a Control Enclosure is decommissioned or before a drive is removed from the system during a repair activity.

Secure data deletion effectively erases or overwrites all traces of data from a data storage device. The original data on that device becomes inaccessible and cannot be reconstructed. You can securely delete data on individual drives and on a boot drive of a Control Enclosure. The methods and commands that are used to securely delete data enable the system to be used in compliance with European Regulation EU2019/424.

The following types of drives can be used for this process:

- ▶ Expansion Enclosure SAS SSDs
- ▶ NVMe drives (IBM FlashCore Modules and industry standard)
- ▶ Control Enclosure node canister SSD boot drives

The methods that the system uses to securely delete data from the drives varies according to the CLI commands that each type of drive can support. The completion time for the erase procedure also varies, depending on the amount of data and the method that is used to delete the data. In each case, when the operation completes, the result is that the data on the drive effectively becomes impossible to access.

Table 7 lists the types of erasure, the methods used, and the time taken.

*Table 7 Comparison of methods to securely delete data from drives*

Priority	Deletion type	Method	Completion time
1	Cryptographic erase	Changes the encryption key and makes the data inaccessible.	Instant
2	Block erase	Quickly raises and lowers the voltage level of the storage element. Physical blocks are altered with a vendor-specific value.	Fast

Priority	Deletion type	Method	Completion time
3	Data Overwrite	Replaces the existing data with random data.	Slow

The methods that are used to securely delete data vary according to manufacture, drive type, and drive firmware. For more information, see the documentation that is provided by the drive manufacturer.

If a drive supports more than one data deletion method, the system uses the highest-priority method.

For more information about the CLI commands that are used to run this secure erase function, see [IBM Knowledge Center](#).

## Options and feature codes

This section describes the options and feature codes of the IBM FlashSystem 9200 Control Enclosure.

### Memory options

Table 8 lists the following memory options by feature code:

*Table 8 IBM FlashSystem 9200 memory options per Control Enclosure*

Base Memory (GB)	#ACGJ Plant or Field Upgrade (GB)	#ACGB Plant or Field Upgrade (GB)	Total Memory (GB)
256	N/A	N/A	256
256	512	N/A	768
256	512	768	1536

► (#ACGJ): 512 GB Cache upgrade

This feature indicates that the base machine is configured with 512 GB (256 GB for each node canister). Selecting this feature determines the cache upgrade paths the machine uses.

► (#ACGB): 768 GB Cache upgrade

This feature provides another 768 GB of cache (384 GB for each node canister) to increase the total system cache by 768 GB.

**Note:** The quantity of one ACGJ must be ordered with this feature, if it is not already fitted.

## Host I/O connectivity and Expansion Enclosure adapters

Six PCIe slots are available for port expansions in the IBM FlashSystem 9200 Control Enclosure. Each canister has three PCIe adapter slots and both canisters must have the same configuration. The PCIe adapter feature codes offers a pair of adapters to ensure that they are supplied symmetrically in each canister.

The Control Enclosure can be configured with three I/O adapter features to provide up to 24 16 Gb FC ports or up to 12 25 Gb Ethernet (iSCSI or iSCSI Extensions for RDMA (iSER) capable) ports. The Control Enclosure also includes eight 10 Gb Ethernet ports as standard for iSCSI connectivity and two 1 Gb Ethernet ports for system management. A feature code also is available to include the SAS Expansion card if the user wants to use optional Expansion Enclosures.

For more information about the limits and rules for adapter placement to ensure correct best practices, see [IBM Spectrum Virtualize FAQ: IBM Spectrum Virtualize with the IBM FlashSystemfamily and IBM SAN Volume Controller](#).

Table 9 lists the maximum host port count per building block configuration (1, 2, 3, or 4 Control Enclosures).

*Table 9 Maximum host port count per Control Enclosure*

<i>Number of Control Enclosures</i>	<b>16 Gb / 32 Gb FC</b>	<b>Onboard iSCSi</b>	<b>25 Gb iSCSI (RoCE)</b>	<b>25 Gb iSCSI (iWARP)</b>
One Control Enclosure	24	8	12	12
Two Control Enclosures	48	16	24	24
Three Control Enclosures	72	24	36	36
Four Control Enclosures	96	32	48	48

**Note:** All connectivity ports are NVMe-oF hardware-ready.

Table 10 lists the current features for host and connectivity for the IBM FlashSystem 9200 Control Enclosure 9846-AG8 and 9848-AG8 machine types.

*Table 10 Supported Expansion Enclosure and interface components MTMs 9846-AG8 and 9848-AG8*

<b>Item</b>	<b>Feature code</b>	<b>Description</b>	<b>Ports</b>
16 Gb FC 4 Port Adapter Pair	#AHB3	This feature provides two I/O adapters. It is used to add 16 Gb FC connectivity.	Each adapter has four 16 Gb FC ports and shortwave SFP transceivers.
32 Gb FC 4 Port Adapter Pair	#AHB4	This feature provides two I/O adapters. It is used to add 32 Gb FC connectivity.	Each adapter has four 32 Gb FC ports and shortwave SFP transceivers.
25 GbE (RoCE) Adapter Pair	#AHB6	This feature provides two I/O adapters. It is used to add 25 Gb Ethernet connectivity. Supports RoCE V2.	Each adapter has two 25 Gb Ethernet ports and SFP28 transceivers.

Item	Feature code	Description	Ports
25 GbE (iWARP) Adapter Pair	#AHB7	This feature provides two I/O adapters. It is used to add 25 Gb Ethernet connectivity. Supports RDMA with iWARP.	Each adapter has two 25 Gb Ethernet ports and SFP28 transceivers.
SAS Expansion Enclosure Attach Card (Pair)	#AHBA	This feature provides two 4-port 12 Gb SAS Expansion Enclosure attachment adapters. This feature is used to attach up to 20 Expansion Enclosures.	Each adapter has two active SAS ports.
16 Gb FC LW SFP Transceivers (Pair)	#ACHU	This feature provides two 16 Gb longwave SFP transceivers for use with 16 Gb FC I/O ports.	#AHB3 is a prerequisite. The maximum allowed is four for each instance of #AHB3.
32 Gb FC LW SFP Transceivers (Pair)	#ACHV	This feature provides two 32 Gb longwave SFP transceivers for use with 32 Gb FC I/O ports.	#AHB4 is a prerequisite. The maximum allowed is four for each instance of #AHB4.

## Cables

The following cable feature codes are available:

- ▶ (#ACSQ): 1 m OM3 Fiber Cable (LC)
- ▶ (#ACSR): 5 m OM3 Fiber Cable (LC)
- ▶ (#ACSS0): 10 m OM3 Fiber Cable (LC)
- ▶ (#ACST): 25 m OM3 Fiber Cable (LC)
- ▶ (#ACUA): 0.6 m 12 Gb SAS Cable (mSAS HD)
- ▶ (#ACUB): 1.5 m 12 Gb SAS Cable (mSAS HD)
- ▶ (#ACUC): 3 m 12 Gb SAS Cable (mSAS HD)
- ▶ (#ACUD): 6 m 12 Gb SAS Cable (mSAS HD)

## IBM FlashCore Modules and industry-standard NVMe drive options

The system supports IBM FlashCore Modules, industry-standard flash drives, and an intermix of both.

IBM FlashCore Modules combine IBM MicroLatency technology, advanced flash management, and reliability into a 2.5-inch SFF NVMe with built-in, performance-neutral hardware compression and encryption.

For improved flexibility, IBM FlashSystem 9200 systems also support various industry-standard, self-encrypting NVMe flash drives.

The following NVMe flash drive feature codes are available:

- ▶ (#AHS5): 4.8 TB NVMe FlashCore Module
- ▶ (#AHS6): 9.6 TB NVMe FlashCore Module
- ▶ (#AHS7): 19.2 TB NVMe FlashCore Module
- ▶ (#AHS8): 38.4 TB NVMe FlashCore Module
- ▶ (#AHT1): 800 GB NVMe Flash Drive
- ▶ (#AHT2): 1.92 TB NVMe Flash Drive
- ▶ (#AHT3): 3.84 TB NVMe Flash Drive
- ▶ (#AHT4): 7.68 TB NVMe Flash Drive

- ▶ (#AHT5): 15.36 TB NVMe Flash Drive
- ▶ (#AHTA): 375 GB NVMe SCM Drive
- ▶ (#AHTB): 750 GB NVMe SCM Drive
- ▶ (#AHTE): 800 GB NVMe SCM Drive
- ▶ (#AHTF): 1.6 TB NVMe SCM Drive

Consider the following points regarding limitations and drives:

- ▶ IBM FlashCore Modules:
  - Six drive minimum.
  - DRAID 6 (recommended) or DRAID5 (supported).
  - IBM FlashCore Modules in the same RAID array must be of the same capacity.
- ▶ Industry-standard NVMe drives:
  - Two drive minimum (varies by RAID type).
  - RAID 10 and DRAID 6 (recommended) and DRAID 5 (supported).
  - Industry-standard NVMe drives in the same RAID array must be of the same capacity.
- ▶ SCM NVMe drives:
  - Two drive minimum (varies by RAID type), 12 drives maximum.
  - DRAID 5 supported.
  - SCM NVMe drives in the same RAID array must be of the same capacity.

## IBM FlashSystem 9000 Expansion Enclosure options (models AFF and A9F)

The following SAS flash drives feature codes are available:

- ▶ Supported on Model AFF only. Maximum of 24:
  - (#AH2A): 1.92 TB 12 Gb SAS 2.5-inch Flash Drive
  - (#AH2B) 3.84 TB 12 Gb SAS 2.5-inch Flash Drive
  - (#AH2C) 7.68 TB 12 Gb SAS 2.5-inch Flash Drive
  - (#AH2D) 15.36 TB 12 Gb SAS 2.5-inch Flash Drive
- ▶ Supported on Model A9F only (maximum of 92):
  - (#AH7J) 1.92 TB 12 Gb SAS 3.5-inch Flash Drive
  - (#AH7K) 3.84 TB 12 Gb SAS 3.5-inch Flash Drive
  - (#AH7L) 7.68 TB 12 Gb SAS 3.5-inch Flash Drive
  - (#AH7M) 15.36 TB 12 Gb SAS 3.5-inch Flash Drive

## Physical and electrical specifications

Specifications for the control and Expansion Enclosures are listed in the following sections.

### IBM FlashSystem 9200 Control Enclosure (9846 and 9848 AG8, and 9848 UF8)

The Control Enclosure has the following specifications:

- ▶ Physical specifications:
  - Height: 8.8 cm (3.5 in.)
  - Width: 48.3 cm (19.0 in.)
  - Depth: 85.0 cm (33.5 in.)
  - Approximate weight:

- Empty: 38.5 kg (84.7 lb.)
- Fully configured: 46.6 kg (102.5 lb.)
- ▶ Air temperature:
  - Operating: 5 - 35° C (41 - 95° F) 0 - 3048 m (0 - 10,000 ft.). Above 900 m, de-rate maximum air temperature 1° per 300 m.
  - Nonoperating: 1 - 50° C (34 - 122° F).
- ▶ Relative humidity:
  - Operating: 8% - 80% noncondensing
  - Non-operating: 8% - 80% noncondensing
- ▶ Electrical power:
  - Voltage range: 200 - 240 V AC
  - Frequency: 50 - 60 Hz
  - Power: 2000 W
  - Heat dissipation (BTU per hour): 6825
  - Acoustical noise emission: 8.1 bels (idling), 8.1 bels (operating)

## **IBM FlashSystem 9000 SFF Expansion Enclosure (9846 and 9848 Model AFF)**

The Expansion Enclosure AFF has 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, de-rate maximum air temperature 1° per 175 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 Expansion Enclosure (9846 and 9848 Model A9F)**

The Expansion Enclosure A9F has 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, de-rate maximum air temperature 1° 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 that are stated 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 9200 and IBM FlashSystem 9200R systems have IBM FlashSystem 9200 Software V8.3.1 or later preinstalled. The following produce numbers are for the base licenses for each model of the IBM FlashSystem 9200 system:

- ▶ IBM Spectrum Virtualize Software for IBM FlashSystem 9200 Controller V8.4.0 (5639-FA3).  
IBM Spectrum Virtualize Software for IBM FlashSystem 9200 Controller (5639-FA3) requires at least one IBM FlashSystem 9200 Control Enclosure 9846-AG8 for installation.
- ▶ IBM Spectrum Virtualize Software for IBM FlashSystem 9200 Expansions V8.4.0 (5639-FA1):
  - IBM Spectrum Virtualize Software for IBM FlashSystem 9000 Expansions (5639-FA1) requires at least one IBM FlashSystem 9000 Expansion Enclosure (9846-AFF, 9846-A9F, 9848-AFF, or 9848-A9F) for installation.
  - The HD enclosures (9846-A9F and 9848-A9F) require four of the base software charge codes to support the number of drive slots in the system.

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 9200 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:

- ▶ IBM FlashSystem 9200 and IBM FlashSystem 9200R Control Enclosures support external storage virtualization. Use of the external virtualization capability is entitled through the acquisition of IBM Spectrum Virtualize Software for SAN Volume Controller (SW PID 5641-VC8 in AAS and SW PID 5725-M19 in IBM Passport Advantage®).
- ▶ With the IBM FlashSystem 9200 system, a license exists for the hardware assisted encryption if it purchased (Encryption Enablement Pack [#ACE7]). This feature code is needed if you want to use USB-Key encryption, IBM Security Key Lifecycle Manager-based encryption or both on the Control Enclosure.
- ▶ The 5641-VC8 (External Virtualization, FlashCopy, and Remote Mirroring Features) and 5641-CP8 (Compression) licenses are licensed per enterprise within one country. These licenses are the same licenses as for IBM SAN Volume Controller. Therefore, existing SAN Volume Controller licenses can be used for the IBM FlashSystem 9200 system for these features.
- ▶ 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 Spectrum Virtualize licensing, see [IBM Offering Information](#) and [IBM Knowledge Center](#).

## IBM Spectrum Virtualize External Licensing

The IBM FlashSystem 9200 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 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 only for virtualized storage that does not have the 5639-FA2 or FA3 base license.

The SCU is defined in terms of the category of the storage capacity, as listed in Table 11.

Table 11 SCU category definitions

License	Drive class	SCU Ratio
SCM	SCM devices	SCU equates to 1.00 TB usable of Category 1 storage
Flash	All flash devices, other than SCM drives	SCU equates to 1.00 TB usable of Category 1 storage
Enterprise	10K or 15K RPM drives	SCU equates to 1.18 TB usable of Category 2 storage

License	Drive class	SCU Ratio
Nearline	Nearline SATA drives	SCU equates to 4.00 TB usable of Category 3 storage

Any storage use case that is not listed in Table 11 is classified as Category 1.

Table 12 shows an example of calculating SCUs. The example is a customer who virtualizes external disk arrays with 30 TB SSD flash drives, 200 TB Enterprise drives, and 2400 TB Nearline capacity.

Table 12 Example of calculating SCUs

Category	Type	Capacity	Rule	Number of SCUs
Category 1	SSD	30	/ 1	30
Category 2	Enterprise	200	/ 1.18	170
Category 3	Nearline	2400	/ 4	600
Total				<b>800</b>

A total of 800 SCUs are required for the example that is shown in Table 12. 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 Spectrum Virtualize Differential Licensing, see [IBM Knowledge Center](#).

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## Ordering information

For more information about ordering IBM FlashSystem 9200 expansions, see “Scaling up and scaling out” on page 34.

For more information about ordering hardware features, see “Options and feature codes” on page 44.

For more information about ordering software licenses, see “Software and licensing” on page 49.

## Related information

For more information, see the following resources:

- ▶ *Introduction and Implementation of Data Reduction Pools and Deduplication*, SG24-8430:  
<https://www.redbooks.ibm.com/abstracts/sg248430.html>
- ▶ IBM Knowledge Center - IBM FlashSystem:  
<https://www.ibm.com/support/knowledgecenter/en/search/flashsystem>
- ▶ IBM FlashSystem 9200 product web page:  
<https://www.ibm.com/us-en/marketplace/flashsystem-9200>
- ▶ IBM Offering Information web page (announcement letters and sales manuals):  
[http://www.ibm.com/common/ssi/index.wss?request\\_locale=en](http://www.ibm.com/common/ssi/index.wss?request_locale=en)
- ▶ IBM Spectrum Virtualize FAQ  
Information the IBM Spectrum Virtualize products, which covers the IBM FlashSystem family and SAN Volume Controller:  
<https://www.ibm.com/downloads/cas/2DWAMWRB>
- ▶ IBM FlashSystem Family Overview 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/9OGKVVW2R>
- ▶ IBM FlashWatch FAQ  
Guidance for the IBM FlashWatch programs:  
<https://www.ibm.com/downloads/cas/YVMYPED>
- ▶ Sales Accelerator Tools Portal for IBM Storage (IBMers only):  
<https://w3.ibm.com/w3publisher/ibm-systems-storage-sales-accelerator-tools-portal>

## Authors

**Jon Herd** is an IBM Storage Technical Advisor working for the ESCC, Germany. He covers the United Kingdom, Ireland, and Sweden, advising customers on a portfolio of IBM storage products, including IBM FlashSystem products. Jon has been with IBM for more than 45 years, and has held various technical roles, including Europe, Middle East, and Africa (EMEA) level support on mainframe servers and technical education development. He has written many IBM Redbooks publications about IBM FlashSystem products and is an IBM Redbooks Platinum level author. He holds IBM certifications in Supporting IT Solutions at an expert level, and Technical IT Specialist at an experienced level. He is also a certified Chartered Member of the British Computer Society (MBCS - CITP), a Certified Member of the Institution of Engineering and Technology (MIET) and a Certified Technical Specialist of the Open Group.

Thanks to the following people for their contributions to this project:

Matt Smith

**IBM FlashSystem V9000/IBM FlashSystem 9200 Offering Manager, IBM Hursley, UK**

Alex Ainscow  
**Senior Technical Staff Member, IBM Hursley, UK**

Shelly Howrigan  
**Storage Virtualization Sales Leader, IBM US**

Evelyn Perez  
**Software Architect for IBM Spectrum Virtualize, SAN Volume Controller/IBM Storwize®, IBM Hursley, UK**

Jon Parkes  
**SAN Volume Controller and Storwize V7000 L3 Engineer, IBM Hursley, UK**

Andy Walls  
**IBM Fellow, CTO and Chief Architect, IBM FlashSystems, IBM US**

This project was managed by:

Jon Tate  
**IBM ITSO**

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REDP-5586-00

ISBN 0738458805

Printed in U.S.A.

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