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IBM FlashSystem V9000 Model AC3 with Flash Enclosure Model AE3 Product Guide

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Product Guide

IBM FlashSystem V9000 with Flash Enclosure AE3

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

Making the correct decision on storage investment is critical. Organizations must have enough storage performance and agility to innovate because they need to implement cloud-based IT services, deploy virtual desktop infrastructure, enhance fraud detection, and use 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 an IBM 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 solutions.

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™, data reductions, dynamic tiering, thin provisioning, snapshots, cloning, replication, data copy services, and IBM HyperSwap® for high availability. Scale out scale up configurations can now add a hot spare node to further enhance availability.

With the release of FlashSystem V9000 Software V8.1, extra functions and features are available, including support for new and more powerful FlashSystem V9000 storage enclosure Model AE3. Software features added include GUI enhancements, a new dashboard, support assistance, and data deduplication.

AE3 capacities include Small (3.6 TB), Medium (8.5 TB), and Large (18 TB) IBM MicroLatency® modules for between 14.4 TB and 180 TB usable capacity (TBu), with inline hardware compression increasing the capacity up to 219 TB effective capacity (TBe).

New SAS-based small form factor (SFF) and large form factor (LFF) expansion enclosures that provide a mixture of nearline hard disk drives (HDDs) and flash MDisks in a pool that can be used for IBM Easy Tier®.

The new IBM FlashSystem V9000 SFF expansion enclosure Model92F offers new tiering options with low-cost solid-state drive (SSD flash drives) and nearline HDDs. Up to 784 drives per node pair of 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.

FlashSystem V9000 Software version 8.1 replaces version 7.8, and is available to all IBM FlashSystem V9000 customers with current warranty or software maintenance agreements.

Figure 1 shows the FlashSystem V9000 with AE3 Storage Enclosure

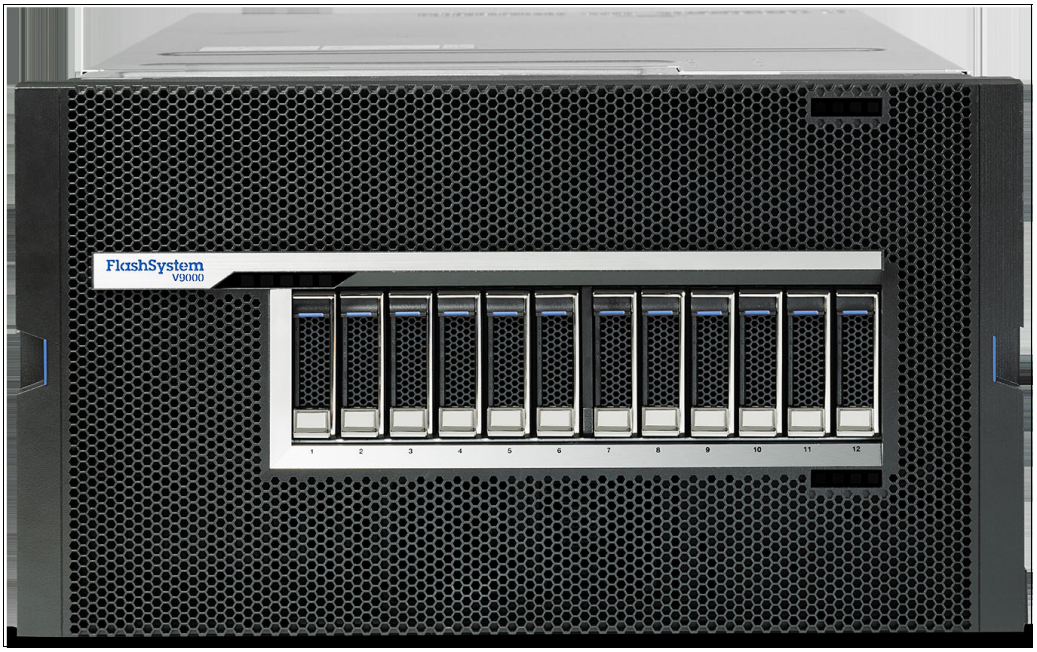

Figure 1 FlashSystem V9000 with AE3 Storage Enclosure

The AE3 enclosure can be recognized by the change of the drive handle color to blue. Labeling on the drive itself does not include capacity. Instead, there is coding that indicates whether it is S/M/L size, which are Small (3.6 TB)/Medium (8.5 TB)/Large (18 TB).

Did you know?

FlashSystem V9000 version 8.1 provides the following functionality that was introduced since the last product guide:

- Support for the AE3 Enclosure including IBM enhanced 3D triple-level cell (3D TLC) flash with flash endurance 3.8x over standard implementations.
- FlashSystem V9000 can either use SKLM or USB key encryption with up to four key servers.
- Support Assistance enabling support personnel to access the system to complete troubleshooting tasks.
- Consistency protection for Global Mirror and Metro Mirror.
- 92F SAS expansion enclosures can be used with the FlashSystem V9000.
- Management GUI support for Host clusters including private and shared volume mappings.
- Throttling allows customers to control resources used when the system is processing I/Os on hosts, host clusters, volumes, copy offload operations, and storage pools.
- Transparent Cloud Tiering is a function of Spectrum Virtualize that uses IBM FlashCopy® mechanisms to produce a point-in-time snapshot of the data.

FlashSystem V9000 version 8.1 with AE3 provides the following functionality:

- Automatic compression of data that is not already compressed by the AC3 control enclosure without a performance impact.
- Supports up to 12 ultra-low latency 3.6 TB, 8.5 TB, or 18 TB MicroLatency modules. The 3.6 TB and 8.5 TB modules offer performance-optimized, hardware-based compression.
- Provides flexible interface types including Fibre Channel and InfiniBand to easily integrate into existing SAN environments.
- Offers both hardware-based AES 256 data-at-rest encryption by using USB key and SKLM key server-based encryption, with no performance impact.

FlashSystem V9000

FlashSystem V9000 is a rack-mount shared flash memory device that is based on IBM 3D TLC flash technology. It provides the following functionality:

- Macro efficiency with up to 219 terabytes (TB) of maximum protected capacity in a 6U form factor with inline hardware data compression.
- Enterprise reliability through IBM Variable Stripe RAID™ and two-dimensional flash Redundant Array of Independent Disks (RAID).
- Extreme performance with MicroLatency.
- Optional expansion enclosures provide new tiering options by combining SSD flash drives and nearline drives.

FlashSystem V9000 provides these advanced data services, among others:

- Business continuity with replication services
- Data protection with IBM FlashCopy services
- Higher storage efficiency with thin provisioning
- Real-time Compression
- IBM Easy Tier
- External virtualization
- IP quorum support
- NPIV support
- VMware vSphere VVOL support and space-efficient copies
- Transparent Cloud Tiering

The FlashSystem V9000 baseline configuration is composed of the following components:

- Two FlashSystem V9000 AC3 control enclosures
- One FlashSystem V9000 AE3 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

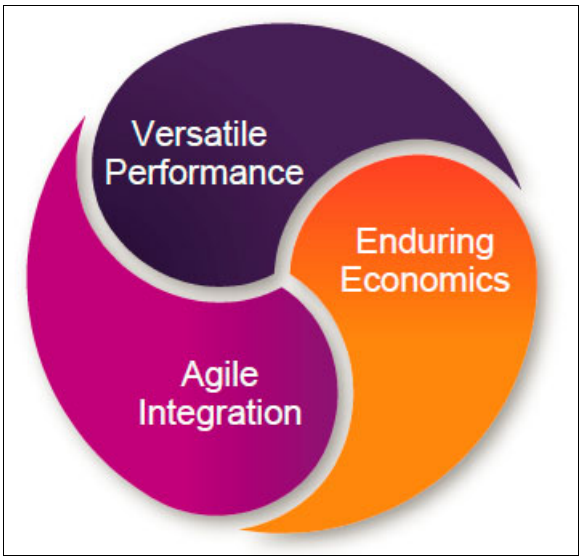

Figure 2 IBM FlashSystem V9000 dimensions of value

Versatile performance

FlashSystem V9000 has the following versatile performance attributes:

- Scale-up or scale-out, independently
- Scalable to 5.2 million IOPS
- Scalable to 80 Gigabytes per second (GBps) bandwidth
- Sustained IBM MicroLatency
- Quality of service
- Faster applications

Enduring economics

FlashSystem V9000 provides the following enduring economics attributes:

- Delivers internal flash capacity up to 1.7 PB
  (effective, assuming 2:1 or better hardware compression)
- Scalable to 7.2 PB using native flash storage as tier 0
  (effective, assuming 5:1 data reduction using Real-time Compression (RtC))
- Expandable to 32 PB using SSD flash drives as tier 1 capacity
- Flash for less than the cost of disk with IBM RtC
- 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 (ERP) and supply chain management (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 3D TLC flash endurance 3.8x over standard implementations, without sacrificing latency

Figure 3 shows IBM FlashCore Technology, the DNA of the FlashCore family.

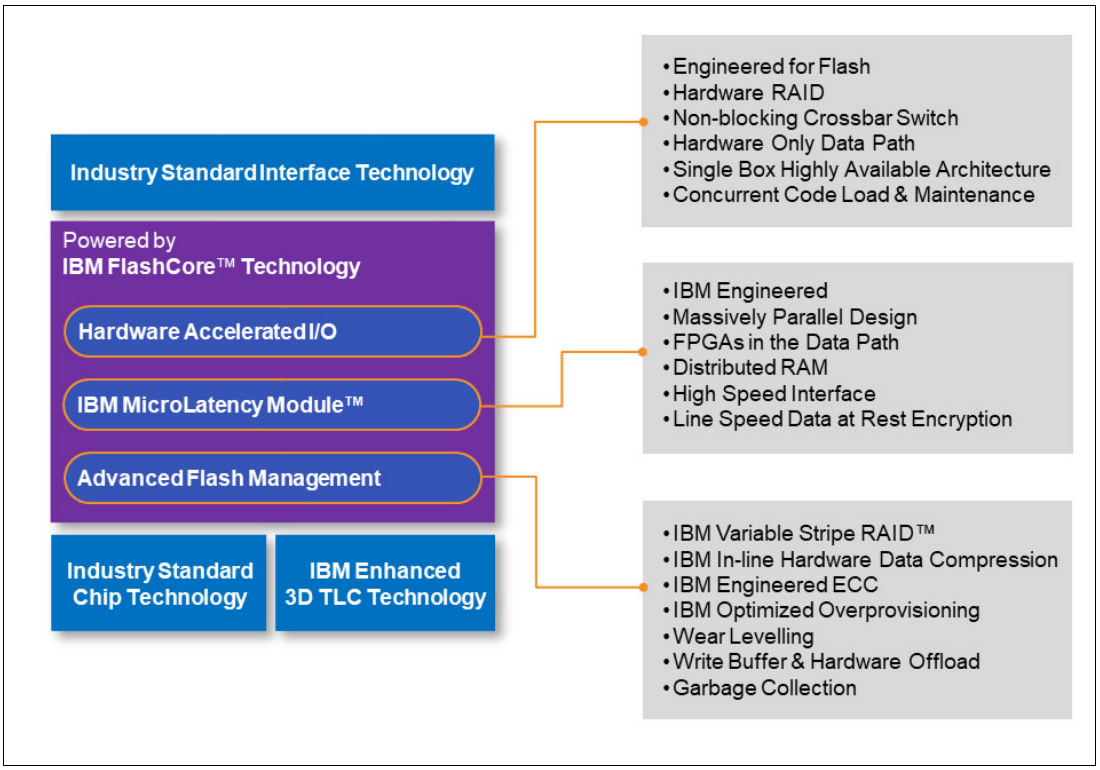

Figure 3 IBM FlashCore technology

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

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

The IBM Peace of Mind Initiative

IBM Storage has developed three new programs anchored to all-flash IBM storage offerings, including the following:

- Data reduction program is designed to reduce planning risks and help lower storage costs by meeting baseline levels of data compression effectiveness in IBM Spectrum™ Virtualize-based offerings.
- Controller upgrade program enables customers of designated all-flash IBM storage systems to reduce costs while maintaining leading-edge controller technology for essentially the cost of ongoing system maintenance.
- A new high-availability program helps enterprises avoid the costs and risks that are related to business downtime by ensuring the availability of business-critical data and storage systems.

Separately, the Data Reduction Guarantee, Controller Upgrade Program, and High-Availability Guarantee each offer many benefits. But when combined as part of an IBM all-flash storage solution, the power of all three to help you lower costs, reduce business risk, and maintain the most current technologies can be even more significant:

- Flash endurance coverage while hardware maintenance is current ensuring Flash wear never becomes a problem.
- Enhanced support is available from IBM through the Enterprise Class Support service that comes with the 9848 machine type.

Confidence. Trust. Peace of mind. IBM understands that real solutions include more than simply great engineering.

For further information, see the IBM Peace of Mind Initiative Technical White Paper.

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. These batteries supply power to the control enclosure during a sudden power loss or failure so that the system can correctly commit all transactions to the storage medium.

IBM FlashSystem V9000 storage enclosure

FlashSystem V9000 AE3 storage enclosures are 2U rack-mount units that support up to 12 flash modules. The sizes offered are Small (3.6 TB), Medium (8.5 TB), and Large (18 TB). All flash modules in a FlashSystem V9000 storage enclosure must have the same capacity.

IBM FlashSystem V9000 expansion enclosures

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

- Model 12F: Supports up to 12 x 8 TB LFF HDD drives formatted as RAID 5 or Distributed RAID 6.
- Model 24F: Supports up to either 12 or 24 SFF drives of either 3.84 TB and 1.92 TB SSD flash drives that can be formatted as RAID 5 or Distributed RAID 6.
- Model 92F: Supports up to 92 LFF High Density Drives in 8 TB, and 10 TB size or SSD flash drives in 1.92 TB, 3.84 TB, 7.68 TB, and 15.6 TB capacities formatted as RAID 5 or Distributed RAID 6.

- Multiple expansion enclosures are supported per FlashSystem V9000 controller pair, providing up to 480 drives with expansion enclosure Model 24F, up to 240 drives with expansion enclosure Model 12F, and up to 736 drives with expansion enclosure Model 92F.

Software-defined flash services

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

Scalability and performance

FlashSystem V9000 with AE3 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 180 TB usable and 219 TB maximum flash capacity in only 6U
- Up to 1.4 PB usable and 7.2 PB maximum flash capacity in only 34U
- Extra scalability through expansion enclosures models 12F, 24F and 92F, and increased raw capacity of up to a maximum of 32 PB
- Up to 5.2 million IOPS and 80 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 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 because a spare is available. IBM Variable Stripe RAID is a patented IBM technology that provides an intra-module RAID stripe within each flash module. Variable Stripe RAID technology helps reduce downtime, and 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.
- IBM-enhanced Micron 3D TLC technology for higher storage density and improved endurance
- FlashSystem V9000 control enclosures are an active-active pair, and support concurrent code load.

Flash for less than the cost of disk

Integral to the V9000 system is the IBM FlashCore technology as found in the IBM FlashSystem 900. The recent evolution of this technology saw the introduction of inline hardware compression and decompression. FlashSystem V9000 Model AE3 has built-in hardware data compression as standard, and this data reduction is “always on”. This compression has been implemented in hardware using Field Programmable Gate Arrays (FPGAs) within each module and uses a modified dynamic GZIP algorithm. This approach allows IBM to deliver the level of performance that you expect without compression, with the added benefit of better utilization of the physical storage.

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

The FlashSystem V9000 control enclosure Real-time Compression 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. These features include 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. In addition, the FlashSystem AE3 storage enclosure applies compression to any data that is not already compressed.

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.
- Encryption Capable: Provides optional AES-XTS 256-bit data-at-rest encryption.
- Disaster recovery (DR) techniques: You can practice them and validate business continuity plans.
- Simple GUI: 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 later, supports the IBM FlashSystem V9000 GUI. You can download the dashboard at no cost from iTunes.

Deep application integration

IBM FlashSystem V9000 Software V8.1 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 programming interfaces (APIs) for Array Integration (VAAI) support: This functionality supports hardware-accelerated virtual machine (VM) copy/migration and hardware-accelerated VM initiation, and accelerates VMware Virtual Machine File System (VMFS).
- Microsoft Windows System Resource Manager (SRM) for VMware Site Recovery Manager: Supports automated storage and host failover, failover testing, and failback.
- 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 Virtual Machine 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, it could be 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 version 8.1 currently supports integration of VASA and VAAI by using IBM Spectrum Control Base Edition 3.2.1. 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 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

This section describes several new functions and features available in recent FlashSystem V9000 releases.

New in FlashSystem V9000 version 8.1 software

The following functions are new in the FlashSystem V9000 version 8.1 software:

- IBM AE3 Storage Enclosure support
- Remote Support Assistance provides secure connection for remote support with audit logging
- New GUI look and feel
- AE3 Storage Enclosure management coupling has been reduced to increase the flexibility of the overall solution
- IBM SKLM coexistence with USB encryption key management and SKLM clone server support
- Pause capability in concurrent code update allows flexibility during code updates

New in FlashSystem V9000 version 7.8.1 software

The following functions were new in the FlashSystem V9000 version 7.8.1 software:

- Host cluster I/O throttling: I/O throttling can be managed at the host level (individual or groups) and at managed disk levels for improved performance management.
- Host groups with GUI support: Host groups can be more easily managed through the GUI, adding more management flexibility to existing CLI support.
- Increased background FlashCopy transfer rates: This feature enables you to increase the rate of background FlashCopy transfers. It provides faster copies because the infrastructure allow you to take advantage of the higher performance capabilities of today's systems, while processing the copy in a shorter amount of time.
- Port Congestion Statistic: Zero buffer credits help detect SAN congestion in performance-related issues, improving support in high-performance environments.
- Resizing of volumes in remote mirror relationships: Target volumes in remote mirror relationships will be automatically resized when source volumes are resized.
- Consistency protection for Metro/Global Mirror relationships: An automatic restart of mirroring relationships after a link fails between the mirror sites improves disaster recovery scenarios, helping to ensure that the applications are protected throughout the process.

New in FlashSystem V9000 version 7.8 software

The following functions were new in the FlashSystem V9000 version 7.8 software:

- IBM Spectrum Virtualize™ V7.8 delivers support for the latest platforms in the IBM Storwize® product family, and adds new software functionality and improvements
- More flexible data protection with transparent cloud tiering to use the cloud as a snapshot target and restore snapshots from the cloud
- Improved data economics through advanced functions for lower endurance flash drives
- Improved security with support for encryption key management software

New in FlashSystem V9000 version 7.7.1 software

IBM Spectrum Virtualize Software V7.7.1 delivered 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) CID and support of 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. This process does not compromise redundancy during this period. It then rebuilds the data when the issue causing the slow performance is resolved.
  - Support for SSD flash drives: SSD flash drives offer performance comparable to enterprise-grade flash drives at a lower cost, but with lower endurance. Flash drive endurance is measured in drive writes per day (DWPD). The GUI and CLI provide information about the actual percentage of DWPD consumption.
  - Performance improvement with DRAID multi-threading by improved use of CPU cores.
- Support for up to 20 expansion enclosures per FlashSystem V9000 controller pair, providing up to 480 drives with expansion enclosure Model 24F and up to 240 drives with expansion enclosure Model 12F.
- Manageability with CLI support for Host Groups, enabling multiple hosts to be grouped for easier mapping and management, and the same virtual disk to be mapped to all hosts on 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 that 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. For details about licensing, see “Software and licensing” on page 45

IBM FlashSystem V9000 Software V8.1 includes Remote Mirroring for the AE3 flash enclosures and expansion enclosures. IBM Spectrum Virtualize software is used to provide functionality for externally virtualized storage.

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

- The HyperSwap topology locates both nodes of an I/O group in the same site. Therefore, to get a volume that is resiliently stored on both sites, at least two I/O groups are required.
- The HyperSwap topology uses additional system resources to support a full independent cache on each site. This configuration provides full performance even if one site is lost. In some environments, a HyperSwap topology provides better performance than a *stretched topology*.
- The HyperSwap function can now be configured through a new CLI that greatly simplifies the setup process to a handful of commands. The HyperSwap function also adds the ability to configure and manage local HyperSwap through the GUI for simpler configuration and operation.
- Hosts, 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.

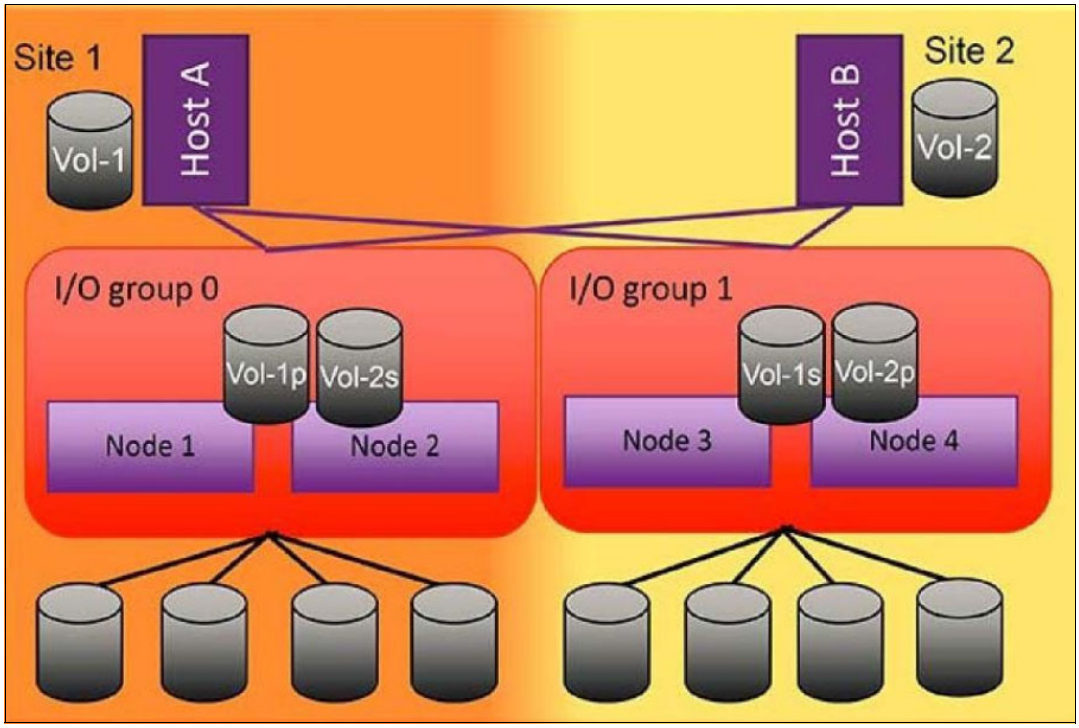

Figure 4 HyperSwap function

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.

HyperSwap has these characteristics:

- The 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 (ALUA)/Target Port Groups Support (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, and when connectivity between sites 1 and 2 is lost. In a HyperSwap setup, a quorum disk at the third site is needed. The quorum disk on the third site must be the active quorum disk. Only the active quorum disk acts as a tie-breaker.

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

Integrated Comprestimator

RtC is a key differentiator of FlashSystem V9000. IBM Comprestimator is the key sizing tool to estimate how much capacity savings that a client can expect. Comprestimator can recognize the patterns of the actual client data, and estimate the compressibility of data per volume. The RtC tool is built into the GUI for volume management on the FlashSystem V9000.

The IBM FlashSystem V9000 Model AE3 is supported in the stand-alone IBM Comprestimator tool as the FlashSystem 900 AE3. This is a host-based application that allows the user to estimate the mount of compression on the IBM FlashSystem 900 Model AE3 for specific workloads.

The IBM Compresstimator works the same as for previous supported products. IBM FlashSystem 900 Model AE3 has the following additions:

- New “Storage system type” `-s FLASHSYSTEM`
- New options for storage system type - `FLASHSYSTEM`
- Set the number of flash modules in the simulated system `--flash-modules N`
- Set the size of the flash modules in the simulated system `--flash-module-size [SMALL|MEDIUM|LARGE]`

NPIV Support

Starting with version 7.7, FlashSystem V9000 Software offers NPIV support. NPIV allows the virtualization of WWPNs, which increases redundancy during firmware updates and scheduled maintenance where WWPNs transparently move 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 IBM MicroLatency storage modules:
  - AE3 Flash Modules Small (3.6 TB), Medium (8.5 TB), or Large (18 TB)
  - Configurable between 14.4 - 180 TB of usable capacity and 219 TB maximum capacity
- 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, 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 *Implementing IBM FlashSystem V9000 AE3*, SG24-8413.

FlashSystem V9000 provides a flexible architecture for assigning port resources. The following 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 AE3 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 AE3 storage enclosures to be added to the storage system. If 720 TB usable or 876 TB maximum from four building blocks is not enough capacity, up to four extra storage enclosures can be added.

In total, a FlashSystem V9000 can contain a maximum of eight FlashSystem V9000 AE3 storage enclosures. This configuration offers a potential storage capacity of 1.4 PB usable, and up to 1.7 PB (effective capacity assuming 2:1 or better hardware compression). Real-time Compression is also available as a software feature that can yield up to 7.2 PB (effective, assuming 5:1 data reduction using RtC). Real-time compression can be deployed where you want it.

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

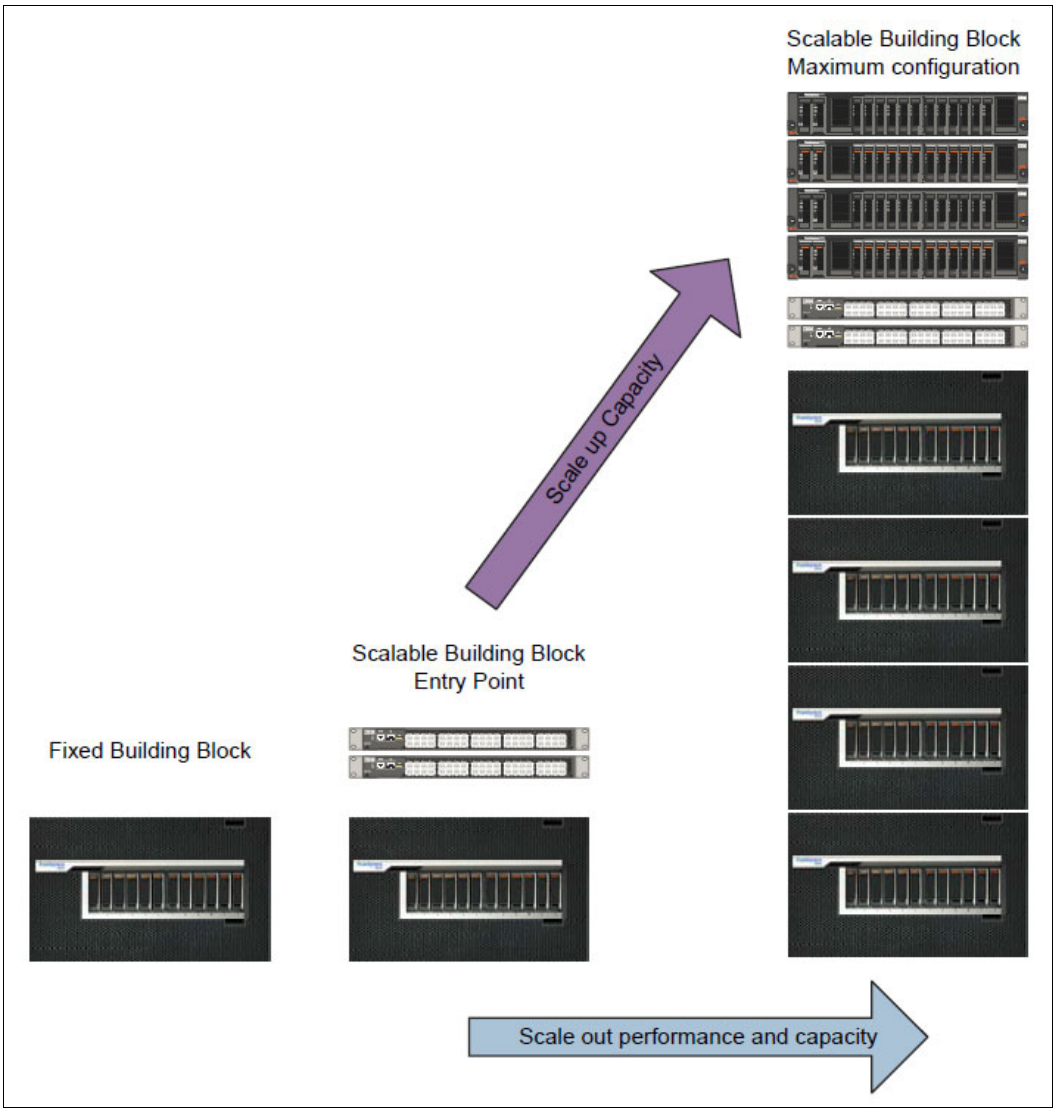

Figure 5 FlashSystem V9000 fixed building block versus scalable building block capacity

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 building block, or to two, three, or four building blocks.

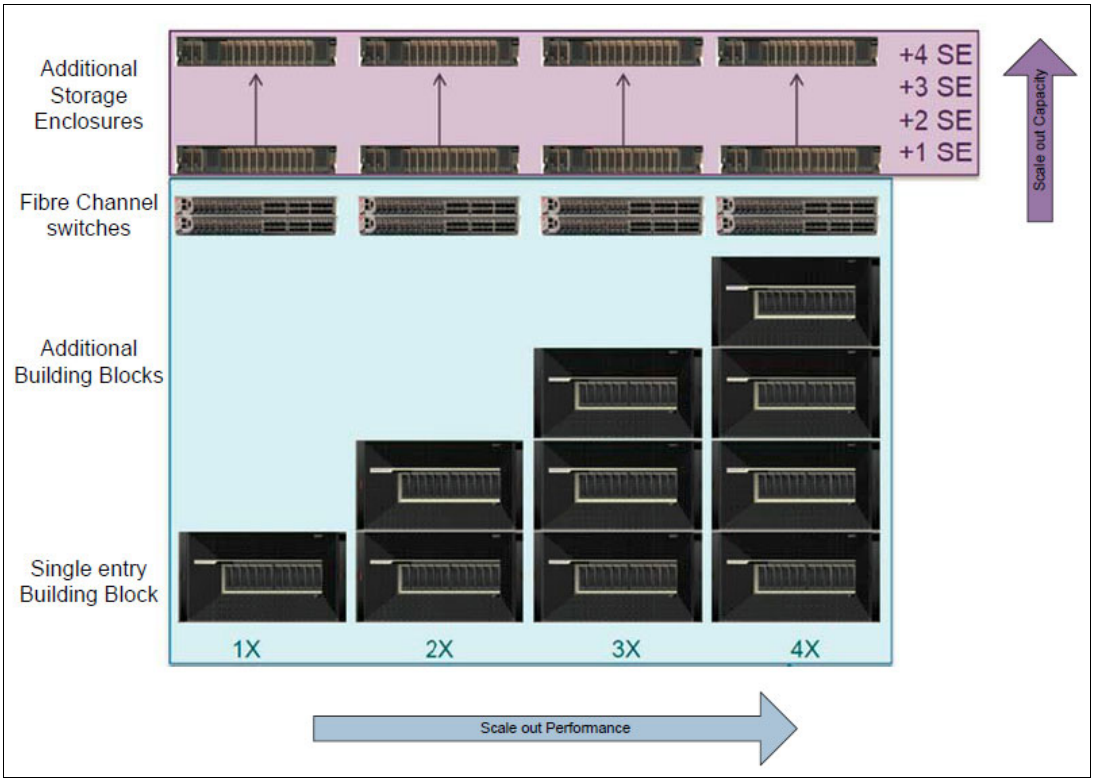

Figure 6 FlashSystem V9000 scalable capacity

Maximum capacity

Table 1 summarizes the minimum, maximum usable, and maximum effective capacity for scalable building blocks built on the AE3 Enclosure.

Table 1 Capacities of the AE3 enclosures

Scalable building blocks	Minimum capacity (TB)	Maximum usable capacity (TB)	Maximum effective capacity (TB) with inline HW compression
1 BB	14.4	180	219
1 BB + 1 SE	28.8	360	438
1 BB + 2 SE	43.2	540	657
1 BB + 3 SE	57.6	720	876
1 BB + 4 SE	72	900	1095
2 BB	86.4	360	438
2 BB + 1 SE	100.8	540	657
2 BB + 2 SE	115.2	720	876
2 BB + 3 SE	129.6	900	1095
2 BB + 4 SE	144	1080	1314

Scalable building blocks	Minimum capacity (TB)	Maximum usable capacity (TB)	Maximum effective capacity (TB) with inline HW compression
3 BB	158.4	540	657
3 BB + 1 SE	172.8	720	876
3 BB + 2 SE	187.2	900	1095
3 BB + 3 SE	201.6	1080	1314
3 BB + 4 SE	216	1260	1533
4 BB	230.4	720	876
4 BB + 1 SE	244.8	900	1095
4 BB + 2 SE	259.2	1080	1314
4 BB + 3 SE	273.6	1260	1533
4 BB + 4 SE	288	1440	1752

Note: FlashSystem 900 AE3 Storage Enclosure compression is hardware based and has no effect on performance.

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 4 BBs).

Table 2 Maximum 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 enclosures

With the introduction of IBM FlashSystem V9000 Software V7.8, FlashSystem V9000 now supports the addition of expansion enclosures. High-density (HD) Enclosure Model 92F accepts both nearline and Flash Drives. This tiering option allows eight enclosures per building block with a max capacity of 1350 TB each. See the maximum enclosure configuration illustration in Figure 7.

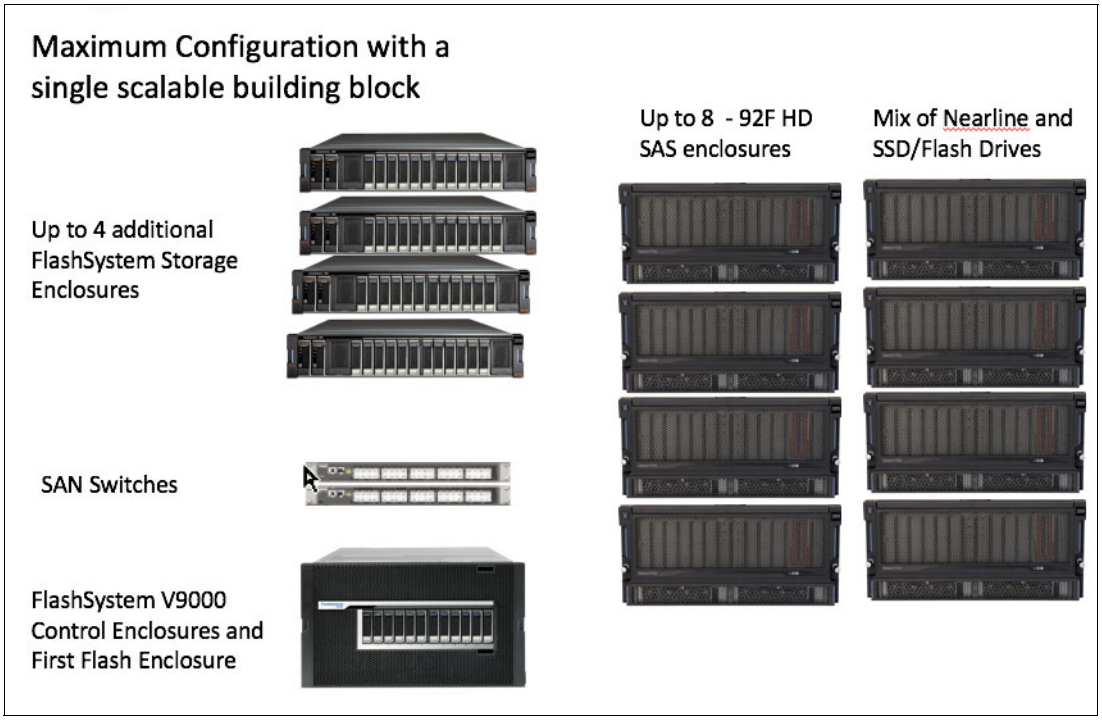

Figure 7 Single Scalable Building Block Max Config with 92F Enclosure

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

Up to 20 expansion enclosures 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 SAS capacity in each building block. With four building blocks, 7.6 PB of raw SAS capacity is supported.

Figure 8 shows the maximum configuration with a single building block that uses a combination of native FlashSystem V9000 expansion enclosures models 12F and 24F.

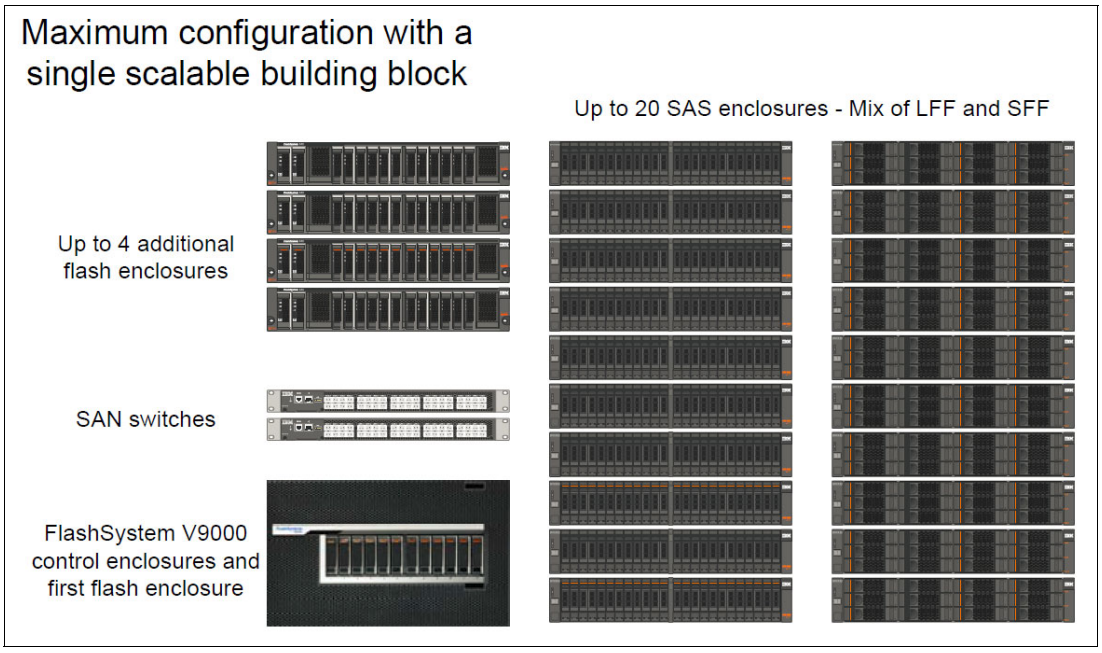

Figure 8 Single scalable building block max configuration

High-Density Expansion Enclosure Nearline or SSD Flash Drive

HD expansion enclosure Model 92F delivers increased storage density and capacity for IBM FlashSystem V9000 with cost-efficiency while maintaining its highly flexible and intuitive characteristics. HD expansion enclosure Model 92F supports a complete range of 3.5-inch drives to easily increase storage capacity and density in a flexible and affordable manner:

- High-capacity, archival-class nearline disk drives in 8 TB and 10 TB 7,200 rpm
- SSD Flash drives in 1.92 TB, 3.84 TB, 7.68 TB, and 15.36 TB

SSD flash drives

High density, low-cost SSD flash drives 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 SSD flash drive options are available for FlashSystem V9000 SFF expansion enclosure model 24F and 92F for a maximum of 32 PB combined flash and SAS capacity with four building blocks.

High capacity nearline drives

High capacity nearline drives enable 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 expansion enclosure model 12F and 92F for a maximum of 32 PB combined flash and SAS capacity with four building blocks.

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

RAID types

RAID5 with standby hotspare is the only available RAID option for FlashSystem V9000 storage enclosure. However, the additional SAS attached expansion enclosures can be configured with various RAID options. Distributed RAID (DRAID5 and DRAID6) offers improved RAID rebuild times. DRAID6 is preferred for expansion enclosures due to the drive sizes in use.

Note: To support SAS attached expansion enclosures, an AH13 - SAS Enclosure Attach 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 makes the migration of data from one storage device to another easier. 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. The FlashSystem V9000 AE3 is treated as external storage, providing the customer increased flexibility with configuration.

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 in dedicated flash capacity for the lowest possible latency
- Sets of data that participate in Easy Tier
- Sets of data that are compressed by using 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.
- Remote Support Assistance provides secure connection for remote support with audit logging.
- 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 storage enclosure	9846-AE3 or 9848-AE3 9846-AE2 or 9848-AE2
FlashSystem V9000 LFF expansion enclosure	9846-12F or 9848-12F
FlashSystem V9000 SFF expansion enclosure	9846-24F or 9848-24F
FlashSystem V9000 HD expansion enclosure	9846-92F or 9848-92F

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 the IBM announcement letters in Table 4.

Table 4 Recent IBM US Announcement Letters

Title	Link to Announcement
New IBM FlashSystem expansion enclosure delivers a tiered storage solution for V9000 **Note:** This is the 12F expansion enclosure	http://ibm.biz/V9000HybridAnnounce
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	https://ibm.biz/BdruCs
IBM FlashSystem V9000 HD Expansion Enclosure Model 92F delivers increased storage density and cost-efficient capacity	https://ibm.biz/BdjVeu
IBM FlashSystem V9000 Control Enclosure Model AE3 delivers ultra-low latency and hardware-based compression for optimized performance	https://ibm.biz/BdjVeC

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.

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

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 machine types shown in Table 5 qualify for this type of enhanced support:

Table 5 Machine types that qualify for Enterprise Class Support

Component	Machine Type - Model
IBM FlashSystem V9000 Control Enclosure	9848-AC3 9848-AC2
IBM FlashSystem V9000 Storage Enclosure	9848-AE3 9848-AE2

Component	Machine Type - Model
IBM FlashSystem V9000 HD Expansion Enclosure	9848-92F
IBM FlashSystem V9000 LFF Expansion Enclosure	9848-24F 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
- Onsite 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 service support representative (SSR) to perform onsite 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 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 coordinated, cross-team support to enable clients to maximize IT availability. The Technical Advisor works with clients, sales teams, and IBM Business Partners to ensure that the Technical Delivery Assessment checklist and site planning steps are complete. Additionally, with the three-year warranty, the Technical Advisor will proactively plan the software updates. This planning ensures that workstation, network access, user ID, and software download steps are completed before 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, which are 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. These features include 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 9 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 AE2or AE3 connections with the hosts servers on the same SAN switch, observing the correct port zoning.

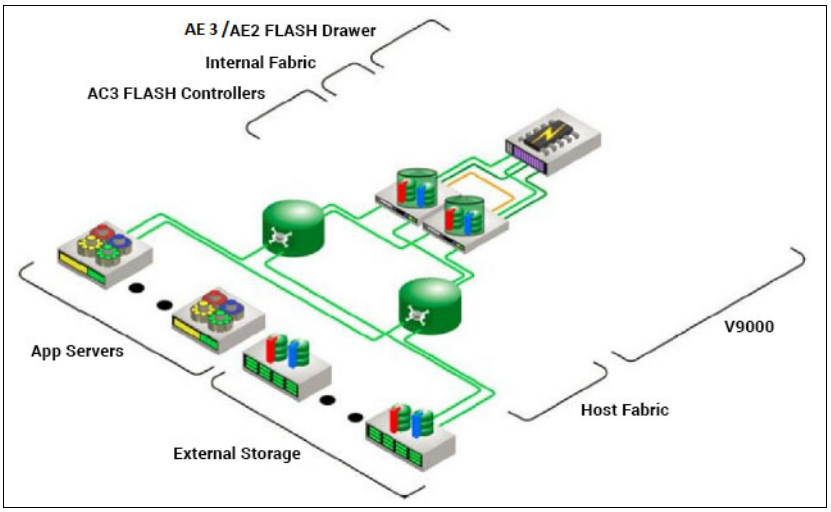

Figure 9 FlashSystem V9000: Generalized view of host connectivity topology

System management

Because FlashSystem V9000 control enclosures cluster together to form a system, a single management interface is used for FlashSystem V9000 control enclosures. Each FlashSystem V9000 node is an individual server in a FlashSystem V9000 clustered system on which the FlashSystem V9000 Software runs. FlashSystem V9000 AE3 Storage enclosures are managed separately using a specialized interface.

FlashSystem V9000 GUI

FlashSystem V9000 includes an easy-to-use management GUI that 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 10 shows the FlashSystem V9000 GUI dashboard.

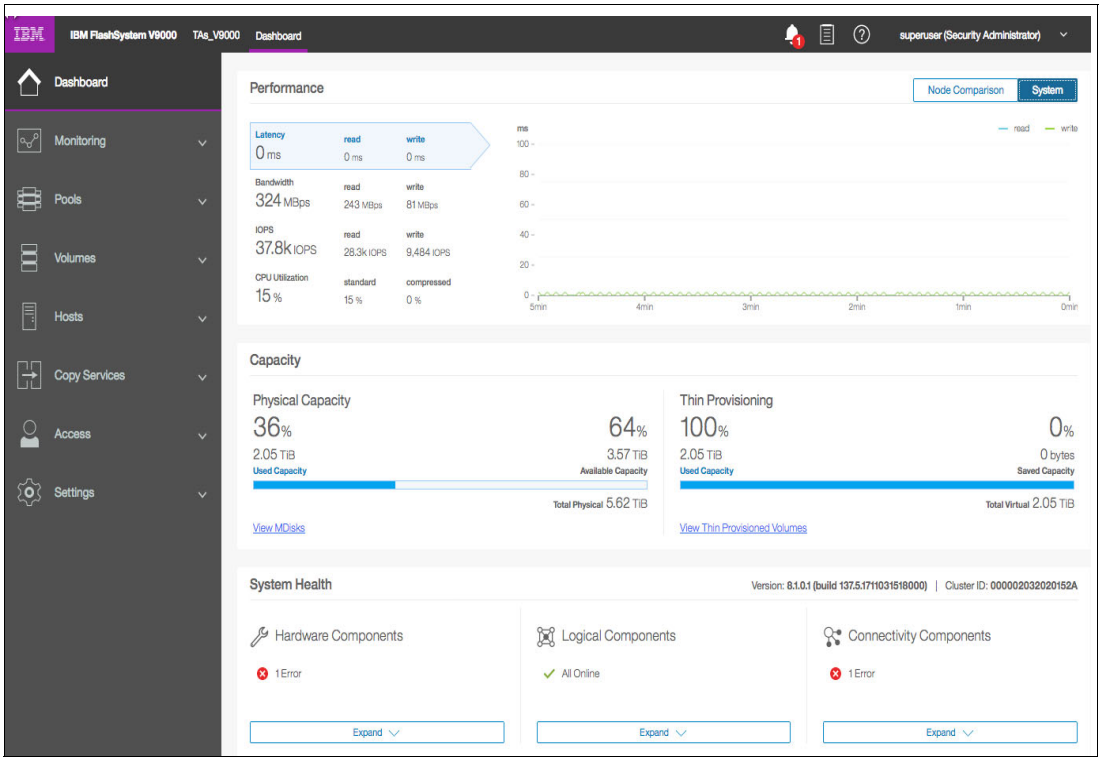

Figure 10 FlashSystem V9000 GUI showing the Dashboard

The GUI supplied in the IBM FlashSystem V9000 control code release 8.1 changes the way that storage enclosures are managed from previous releases. The FlashSystem V9000 containing the FlashSystem V9000 AE2 storage enclosure will continue with consolidated management as illustrated in Figure 11.

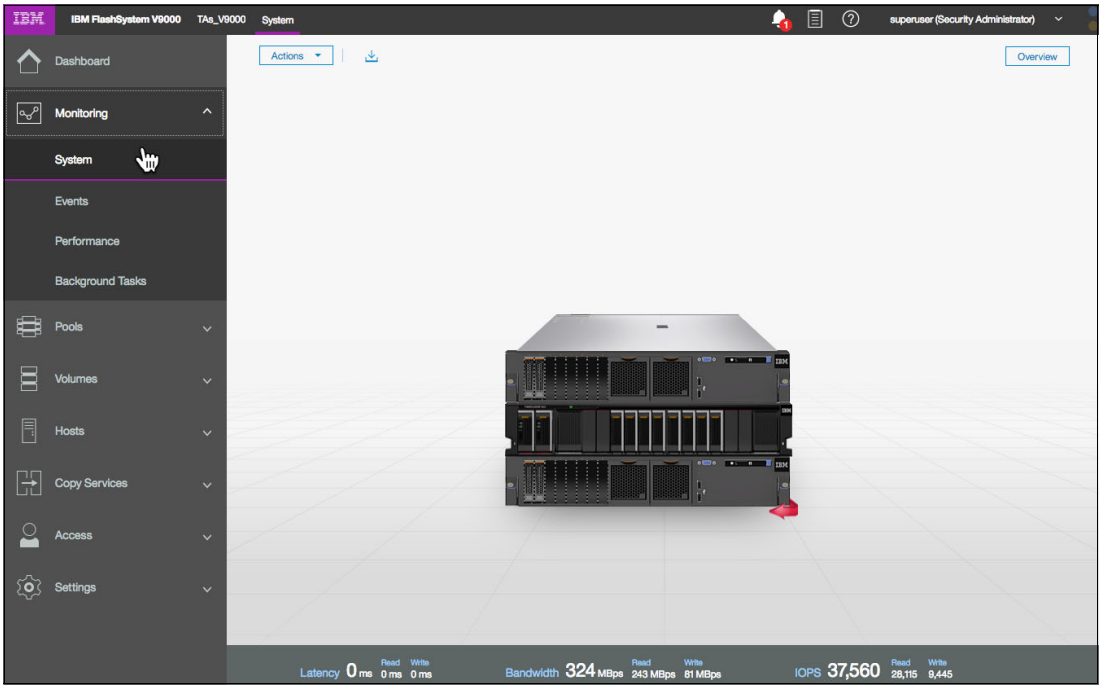

Figure 11 FlashSystem V9000 System View with Model AE2 Storage Enclosure

The FlashSystem V9000 AE3 storage enclosures are managed independently of the control enclosures, providing customers greater configuration flexibility. Essentially, these AE3 enclosures are treated as virtualized storage from the FlashSystem V9000 perspective. See the system view that is shown in Figure 12.

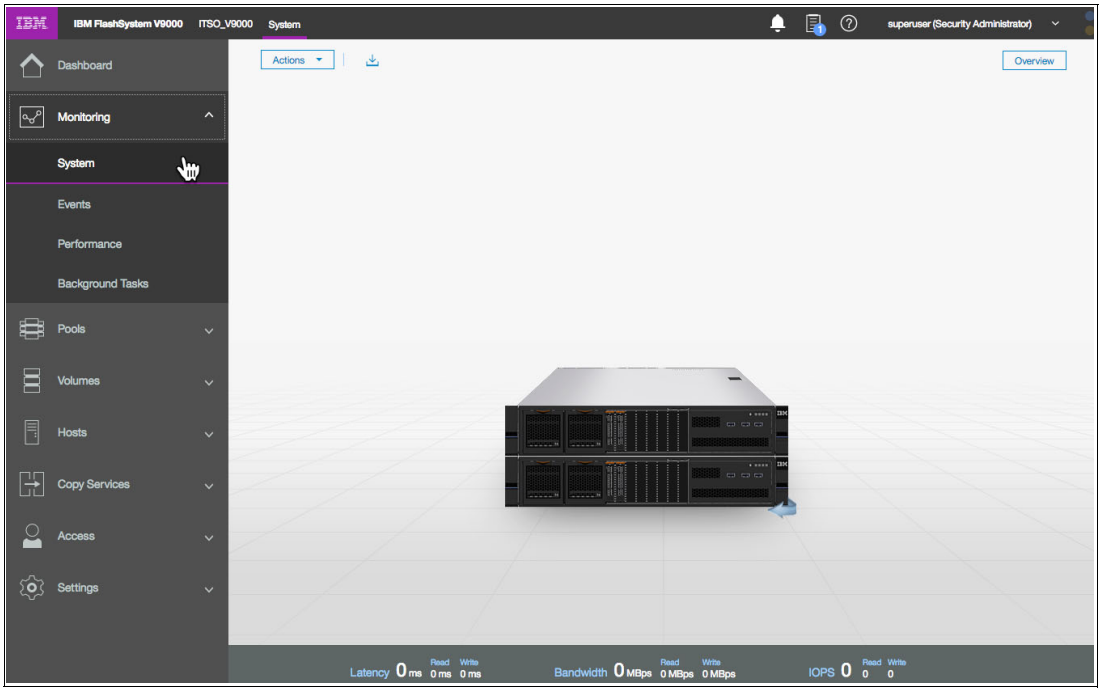

Figure 12 FlashSystem V9000 System View with Model AE3 Storage Enclosure

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. They can connect either directly (with the fixed building block) or through SAN switches (with the scalable building block).

Figure 13 shows the front view of the V9000 AC3 controller.

Figure 13 V9000 AC3 controller front view

IBM FlashSystem V9000 control enclosure Model AC3 has the following features:

- Two 8-core processors with 64 GB memory standard, and options to increase memory up to 256 GB
- 16 Gb Fibre Channel and 10 Gb iSCSI and 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 SSD flash drives with expansion Model 12F
- Up to 8 SAS High Density (HD) 92F expansion controllers are supported per FlashSystem V9000 controller pair, providing up to 736 nearline or SSD flash drives of Tier 1 capacity

Figure 14 shows the rear view of the V9000 AC3 controller.

Figure 14 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).

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 small (3.6 TB), medium (8.5 TB), or large (18 TB) capacities:
  - Small (3.6 TB) are orderable in 4, 6, 8, 10, or 12 module configurations
  - Medium (8.5 TB) and Large (18TB) are orderable in 8, 10, or 12 module configurations
  - All flash modules must be the same capacity
- Up to 180 TB RAID 5 configuration; up to 219 TB maximum capacity with hardware compression on the AE3 enclosure.

- 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 to twelve flash memory modules, and one mid-plane. As viewed from the front of the storage enclosure (see Figure 15), 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 the status LEDs.

Figure 15 shows the front view of the V9000 storage enclosure.

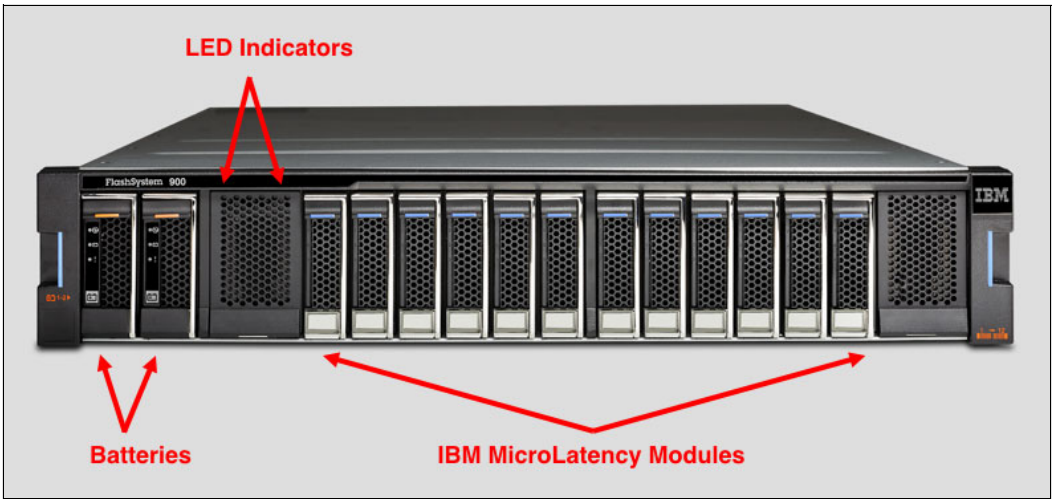

Figure 15 Front view of FlashSystem V9000 storage enclosure

Figure 16 shows the components of IBM FlashSystem V9000 Model AE3 from the rear. One of the two canisters is removed, and you see two interface cards and two fan modules. The power supply unit to the right of the fans provides redundant power to the system. All components are concurrently maintainable except for the passive mid-plane, enclosure LED board, and power interposer board. All external connections are from the rear of the system.

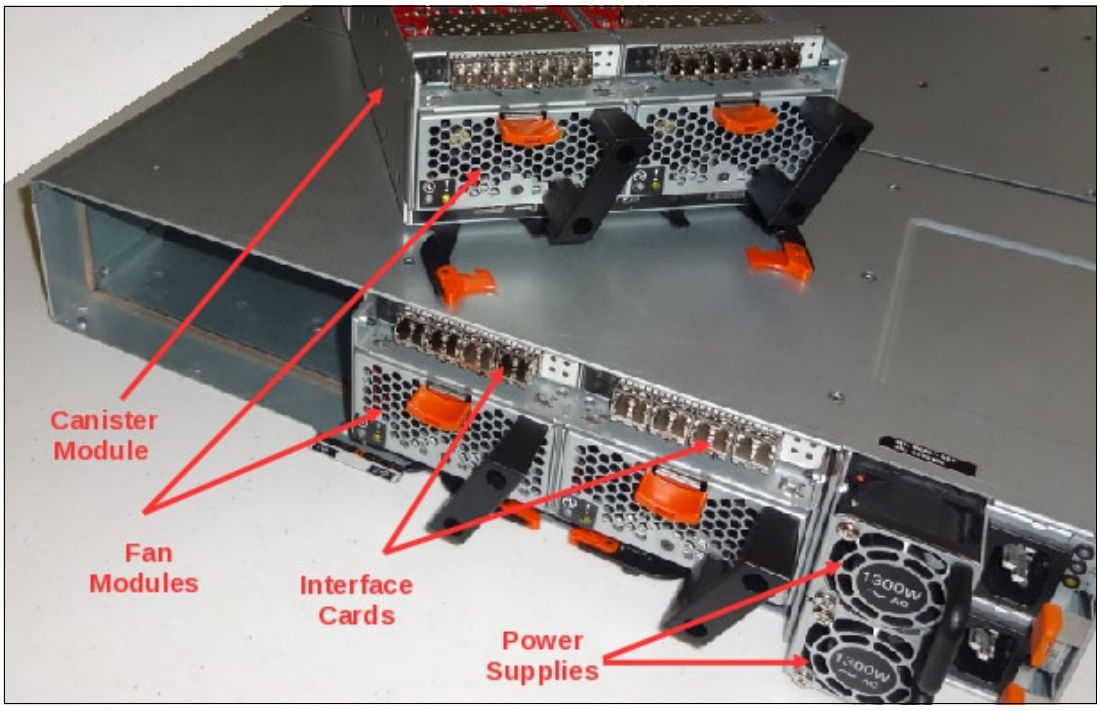

Figure 16 Rear view of FlashSystem V9000 storage enclosure

Figure 17 shows a rear view of IBM FlashSystem V9000 Model AE3 with Fibre Channel interfaces. The canisters are to the left and the two power supply units, stacked on top of one another, are to the right.

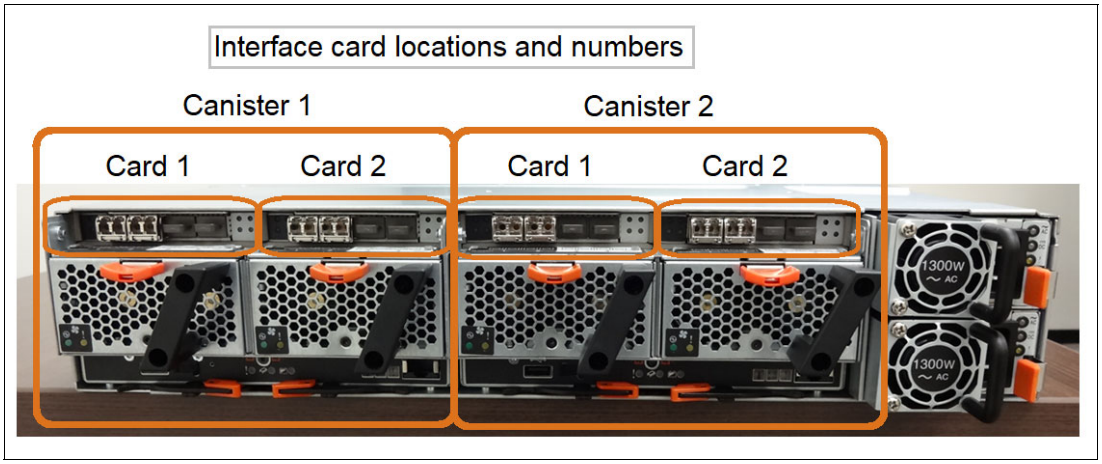

Figure 17 Rear view of FlashSystem V9000 storage enclosure

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

Each 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 enclosure features

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

- LFF Expansion Enclosure Model 12F
- SFF Expansion Enclosure Model 24F
- HD Expansion Enclosure Model 92F

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

Figure 18 shows the front view of the V9000 Expansion Enclosure model 12F.

Figure 18 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 24 slots for 2.5-inch SSD flash drives. These are available in 1.92 TB, 3.84 TB, 7.66 TB, and 15.36 TB capacity versions.

Figure 19 shows the front view of the V9000 Expansion Enclosure Model 24F.

Figure 19 Front View of IBM FlashSystem V9000 SFF Expansion Enclosure Model 24F

Both 12F and 24F models of IBM FlashSystem V9000 expansion enclosures have the same common features:

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

Figure 20 shows the rear view of the V9000 expansion enclosure Models 12F and 24F.

Figure 20 Rear View of IBM FlashSystem V9000 expansion enclosure Models 12F and 24F

IBM FlashSystem HD Expansion Enclosure Model 92F delivers the following features:

- Up to 92 drives are top-loaded into drive slots in this expansion enclosure
- 5U, 19-inch rack mount enclosure with slide rail and cable management assembly
- High-performance disk drives, high-capacity nearline disk drives, and flash drive support
- Redundant 200 - 240 V AC power supplies (new PDU power cord required)

Figure 21 shows the front view of the V9000 model 92F expansion enclosure.

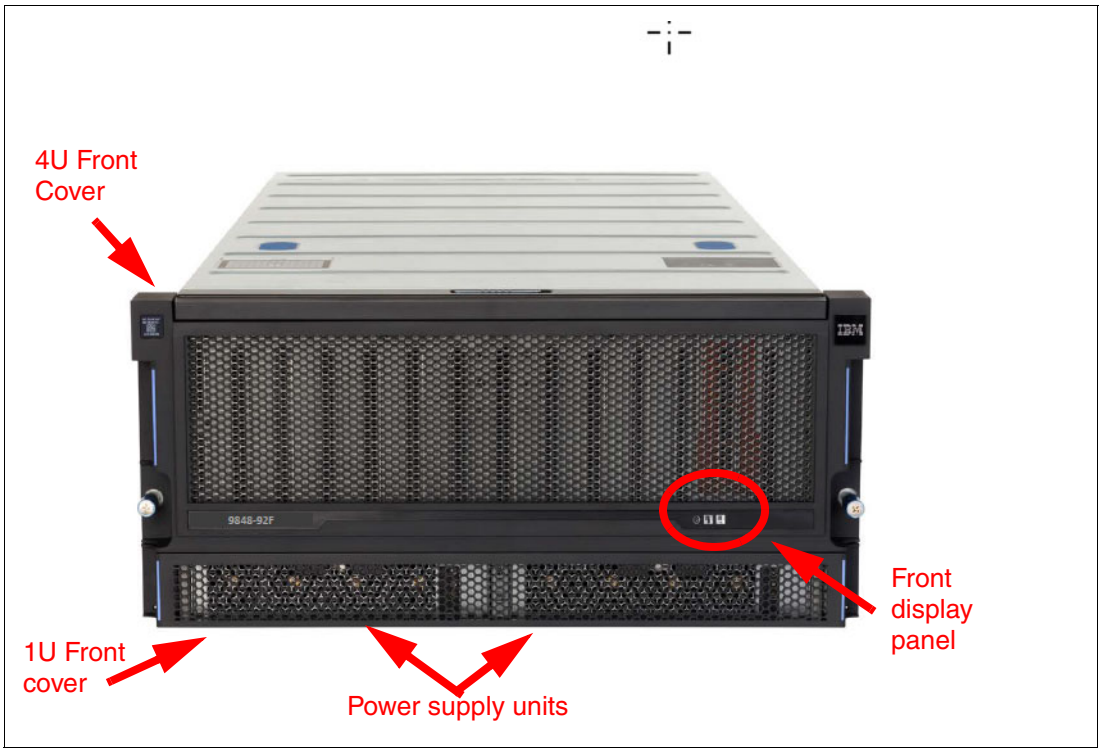

Figure 21 Front view of the FlashSystem V9000 model 92F expansion enclosure

Figure 22 shows the rear view of the FlashSystem V9000 model 92F expansion enclosure.

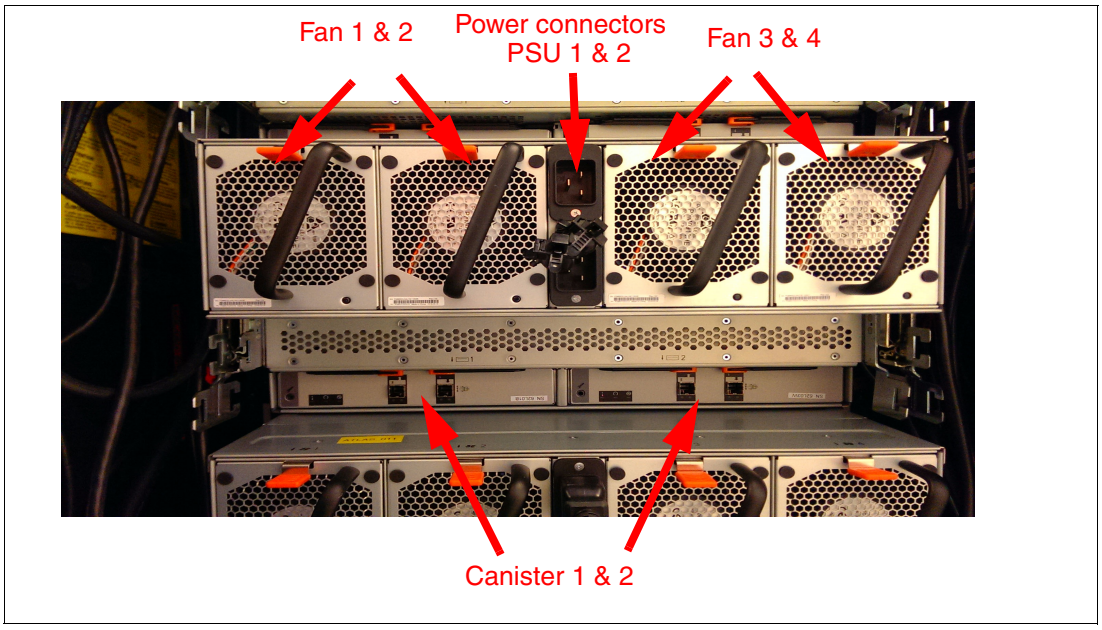

Figure 22 Rear view of the FlashSystem V9000 92F expansion enclosure

Product specifications

Figure 23 lists the specifications for the base configuration of FlashSystem V9000.

IBM FlashSystem V9000 at a glance		
Models	9846/9848 AC3 controllers 9846/9848 AE3 flash enclosure drawers	
System size	Minimum (1 x AE3 and 2 x AC3)	Maximum scaled-out system (8 x AE3 and 8 x AC3)
Flash type	IBM-enhanced 3D TLC	
Flash module configuration	For each AE3: 6, 8, 10 or 12 3.6 TB modules; or 8, 10 or 12 8.5 TB modules; or 8, 10 or 12 18 TB modules	Up to 8 AE3 expansions; up to 4 AC3 pairs
Maximum internal flash capacity	• 43 TB to 219 TB (effective, assuming 2.5:1 or better hardware compression) • 900 TB (effective, assuming 5:1 data reduction)	• Up to 1.7 PB (effective, assuming 2.5:1 or better hardware compression) • 7.2 PB (effective, assuming 5:1 data reduction)
Maximum external storage capacity	External virtualization: Up to 32 PB usable capacity	
Maximum performance (100% read, cache miss)		
Minimum latency (4K)	180 µs	180 µs
IOPS (4K) with h/w compression	1,300,000	5,200,000
Bandwidth (256K)	20 GB/s	80 GB/s
RAS features	Two-dimensional flash RAID • Module-level 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	
Encryption	Data-at-rest AES-XTS 256	
Host connectivity options per building block	16 x 16/8/4 Gb Fibre Channel 8 x 10 Gb Fibre Channel over Ethernet (FCoE) 8 x 10 Gb iSCSI	64 x 16/8/4 Gb Fibre Channel 32 x 10 Gb Fibre Channel over Ethernet (FCoE) 32 x 10 Gb iSCSI
Virtualization software model	5639-RB8	
Tiered solution models	9846/9848 12F, 24F and 92F SAS expansion drawers, with each drawer adding up to a further 1.3 PB of storage	
Controller CPU	Four Intel Xeon E5 v4 Series 8-core 3.2 GHz processors	16 Intel Xeon E5 v4 Series 8-core 3.2 GHz processors
Controller memory	128 GB standard, up to 512 GB	512 GB standard, up to 2,048 GB
Dimensions (height x width x depth)	6U in a standard 19 in. rack 288 mm x 445 mm x 801 mm	4 x 6U blocks in a standard 19 in. rack 1,066 mm x 445 mm x 801 mm Additional AE2 units add 2U or 44.5 mm in height
Weight	82 kg (181 lb) fully loaded	Up to 736 kg (1623 lb) fully loaded

Figure 23 IBM FlashSystem V9000 at a glance

Options and feature codes

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

Host connectivity interface cards

Table 6 shows the current features for host and connectivity on the models of the IBM FlashSystem V9000 storage enclosure 9846-AE3 and 9848-AE3 machine types.

Table 6 Supported storage enclosure and interface components for machine type 9846/8-AE23

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 **Note:** AF18 is only for expansion of legacy 8 Gb scalable V9000s. New V9000 configurations (AC3) are all 16 Gb.	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

Flash modules

IBM FlashSystem V9000 Model AE3 provides configurable IBM MicroLatency module capacity. All modules are hot-swappable. It is important to configure the amount of storage that you will need correctly because it is not possible to dynamically add additional storage.

Attention: Any capacity upgrades to the system involving adding of IBM MicroLatency modules will be disruptive. A full backup of the data on the system is required *before* the upgrade is started. After the upgrade is complete, the data must be restored to the system.

IBM FlashSystem V9000 Model AE3 can be populated with up to 12 x 3.6 TB IBM MicroLatency modules in increments of 6, 8, 10, or 12; or up to 12 x 8.5 TB or 18 TB IBM MicroLatency modules in increments of 8, 10, or 12. These modules of either 3.6 TB, 8.5 TB, or 18 TB cannot be intermixed. Capacity can be upgraded by purchasing the AF3J (3.6 TB), AF3K (8.5 TB), or AF3L (18 TB) IBM MicroLatency module feature codes as MES upgrades. Figure 24 shows the possible capacities.

V9000 AE3 Storage Capacity

	3.6TB				8.5TB			18TB		
Quantity of Modules	6	8	10	12	8	10	12	8	10	12
Usable Capacity	14.44	21.66	28.88	36.1	51.3	68.4	85.5	108	144	180
Effective Capacity (AE3 and RtC mix)*	28	43	57	72	102	136	171	216	288	360
Effective Maximum (AE3 only)**	43	65	87	109	131	175	219	131	175	219
Effective Maximum (RtC only)***	72	108	144	180	256	342	427	540	720	900

* **Effective (AE3 and RtC mix)** capacity assumes a 2:1 reduction in data, using inline hardware compression on the 3.6 and 8.5TB modules and RtC on the 18TB modules.
** **Effective Maximum (AE3 only)** capacity is the maximum amount of data that can be stored, regardless of the compressibility of the workload.
*** **Effective Maximum (RtC only)** assumes a 5:1 reduction in data using Real-time Compression within the IBM Spectrum Virtualize software

Figure 24 V9000 AE3 Storage Capacity Table

Here are the upgrade paths:

- Using AF3J (3.6 TB)

  Start with 14.4 TB usable capacity and grow to 21.6 TB, 28.8 TB, or 36.1 TB
- Using AF3K (8.5 TB)

  Start with 51.3 TB usable capacity and grow to 68.4 TB or 85.5 TB
- Using AF3L (18.0 TB)

  Start with 108 TB usable capacity and grow to 144 TB or 180 TB

Note: IBM FlashSystem V9000 Model AE3 MicroLatency modules are *not* interchangeable with previous models of IBM FlashSystem V9000.

IBM FlashSystem V9000 Model AE3 also provides hardware data compression that is built into the MicroLatency modules. Therefore, the effective capacity is as follows:

- Using AF3J small (3.6 TB)

  Start with 43.96 TB maximum capacity and grow to 65.94 TB, 87.92 TB, or 109.9 TB
- Using AF3K medium (8.5 TB)

  Start with 131.954 TB maximum capacity and grow to 175.92 TB or 219.9 TB
- Using AF3L large (18.0 TB)

  Start with 131.954 TB maximum capacity and grow to 175.92 TB or 219.9 TB

Note: The effective capacity of the large modules assumes a maximum data reduction ratio of 1.2:1. On small and medium modules, it assumes a minimum data reduction ratio of between 2.4 and 3.0:1. If your data is more compressible, you will still get the stated effective capacity. The large capacity modules have the same effective capacity as the medium modules. These are designed for systems that need additional capacity, but have mixed workloads that might not be able to take full advantage of compression. The larger capacity cards can, in some circumstances, give better performance with these types of workloads.

Table 7 lists the supported IBM MicroLatency modules configurations.

Table 7 IBM FlashSystem 900 Model AE3 MicroLatency modules configuration

Description	Feature code	Maximum Quantity Supported
3.6 TB 3D TLC IBM MicroLatency Module	AF3J	12
8.5 TB 3D TLC IBM MicroLatency Module	AF3K	12
18 TB 3D TLC IBM MicroLatency Module	AF3L	12

IBM Variable Stripe RAID

Variable Stripe RAID data protection is a unique, self-healing data protection that is managed independently by each flash controller on each IBM MicroLatency module. With Variable Stripe RAID, every flash controller creates a striped data layout across its set of chips similar to a n+1 RAID 5 array with rotating parity. When the Variable Stripe RAID algorithm detects a failure affecting one or more flash chips in a RAID stripe, the following process happens:

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

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

No system-level rebuild process is necessary to maintain data protection or usable capacity after a failure detected by Variable Stripe RAID. The entire Variable Stripe RAID recovery process is automatic and transparent to the user and administrator, and typically takes place in less than a second. Variable Stripe RAID activities are not normally tracked in system logs, but the root causes of failures that are typically handled by Variable Stripe RAID-plane failures and block failures are tracked in system counters and reflected in the overall IBM MicroLatency module and system health metrics.

IBM Two-dimensional (2D) Flash RAID

The combination of IBM Variable Stripe RAID and system-level RAID 5 protection across IBM MicroLatency modules is called *two-dimensional (2D) Flash RAID*.

Figure 25 shows the 2D RAID and Variable Stripe RAID (VSR) overview.

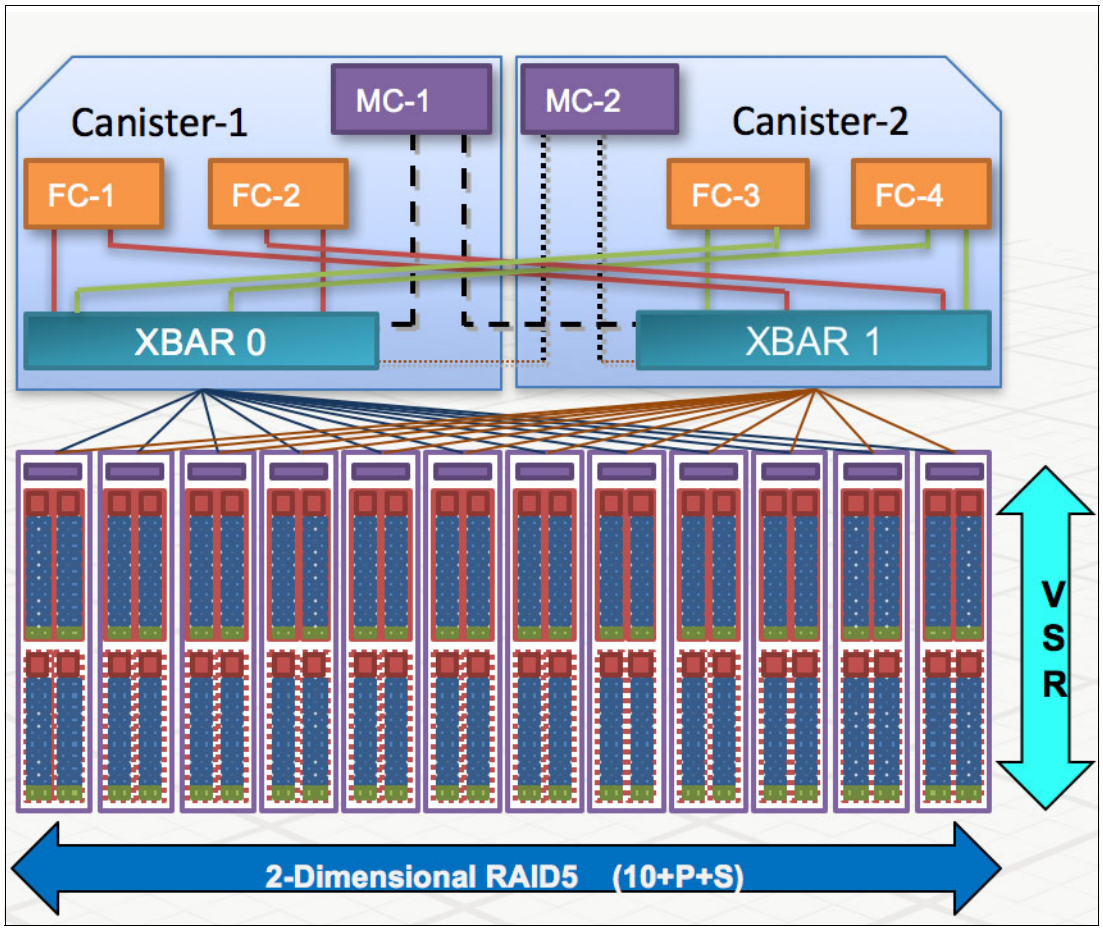

Figure 25 2D RAID and VSR overview

RAID 5

With RAID 5 mode, up to 2048 logical volumes (sometimes referred to as LUNs) can be created in the system. These volumes have 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 5 data layout.

Note: FlashSystem V9000 Model AE3 does not support a RAID 0 configuration

Network cables and UPS

FlashSystem V9000 control enclosure supports various network cables and uninterruptible power supply (UPS) features. See the latest product announcement or your IBM Sales Representative to review the latest information available.

Encryption

FlashSystem V9000 data encryption is protected by the AES algorithm that uses a 256-bit symmetric encryption key in XTS mode, as defined in the IEEE 1619-2007 standard and NIST Special Publication 800-38E as XTS-AES-256. That data encryption key is itself protected by a 256-bit AES key wrap of a key derived from the access key stored on the USB flash drive. The wrapped key is stored in the system in non-volatile form.

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 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 IBM Knowledge Center for FlashSystem V9000.

System management and web interface

IBM FlashSystem V9000 introduces a new user interface (UI) with the same look and feel as other IBM FlashSystem solutions, for a consistent management experience across all platforms. The UI has an improved overview dashboard that provides all information in an easy-to-understand format and allows visualization of effective capacity. Along with the IBM Compretimator tool, which estimates data compression rates for targeted workloads, the new UI enables much easier storage planning and management.

New with the introduction of the FlashSystem V9000 AE3 storage enclosure is the separation of the management interfaces from the FlashSystem V9000 Control Enclosure.

In Figure 26, the V9000 Control Enclosure interface is shown with four Building Blocks and several internal expansion controllers. Starting with release 8.1 the FlashSystem V9000 AE3 storage enclosures are no longer appear in this GUI.

Figure 26 FlashSystem V9000 Control Enclosure Interface

Note: After the AE3 storage enclosure is configured and call home notifications are set up, you will seldom need to do any management. However, you still need to review of error logs regularly.

The V9000 storage enclosures can be effectively managed as a group using the Network Neighborhood that is shown in Figure 27. This display can also include FlashSystem 900 in the environment. This dashboard allows you to quickly identify issues in the environment.

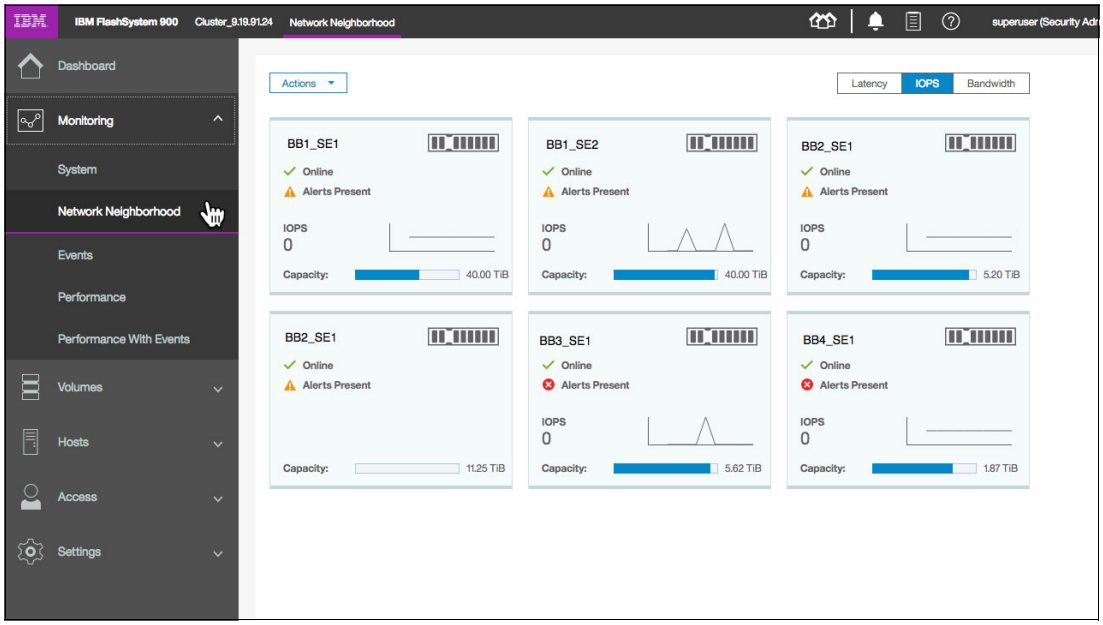

Figure 27 FlashSystem V9000 Storage Enclosures

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. The same is true for the GUI V9000 storage enclosure. All that you need to do is point your web browser to the system IP address, and then you can manage all of the storage enclosures by using the network neighborhood capability.

Note: IBM Storage Mobile Dashboard, version 1.5.6 and later, supports the IBM FlashSystem V9000 GUI. You can download the dashboard at no cost from iTunes.

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.

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).

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 - 35 °C (50°F - 95 °F) at 0 to 914 m (0 - 3,000 ft.) and 10°C - 32 °C (50°F - 90 °F) at 914 - 2,133 m (3,000 - 7,000 ft)
  - Powered off: 10°C - 43 °C (50°F - 109 °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)
- Electrical power:
  - Voltage: 200 - 240 Vac, 3.8 A
  - Frequency: 50/60 Hz
  - Power consumption: 700 watts maximum, 450 watts typical operation
  - Heat dissipation: 512 BTU per hour
- 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-AE3 or 9848-AE3)

The FlashSystem V9000 storage enclosure AE3 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
  - Power consumption: 1300 watts maximum, 625 watts typical operation
  - Heat dissipation: 1194 BTUs per hour
- Acoustical noise emission: 7.2 bels (LwAd) when operating in a 19-inch system rack

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

The FlashSystem V9000 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 - 40°C (41°F - 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
  - Power: 304 watts
  - Heat dissipation (BTU per hour): 1,037

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

The FlashSystem V9000 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 - 40°C (41°F - 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 - 60°C (33.8°F - 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
    - Power consumption: 1300 watts maximum, 764 watts typical operation
    - Heat dissipation: 2607 BTUs per hour
- DC power:
    - Voltage range: -42 to -60 V DC
    - Voltage nominal: -48 V DC
    - Current: 12.0 A

FlashSystem V9000 expansion enclosure (9846-92F or 9848-92F)

The FlashSystem V9000 expansion enclosure 92F has the following specifications:

- Dimensions and weight:
  - Width: 438 mm (17.24 in)
  - Depth: 1013 mm (39.88 in)
  - Height: 220 mm (8.66 in)
  - Approximate weight:
    - Empty: 42.5 kg (93.7 lb)
    - Fully configured with 2.5 SSDs: 78.6 kg (173.3 lb)
    - Fully configured with 2.5 HDDs: 86 kg (189.6 lb)
    - Fully configured with 3.5 HDDs: 138.6 kg (305.6 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.
  - Nonoperating: -30°C to 60°C (-22°F to 140°F)
- Relative humidity:
  - Operating: 8% - 80%
  - Non-operating: 8% - 80%
- Electrical power:
  - Voltage range: 200 - 240 V AC
  - Frequency: 50 - 60 Hz
  - Power consumption: 2400 watts maximum, 2400 watts typical operation
  - Heat dissipation: 8189 BTUs per hour

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

Software and licensing

FlashSystem V9000 uses IBM Spectrum Virtualize software-defined storage features. All FlashSystem V9000 model AE3 systems have the FlashSystem V9000 software preinstalled. One 5639-RB8 license is required for each model AE3, 12F, and 24F storage enclosure, with four 5639-RB8 licenses being required for each model 92F storage enclosure. These models are the FlashSystem virtualized storage and expansion enclosures.

The system requires Storage Capacity Units (SCU) licenses for any external systems that are being virtualized. For more information about IBM Spectrum Virtualize licensing, see 5641-VC8 IBM Spectrum Virtualize Software for SAN Volume Controller V8.1.

With the AE3 storage enclosure, there is also a licensed feature code for hardware assisted encryption: Feature code AF14 - Encryption Enablement Pack. This feature code is needed if you want to use USB-Key encryption, SKLM-based encryption, or both on the AE3 storage enclosure.

5639-RB8 Base Software licensed features and functions

The following functions are provided with the IBM FlashSystem Family Software for FlashSystem V9000 V8 Base Software 5639-RB8:

- 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 reduce data migrations from weeks or months to days, eliminating the cost of add-on migration tools, and provides continuous availability of applications by eliminating downtime.
- Simple GUI: Simplified management with the intuitive GUI enables storage to be quickly deployed and efficiently managed. The GUI runs on the FlashSystem V9000 system, so having a separate console is unnecessary. Simply point your web browser to the control enclosure and storage enclosure.
- 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 is useful for cost-effective expansion and usage of your existing storage capacity investment.

  Easy Tier supports up to three tiers of storage. For example, you can set up a storage pool intended for Easy Tier volumes where the pool is composed of the native FlashSystem V9000 storage enclosures, SSD flash drives, 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 process helps grow storage environments more easily while retaining the performance benefits of striping the data across the disk systems in a storage pool.

- FlashCopy: Provides a volume level point-in-time copy function for any storage that is virtualized by 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.
- Encryption: The system provides optional encryption of data at rest, which protects against the potential exposure of sensitive user data and user metadata that is stored on discarded, lost, or stolen storage devices. Encryption can be activated only on enclosures that support encryption.

  The feature code AF14 “Encryption Enablement Pack” is needed if you want to use USB-Key encryption, SKLM-based encryption, or both on the AE3 storage enclosure.
- 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 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 250 milliseconds round trip time when using FC connections).

  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 5639-RB8 is available for FlashSystem V9000 model AE3, 12F, and 24F storage enclosure, with four 5639-RB8 licenses being required for each model 92F storage enclosure.

Optional licensed features

All externally virtualized storage that is not part of the V9000 machine type, and that do not have a 5639-RB8 license require a Storage Capacity Units license. For more information about the IBM Spectrum Virtualize licensing, see 5641-VC8 IBM Spectrum Virtualize Software for SAN Volume Controller V8.1.

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

For details about the IBM Spectrum Virtualize software requirements, see IBM Spectrum Virtualize Software V8 delivers remote support assistance, enhanced encryption capabilities, and GUI improvements.

The 5641-VC8 (External Virtualization, FlashCopy, and Remote Mirroring Features) and 5641-CP8 (Compression) licenses are licensed per enterprise within one country. These are the same licenses as for IBM SAN Volume Controller. Therefore, existing SAN Volume Controller licenses can be used for the FlashSystem V9000 for these features.

Table 8 lists the software license description. Details can be found in IBM Spectrum Virtualize Software V8 delivers remote support assistance, enhanced encryption capabilities, and GUI improvements. This announcement contains the feature codes that are used for version 8.1.

Table 8 Base and optional software licenses

Program number or product ID	License type	Name or Feature description
5639-RB8	Base	IBM FlashSystem Family Software for FlashSystem V9000 V8 Base Software V8.
5641-VC8	Optional	IBM Spectrum Virtualize Software for SAN Volume Controller V8, per SCU.
5641-VC8	Optional	IBM Spectrum Virtualize FlashCopy Software, per SCU.
5641-VC8	Optional	IBM Spectrum Virtualize Metro/Global Mirror Software, per SCU.
5641-CP8	Optional	IBM Spectrum Virtualize Software for SAN Volume Controller Compression Software V8 per SCU.
5641-B08	Optional	IBM Spectrum Virtualize Software for SAN Volume Controller Encryption Software V8.
5608-ACL	Optional	IBM Virtual Storage Center (VSC) for Storwize can be used for FlashSystem V9000 storage enclosures having the 5639-RB8 license only. Can be combined with 5608-AE1.
5608-AE1	Optional	IBM Virtual Storage Center can be used for all FlashSystem V9000 attached 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 Virtual Storage Center for Storwize Family (5608-ACL), which uses a storage device (also referred to as enclosure) pricing model, can be licensed only for the capacity of the FlashSystem V9000 system that has the 5639-RB8 license. All other capacity that is managed and virtualized by the FlashSystem V9000 must be licensed with Virtual Storage Center (standard), 5608-AE1, license (priced per SCU). 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 28 shows the base and the optional software licenses that can be ordered for FlashSystem V9000. Also shown in Figure 28 is a color key for each software license that maps to the licenses used in the examples in the following sections.

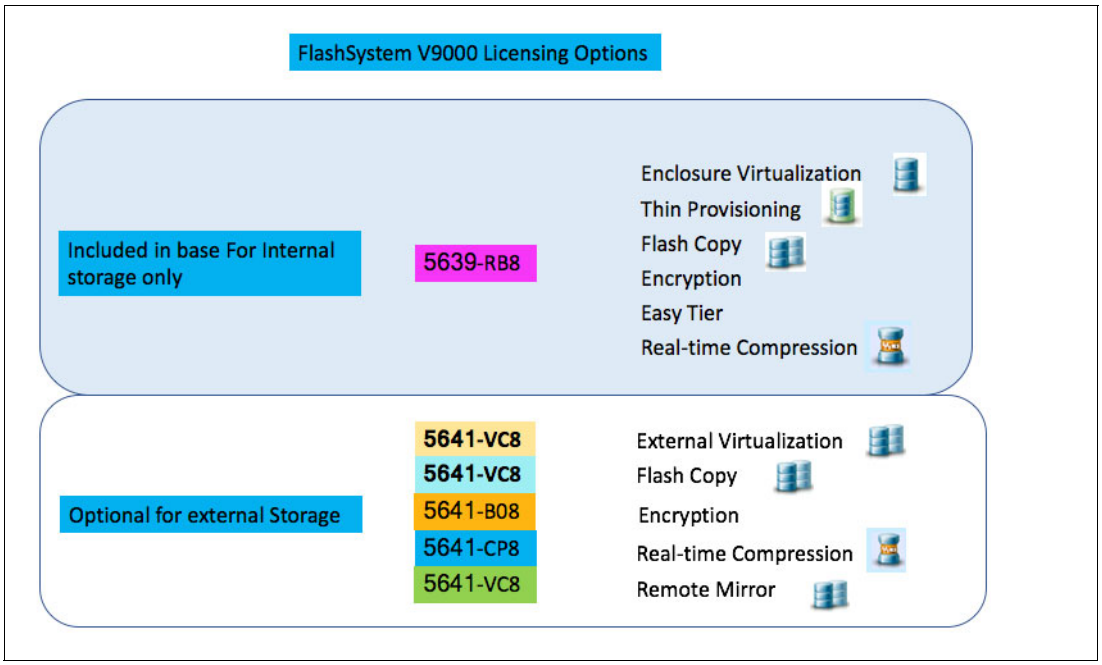

Figure 28 FlashSystem V9000 licensing options

Differential Licensing

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

Note: SCUs are only needed for virtualized storage that does not have the 5639-RB8 base license.

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

- Category 1: Flash and SSD flash drives
- Category 2: SAS drives, Fibre Channel drives, and systems that use drives with advanced architectures to deliver high-end storage performance
- Category 3: Nearline SAS (NL-SAS) and Serial Advanced Technology Attachment (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 9 shows an example of calculating SCUs. The example is a customer who virtualizes external disk arrays with 30 TB SSD flash drives, 200 TB SAS, and 2400 TB nearline capacity.

Table 9 Example of calculating SCUs

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

800 SCUs are required for the example in Table 9. When you calculate the number of SCUs per category, fractions must be rounded up to the next higher integer number.

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

IBM FlashSystem V9000 Base Software (5639-RB8)

IBM FlashSystem V9000 Base Software (5639-RB8) 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 (9846/9848-AE2, 9846/9848-AE3, 9846/9848-12F, and 9846/9848-24F) requires one 5639-RB8 FlashSystem V9000 Base Software license. The 9846/9848-92F enclosure requires four 5639-RB8 FlashSystem V9000 Base Software licenses.

Example 1

A FlashSystem V9000 order consisting of two control enclosures and one storage enclosure requires one FlashSystem V9000 Base Software license. No SCUs are required. Figure 29 shows the FlashSystem V9000 Base Software license.

Figure 29 FlashSystem V9000 Base Software license with two control enclosures and one storage enclosure

Example 2

A FlashSystem V9000 order consisting of two control enclosures and four storage enclosures requires four FlashSystem V9000 Base Software licenses. No SCUs are required. Figure 30 illustrates the FlashSystem V9000 Base Software license with two additional expansion enclosure model AE3 and one model 24F.

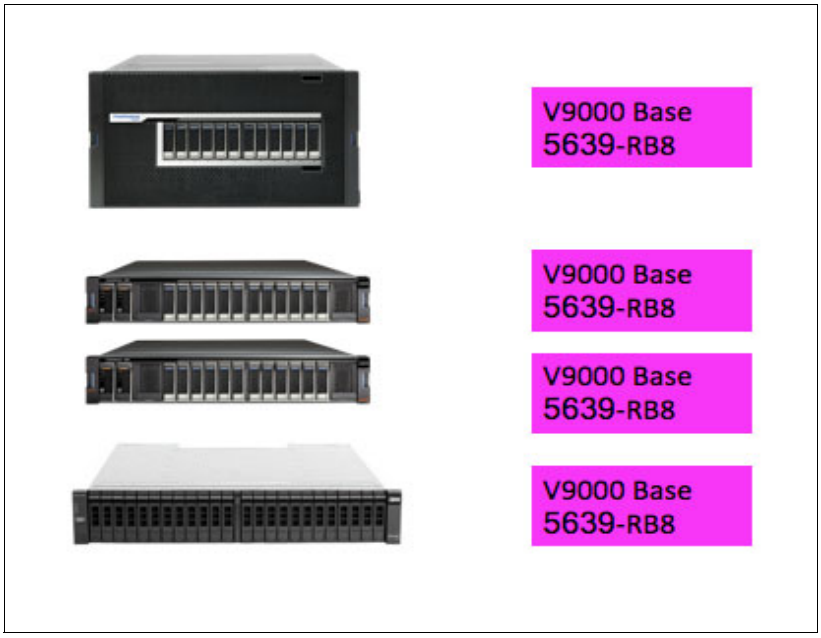

Figure 30 FlashSystem V9000 Base Software license with two control enclosures and four storage enclosures

Example 3

A FlashSystem V9000 order consisting of two control enclosures and two storage enclosures, one enclosure being a 92F enclosure, requires six FlashSystem V9000 Base Software licenses. No SCUs are required. Figure 31 illustrates the FlashSystem V9000 Base Software license with one additional expansion enclosure model AE3 and one model 92F High Density Enclosure that requires four licenses.

Figure 31 FlashSystem V9000 Base License with two Expansion Controllers and AE3 and 92F

IBM Spectrum Virtualize External Virtualization Software (5641-VC8)

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-AE3, 9848-AE3, 9846-12F, 9846-24F, 9846-92F, 9848-12F, 9848-24F, and 9848-92F) are not considered externally attached expansion 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 SCU.

Example 4

For a FlashSystem V9000 to virtualize a Storwize V5030 with 10 TB SSD flash drives, 40 TB SAS, and 50 TB nearline capacity, a quantity of one FlashSystem V9000 Base Software license and one 5641-VC8 (External Virtualization) are required. 57 SCUs are required for External Virtualization. Figure 32 illustrates this configuration.

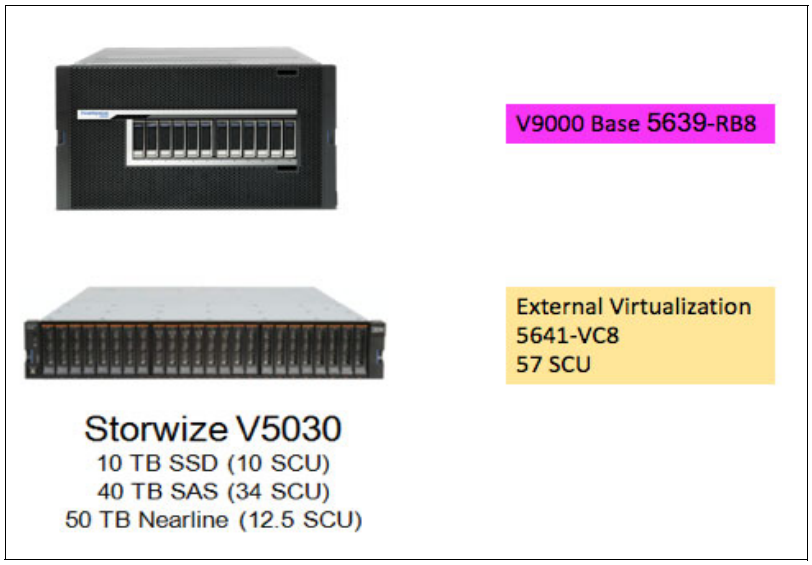

Figure 32 FlashSystem V9000 with External Virtualization license

In the example in Figure 32, 12.5 SCU from nearline capacity must be rounded up to 13 SCUs.

IBM Spectrum Virtualize Real-time Compression for external storage (5641-CP8)

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. Enough SCUs are required to cover actual managed disk capacity that is used by the compressed volumes.

For details about the IBM Spectrum Virtualize Real-time Compression licensing rules, see IBM Software Announcement 216-212 regarding new IBM Spectrum Virtualize Software V7.7 software features.

Example 5

A FlashSystem V9000 virtualizing a Storwize V5030 with 50 TB of physical SAS-disk storage and 100 TB of uncompressed volumes requires one FlashSystem V9000 Base Software license, one 5641-VC8 (External Virtualization license), and one 5641-CP8 (Real-time Compression license). 43 SCUs are required for External Virtualization, and 12 SCUs for Real-time Compression.

Note: This model assumes a compression ratio of 4:1 on the uncompressed volumes for resulting 12.5 TB (13 TB) of managed disk usage of compressed volumes. This amount is purely for the example to show the new compression charging model. Compression ratio of volumes depends on data types and other factors, and might achieve this level of compression.

Figure 33 illustrates this configuration.

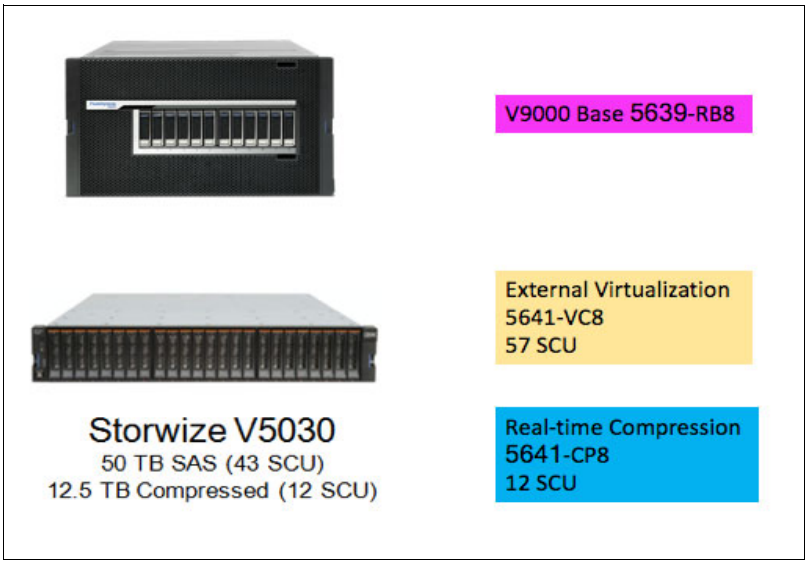

Figure 33 FlashSystem V9000 with External Virtualization and Compression license

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

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 6

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 two FlashSystem V9000 Base Software licenses, two 5641-VC8 (External Virtualization license), and two 5641-VC8 (Remote Mirror license) for 100 TB. 170 (2 times 85) SCUs are required in total for the External Virtualization licenses, and 170 SCU (85 SCU for source and 85 SCU for target) in total for remote mirroring. Figure 34 illustrates this configuration.

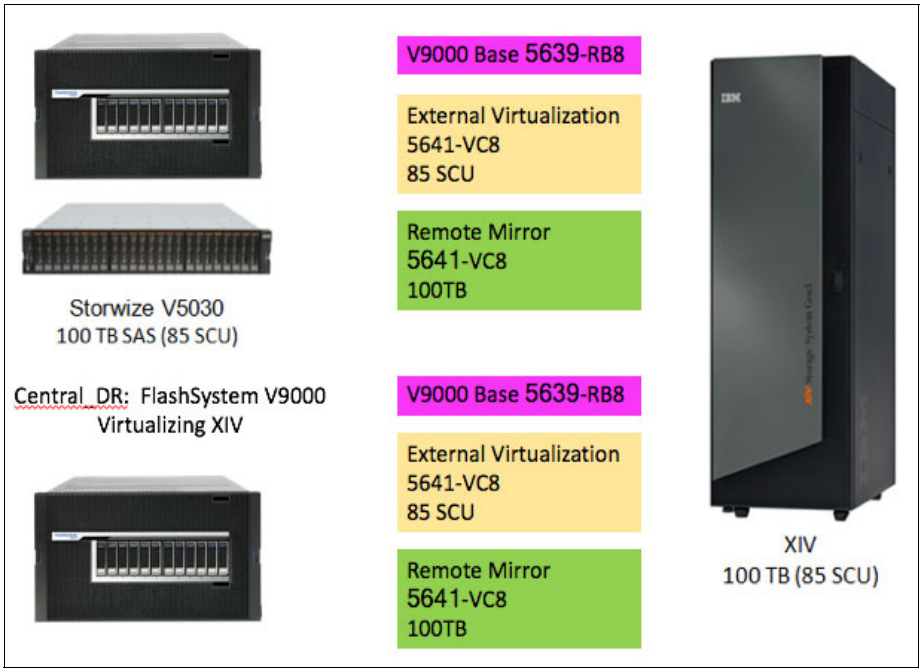

Figure 34 FlashSystem V9000 with External Virtualization and Remote Mirror license

IBM Spectrum Virtualize FlashCopy for external storage (5641-VC8)

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 7

A FlashSystem V9000 virtualizing a Storwize V5030 with 50 TB SAS-disk capacity and 25 TB FlashCopy volumes requires one FlashSystem V9000 Base Software license, one 5641-VC8 (External Virtualization license), and one 5641-VC8 (FlashCopy license) for 25 TB. 43 SCUs are required for External Virtualization. Figure 35 illustrates this configuration.

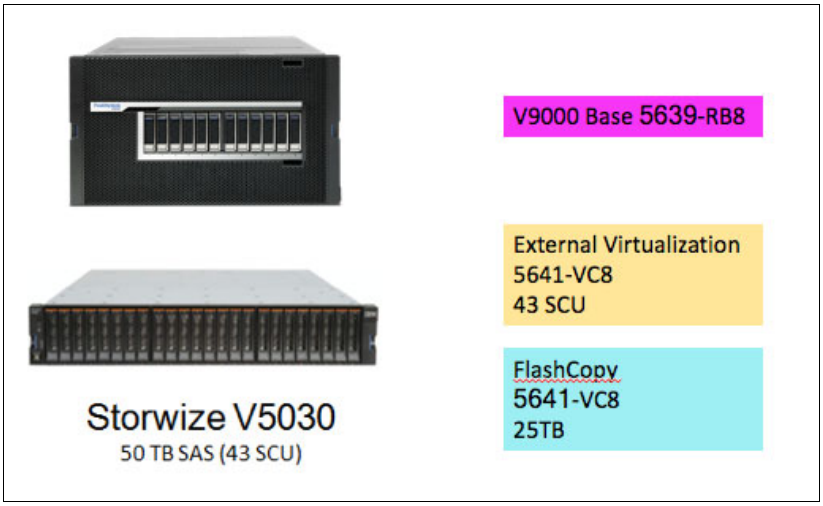

Figure 35 FlashSystem V9000 with External Virtualization and FlashCopy license

Warranty information and upgrades

FlashSystem V9000 includes a one-year (9846) or a three-year (9848) warranty.

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

Technical Advisor support for FlashSystem V9000 is delivered remotely. It includes a documented support plan, coordinated problem and crisis management that reports on your hardware inventories and software levels, and consultation about 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 machine type 9848 purchased with a three-year warranty. FlashSystem V9000 machine type 9846 comes with a 1-year warranty and IBM base support.

For more information about this offering, see "FlashSystem V9000 Enterprise Class Support" on page 24.

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Ordering information

For information about ordering FlashSystem V9000 building block components, see “FlashSystem V9000 components” on page 23.

For information about ordering hardware features, see “Options and feature codes” on page 35.

For information about ordering software licenses, see “Software and licensing” on page 45.

Related information

For more information, see the following documents:

- *IBM FlashSystem 900 Model AE3 Product Guide*, REDP-5467
- *IBM FlashSystem V9000 Version 7.6 Product Guide*, REDP-5317
- *IBM FlashSystem V9000 Version 7.7 Product Guide*, REDP-5409
- *Implementing IBM FlashSystem 900 Model AE3*, SG24-8414
- *Implementing IBM FlashSystem V9000 AE3*, SG24-8413
- 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`

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REDP-5468-00

ISBN 0738456748

Printed in U.S.A.