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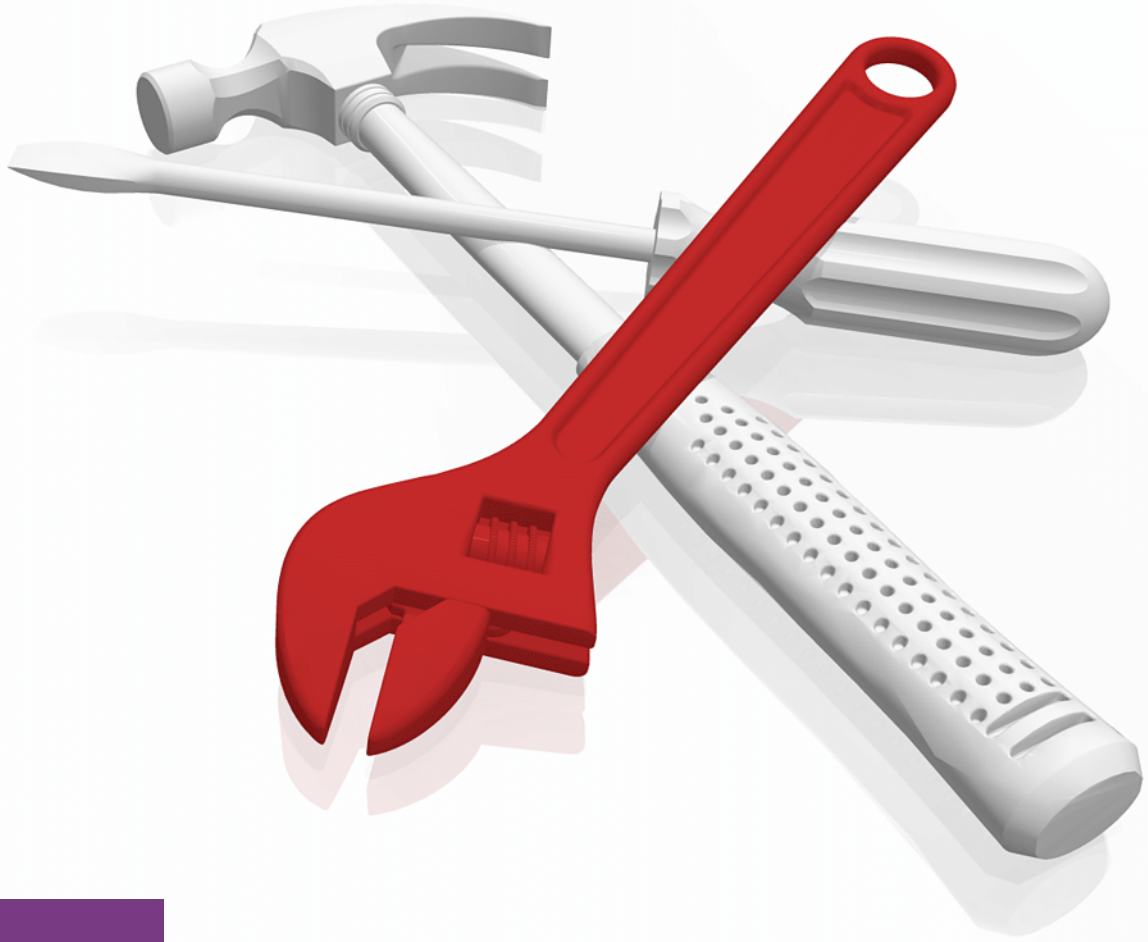
IBM FlashSystem V9000 Version 7.7 Product Guide

Jon Herd

Carsten Larsen



Storage

IBM

Product Guide

IBM FlashSystem V9000 Version 7.7 Product Guide

The success or failure of businesses will likely depend on how well organizations exploit their data assets for competitive advantage. Deeper insights from data require better information technology. As organizations modernize their IT infrastructure to boost innovation rather than limit it, 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, real-time analytics.

Making the right decision on storage investment is critical. Organizations must have enough storage performance and agility to innovate as they need to implement cloud-based IT services, deploy virtual desktop infrastructure, enhance fraud detection and leverage new analytics capabilities. At the same time, future storage investments must lower IT infrastructure costs while helping organizations to derive the greatest possible value from their data assets.

IBM® FlashSystem storage solutions can accelerate the transformation of the modern organizations into a Cognitive Business™. FlashSystem all-flash storage arrays are purpose-engineered to support the organization's active data sets. 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, FlashSystem can be less expensive than conventional enterprise storage solution.

This IBM Redbooks® Product Guide describes IBM FlashSystem® V9000, which is a comprehensive all-flash enterprise storage solution that delivers the full capabilities of IBM FlashCore™ technology. In addition, it provides a rich set of software-defined storage features, including IBM Real-time Compression™, dynamic tiering, thin provisioning, snapshots, cloning, replication, data copy services, and IBM HyperSwap® for high availability.

With the release of FlashSystem V9000 Software V7.7.1, extra functions and features are available, including support for new and more powerful FlashSystem V9000 Control Enclosure Model AC3 and new SAS-based small form factor (SFF) and large form factor (LFF) storage enclosures providing a mixture of nearline hard disk drives (HDDs) and flash mdisks in a pool, which can be used for IBM Easy Tier®.

The new IBM FlashSystem V9000 SFF Expansion Enclosure Model 24F offers new tiering options with low cost solid-state drive (SSD). Up to 20 Serial Attached SCSI (SAS) expansions are supported per FlashSystem V9000 controller pair, providing up to 480 drives with expansion Model 24F and up to 240 drives with expansion Model 12F.

Also new with FlashSystem V9000 Software V7.7.1 is N_Port ID Virtualization (NPIV) support which virtualizes World Wide Port Names (WWPN) for zero path reduction during controller maintenance and outages.

FlashSystem V9000 Software version 7.7.1 replaces version 7.7, and is available to all IBM FlashSystem V9000 customers with current warranty or software maintenance agreements.

Note: For information about IBM FashSystem V9000 version 7.6, see *IBM FashSystem V9000 Version 7.6 Product Guide*, REDP-5317 at
http://www.redbooks.ibm.com/abstracts/redp5317.html?Open

Figure 1 shows the IBM FlashSystem V9000 product.

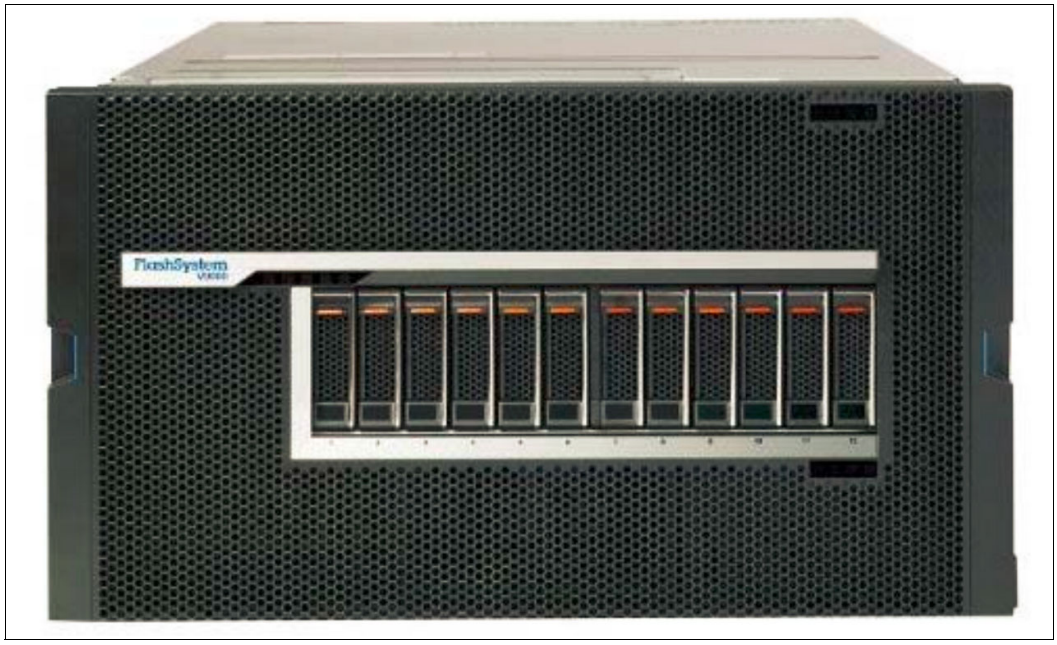


Figure 1 IBM FlashSystem V9000

Did you know?

FlashSystem V9000 version 7.7 provides the following functionality:

- FlashSystem V9000 with IBM FlashCore Technology drives real-time analytical insights with up to 50x faster performance than enterprise disk systems.
- FlashSystem V9000 scales up to 2.5 million input/output operations per second (IOPS) and over 2 petabytes (PB) effective capacity with IBM MicroLatency®, under a single, fully integrated management interface.
- FlashSystem V9000 now supports encryption for externally virtualized storage, even if the supported virtualized array does not have encryption capabilities.
- FlashSystem V9000 with VMware vSphere Virtual Volumes (vVol) support enables more efficient operations and control of external storage resources.
- FlashSystem V9000 with HyperSwap offers simplified setup and management through a graphical user interface (GUI).
- FlashSystem V9000 now incorporates integrated IBM Comprestimator, the key sizing tool to estimate how much capacity savings the client can expect with IBM Real-time Compression.
- FlashSystem V9000 offers new tiering options with low cost SSDs and nearline drives which can be used for Easy Tier.
- FlashSystem V9000 now includes Internet Protocol (IP) quorum base support for lower-cost IP-attached hosts as a quorum disk.
- FlashSystem V9000 supports a new four-port 16 gigabit (Gb) Fibre Channel (FC) host adapter (feature code #AF44).
- FlashSystem V9000 now supports NPIV capable of transparently moving WWPNs between controllers.
- FlashSystem V9000 support with IBM Virtual Storage Center (VSC) includes performance statistics and metrics of monitored storage systems and switches. These reports can be viewed in the VSC web-based GUI or stand-alone GUI. See the IBM Virtual Storage Center IBM Knowledge Center for more information:

  http://ibm.co/1Px9UU6

FlashSystem V9000

FlashSystem V9000 is a rack-mount shared flash memory device that is based on IBM enhanced multi-level cell (MLC) flash technology. It provides the following functionality:

- Macro efficiency with up to 57 terabytes (TB) of protected capacity in a 6U form factor
- Enterprise reliability through IBM Variable Stripe RAID™ and two-dimensional flash Redundant Array of Independent Disks (RAID)
- Extreme performance with MicroLatency
- Optional SAS SFF and LFF storage enclosures providing new tiering options by combining low cost SSDs and nearline drives

FlashSystem V9000 provides advanced data services, including business continuity with replication services, data protection with IBM FlashCopy® services, and higher storage efficiency with thin provisioning, Real-time Compression, IBM Easy Tier, external virtualization, IP quorum support, NPIV support, VMware vSphere Virtual Volumes (vVol)

support and space-efficient copies. The FlashSystem V9000 baseline configuration is composed of the following components:

- Two FlashSystem V9000 control enclosures
- One FlashSystem V9000 flash storage enclosure

Highlights

Easy to deploy and manage, FlashSystem V9000 is designed to accelerate the applications that drive business. Powered by IBM FlashCore Technology, IBM FlashSystem V9000 provides three dimensions of value, as Figure 2 shows:

- Versatile performance
- Enduring economics
- Agile integration

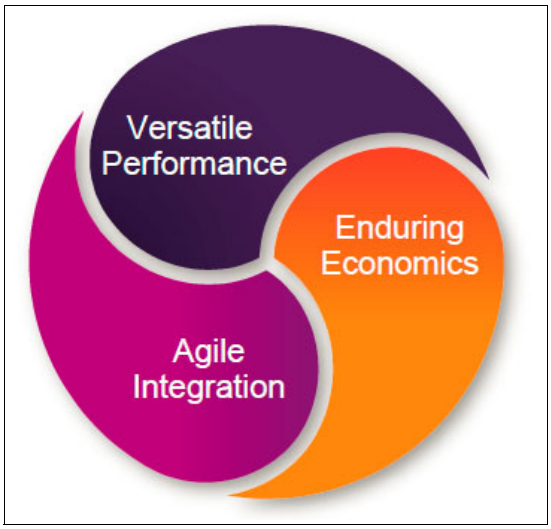


Figure 2 IBM FlashSystem V9000 dimensions of value

Versatile performance

FlashSystem V9000 has the following versatile performance attributes:

- Scale-up or scale-out, independently
- Scalable to 3 million IOPS
- Scalable to 68 Gigabytes per second (GBps) bandwidth
- Sustained IBM MicroLatency
- Quality of service
- Faster applications

Enduring economics

FlashSystem V9000 provides the following enduring economics attributes:

- Scalable to 2.2 PB effective capacity using native flash storage
- Expandable with up to 480 low cost SSDs
- Expandable with up to 240 high capacity nearline drives
- Flash for less than the cost of disk with IBM Real-time Compression
- Low power and cooling requirements

- Virtualized storage
- Flash wear warranty
- Infrastructure continuity with space efficient snapshots, cloning, and replication

Agile integration

FlashSystem V9000 has the following agile characteristics:

- Fully integrated system management
- Application-aware data services
- Advanced Encryption Standard (AES), data at rest encryption
- Tier or mirror to existing storage
- Mixed workload consolidation
- Nondisruptive data migrations
- Concurrent code load

By accelerating applications, both physical and virtual, FlashSystem V9000 can help organizations reduce costs, increase revenue, and improve customer satisfaction for all types of applications, including the following categories:

- Transactional
- Enterprise resource planning and supply chain management (ERP and SCM)
- Big data and analytics
- Server and desktop virtualization
- Cloud

FlashCore Technology

At the heart of FlashSystem V9000 is IBM FlashCore Technology, which consists of these key elements:

- Hardware-accelerated architecture that is engineered for flash, with a hardware-only data path
- IBM MicroLatency modules that are designed for low latency, for density, and for reliability
- IBM advanced flash management that improves MLC flash endurance 9x over standard implementations without sacrificing latency

Figure 3 shows the main components of IBM FlashCore technology.

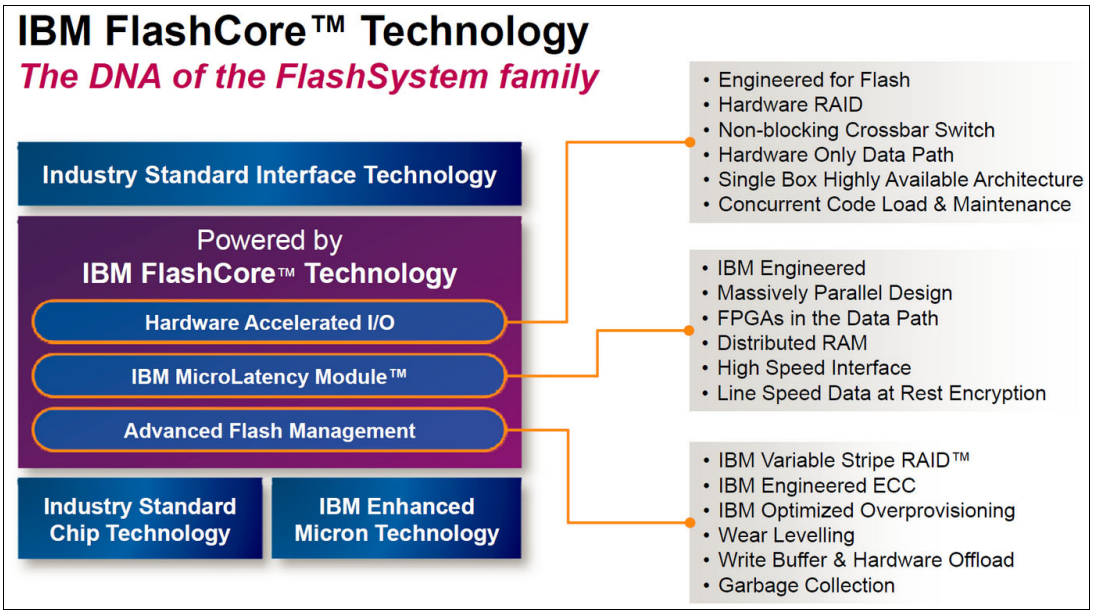


Figure 3 IBM FlashCore technology

To learn more about IBM FlashCore technology, visit the following web page:

http://www.ibm.com/systems/storage/flash/900/technology.html

The IBM FlashSystem Tier 1 Guarantee

The IBM FlashSystem Tier 1 Guarantee provides the following advantages:

Performance IBM MicroLatency performance.

Data reduction Flexible; up to 5:1 storage efficiency savings, based on Compretimator results.

Estimate-free; sight unseen 2:1 guarantee for rapid workload deployment.

Endurance Flash memory will be covered for read/write endurance while you are under warranty or maintenance.

Seven years 24 x 7 support

Up to 7 years support available with optional price protection and flash media retention offerings.

New enterprise class service offerings.

Peace of mind No charge, complimentary IBM services for Tier 1 opportunities.

New IBM FlashCore Forever program; controller upgrade included with 3 year maintenance extension.

Component overview

The FlashSystem V9000 building block is composed of two FlashSystem V9000 control enclosures and one FlashSystem V9000 flash storage enclosure.

FlashSystem V9000 control enclosure

The FlashSystem V9000 control enclosure is a 2U rack mount unit that provides the primary management interface for the FlashSystem V9000 storage enclosure and the host interface configuration. The FlashSystem V9000 control enclosures support FC Protocol (FCP), FC over Ethernet (FCoE), and Internet Small Computer System Interface (iSCSI) interfaces.

The control enclosure includes integrated alternating current (ac) power supplies and battery units, which supply power to the control enclosure during a sudden power loss or failure, to correctly commit all transactions to the storage medium.

IBM FlashSystem V9000 storage enclosure

FlashSystem V9000 storage enclosures are 2U rack-mount units that support up to 12 flash modules. Flash modules are offered in 1.2 TB, 2.9 TB, and 5.7 TB capacities. All flash modules in a FlashSystem V9000 storage enclosure must have the same capacity.

IBM FlashSystem V9000 expansion storage enclosures

FlashSystem V9000 expansion storage enclosures are 2U rack-mount units. The SAS expansion enclosures are offered in two models and three drive features:

- Model 12F - supports up to 12 x 8 TB LFF HDD drives providing 80 TB RAID5 capacity
- Model 24F - supports up to either 12 or 24 SFF drives of either 3.84 TB and 1.92 TB low cost SSDs, providing a maximum RAID5 capacity of 85 TB.

Up to 20 SAS expansions are supported per FlashSystem V9000 controller pair, providing up to 480 drives with expansion Model 24F and up to 240 drives with expansion Model 12F.

Software-defined flash services

FlashSystem V9000 data services are provided through IBM FlashSystem V9000 software, which offers a rich set of software-defined storage features that include FlashCopy, thin provisioning, remote mirroring (Metro Mirror and Global Mirror), external virtualization, Easy Tier 3rd Generation, IBM Real-time Compression, IBM HyperSwap function and distributed RAID Component in Distress (CID) recovery

Scalability and performance

FlashSystem V9000 has the following scalability and performance features:

- FlashSystem V9000 eliminates input/output (I/O) bottlenecks while generating higher levels of application efficiency (improved performance)
- Up to 57 TB usable and 285 TB effective flash capacity in only 6U
- Up to 456 TB usable and 2.28 PB effective flash capacity in only 34U

- Extra scalability through expansion storage enclosures models 12F and 24F and increased raw capacity of up to a maximum of 7.6 PB, is supported within 80 x 2U enclosures
  - Four I/O groups x twenty 2U enclosures means you can install 21 of them per rack, which will require another 4 racks (or 160U total)
- Up to 3.0 million IOPS and 68 GBps bandwidth on a fully configured 8 x 8 FlashSystem V9000
- IBM MicroLatency

Reliability, availability, and serviceability

FlashSystem V9000 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 modules.
- Redundant hot-swappable components: FlashSystem V9000 flash storage enclosure has two clustered, hot-swappable canisters that each contain two hot-swappable fan modules, two management controllers, two management Ethernet ports, and a Universal Serial Bus (USB) port. The batteries, fans, and power supplies are all redundant and hot-swappable.

  If a flash module failure occurs, critical customer applications can remain online while the defective module is replaced. 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 maintain performance and capacity during partial or full flash chip failures.
- Two-dimensional (2D) flash RAID consists of IBM Variable Stripe RAID and system-wide RAID 5.
- FlashSystem V9000 control enclosures are an active-active pair, and support concurrent code load.

Flash for less than the cost of disk

With Real-time Compression, FlashSystem V9000 can increase the effective capacity of your flash memory up to 5x, decreasing the cost for effective capacity up to 80%. Real-time Compression supports active data, unlike other data reduction solutions. The model AC3 control enclosure offers several features for Real-time Compression workloads, including two Intel Xeon E5 v4 Series eight-core processors with up to 256 GB of memory, and up to two compression accelerator cards for hardware-assisted compression.

Software-defined services

FlashSystem V9000 merges IBM software-defined storage with the scalable performance of IBM FlashSystem technology to help you more easily manage your entire storage environment while preserving your investments in storage. Software-defined storage services enable you to 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 lower overall cost.
- High availability (HA) configurations. Enables near-continuous data availability.
- Copy Services. Enables space-efficient backups.

- Disaster recovery (DR) techniques. You can practice them and validate business continuity plans.
- Simple GUI. Enables storage to be quickly deployed and efficiently managed.
- HyperSwap capability. Enables each volume to be presented by two I/O groups. The configuration can tolerate combinations of node and site failures.

Note: IBM Storage Mobile Dashboard, version 1.5.4 and above, supports the IBM FlashSystem V9000 GUI. You can download the dashboard at no cost from iTunes:

https://itunes.apple.com/us/app/ibm-storage-mobile-dashboard/id677826483?mt=8

Deep application integration

IBM FlashSystem V9000 Software V7.7 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 application program interface (API) for Array Integration (VAAI) support. This functionality supports hardware-accelerated virtual machine (VM) copy/migration, supports 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.
- vVOLs 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 virtual volumes, and resiliency has been improved for VMs if volumes start running out of space.

vVOL

Before the availability of vVOLs, a virtual machine in a VMware environment would be presented a disk in the form of a file called a VMware disk (VMDK). This file represented a physical disk to the VM, and could then be accessed by the operating system (OS) installed on the VM in the same way that a physical volume on a regular server was.

The VMDK file was then placed onto a file system called Virtual Machine File System (VMFS), hosted by a standard volume (LUN), for example implemented on an external storage system, such as FlashSystem V9000. With the availability of the vVOL technology, each VM disk can now be mapped to an external storage volume (for example, a FlashSystem V9000 volume).

With vVOL, FlashSystem V9000 becomes “aware” of individual VMDK files. Therefore, data operations, such as snapshot and replication, can be performed directly by FlashSystem V9000, at the VMDK level rather than the entire VMFS data store.

Note: The integration of vVOL with FlashSystem V9000 is based on the VMware APIs for Storage Awareness (VASA). The IBM support for VASA is delivered as part of IBM Spectrum™ Control. VASA version 2 is required to use vVOL capability.

IBM Spectrum Control Base Edition

FlashSystem V9000 currently supports integration of VASA and VAAI by using IBM Spectrum Control™ Base Edition 3.0.1. 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.

This platform provides insight and awareness to VMware and vSphere about the configuration capabilities, storage health, and events of a storage system. With this capability, VMware administrators can independently and centrally manage their storage resources on IBM storage systems.

Current release functions

Several new functions and features are available with FlashSystem V9000 Software V7.7.1.

New in FlashSystem V9000 V7.7.1 software

IBM Spectrum Virtualize™ Software V7.7.1 delivers increased software functionality and support for new hardware models.

- Scalability with support for up to 10,000 Virtual Disks
- Increased flexibility with iSCSI virtualization support of IBM XIV® Gen 3, Spectrum Accelerate, FlashSystem A9000, and FlashSystem A9000R arrays
- Reliability, availability, and serviceability improvements with Distributed RAID (DRAID) Component in Doubt (CID) and support of low cost SSD flash drives:
  - DRAID CID: When a limited number of drives are delivering poor performance in events such as enclosure canister reset or drive code download, CID temporarily writes data in rebuild areas of regular performance drives, not compromising redundancy during this period, and rebuilds the data when the issue causing the slow performance is resolved.
  - Support for low cost SSD drives: low cost SSD flash drives offer performance comparable to enterprise-grade flash drives at a lower cost, but with lower endurance. Flash drive endurance is measured on drive writes per day (DWPD). GUI and CLI will provide information on the actual percentage of DWPD consumption.
  - Performance improvement with DRAID multi-threading by improved use of CPU cores.
- Support for up to 20 SAS expansions per FlashSystem V9000 controller pair, providing up to 480 drives with expansion Model 24F and up to 240 drives with expansion Model 12F.
- Manageability with CLI support for Host Groups, enabling multiple hosts to be grouped together for easier mapping and management and the same virtual disk to be mapped to all hosts in the host cluster in one step.

Advanced functions

FlashSystem V9000 provides several advanced functions

HyperSwap for FlashSystem V9000

Available with FlashSystem V9000 Software V7.6 and later is the HyperSwap capability which enables each volume to be presented by 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 V9000. 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.

IBM FlashSystem V9000 Software V7.7.1 includes Remote Mirroring for the internal flash enclosures (AE2s) as well as SAS attached expansion enclosures. IBM Spectrum Virtualize software is used to provide functionality for externally virtualized storage.

The HyperSwap function uses a *HyperSwap topology* by spreading the nodes of the system across two sites, with storage at a third site acting 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 resiliently stored on both sites, at least two I/O groups are required.
- The HyperSwap topology uses additional system resources to support a full independent cache on each site, providing 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 command-line interface (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, FlashSystem V9000 control enclosures, and FlashSystem V9000 storage enclosures are in one of two failure domains or sites.
- Volumes are visible as a single object across both sites (I/O groups).

Figure 4 shows how the HyperSwap function works.

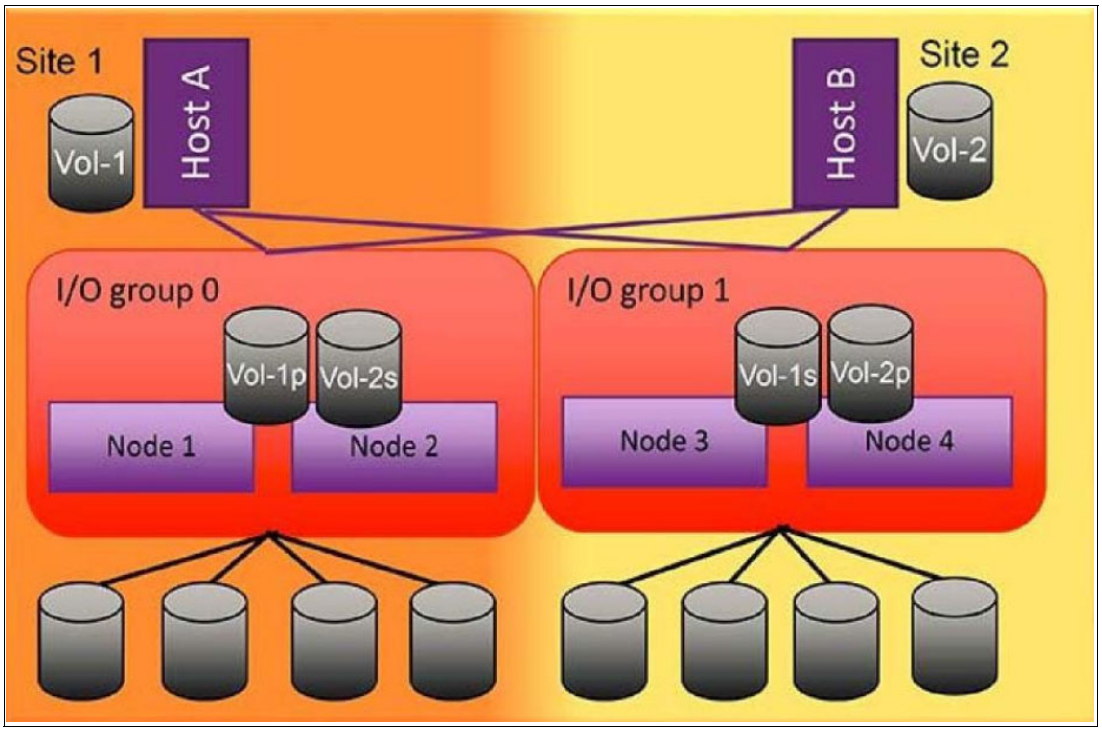


Figure 4 HyperSwap function

Each primary volume (denoted by the letter “p” in the volume name in Figure 4) has a secondary volume (denoted by the letter “s” in the volume name) 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 V9000 HyperSwap function and is transparent to the hosts.

Several HyperSwap characteristics are as follows:

- HyperSwap function is available on a FlashSystem V9000 running software version 7.6 and later, and with two or more I/O groups.
- Multiple step CLI-based configuration can be done on a single system, 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 host site (requires Asymmetric Logical Unit Access/Target Port Groups Support (ALUA/TPGS) support from the multipathing driver).
- Stale-consistent data is retained during resynchronization for disaster recovery.
- 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 high availability solution, IP quorum base support enables the use of lower-cost IP network-attached hosts as a quorum disk. HyperSwap implementations require Fibre Channel storage on a third site to cope with tie-break situations if the intersite link fails, 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).

Integrated Compretimator

Real-time Compression is a key differentiator of FlashSystem V9000. IBM Compretimator is the key sizing tool to estimate how much capacity savings a client can expect. Compretimator can recognize the patterns of the actual client data, and estimate the compressibility of data per volume.

The integration of Compretimator in FlashSystem V9000 software eases the process of estimating capacity savings by having this sizing tool integrated in FlashSystem V9000. This integration avoids the need to install Compretimator, and enables estimates of Real-time Compression effectiveness from a central console.

NPIV Support

Starting with version 7.7, FlashSystem V9000 Software offers N_Port ID Virtualization (NPIV) support. NPIV allows the virtualization of World Wide Port Names (WWPN) which increases redundancy during firmware updates and scheduled maintenance where WWPNs transparently moves to the controller not being maintained. As a consequence FC-attached hosts experience zero path reduction during controller outages.

Scale up and scale out

FlashSystem V9000 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.

FlashSystem V9000 has the following scalability features per building block:

- Slots for up to 12 hot-swappable flash memory modules (1.2 TB, 2.9 TB, or 5.7 TB)
- Configurable 2.4 - 57 TB of capacity for increased flexibility per storage enclosure
- FlashSystem V9000 has the following flexible scalability configuration options:
  - Base configuration
  - Scale up: Add capacity
  - Scale out: Add controllers and capacity

A fixed FlashSystem V9000 storage platform consists of two FlashSystem V9000 control enclosures directly cabled to one FlashSystem V9000 flash storage enclosure, representing a fixed building block. For balanced increase of performance and scale, up to four FlashSystem

building blocks can be clustered into a single storage system, multiplying performance and capacity with each addition.

The scalable building blocks can have dedicated internal Fibre Channel switches. However, two other ways are available to configure the switches and ports to provide performance improvements. Some of the following information is from *Introducing and Implementing IBM FlashSystem V9000*, SG24-8273

http://www.redbooks.ibm.com/abstracts/sg248273.html?Open

FlashSystem V9000 provides a flexible architecture for assigning port resources. Two primary methods of port utilization in a Fibre Channel environment are suggested, depending on your needs:

- V9000 port utilization for infrastructure savings
- V9000 port utilization for performance
- Comparison of port utilization methods

The *infrastructure savings method* has dedicated internal switches for the V9000 AE2 flash storage enclosure connections, and also intra-cluster communication with a reduced number of customer host-facing ports.

The *performance method* uses the customer fabric for all connections (with the option to use dedicated internal switches for intra-cluster communication). The ports have designated purposes based on fabric attachment, zone assignments, and port masking. This method provides shared-use ports that use the full bidirectional capabilities of Fibre Channel.

The performance method has up to 80% improved sequential write performance and 40% improved sequential read performance when compared with the infrastructure savings method. Either method can designate host ports for remote copy and mirroring. The performance method has the least effect on overall system performance when ports are designated to remote copy. Either method supports attachment to external storage. In both cases, zones in the customer fabric are required for attaching external storage.

The scalable building block configurations also allow for the addition of up to four individual FlashSystem flash storage enclosures to be added to the storage system. If 228 TB from four building blocks is not enough capacity, up to four extra flash storage enclosures can then be added.

In total, a FlashSystem V9000 Storage System can contain a maximum of eight FlashSystem V9000 flash storage enclosures, offering a potential storage capacity of 456 TB, and up to 2.2 PB effective capacity is available at 80% compression. Real-time Compression is available as a software feature that enables you to elect to deploy Real-time Compression where you want it.

Figure 5 illustrates the FlashSystem V9000 fixed building block versus the scalable capacity of scale up and scale out feature in FlashSystem V9000.

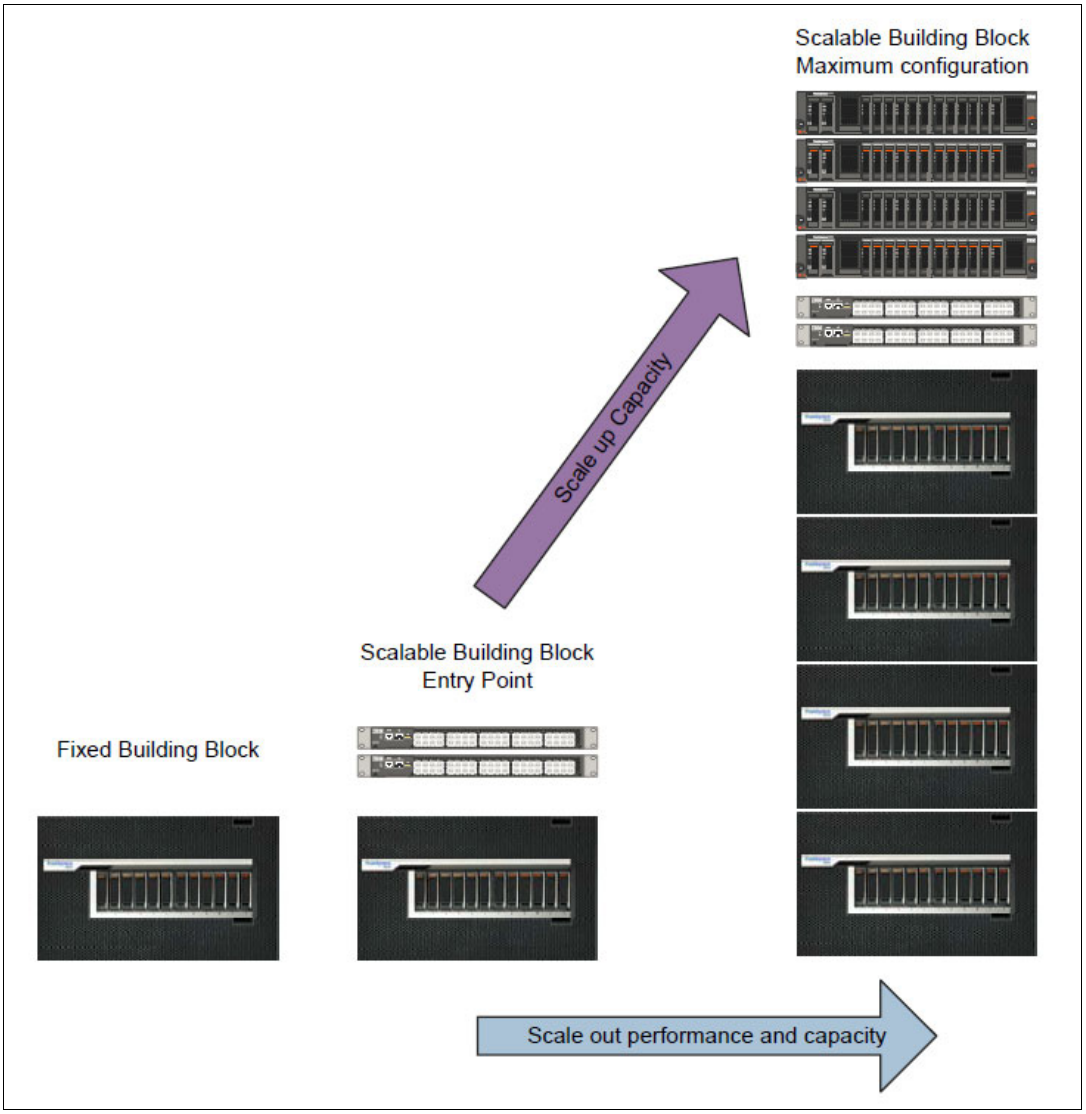


Figure 5 FlashSystem V9000 fixed building block versus scalable building block capacity

Figure 6 illustrates the increments in the scalable capacity of FlashSystem V9000. It also shows that additional flash storage enclosures can be added to a single building block, or to two, three, or four building blocks.

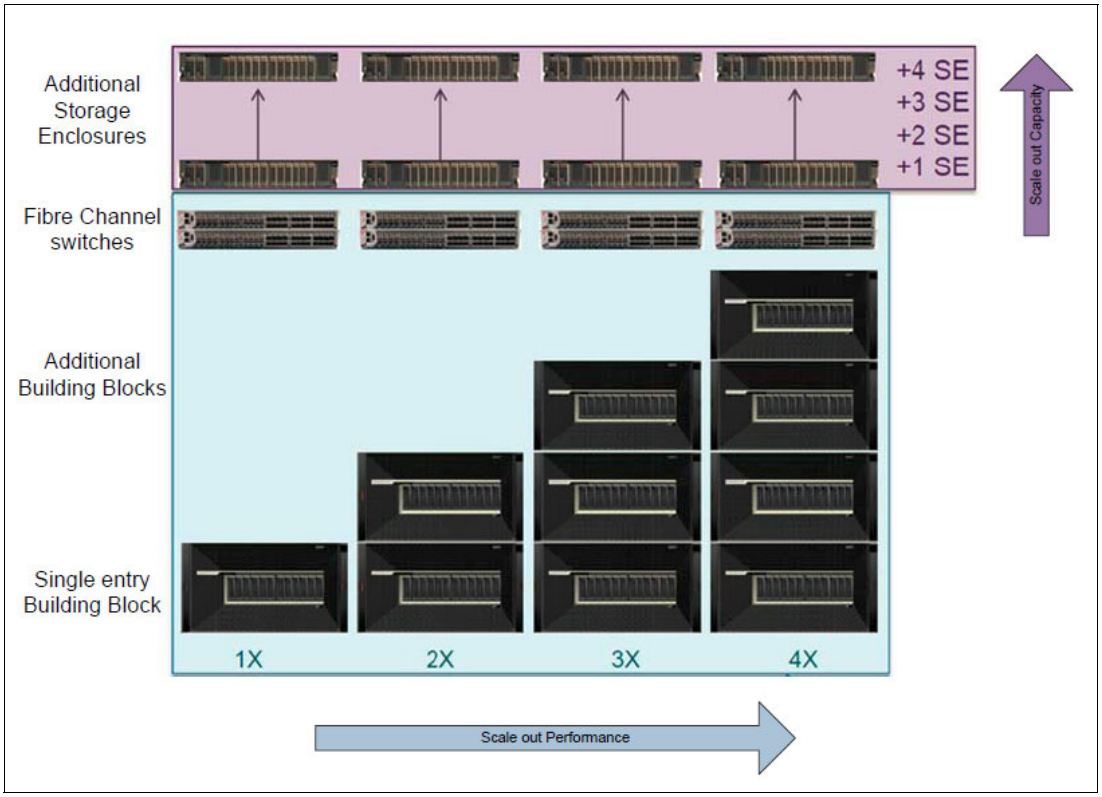


Figure 6 FlashSystem V9000 scalable capacity

Maximum capacity

Table 1 summarizes the minimum and maximum capacity for scalable building blocks using flash storage expansion enclosures.

Table 1 FlashSystem V9000 capacities: Scalable building blocks with extra storage enclosures

Scalable building blocks	Minimum capacity (TB)	Maximum capacity (TB)	Maximum effective capacity (TB) with Real-time Compression
1 BB	2.2	57	285
1 BB + 1 SE	4.4	114	570
1 BB + 2 SE	6.6	171	855
1 BB + 3 SE	8.8	228	1,140
1 BB + 4 SE	11.0	285	1,425
2 BB	4.4	114	570
2 BB + 1 SE	6.6	171	855
2 BB + 2 SE	8.8	228	1,140
2 BB + 3 SE	11.0	285	1,425

2 BB + 4 SE	13.2	342	1,710
Scalable building blocks	**Minimum capacity (TB)**	**Maximum capacity (TB)**	**Maximum effective capacity (TB) with Real-time Compression**
3 BB	6.6	171	855
3 BB + 1 SE	8.8	228	1,140
3 BB + 2 SE	11.0	285	1,425
3 BB + 3 SE	13.2	342	1,710
3 BB + 4 SE	15.4	399	1,995
4 BB	8.8	228	1,140
4 BB + 1 SE	11.0	285	1,425
4 BB + 2 SE	13.2	342	1,710
4 BB + 3 SE	15.4	399	1,995
4 BB + 4 SE	17.6	456	2,280

PCIe expansion ports

Seven PCIe slots are available for port expansions in the FlashSystem V9000 AC3 control enclosures.

Table 2 shows the maximum host port count per building block configuration (1, 2, 3, or up to 4 BBs).

Table 2 Host port count per building blocks

	16 GB FC	**10 GB iSCSI**	**10 GB FCoE**
1X	32	8	8
2X	64	16	16
3X	96	24	24
4X	128	32	32

Expansion storage enclosures

With the introduction of IBM FlashSystem V9000 Software V7.7.1 FlashSystem V9000 now support the addition of storage expansion enclosures.

IBM FlashSystem V9000 Small Form Factor (SFF) Expansion Enclosure Model 24F offers new tiering options with low cost SSDs. Each SFF expansion enclosure supports up to 24 2.5-inch low cost flash drives.

Up to 20 SAS expansions are supported per FlashSystem V9000 Building Block, providing up to 480 drives with expansion Model 24F and up to 240 drives with expansion Model 12F (LFF) for up to 1.9 PB of raw SAS capacity in each Building Block. With four building blocks 7.6 PB of raw SAS capacity is supported.

Figure 7 on page 18 shows the maximum possible configuration with a single building block using a combination of native FlashSystem V9000 flash storage expansion enclosures and SAS attached storage expansion enclosures.

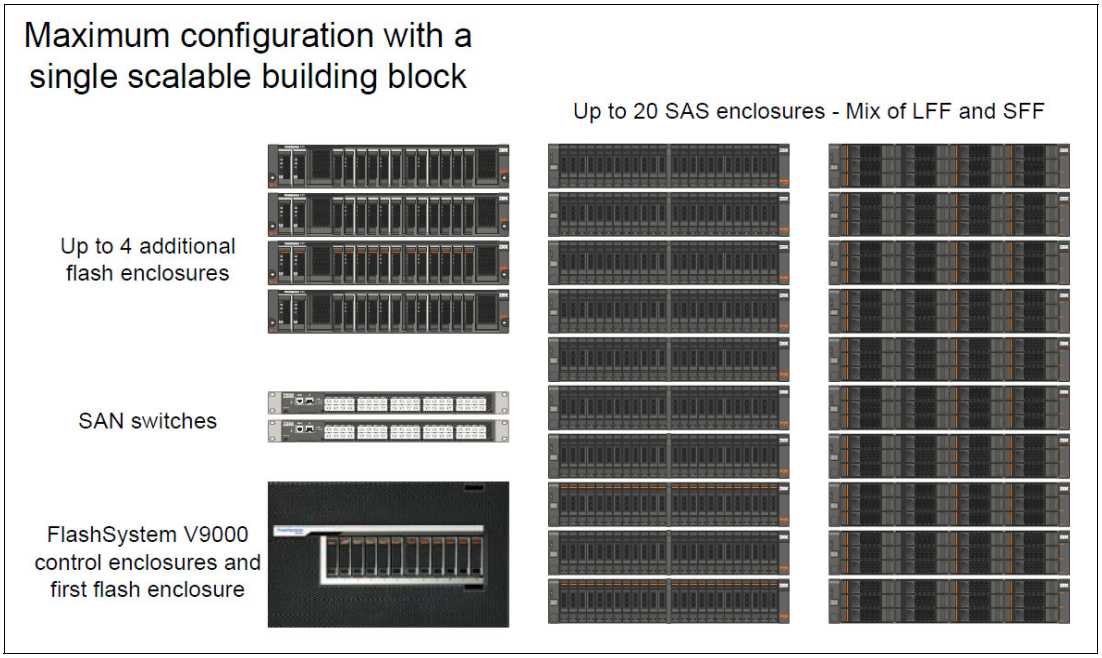


Figure 7 Single scalable building block max configuration

Low cost flash drives (SSD)

High density, low cost SSDs allow applications to scale and achieve high read performance while maintaining traditional reliability and endurance levels. 1.92 TB and 3.84 TB SAS 2.5-inch low costlow cost SSD flash drive options are available for FlashSystem V9000 SFF Storage Expansion enclosure model 24F for a maximum of 33 PB combined flash and SAS capacity with four Building Blocks.

High capacity nearline drives

High capacity nearline drives enables high value tiered storage with hot data stored in flash and warm data on lower cost nearline SAS HDDs all managed by IBM Easy Tier. 8 TB SAS 3.5-inch nearline drives are available for FlashSystem V9000 LFF Storage Expansion Enclosure model 12F for a maximum of 34 PB combined flash and SAS capacity with four building blocks.

RAID types

RAID5 with standby hotspare is the only available RAID option for FlashSystem V9000 native flash storage expansion. However, the addional SAS attached storage expansion enclosures can be configured with various RAID options. Recommended for SAS attached storage expansion enclosures is however Distributed RAID (DRAID5 and DRAID6) which offers improved RAID rebuild times.

Note: To support SAS attached expansion enclosures, an AH13 - SAS Enclosure Attach adapter card must be installed in expansion slot 2 of each AC3 control enclosure in the building block.

Improving what you have for both IBM and non-IBM resources

FlashSystem V9000 offers software-defined storage virtualization technology that helps you manage other IBM or third-party storage arrays with thin provisioning, space-efficient copies, and disaster recovery tools, such as data replication. Software-defined storage virtualization also helps ease the migration of data from one storage device to another. Virtualization of FlashSystem V9000 storage enclosures enables rapid and flexible provisioning and simple configuration changes.

FlashSystem V9000 enables you to manage the capacity of other disk systems with external storage virtualization. When FlashSystem V9000 virtualizes a storage system, its capacity becomes part of the FlashSystem V9000 system and is managed in the same way as the capacity on internal flash modules within FlashSystem V9000. Capacity in external storage systems inherits all the rich functions and ease of use of FlashSystem V9000.

FlashSystem V9000 enables you to preserve your existing investments in storage, centralize management, and make storage migrations easier with storage virtualization and Easy Tier. FlashSystem V9000 provides nondisruptive operations, thanks to 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

Flexible deployment options enable organizations to 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 using Real-time Compression, and data replication to disaster recovery sites. Clients can implement optimal business performance and enterprise features and choose how to deploy the following items:

- Sets of data that are dedicated flash capacity for the lowest possible latency
- Sets of data that participate in Easy Tier
- Sets of data that are compressed using Real-time Compression
- Sets of data for replication to disaster recovery sites
- All of these sets, or any combination of them

Driving new business opportunities

Clients can drive new business opportunities with IBM FlashSystem V9000:

- Improve workforce productivity
- Lower power consumption
- Enable data center consolidation
- Run mixed workloads
- Accelerate Infrastructure
- Accelerate latency sensitive applications
- Accelerate virtualization and virtual desktop infrastructure (VDI)
- Accelerate databases and data warehousing

Manageability and security

FlashSystem V9000 offers the following manageability and security features:

- Advanced security for data at rest with hardware-accelerated AES-XTS 256 encryption.

- GUI to manage the FlashSystem V9000 control enclosures and the FlashSystem V9000 storage enclosures. The GUI is available in any supported browser. Also included is the FlashSystem V9000 CLI, which is a collection of commands that you can use to manage the FlashSystem V9000.
- Email alerts
- SNMP alerts
- Syslog redirect to send system log messages to another host.

FlashSystem V9000 components

The following sections describe the components. Table 3 lists the part numbers that are associated with FlashSystem V9000.

Table 3 FlashSystem V9000 components and model numbers

Description	Machine type-model
FlashSystem V9000 control enclosure	9846-AC3 or 9848-AC3
FlashSystem V9000 flash storage enclosure	9846-AE2 or 9848-AE2
FlashSystem V9000 LFF storage expansion enclosure	9846-12F or 9848-12F
FlashSystem V9000 SFF storage expansion enclosure	9846-24F or 9848-24F

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

For more information, see IBM announcement letter *IBM FlashSystem V9000 Control Enclosure Model AC3 and SFF Expansion Enclosure Model 24F deliver enhanced performance, scalability, and new tiering options for IBM FlashSystem V9000* at https://ibm.biz/BdruCs

Warranty

FlashSystem V9000 is available with either one-year or three-year warranties, so clients can select the warranty period that best addresses their business and financial needs as follows:

- Models that are ordered using machine type 9846 have a one-year warranty.
- Models that are ordered using machine type 9848 have a three-year warranty.

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

Flash media within IBM FlashSystem V9000 is covered in full during the warranty and maintenance period.

IBM FlashSystem V9000, including its MicroLatency Modules (flash modules), is covered by up to seven years of total hardware support through the applicable warranty period plus up to six years of optional post-warranty hardware maintenance for a total of seven years. Clients can purchase additional years of maintenance either with the purchase of the system or until IBM announces withdrawal from marketing or withdrawal from service as applicable.

FlashSystem V9000 Enterprise Class Support

Enterprise Class Support is available only for the FlashSystem V9000 machines that are purchased with a three-year warranty. The following new machine types qualify for this type of enhanced support:

- IBM FlashSystem V9000 Control Enclosure (9848-AC3) and
- IBM FlashSystem V9000 SFF Expansion Enclosure (9848-24F)

In addition, the following previously announced IBM FlashSystem V9000 elements also qualify, if they are purchased after August 23, 2016 with a 3 year warranty”

- IBM FlashSystem V9000 Control Enclosure (9848-AC2)
- IBM FlashSystem V9000 Storage Enclosure (9848-AE2)
- IBM FlashSystem V9000 LFF Expansion Enclosure (9848-12F)

The Enterprise Class Support offering gives the following key enhancements to the product base three-year warranty terms and conditions:

- Technical Advisors to proactively improve problem management and communication
- Software installation
- Configuration support
- On-site and remote software updates 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 will also provide an IBM System Service Representative (SSR) to perform on-site product setup and installation. In addition, the IBM SSR or IBM Remote Support Center will perform up to six software updates during the warranty period.

IBM Technical Advisor support will be provided during the warranty period. This support enhances end-to-end support for the client's complex IT solutions. The Technical Advisor uses an integrated approach for coordinated, cross-team support to enable clients to maximize IT availability. The Technical Advisor will work 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 three-year warranty, the Technical Advisor will proactively plan the software updates and ensure workstation, network access, user ID, and software download steps are completed prior to deploying the SSR or IBM Remote Support Center to perform the software update.

FlashSystem V9000 control enclosure features

The FlashSystem V9000 control enclosure provides advanced data services for flash memory. It is a 2U, 19-inch rack-mount enclosure. The FlashSystem V9000 includes two control enclosures, also called controller nodes, for redundant host access. The control enclosures include up to 16 ports that are used for connectivity, with options for 16 Gb Fibre Channel, and 10 Gb Ethernet (GbE) FCoE and iSCSI.

The FlashSystem V9000 control enclosure consists of the components described here.

Two control enclosures in each FlashSystem V9000 provide redundancy. Each control enclosure consists of the following items:

- 2U server node

- Two Intel Xeon E5 v4 series eight-core processors with 64 GB expandable to 256 GB memory (supported in future releases of code)
- Options for connectivity including four host interface cards (16 Gb FC, and 10 GbE)
- Up to two optional compression accelerator feature (#AH1A) cards, required to run Real-time Compression
- Two integrated ac power supplies and battery units and dual SSD boot drives

The control enclosure runs the FlashSystem V9000 Software, providing a rich set of software-defined storage features, including FlashCopy, thin provisioning, remote mirroring, external virtualization, Easy Tier, and Real-time Compression.

The FlashSystem V9000 control enclosure supports Fibre Channel Protocol 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. Full active-active multipathing across all interfaces is supported, although host software support for this function can vary.

Figure 8 shows a generalized view of storage area network (SAN) host connectivity topology in a FlashSystem V9000 environment. The host fabric can consist of Fibre Channel switches that are zoned so that each FlashSystem V9000 control enclosure (AC3) cannot see the other FlashSystem V9000 control enclosure. They can also share the AC3 to AE2 connections with the hosts servers on the same SAN switch, observing the correct port zoning.

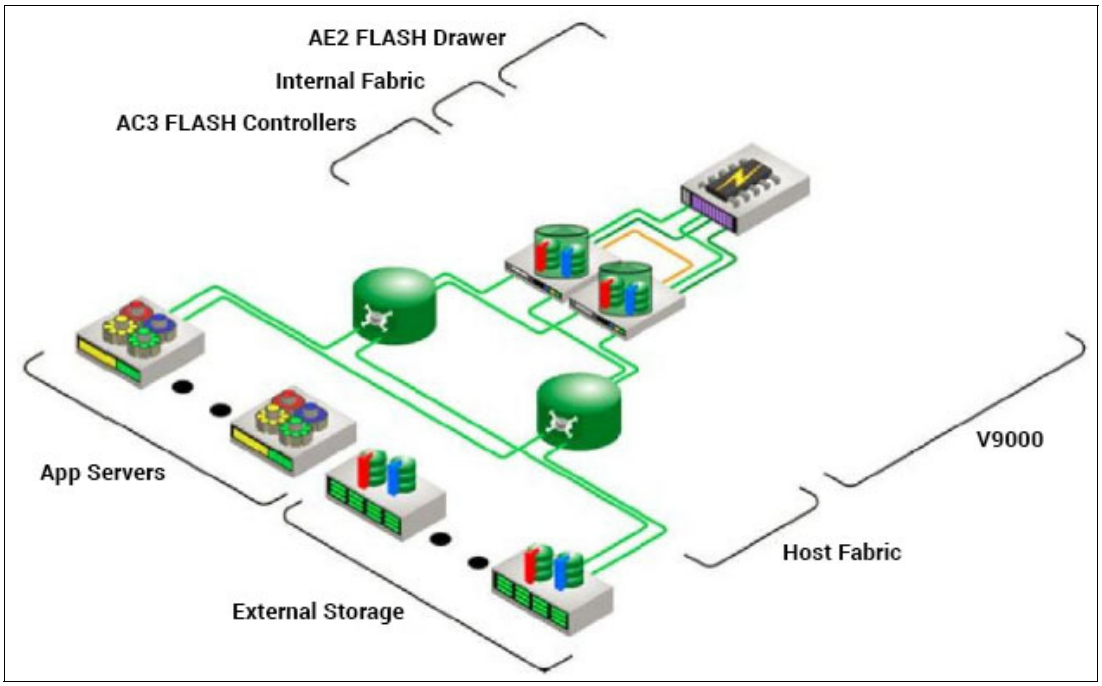


Figure 8 FlashSystem V9000: Generalized view of host connectivity topology

System management

Because FlashSystem V9000 control enclosures cluster together to form a system, a single management interface is used for FlashSystem V9000. Each FlashSystem V9000 node is an individual server in a FlashSystem V9000 clustered system on which the FlashSystem V9000 Software runs.

FlashSystem V9000 GUI

FlashSystem V9000 includes an easy-to-use management GUI, which runs on the FlashSystem V9000 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 FlashSystem V9000. The FlashSystem Control Enclosure Model AC3 is delivered in a 2U, 19-inch rack-mount enclosure. The V9000 solution includes two AC3 controllers and the FlashSystem V9000 comes with IBM SSR installation as part of the product offering.

Figure 9 shows the FlashSystem V9000 GUI main screen

Figure 9 FlashSystems V9000 GUI showing a single building block

The GUI supplied in the IBM FlashSystem V9000 control code release 7.7.1, also provides support for the optional SAS expansion enclosures

FlashSystem V9000 control enclosure features

IBM FlashSystem V9000 Control Enclosure Model AC3 is a component of the V9000 storage system that provides increased performance and additional storage capacity

The FlashSystem V9000 control enclosure is a purpose-built 2U 19-inch rack-mount enclosure with two AC power supplies, two backup batteries and dual SSD boot drives. The control enclosure provides up to eight 16 Gb Fibre Channel ports to connect to FlashSystem V9000 storage enclosures, either directly (with the fixed building block) or through SAN switches (with the scalable building block).

Figure 10 shows the front view of the V9000 AC3 controller

Figure 10 V9000 AC3 controller front view

IBM FlashSystem V9000 Control Enclosure Model AC3 has the following features:

- Two eight-core processor with 64 GB memory standard, and options to increase memory up to 256 GB (supported in future releases of code)
- 16 Gb Fibre Channel (FC) and 10 Gb iSCSI and Fibre Channel over Ethernet (FCoE) connectivity options
- Hardware-assisted compression acceleration for Real-time Compression workloads
- Capability for adding into existing clustered systems with previous generation V9000 control enclosures
- Up to 20 SAS attached expansion enclosures are supported per FlashSystem V9000 controller pair, providing up to 480 HDD type drives with expansion Model 24F and up to 240 low cost SSD drives with expansion Model 12F.

Figure 11 shows the rear view of the V9000 AC3 controller

Figure 11 V9000 AC3 controller rear view

IBM FlashSystem V9000 Control Enclosure Model AC3 requires IBM FlashSystem V9000 Software V7.7.1 or later for operation. Use of the software is entitled through the acquisition of IBM FlashSystem V9000 Software licenses.

FlashSystem V9000 storage enclosure features

FlashSystem V9000 storage enclosure is a purpose-built, all-flash storage shelf. It is a 2U 19-inch rack-mount enclosure with 12 slots for flash modules. The storage enclosure provides eight 16 Gb Fibre Channel ports to connect to FlashSystem V9000 control enclosures, either directly or through dedicated internal switches (with the scalable building block). Flash modules within any individual building block are available in 1.2 TB, 2.9 TB, or 5.7 TB capacity. Capacities cannot be inter-mixed.

The FlashSystem V9000 storage enclosure has the following attributes and components:

- Provides flash memory
- FlashSystem V9000 storage enclosure has full internal redundancy:
  - Redundant and hot-swappable flash interface controllers
  - Redundant and hot-swappable batteries

  - Redundant and hot-swappable power supplies and fans
- Twelve flash modules in 1.2 TB, 2.9 TB, or 5.7 TB capacities:
  - Orderable in 4, 6, 8, 10, or 12 module configuration
  - All flash modules must be the same capacity
- Up to 57 TB RAID 5 configuration; up to 285 TB effective capacity with Real-time Compression

IBM FlashSystem V9000 storage enclosure includes two RAID controller modules, two battery modules, one power interposer, two power supplies, four interface cards, four fan modules, four - twelve flash memory modules, and one mid-plane. As viewed from the front of the storage enclosure (Figure 8), two battery modules are at the far left of the enclosure, and 12 flash module slots are to the right of the battery modules. The front bezel of the systems contains status LEDs.

Figure 12 shows the front view of the V9000 storage enclosure

Figure 12 Front view of FlashSystem V9000 storage enclosure

The rear of the FlashSystem V9000 storage enclosure (Figure 13) includes four Fibre Channel interface cards at the top, four fan modules in the middle, and two RAID modules at the bottom. To the right of the fans are two power supply modules that provide redundant power to the system. All components are concurrently maintainable except the mid-plane and power interposer, which have no active components. Interface maintenance requires the removal of a RAID module. All external connections are from the rear of the system.

Figure 13 shows the rear view of the V9000 storage enclosure

Figure 13 Rear view of FlashSystem V9000 storage enclosure

Each flash memory module contains IBM enhanced MLC 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 flash controller manages a set of 20 flash chips.

Each flash controller implements a sophisticated flash translation layer (FTL) incorporating error correction code (ECC) error correction, address translation, and IBM patented Variable Stripe RAID self-healing data protection that handles 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.

FlashSystem V9000 expansion storage enclosure features

Two models of FlashSystem V9000 expansion storage enclosures are offered as follows:

- LFF Expansion Enclosure Model 12F
- SFF Expansion Enclosure Model 24F

FlashSystem V9000 LFF Expansion Enclosure Model 12F supports twelve 8 TB SAS 3.5-inch HDD drives

Figure 14 shows the front view of the Flashsystem V9000 expansion enclosure model 12F

Figure 14 Front View of FlashSystem V9000 LFF Expansion Enclosure Model 12F

IBM FlashSystem V9000 SFF Expansion Enclosure Model 24F offers new tiering options and up to twenty-four slots for 2.5-inch low cost SSD drives. These are available in 3.84 TB and 1.92 TB capacity.

Figure 15 shows the front view of the Flashsystem V9000 expansion enclosure model 24F.

Figure 15 Front View of IBM FlashSystem V9000 SFF Expansion Enclosure Model 24F

Both models of IBM FlashSystem V9000 Expansion Enclosures have the same common features as follows:

- Two expansion canisters
- 12 Gb SAS ports for attachment to the V9000 controllers
- 2U, 19-inch rack-mount enclosure with AC power supplies

Example 16 shows the rear view of the Flashsystem V9000 expansion enclosure models 12F and 24F.

Figure 16 Rear View of IBM FlashSystem V9000 Expansion Enclosure Models 12F and 24F

Product specifications

Table 4 lists the specifications for the base configuration of FlashSystem V9000.

Table 4 IBM FlashSystem V9000 configuration specifications

IBM FlashSystem V9000	
Models	9846/8-AC3 and 9846/8-AE2
Flash type	IBM-enhanced MLC
Flash module configuration	4 x 1.2 TB, 6 x 1.2 TB, 8 x 1.2 TB, 10 x 1.2 TB, 12 x 1.2 TB, 6 x 2.9 TB, 8 x 2.9 TB, 10 x 2.9 TB, 12 x 2.9 TB, 6 x 5.7 TB, 8 x 5.7 TB, 10 x 5.7 TB, 12 x 5.7 TB
Maximum internal flash capacity	► Scalable from 2.2 TB (usable) up to 456 TB with full scale-out of control and storage enclosures. ► From 12 TB to 2.2 PB with full scale-out of control enclosures and storage enclosures (at 80% reduction with Real-time Compression).
Maximum expansion enclosure capacity	► Up to 80 expansion enclosures (up to 20 expansion enclosures per controller pair) with twelve 3.5" hard disk drives (HDDs) or twenty four 2.5" low cost flash drives (SSDs) per enclosure ► 7.68 PB raw capacity using NL-SAS HDDs ► 7.37 PB raw capacity using SSDs
Maximum external storage capacity	► Up to 32 PB usable capacity (requires External Virtualization).
Maximum Performance: Per building block (100% read, cache miss)	
Latency (4K)	180 µs
IOPS (4K)	750,000
Bandwidth (256K)	9.5 GBps
Maximum Performance: Scaled out (100% read, fully scaled out with 4 building blocks)	
Minimum Latency (4K)	180 µs
IOPS (4K)	3,000,000
Bandwidth (256K)	68 GBps
Data reduction IOPS (4K)	1,200,000

Reliability, availability, and serviceability (RAS) features	► Two-dimensional flash RAID ► Module-level IBM Variable Stripe RAID ► System-level RAID 5 across modules ► Hot-swappable flash modules ► Tool-less module installation/replacement ► Concurrent code load ► Redundant and hot-swappable components
Supported platforms	Information about servers, operating systems, host adapters, and connectivity products that are supported by FlashSystem products is available at the SSIC website: http://www.ibm.com/systems/support/storage/config/ssic
Encryption	Data-at-rest AES-XTS 256
FlashSystem V9000 host connectivity options per building block	► 32 x 16/8/4 Gb Fibre Channel ► 8 x 10 Gb Fibre Channel over Ethernet (FCoE) ► 8 x 10 Gb iSCSI
Virtualization software model	5639-RB7
Tiered Solution Models	9846/8-12F, 9846/8-24F
Shared symmetric multiprocessing (SMP) processor configuration	Two Intel Xeon E5 v4 series 8-core 3.2 GHz processors
Controller memory	64 GB standard, up to 256 GB option (per controller and supported in future releases of code)
Dimensions (height x width x depth)	6U x 445 mm x 761 mm (6U x 17.5 in. x 29.96 in.)
Weight (V9000 single block)	78 kg (171.8 lb.) fully loaded
Weight (SAS expansion enclosure model 12F)	Fully configured: 26.7 kg (58.76 lb)
Weight (Expansion 24F enclosure)	Fully configured: 27.3 kg (60.19 lb)

Options and feature codes

This section describes the options and feature codes of IBM FlashSystem V9000.

Host connectivity interface cards

Table 5 shows the current features for host and connectivity on the models of the IBM FlashSystem V9000 storage enclosure 9846-AE2 and 9848-AE2 machine types.

Table 5 Supported storage enclosure and interface components for machine type 9846/8-AE2

Item	Feature code	Max quantity	Description	Ports
FC Host Interface Card	AF15	2	Enclosure connection card for Fibre Channel connectivity	Up to 16 ports of 8 Gbps Fibre Channel (with AF18 or AF19)

Item	Feature code	Max quantity	Description	Ports
8 Gb FC 8 Port Host Optics	AF18	2	Set of 8 Gb Fibre Channel optics to enable eight ports Note: AF18 only for expansion of legacy 8Gb scalable V9000 new V9000 configurations (AC3) are all 16Gb	Up to 16 ports of 8 Gb Fibre Channel
16 GB FC 4 Port Host Optics	AF19	2	Set of 16 Gb Fibre Channel optics to enable four ports	Up to 16 ports of 16 Gb Fibre Channel

Table 6 shows the current features for host and connectivity on the models of the IBM FlashSystem V9000 control enclosures 9846-AC3 and 9848-AC3 machine types.

Table 6 Control enclosures and interface components support for machine type 9846/8-AC3 (part 1 of 2)

Item	Feature code	Max quantity	Description	Ports
10 GB Ethernet with 4-port host optics	AH12	1	This feature provides one I/O adapter with four 10 Gb Ethernet ports and SFP+ transceivers. It is used to add 10 Gb iSCSI/FCoE connectivity. Corequisites: If ordered, one of the following requirements must be met: ► Three of #AH44 must be ordered on model AC3 and two of #AF19 must be ordered on model AE2, or ► Two of #AH44 must be ordered on model AC3 and two of #AF19 must be ordered on model AE2, or ► Three of #AH11 must be ordered on model AC3 and two of #AF19 must be ordered on model AE2, or ► Two of #AH11 must be ordered on model AC3 and two of #AF19 must be ordered on model AE2, or ► One of #AH10 and 2 of #AH11 must be ordered on model AC3 and two of #AF18 must be ordered on model AE2, or ► Two of #AH10 and 2 of #AH11 must be ordered on model AC3 and two of #AF18 must be ordered on model AE2	Up to 4 ports of 10 Gb Ethernet
16 Gb FC with 4-port host optics	AF44	4	This feature provides one I/O adapter with four 16 Gb Fibre Channel ports and shortwave SFP transceivers: ► Compatibility conflicts: Cannot coexist with feature #AH10 or #AH11. ► Notes: – If four of #AH44 are ordered, no additional adapters can be ordered on model AC3. – If three of #AH44 are ordered, zero or one of #AH12 can be ordered on model AC3. – Two of #AF19 must be ordered on model AE2. ► Limitations: Must be ordered in quantities of 3,or 4.	Up to 16 ports of 16 Gb Fibre Channel
16 Gb FC longwave SFP transceivers (2)	ACHU	8	This feature provides two 16 Gb longwave SFP transceivers for use with 4-Port 16 Gb FC Card (feature #AF44). Prerequisites: Feature #AH11 or #AF44.	Up to 16 ports of 16 Gb FC for #AF44
8 Gb FC longwave SFP transceivers (2)	AH1T	8	This feature provides two 8 Gb longwave SFP transceivers for use with 4-Port 16 Gb FC Card (feature #AF44). Prerequisites: Feature #AH11 or #AF44.	Up to 16 ports of 8 Gb FC for #AF44
SAS Expansion Enclosure Attach Card	AH13	1	This feature provides one four port 12 Gb SAS expansion enclosure attachment card. The SAS Expansion Enclosure Attach Card (AH13) can only be present when the total quantity of I/O adapter features is less than four.	Four SAS ports per card

Flash modules

FlashSystem V9000 provides configurable flash module capacity. All modules are hot-swappable. FlashSystem V9000 can be populated with four, six, eight, ten, or twelve flash

modules. Flash modules capacities are 1.2 TB (feature number AF23), 2.9 TB (feature number AF24), or 5.7 TB (feature number AF25). Capacities cannot be inter-mixed within a single building block.

Usable RAID 5 protected capacity points are described in the following lists for 1.2 TB, 2.9 TB, and 5.7 TB modules.

The following capacity points are possible by using (AF23) 1.2 TB flash modules:

- 2.2 TB: Four 1.2 TB flash modules with RAID 5 protection
- 4.5 TB: Six 1.2 TB flash modules with RAID 5 protection
- 6.8 TB: Eight 1.2 TB flash modules with RAID 5 protection
- 9.1 TB: Ten 1.2 TB flash modules with RAID 5 protection
- 11.4 TB: Twelve 1.2 TB flash modules with RAID 5 protection

The following capacity points are possible by using (AF24) 2.9 TB flash modules:

- 11.4 TB: Six 2.9 TB flash modules with RAID 5 protection
- 17.1 TB: Eight 2.9 TB flash modules with RAID 5 protection
- 22.8 TB: Ten 2.9 TB flash modules with RAID 5 protection
- 28.5 TB: Twelve 2.9 TB flash modules with RAID 5 protection

The following capacity points are possible by using (AF25) 5.7 TB flash modules:

- 22.8 TB: Six 5.7 TB flash modules with RAID 5 protection
- 34.2 TB: Eight 5.7 TB flash modules with RAID 5 protection
- 45.6 TB: Ten 5.7 TB flash modules with RAID 5 protection
- 57 TB: Twelve 5.7 TB flash modules with RAID 5 protection

Table 7 lists the supported flash modules.

Table 7 Supported flash modules

Description	Machine type	Feature code	Maximum quantity
1.2 TB IBM MicroLatency Module	9846/8-AE2	AF23	12
2.9 TB IBM MicroLatency Module	9846/8-AE2	AF24	12
5.7 TB IBM MicroLatency Module	9846/8-AE2	AF25	12

IBM Variable Stripe RAID

Variable Stripe RAID data protection is managed independently by each flash controller on each flash module within each building block. With Variable Stripe RAID, every flash controller creates a striped data layout across sets of chips. The Variable Stripe RAID stripe (page) size is 4 kilobytes (KB). When the Variable Stripe RAID algorithm detects a failure affecting one or more regions in a RAID stripe, the following process occurs:

1. Data that is stored in the affected regions is reconstructed from the remaining data/parity elements in the stripe.
2. All pages in the affected stripe, including the reconstructed data, are moved to reserved space (overprovisioned area).
3. Subsequent requests for data in the affected stripe are directed to the new locations (now part of the normal storage area in the system).
4. The original location of the affected stripe is added to the available overprovisioned area as an (n-1) + parity stripe. For example, if the affected stripe was a 15 +1 stripe, it becomes a 14 + 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. Further, 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.

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 flash module and system health metrics. FlashSystem V9000 modules use 20 nanometer (nm) micron multi-level cell (MLC) flash chips.

Two-dimensional (2D) Flash RAID

The combination of Variable Stripe RAID and system-level RAID 5 protection across flash modules is called two-dimensional (2D) Flash RAID. Variable Stripe RAID automatically and transparently protects against partial or full flash chip failures within the flash module, with no downtime or maintenance required.

System-level RAID 5 adds protection against complete flash module failure, and enables hot-swappable flash modules. Additionally, all active components are redundant and hot-swappable with tool-less access from the front or back of the system, enhancing two-dimensional RAID protection.

RAID 5 support

Up to 2048 logical volumes (sometimes referred to as LUNs) can be created in the system, with a minimum size of 1 MB and a maximum size of the full available system capacity under the direction of the management module. RAID module Field Programmable Gate Arrays (FPGAs) can coordinate data transfer between modules, for example, to rebuild the system-level RAID data layout.

Network cables and UPS

FlashSystem V9000 control enclosure supports the network cables and uninterruptible power supply (UPS) features that are listed in Table 8.

Table 8 FlashSystem V9000 control enclosure data cables and UPS features

FlashSystem V9000 control enclosure: Data cables	**Feature code**
Trade Agreement Act (TAA) compliance	0983
1 m Fiber Cable (LC-LC)	5301
2 m Fiber Cable (LC-LC)	AF1P
5 m Fiber Cable (LC-LC)	5305
25 m Fiber Cable (LC-LC)	5325
1.5m 12 Gb SAS Cable (mSAS HD)	ACUB
3m 12 Gb SAS Cable (mSAS HD)	ACUC
6m 12 Gb SAS Cable (mSAS HD)	ACUD
Power supplies	**Feature code**
1300 W power supply	AF1H
Priced optional features: Power cords for control enclosure	**Feature code**
US 250V/10A 6 ft.	9714
US/Japan/South America 9 ft.	9715
Europe, Mid-East, Africa	9716
Australia, New Zealand	9717
Europe, Africa	9718
Europe, Denmark	9719
Pakistan, South Africa	9720
Switzerland, Liechtenstein	9721
Chile, Italy, Ethiopia	9722
Israel	9723
Argentina	9725
China	9726
Taiwan	9727
Priced optional features: Other for control enclosure	**Feature code**
Compression Accelerator	AH1A

FlashSystem V9000 storage enclosure supports the network cables and UPS features that are listed in Table 9.

Table 9 FlashSystem V9000 storage enclosure data cables and UPS features

FlashSystem V9000 control enclosure: Data cables	**Feature code**
Trade Agreement Act (TAA) compliance	0983
1 m Fiber Cable (LC-LC)	5301
2 m Fiber Cable (LC-LC)	AF1P
5 m Fiber Cable (LC-LC)	5305
25 m Fiber Cable (LC-LC)	5325
Power supplies	**Feature code**
1300 W power supply	AF1H
Priced optional features: Power cords for control enclosure	**Feature code**
US 250V/10A 6 ft.	9714
US/Japan/South America 9 ft.	9715
Europe, Mid-East, Africa	9716
Australia, New Zealand	9717
Europe, Africa	9718
Europe, Denmark	9719
Pakistan, South Africa	9720
Switzerland, Liechtenstein	9721
Chile, Italy, Ethiopia	9722
Israel	9723
Argentina	9725
China	9726
Taiwan	9727
Priced optional features: Other for control enclosure	**Feature code**
Compression Accelerator	AH1A

Encryption

FlashSystem V9000 supports AES XTS 256 data at rest encryption when the Encryption Enablement Pack, feature AF14, is ordered. For improved data security and confidentiality, encryption is now available for both internal capacities of FlashSystem V9000, IBM SAN Volume Controller, IBM Storwize® V7000 and externally virtualized capacities of FlashSystem V9000, Storwize V7000, and SAN Volume Controller.

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, FlashSystem V9000 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 do require that you purchase the Feature Code AF14: Encryption Enablement Pack. If you plan to implement either Hot Encryption Activation or Encryption Rekey, inform IBM support so that they can monitor the operation.

For more information, see the IBM Knowledge Center for FlashSystem V9000:

https://ibm.biz/BdruCq

System management and web interface

FlashSystem V9000 includes the IBM CLI, which is also useful for scripting, and an intuitive GUI for simple and familiar management of the product. FlashSystem V9000 supports Simple Network Management Protocol (SNMP), email forwarding using Simple Mail Transfer Protocol (SMTP), and syslog redirection for complete enterprise management access.

The simple GUI enables storage to be quickly deployed and efficiently managed. The GUI runs on the FlashSystem V9000 control enclosure, so there is no need for a separate console. All you need to do is point your web browser to the system.

Note: IBM Storage Mobile Dashboard, version 1.5.4, and above, supports the IBM FlashSystem V9000 GUI. You can download the dashboard at no cost from iTunes:

https://itunes.apple.com/us/app/ibm-storage-mobile-dashboard/id677826483?mt=8

The FlashSystem V9000 storage enclosure management modules are configured for active-passive redundancy. The management modules run a highly customized Linux-based operating system that coordinates and monitors all significant functions in the system.

The management modules 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. Because FlashSystem V9000 clusters together to form a system, a single management interface is used for FlashSystem V9000.

The storage configuration includes defining logical units with capacities, access policies, and other parameters. No software must be installed on host computers to administer FlashSystem V9000 beyond a web browser or a standard SSH client.

Supported platforms

FlashSystem V9000 has extensive interoperability with support for a wide range of operating systems (Microsoft Windows Server 2008 and 2012, Linux, and IBM AIX®),and IBM i), hardware platforms (IBM System x, IBM Power Systems™, and x86 servers not from IBM), HBAs, and SAN fabrics. For specific information, see the IBM System Storage® Interoperation Center (SSIC) website:

http://www.ibm.com/systems/support/storage/ssic/interoperability.wss

Physical and electrical specifications

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

FlashSystem V9000 control enclosure (9846-AC3 or 9848-AC3)

The FlashSystem V9000 control enclosure AC3 has the following specifications:

- Dimensions and weight
  - Height: 87.5 mm (3.44 in)
  - Width: 447.6 mm (17.62 in)
  - Depth: 801 mm (31.54 in)
  - Approximate weight:
    - Empty: 22.1 kg (48.72 lb)
    - Fully configured: 23.8 kg(52.47 lb)
- Temperature
  - Operating: 10°C to 35 °C (50°F to 95 °F) at 0 to 914 m (0 to 3,000 ft) and 10°C to 32 °C (50°F to 90 °F) at 914 to 2,133 m (3,000 to 7,000 ft)
  - Powered off: 10°C to 43 °C (50°F to 109 °F)
  - Storage: 1°C to 60 °C (34°F to 140 °F) at 0 to 2,133 m (0 to 7,000 ft)
  - Shipping: -20°C to 60 °C (-4°F to 140 °F) at 0 to 10,668 m (0 to 35,000 ft)
- Electrical power
  - Voltage: 200-240 Vac, 3.8 A,
  - Frequency: 50/60 Hz
- Relative humidity
  - Operating and powered off: 8% - 80%
  - Storage: 5% - 80%
  - Shipping: 5% - 100% (including condensation but excluding rain)
- Wet bulb:
  - Operating temp: 23 °C
  - Powered off temp: 27 °C
  - Storage and shipping temp: 29 °C
- Noise level:
  - 6.5 bels LwAd - when operating in a 19-inch system rack

FlashSystem V9000 storage enclosure (9846-AE2 or 9848-AE2)

The FlashSystem V9000 storage enclosure AE2 has the following specifications:

- Dimensions and weight
  - Width: 445 mm (17.5 in.) (19-inch Rack Standard)
  - Depth: 761 mm (29.96 in.)
  - Height: 86.2 mm (3.39 in.)
  - Weight: 34 kg (75 lb. fully loaded)
- Air temperature
  - Operating: 5°C - 35°C (50°F - 95°F) at 30.5 m below to 3,000 m above sea level (100 ft. below to 9,840 ft. above)
  - Non-operating: -10°C - 50°C (14°F - 125°F)

- Relative humidity
  - Operating: 20 - 80%
  - Non-operating: 10 - 90%
- Electrical power
  - Voltage range: 100 - 240 VAC
  - Frequency: 50 - 60 Hz
- Acoustical noise emission: 7.2 bels (LwAd) when operating in a 19-inch system rack
- Power consumption: 1300 watts maximum, 625 watts typical operation
- Heat dissipation: 1194 BTUs per hour

FlashSystem V9000 expansion storage enclosure (9846-24F or 9848-24F)

The FlashSystem V9000 storage expansion enclosure 24F has the following specifications:

- Dimensions and weight
  - Height: 87.5 mm (3.44 in)
  - Width: 447.6 mm (17.62 in)
  - Depth: 801 mm (31.54 in)
  - Approximate weight:
    - Empty: 19.0 kg (41.89 lb)
    - Fully configured: 27.3 kg (60.19 lb)
- Air temperature:
  - Operating: 5°C to 40°C (41°F to 104°F) up to 950 m (3,117 ft) above sea level. Above 950 m, de-rate maximum air temperature 1 degree per 175 m.
  - Non-operating: 1°C to 60°C (33.8°F to 140°F)
- Relative humidity:
  - Operating: 8% - 85%
  - Non-operating: 8% - 85%
- Electrical power:
  - AC Power
    - Voltage range: 100-240 V A
    - Frequency: 50-60 Hz
  - DC power:
    - Voltage range: -42 to -60 V DC
    - Voltage nominal: -48 V DC
    - Current: 12.0 A

FlashSystem V9000 expansion storage enclosure (9846-12F or 9848-12F)

The FlashSystem V9000 storage expansion enclosure 12F has the following specifications:

- Dimensions and weight
  - Width: 445 mm (17.5 in)
  - Depth: 556 mm (21.9 in)
  - Height: 87 mm (3.4 in)
  - Approximate weight:
    - Empty: 16.4 kg (36.1 lb)
    - Fully configured: 26.7 kg (58.7 lb)

- Air temperature:
  - Operating: 5°C to 40°C (41°F to 104°F) up to 950 m (3,117 ft) above sea level. Above 950 m, de-rate maximum air temperature 1 degree per 175 m.
  - Non-operating: 1°C to 60°C (33.8°F to 140°F)
- Relative humidity:
  - Operating: 8% - 85%
  - Non-operating: 8% - 85%
- Electrical power:
  - AC power:
    - Voltage range: 100-240 V AC
    - Frequency: 50-60 Hz
- DC power:
    - Voltage range: -42 to -60 V DC
    - Voltage nominal: -48 V DC
    - Current: 12.0 A

Note: All the noise emission levels stated above is 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

FlashSystem V9000 uses IBM Spectrum Virtualize software-defined storage features. FlashSystem V9000 data services are provided through FlashSystem V9000 Software. FlashSystem V9000 has both base and optional software licenses.

Base licensed features and functions

The following functions are provided with the FlashSystem V9000 base software license:

- 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 onto the FlashSystem V9000 system by using Fibre Channel connectivity. Dynamic migration helps speed data migrations from weeks or months to days, eliminating the cost of add-on migration tools and providing 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 FlashSystem V9000 system, so having a separate console is unnecessary. Point your web browser to the system.
- Easy Tier technology. This feature provides a mechanism to seamlessly migrate data to the most appropriate tier within the FlashSystem V9000. This migration can be to the internal flash memory within FlashSystem V9000 storage enclosure, or to external storage systems that are virtualized by FlashSystem V9000 control enclosure. EasyTier technology adds more blended economy of capacity, and is useful for cost-effective expansion and usage of your existing storage capacity investment.

  Easy Tier now supports up to three tiers of storage. For example, you can set up a storage pool intended for Easy Tier volumes where the pool is composed of the native

FlashSystem V9000 storage enclosures, low cost SSDs and high capacity nearline SAS drives.

- Automatic restriping of data across storage pools. When growing a storage pool by adding more storage to it, FlashSystem V9000 software can restripe your data on pools of storage without having to implement any manual or scripting steps. This helps grow storage environments with greater ease while retaining the performance benefits of striping the data across the disk systems in a storage pool.

The following functions are included with the FlashSystem V9000 base software license only for internal storage:

- FlashCopy. Provides a volume level point-in-time copy function for any storage that is virtualized by FlashSystem V9000. FlashCopy and snapshot functions enable you to create copies of data for backup, parallel processing, testing, and development, and have the copies available almost immediately.
- Real-time 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, Real-time Compression is designed to be 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 Fibre Channel 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 8000 km).

  Both functions support VMware Site Recovery Manager to help speed disaster recovery. FlashSystem V9000 remote mirroring interoperates with other FlashSystem V9000, FlashSystem V840, SAN Volume Controller, and Storwize V7000 storage systems.

FlashSystem Software is installable only on FlashSystem V9000 control enclosures and storage enclosures (9846-AC3, 9846-AE2, 9848-AC3, 9848-AE2, 9846-12F, 9846-24F, 9848-12F and 9848-24F).

Optional licensed features

The following optional licensed features are offered with the FlashSystem V9000 Software for external storage:

- External storage virtualization. Enables FlashSystem V9000 to manage capacity in other Fibre Channel SAN storage systems. When FlashSystem V9000 virtualizes a storage system, its capacity becomes part of the FlashSystem V9000 system. Capacity in external storage systems inherits all the functional richness of the FlashSystem V9000.
- Real-time 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, Real-time Compression is designed to be used with active primary data, such as production databases and email systems, dramatically expanding the range of candidate data that can benefit from compression.

  The IBM Spectrum Virtualize Real-time Compression for external storage license is a priced optional feature for external storage only. It is priced by capacity. A sufficient number of Storage Capacity Units (SCUs) is required to cover actual managed disk capacity consumed by the compressed volumes.

For details about the IBM Spectrum Virtualize Real-time Compression licensing rules, see

https://ibm.biz/BdrAyZ

- FlashCopy. Provides a volume level point-in-time copy function for any storage that is virtualized by FlashSystem V9000. 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.
- Remote Mirroring. Provides storage system-based data replication by using either synchronous or asynchronous data transfers over Fibre Channel 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 8000 km).

  Both functions support VMware Site Recovery Manager to help speed disaster recovery. FlashSystem V9000 remote mirroring interoperates with other FlashSystem products V9000, V840, and also IBM SAN Volume Controller, and V7000 storage systems.

IBM FlashSystem V9000 Software includes license compatibility with IBM Virtual Storage Center (VSC) through 5608-ACL. A VSC standard license, product identifier (PID) 5608-AE1, can be used to satisfy the license condition for External Virtualization, Remote Mirror, and FlashCopy.

The 5641-VC7 (External Virtualization, FlashCopy, and Remote Mirroring Features) and 5641-CP7 FC 0708 (Compression) licenses are licensed per enterprise within one country, and are the same licenses as for IBM SAN Volume Controller. Therefore, existing SAN Volume Controller licenses can be used for the FlashSystem V9000 for these features.

Table 10 lists the software license descriptions and feature codes.

Table 10 Base and optional software licenses

Program number or product ID	License type	Name
5639-RB7	Base	IBM FlashSystem V9000 Base: ► Thin Provisioning ► Easy Tier 3 ► Data migration ► Simple GUI ► Automatic re-striping of data across storage pools ► Single enclosure ► System entitled For internal storage only: ► FlashCopy ► Real-time Compression ► Remote Mirroring
5641-VC7 FC 0663	Optional	IBM Spectrum Virtualize External Virtualization
5641-VC7 FC 0679	Optional	IBM Spectrum Virtualize Remote Mirroring Software for external storage
5641-VC7 FC 0671	Optional	IBM Spectrum Virtualize FlashCopy for external storage
5641-CP7 FC 0708	Optional	IBM Spectrum Virtualize Real-time Compression for external storage

5608-ACL	Optional	IBM SmartCloud® Virtual Storage Center (VSC) for Storwize can be used for internal FlashSystem V9000 storage only. Can be combined with 5608-AE1
5608-AE1	Optional	IBM SmartCloud Virtual Storage Center Standard can be used for FlashSystem V9000 internal storage and external storage. Can be combined with 5608-ACL

Note: When a FlashSystem V9000 Control Enclosure 9846 or 9848 is used as the hardware virtualization engine, IBM SmartCloud Virtual Storage Center for Storwize Family (5608-ACL), which uses a storage device (also referred to as enclosure) pricing model, may be licensed only for the capacity internal to the FlashSystem V9000 system. All external capacity managed and virtualized by the FlashSystem V9000 must be licensed with SmatCloud Virtual Storage Center (standard), 5608-AE1, license (priced per terabyte). All required base software licenses for FlashSystem V9000 must also be purchased.

How to count and order licenses

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

Figure 17 shows the base and the optional software licenses that can be ordered for FlashSystem V9000. Also shown in Figure 17 is a color key for each software license that maps to the licenses used in the examples in the following sections.

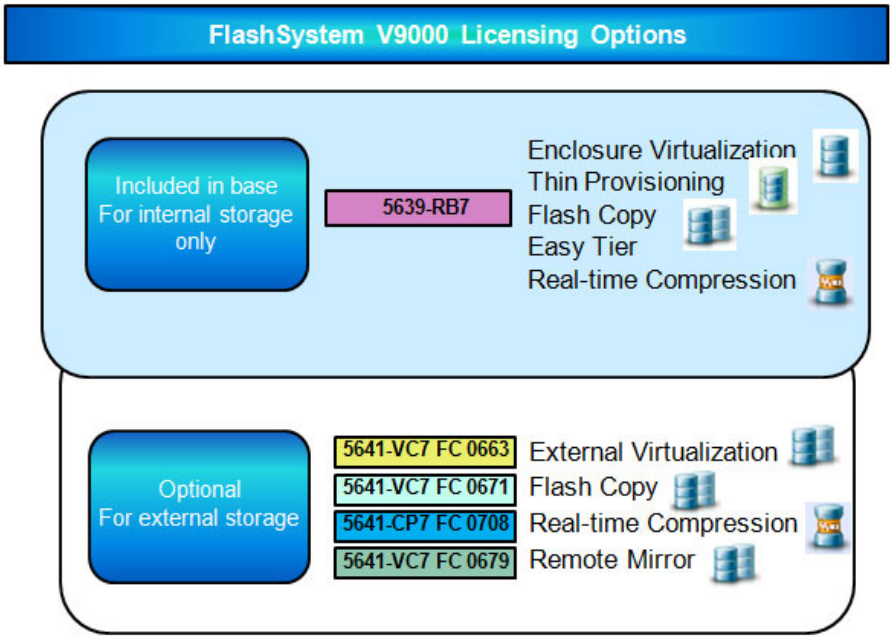


Figure 17 FlashSystem V9000 license structure

Differential Licensing

Starting with version 7.7 of IBM Spectrum Virtualize, Differential Licensing is used to calculate the license needed for a given configuration. With Differential Licensing, licenses change from per terabyte to per storage capacity unit (SCU).

Note: Storage Capacity Units (SCUs) are only needed for external virtualized storage. The FlashSystem V9000 Base software license (5639-RB7) includes all needed licenses to use capacity and functions on FlashSystemV9000 storage enclosures (9846-AE2, 9848-AE2, 9846-12F, 9846-24F, 9848-12F and 9848-24F).

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

- Category 1: Flash and solid-state drives (SSD)
- Category 2: Serial-attached SCSI (SAS) drives, Fibre Channel drives, and systems using drives with advanced architectures to deliver high-end storage performance
- Category 3: Nearline SAS (NL-SAS) and Serial ATA (SATA) drives

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

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

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

Table 11 shows an example of calculating SCUs. The example is a customer who virtualizes external disk arrays with 30 TB SSD, 200 TB SAS and 2400 TB nearline capacity.

Table 11 Example of calculating SCUs

Category	Type	Capacity	Factor	SCU
Category 1	SSD	30	x 1	30
Category 2	SAS	200	x 0.85	170
Category 3	Nearline	2400	x 0.25	600
				800

800 SCUs are required for the example in Table 11. When calculating the count 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, a sufficient number of SCUs is required to cover actual managed disk capacity consumed by the compressed volumes.

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

For more information about Differential Licensing, see IBM Software Announcement 216-212 regarding new IBM Spectrum Virtualize Software V7.7 software features.

https://ibm.biz/BdrAyZ

IBM FlashSystem V9000 Base Software (5639-RB7)

IBM FlashSystem V9000 Base Software (5639-RB7) provides core software functionality, and is required in all FlashSystem V9000 offerings. The software includes components that are installed on FlashSystem V9000 control enclosures (9846-AC3 or 9848-AC3), but licensing is based solely on the quantity of storage enclosures that are included in the system. Each FlashSystem V9000 storage enclosure (9846-AE2, 9848-AE2, 9846-12F, 9846-24F, 9848-12F and 9848-24F) requires one 5639-RB7 FlashSystem V9000 Base Software license.

Example 1

A FlashSystem V9000 order consisting of two control enclosures and one storage enclosure requires a quantity of one FlashSystem V9000 Base Software license. No SCUs are required. Figure 18 illustrates the FlashSystem V9000 Base Software license.

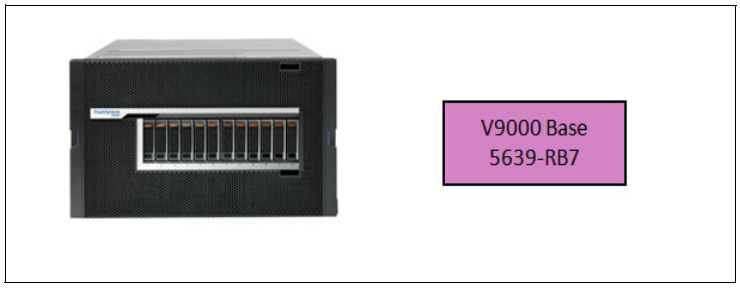


Figure 18 FlashSystem V9000 Base Software license two control enclosures and one storage enclosure

Example 2

A FlashSystem V9000 order consisting of two control enclosures and four storage enclosures requires a quantity of four FlashSystem V9000 Base Software licenses. No SCUs are required. Figure 19 illustrates the FlashSystem V9000 Base Software license with two additional Storage Expansion enclosure model AE2 and one model 24F.

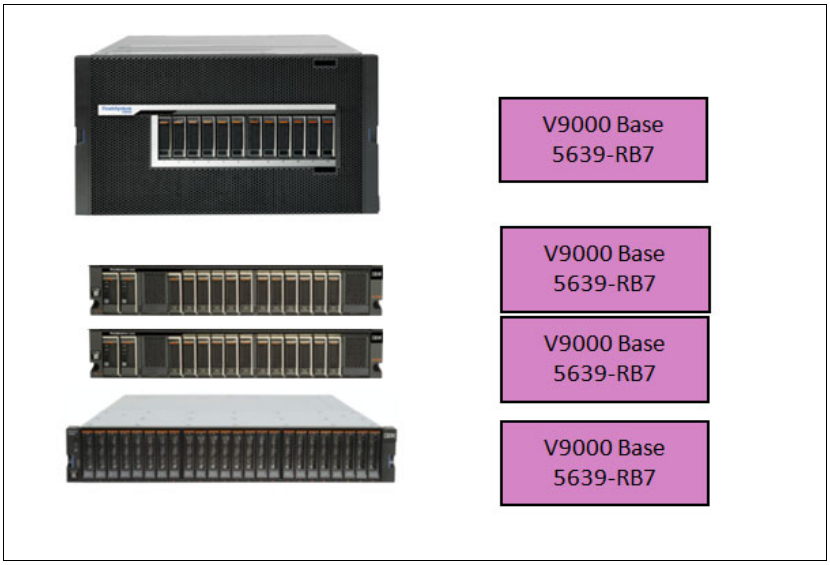


Figure 19 FlashSystem V9000 Base Software license with two control enclosures and four storage enclosures

IBM Spectrum Virtualize External Virtualization Software (5641-VC7 FC 0663)

Each FlashSystem V9000 control enclosure (9846-AC3 or 9848-AC3) can attach and manage external storage devices in the SAN in the same way, as the IBM SAN Volume Controller. To authorize the usage of this function, you must license the IBM Spectrum Virtualize software External Virtualization feature code. FlashSystem V9000 storage enclosures (9846-AE2, 9848-AE2, 9846-12F, 9846-24F, 9848-12F and 9848-24F) are not considered externally attached storage enclosures, and do not require separate licenses.

The FlashSystem V9000 External Virtualization feature is an optional feature only for external storage, and is priced per storage capacity units.

Example 3

For a FlashSystem V9000 to virtualize a Storwize V5030 with 10 TB SSD, 40 TB SAS and 50 TB nearline capacity, a quantity of one FlashSystem V9000 Base Software license and one 5641-VC7 FC 0663 (External Virtualization) are required. 57 SCUs are required for External Virtualization. Figure 20 illustrates this configuration.

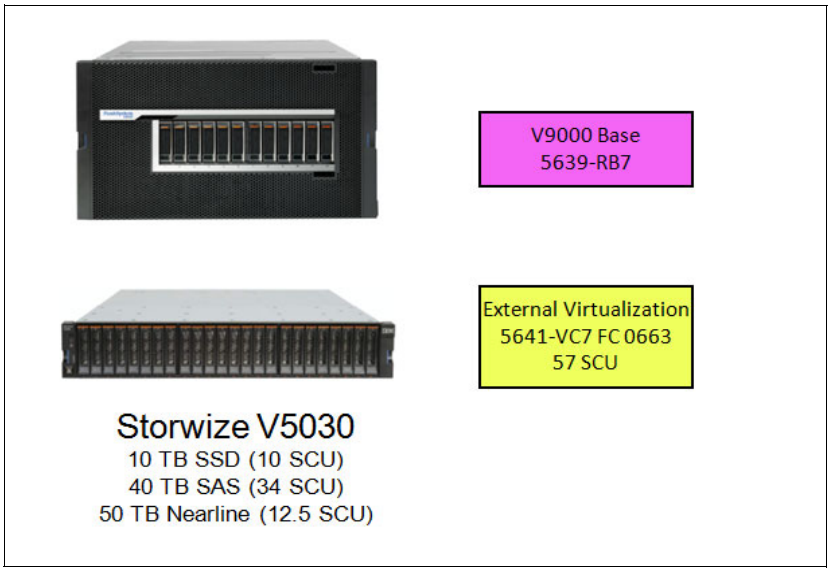


Figure 20 FlashSystem V9000 with External Virtualization license

In the example in Figure 20, 12.5 SCU from nearline capacity has to be rounded up to 13 SCUs.

IBM Spectrum Virtualize Real-time Compression for external storage (5641-CP7 FC 0708)

To authorize the use of Real-time Compression capabilities of the FlashSystem V9000 for external storage, you must purchase the IBM Spectrum Virtualize Real-time Compression for external storage license.

The IBM Spectrum Virtualize Real-time Compression for external storage license is a priced optional feature for external storage only. It is priced by capacity. A sufficient number of SCUs is required to cover actual managed disk capacity consumed by the compressed volumes.

For details about the IBM Spectrum Virtualize Real-time Compression licensing rules, see

https://ibm.biz/BdrAyZ

Example 4

A FlashSystem V9000 virtualizing a Storwize V5030 with 50 TB of physical SAS-disk storage and 100 TB of uncompressed volumes requires a quantity of one FlashSystem V9000 Base Software license, one 5641-VC7 FC 0663 (External Virtualization license), and one 5641-CP7 FC 0708 (Real-time Compression license). 43 SCUs are required for External Virtualization and 12 SCU for Real-time Compression.

Note: This model assumes a compression ratio of 4:1 on the uncompressed volumes for resulting 12,5 TB(13TB) of managed disk usage of compressed volumes. This is purely for the example to show the new compression charging model. Compression ratio of volumes is dependent on data types and so on, and might not actually be to this level of compression.

Figure 21 illustrates this configuration.

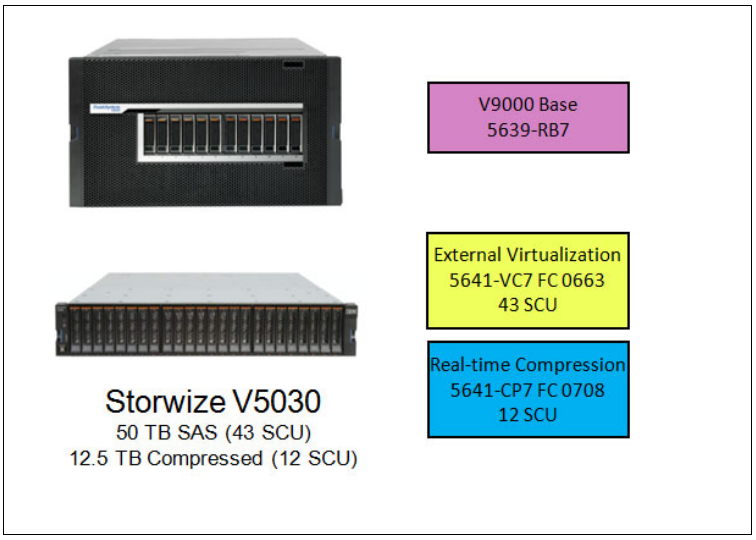


Figure 21 FlashSystem V9000 with External Virtualization and Compression license

IBM Spectrum Virtualize Remote Mirroring Software for external storage (5641-VC7 FC 0679)

To authorize the use of Remote Mirroring Software capabilities of the FlashSystem V9000 for external storage, you must purchase the IBM Spectrum Virtualize Remote Mirroring Software for external storage license.

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

Example 5

A FlashSystem V9000 virtualizing a Storwize V5030 with 100 TB SAS-disk storage and mirroring it to a second FlashSystem V9000 with an IBM XIV with 100 TB requires a quantity of two FlashSystem V9000 Base Software licenses, two 5641-VC7 FC 0663 (External Virtualization license) and two 5641-VC7 FC 0679 (Remote Mirror license) for 100 TB. 85 SCUs are required for each of the External Virtualization licenses. Figure 22 illustrates this configuration.

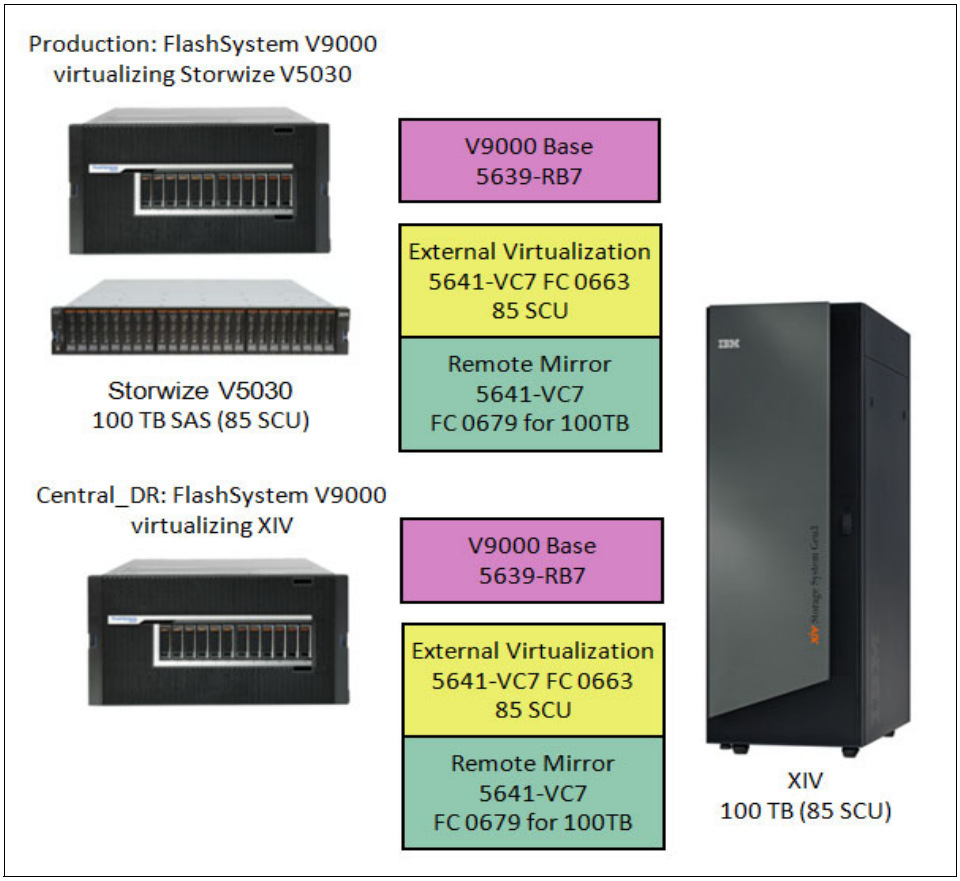


Figure 22 FlashSystem V9000 with External Virtualization and Remote Mirror license

IBM Spectrum Virtualize FlashCopy for external storage (5641-VC7 FC 0671)

To authorize the use of FlashCopy Software capabilities of the FlashSystem V9000 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 6

A FlashSystem V9000 virtualizing a Storwize V5030 with 50 TB SAS-disk capacity and 25 TB FlashCopy volumes requires a quantity of one FlashSystem V9000 Base Software license, one 5641-VC7 FC 0663 (External Virtualization license) and one 5641-VC7 FC 0671 (FlashCopy license) for 25 TB. 43 SCUs are required for External Virtualization. Figure 23 illustrates this configuration.

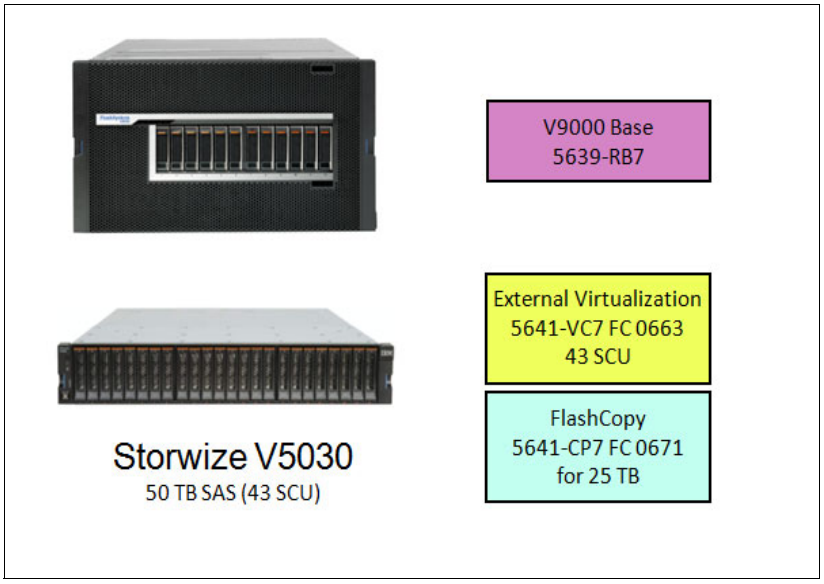


Figure 23 FlashSystem V9000 with External Virtualization and FlashCopy license

Warranty information and upgrades

FlashSystem V9000 includes a one-year or a three-year warranty.

Technical Advisor support is provided during the warranty period. 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 to allow customers to maximize IT availability.

Technical Advisor support for FlashSystem V9000 is delivered remotely, and includes a documented support plan, coordinated problem and crisis management that reports on your hardware inventories and software levels, and consultation regarding FlashSystem software updates. The Technical Advisor conducts a Welcome Call with the client, and provides a statement of work for this support.

FlashSystem V9000 Enterprise Class Support

Enterprise Class Support is available only for the FlashSystem V9000 machines types 9848 that have been purchased with a three-year warranty. The following machine and model types qualify for Enterprise Class Support:

- IBM FlashSystem V9000 Control Enclosure (9848- AC3)
- IBM FlashSystem V9000 SFF Expansion Enclosure (9848-24F)

For more information about this offering see “FlashSystem V9000 Enterprise Class Support” on page 21.

In addition, the following previously announced IBM FlashSystem V9000 elements also qualify, if they are purchased after August 23, 2016, with a three-year warranty,

- IBM FlashSystem V9000 Control Enclosure (9848-AC2)
- IBM FlashSystem V9000 Storage Enclosure (9848-AE2)
- IBM FlashSystem V9000 LFF Expansion Enclosure (9848-12F)

IBM Global Financing

IBM Global Financing offers competitive financing to credit-qualified customers and IBM Business Partners to assist them in acquiring IT solutions. Our offerings include financing for IT acquisition, including hardware, software, and services, from both IBM and other manufacturers or vendors, and commercial financing (revolving lines of credit, term loans, acquisition facilities, and inventory financing credit lines) for IBM Business Partners.

Offerings (for all customer segments: small, medium, and large enterprise), rates, terms, and availability can vary by country. For more information, contact your local IBM Global Financing organization or go to the following website:

http://www.ibm.com/financing

Ordering information

For information about ordering FlashSystem V9000 building block components see “FlashSystem V9000 components” on page 20.

For information about ordering hardware features see “Options and feature codes” on page 28.

For information about ordering software licenses see “Software and licensing” on page 38.

Related information

For more information, see the following documents:

IBM Redbooks:

- *IBM FlashSystem V9000 Version 7.6 Product Guide,* REDP-5317

  http://www.redbooks.ibm.com/abstracts/redp5317.html
- *Introducing and Implementing IBM FlashSystem V9000*, SG24-8273
- IBM FlashSystem V9000 product page

  http://www.ibm.com/systems/storage/flash/v9000/
- IBM Offering Information page (announcement letters and sales manuals)

  http://www.ibm.com/common/ssi/index.wss?request_locale=en

Authors

This Product Guide was produced by a team of specialists from around the world working in partnership with the IBM International Technical Support Organization.

Jon Herd is an IBM Storage Technical Advisor working for the European Storage Competence Center (ESCC), Germany. He covers the United Kingdom (UK) and Ireland, advising IBM clients on a portfolio of IBM storage products, including FlashSystem products. Jon has been with IBM for more than 40 years, and has held various technical roles, including Europe, Middle East, and Africa (EMEA)-level support on mainframe servers and technical education development. He holds IBM certifications in Supporting IT Solutions at an expert level, and Actualizing IT Solutions at an experienced level. He is also a certified Member of the British Computer Society (MBCS) Chartered IT Professional (CITP), and a certified Member of the Institution of Engineering and Technology (MIET).

Carsten Larsen is an IBM Certified Senior IT Specialist working for the Technical Services Support (TSS) in IBM Denmark. Carsten delivers consultancy services to IBM clients on storage technologies. Carsten's responsibilities include delivering project management and storage implementation and migration services. Carsten joined IBM in 2007, leaving behind a job at Hewlett-Packard where he worked on HP Storage Arrays and UNIX for 10 years. Carsten has a obtained several Brocade and NetApp certifications. Carsten is the author of a number of IBM Redbooks on Brocade, NetApp and IBM Spectrum Virtualize products.

The project that produced this publication was managed by **Marcela Adan**, IBM Redbooks Project Leader, ITSO.

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

Dave Gimpl
Senior Technical Staff Member (STSM) and Integration Architect, IBM Flash Solutions

Philip Clark
Senior Product Manager, IBM FlashSystem

Oiza Dorgu
Delivery Project Executive, IBM FlashSystem

Megan Grohman
Offering Manager, IBM FlashSystem

Kim Miller
Education Developer, IBM Global Technology Services®

Emily Richuso
Offering Manager, IBM FlashSystem

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