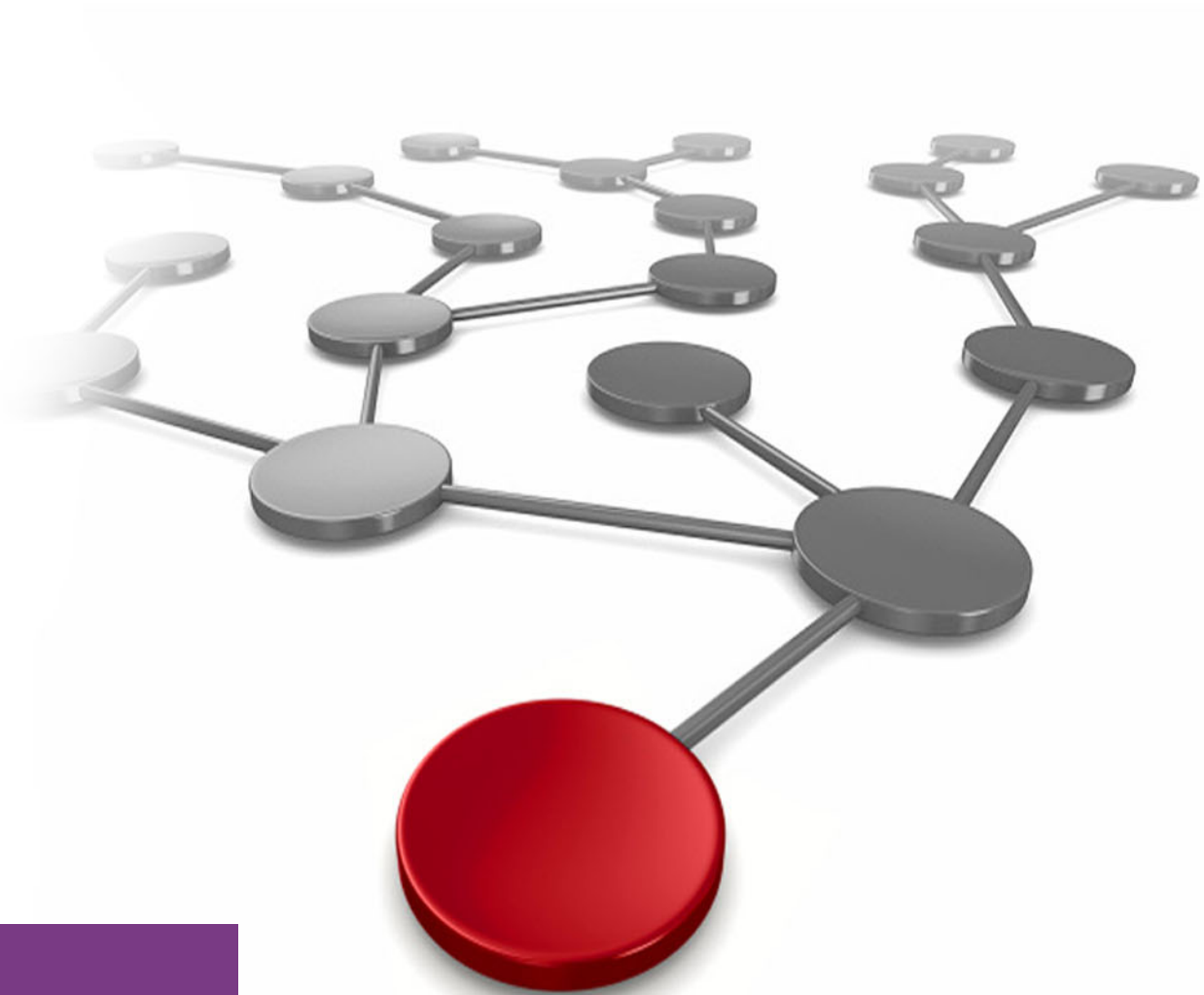


IBM FlashSystem 9100 Product Guide

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Storage



IBM FlashSystem 9100 Product Guide

This IBM® Redbooks® Product Guide publication describes IBM FlashSystem® 9100 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 organizations 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 need to 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 are engineered to 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. Even better, IBM FlashSystem solutions can be less expensive than conventional enterprise storage solutions.

With the release of IBM FlashSystem 9100 V8.2, extra functions and features are available, including support for new and more powerful IBM FlashCore Module NVMe types within the control enclosure. New software features include GUI enhancements, a new dashboard, RSA, data de-duplication, and an IBM Storage Insights configuration.

Figure 1 shows the IBM FlashSystem 9100 Control Enclosure with one of the IBM NVMe drives partially removed.



Figure 1 IBM FlashSystem 9100 Control Enclosure with one NVMe drive partially removed

The IBM FlashSystem 9100 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.
- ▶ An expansion enclosure increases the available capacity of an IBM FlashSystem 9100 cluster. It communicates with the control enclosure through a dual pair of 12 Gbps SAS connections. These expansion enclosures can house many of flash (solid-state drive (SSD)) serial-attached SCSI (SAS) type drives, depending on which model of enclosure is ordered.

Control enclosures

Each control enclosure can have multiple attached expansion enclosures, which expand the available capacity of the whole system. The IBM FlashSystem 9100 solution supports up to four control enclosures and up to two chains of SAS expansion enclosures per control enclosure.

The IBM FlashSystem 9100 Control Enclosure supports up to 24 NVMe-capable flash drives in a 2U high form factor.

There are two standard models of the IBM FlashSystem 9100 system: 9110-AF7 and 9150-AF8.

There are also two utility models of the IBM FlashSystem 9100 system: the 9110-UF7 and 9150-UF8.

Note: The 9848-UF7 and 9150-UF8 models are the IBM FlashSystem 9110 solution with a 3-year warranty, and are intended in the Storage Utility Offering space. These models are physically and functionally identical to the IBM FlashSystem 9848-AF7 and AF8 models, except for target configurations and variable capacity billing. The variable capacity billing uses IBM Spectrum™ Control IBM Storage Insights to monitor the system usage, allowing 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

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®.

- ▶ The new IBM FlashSystem 9100 SFF expansion enclosure Model AFF offers new tiering options with SSD flash drives. Up to 480 drives of SAS expansions are supported per IBM FlashSystem 9100 Control Enclosure. The expansion enclosure is 2U high.
- ▶ The new IBM FlashSystem 9100 LFF expansion enclosure Model A9F offers new tiering options with SSD flash drives. Up to 784 drives of SAS expansions are supported per IBM FlashSystem 9100 Control Enclosure. The expansion enclosure is 5U high.

The IBM FlashSystem 9100 Control Enclosure can be recognized by the nomenclature “IBM FlashSystem 9100” on the left side of the bezel cover, which covers the rack-mounting screws.

Figure 2 shows the IBM FlashSystem 9100 bezel and NVMe drive description.



Figure 2 IBM FlashSystem 9100 bezel and IBM FlashCore Module description

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

Did you know

IBM FlashSystem 9100 V8.2 provides the following functionality:

- ▶ Support for the IBM FlashCore Module NVMe type with IBM enhanced 3D triple-level cell (3D TLC) flash technology with an endurance of 3.8x over standard implementations.
- ▶ The IBM FlashSystem 9100 Control Enclosure supports up to 24 ultra-low latency 2.5-inch (SFF) 4.8 TB, 9.6 TB, or 19.2 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.
- ▶ IBM FlashCore Module NVMe types provide automatic data compression and encryption without impacting the system performance.
- ▶ The model A9F and AFF SAS expansion enclosures can be used with the IBM FlashSystem 9100 control expansion.
- ▶ The IBM FlashSystem 9100 system can either use IBM Security Key Lifecycle Manager (SKLM) or USB key encryption. Up to four SKLM key servers are supported. Offers both hardware-based AES 256 data-at-rest encryption by using USB key and SKLM key server-based encryption, with no performance impact.
- ▶ Remote Support Assistance (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.
- ▶ Transparent Cloud Tiering 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 Fibre Channel (FC) and Ethernet (iWARP and 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, the storage, and the user. IBM Storage Insights provides advanced customer service, and monitors the performance, capacity, and health of each device.

IBM FlashSystem 9100 Control Enclosure

The IBM FlashSystem 9100 Control Enclosure is NVMe-accelerated and multi-cloud enabled.

NVMe-accelerated enterprise flash array: 100% NVMe

- ▶ Industry-leading performance and scale
- ▶ Flexible, modern, and agile
- ▶ Supports physical, virtual, and Docker environments
- ▶ NVMe end-to-end enabled and Storage Class Memory (SCM) capable

AI-empowered

- ▶ AI-empowered storage analytics, storage resource management, and 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 support platform delivered over the cloud

Multi-cloud enabled

- ▶ Private, hybrid, or public cloud deployments
- ▶ Multi-cloud API automation, replication, and secondary data orchestration software included in offering
- ▶ Proven, validated “Multi-Cloud blueprints”:
 - IBM FlashSystem 9100 Solution for Data Reuse, Protection, and Efficiency
 - IBM FlashSystem 9100 Solution for Business Continuity and Data Reuse
 - IBM FlashSystem 9100 Solution for Private Cloud Flexibility and Data Protection

The IBM FlashSystem 9100 system is a 2U, rack-mounted NVMe flash memory enclosure that is based on IBM 3D TLC flash technology. It provides the following NVMe technologies:

- ▶ Supports unique world class IBM FlashCore Module drives with inline compression.
- ▶ Supports industry-standard NVMe drives.
- ▶ SCM-capable.
- ▶ NVMe-oF ready. Requires a software update when available.
- ▶ The IBM FlashSystem 9100 system is offered as four models:
 - Model AF7 - IBM FlashSystem 9110 SFF NVMe Control Enclosure
 - Model AF8 - IBM FlashSystem 9150 SFF NVMe Control Enclosure
 - Model UF7 - IBM FlashSystem 9110 SFF NVMe Control Enclosure
 - Model UF8 - IBM FlashSystem 9150 SFF NVMe Control Enclosure

Note: The UF7 and UF8 utility-based models have fixed configurations because they are Capacity on Demand (CoD) based offerings.

- ▶ Macroefficiency with up to 460 TB of 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 new tiering options with SSD flash drives.

The IBM FlashSystem 9100 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 de-duplication
- ▶ IBM Easy Tier
- ▶ External virtualization
- ▶ IP quorum support
- ▶ N-Port ID Virtualization (NPIV) support
- ▶ VMware vSphere virtual volume (VVOL) support and space-efficient copies
- ▶ Transparent Cloud Tiering

The IBM FlashSystem 9100 configuration is composed of the following components:

- ▶ One to four IBM FlashSystem 9100 Control Enclosures
- ▶ One to eight IBM FlashSystem 9100 LFF Expansion Enclosures
- ▶ One to twenty IBM FlashSystem 9100 LFF Expansion Enclosures

IBM FlashSystem 9100 Utility Models UF7 and UF8

IBM FlashSystem 9100 Utility Models UF7 and UF8 provide a variable capacity storage offering. These models offer a fixed capacity, with a base subscription of 35% of the total capacity.

IBM Storage Insights is used to monitor system usage, and capacity that is used beyond the base 35% is billed on a per month per terabyte 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 up to 35% of the total system capacity at no additional cost. If storage needs increase beyond that 35% 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 9100 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, there is no additional billing.

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 as shown in Table 1, rounding to the nearest terabyte.

Table 1 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 may be ordered with the system in all supported configurations.

Table 2 shows the feature codes that are associated with the UF7 and UF8 utility model billing.

Table 2 9100 UF7 and UF8 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, and 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 use only as much as is necessary during any month. Usage can increase or decrease, and is billed accordingly. Provisioned capacity is considered capacity that is reserved by the system. In thick-provisioned environments, this is the capacity that is allocated to a host, whether it has data that is written or not. 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.

Highlights

Easy to deploy and manage, the IBM FlashSystem 9100 system is designed to accelerate the applications that drive business. The following topics are described in more detail:

- ▶ Versatile performance
- ▶ Enduring economics
- ▶ Agile integration
- ▶ Features and capabilities

Versatile performance

The IBM FlashSystem 9100 solution has the following versatile performance attributes:

- ▶ Scale-up or scale-out, independently
- ▶ Scalable to 10 million IOPS
- ▶ Scalable to 136 GBps bandwidth
- ▶ Sustained IBM MicroLatency
- ▶ Quality of service
- ▶ Faster applications

Enduring economics

The IBM FlashSystem 9100 system provides the following enduring economics attributes:

- ▶ Delivers scalable internal flash capacity up to 3.0 PB (effective, assuming 2:1 or better hardware compression)
- ▶ Scalable to 7.5 PB by using native flash storage as tier 0 (effective, assuming 5:1 data reduction by using Data Reduction Pools)
- ▶ Expandable to 32 PB by using SSD flash drives as tier 1 capacity
- ▶ Flash for less than the cost of disk with Data Reduction Pools
- ▶ Low power and cooling requirements
- ▶ Virtualized storage
- ▶ Flash wear warranty
- ▶ Infrastructure continuity with space efficient snapshots, cloning, and replication

Agile integration

The IBM FlashSystem 9100 system has the following agile characteristics:

- ▶ Fully integrated system management
- ▶ Application-aware data services
- ▶ Advanced Encryption Standard (AES), data at rest encryption with IBM FlashCore Module type drives
- ▶ In-line hardware compression with IBM FlashCore Module type drives
- ▶ Tier or mirror to existing storage
- ▶ Mixed workload consolidation
- ▶ Nondisruptive data migrations
- ▶ Concurrent code load

By accelerating applications, both physical and virtual, the IBM FlashSystem 9100 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

Features and capabilities

Table 3 shows the features and capabilities.

Table 3 Features and capabilities

<ul style="list-style-type: none">▶ Storage virtualization▶ Virtual disk Mirroring▶ HyperSwap▶ Metro Mirror: Synchronous remote replication▶ Global Mirror: Asynchronous remote replication▶ Global Mirror over IP: Remote replication over the internet▶ Importing and exporting existing LUNs through Image Mode▶ Unmap▶ VVOLs▶ Public cloud offerings▶ IBM Cloud™ Private▶ Container support	<ul style="list-style-type: none">▶ Thin-provisioning▶ Fast-write cache▶ Auto-tiering (Easy Tier)▶ Distributed RAID (DRAID) 5 and 6▶ Transparent Cloud Tiering▶ Cloud Snapshot▶ Compression▶ Deduplication▶ FlashCopy (Snapshot)▶ FlashCopy rollback▶ Encryption of data at rest▶ Data migration and pooling
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IBM FlashCore technology

At the heart of the IBM FlashSystem 9100 system is IBM FlashCore technology (if the IBM FlashCore Module NVMe type drives are ordered), which consists of these 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, so there is no processor intervention.
- ▶ IBM FlashCore Modules, which are designed for low latency, density, and reliability.
- ▶ IBM Advanced Flash Management, which improves 3D TLC flash endurance over standard implementations without sacrificing latency.

Figure 3 shows IBM FlashCore technology.

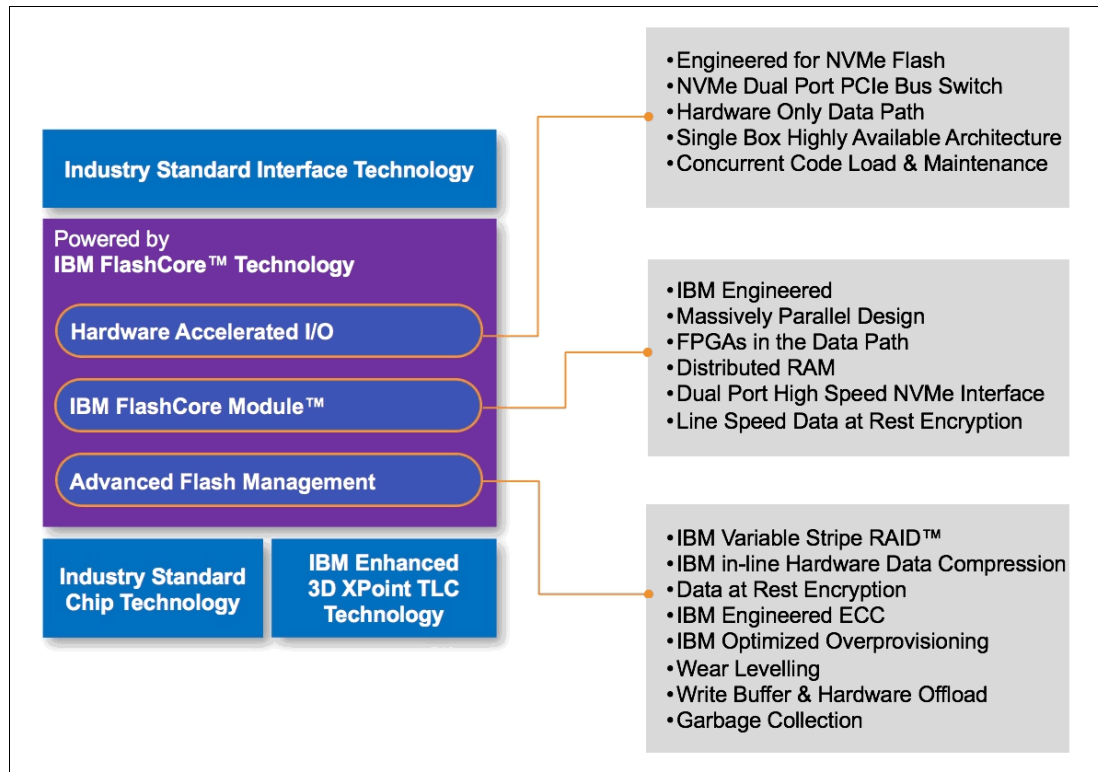


Figure 3 IBM FlashCore technology

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

The IBM Peace of Mind initiative

IBM Storage developed new programs that are anchored to all-flash IBM storage offerings, including the following ones:

- ▶ Multi-Cloud Enabled Today:
 - Proven solution blueprints to ease deployment.
- ▶ NVMe – SCM-capable:
 - NVMe end to end today with industry-leading performance.
 - NVMe-oF (FC and Ethernet) support when the standard solidifies.
- ▶ IBM data reduction guarantee reduces planning risks and lowers storage costs by meeting baseline levels of data compression effectiveness:
 - Flexible: Up to 5:1 data reduction.
 - Express: 2:1 data reduction.
- ▶ IBM availability is unmatched in the industry:
 - IBM ensures 100% data availability for systems that use HyperSwap and are deployed by IBM Lab Services.

- ▶ The IBM Controller upgrade program enables customers of designated all-flash IBM storage systems to reduce costs while maintaining leading-edge controller technology for essentially the cost of ongoing system maintenance. There are no up-front charges or contractual commitments.
- ▶ Migration: Up to 45 days to migrate data at no extra charge.
- ▶ Seven-year 24x7 support and endurance:
 - Up to 7 years support is available with flash media retention offerings.
 - All flash memory is covered for read and write endurance while under warranty or maintenance.
- ▶ A new high-availability program helps enterprises avoid the costs and risks that are related to business downtime by ensuring the availability of business-critical data and storage systems.

The data reduction guarantee, controller upgrade program, and high-availability guarantee each offer many benefits. But, when combined as part of an IBM all-flash storage solution, the power of all of these offerings that help you lower costs, reduce business risk, and maintain the most current technologies can be even more significant:

- ▶ Flash endurance coverage while hardware maintenance is current ensures that flash wear never becomes a problem.
- ▶ Enhanced support is available from IBM through the ECS service that comes with the 9848 machine type.

For more information, see [IBM Peace of Mind Initiative](#).

IBM Storage Insights

IBM Storage Insights is a part of the monitoring and ensuring continued availability of the IBM FlashSystem 9100 system.

Available at no charge, cloud-based IBM Storage Insights provides a single dashboard that gives you a clear view of all your IBM block storage. You can make better decisions by seeing trends in performance and capacity. 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.

Some of these features are:

- ▶ A unified view of IBM systems:
 - Provides a single view to see all your system's characteristics.
 - See 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 fast.
- ▶ IBM Storage Insights collects telemetry data and call home data and provides real-time system reporting of capacity and performance.

- ▶ Overall storage monitoring looking at:
 - The overall health of the system.
 - Monitoring of the configuration to see whether it meets preferred practices.
 - System resource management determines 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 shows a view of the IBM Storage Insights main dashboard and the systems that it monitors.

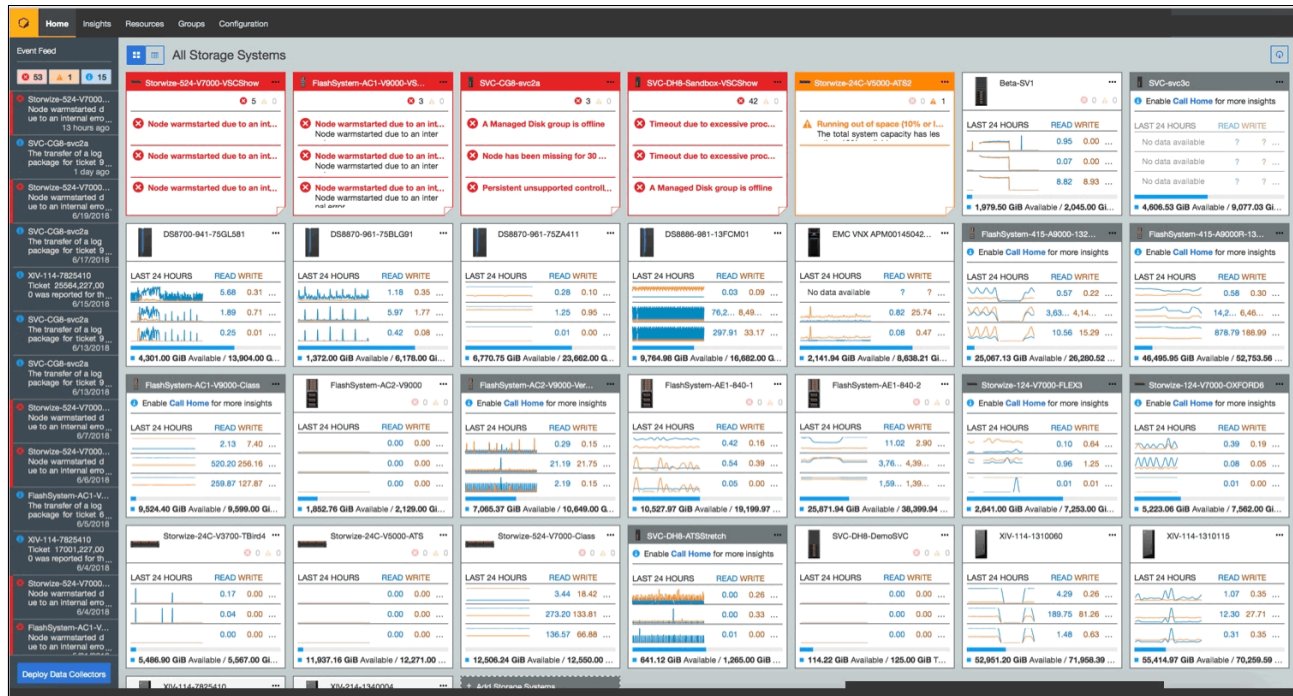


Figure 4 IBM Storage Insights dashboard

Further views and images of dashboard displays can be found in “IBM Storage Insights: Information and registration” on page 13.

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 websites. The last link can be used to sign up and register for this no additional charge service.

- ▶ [Fact Sheet](#)
- ▶ [Demonstration](#)
- ▶ *IBM Storage Insights Security Guide*, SC27-8774-05, found at ibm.biz/insightssecurity
- ▶ [IBM Knowledge Center: IBM Storage Insights](#)
- ▶ [Registration](#)

Multi-cloud offerings and solutions

The IBM FlashSystem 9100 system includes software that can help you develop a multi-cloud strategy if your storage environment includes cloud services, whether a public, private, or hybrid cloud.

The IBM FlashSystem 9100 system offers a series of multi-cloud software options. A set of base software options is provided with the system purchase, and you can investigate the integration of the IBM FlashSystem 9100 system with the following cloud-based software offerings:

- ▶ IBM Spectrum Protect™ Plus Multi-Cloud starter for IBM FlashSystem 9100
- ▶ IBM Spectrum Copy Data Management Multi-Cloud starter for IBM FlashSystem 9100
- ▶ IBM Spectrum Virtualize for Public Cloud Multi-Cloud starter for IBM FlashSystem 9100

In addition, IBM offers a set of integrated software solutions that is associated with the IBM FlashSystem 9100 system. These multi-cloud solutions are provided as optional software packages that are available with the IBM FlashSystem 9100 system. Each of the following software solutions includes all the software that is needed to construct the solution and an IBM-tested blueprint that describes how to construct the solution:

- ▶ IBM FlashSystem 9100 Multi-Cloud Solution for Data Reuse, Protection, and Efficiency
- ▶ IBM FlashSystem 9100 Multi-Cloud Solution for Business Continuity and Data
- ▶ IBM FlashSystem 9100 Multi-Cloud Solution for Private Cloud Flexibility, and Data Protection

For more information about the software products that are included with the IBM FlashSystem 9100 system, see [IBM Knowledge Center: IBM FlashSystem 9100](#).

Component overview

The IBM FlashSystem 9100 system is composed of one or more control enclosures and optional expansion enclosures.

IBM FlashSystem 9100 Control Enclosure

The IBM FlashSystem 9100 Control Enclosure is a 2U rack mount unit that provides the primary management interface (GUI) and the host interface configuration. The IBM FlashSystem 9100 Control Enclosures support FC Protocol (FCP) and iSCSI interfaces. For iSCSI, both the RoCE and iWARP protocols are supported.

There are two machine types that are offered for the IBM FlashSystem 9100 system:

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

Machine type 9848 also comes with Enterprise Class Support (ECS) support and 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.

Each control enclosure houses two node canisters, which are the processing engines of the IBM FlashSystem 9100 system. The control enclosures are offered as two models:

- ▶ IBM FlashSystem 9110 SFF NVMe Control Enclosure Model AF7/ UF7:
 - Two node canisters, each with two 8-core processors and integrated hardware-assisted compression acceleration
 - Cache options from 128 GB (64 GB per canister) to 1.5 TB (768 GB per canister)
 - Eight 10 Gb Ethernet ports standard for iSCSI connectivity
 - 16 Gb FC, 25 Gb Ethernet, and 10 Gb Ethernet ports for FC and iSCSI connectivity
 - 12 Gb SAS ports for expansion enclosure attachment
 - Twenty-four slots for 2.5-inch NVMe flash drives
 - 2U 19-inch rack mount enclosure with AC power supplies
- ▶ IBM FlashSystem 9150 SFF NVMe Control Enclosure Model AF8 / UF8:
 - Two node canisters, each with two 14-core processors and integrated hardware-assisted compression acceleration
 - Cache options from 128 GB (64 GB per canister) to 1.5 TB (768 GB per canister)
 - Eight 10 Gb Ethernet ports standard for iSCSI connectivity
 - 16 Gb FC, 25 Gb Ethernet, and 10 Gb Ethernet ports for FC and iSCSI connectivity
 - 12 Gb SAS ports for expansion enclosure attachment
 - Twenty-four slots for 2.5-inch NVMe flash drives
 - 2U 19-inch rack mount enclosure with AC power supplies

Figure 5 on page 15 show a summary of the IBM FlashSystem 9100 machine types and the models.

MTM ²	9846-AF7	9846-AF8	9848-AF7/UF7	9848-AF8/UF8
Mktg Name	FlashSystem 9110	FlashSystem 9150	FlashSystem 9110	FlashSystem 9150
Warranty	1 Year; 24x7		3 Year; 24x7	
Install	SSR			
Services	Optional priced service offerings		ECS and TA Included	
Model Conversion	AF7 to AF8 ¹		AF7 to AF8 ¹	
Expansion Enclosures	AFF, A9F		AFF, A9F	
Misc	All Flash		All Flash, Eligible for controller upgrade program	

Figure 5 IBM FlashSystem 9100 machine type and models

Note: The conversion from model AF7 to AF8 will be available later after GA.

The control enclosures support up to 24 NVMe 2.5-inch drives, which can be either 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 9100 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

The following 2.5-inch (SFF) NVMe industry-standard drives are supported in IBM FlashSystem 9100 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

All drives are dual-port and hot-swappable. Drives of the same form factor and connector type can be intermixed within an enclosure.

IBM FlashSystem 9100 Expansion Enclosures

IBM FlashSystem 9100 Expansion Enclosures are either 2U or 5U rack-mounted units. The expansion enclosures are offered in two 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 High-Density 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 9100 Expansion Enclosures:
 - 1.92 TB 12 Gb SAS flash drive (2.5-inch and 3.5-inch form factor features)
 - 3.84 TB 12 Gb SAS flash drive (2.5-inch and 3.5-inch form factor features)
 - 7.68 TB 12 Gb SAS flash drive (2.5-inch and 3.5-inch form factor features)
 - 15.36 TB 12 Gb SAS flash drive (2.5-inch and 3.5-inch form factor features)

Multiple expansion enclosures are supported per IBM FlashSystem 9100 controller pair, providing 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 9848-AFF expansion enclosure adds a value of 1 to the SAS chain weight.

For example, each of the following expansion enclosure configurations has a total SAS weight of 10:

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

Software-defined flash services

The IBM FlashSystem 9100 data services are provided through IBM Spectrum Virtualize software. The IBM FlashSystem 9100 system offers a rich set of SDS features that includes FlashCopy, thin-provisioning, remote mirroring (Metro Mirror and Global Mirror), Easy Tier Third Generation, IBM Compression through Data Reduction Pools, IBM HyperSwap, IBM Security Key Lifecycle Manager (SKLM) Encryption, and DRAID 6.

Scalability and performance

The IBM FlashSystem 9100 system with SAS SSD expansion enclosures has the following scalability and performance features:

- ▶ The IBM FlashSystem 9100 system eliminates I/O bottlenecks while generating higher levels of application efficiency (improved performance).
- ▶ Up to 379 TB usable and 758 TB effective flash capacity in only 2U with 2:1 compression.
- ▶ Up to 1.5 PB usable and 7.5 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.
- ▶ Up to 10 million IOPS and 136 GBps bandwidth on a fully configured 4x IBM FlashSystem 9100 cluster.
- ▶ IBM MicroLatency in the form of the IBM FlashCore Modules.

Reliability, availability, and serviceability

IBM FlashSystem 9100 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 9100 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 Micron 3D TLC technology for higher storage density and improved endurance.
- ▶ IBM FlashSystem 9100 Control Enclosures support concurrent code load.

Flash for less than the cost of disk

Integral to the IBM FlashSystem 9100 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.

IBM FlashSystem 9100 with IBM FlashCore Module NVMe type drives have built-in hardware data compression as standard, and this data reduction is “always on”. This compression is implemented in hardware by using FPGAs within each module and uses 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 Module except for management of space. Performance is not affected and scales linearly with the number of instances.

IBM FlashSystem 9100 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 9100 Control Enclosure offers several features for Data Reduction Pool compression workloads. These features include 8 or 14 Intel core processors with up to 734 GB of memory, and a built-in compression accelerator for hardware-assisted compression. In addition, the IBM FlashSystem 9100 system with IBM FlashCore Module NVMe type drives applies compression to any data that is not already compressed.

Software-defined services

The IBM FlashSystem 9100 system merges SDS with the scalable performance of IBM FlashSystem technology to help you more easily manage your entire storage environment while preserving your investments in storage. The SDS services use the following features across all of your storage:

- ▶ Thin-provisioning: Enables dynamic growth so you can purchase only the storage you need when you need it.
- ▶ Easy Tier flash memory management: Optimizes performance at a lower overall cost.
- ▶ HA configurations: Enables near-continuous data availability.
- ▶ Copy services: Enables space-efficient backups.
- ▶ Encryption-capable: Provides optional AES-XTS 256-bit data-at-rest encryption.
- ▶ Disaster recovery (DR) techniques: You can practice them and validate business continuity plans.
- ▶ Simple GUI: Storage can be quickly deployed and efficiently managed.
- ▶ HyperSwap capability: Each volume can be presented by two I/O groups. The configuration can tolerate combinations of node and site failures.

Note: IBM Storage Mobile Dashboard V1.5.4 and later supports the IBM FlashSystem 9100 GUI. You can download the dashboard at no cost from [iTunes](#).

Deep application integration

IBM FlashSystem 9100 Software V8.2 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.
- ▶ vStorage APIs for Array Integration (VAAI) support: This function supports hardware-accelerated virtual machine (VM) copy/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.

Virtual volume

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

The VMDK file was placed in a file system that is called VMFS, which is hosted by a standard volume (LUN). For example, it could be implemented on an external storage system, such as the IBM FlashSystem 9100 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 9100 volume).

With VVOL, the IBM FlashSystem 9100 solution is “aware” of individual VMDK files. Therefore, data operations such as snapshot and replication can be performed directly by the IBM FlashSystem 9100 system at the VMDK level rather than the entire VMFS data store.

Note: The integration of VVOL with the IBM FlashSystem 9100 system is based on the VMware APIs for Storage Awareness (VASA). IBM support for VASA is delivered as part of IBM Spectrum Control™. VASA V2 is required to use the VVOL capability.

IBM Spectrum Control Connect

IBM FlashSystem 9100 Software V8.2 supports integration of VASA and VAAI by using IBM Spectrum Control Connect V3.2.5 (formally known as IBM Spectrum Control Base) or later. This is a centralized server system that 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.

Current release functions

This section describes several new functions and features that are available in the current IBM FlashSystem 9100 release.

New in IBM FlashSystem 9100 Software V8.2

The following functions are new in IBM FlashSystem 9100 Software V8.2:

- ▶ Support for IBM FlashSystem 9100 enclosures with NVMe drives.
- ▶ RSA provides a secure connection for remote support with audit logging.
- ▶ Management GUI enhancements.
- ▶ SAS expansion enclosure management to increase the flexibility of the overall solution.
- ▶ IBM SKLM coexistence with USB encryption key management and IBM SKLM clone server support.
- ▶ Pause capability in concurrent code update allows flexibility during code updates.
- ▶ Compression and de-duplication through Data Reduction Pools.
- ▶ Support for 25 Gb iSCSI remote direct memory access (RDMA) over Converged Ethernet (RoCE) and internet Wide-area RDMA Protocol (iWARP) protocols.

Advanced functions

The IBM FlashSystem 9100 system provides several advanced functions:

- ▶ HyperSwap for the IBM FlashSystem 9100 system
- ▶ IP quorum base support
- ▶ Data reduction tools
- ▶ N-Port ID Virtualization support
- ▶ Scaling up and scaling out
- ▶ Expansion enclosures
- ▶ Improving what you have for both IBM and third-party resources
- ▶ Deploying quickly and flexibly
- ▶ Driving new business opportunities
- ▶ Manageability and security

HyperSwap for the IBM FlashSystem 9100 system

HyperSwap is available with IBM FlashSystem 9100 Software V8.2 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 9100 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 50.

IBM FlashSystem 9100 Software V8.2 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:

- ▶ The HyperSwap topology locates both nodes of an I/O group in the same site. Therefore, to get a volume that is resiliently stored on both sites, at least two I/O groups are required.
- ▶ The HyperSwap topology uses extra system resources to support a fully independent cache on 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 9100 Control Enclosures, and IBM FlashSystem 9100 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 6 on page 21 shows how the HyperSwap function works.

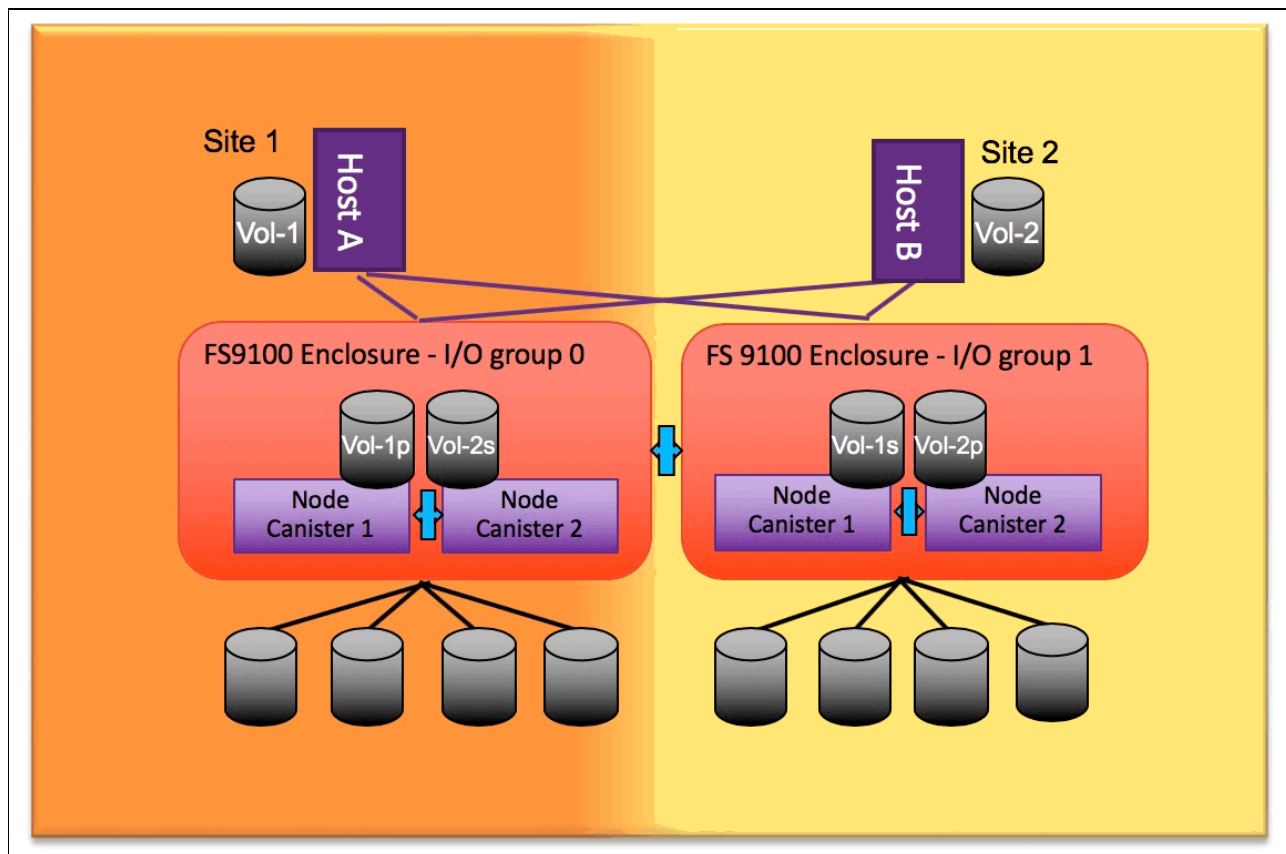


Figure 6 HyperSwap function

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 9100 HyperSwap function, and is transparent to the hosts.

HyperSwap has these characteristics:

- ▶ The HyperSwap function is available on IBM FlashSystem 9100 Software V8.2 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 additional 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 1024.
- ▶ Requires a remote mirroring license for volumes. Exact license requirements can vary by product.

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.

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

Data reduction tools

Compression and de-duplication is a key differentiator of the IBM FlashSystem 9100 system. IBM Comprestimator and Data Reduction Estimator Tool is the key sizing tool to estimate how much capacity savings that a client can expect. IBM Comprestimator and Data Reduction Estimator Tool can recognize the patterns of the actual client data, and estimate the compressibility of data per volume.

IBM FlashSystem models are supported in the stand-alone IBM Comprestimator and Data Reduction Estimator Tool as the IBM FlashSystem 9100 system. This is a host-based application that the user uses to estimate the amount of compression and de-duplication on the IBM FlashSystem 9100 system for specific workloads.

Note: Use the *host-based* tools.

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 already 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 Data Reduction Estimator Tool shows the savings for thin-provisioning, compression, and deduplication.
 - IBM Comprestimator and Data Reduction Estimator Tool 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 Version 8.2, IBM FlashSystem 9100 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 9100 system has NPIV enabled by default, so if the customer does not want to use it, they must turn it off before configuring FC ports for host communications.

Scaling up and scaling out

The IBM FlashSystem 9100 system has a scalable architecture that enables flash capacity to be added (scaled up) to support multiple applications. The virtualized system can also be expanded (scaled out) to support higher IOPS and bandwidth, or the solution can be simultaneously scaled up and out to improve capacity, IOPS, and bandwidth while maintaining MicroLatency. As a result, your organization can gain a competitive advantage through a more flexible, responsive, and efficient storage environment.

The IBM FlashSystem 9100 system has the following scalability features:

- ▶ Slots for up to 24 hot-swappable NVMe industry-standard or IBM FlashCore Modules:
 - Twenty-four NVMe 800 GB, 1.92 TB, 3.84 TB, 7.68 TB, or 15.36 TB industry-standard drives, or a mixture of both
 - Twenty-four ultra-low latency 2.5-inch (SFF) 4.8 TB, 9.6 TB, or 19.2 TB IBM FlashCore Module NVMe types

An enclosure supports a mixture of both types of drive, but only one type must be used for each DRAID 6 array that is configured within the control enclosure.
- ▶ Scalable internal flash capacity up to 3.0 PB (assuming 2:1 or better hardware compression):
 - Expandable to 32 PB by using SSDs in expansion enclosures as tier 1 capacity
- ▶ The IBM FlashSystem 9100 system has the following flexible scalability configuration options:
 - Base configuration
 - Scale up: Add capacity
 - Scale out: Add control enclosures and capacity

A basic configuration of an IBM FlashSystem 9100 storage platform consists of one IBM FlashSystem 9100 Control Enclosure. For a balanced increase of performance and scale, up to four IBM FlashSystem 9100 Control Enclosures can be clustered into a single storage system, multiplying performance and capacity with each addition.

The clustered IBM FlashSystem 9100 system can have dedicated internal FC switches for internal communications. However, there are other methods that 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 FC port masking information in [IBM Knowledge Center](#).

With the scalable IBM FlashSystem 9100 configurations, you can add up to three extra IBM FlashSystem 9100 Control Enclosures to the storage system. If 379 TB usable and up to 1.5 PB maximum from four control enclosures is not enough capacity, then you can add extra capacity by adding SAS expansion enclosures with SDD drives.

In total, an IBM FlashSystem 9100 system can contain a maximum of four IBM FlashSystem 9100 Control Enclosures. This configuration offers a potential storage capacity of 1.5 PB usable and up to 3.0 PB effective capacity, assuming 2:1 or better hardware compression.

With the Data Reduction Pool feature, you can scale to 7.5 PB effective, assuming 5:1 data reduction by using IBM Real-time Compression™. Data Reduction Pool compression can be deployed where you need it.

Figure 7 illustrates an IBM FlashSystem 9100 single control enclosure that can scale up through one or more expansion enclosures.

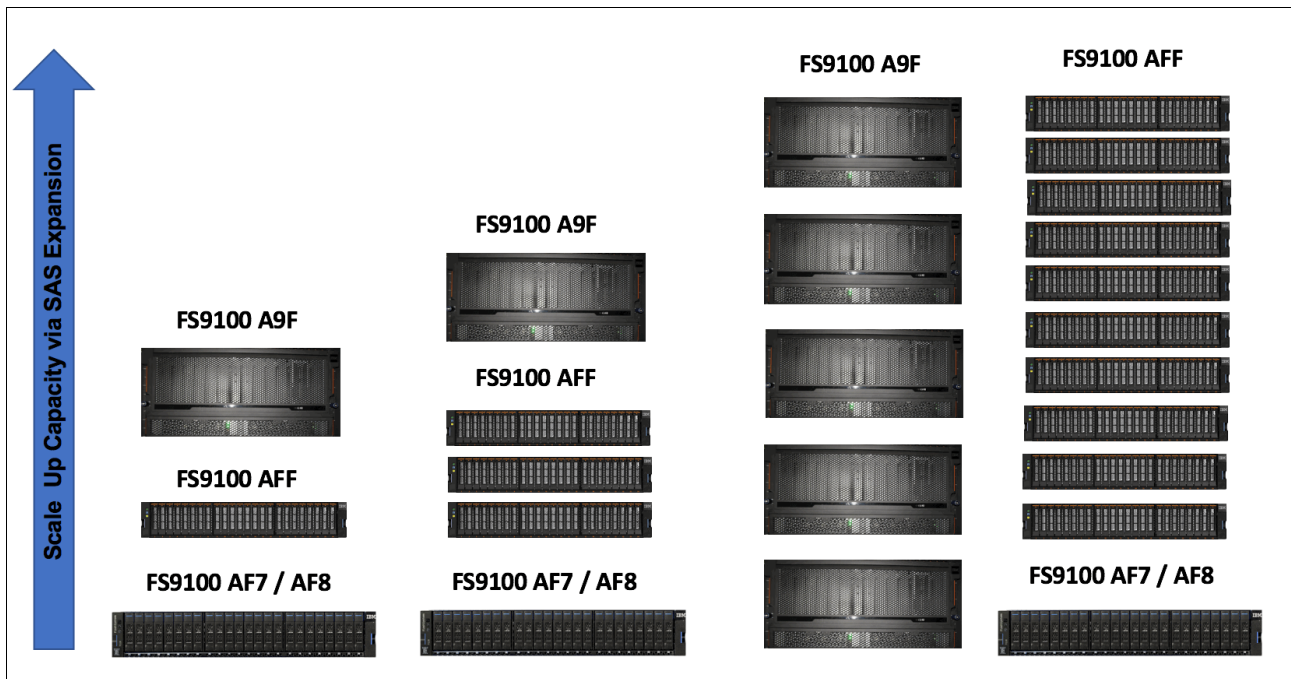


Figure 7 IBM FlashSystem 9100 scaling up by using expansion enclosures

Figure 8 on page 25 illustrates the increments in the scaled-out capacity of the IBM FlashSystem 9100 system. More expansion enclosures can be added behind a maximum of four control enclosures.

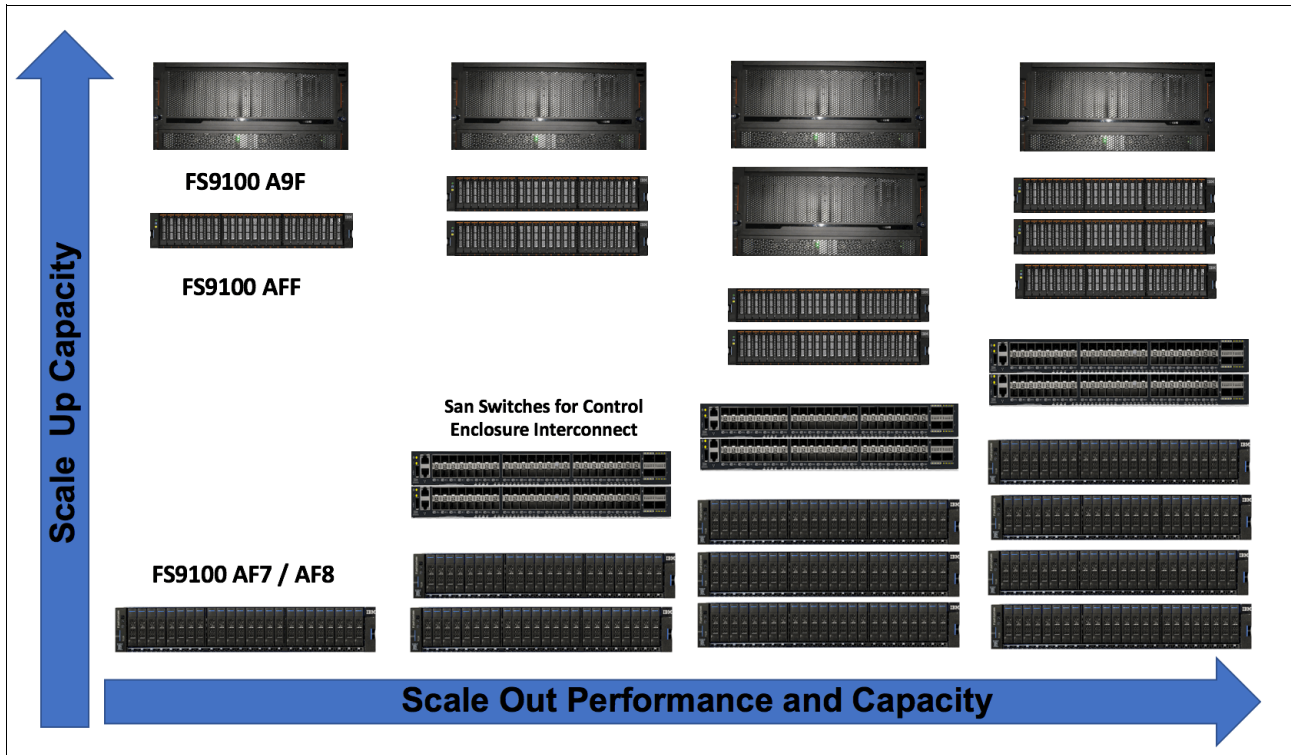


Figure 8 IBM FlashSystem 9100 scalable capacity

Maximum capacity

Table 4 provides a summary of maximum raw capacity, usable capacity, and maximum effective capacity for scalable configurations built on the IBM FlashSystem 9100 Control Enclosures.

Table 4 IBM FlashSystem 9100 capacity by using IBM FlashCore Module NVMe type drives

Number of control enclosures	Maximum raw capacity with 24 drives (terabytes)	Maximum usable capacity by using DRAID 6 with 24 drives (terabytes)	Maximum effective capacity (terabytes) with inline compression @ 2:1 ratio
One control enclosure	461	379	758
Two control enclosures	922	758	1516
Three control enclosures	1383	1137	2274
Four control enclosures	1844	1516	3032

Note the following considerations:

- ▶ 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.

Note: IBM FlashCore Module inline compression is hardware-based and has no effect on performance.

DRAID6 space calculations

To calculate the approximate amount of usable space that is available when creating a DRAID6 array, use the following formula:

$$\text{Array Capacity} = D / ((W * 256) + 16) * ((N - S) * (W - 2) * 256)$$

Where:

D - Drive capacity

N - Drive count

S - Rebuild areas (spare count) which is 1 for all FCM arrays

W - Stripe width

Example #1:

Capacity of DRAID6 array out of 16 x 9.6 TB FlashCore modules.

$$D = 9.6 \text{ TB} = 8.7 \text{ TiB}$$

$$N = 16$$

$$S = 1$$

$$W = 12$$

$$\begin{aligned} \text{Array capacity} &= 8.7 \text{ TiB} / ((12 * 256) + 16) * ((16 - 1) * (12 - 2) * 256) = \\ &= 8.7 \text{ TiB} / 3088 * 38400 = 108.2 \text{ TiB} \end{aligned}$$

Example #2:

Capacity of DRAID6 array out of 6 x 4.8 TB FlashCore modules.

$$D = 4.8 \text{ TB} = 4.36 \text{ TiB}$$

$$N = 6$$

$$S = 1$$

$$W = 5$$

$$\begin{aligned} \text{Array capacity} &= 4.36 \text{ TiB} / ((5 * 256) + 16) * ((6 - 1) * (5 - 2) * 256) = \\ &= 4.36 \text{ TiB} / 1296 * 3840 = 12.8 \text{ TiB} \end{aligned}$$

Note: This formula gives only a close estimate. It is not intended to give exact result. For exact results, use capacity estimation tool or `lspotentialarraysize` CLI command.

PCIe expansion slots

Six PCIe slots are available for port expansions in the IBM FlashSystem 9100 Control Enclosure.

Table 5 on page 26 shows the maximum host port count per building block configuration (1, 2, 3, or 4 control enclosures).

Table 5 Maximum host port count per control enclosure

Number of control enclosures	16 Gb FC	Onboard iSCSI 10 Gb ports	25 Gb iSCSI (RoCE)	25 Gb iSCSI (iWARP)
One control enclosure	24	8	12	12
Two control enclosures	48	16	24	24
Three control enclosures	72	24	36	36

Number of control enclosures	16 Gb FC	Onboard iSCSI 10 Gb ports	25 Gb iSCSI (RoCE)	25 Gb iSCSI (iWARP)
Four control enclosures	96	32	48	48

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

Expansion enclosures

With IBM FlashSystem 9100 Software V8.2, the IBM FlashSystem 9100 system supports the addition of expansion enclosures.

High-density (HD) Enclosure Model A9F accepts only SAS SSDs. With this tiering option, you may have eight enclosures per control enclosure with a maximum capacity of 1350 TB each.

Figure 9 shows the maximum enclosure configuration.

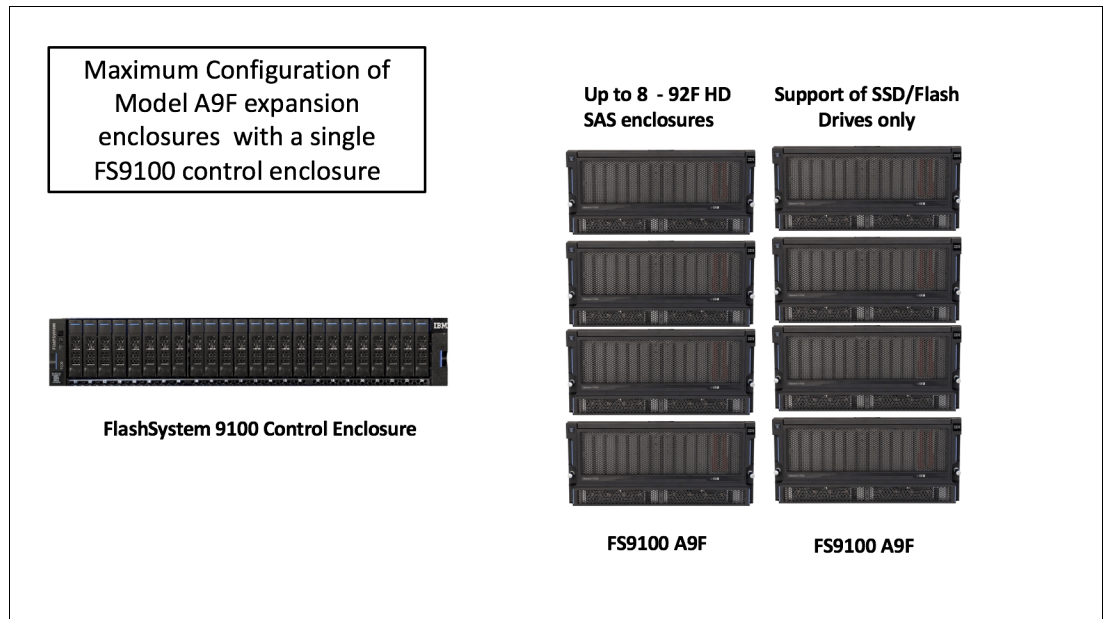


Figure 9 Single IBM FlashSystem 9100 Control Enclosure with the maximum configuration for model A9F enclosures

IBM FlashSystem 9100 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 9100 Control Enclosure, which provides up to 480 drives with up to 1.9 PB of SAS SSD capacity.

Figure 10 shows the maximum configuration of 20 expansion enclosures in the AFF models.

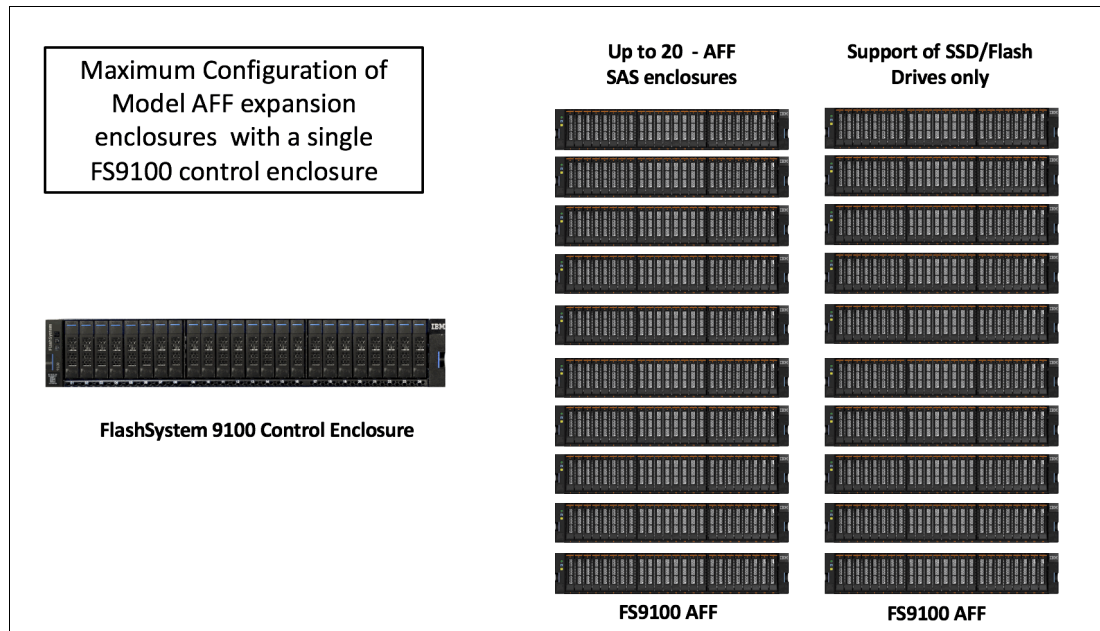


Figure 10 Single IBM FlashSystem 9100 Control Enclosure with the maximum configuration for model AFF enclosures

Expansion enclosure drive offerings

Both the SFF expansion enclosure Model AFF and LFF expansion enclosure Model A9F deliver increased storage density and capacity for the IBM FlashSystem 9100 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 9100 solution with a maximum of 32 PB combined NVMe flash and SAS capacity that is configured on four IBM FlashSystem 9100 control enclosures.

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

RAID types

The IBM FlashSystem 9100 system supports two main DRAID types and one optional RAID type as follows:

- ▶ IBM FlashCore Modules:
 - Six drive minimum.
 - 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 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.

The additional SAS attached expansion enclosures can be configured with various RAID options. DRAID (DRAID 5 and DRAID 6) offers improved RAID rebuild times. DRAID 6 is preferred for expansion enclosures due to the drive sizes in use.

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

Note: To support SAS-attached expansion enclosures, an AHBA - SAS Enclosure Attach adapter must be installed in the control enclosure of the IBM FlashSystem 9100 system.

Improving what you have for both IBM and third-party resources

The IBM FlashSystem 9100 system offers SDS 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. SDS virtualization also makes the migration of data from one storage device to another easier. Virtualization of IBM FlashSystem 9100 Expansion Enclosures enables rapid and flexible provisioning and simple configuration changes.

You can use the IBM FlashSystem 9100 system to manage the capacity of other disk systems with external storage virtualization. When the IBM FlashSystem 9100 system virtualizes a storage system, its capacity becomes part of the IBM FlashSystem 9100 system and is managed in the same manner as the capacity on internal flash modules within the IBM FlashSystem 9100 system. Capacity in external storage systems inherits all the rich functions and ease of use of the IBM FlashSystem 9100 system.

You can use IBM FlashSystem 9100 to preserve your existing investments in storage, centralize management, and make storage migrations easier with storage virtualization and Easy Tier. The IBM FlashSystem 9100 system provides nondisruptive operations because of storage virtualization. Virtualization 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, so you have minimal downtime.

Deploying quickly and flexibly

With flexible deployment options, organizations can tailor the deployment architecture to the workload. This tailoring includes data access that bypasses the storage virtualization layer for low latency, data access through Easy Tier, data compression by using Data Reduction Pools, and data replication to DR sites. Clients can implement optimal business performance and enterprise features and choose how to deploy the following items:

- ▶ Sets of data that are in dedicated flash capacity for the lowest possible latency
- ▶ Sets of data that participate in Easy Tier
- ▶ Sets of data that are compressed by using Data Reduction Pools
- ▶ Sets of data for replication to DR sites
- ▶ All of these sets, or any combination of them

Driving new business opportunities

Clients can drive new business opportunities by using the IBM FlashSystem 9100 system:

- ▶ Improve workforce productivity.
- ▶ Lower power consumption.
- ▶ Consolidate data centers.

- ▶ Run mixed workloads.
- ▶ Accelerate infrastructure.
- ▶ Accelerate latency sensitive applications.
- ▶ Accelerate virtualization and VDI.
- ▶ Accelerate databases and data warehousing.

Manageability and security

The IBM FlashSystem 9100 system offers the following manageability and security features:

- ▶ Advanced security for data at rest with hardware-accelerated AES-XTS 256 encryption.
- ▶ IBM intends to obtain FIPS 140-2 Level 1 certification for IBM FlashCore Modules. IBM FlashCore Modules are expected to be submitted to the FIPS validation queue within 30 days of the planned availability date.
- ▶ A GUI to manage the IBM FlashSystem 9100 Control Enclosures and the IBM FlashSystem 9100 Expansion Enclosures. The GUI is available in any supported browser. Included in the GUI is the IBM FlashSystem 9100 command-line interface (CLI), which support a collection of commands that you can use to manage the IBM FlashSystem 9100 system.
- ▶ RSA provides secure connection for IBM Remote Support, which can do remote troubleshooting, remote code load, and obtain diagnostic logs.
- ▶ Email alerts.
- ▶ SNMP alerts.
- ▶ Syslog redirect to send system log messages to another host.

IBM FlashSystem 9100 components

The following sections describe the components. Table 6 lists the part numbers that are associated with the IBM FlashSystem 9100 system.

Table 6 IBM FlashSystem 9100 components and model numbers

Description	Machine type-model
IBM FlashSystem 9100 Control Enclosure. Marketing names are 9110 for AF7 and 9150 for AF8.	9846-AF7 or 9848-AF7 9846-AF8 or 9848-AF8
IBM FlashSystem 9100 SFF expansion enclosure.	9846-AFF or 9848-AFF
IBM FlashSystem 9100 LFF expansion enclosure.	9846-A9F or 9848-A9F

Note: IBM Configurator for e-business (e-config) has a convenience function. Extra FC switches can be easily and quickly added to the order to create a scalable configuration.

For more information, see the IBM announcement letters in Table 7.

Table 7 Recent IBM US announcement letters

Title	Link to announcement
<p><i>New IBM FlashSystem expansion enclosure delivers a tiered storage solution for IBM FlashSystem 9100</i> Note: This is the AFF expansion enclosure.</p>	<p>https://www.ibm.com/uk-en/marketplace/flashsystem-9100/details</p>
<p><i>IBM FlashSystem 9100 Control Enclosure, the SFF Expansion Enclosure Model AFF and the LFF Expansion Enclosure Model A9F deliver enhanced performance, scalability, and new tiering options for IBM FlashSystem 9100</i></p>	<p>http://www-01.ibm.com/common/ssi/ShowDoc.wss?docURL=/common/ssi/rep_sm/3/877/ENUS9848-h03/index.html&lang=en&request_locale=en#Header_15</p>
<p><i>IBM FlashSystem 9100 Control Enclosure Model AF7/AF8 delivers ultra-low latency and hardware-based compression for optimized performance</i></p>	<p>https://www-01.ibm.com/common/ssi/rep_ca/5/897/ENUS118-035/ENUS118-035.PDF</p>

Warranty

The IBM FlashSystem 9100 system is available with either a 1-year or 3-year warranty. Clients may select the warranty period that addresses their business and financial needs.

- ▶ Models that are ordered by using machine type 9846 have a 1-year warranty.
- ▶ Models that are ordered by using machine type 9848 have a 3-year warranty.

The models that are offered under both machine types for each component are functionally identical.

The IBM FlashSystem 9100 system, including its IBM FlashCore MicroLatency Modules (flash modules) and SSD, are covered by up to 7 years of total hardware support through the applicable warranty period, including up to 6 years of optional post-warranty hardware maintenance for a total of 7 years. Clients can purchase more years of maintenance either with the purchase of the system or until IBM announces withdrawal from marketing or withdrawal from service, as applicable.

IBM FlashSystem 9100 Enterprise Class Support

ECS is available only for the IBM FlashSystem 9100 systems that are purchased with a 3-year warranty. The machine types that are shown in Table 8 qualify for this type of enhanced support.

Table 8 Machine types that qualify for Enterprise Class Support

Component	Machine Type Model
<p>IBM FlashSystem 9100 Control Enclosure</p>	<p>9848-AF7 9848-AF8</p>
<p>IBM FlashSystem 9100 Expansion Enclosure</p>	<p>9848-AFF 9848-A9F</p>

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 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 checklist and site planning steps are complete. Additionally, 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 9100 Control Enclosure features

The IBM FlashSystem 9100 Control Enclosure provides advanced data services for flash memory. It is a 2U 19-inch rack-mounted enclosure. The IBM FlashSystem 9100 Control Enclosure includes two node canisters for redundant host access. The control enclosures include up to 24 ports that are used for connectivity, with options for 16 Gb FC, and 25 GbE iSCSI.

The IBM FlashSystem 9100 Control Enclosure is composed of the following components:

- ▶ Two node canisters in each IBM FlashSystem 9100 system provide redundancy. Each control enclosure consists of the following items:
 - IBM FlashSystem 9110 SFF NVMe Control Enclosure Model AF7:
 - Two node canisters, each with two 8-core processors and integrated hardware-assisted compression acceleration
 - Cache options from 128 GB (64 GB per canister) to 1.5 TB (768 GB per canister)
 - Eight 10 Gb Ethernet ports standard for iSCSI connectivity
 - 16 Gb FC, 25 Gb Ethernet, and 10 Gb Ethernet ports for FC and iSCSI connectivity
 - 12 Gb SAS ports for expansion enclosure attachment
 - Twenty-four slots for 2.5-inch NVMe flash drives
 - 2U 19-inch rack mount enclosure with dual N+1 AC power supplies
 - IBM FlashSystem 9150 SFF NVMe Control Enclosure Model AF8:
 - Two node canisters, each with two 14-core processors and integrated hardware-assisted compression acceleration
 - Cache options from 128 GB (64 GB per canister) to 1.5 TB (768 GB per canister)
 - Eight 10 Gb Ethernet ports standard for iSCSI connectivity

- 16 Gb FC, 25 Gb Ethernet, and 10 Gb Ethernet ports for FC and iSCSI connectivity
 - 12 Gb SAS ports for expansion enclosure attachment
 - Twenty-four slots for 2.5-inch NVMe flash drives
 - 2U, 19-inch rack mount enclosure with dual N+1 AC power supplies
- ▶ The control enclosure runs the IBM FlashSystem 9100 Software, which provides a rich set of SDS features. These features include FlashCopy, thin-provisioning, remote mirroring, Easy Tier, Data Reduction Pool compression, and de-duplication.
 - ▶ The IBM FlashSystem 9100 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 is the preferred configuration for their installation. If not, then this configuration must be changed from the default when you set up the SAN infrastructure. Full active-active multipathing across all interfaces is supported, although host software support for this function can vary.

System management

Because IBM FlashSystem 9100 Control Enclosures cluster to form a system, a single management interface is used for IBM FlashSystem 9100 Control Enclosures. Each IBM FlashSystem 9100 node canister is an individual server in An IBM FlashSystem 9100 clustered system on which the IBM FlashSystem 9100 Software runs.

IBM FlashSystem 9100 GUI

The IBM FlashSystem 9100 system includes an easy-to-use management GUI that runs on the IBM FlashSystem 9100 Control Enclosure to help you monitor, manage, and configure your system. 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 9100 system. The IBM FlashSystem 9100 Control Enclosure is delivered in a 2U 19-inch rack-mount enclosure. The IBM FlashSystem 9100 system comes with IBM SSR installation as part of the product offering.

Figure 11 shows the IBM FlashSystem 9100 GUI dashboard.

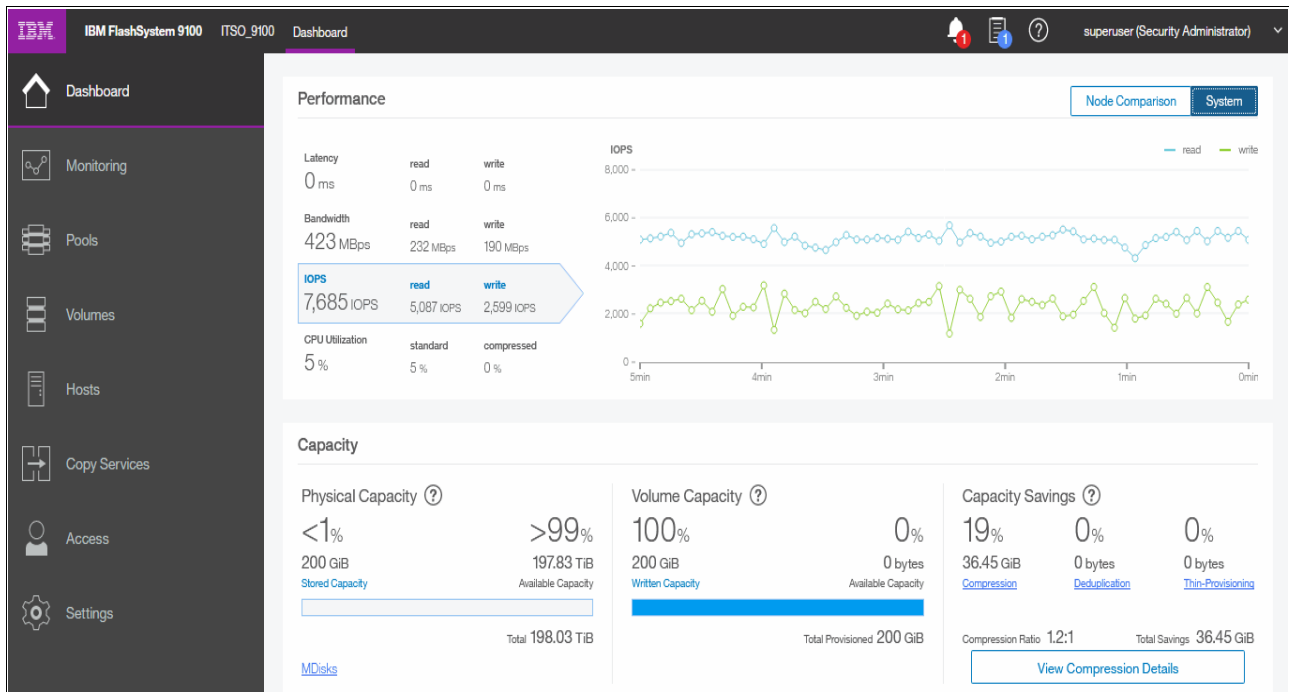


Figure 11 IBM FlashSystem 9100 GUI showing the dashboard

Figure 12 shows the control enclosure window. You can open this window by selecting **Monitoring** → **System Overview** from the left graphical menu.

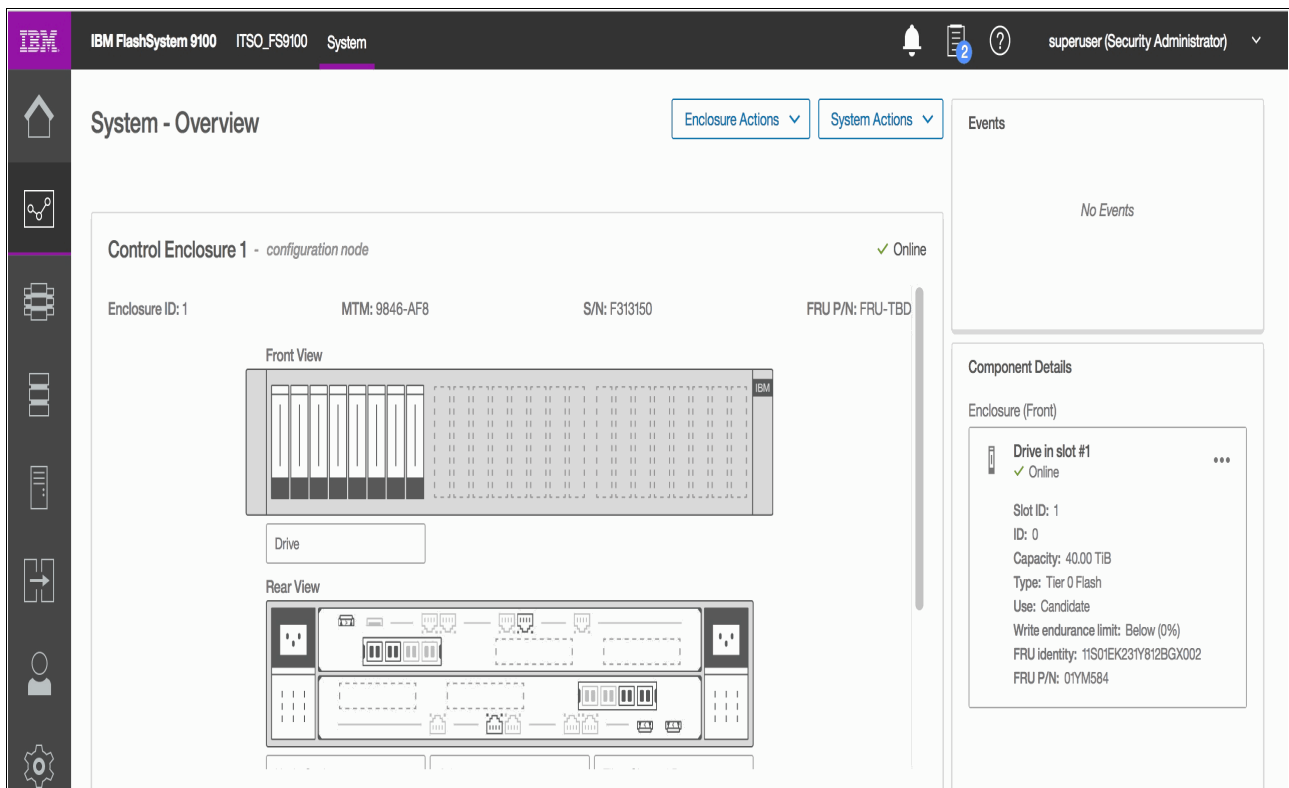


Figure 12 IBM FlashSystem 9100 system overview of the control enclosure

IBM FlashSystem 9100 Control Enclosure features

IBM FlashSystem 9100 Control Enclosure Models AF7 and AF8 are the heart of the storage system, and provide increased performance and more storage capacity.

The IBM FlashSystem 9100 Control Enclosure is a purpose-built 2U 19-inch rack-mounted enclosure with two AC power supplies, two node canisters with backup batteries, and SSD boot drives. The control enclosure provides up to twenty-four 16 Gb FC ports to connect to hosts and external expansion enclosures. They can connect either directly or through SAN switches.

Figure 13 shows the front view of the IBM FlashSystem 9100 Control Enclosure.



Figure 13 IBM FlashSystem 9100 Control Enclosure front view

The IBM FlashSystem 9100 Control Enclosure has the following features:

- ▶ Model AF7: Two 8-core processors with 128 GB memory standard, and options to increase memory up to 1536 GB.
- ▶ Model AF8: Two 14-core processors with 128 GB memory standard, and options to increase memory up to 1536 GB.
- ▶ 16 Gb FC and 25 Gb iSCSI connectivity options through PCIe adapters.
- ▶ Hardware-assisted compression acceleration on the nodes canisters for Data Reduction Pool workloads.
- ▶ Capability for adding into existing clustered systems with more IBM FlashSystem 9100 Control Enclosures or IBM V7000 Gen2 controllers.
- ▶ Up to 20 SAS attached expansion enclosures are supported per IBM FlashSystem 9100 controller pair, providing up to 480 HDD type drives with expansion Model AFF.
- ▶ Up to eight SAS High Density (HD) A9F expansion controllers are supported per IBM FlashSystem 9100 Control Enclosure pair, providing up to 736 SSD flash drives of Tier 1 capacity.

Figure 14 shows the rear view of the IBM FlashSystem 9100 Control Enclosure.

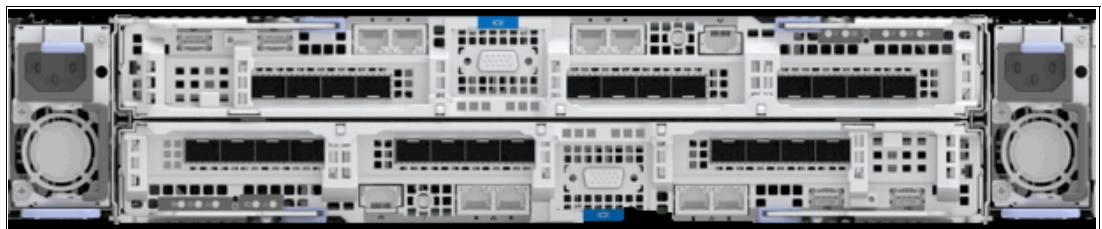


Figure 14 IBM FlashSystem 9100 Control Enclosure rear view

The IBM FlashSystem 9100 Control Enclosure requires IBM FlashSystem 9100 Software V8.2 or later for operation. You are entitled to the software when you acquire IBM FlashSystem 9100 Software licenses.

IBM FlashSystem 9100 Control Enclosure features

The IBM FlashSystem 9100 Control Enclosure requires IBM FlashSystem 9100 Software V8.2 or later for operation. You are entitled to the software when you acquire IBM FlashSystem 9100 Software licenses.

- ▶ The IBM FlashSystem 9100 Control Enclosure has full internal redundancy:
 - Redundant and hot-swappable node canisters.
 - Redundant and hot-swappable batteries within each node canister.
 - Hot-swappable PCIe adapters.
 - Redundant and hot-swappable power supplies, DIMMs, and fans.
- ▶ Up to 24 IBM FlashCore Module NVMe type or SSD flash modules in the following capacities:
 - 2.5-inch IBM FlashCore Module NVMe types: 4.8 TB, 9.6 TB, and 19.2 TB compressing IBM FlashCore Modules.
 - 2.5-inch NVMe flash drives: 800 GB, 1.92 TB, 3.84 TB, 7.68 TB, and 15.36 TB.
 - All flash modules must be the same type and capacity with the same DRAID 6 array.
- ▶ Up to 416 TB raw capacity, with 379 TB usable after DRAID 6 configuration and up to 758 TB maximum capacity, with hardware compression on the IBM FlashCore Module drives at a 2:1 ratio.
- ▶ IBM FlashSystem 9100 Control Enclosure includes two node controllers:
 - Each node controller contains two CPUs, a battery module, five fans, memory DIMMs, and up to three PCIe adapters. It also has a TPM module for encryption handling and a complementary metal–oxide–semiconductor (CMOS) battery for internal clock running.
 - The expansion enclosure has two power interposers, two power supplies, and one midplane. As viewed from the front of the expansion enclosure, the 24 NVMe flash module slots are from left to right.
- ▶ The front right side of the bezel contains the status LEDs.

Note: The upper node canister is mounted upside down in the expansion enclosure. This means the port numbering must be read *right to left*.

Figure 15 on page 37 shows the components of the IBM FlashSystem 9100 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.

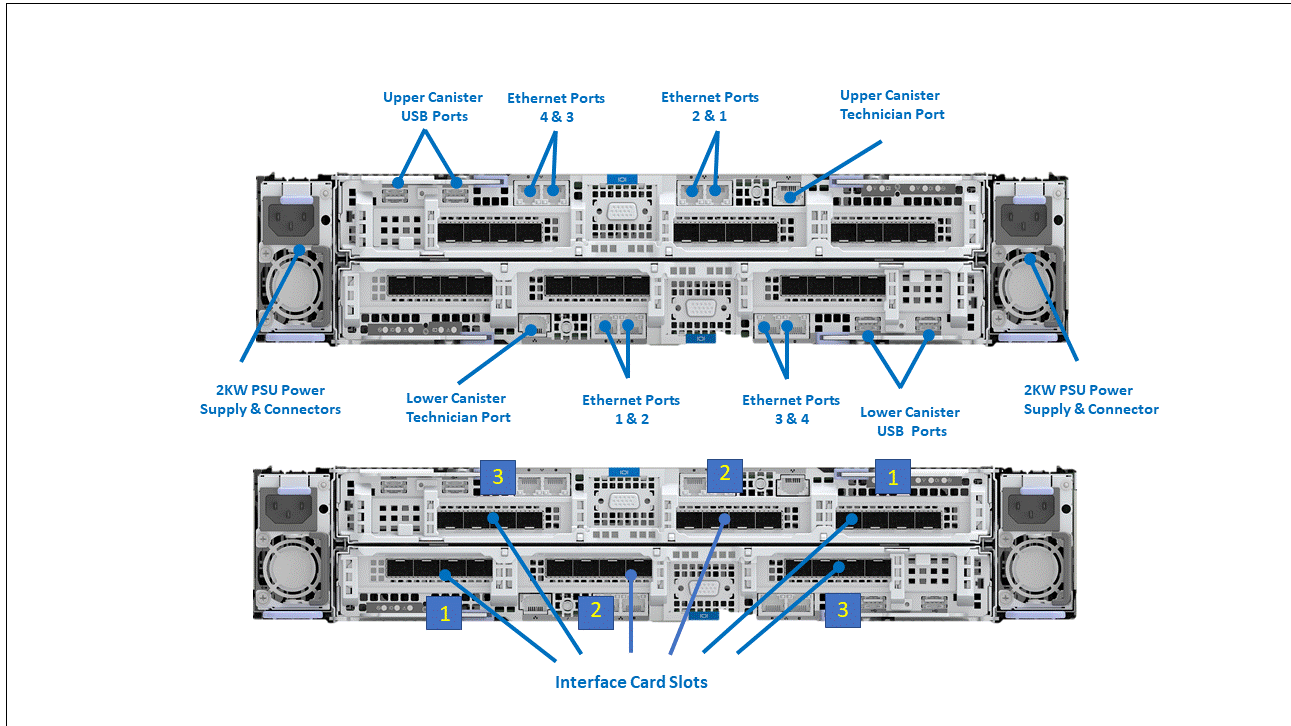


Figure 15 Rear view of IBM FlashSystem 9100 Control Enclosure

Each flash memory module contains IBM enhanced 3D TLC flash chips, FPGA chips, an IBM PowerPC® processor, and dynamic random access memory (DRAM) devices that are connected to the flash controllers and processor.

Each node canister implements a sophisticated Flash Translation Layer (FTL) incorporating error correction code (ECC), address translation, and Variable Stripe RAID self-healing data protection that handle failures at the flash page level or higher. ECC checksums, which are used to reconstruct subpage failures, are stored in manufacturer-reserved areas of the flash chips that are not included in specifications for usable capacity.

IBM FlashSystem 9100 Expansion Enclosure features

Two models of IBM FlashSystem 9100 Expansion Enclosures are offered:

- ▶ SFF Expansion Enclosure Model AFF
- ▶ LFF Expansion Enclosure Model A9F

IBM FlashSystem 9100 SFF Expansion Enclosure Model AFF offers new tiering options and up to 24 slots for 2.5-inch SSD flash drives. These drives are available in 1.92 TB, 3.84 TB, 7.66 TB, and 15.36 TB versions.

Figure 16 shows the front view of the IBM FlashSystem 9100 Expansion Enclosure Model AFF.



Figure 16 Front view of the IBM FlashSystem 9100 SFF Expansion Enclosure Model AFF

The AFF model of IBM FlashSystem 9100 SFF Expansion Enclosure has the following features:

- ▶ Two expansion canisters
- ▶ 12 Gb SAS ports for attachment to the IBM FlashSystem 9100 Control Enclosures
- ▶ 2U 19-inch rack-mount enclosure with AC power supplies

Figure 17 shows the rear view of IBM FlashSystem 9100 SFF Expansion Enclosure model AFF.



Figure 17 Rear view of IBM FlashSystem 9100 Expansion Enclosure Model AFF

IBM FlashSystem 9100 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 are 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 18 on page 39 shows the front view of IBM FlashSystem 9100 LFF model A9F Expansion Enclosure.

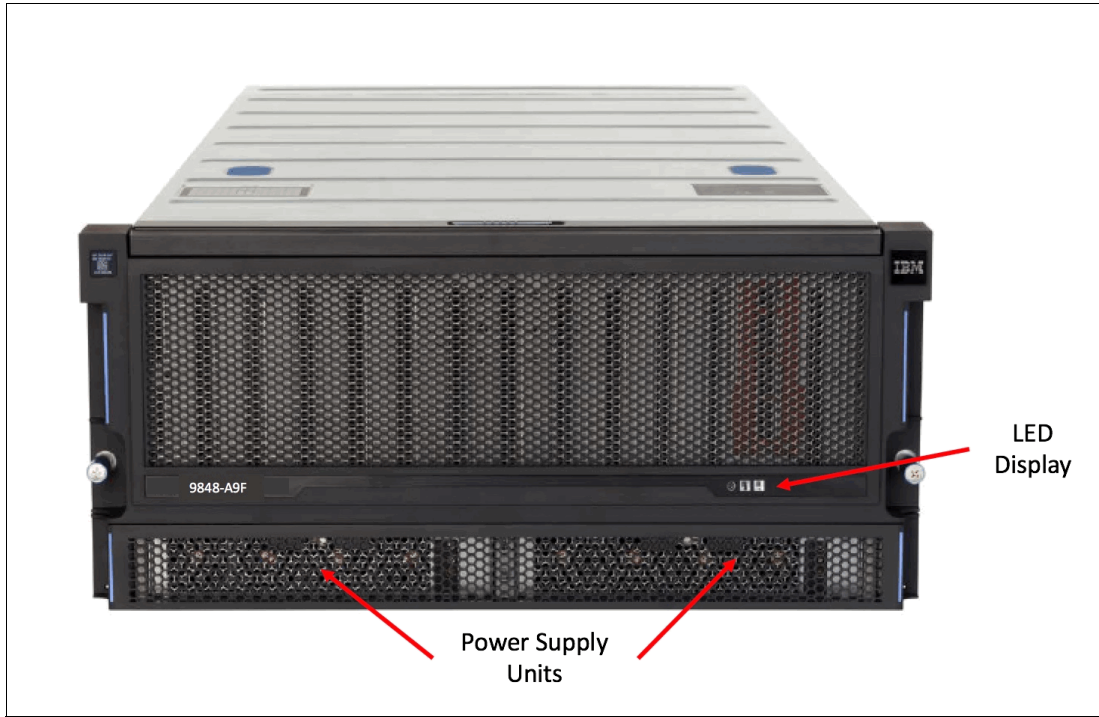


Figure 18 Front view of IBM FlashSystem 9100 LFF model A9F expansion enclosure

Figure 19 shows the rear view of IBM FlashSystem 9100 LFF model A9F Expansion Enclosure.

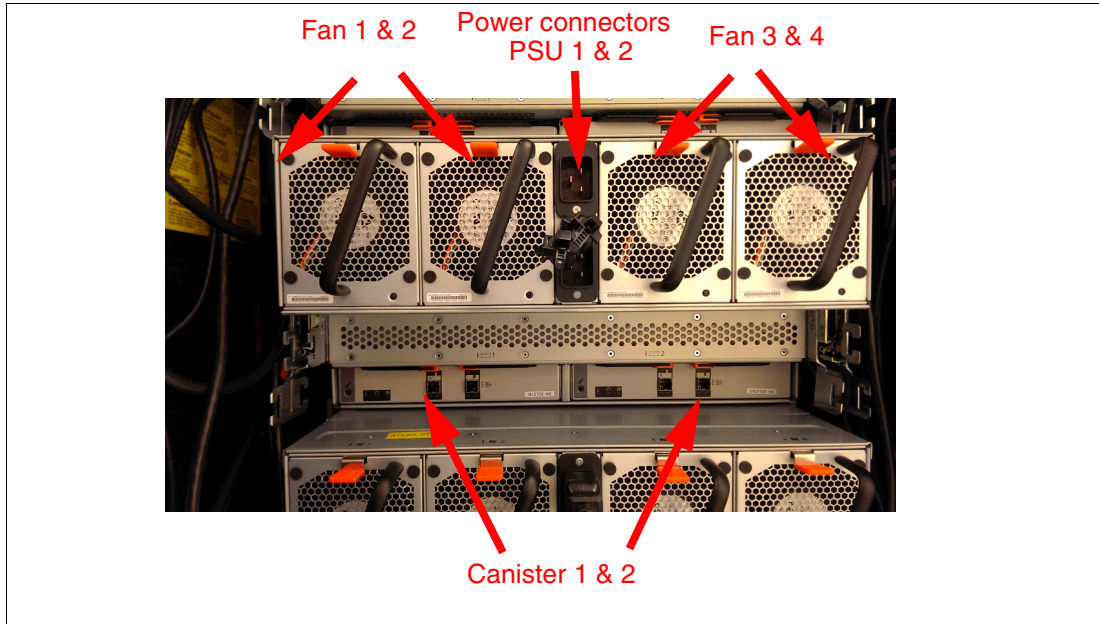


Figure 19 Rear view of IBM FlashSystem 9100 LFF model A9F expansion enclosure

Product specifications

The products specification sheet is at [IBM FlashSystem 9100](#), and it provides specifications for the base configuration of the IBM FlashSystem 9100 system.

Options and feature codes

This section describes the options and feature codes of the IBM FlashSystem 9100 Control Enclosure.

Memory

Here are the memory options:

▶ 128 GB Base Cache (#ACG0)

This feature indicates that the base machine is configured with 128 GB (eight 16 GB DDR4 DIMMs with 64 GB for each node canister). Selecting this feature determines the number of cache upgrade paths for machine. You may not have more than one per machine.

▶ 768 GB Base Cache (#ACG1)

This feature indicates the base machine is configured with 768 GB (twenty-four 32 GB DDR4 DIMMs with 384 GB for each node canister). Selecting this feature determines the number of cache upgrade paths for the machine. You may not have more than one per machine.

▶ 128 GB Cache upgrade (#ACGA)

This feature provides an extra 128 GB of cache (64 GB for each node canister) to increase the total system cache by 128 GB. You may not have more than two per machine.

▶ 768 GB Cache upgrade (#ACGB)

This feature provides an extra 768 GB of cache (384 GB for each node canister) to increase the total system cache by 768 GB. The following maximum number of this feature are as follows:

- One when #ACG1 is also ordered.
- Two only as part of a field installation or a Miscellaneous Equipment Specification (MES) upgrade when #ACG0 is also ordered.

120 GB M.2 Boot drive Pair (#ACGW)

120 GB M.2 Boot drive Pair (#ACGW) is a feature that is mandatory. It indicates that the base machine is configured with a pair of 120 GB M.2 boot drives.

The minimum and maximum numbers of this feature that are required or allowed are identical:

- ▶ Model AF7: One
- ▶ Model AF8: Two

Host I/O connectivity and expansion enclosure adapters

Table 9 on page 41 shows the current features for host and connectivity for the IBM FlashSystem 9100 Expansion Enclosure 9846-AF7, 9848-AF8, 9846-AF7, and 9848-AF8 machine types.

Table 9 Supported expansion enclosure and interface components MTMs 9846-AF7, 9848-AF8, 9846-AF7, 9848-AF8

Item	Feature code	Description	Ports
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.
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.
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.

FC and iSCSI (with iSCSI Extensions for RDMA support) connectivity with intermix flexibility

IBM FlashSystem 9100 systems include eight 10 Gb Ethernet ports as standard for iSCSI connectivity and two 1 Gb Ethernet ports for system management. The system can be configured with three I/O adapter features to provide up to twenty-four 16 Gb FC ports or up to twelve 25 Gb Ethernet (iSCSI or iSCSI Extensions for RDMA (iSER) capable) ports.

A minimum quantity of one 16 Gb FC adapter feature or one 25 Gb Ethernet adapter feature is required.

Configuration rules: Maximum adapters allowed per canister node

- ▶ 16 Gb FC 4 Port Adapters (Pair) (#AHB3):
 - None when the total quantity of features #AHB6, #AHB7, and #AHBA is three.
 - One when the total quantity of features #AHB6, #AHB7, and #AHBA is two.
 - Two when the total quantity of features #AHB6, #AHB7, and #AHBA is one.
 - Three when the total quantity of features #AHB6, #AHB7, and #AHBA is zero.
- ▶ 25 GbE (RoCE) Adapters (Pair) (#AHB6):
 - None when the total quantity of features #AHB3, #AHB7, and #AHBA is three.
 - One when the total quantity of features #AHB3, #AHB7, and #AHBA is two.
 - Two when the total quantity of features #AHB3, #AHB7, and #AHBA is one.
 - Three when the total quantity of features #AHB3, #AHB7, and #AHBA is zero.

- ▶ 25 GbE (iWARP) Adapters (Pair) (#AHB7):
 - None when the total quantity of features #AHB3, #AHB6, and #AHBA is three.
 - One when the total quantity of features #AHB3, #AHB6, and #AHBA is two.
 - Two when the total quantity of features #AHB3, #AHB6, and #AHBA is one.
 - Three when the total quantity of features #AHB3, #AHB6, and #AHBA is zero.
- ▶ SAS Expansion Enclosure Attach Card (Pair) (AHBA):
 - None when the total quantity of features #AHB3, #AHB6, and #AHB7 is three.
 - One when the total quantity of features #AHB3, #AHB6, and #AHB7 is two or less.

Cables

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

IBM FlashCore Modules and industry-standard NVMe drive options

The IBM FlashSystem 9100 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 9100 systems also support various industry-standard self-encrypting NVMe flash drives.

Here are the NVMe flash drive feature codes:

- ▶ 4.8 TB 2.5-inch NVMe Flash Core Module (#AHS1)
- ▶ 9.6 TB 2.5-inch NVMe Flash Core Module (#AHS2)
- ▶ 19.2 TB 2.5-inch NVMe Flash Core Module (#AHS3)
- ▶ 800 GB 2.5-inch NVMe Flash Drive (#AHT1)
- ▶ 1.92 TB 2.5-inch NVMe Flash Drive (#AHT2)
- ▶ 3.84 TB 2.5-inch NVMe Flash Drive (#AHT3)
- ▶ 7.68 TB 2.5-inch NVMe Flash Drive (#AHT4)
- ▶ 15.36 TB 2.5-inch NVMe Flash Drive (#AHT5)

Here are the limitations and drive considerations:

- ▶ 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.

IBM FlashSystem 9100 Expansion Enclosure options (models AFF and A9F)

Here are the SAS flash drives feature codes:

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

Variable Stripe RAID

Variable Stripe RAID is unique, self-healing data protection that is managed independently by each flash controller on each IBM FlashCore Module.

In the IBM FlashSystem 9100 system, the IBM FlashCore Module supports a variable stripe size, just like the MicroLatency modules in an IBM FlashSystem 900 system.

An IBM FlashSystem 900 system dedicates large amounts of spare flash memory per module and performs the RAID rebuild in the module. However, when IBM FlashCore Module encounters an uncorrectable error, it communicates with the system-level DRAID to reconstruct the data. The IBM FlashCore Module then writes the data like the MicroLatency modules in An IBM FlashSystem 900 system.

The IBM FlashCore Modules and DRAID work together with the IBM FlashCore Module offloading the RAID rebuild operation to DRAID so that the IBM FlashCore Module is more reliable and does not fail the module on a die or plane failure like an industry-standard SSD does.

When the Variable Stripe RAID algorithm detects a failure affecting one or more flash chips in a RAID stripe, the following process happens:

- ▶ Data that is stored in the affected regions is reconstructed from the remaining data and parity elements in the stripe.
- ▶ All pages in the affected stripe, including the reconstructed data, are moved to reserved space (overprovisioned area).
- ▶ Subsequent requests for data in the affected stripe are directed to the new locations (now part of the normal storage area in the system).

The original location of the affected stripe is added to the available overprovisioned area as a (n-1) + parity stripe. (For example, if the affected stripe was a 9+1 stripe, it becomes an 8+1 stripe.)

No system-level rebuild process is necessary to maintain data protection or usable capacity after a failure is detected by Variable Stripe RAID. The entire Variable Stripe RAID recovery process is automatic and transparent to the user and administrator, and typically takes place in less than a second.

Variable Stripe RAID activities are not normally tracked in system logs, but the root causes of failures that are typically handled by Variable Stripe RAID plane failures and block failures are tracked in system counters and reflected in the overall IBM FlashCore Module and system health metrics.

RAID configurations

The IBM FlashSystem 9100 system supports various RAID and DRAID configurations as follows:

- ▶ IBM FlashSystem 9100 Control Enclosure
 - IBM FlashCore Modules: DRAID 6 (recommended) and DRAID5 (supported).
 - Industry-standard NVMe drives: RAID 10 and DRAID 6 (recommended) and DRAID 5 (supported).
- ▶ IBM FlashSystem 9100 Expansion Enclosure:
 - SAS SSD flash drives: RAID 0, 1, and 10 and DRAID 6 (recommended), and DRAID 5 (supported).

Summary of supported array types and RAID levels

IBM FlashSystem 9100 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 10 summarizes the supported drives, array types, and RAID levels. For all types of drives, DRAID 6 is recommended.

The IBM FlashSystem 9100 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 10 Summary of supported drives, array types, and RAID levels

Supported drives	Non-distributed arrays (RAID)					Distributed arrays (DRAID)	
	RAID 0	RAID 1	RAID 5	RAID 6	RAID 10	RAID 5	RAID 6
Industry-standard NVMe drives or SAS SSD drives (expansion enclosure)	X	X			X	X	X
IBM FlashCore Module NVMe drives						X	X

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

Network cables and uninterruptible power supply features

IBM FlashSystem 9100 Control Enclosure supports various network cables and uninterruptible power supply (UPS) features. For more information, see [Family 9848+03 IBM FlashSystem 9100](#) or contact your IBM Sales Representative.

Encryption

IBM FlashSystem 9100 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 itself 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 9100 system requires the following feature codes:

- ▶ Encryption Enablement (#ACE7)

This feature enables the encryption function. A single instance of this feature enables the function on the entire IBM FlashSystem 9100 system (IBM FlashSystem 9100 Control Enclosure and all attached IBM FlashSystem 9100 Expansion Enclosures) and on externally virtualized storage subsystems.

USB flash drives (#ACEA) or IBM SKLM 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 SKLM is used for encryption keys management, a total of three USB flash drives are required per IBM FlashSystem 9100 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 9100 system, resulting 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. Encrypted volumes are transparent to applications, easing implementation and operation. In addition, the IBM FlashSystem 9100 system has the following functions:

- ▶ Hot Encryption Activation: Adding an encryption license to a previously initialized system
- ▶ Encryption Rekey: Changing the encryption key on a previously initialized system

Both operations can be done concurrently, and do not cause loss of access to data. Both operations require that you purchase Encryption Enablement Pack (#ACE7).

Self-encrypting drives

The IBM FlashCore Module NVMe and NVMe SSD type drives in the IBM FlashSystem 9100 Control Enclosure are self-encrypting drives (SEDs). With SEDs, you can encrypt the data on the drive within the hardware.

Here are some features for these types of flash drives:

- ▶ Encryption of data is done in the electrical circuit of the drive, so it is not impacted 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 whole device to factory settings.
- ▶ Support 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 boot time to unlock and allow I/O operations.
- ▶ SEDs are manufactured to comply with FIPS 140-2.

Combining system encryption with self-encrypting drives

Consider the following items:

- ▶ SEDs are always encrypting, and you cannot stop them from doing so.
- ▶ You can use SEDs without enabling encryption on the system, but SEDs are unlocked by default unless configured with extra protection.
- ▶ With system encryption in IBM Spectrum Virtualize, you can use USB flash drives or IBM SKLM to manage access to encrypted objects on the system.
- ▶ Software in the OS 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 either the USB or IBM SKLM type encryption, or a mixture of both.

Transparent cloud tiering and encryption

The following consideration apply to transparent cloud tiering 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 may 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 transparent cloud tiering data is supported only from systems whose backup data was created at V7.8.0.1 or later.
- ▶ Transparent cloud tiering uses Sig V2 when connecting to Amazon regions, and does not currently support regions that require Sig V4.

For more information, see [IBM Knowledge Center - Encryption](#).

System management and the browser interface

The IBM FlashSystem 9100 system introduces an improved GUI with the same look and feel as other IBM FlashSystem solutions for a consistent management experience across all platforms. The GUI has an improved overview dashboard that provides all information in an easy-to-understand format and allows visualization of effective capacity.

Figure 20 on page 47 shows the IBM FlashSystem 9100 dashboard view. This is the default view that is displayed after the user logs on to the IBM FlashSystem 9100 system.

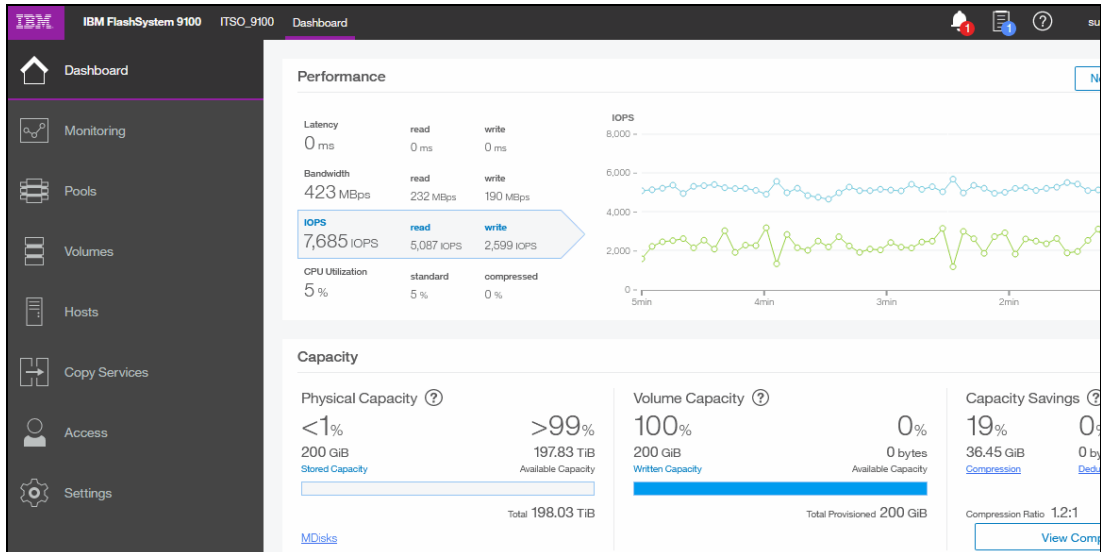


Figure 20 IBM FlashSystem 9100 Control Enclosure Dashboard view

In Figure 21, the GUI shows one IBM FlashSystem 9100 Control Enclosure. This is the System Overview window.

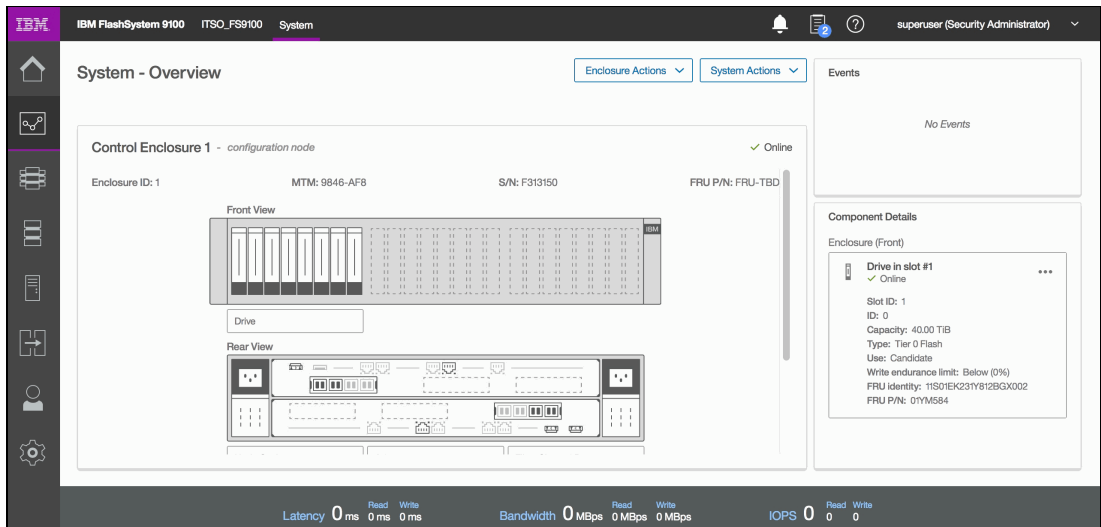


Figure 21 IBM FlashSystem 9100 Control Enclosure System Overview

The IBM FlashSystem 9100 system includes a CLI, which is useful for scripting, and an intuitive GUI for simple and familiar management of the product. The IBM FlashSystem 9100 system supports Simple Network Management Protocol (SNMP), email forwarding that uses Simple Mail Transfer Protocol (SMTP), and syslog redirection for complete enterprise management access.

With the GUI you can quickly deploy storage and manage it efficiently. The GUI runs on the IBM FlashSystem 9100 Control Enclosure, so there is no need for a separate console. Point your web browser to the system IP address, and then you can manage all of the expansion enclosures from one place.

Note: IBM Storage Mobile Dashboard V1.5.6 and later supports the IBM FlashSystem 9100 GUI. You can download the dashboard at no cost from [iTunes](#).

The IBM FlashSystem 9100 Control Enclosure node canisters are configured for active-passive redundancy. The node canisters run a highly customized Linux -based OS 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. With 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 9100 system beyond a web browser or a standard SSH client.

Supported platforms

The IBM FlashSystem 9100 system has extensive interoperability with support for a wide range of OSs (Microsoft Windows Server 2008 and 2012, Linux, and IBM AIX®, and IBM i), hardware platforms (IBM System x, IBM Power Systems™, and x86 servers not from IBM), host bus adapters (HBAs), and SAN fabrics. For more information, see the [IBM System Storage Interoperation Center \(SSIC\)](#).

Physical and electrical specifications

Specifications for the control and expansion enclosures are listed in the following sections.

IBM FlashSystem 9100 Control Enclosure (9846 and 9848 AF7, AF8, UK7, and UF8)

The IBM FlashSystem 9100 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 degrees C (41 - 95 degrees F) 0 - 3048 m (0 - 10,000 ft). Above 900 m, de-rate maximum air temperature 1 degree per 300 m.
 - Nonoperating: 1 - 50 degrees C (34 - 122 degrees 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 9100 SFF Expansion Enclosure (9846 and 9848 Model AFF)

The IBM FlashSystem 9100 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 degrees C (41 - 95 degrees F) 0 - 3048 m (0 - 10,000 ft). Above 900 m, de-rate maximum air temperature 1 degree per 175 m.
 - Nonoperating: 1 - 50 degrees C (34 - 122 degrees 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 9100 LFF Expansion Enclosure (9846 and 9848 Model A9F)

The IBM FlashSystem 9100 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 degrees C (41 - 95 degrees F) 0 - 3048 m (0 - 10,000 ft). Above 900 m, de-rate maximum air temperature 1 degree per 300 m.
 - Nonoperating: 1 - 50 degrees 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 the 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 9100 systems have IBM FlashSystem 9100 Software V8.2 or later preinstalled. Here are the product numbers for the base licenses for each model of the IBM FlashSystem 9100 system:

- ▶ IBM Spectrum Virtualize Software for IBM FlashSystem 9110 Controller V8.2.0 (5639-FA2)

IBM Spectrum Virtualize Software for IBM FlashSystem 9110 Controller (5639-FA2) requires at least one IBM FlashSystem 9110 control enclosure (9846-AF7 or 9848-AF7) for installation.
- ▶ IBM Spectrum Virtualize Software for IBM FlashSystem 9150 Controller V8.2.0 (5639-FA3)

IBM Spectrum Virtualize Software for IBM FlashSystem 9150 Controller (5639-FA3) requires at least one IBM FlashSystem 9150 control enclosure (9846-AF8 or 9848-AF8) for installation.
- ▶ IBM Spectrum Virtualize Software for IBM FlashSystem 9100 Expansions V8.2.0 (5639-FA1)

IBM Spectrum Virtualize Software for IBM FlashSystem 9100 Expansions (5639-FA1) requires at least one IBM FlashSystem 9100 Expansion Enclosure (9846-AFF, 9846-A9F, 9848-AFF, or 9848-A9F) for installation.

The high-density enclosures (9846-A9F and 9848-A9F) require four of the base software charge codes to support the number of drive slots in the system.

The base license that is provided with the system includes its basic functions. However, there are also extra licenses that can be purchased to expand the capabilities of your system. Administrators are responsible for purchasing extra licenses and configuring the systems within the license agreement, which includes configuring the settings of each licensed function on the system.

The base license entitles the system (machine types 9846 and 9848 models AF7, AF8, AFF, and A9F) to all the licensed functions:

- ▶ Thin-provisioning
- ▶ Deduplication
- ▶ Compression
- ▶ FlashCopy
- ▶ IBM Easy Tier
- ▶ Remote mirroring (for internal storage)
- ▶ Data migration

However, some functions require more licenses if you are virtualizing external storage. These can be one or more of the following licenses:

- ▶ Spectrum Virtualize for SAN Volume Controller - PID 5641-VC8
- ▶ IBM Virtual Storage Center - PID 5648-AE1

Figure 22 shows a summary of the licenses that are applicable to the IBM FlashSystem 9100 Control Enclosure.

	FlashSystem 9100 SW	Control or Control Select	FS9100 SW plus VSC or VSC for Storwize
External Virtualization	See EXTERNAL Virtualization	See EXTERNAL Virtualization	See EXTERNAL Virtualization
Volume Migrations	✓	requires separate product	✓
Thin Provisioning	✓	requires separate product	✓
Easy Tier	✓	requires separate product	✓
FlashCopy	✓	requires separate product	✓
Remote Mirroring	✓	requires separate product	✓
RtC Compression	N/A	requires separate product	N/A
Encryption	⊕ HW license key add on	requires separate product	⊕ HW license key add on
Data Reduction Pool Compression	✓	requires separate product	✓
Deduplication	✓	requires separate product	✓
Performance Troubleshooting / Reports	requires separate product	✓ Standard/Advanced	✓
Replication Management	requires separate product	✓ Standard/Advanced	✓
Device Relationship Views	requires separate product	✓ Standard/Advanced	✓
Capacity Reporting (Application/Dept.)	requires separate product	✓ Standard/Advanced	✓
Storage Provisioning	requires separate product	✓ Advanced Only	✓
Storage Service Classes	requires separate product	✓ Advanced Only	✓
Volume Tiering-Tiered Storage Optimizer	requires separate product	✓ Advanced Only	✓
Volume Transformation	requires separate product	✓ Advanced Only	✓
Application Aware FlashCopy	requires separate product	✓ Advanced Only	✓

Note: All INTERNAL enclosures in the FS9100 require a license
VSC and VSC for Storwize can be licensed against the INTERNAL enclosures however that is not the most cost effective option

Figure 22 Summary of the IBM FlashSystem 9100 Control Enclosure licenses

Any connected storage that is not an IBM FlashSystem 9100 Control Enclosure requires the External Virtualization license per storage capacity unit (SCU) based on the tier of storage that is available on the external storage system. In addition, if you are using FlashCopy and Remote Mirroring on an external storage system, you must purchase a per-terabyte license to use these functions.

To set these licenses, use either the Licensed Function page in the System Setup wizard, or if you are adding these licenses to an existing system, select **Settings** → **System** → **Licensed Function** in the management GUI. You can also use the `ch1 license` command to update current license settings on the system.

Figure 23 shows a summary of the IBM FlashSystem 9100 external licenses that are required.


	FS9100 Licensing Options – <u>EXTERNAL Virtualization</u> FS9100 requires Virtualize or VSC for all External Virtualization SCUs		
	Spectrum Virtualize (SVC SW)	Control or Control Select	VSC
External Virtualization	✓	requires separate product	✓
Volume Migrations	✓	requires separate product	✓
Thin Provisioning	✓	requires separate product	✓
Easy Tier	✓	requires separate product	✓
FlashCopy	✓ Controlled by FS9100	requires separate product	✓
Remote Mirroring	✓ Controlled by FS9100	requires separate product	✓
RtC Compression	N/A	requires separate product	N/A
Encryption	✓ Controlled by FS9100	requires separate product	✓ Controlled by FS9100
Data Reduction Pool Compression	✓	requires separate product	✓
Deduplication	✓	requires separate product	✓
Performance Troubleshooting / Reports	requires separate product	✓ Standard/Advanced	✓
Replication Management	requires separate product	✓ Standard/Advanced	✓
Device Relationship Views	requires separate product	✓ Standard/Advanced	✓
Capacity Reporting (Application/Dept.)	requires separate product	✓ Standard/Advanced	✓
Storage Provisioning	requires separate product	✓ Advanced Only	✓
Storage Service Classes	requires separate product	✓ Advanced Only	✓
Volume Tiering-Tiered Storage Optimizer	requires separate product	✓ Advanced Only	✓
Volume Transformation	requires separate product	✓ Advanced Only	✓
Application Aware FlashCopy	requires separate product	✓ Advanced Only	✓

Figure 23 IBM FlashSystem 9100 external licenses summary

The system supports differential and capacity-based licensing. For external virtualization, differential licensing uses different pricing rates for different types of storage to provide cost-effective management of capacity across multiple tiers of storage. Licensing for these functions is based on the number of SCUs that is purchased.

For other licensed functions, the system supports capacity-based licensing per enclosure. The system supports the following licensed functionality. The IBM FlashSystem 9100 system uses IBM Spectrum Virtualize SDS features.

- ▶ IBM FlashSystem 9100 Models AF7 and AF8 support external virtualization. You are entitled to use external virtualization capability by acquiring IBM Spectrum Virtualize Software for SAN Volume Controller (SW PID 5641-VC8 in AAS and SW PID 5725-M19 in IBM Passport Advantage®).
- ▶ IBM FlashSystem 9100 Models AF7 and AF8 require IBM Multi-Cloud starter software for the IBM FlashSystem 9100 system (SW PIDs 5639-MC4, 5639-MC5, and 5639-MC6).
- ▶ IBM FlashSystem 9100 3-year warranty machines (machine type 9848) require the ECS administrative software indicator (5773-FLH).

With the IBM FlashSystem 9100 system, there is also a licensed feature code for hardware assisted encryption if it purchased (Encryption Enablement Pack (#ACE7)). This feature code is needed if you want to use USB-Key encryption, SKLM-based encryption, or both on the control enclosure.

For more information about the hardware requirements and compatibility information, see [SSIC](#).

5639-FA2 and 5639-FA3 Base Software licensed features and functions

The following functions are provided with the IBM FlashSystem Family Software for IBM FlashSystem 9100 V8.2 Base Software:

- ▶ Thin-provisioning: Helps improve efficiency by allocating disk storage space in a flexible manner among multiple users, based on the minimum space that is required by each user at any time.
- ▶ Data migration: Enables easy and nondisruptive moves of volumes from another storage system on to the IBM FlashSystem 9100 system by using FC connectivity. Dynamic migration helps reduce data migrations from weeks or months to days, eliminating the cost of add-on migration tools, and provides continuous availability of applications by eliminating downtime.
- ▶ Simple GUI: Simplified management with the intuitive GUI enables storage to be quickly deployed and efficiently managed. The GUI runs on the IBM FlashSystem 9100 system, so having a separate console is unnecessary. Point your web browser to the control enclosure and expansion enclosure.
- ▶ Easy Tier technology: This feature provides a mechanism to seamlessly migrate data to the most appropriate tier within the IBM FlashSystem 9100 system. This migration can be to the internal flash memory within IBM FlashSystem 9100 Expansion Enclosure, or to external storage systems that are virtualized by IBM FlashSystem 9100 Control Enclosure. Easy Tier is useful for cost-effective expansion and usage of your existing storage capacity investment.

Easy Tier supports up to three tiers of storage. For example, you can set up a storage pool that is intended for Easy Tier volumes where the pool is composed of the IBM FlashSystem 9100 Expansion Enclosures, SSD flash drives, and high-capacity, NLS drives.

- ▶ Automatic restriping of data across storage pools: When growing a storage pool by adding more storage to it, IBM FlashSystem 9100 Software can restripe your data on pools of storage without having to implement any manual or scripting steps. This process helps grow storage environments more easily while retaining the performance benefits of striping the data across the disk systems in a storage pool.

- ▶ **FlashCopy:** Provides a volume-level, point-in-time copy function for any storage that is virtualized by the IBM FlashSystem 9100 system. With FlashCopy and snapshot functions, you can create copies of data for backup, parallel processing, testing, and development, and have the copies available almost immediately.
- ▶ **Encryption:** The system provides optional encryption of data at rest, which protects against the potential exposure of sensitive user data and user metadata that is stored on discarded, lost, or stolen storage devices. Encryption can be activated only on enclosures that support encryption.
- ▶ The Encryption Enablement (#ACE7) feature enables the encryption function. A single instance of this feature enables the function on the entire IBM FlashSystem 9100 system (IBM FlashSystem 9100 Control Enclosure and all attached IBM FlashSystem 9100 Expansion Enclosures) and on externally virtualized storage subsystems.
- ▶ USB flash drives (#ACEA) or IBM SKLM are required for encryption key management. The Encryption USB Flash Drives (Four Pack) (#ACEA) feature provides four USB flash drives for storing the encryption master access key. Unless IBM SKLM is used for encryption keys management, a total of three USB flash drives are required per IBM FlashSystem 9100 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 9100 system, resulting in a shipment of four USB flash drives.
- ▶ **Data Reduction Pool Compression:** Helps improve efficiency by compressing data by as much as 80%, enabling storage of up to 5x as much data in the same physical space. Unlike other approaches to compression, Data Reduction Pool Compression is used with active primary data, such as production databases and email systems, dramatically expanding the range of candidate data that can benefit from compression.
- ▶ **Remote mirroring:** Provides storage-system-based data replication by using either synchronous or asynchronous data transfers over FC communication links:
 - Metro Mirror maintains a fully synchronized copy at metropolitan distances (up to 300 km).
 - Global Mirror operates asynchronously, and maintains a copy at much greater distances (up to 250 milliseconds round-trip time when using FC connections).

Both functions support VMware Site Recovery Manager to help speed DR. IBM FlashSystem 9100 remote mirroring interoperates with other IBM FlashSystem 9100, IBM FlashSystem V840, SAN Volume Controller, and IBM Storwize® V7000 storage systems.

Optional licensed features

All externally virtualized storage that is not part of the IBM FlashSystem 9100 machine types and that do not have a 5639-FA2 or 5639-FA3 license require a SCU license. For more information about IBM Spectrum Virtualize licensing, see [5641-VC8 IBM Spectrum Virtualize Software for SAN Volume Controller V8.x](#).

A storage system that is only used as a quorum device does not need a software license.

The 5641-VC8 (External Virtualization, FlashCopy, and Remote Mirroring Features) and 5641-CP8 (Compression) licenses are licensed per enterprise within one country. These are the same licenses as for IBM SAN Volume Controller. Therefore, existing SAN Volume Controller licenses can be used for the IBM FlashSystem 9100 system for these features.

Table 11 lists the software license descriptions. For more information, see [IBM Spectrum Virtualized Software V8.2](#). This announcement contains the feature codes that are used for Version 8.2.

Table 11 Base and optional software licenses

Program number or product ID	License type	Name or feature description
5639-FA2	Base	IBM FlashSystem Family Software for IBM FlashSystem 9100 V8 Base Software V8.2 for 9110 Model AF7 and UF7.
5639-FA3	Base	IBM FlashSystem Family Software for IBM FlashSystem 9100 V8 Base Software V8.2 for Model 9150 Model AF8 and UF8.
5639-FA1	Optional	IBM Spectrum Virtualize Software for IBM FlashSystem 9100 V8 Expansions V8.2.
5641-VC8	Optional	IBM Spectrum Virtualize Software for SAN Volume Controller V8, per SCU.
5641-VC8	Optional	IBM Spectrum Virtualize FlashCopy Software, per SCU.
5641-VC8	Optional	IBM Spectrum Virtualize Metro/Global Mirror Software, per SCU.
5648-AE1	Optional	IBM Virtual Storage Center can be used for all IBM FlashSystem 9100 attached storage, and it can be combined with 5608-ACL.

Note: When An IBM FlashSystem 9100 Control Enclosure model 9846 or 9848 is used as the hardware virtualization engine to control external virtualized storage, the IBM Spectrum Virtualize Software for IBM FlashSystem 9100 V8 Expansion V8.2 can be used, which uses a SCU pricing model. All other capacity that is managed and virtualized by the IBM FlashSystem 9100 system must be licensed with Virtual Storage Center (standard), 5648-AE1, license (priced per SCU). All required base software licenses for the IBM FlashSystem 9100 system must also be purchased.

How to count and order licenses

The information in this section helps you understand the planning of base and optional licensing features, and how to calculate and determine the software licenses to order for your environment.

Figure 24 shows the base and the optional software licenses that can be ordered for the IBM FlashSystem 9100 system. It also shows a color key for each software license that maps to the licenses that are used in the examples in the following sections.

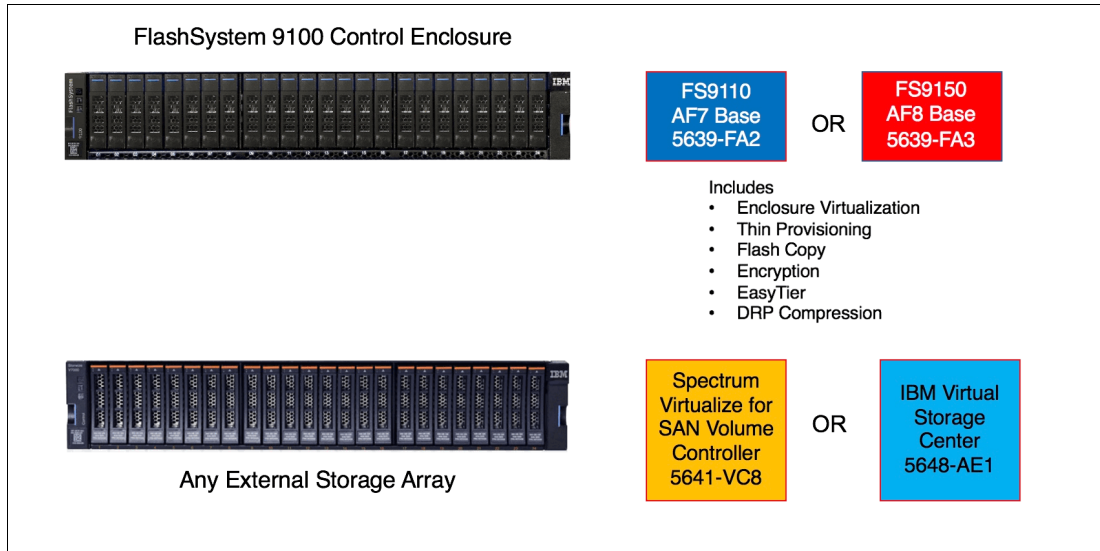


Figure 24 IBM FlashSystem 9100 licensing options

IBM Spectrum Virtualize Differential Licensing

IBM Spectrum Virtualize Differential Licensing is used to calculate the license that is needed for a configuration. With IBM Spectrum Virtualize Differential Licensing, licenses change from per terabyte to per SCU.

Note: SCUs are needed only for virtualized storage that does not have the 5639-FA2 or FA3 base license.

SCU is defined in terms of the category of the storage capacity:

- ▶ Category 1: Flash and SSD flash drives
- ▶ Category 2: SAS drives, FC drives, and systems that use drives with advanced architectures to deliver high-end storage performance
- ▶ Category 3: Nearline SAS (NL-SAS)

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

For each SCU, the following number of terabytes (TB) by storage classification applies:

- ▶ One SCU equates to 1.00 TB usable of Category 1.
- ▶ One SCU equates to 1.18 TB usable of Category 2.
- ▶ One SCU equates to 4.00 TB usable of Category 3.

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 SAS drives, and 2400 TB nearline capacity.

Table 12 Example of calculating SCUs

Category	Type	Capacity	Rule	# of SCUs
Category 1	SSD	30	/ 1	30
Category 2	SAS	200	/ 1.18	170
Category 3	Nearline	2400	/ 4	600
Total				800

800 SCUs are required for the example in Table 12. When you calculate the number of SCUs per category, fractions must be rounded up to the next higher integer number.

For the IBM Spectrum Virtualize Real-time Compression for external storage software license, enough SCUs are required to cover actual managed disk capacity that is used by the compressed volumes.

FlashCopy and Remote Replication licensing are unchanged and remain based on the virtual disk capacity.

For more information about IBM Spectrum Virtualize Differential Licensing, see [IBM Knowledge Center - Licensing](#).

Licensing examples

The following sections show a selection of licensing examples.

Example 1: IBM FlashSystem 9100 order consisting of one control enclosure

An IBM FlashSystem 9100 order consisting of one control enclosure requires one IBM FlashSystem 9100 Base Software license. No SCUs are required. Figure 25 shows the IBM FlashSystem 9100 Base Software license.

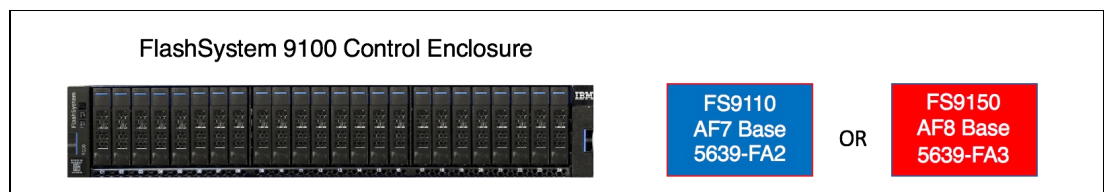


Figure 25 IBM FlashSystem 9100 Base Software license with one control enclosure

Example 2: IBM FlashSystem 9100 order consisting of two control enclosures and one expansion enclosure

An IBM FlashSystem 9100 order consisting of two control enclosures and one expansion enclosure Model AFF requires three IBM FlashSystem 9100 Base Software licenses. No SCUs are required.

Figure 26 illustrates the IBM FlashSystem 9100 Base Software license with two control enclosures and one model AFF.

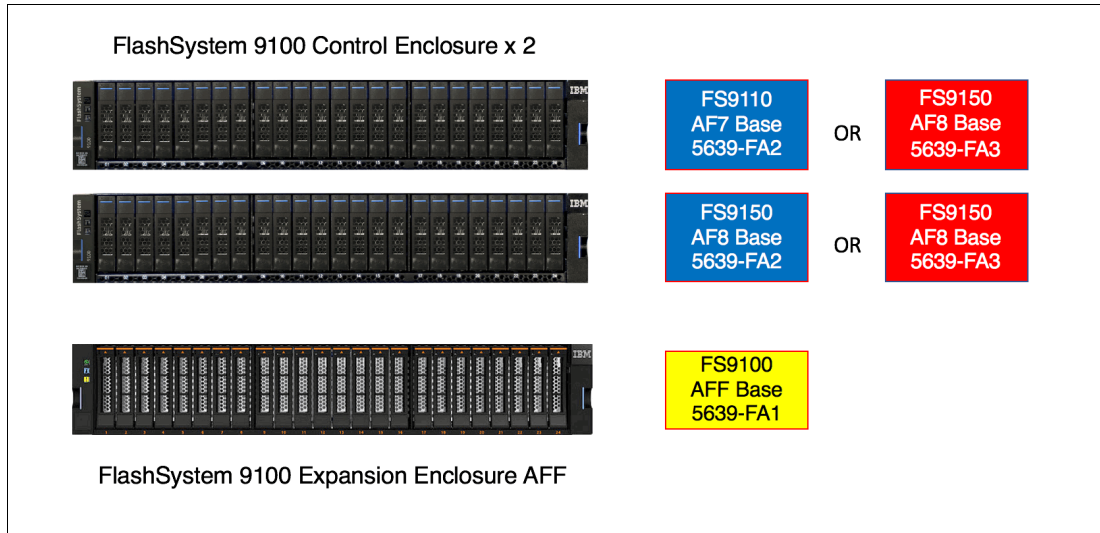


Figure 26 IBM FlashSystem 9100 Base Software license with two control enclosures and one AFF expansion enclosure

Example 3: IBM FlashSystem 9100 order consisting of two control enclosures and one expansion enclosure

An IBM FlashSystem 9100 order consisting of two control enclosure model A9F requires six IBM FlashSystem 9100 Base Software licenses. No SCUs are required. Figure 27 illustrates the IBM FlashSystem 9100 Base Software license with one additional expansion enclosure model A9F High-Density Enclosure that requires four licenses.

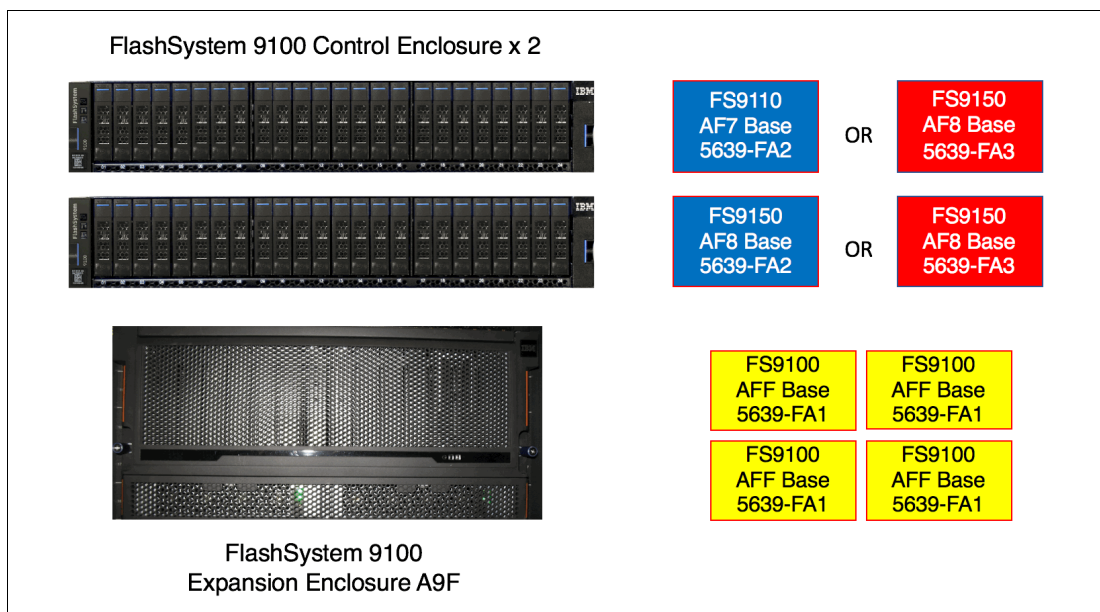


Figure 27 IBM FlashSystem 9100 Base License with two Control enclosures and one A9F expansion enclosure

IBM Spectrum Virtualize External Virtualization Software (5641-VC8)

IBM FlashSystem 9100 Models AF7 and AF8 support external 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).

To authorize the usage of this function, you must license the IBM Spectrum Virtualize Software External Virtualization feature code on IBM FlashSystem 9100 Expansion Enclosures (9846-AF7, 9848-AF7, 9846-AF8, and 9848-AF8). Models 9846-AFF, 9848-AFF, 9846-A9F, and 9848-A9F are not considered externally attached expansion enclosures, and do not require separate licenses.

The IBM Spectrum Virtualize External Virtualization feature is an optional feature only for external storage, and is priced per SCU.

Example 4: IBM FlashSystem 9100 system virtualizing a Storwize V7000 system with flash drives

For an IBM FlashSystem 9100 system to virtualize a Storwize V7000 system with 10 TB SSD flash drives, 40 TB SAS drives, and 50 TB nearline capacity, a quantity of one IBM FlashSystem 9100 Base Software license and one 5641-VC8 (IBM Spectrum Virtualize External Virtualization) are required. Fifty-seven SCUs are required for external virtualization. Figure 28 illustrates this configuration.

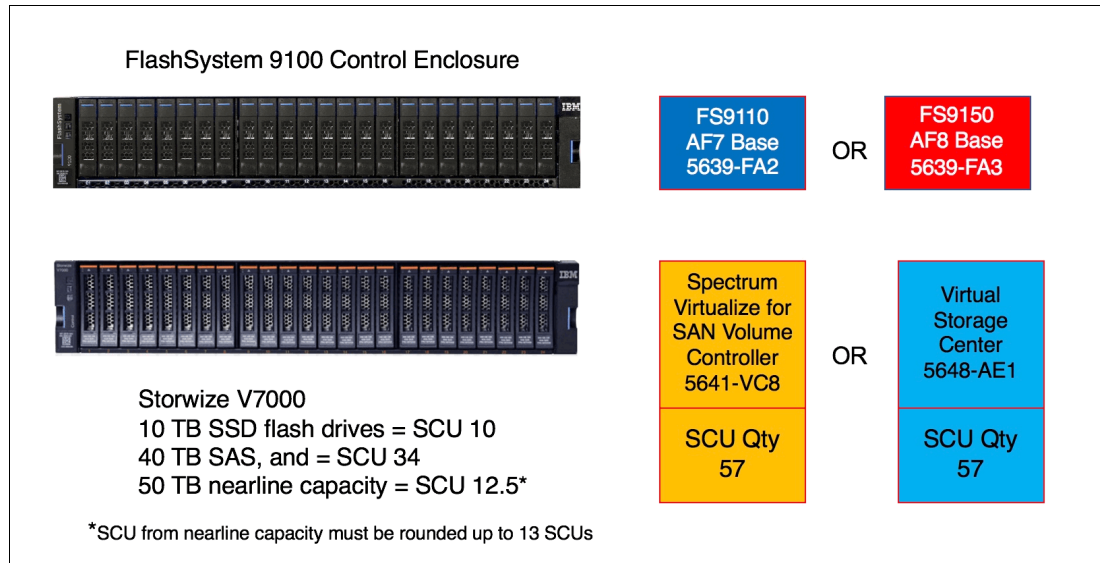


Figure 28 IBM FlashSystem 9100 system with an IBM Spectrum Virtualize External Virtualization license

In the example in Figure 28, The 12.5 SCUs for nearline capacity must be rounded up to 13 SCUs.

Compression for external storage

The base license for the IBM FlashSystem 9100 system includes the Data Reduction Pool compression licensing for the base control enclosure and any additional external storage arrays that you might want to compress the data on by using the new Data Reduction Pool compression mechanism.

You do not need to purchase an additional compression license. The only extra charge is based on the SCU calculations of the compressed amount of storage that is used.

Example 5: IBM FlashSystem 9100 system virtualizing a Storwize V7000 system with physical SAS disk

An IBM FlashSystem 9100 system virtualizing a Storwize V7000 system with 50 TB of physical SAS disk storage and 100 TB of uncompressed volumes requires one IBM FlashSystem 9100 Base Software license and one 5641-VC8 (External Virtualization license). You must also add a charge for the 43 SCUs that are required for external virtualization.

You can select IBM Virtual Storage Center (5648-AE1) instead of SAN Volume Controller (5641-VC8).

Note: This compression amount is only to demonstrate that the new compression charging model is included in the base IBM FlashSystem 9100 license. The compression ratio of volumes depends on data types and other factors, and might achieve this level of compression.

Figure 29 illustrates this configuration.

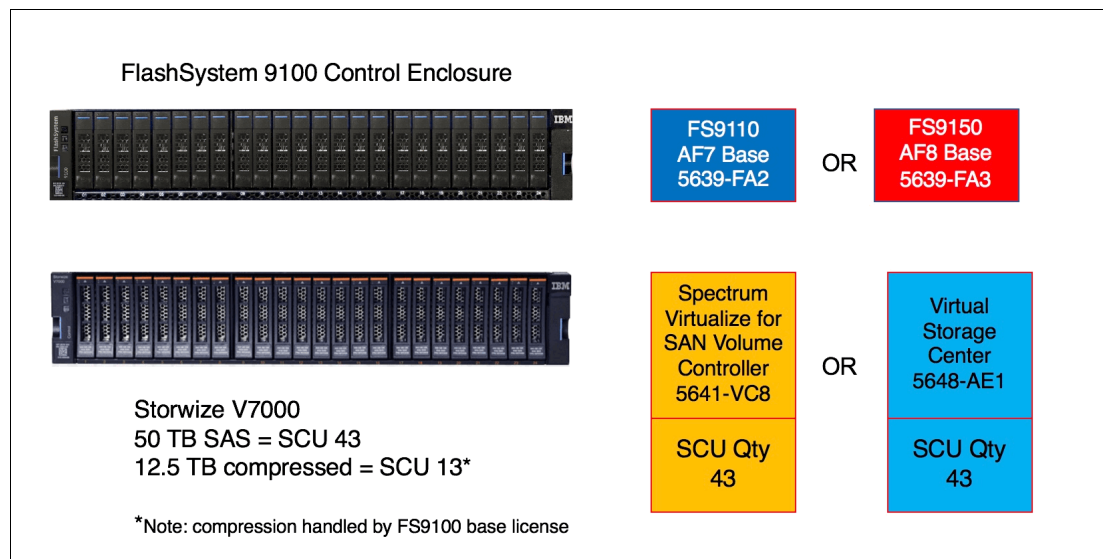


Figure 29 IBM FlashSystem 9100 system with External Virtualization and Compression license

IBM Spectrum Virtualize Remote Mirroring Software for external storage (5641-VC8)

To authorize the use of the Remote Mirroring Software capabilities of the IBM FlashSystem 9100 system for external storage, you do not need an external storage license; it is included in the IBM FlashSystem 9100 base license.

The IBM Spectrum Virtualize SAN Volume Controller 5641-VC8 for external storage license is a priced optional feature for external storage only. It is priced per SCU capacity in terabytes (TB).

Example 6: IBM FlashSystem 9100 system virtualizing a Storwize V7000 system with 100 TB SAS-disk storage and mirroring

An IBM FlashSystem 9100 system virtualizing a Storwize V7000 system with 100 TB SAS disk storage and mirroring it to a second IBM FlashSystem 9100 system with an IBM XIV® system with 100 TB requires two IBM FlashSystem 9100 Base Software licenses and two 5641-VC8 (External Virtualization license) or two 5648-AE1 (Virtual Storage Center) of 85 TB each. Figure 30 illustrates this configuration.

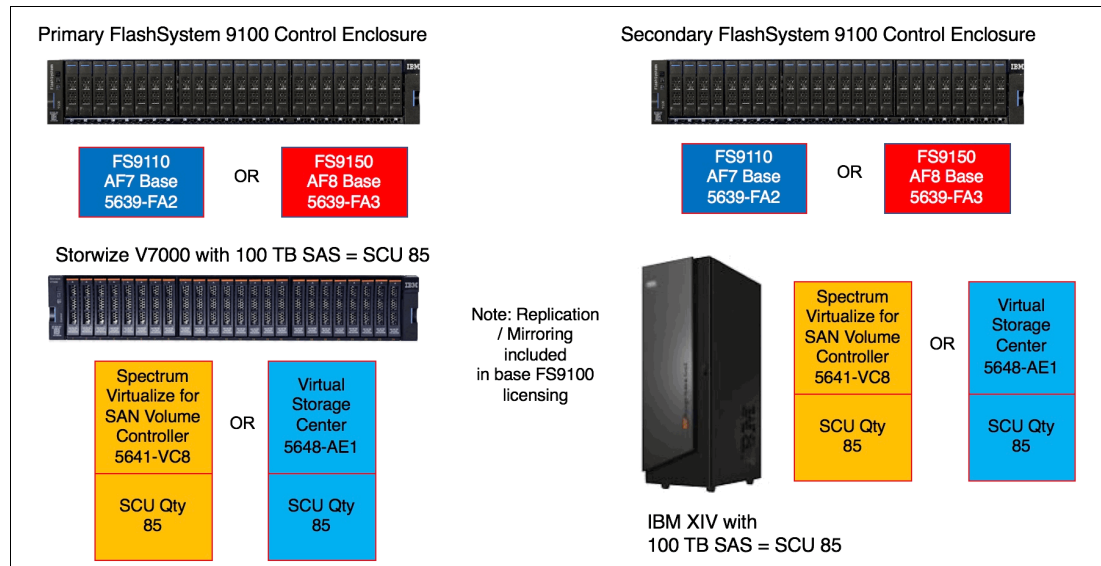


Figure 30 IBM FlashSystem 9100 system with External Virtualization and Remote Mirror license

IBM Spectrum Virtualize FlashCopy for External Storage (5641-VC8)

To authorize the use of the FlashCopy software capabilities of the IBM FlashSystem 9100 system for external storage, you must purchase the IBM Spectrum Virtualize FlashCopy Software for External Storage license.

The IBM Spectrum Virtualize FlashCopy Software for External Storage license is a priced optional feature for external storage only. It is priced per capacity in terabytes (TB).

Example 7: IBM FlashSystem 9100 system virtualizing a Storwize V7000 system with 50 TB SAS disk capacity and 25 TB FlashCopy volumes

An IBM FlashSystem 9100 system virtualizing a Storwize V7000 system with 50 TB SAS disk capacity and 25 TB FlashCopy volumes requires one IBM FlashSystem 9100 Base Software license and one 5641-VC8 (External Virtualization license). The FlashCopy license for 25 TB is included in the IBM FlashSystem 9100 base license. Forty-three SCUs are required for external virtualization.

Figure 31 illustrates this configuration.

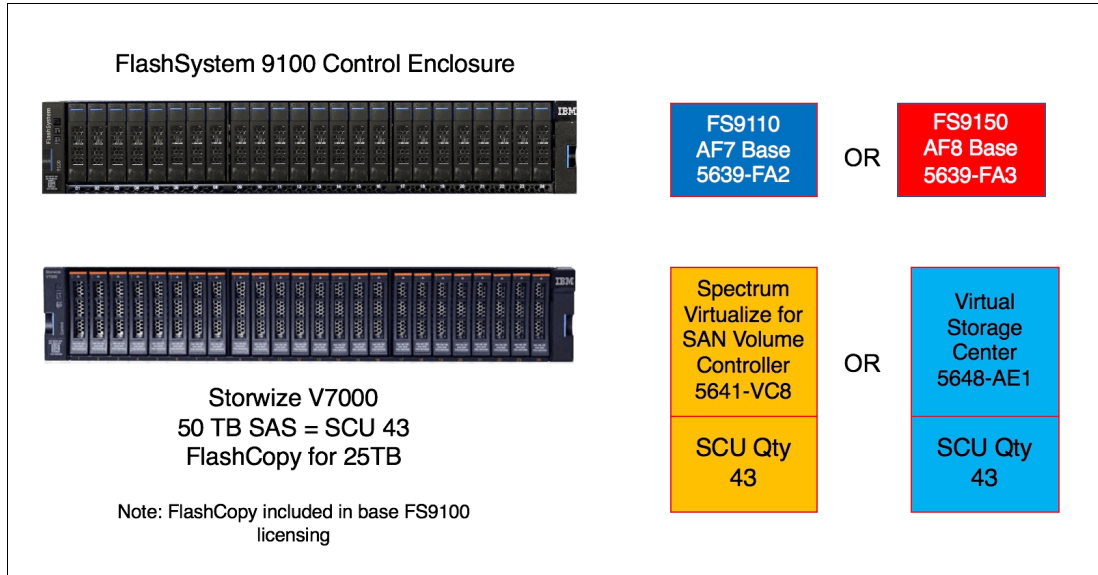


Figure 31 IBM FlashSystem 9100 system with External Virtualization and FlashCopy license

Example 8: IBM FlashSystem 9100 system virtualizing two Storwize V7000 external enclosures each with 50 TB SAS disk capacity

An IBM FlashSystem 9100 system virtualizing two Storwize V7000 external enclosures each with 50 TB SAS disk capacity requires one IBM FlashSystem 9100 Base Software license and one 5641-VC8 (External Virtualization license) or one 5648-AE1 (Virtual Storage Center license). Eighty-six SCUs are required for external virtualization.

Figure 32 illustrates this configuration.

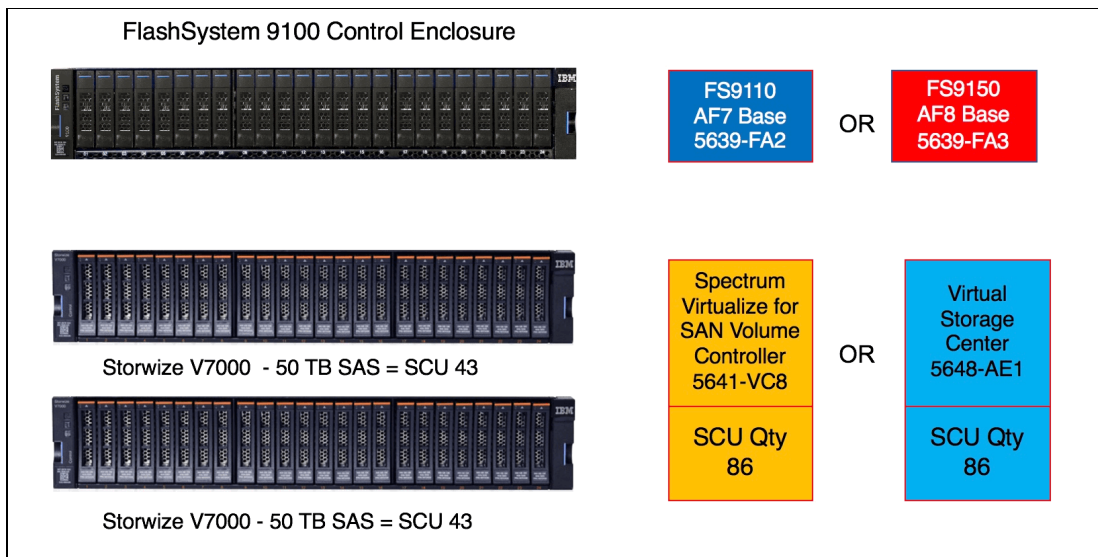


Figure 32 IBM FlashSystem 9100 system with two external enclosures for virtualization

Warranty information

The IBM FlashSystem 9100 system includes a 1-year 24x7 (9846) or a 3-year 24x7 (9848) warranty.

The 7-year 24x7 Support & Endurance warranty includes up to 7 years support for flash media retention offerings. All flash memory is covered for read and write endurance while under warranty or maintenance.

Services

Technical Advisor support is provided during the warranty period for machine type 9848 only. This support enhances end-to-end support for the client's complex IT solutions. The Technical Advisor uses an integrated approach for proactive, coordinated cross-team support so that customers can maximize IT availability.

Technical Advisor support for the IBM FlashSystem 9100 system is delivered remotely. It includes a documented support plan, coordinated problem and crisis management that reports on your hardware inventories and software levels, and consultation about IBM FlashSystem Software updates. The Technical Advisor conducts a Welcome Call with the client, and provides a statement of work for this support.

Optional priced service offerings are available with model 9846.

IBM FlashSystem 9100 Enterprise Class Support

ECS is available only for the IBM FlashSystem 9100 machine type 9848 that is purchased with a 3-year warranty. IBM FlashSystem 9100 machine type 9846 comes with a 1-year warranty and IBM base support.

For more information about this offering, see "IBM FlashSystem 9100 Enterprise Class Support" on page 31.

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Ordering information

For more information about ordering IBM FlashSystem 9100 components, see "IBM FlashSystem 9100 components" on page 30.

For more information about ordering hardware features, see “Options and feature codes” on page 40.

For more information about ordering software licenses, see “Software and licensing” on page 50.

Related information

For more information, see the following documents:

- ▶ *Implementing IBM FlashSystem V9000 - AC3 with Flash Enclosure Model AE3*, SG24-8413
- ▶ *Implementing the IBM Storwize V7000 with IBM Spectrum Virtualize V8.1*, SG24-7938
- ▶ *Implementing the IBM System Storage SAN Volume Controller with IBM Spectrum Virtualize V8.1*, SG24-7933
- ▶ *Introduction and Implementation of Data Reduction Pools and Deduplication*, SG24-8430
- ▶ IBM Knowledge Center - IBM FlashSystem 9100 documentation:
https://www.ibm.com/support/knowledgecenter/en/STSLR9_8.2.0/com.ibm.fs9100_820.doc/fs9100_ichome.html
- ▶ IBM FlashSystem 9100 product page:
<https://www.ibm.com/us-en/marketplace/flashsystem-9100>
- ▶ IBM Offering Information page (announcement letters and sales manuals):
http://www.ibm.com/common/ssi/index.wss?request_locale=en

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