

IBM FlashSystem V9000 Version 7.6 Product Guide

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Storage

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Today's information technology (IT) infrastructure is fully entwined with basic business operations, so crucial business questions become IT questions. What is it worth to stay ahead of the competition? What is a better online customer experience worth to the bottom line? What advantages are gained by making faster, more informed business decisions?

Can you afford not to have the best possible fraud protection and data security? When you answer these business-critical questions in terms of IT infrastructure, and recognize the crucial role storage plays in correct answers, the value of IBM® FlashSystem™ skyrockets.

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 V7.6, extra functions are available, including VMware vSphere Virtual Volumes (vVol) support, encryption support for externally virtualized storage, and an integrated IBM Comprestimator utility. Support also exists for VMware 6 that enhances and improves scalability in a VMware environment. FlashSystem V9000 Software version 7.6 replaces version 7.5, and is available to all IBM FlashSystem V9000 customers with current warranty or software maintenance agreements.

Note: For information about IBM FlashSystem V9000 version 7.7, see *IBM FlashSystem V9000 Version 7.7 Product Guide* at <http://www.redbooks.ibm.com/abstracts/redp5409.html>

Figure 1 on page 2 shows the IBM FlashSystem V9000 product.



Figure 1 IBM FlashSystem V9000

Did you know?

FlashSystem V9000 version 7.6 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 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 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 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 VSC 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

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

- ▶ Two FlashSystem V9000 control enclosures (CEs)
- ▶ One FlashSystem V9000 storage enclosure (SE)

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:

- ▶ Scalable performance
- ▶ Enduring economics
- ▶ Agile integration

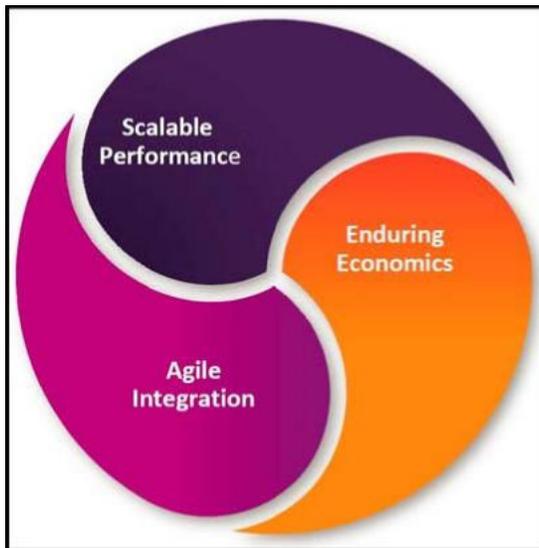


Figure 2 IBM FlashSystem V9000 dimensions of value Scalable performance

Scale-up or scale-out, independently

FlashSystem V9000 has the following scalable performance attributes:

- ▶ Scalable to 2.5 million IOPS
- ▶ Scalable to 19.2 Gigabytes per second (GBps) bandwidth
- ▶ Sustained IBM MicroLatency
- ▶ Quality of service
- ▶ Faster applications

Enduring economics

FlashSystem V9000 provides the following performance economics:

- ▶ Scalable to 2.2 PB effective capacity
- ▶ 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.

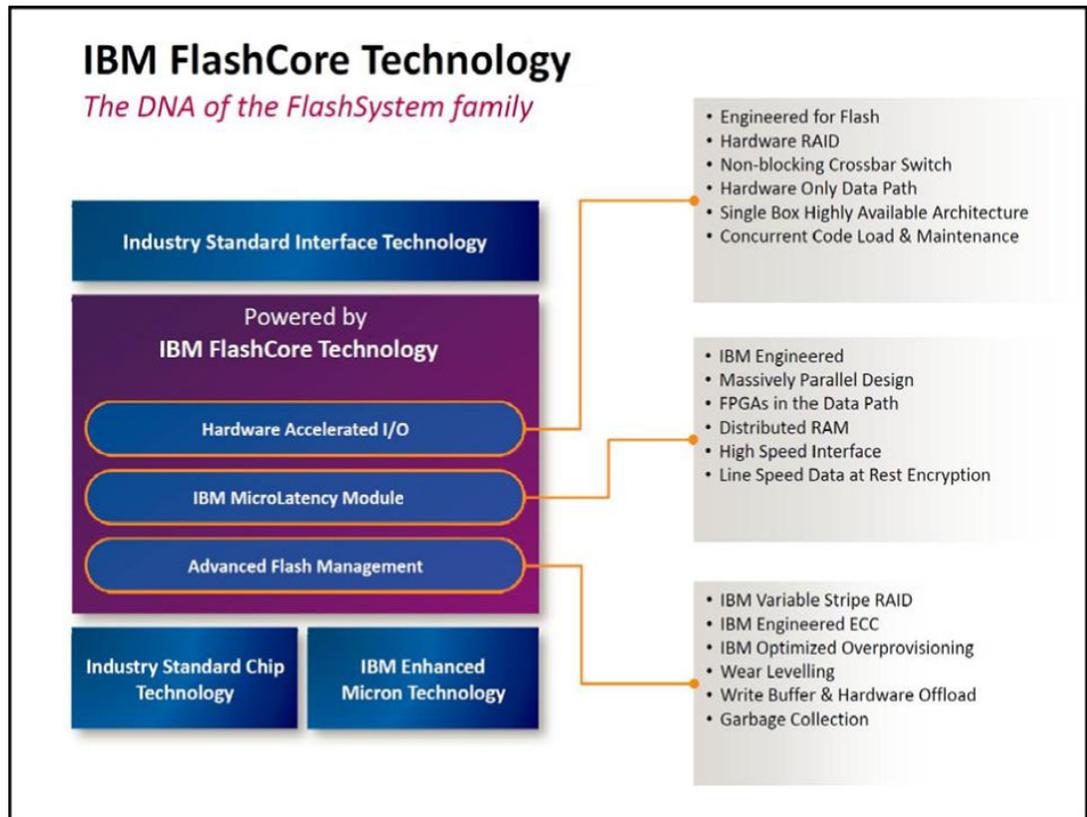


Figure 3 IBM FlashCore technology

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 Comprestimator 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 (BB) is composed of two FlashSystem V9000 control enclosures and one FlashSystem V9000 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.

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, Real-time Compression, and HyperSwap capability.

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 capacity in only 6U.
- ▶ Up to 456 TB usable and 2.28 PB effective capacity in only 36U.
- ▶ Up to 2.5 million IOPS and 19.2 GBps bandwidth.
- ▶ 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 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

By offering extreme performance and MicroLatency, FlashSystem V9000 can take the place of multiple racks of hard disk drives (HDDs) in a small footprint. FlashSystem V9000 can decrease your total cost of ownership (TCO) by lowering your power, space, and cooling costs, and reducing your software licensing expenses.

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 AC2 control enclosure offers several features for Real-time Compression workloads, including a second Intel Xeon E5 v2 Series eight-core processor with 32 GB of memory, and up to two optional 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, 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 V7.6 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 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 2.1. 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 configurations, 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 are available with this release.

HyperSwap for FlashSystem V 9000

HyperSwap capability 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 V7.6 includes Remote Mirroring for the internal enclosures (AE2s). 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.

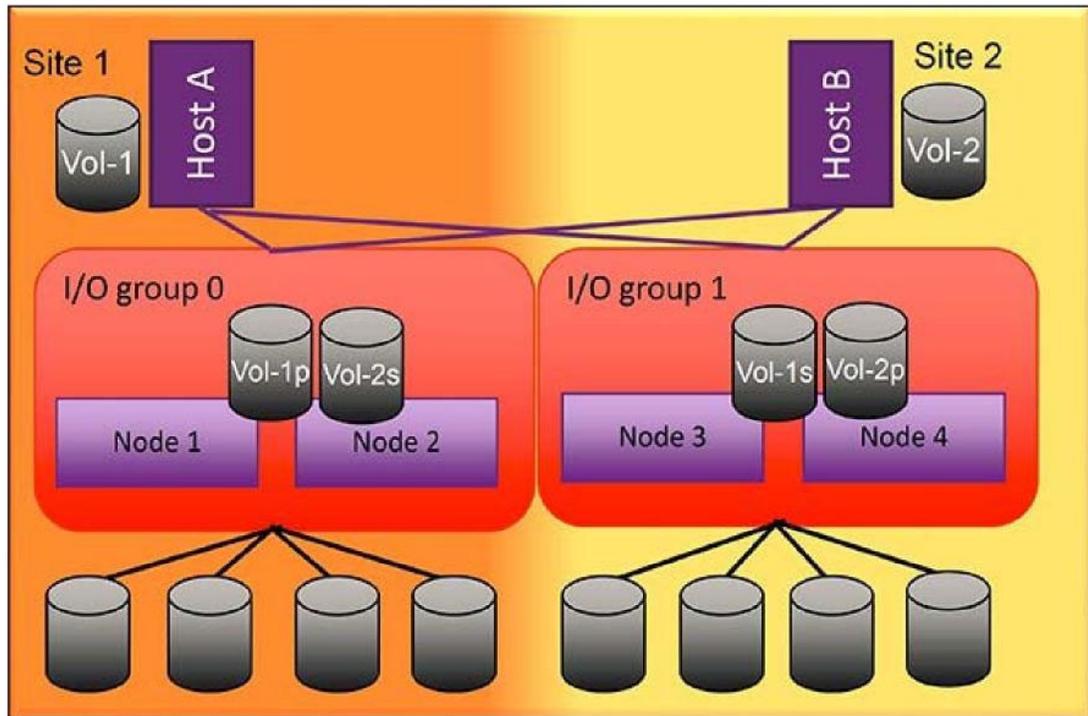


Figure 4 HyperSwap function

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

Integrated Comprestimator

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

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

Increased maximum quantity of iSCSI hosts

For more scalable iSCSI host support, release 7.6 increases the maximum number of iSCSI host sessions from 256 to 1024 per node, offering more fanout for each FlashSystem V9000 I/O group.

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 storage enclosure (SE), representing a fixed building block (BB). 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, Appendix A:

<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 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 storage enclosures to be added to the storage system. If 228 TB from four building blocks is not enough capacity, up to four extra storage enclosures (SEs) can then be added.

In total, a FlashSystem V9000 Storage System can contain a maximum of eight FlashSystem V9000 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.

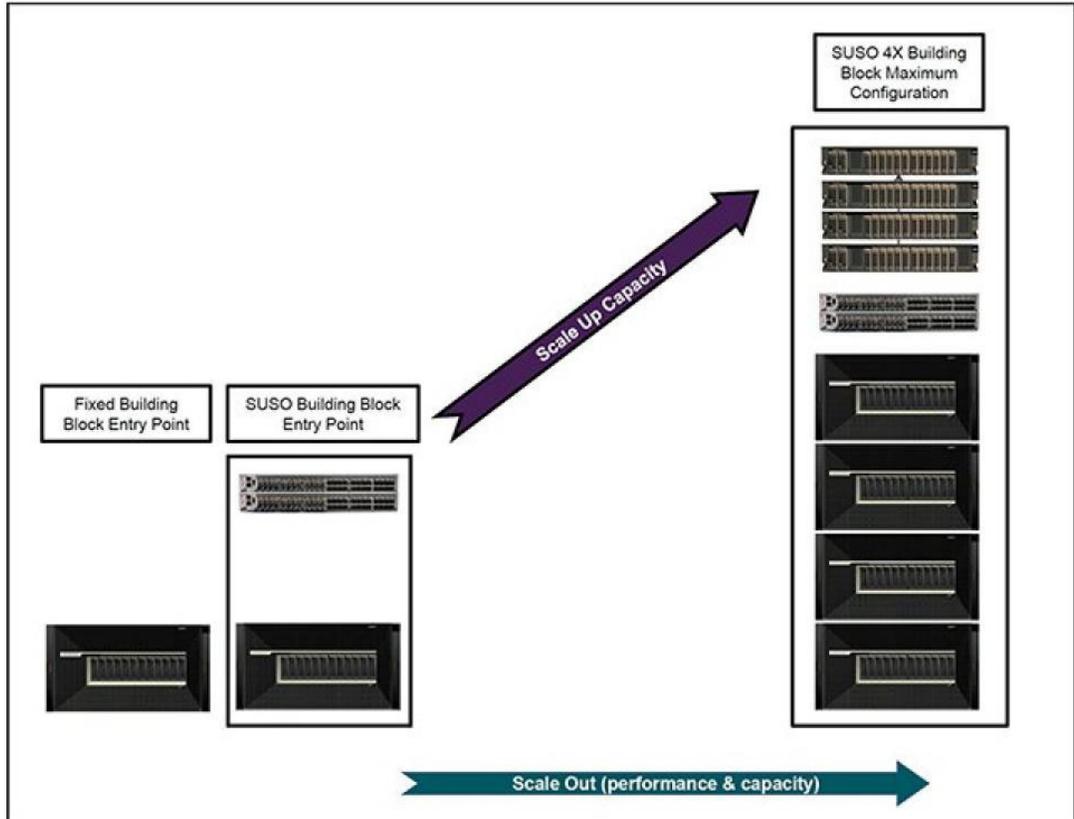


Figure 5 FlashSystem V9000 fixed building block versus scalable building block capacity

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

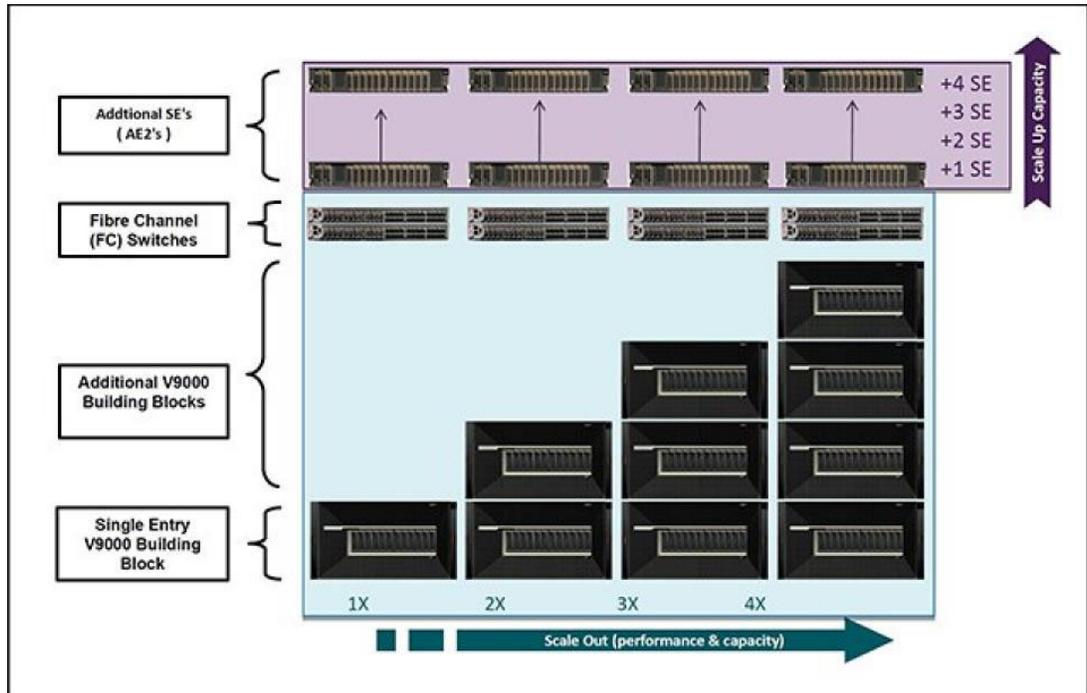


Figure 6 FlashSystem V9000 scalable capacity

Table 1 summarizes the minimum and maximum capacity for scalable BBs, including the addition of storage enclosures SEs.

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

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

Table 2 Host port count per building blocks

	8 GB FC	16 GB FC	10 GB FCoE	8 GB & 10 GB IP Mirror	16 GB FC & 10 GB Mirror
1X	16	8	8	8,8	4,8
2X	32	16	16	16,16	8,16
3X	48	24	24	24,24	12,24
4X	64	32	32	32,32	16,32

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 EasyTier, 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 enclosure and the FlashSystem V9000 storage enclosure. 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.
- ▶ 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 part numbers

Description	Machine type-model
FlashSystem V9000 control enclosure	9846-AC2 or 9848-AC2
FlashSystem V9000 storage enclosure	9846-AE2 or 9848-AE2

Note: The Ordering System (eConfig) has a convenience function. Extra Fibre Channel switches can be easily and quickly added to the order to create a scalable configuration.

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:

- ▶ 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 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 control enclosure features

FlashSystem V9000 control enclosure provides advanced data services for flash memory. It is a 2U, 19-inch rack-mount enclosure. 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 8 Gb Fibre Channel, 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
- ▶ Dual eight-core processor
- ▶ 64 GB memory
- ▶ Options for connectivity including four host interface cards (8 Gb FC, 16 Gb FC, and 10 GbE)
- ▶ Optional compression accelerator feature (#AH1A), required to run Real-time Compression (must purchase a quantity of two)
- ▶ Two integrated ac power supplies and battery units

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 7 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 (AC2) cannot see the other FlashSystem V9000 control enclosure.

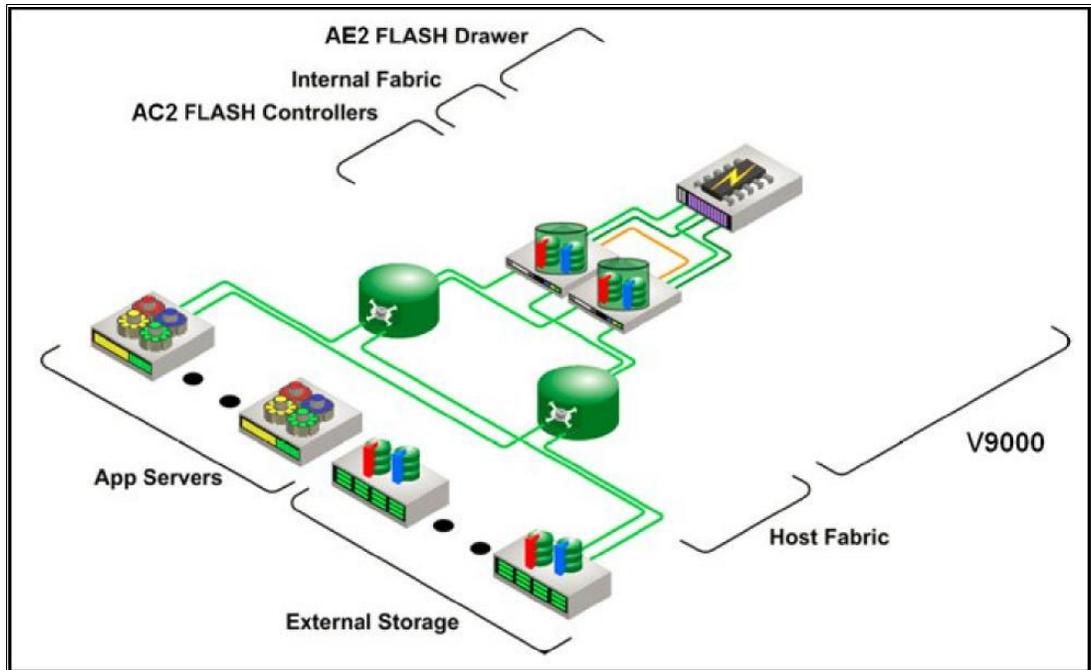


Figure 7 FlashSystem V9000: Generalized view of host connectivity topology

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 system.

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 8 Front view of FlashSystem V9000 storage enclosure

The rear of the FlashSystem V9000 storage enclosure (Figure 9) 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 9 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.

Product specifications

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

Table 4 IBM FlashSystem V9000 base configuration specifications

IBM FlashSystem V9000	
Models	9846/8-AC2 and 9846/8-AE2
Flash type	IBM-enhanced MLC
Form Factor	6U rack-mount
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, 8 x 2.9 TB, 10 x 2.9 TB, 12 x 2.9 TB, 8 x 5.7 TB, 10 x 5.7 TB, and 12 x 5.7 TB
Maximum storage capacity	<ul style="list-style-type: none"> ▶ Internal storage enclosures: Scalable from 2.2 TB (usable) up to 456 TB with full scale-out of control and storage enclosures. ▶ Effective internal: From 12 TB to 2.2 PB with full scale-out of CEs and SEs (@ 80% reduction with Real-time Compression). ▶ External: Up to 32 PB usable capacity (requires External Virtualization).
Maximum Performance: Fixed building block (100% read, cache miss)	
Minimum latency (4K)	200 µs
IOPS (4K)	526,000
Bandwidth (128K)	6.2 GBps
Maximum Performance: Scalable building block (100% read, cache miss)	
Latency (4K)	200 µs
IOPS (4K)	630,000
Bandwidth (128K)	6.2 GBps
Maximum Performance: Scaled out (100% read, 4 building blocks)	
Latency (4K)	200 µs
IOPS (4K)	2,520,000
Bandwidth (128K)	19.2 GBps
Data reduction IOPS (4K)	1,250,000
Reliability, availability, and serviceability (RAS) features	<ul style="list-style-type: none"> ▶ 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

Maximum Performance: Scaled out (100% read, 4 building blocks)	
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	AES-XTS 256
FlashSystem V9000 fixed building block - host connectivity options	<ul style="list-style-type: none"> ▶ 8 x 16 Gb Fibre Channel ▶ 10 x 8 Gb Fibre Channel ▶ 8 x 10 Gb Fibre Channel over Ethernet (FCoE) ▶ 8 x 10 Gb iSCSI
FlashSystem V9000 scalable building block - host connectivity options	<ul style="list-style-type: none"> ▶ 12 x 16 Gb Fibre Channel ▶ 16 x 8 Gb Fibre Channel ▶ 8 x 10 Gb Fibre Channel over Ethernet (FCoE) ▶ 8 x 10 Gb iSCSI
Virtualization software model	5639-RB7
Shared symmetric multiprocessing (SMP) processor configuration	Two Intel Xeon E5 v2 Series eight-core processor
Processor memory	64 GB
Dimensions (height x width x depth)	6U x 445 mm x 761 mm (6U x 17.5 in. x 29.96 in.)
Weight	78 kg (171.8 lb.) fully loaded

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)
8 Gb FC 8 Port Host Optics	AF18	2	Set of 8 Gb Fibre Channel optics to enable eight ports	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 eight 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-AC2 and 9848-AC2 machine types.

Table 6 Control enclosures and interface components support for machine type 9846/8-AC2 (part 1 of 2)

Item	Feature code	Max quantity	Description	Ports
8 Gb FC with 4-port host optics	AH10	3	This feature provides one I/O adapter with four 8 Gb Fibre Channel ports and shortwave SFP transceivers: <ul style="list-style-type: none"> ► Compatibility conflicts: Cannot coexist with #AF44. ► Limitations: Three of #AH10 must be ordered if #AH11 or #AH12 or #AF44 are not present on the order. 	Up to 12 ports of 8 Gb Fibre Channel
16 Gb FC with 2-port host optics	AH11	4	This feature provides one I/O adapter with two 16 Gb Fibre Channel ports and shortwave SFP transceivers: <ul style="list-style-type: none"> ► Compatibility conflicts: Cannot coexist with feature #AF44. 	Up to eight ports of 16 Gb Fibre Channel
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: <ul style="list-style-type: none"> ► Three of #AH44 must be ordered on model AC2 and two of #AF19 must be ordered on model AE2, or ► Two of #AH44 must be ordered on model AC2 ordered and two of #AF19 must be ordered on model AE2, or ► Three of #AH11 must be ordered on model AC2 and two of #AF19 must be ordered on model AE2, or ► Two of #AH11 must be ordered on model AC2 ordered and two of #AF19 must be ordered on model AE2, or ► One of #AH10 and 2 of #AH11 must be ordered on model AC2 and two of #AF18 must be ordered on model AE2, or ► Two of #AH10 and 2 of #AH11 must be ordered on model AC2 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: <ul style="list-style-type: none"> ► Compatibility conflicts: Cannot coexist with feature #AH10 or #AH11. ► Notes: <ul style="list-style-type: none"> – If four of #AH44 are ordered, no additional adapters can be ordered on model AC2. – If three of #AH44 are ordered, zero or one of #AH12 can be ordered on model AC2. – If two of #AH44 are ordered, one of #AH12 must be ordered on model AC2. – Two of #AF19 must be ordered on model AE2. ► Limitations: Must be ordered in quantities of 0, 2, 3, or 4. 	Up to 16 ports of 16 Gb Fibre Channel
8 Gb FC longwave small form-factor pluggable (SFP) transceivers (2)	AH1T	3	Set of 8 Gb Fibre Channel longwave transceivers for use with 4-Port Gb FC Card, prerequisite # AH10.	Up to 12 ports of 8 Gb Fibre Channel
16 Gb FC longwave SFP transceivers (2)	ACHU	4	This feature provides two 16 Gb longwave SFP transceivers for use with 2-Port 16 Gb FC Card (feature #AH11) or 4-Port 16 Gb FC Card (feature #AF44). Prerequisites: Feature #AH11 or #AF44.	Up to eight ports of 16 Gb FC for #AH11 or Up to 16 ports of 16 Gb FC for #AF44

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 $(n-1) + \text{parity stripe}$. 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
5 m Fiber Cable (LC-LC)	5305
25 m Fiber Cable (LC-LC)	5325
US 250V/10A 6 ft.	9714
Power supplies	Feature code
1300 W power supply	AF1H
Priced optional features: Power cords for control enclosure	Feature code
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
Fixed V9000 Building Block (NOT SCALABLE)	AF3F

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
5 m Fiber Cable (LC-LC)	5305
25 m Fiber Cable (LC-LC)	5325
US 250V/10A 6 ft.	9714
Power supplies	Feature code
1300 W power supply	AF1H
Priced optional features: Power cords for control enclosure	Feature code
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
Fixed V9000 Building Block (NOT SCALABLE)	AF3F

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 doesn't 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/fsV9000kc>

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, 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®), hardware platforms (IBM System x, IBM Power Systems™, and x86 servers not from IBM), HBAs, and SAN fabrics. For specific information, see the 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-AC2 or 9848-AC2)

The FlashSystem V9000 CE has the following specifications:

- ▶ Dimensions and weight
 - Width: 445 mm (17.5 in.)
 - Depth: 746 mm (29.4 in.)
 - Height: 86 mm (3.4 in.)
 - Weight:
 - Empty: 21.1 kg (46.4 lb.)
 - Fully configured: 22.0 kg (48.4 lb.)
- ▶ Air temperature
 - Operating: 5°C - 40°C (41°F - 104°F) up to 950 m (3,117 ft.)
 - Powered off: 1°C - 60°C (33.8°F - 140°F)
 - Storage: 1°C - 60°C (34°F - 140°F) at 0 - 2,133 m (0 - 7,000 ft.)
 - Shipping: -20°C - 60°C (-4°F - 140°F) at 0 - 10,668 m (0 - 35,000 ft.)
- ▶ Relative humidity
 - Operating: 8 - 85%
 - Non-operating: 8 - 85%
- ▶ Electrical power
 - Voltage range: 100 - 240 V ac o Frequency: 50 - 60 Hz
 - Power: 750 watts
- ▶ Heat dissipation (British thermal units (BTUs) per hour): 512
- ▶ Acoustical noise emission: 6.3 bels (idling and operating)

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

The FlashSystem V9000 SE has the following specifications:

- ▶ Dimensions and weight
 - o Width: 445 mm (17.5 in.) (19-inch Rack Standard)
 - o Depth: 761 mm (29.96 in.)
 - o Height: 86.2 mm (3.39 in.)
 - o 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

Software and licensing

FlashSystem V9000 uses IBM Storwize 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 FlashSystem V9000 storage enclosures, 15,000 RPM Fibre Channel disk drives, and SAS disk 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-AC2, 9846-AE2, 9848-AC2, and 9848-AE2).

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.

Note (revised licensing rules for SAN Volume Controller Real-time Compression Software (5641-CP7): SAN Volume Controller Real-time Compression Software (5641-CP7) is used to provide compression functionality for storage externally virtualized by the IBM FlashSystem V9000. Rather than using the volume size as the measure for determining how many terabytes of SAN Volume Controller Real-time Compression 5641-CP7 to license as previously announced, effective immediately for all licensed SAN Volume Controller Real-time Compression users, the measured terabyte capacity now applies to the actual managed disk capacity consumed by the compressed volumes.

For details about the new IBM Spectrum Virtualize Software Real-time Compression licensing rules, see *RFA Announcement 70772 - IBM FlashSystem V9000 Software V7.6*.

- ▶ 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: <ul style="list-style-type: none"> ▶ 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: <ul style="list-style-type: none"> ▶ FlashCopy ▶ Real-time Compression ▶ Remote Mirroring
5641-VC7 FC 0663	Optional	IBM FlashSystem V9000 External Virtualization
5641-VC7 FC 0679	Optional	IBM FlashSystem V9000 Remote Mirroring Software for external storage
5641-VC7 FC 0671	Optional	IBM FlashSystem V9000 FlashCopy for external storage
5641-CP7 FC 0708	Optional	IBM FlashSystem V9000 Real-time Compression for external
5608-ACL	Optional	IBM Virtual Storage Center (VSC) for Storwize Notes: <ul style="list-style-type: none"> ▶ Can be used only for FlashSystem V9000 internal storage ▶ 5608-AE1 can be used for FlashSystem V9000 internal storage and external storage

How to count and order licenses

Understand the base and optional licensing features, and how to calculate and determine the software licenses to order for your environment.

Figure 10 shows the base and the optional software licenses that can be ordered for FlashSystem V9000. Also shown in Figure 10 is a color key that maps to the software licenses that are described for the following topics and diagrams.

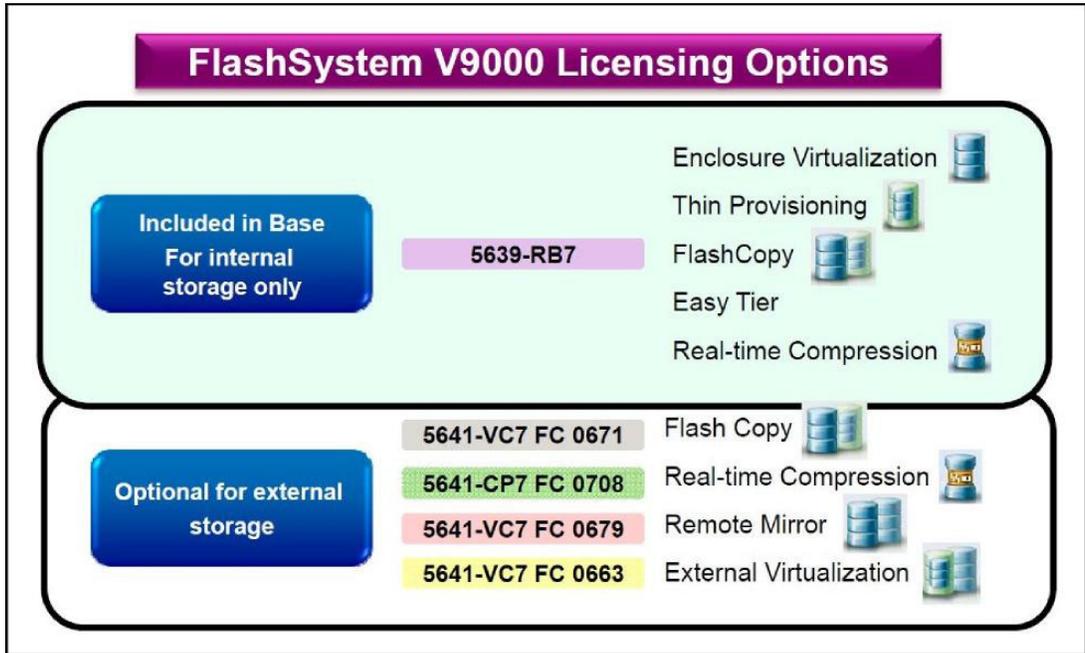


Figure 10 FlashSystem V9000 license structure

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-AC2 or 9848-AC2), but licensing is based solely on the quantity of FlashSystem V9000 storage enclosures that are included in the system. Each FlashSystem V9000 storage enclosure (9846-AE2 or 9848-AE2) 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. Figure 11 illustrates the FlashSystem V9000 Base Software License.

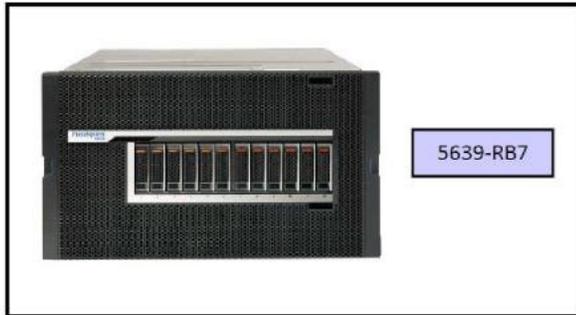


Figure 11 FlashSystem V9000 Base Software License: Example 1

Example 2

A FlashSystem V9000 order consisting of two control enclosures and three storage enclosures requires a quantity of three FlashSystem V9000 Base Software licenses. Figure 12 illustrates the FlashSystem V9000 Base Software License.

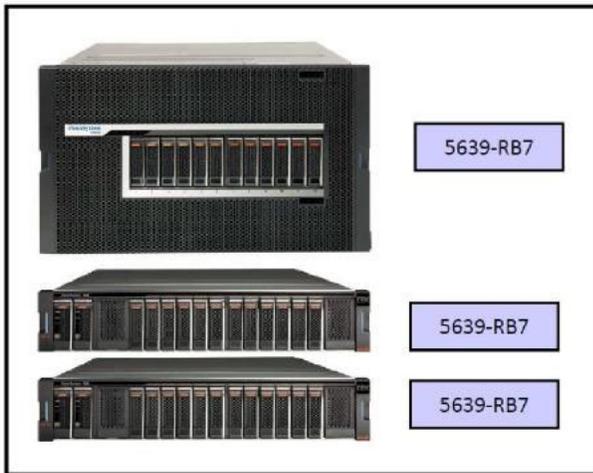


Figure 12 FlashSystem V9000 Base Software License: Example 2

IBM FlashSystem V9000 External Virtualization Software (5641-VC7 FC 0663)

Each FlashSystem V9000 control enclosure (9846-AC2 or 9848-AC2) can attach and manage external storage devices in the SAN in the same way, for example, as the IBM SAN Volume Controller. To authorize the usage of this function, you must license the IBM FlashSystem V9000 External Virtualization feature code. FlashSystem V9000 storage enclosures (9846-AE2 or 9848-AE2) are not considered externally attached storage enclosures, and do not require separate licenses.

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

Example 3

For a FlashSystem V9000 to virtualize a Storwize V5000 with 50 TB, a quantity of one FlashSystem V9000 Base Software license and 5641-VC7 FC 0663 for 50 TB are required. Figure 13 illustrates this configuration.

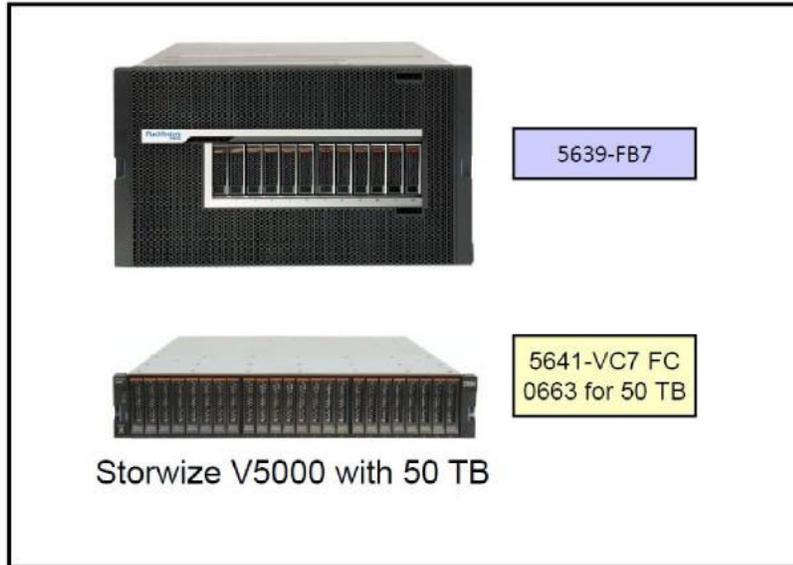


Figure 13 FlashSystem V9000 License: Example 3

IBM FlashSystem V9000 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 FlashSystem V9000 Real-time Compression for external storage license.

The IBM FlashSystem V9000 Real-time Compression for external storage license is a priced optional feature for external storage only. It is priced by capacity of the volumes that have been compressed.

Revised licensing rules for SAN Volume Controller Real-time Compression Software (5641-CP7)

SAN Volume Controller Real-time Compression Software (5641-CP7) is used to provide compression functionality for storage externally virtualized by the IBM FlashSystem V9000. Rather than using the volume size as the measure for determining how many terabytes of SAN Volume Controller Real-time Compression 5641-CP7 to license as previously announced, effective immediately for all licensed SAN Volume Controller Real-time Compression users, the measured terabyte capacity now applies to the actual managed disk capacity consumed by the compressed volumes.

For details about the new SAN Volume Controller Real-time Compression licensing rules, see *RFA Announcement 70772 - IBM FlashSystem V9000 Software V7.6*.

Example 4

A FlashSystem V9000 virtualizing a Storwize V5000 with 50 TB of physical storage and 100 TB of uncompressed volumes requires a quantity of one FlashSystem V9000 Base Software license, 5641-VC7 FC 0663 (External Virtualization license) for 50 TB, and 5641-CP7 FC 0708 (Real-time Compression license) for 25 TB. Figure 14 illustrates this configuration.

Note: This model assumes a compression ratio of 4:1 on the uncompressed 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 14 FlashSystem V9000 License: Example 4

IBM FlashSystem V9000 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 FlashSystem V9000 Remote Mirroring Software for external storage license.

The IBM FlashSystem V9000 Remote Mirroring Software for external storage license is a priced optional feature for external storage only. It is priced per capacity.

Example 5

A FlashSystem V9000 virtualizing a Storwize V5000 with 50 TB and mirroring it to a second V9000 with an IBM XIV® with 50 TB requires a quantity of two FlashSystem V9000 Base Software licenses, 5641-VC7 FC 0663 (External Virtualization license) for 100 TB and 5641-VC7 FC 0679 (Remote Mirror license) for 100 TB. Figure 15 illustrates this configuration.

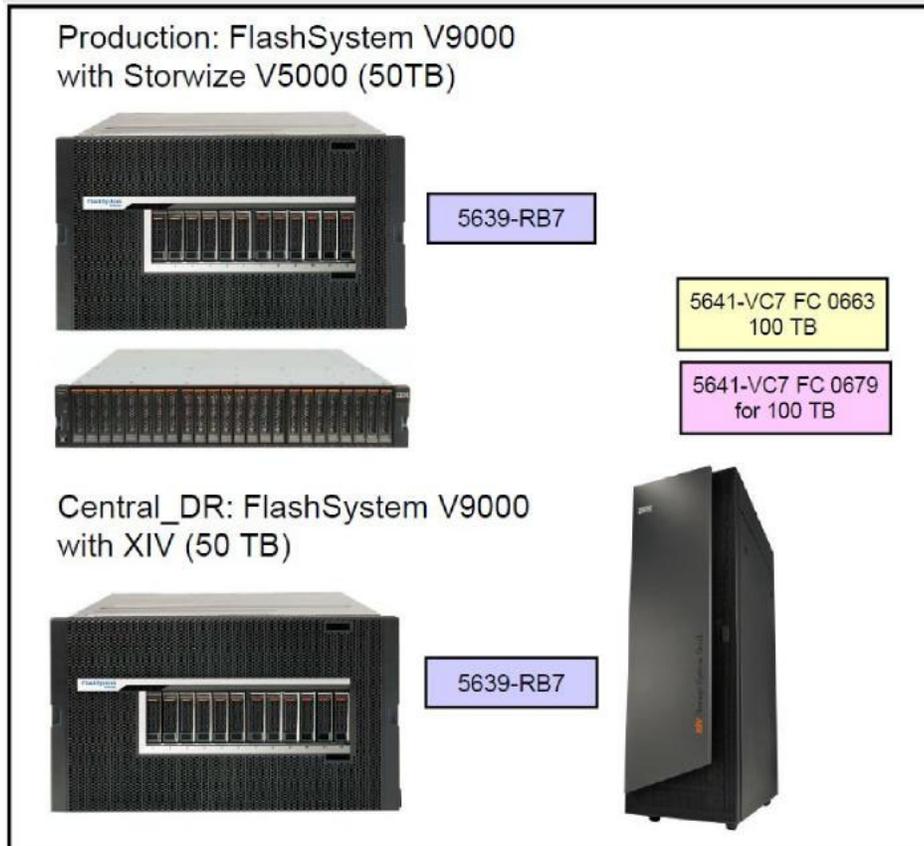


Figure 15 FlashSystem V9000 License: Example 5

IBM FlashSystem V9000 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 FlashSystem V9000 FlashCopy Software for external storage license.

The IBM FlashSystem V9000 FlashCopy Software for external storage license is a priced optional feature for external storage only. It is priced per capacity.

Example 6

A FlashSystem V9000 virtualizing a Storwize V5000 with 50 TB of FlashCopy volumes requires a quantity of one FlashSystem V9000 Base Software license, 5641-VC7 FC 0663 for 50 TB and 5641-VC7 FC 0671 for 25 TB. Figure 16 illustrates this configuration.

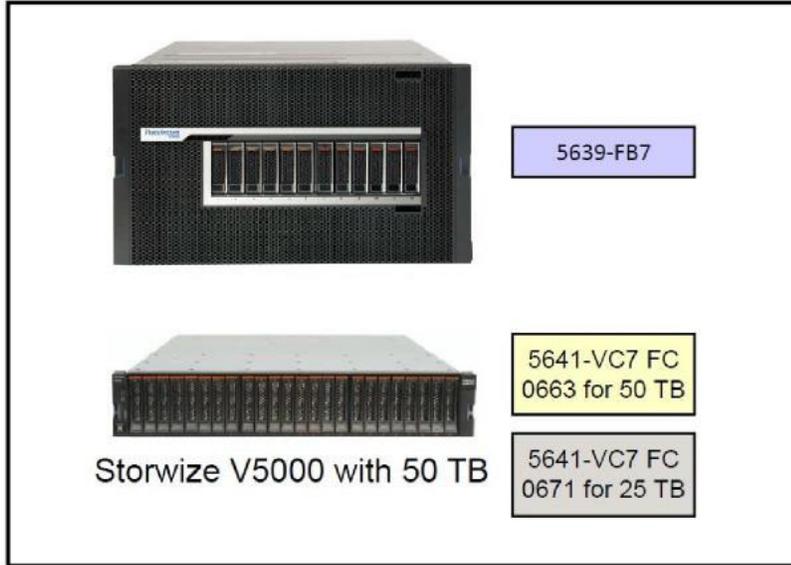


Figure 16 FlashSystem V9000 License: Example 6

Software product structure summary

Figure 17 shows an overview of the IBM FlashSystem V9000 license structure.

Base Configuration for Internal Storage	Priced Optional Features (Priced per Capacity) for External Storage
Base Software Per 9846/8-AE2 Storage Enclosure <ul style="list-style-type: none"> • 5639-RB7 V7.5 System Software, 1 year SWMA 	External Virtualization, Flash Copy, and Remote Mirroring <ul style="list-style-type: none"> • 5641-VC7 FC 0663 External Virtualization • 5641-VC7 FC 0671 Flash Copy • 5641-VC7 FC 0679 Remote Mirror
Licensed to the 9846/8 AE2 Storage Enclosure <ul style="list-style-type: none"> • All enterprise class functions: <ul style="list-style-type: none"> • Flash Copy, Thin Provisioning, Virtualization, Easy Tier 3, Remote Mirroring, and Real-time Compression • The above license applies to the 9846/8 AE2 only • Pooling/virtualization of storage enclosure capacity • Virtualized onboard of storage data • Initial registration/renewal via AAS. Lapse/post sale via CHIS • Not transferrable 	OR <ul style="list-style-type: none"> • 5608-AE1 – IBM Virtual Storage Center (VSC) Standard Note: supports virtualized storage
Additional optional software <ul style="list-style-type: none"> • 5608-ACL – IBM Virtual Storage Center (VSC) for Storwize Note: Can only be used for V9000 Internal Storage 	Real time Compression (RTC) <ul style="list-style-type: none"> • 5641-CP7 FC 0708 Real time Compression <ul style="list-style-type: none"> • Configure with two (2) FC AH1A Compression Accelerator adapters
	Transferable software license, Capacity Priced <ul style="list-style-type: none"> • 5641-VC7 and 5641-CP7 are licensed per Enterprise per Country • 5608-ACL and 5608-AE1 are licensed per Enterprise World Wide
	Note: 5641-VC7 and 5641-CP7 are part of the IBM Spectrum Virtualize Software V7.5 for SAN Volume Controller

Figure 17 Overview of the IBM FlashSystem V9000 license structure

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.

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