IBM System Storage Solutions Handbook

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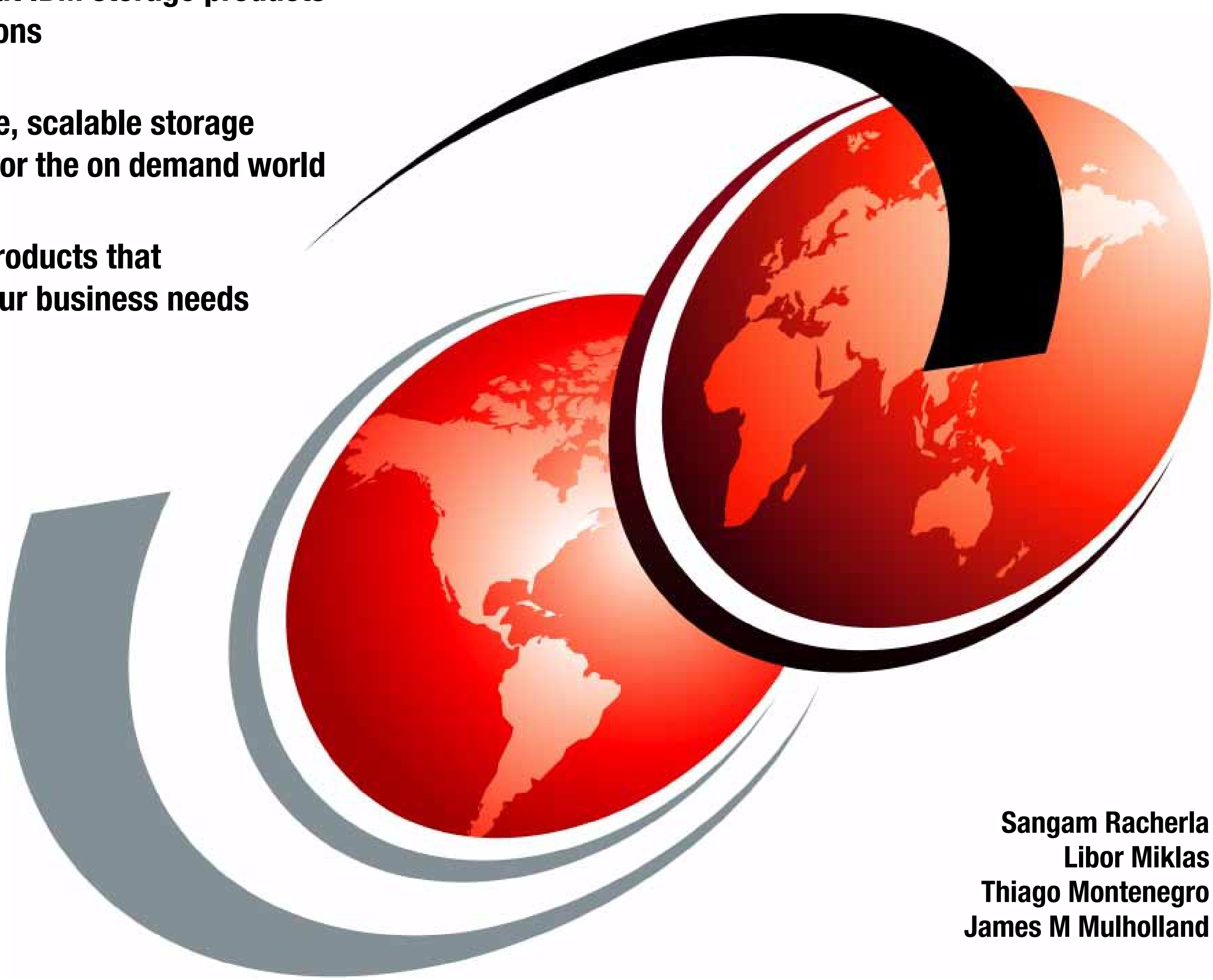

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IBM System Storage Solutions Handbook

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Note: Before using this information and the product it supports, read the information in “Notices” on page xix.

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Contents

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Preface

IBM® System Storage® solutions provide the capabilities needed to help organizations reduce cost and mitigate risks while managing continued information growth and service level demands. Dynamic environments, such as Cloud Computing and Service Oriented Architecture, require scalable, always on information services delivered by a robust storage infrastructure.

This IBM Redbooks® publication provides overviews and pointers for information about the most current IBM System Storage products, showing how IBM delivers the right mix of products for nearly every aspect of business continuance and business efficiency. IBM System Storage products can help you store, safeguard, retrieve, and share your data.

We cover these topics:

- First, we introduce the IBM Dynamic Infrastructure® and the Smarter Planet™ Strategy.
- Part 1 describes disk products that include IBM System Storage DS® Series (entry-level, midrange, and enterprise offerings), IBM XIV® Storage System, IBM System Storage N Series, and the IBM Information Archive.
- Part 2 presents an overview of the IBM TotalStorage® and System Storage Tape Drives, IBM Tape Automation Products, and IBM Tape Virtualization solutions Products.
- Part 3 describes storage networking infrastructure and presents the switches and directors to form SAN solutions. Also provided is an overview of the recently introduced IBM Ethernet switches and routers.
- Part 4 discusses the IBM System Storage software portfolio, which includes IBM System Storage Virtualization, IBM Tivoli® Storage Manager, IBM Tivoli Storage Productivity Center (TPC) Suite, and IBM Tivoli Key Lifecycle Manager (TKLM). We also introduce the IBM General Parallel File System (GPFS™) and the IBM scale out file services (SOFS).
- Part 5 describes the z/OS® storage management software (DFSMS and DFSORT) and z/OS storage management tools, including an overview of the IBM Smart Business Storage Cloud solution.
- Finally, in the Appendixes, we provide information about the Simplified Storage Management, High Performance Storage System (HPSS), iSCSI, RAID, and standards such as Storage Management Initiative Specification (SMI-S), Common Information Model (CIM), and Web Based Enterprise Management (WBEM).

This book is intended as a reference for basic and comprehensive information about the IBM System Storage products portfolio. This book provides a starting point when establishing your own enterprise storage environment.

Attention: This book, previously published in 2010, has since been extensively updated for the 2011 edition.

The team who wrote this book

This book was produced by a team of specialists from around the world working at the International Technical Support Organization, Tucson Center.

Thiago, Libor, Sangam, and James

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Introduction: Dynamic Infrastructure and IBM Smarter Planet Strategy

In this chapter, we present an introduction to the book as a whole. Subsequent chapters are organized under parts according to specific topics.

The IBM vision is to bring a new level of intelligence to the way the world works, and how every person, business, organization, government, natural system, and man-made system interacts. Each interaction represents a chance to do something better, more efficiently, and more productively. But, more than that, as the systems of the planet become smarter, we have a chance to open up meaningful new possibilities for progress. By harnessing our increasingly digitized world, we can help to solve intractable social problems, bring organizations closer to our customers, and vastly shrink decision windows that help executives drive better business outcomes. Success in achieving a smarter planet demands smarter systems.

Yet, as the pace of business continues to accelerate and the planet becomes smarter, the physical and digital foundations on which progress depends are straining to keep up. They are too complex, too inefficient, and too inflexible, and the current explosion of network connected devices and data will only intensify the demands that we continue to place on IT.

Within our own organizations, we face a growing realization that our physical and IT infrastructure is not built for what is coming. Going forward, the most successful organizations will be those with technology that enables informed, real-time decision making at the point of greatest business impact without requiring analytical expertise.

Consider what might it mean to your organization if you were always able to access critical business data at the exact moment you needed it. Likewise, imagine that you can improve service and reduce costs by delivering IT services when the customer requests those services, and automatically reclaim the services when they are no longer needed.

Storage is as important to a dynamic infrastructure as servers and networks. Because of the explosion of information in most data centers, storage can be more challenging to manage than server resources, but the payoff is potentially more beneficial.

IBM is a market leader in the storage industry. IBM System Storage solutions offer excellent performance, innovative technology, and open standards. IBM System Storage solutions can help you manage information growth more effectively, dramatically improve service levels, lower costs associated with energy consumption and footprint, mitigate risks, and extract new intelligence for business insight.

For today's information explosion, there is a necessity for smarter means to provision and protect critical business data, IBM Storage solutions provide the capabilities needed to help organizations reduce cost and mitigate risks while managing continued information growth and service level demands. Dynamic environments, such as Cloud Computing and Service Oriented Architecture, require scalable, always-on information services delivered by a robust storage infrastructure.

IBM Smart Business Storage Cloud solutions facilitate the growth of data. As the ability to handle various file formats becomes more complex, supporting efficient and cost-effective access to data can be increasingly difficult, with users experiencing reduced performance and outages. IBM Smart Business Storage Cloud can help you to successfully deploy high-performance, scalable storage-virtualization solutions to facilitate growth and innovation at lower operational costs.

Allocating the right amount of data storage to the right users at the right time is an ongoing challenge for organizations of all sizes. The explosive growth of workgroup communities and multiple data volumes demands efficient and cost-effective interdepartmental data sharing. Although traditional solutions might offer simplicity, they can lack the crucial scalability to expand the storage space to serve large end-user communities.

IBM Smart Business Storage Cloud offers a storage-virtualization solution designed to support your storage optimization efforts. It can help alleviate your data storage challenges by enabling rapid implementation of a scalable, global file storage system with flexibility in deployment and management options. The solution provides virtualized storage to enable storage and server consolidation, a unified management platform to help reduce outages and storage management labor demands and costs, and advanced data replication for cost-effective business continuity and disaster recovery.

One of the aims of the IBM Smarter Planet strategy is to enable the dynamic infrastructure in order to deliver this improved service at a reduced cost and with better managed risk.

To learn more about the IBM Smarter Planet strategy, see the following link:

http://www.ibm.com/smarterplanet

1.1 What a dynamic infrastructure is

To succeed in business on a smarter planet, where the world is more instrumented, intelligent, interconnected, and the demands on your infrastructure are constantly growing, a smarter kind of infrastructure is needed; one that can help improve service, reduce cost, and manage risk, while accelerating growth in your business. That means developing a dynamic infrastructure, one that is designed for a smarter planet.

A dynamic infrastructure aligns business and IT assets to support the overall goals of the business while taking a new, smarter, and more streamlined approach, focused as follows:

- Integrates visibility, control, and automation across all business and IT assets
- Is highly optimized to do more with less
- Addresses the information challenge
- Manages and mitigates risks
- Utilizes flexible delivery choices like clouds

The cornerstones of a dynamic infrastructure (Figure 1-1) are clear:

- Improving service
- Reducing cost
- Managing risk

In this book we look at several IBM system storage offerings available today and explore how they can be used to help deliver the benefits of a dynamic infrastructure.

Figure 1-1 The dynamic infrastructure

A dynamic infrastructure integrates the management of business and IT assets and aligns them with the overall goals of the business while taking a new, smarter, and more streamlined approach to help improve service, reduce cost, and manage risk. In today's ever more competitive and growing business environment, information is increasingly valuable, but a costly organizational asset. The volume of information is growing very rapidly in most organizations, and with this, the need to protect and manage information also continues to increase. Organizations are seeking to minimize risk, reduce costs, and increase flexibility by aligning IT investments according to information value and business needs.

1.2 Delivering a dynamic infrastructure

A dynamic infrastructure is designed for today's instrumented and interconnected world, helping clients to integrate their growing intelligent business infrastructure with the necessary underlying design of a flexible, secure, and seamlessly managed IT infrastructure.

IBM System Storage products can help deliver the solutions required to implement a dynamic infrastructure. Such solutions include the following capabilities:

- Information infrastructure
- Smarter Security and resiliency
- Virtualization
- Energy efficiency
- IBM data and information security
- Service management
- Outsourcing

1.2.1 Information infrastructure

IBM information infrastructure solutions are designed to help you manage the information explosion and address challenges around information compliance, availability, retention, and security.

The goal, the advantage, the benefits

IBM infrastructure solutions can lead your company toward improved productivity, service delivery, and reduced risk while streamlining costs:

- The goal: Continuous and reliable access to information

  Your organization's success can hinge on information availability. Providing access to critical information, when and where it is needed, has an immediate impact on employee productivity, client satisfaction, and your bottom line. Even one hour of downtime can have dramatic effects and cause significant expense. Organizations must take steps to ensure information availability so users have reliable access to critical information in real time.

- The advantage: Managing information availability for efficiency and cost effectiveness

  IBM can help. IBM offers comprehensive services, hardware, and software to help you build and implement an information availability strategy. The IBM information infrastructure helps you to deliver quality information services, even as demand increases or if components fail.

- The benefits: Information and business resiliency

  IBM information infrastructure solutions can help you establish a solid foundation for keeping your information available. By optimizing the software, servers, storage, and networks, we can help you create a secure, resilient information infrastructure that allows you to exploit your data, maximize its value, and deliver the required information to the right people at the right time.

What IBM has to offer

IBM offers innovative solutions that enable smart movement and management of information, and capacity growth without complexity. IBM Information infrastructure solutions are designed to help you manage the information explosion and address challenges around storage efficiency, service delivery, or data protection.

Storage efficiency

Manage your information more intelligently with storage solutions from IBM. With data growing at 40% or more per year, companies cannot address challenges in a traditional way; and new technologies are required, such as virtualization, thin provisioning, deduplication, compression, and automated tiering. Let IBM show you how our storage efficiency solutions not only improve productivity, but at the same time, reduce costs.

Data protection and retention

Maintain access to information throughout its useful life. IBM can help you meet recovery objectives reliably and efficiently with solutions that deliver continuous data availability, more efficient backup and recovery systems, and optimized data archive processes to meet retention and compliance requirements.

Service delivery

If you are having trouble maintaining service levels while information grows, IBM can help you improve service delivery, beat expectations, and maximize the business value of your information infrastructure. IBM solutions include flexible delivery options, such as cloud and managed services, and products to help improve the visibility, control, and automation of the infrastructure you own.

Here is how IBM system storage products can help you to develop your information infrastructure:

- Scale Out NAS: Managing vast repositories of information in enterprise environments
- Storage virtualization: Reducing SAN disk cost by increasing utilization
- Data deduplication: Lowering storage acquisition costs while reducing energy, cooling, floor space, management requirements, and maintenance costs
- Solid-state storage architectures: Improving drive response time up to 800% without application tuning
- Enterprise Storage: Choosing optimized enterprise storage solutions for Linux, UNIX®, Windows, and z/OS environments
- Information Archiving: Optimizing application performance and simplifying application administration, while lowering total costs
- Next Generation Storage Systems: Revolutionary disk systems that can help deliver Tier 1 functionality at Tier 2 costs
- Encryption and Security Management: Encryption at the drive level that improves security with little or no performance impact
- Storage Management: Improving storage utilization and simplifying administration
- Business Intelligence Platform Integration: Correlating disparate information across the value chain up to 600% faster
- Continuous Data Protection: Getting applications and users up and running within minutes following a data loss

For more details about information infrastructure, see the website:

http://www.ibm.com/systems/information_infrastructure

1.2.2 Smarter security and resiliency

Fundamentally, security is the posture taken to protect people, assets, data, and technology across an entire enterprise. Resilience is the ability to rapidly adapt and respond to business disruptions and to maintain continuous business operations.

Security and resiliency address the following topics:

- Business continuity planning: Evaluating, planning, and mitigating the business impact of various types of risks
- Regulatory compliance: Responding to regulatory requirements associated with business resiliency
- High availability: Assessing, planning for, creating, and running an infrastructure that supports the ongoing availability and performance objectives of the business
- Information protection: Ensuring that data is available and accessible in the event of a disruption
- Disaster recovery: Ensuring that human capital, processes, and systems are able to predictably recover and respond to catastrophic disruptive events that might require recovery at a remote location

For more information about business continuity and resiliency, see the website:

http://www.ibm.com/systems/business_resiliency

1.2.3 Virtualization

Virtualization and consolidation can reduce IT complexity to help your data center become more resilient and secure while reducing costs. The ability to deploy capacity and server images virtually increases speed of deployment roughly by a factor of 30 times[1].

Virtualization of physical storage resources is an essential part of a dynamic infrastructure environment. Such resources are more flexible because the logical files and disks can be manipulated more easily than numerous individual physical disk and tape devices. Virtualization can further improve resource utilization, simplify storage management, and accelerate application deployment with improved resource sharing. These capabilities can help organizations enact a tiered storage environment, where information is stored at a cost befitting its value at that point in time.

IBM storage virtualization unlocks “logical” volumes from physical locations, making information more readily available to business applications across the infrastructure. With a virtualized storage infrastructure, organizations can drive greater utilization of storage assets, enable greater flexibility and responsiveness to rapidly changing business demands, and significantly simplify storage infrastructure management.

IBM storage virtualization can help you:

- Support business agility by making storage provisioning fast, easy, and flexible
- Dramatically improve storage utilization rates
- Extend the value of investments by transparently pooling diverse storage assets
- Improve productivity with reliable data access across the organization
- Optimize physical media access for energy efficiency
- Enable easy scalability to keep pace with data demands
- Simplify storage infrastructure management, even to a single point of control

[1] Tom Bittman, Gartner 27th Annual Data Center Conference. December 2008

Ultimately, the business value of the IT infrastructure is defined by its ability to deliver the right data to the right resources at the right time. IBM storage virtualization makes that process faster, easier, and more efficient, helping you extract more value from your infrastructure investments and from your available data.

For more information about virtualization, see the website:

http://www.ibm.com/itsolutions/virtualization

1.2.4 Energy efficiency

Energy efficiency solutions can help lower data center energy costs by up to 40% or more through facilities design, power, and cooling infrastructure, active energy management, efficient, scalable IBM systems and, most importantly, better utilization of existing resources.

The challenges have become clear: the need for clean water and air; affordable and reliable delivery of energy; the dwindling supply of fossil fuels; the reality of climate change and its implications for future generations.

At IBM, our approach is two-fold: we are working to make our existing products and processes more efficient for both the environment and for business, while also developing new innovations that can accelerate the adoption of products and services that have lesser environmental impact.

Today's energy-related and climate-related issues are at the top of our strategic agenda. We recognize that information technology plays an extremely important role in helping solve the myriad of ecological challenges faced by the global society, such as conserving our scarce resources even as global demand skyrockets, reducing pollution, minimizing the environmental impact of our activities, and enabling safe and renewable alternative sources of energy.

In the past year, IBM conducted more than 30 energy assessments around the world and found the average data center infrastructure efficiency (DCiE) index was 43 percent. This means that 43 cents of every energy dollar are spent to power IT, while 57 cents are spent on the physical infrastructure for conditioned power and cooling.

Energy is used by the IT equipment (servers, storage and network equipment), as well as the physical infrastructure equipment, like the computer room air conditioners, uninterruptible power supplies and chillers. As a result 60 to 70 percent of the energy in a data center is used on the physical infrastructure equipment, while only 30 to 40 percent is used on the IT equipment.

For more information about energy efficiency, see the website:

http://www.ibm.com/itsolutions/energy-efficiency

1.2.5 IBM data and information security

Security is one critical component of a dynamic infrastructure. A flexible, dynamic infrastructure can enable real business innovation by integrating security with other key IT components so they function together to help you reduce cost, improve service, and manage risk.

IT security used to rely on a perimeter-based approach. But in today’s environment, it is hard to define the perimeter. Web-based applications improve the productivity of your employees, partners, and customers, but they also expose you to risk. A service oriented infrastructure offers extraordinary flexibility and efficiency, but it forces you to re-think data security.

It used to be possible to protect your data with a perimeter, but now you have to secure that data wherever it resides and while it is in motion.

Today, information is at the heart of businesses, and organizations face many challenges trying to safeguard it. Data and information security is about enabling collaboration while managing risk with an approach that balances availability versus the confidentiality of data.

IBM data and information security capabilities

IBM data and information security solutions deliver comprehensive capabilities for data protection and access management that can be integrated to help address information lifecycle security across the enterprise with:

- Data discovery and classification to identity sensitive mission critical information
- Data encryption and key management
- Executable access protection policy management
- Messaging security and data loss prevention
- Secure storage and archiving for data retention
- Services to assess, protect, monitor and manage information

IBM data and information security products and services

IBM offers the following security products and services to provide data and information security:

- IBM Tivoli Security Information and Event Manager centralizes security event and compliance policy management providing visibility to the enterprise-wide security posture. It includes centralized log management, event correlation, a policy compliance dashboard, and comprehensive reporting capabilities.
- IBM Tivoli Access Manager for e-business serves as a hub for authentication and authorization for web and other applications, centralizes access management, and makes it easy and cost effective to deploy secure applications.
- IBM Tivoli Access Manager for Operating Systems protects individual application and operating system resources by addressing system vulnerabilities surrounding UNIX/Linux super user or root accounts.
- IBM Tivoli Key Lifecycle Manager Helps IT organizations better manage the encryption key lifecycle by allowing them to simplify, centralize, automate and strengthen key management processes across the computing environment.
- IBM Security zSecure suite (formerly known as IBM Tivoli zSecure suite) improves organizations' ability to facilitate security compliance, monitor and audit incidents, and automate routine administrative tasks for the mainframe.
- IBM FileNet® Records Manager streamlines records-based activities to help enforce compliance without user participation. Enterprises can use it to classify, apply retention policies and store electronic records according to fiscal, legal and regulatory requirements.
- IBM Data Security Services for activity compliance monitoring and reporting helps you stay on top of your database security initiatives and improve visibility into activities of administrators and others who support critical applications. Powered by IBM Tivoli Compliance Insight Manager software and Application Security's DbProtect AppDetective, the solution utilizes the IBM security expertise and proven services methodology.
- IBM Data Security Services for endpoint data protection is designed to help you improve endpoint security. With rapid implementation, reliable managed security services and industry-leading software, IBM can help you protect sensitive data that is accessed, stored, and transmitted on your endpoint devices.

- IBM Data Security Services for enterprise content protection provides a comprehensive solution for your unique environment that uses market-leading data loss prevention technology to drive consistent coverage from endpoint to network. From policy creation and implementation to continued management and remediation, the solution utilizes the IBM security expertise and proven services methodologies.

For more information about IBM data and information security solutions, see the website:

http://www.ibm.com/software/tivoli/governance/security/information.html

1.2.6 Service management

A smart planet is more instrumented, interconnected, and intelligent, creating new opportunities for business to deliver innovative, differentiated services across a dynamic infrastructure. IBM Service Management provides visibility, control, and automation across all stages of the service life cycle. Organizations can build, run, and manage services across both IT and business environments to support rapidly changing business requirements.

Only Integrated Service Management provides the software, systems, best practices, and expertise needed to manage infrastructure, people and processes—across the entire service chain—in the data center, across design and delivery, and tailored for specific industry requirements. With Integrated Service Management, you gain the Visibility. Control. Automation.™ needed to deliver quality services, manage risk and compliance, and accelerate business growth.

We back this feature with years of industry expertise and worldwide experience.

For more information about Service Management, see the website:

http://www.ibm.com/ibm/servicemanagement/us/en/

1.2.7 Outsourcing

Outsourcing your IT needs to IBM helps enable you to focus on strategic direction while trusting IBM to manage the day-to-day operations that monopolize your time. Consider the breadth of IBM expertise and experience managing business processes, applications, and IT infrastructure.

Industry-specific business processes are available 24/7. When your company is looking to access new business services quickly and cost-effectively, IBM hosted business processes can be the answer. IBM provides one of the most comprehensive application hosting capabilities in the industry, from basic support to global deployments.

By outsourcing to IBM, you can utilize the leading business applications that can help reduce your time-to-market or boost customer satisfaction without the usual upfront infrastructure costs, or the ongoing implementation and management headaches.

IBM Managed Storage Services provides state of the art storage technologies and on demand storage capacity, monitoring and management services for clients' disk, backup and restore, and archive infrastructures in a security-rich environment. Combining best-in-class networking technologies with world-class service management helps enable highly available, cost-effective storage management.

For more information about Service management, see the website:

http://www-935.ibm.com/services/us/index.wss/itservice/outscg/a1029376/?met=direllinks

1.3 IBM cloud computing and storage

Cloud computing has the potential to make an enormous impact to your business as follows:

- Reducing IT labor cost by 50% in configuration, operations, management, and monitoring
- Improving capital utilization by 75%, significantly reducing license costs
- Reducing provisioning cycle times from weeks to minutes
- Improving quality, eliminating 30% of software defects
- Reducing end user IT support costs by up to 40%

Storage services are among the easiest to adapt to the cloud computing model. IT storage teams commonly provide storage “as a service” to other departments, so best practices and service level agreements have become standardized over the years.

IBM offers an expanding menu of cloud storage services, available on a pay-per-use basis, delivered from state-of-the-art IBM data centers. IBM also helps clients implement public, private, and hybrid cloud storage services, with expert consulting and workload optimized systems.

1.3.1 What a storage cloud is

A storage cloud is an emerging technology and an integral part of the future of data storage. Designed for affordability and efficiency, a flexible storage cloud solution can optimize your available storage capacity, enabling fast, easy access to storage where and when you need it.

There are two types of scenarios available for a storage cloud: public or private. An example of a public implementation of a storage cloud might be a service that allows you to back up your video files to the Internet so that end users will be able to access them on demand. An example of a private implementation of a storage cloud might be enabling hospitals and facilities within a network to access stored images from a medical imaging provider.

While the public storage cloud provides for variable billing options and shared tenancy, the private cloud offers fixed charges and dedicated tenancy for enterprises looking for flexibility around ownership, management, and maintenance of the storage cloud.

The IBM Information Infrastructure includes next generation virtualized storage and storage management products that can support the demands of cloud computing. Cloud computing applications are typically deployed in a virtualized environment with a strong security model.

1.3.2 Private storage cloud architecture: An overview

Storage area network (SAN) technology introduced the ability to connect storage through a network, which was a great improvement to disks attached using small computer system interface (SCSI) or another type of direct connection. For the first time, the SAN allowed storage administrators to more easily, and with far less wiring, attach multiple hosts to shared storage or multiple storage servers. Although SAN was a great improvement over locally attached devices within the SAN, there is still a direct relationship between a host and the associated storage. For example, if you need more space, the administrator can add a logical unit number (LUN), zone it to the host, and expand the file system. This works well in cases where there is extra capacity on the SAN and the host operating system supports dynamically growing a file system.

A private storage cloud architecture takes this idea further by decoupling the server and the storage. When a host needs more space in a storage cloud infrastructure, the administrator clicks to assign more space to that host from a pool of available storage, and the application continues. The additional space is not simply whatever is available in the storage server attached to the host. Instead, it is the proper storage type for the application based on performance, availability, and quality of service levels. When more of a particular type of storage is required, it is added to the cloud, assigned characteristics such as level of performance and reliability, and made available for use.

Many organizations have not implemented tiered storage yet because they lack a tightly integrated infrastructure between the tiers and high-performance tools to effectively manage the data. It was not always practical to provide three different classes of storage to each host or application due to SAN complexity and tool limitations. An effective private storage cloud solution makes managing tiers of storage a practical reality. To the host, the private storage cloud is accessed in a common manner through standard network file access protocols, regardless of the use of the storage. The data is available concurrently through multiple protocols. By providing access to pools of storage to a variety of applications, you can more efficiently utilize the storage available instead of fragmenting across hosts.

1.3.3 IBM and storage cloud technology

Although many vendors offer storage cloud solutions in the market with promising levels of scalability and performance, often these solutions can be built on relatively new software and hardware combinations. In 2007, IBM introduced a second-generation storage cloud technology called IBM Storage Optimization and Integration Services – scale out file services (SOFS).

Like SOFS, IBM Smart Business Storage Cloud, the next generation of storage cloud solutions from IBM are built on the proven reliability of IBM System x servers and IBM TotalStorage disk technologies paired with industry-leading software, such as the IBM General Parallel File System (GPFS) and IBM Tivoli Storage Manager. These technologies have been integrated into a storage cloud solution based on years of internal use providing file services to more than 300,000 employees of IBM. The result is a flexible, standards-based and enterprise-ready storage cloud solution that can support advanced virtualization. Private storage cloud solution technology and services from IBM address multiple areas of functionality, including these:

- Dynamic storage management
- Scalable capacity and performance
- Concurrent, multiprotocol data access
- New levels of manageability

1.4 IBM System Storage Disk Systems

The IBM System Storage Disk Systems products and offerings provide storage solutions with superior value for all levels of business from small and medium business (SMB) to high-end and enterprise systems. IBM System Storage solutions are designed to reduce the cost and complexity of managing vast amounts of data while improving the productivity of your storage administration staff—and storage space—as the volumes of data grow.

IBM offers a range of disk storage systems to meet these demands:

- IBM Storwize V7000, a midrange disk system that delivers storage efficiency technologies, exceptional ease of use and performance—all integrated into a compact, modular design that’s offered at a competitive, midrange price.
- Enterprise storage systems such as the IBM System Storage DS8000® and the IBM XIV Storage System with capacities up to thousands of terabytes and a range of reliability and performance features to support the most demanding storage challenges.

- Multiterabyte mid-range storage systems for organizations with growing storage needs.
- Multi gigabyte entry storage enclosures designed for small and medium businesses.

1.4.1 High-end and enterprise disk systems

IBM offers a range of disk storage systems to meet these demands, as discussed next.

IBM System Storage DS8000

The IBM System Storage DS8000 Turbo offers high-performance, high-capacity, secure storage systems that are designed to deliver resiliency and total value for the most demanding, heterogeneous storage environments.

IBM introduces the new IBM System Storage DS8800, the most advanced model in the high-end disk portfolio, with new hardware that offers faster performance and a significant reduction in floor space and energy requirements.

This fourth-generation DS8000 system includes high-density, 2.5-inch, 6 Gigabits per second (Gbps) SAS drives that can enable clients to pack almost 90% more drives in the same frame footprint. Fully configured with a base frame and two expansion frames, the new DS8800 can reduce floor space requirements by 40% and energy requirements by over 35%, all while supporting more drives than a five-frame DS8700 model.

See 4.3, "DS8000 series" for more information.

IBM XIV Storage System

The IBM XIV Storage System is a ground breaking, high-end, open disk system designed to support business requirements for a highly available information infrastructure. The XIV architecture is a grid of standard Intel/Linux components connected in any-to-any topology by means of massively paralleled, non-blocking Gigabit Ethernet, providing outstanding enterprise-class reliability, performance, and scalability.

See 4.4, "IBM XIV Storage System" for more information.

IBM Scale Out Network Attached Storage

IBM has designed IBM Scale Out Network Attached Storage (SONAS) to embrace cloud storage and the petabyte age. It can meet today's storage challenges with quick and cost-effective IT-enabled business enhancements designed to grow with unprecedented scale:

- Manage multiple petabytes of storage and up to a billion files in a single file system
- Achieve operational efficiency with automated, policy-driven tiered storage
- Lower TCO with automated life cycle management and migration to tape
- Scale-out performance to satisfy bandwidth hungry applications
- Asynchronous replication for disaster recovery and business continuity

It can also deliver computing services that make the technology underlying user devices almost invisible. It enables applications and services to be uncoupled from the underlying infrastructure, enabling the business to adjust quickly to change. As a result, IBM SONAS can easily integrate with your organization's strategies to develop a more dynamic enterprise.

See Chapter 6, "IBM Scale Out Network Attached Storage" on page 245 for more information.

1.4.2 Midrange disk storage

Midrange disk storage products provide convenient solutions for an on demand world.

IBM Storwize V7000

IBM Storwize V7000 is a midrange disk system that delivers storage efficiency technologies, exceptional ease of use and performance—all integrated into a compact, modular design that is offered at a competitive, midrange price.

See Chapter 17, “IBM Storwize V7000” on page 521 for more information.

IBM System Storage DCS9900 Storage System

The IBM System Storage DCS9900 Storage System is designed for applications with high-performance streaming data requirements served by Deep Computing systems, IBM System p High Performance Computing (HPC) systems, and System x 1350™ Linux Cluster systems.

Applications such as those in HPC, rich media, life sciences, and government research require high-performance, reliable access to streaming data, and extreme capacity and density to simplify management and reduce cost. Examples of such applications include weather forecasting, seismic processing, reservoir modelling, high definition (HD) creation and distribution, proteomics, structural analysis, fluid dynamics, and gene sequencing. With its parallel storage solution architecture, the DCS9900 is specifically designed to address those needs.

See 3.6, “IBM System Storage Model DCS9900” on page 81 for more information.

IBM System Storage DS5020 Express

In a continuing effort to provide storage solutions that are designed to provide low total cost of ownership, high performance, robust functionality, and unparalleled ease of use, IBM offers the IBM System Storage DS5020 Express. As part of the DS series, the DS5020 Express offers high-performance 8 Gbps capable Fibre Channel connections, optional 1 Gbps iSCSI interface for less demanding applications and lower cost implementation, up to 50.4 TB of Fibre Channel physical storage capacity, up to 112 TB of SATA physical storage capacity.

See 3.4, “IBM System Storage model DS5020” for more information.

IBM System Storage DS5000 series

The IBM System Storage DS5000 series is designed to meet today's and tomorrow’s demanding open-systems requirements while establishing a new standard for life cycle longevity with field-replaceable host interface cards.

See 3.5, “IBM System Storage Models 5100 and 5300” for more information.

IBM System Storage DS3950 Express

IBM offers the IBM System Storage DS3950 Express. As part of the DS series, the DS3950 Express offers high-performance 8 GBps capable FC connections, optional 1 GBps iSCSI interface for less demanding applications and lower cost implementation, up to 67.2 TB of FC physical storage capacity, 224 TB of SATA physical storage capacity, and powerful system management, data management, and data protection features. The DS3950 Express is designed to expand from workgroup to enterprise-wide capability with up to six FC expansion units with the EXP395 Expansion Unit.

See 3.3, “IBM System Storage DS3950 Express” for more information.

1.4.3 Entry-level disk

Designed to deliver advanced functionality at a breakthrough price, these systems provide an exceptional solution for workgroup storage applications such as email, file, print, and web servers, as well as collaborative databases and remote boot for diskless servers.

IBM System Storage DS3400

The IBM System Storage DS3400 Express is a FC host-based external storage system specifically designed for a wide range of organizations. With FC interface technology, next-generation SAS back-end technology, SAS and SATA drive intermix support, and DS Storage Manager software, the DS3400 storage system provides businesses with robust, reliable, cost-effective FC networked storage.

> **DS3400:** The DS3400 Single Controller model was withdrawn from marketing effective January 15, 2011. At the time of writing, only the dual controller models are available.

See 2.4, “IBM System Storage model DS3400” on page 56 for more information.

IBM System Storage DS3500 Express

IBM has combined best-of-breed development with leading 6 Gbps host interface and drive technology in the IBM System Storage DS3500 Express. With its simple, efficient and flexible approach to storage, the DS3500 is a cost-effective, fully integrated complement to System x servers, BladeCenter® and Power Systems™. Offering substantial improvements at a price that will fit most budgets, the DS3500 delivers superior price to performance ratios, functionality, scalability, and ease of use for the entry-level storage user. DS3500 Express is designed to offer scalability to midrange performance and features, efficiency to help reduce annual energy expenditures and environmental footprint, and simplicity that does not sacrifice control with the perfect combination of robustness and ease of use.

See 2.2, “IBM System Storage DS3500” on page 45 for more information.

IBM System Storage EXP2500 Express

IBM has combined best-of-breed development with leading 6 Gbps host interface and drive technology in the IBM System Storage EXP2500 Express, a cost-effective, fully integrated complement to System x servers. The EXP2500 Express delivers superior price-to-performance ratios, functionality, scalability and ease of use for the entry-level storage user.

Easy to manage, flexible, and extendable, the EXP2500 Express is designed to work as a direct-attach solution for IBM System x servers by ServeRAID host bus adapters. The EXP2500 Express help organizations enhance capacity seamlessly to address their current and future data needs.

The new EXP2500 Express is a performance-oriented SAS platform designed to help increase both bandwidth and throughput with next-generation storage technology.

See 2.7, “IBM System Storage EXP2500” on page 62 for more information.

IBM System Storage EXP3000

The EXP3000 Express supports attachment to the DS3000 Express Series, providing a highly available storage system scaling up to 48 SAS and/or SATA disk drives. Up to three EXP3000s can be connected to expand capacity and IOPs performance of the solution to help address your data needs today and tomorrow. The IBM System Storage EXP3000 provides support for a combination of 12 SAS up to 7.2 TB or 12 SATA up to 24.0 TB drives per enclosure or for three EXP3000 enclosures on a DS3000 system up to 28.8 TB with SAS or up to 96.0 TB SATA.

See 2.5, “IBM System Storage EXP3000” on page 57 for more information.

1.5 IBM Tape systems

IBM Tape storage, backup, and information management systems address a range of needs.

1.5.1 Enterprise class tape systems

IBM enterprise class tape products are designed to offer high performance, availability, reliability, and capacity to help meet the needs of customers seeking enterprise class storage solutions for mass storage, data archiving, enterprise backup, and disaster recovery. IBM enterprise class storage products provide on demand solutions for business.

TS7700 Virtualization Engine

The IBM Virtualization Engine TS7700 (TS7700 Virtualization Engine) is a family of mainframe virtual-tape solutions that are designed to optimize tape processing. With one solution, the implementation of a fully integrated tiered storage hierarchy of disk and tape utilizes the benefits of both technologies to help enhance performance and provide the capacity needed for today’s tape processing requirements. Deploying this innovative subsystem can help reduce batch processing time, total cost of ownership and management overhead.

See 10.7, “IBM Virtualization Engine TS7700” on page 353 for more information.

TS7650G ProtecTIER Deduplication Gateway

The IBM System Storage TS7650G ProtecTIER® Deduplication Gateway offers industry leading inline deduplication performance and scalability up to 1 petabyte (PB) of physical storage capacity per system that can provide up to 25 PB of storage capacity. Combined with IBM storage, the ProtecTIER Gateway solution provides a powerful disk-based repository to improve the retention and availability of backup and archive data.

See 10.5, “TS7650G ProtecTIER Deduplication Gateway” on page 349 for more information.

TS7680 ProtecTIER Deduplication Gateway for System z

The IBM System Storage TS7680 ProtecTIER Deduplication Gateway for System z® helps improve tape application performance in the System z environment while enabling significant infrastructure cost reductions. The solution offers high-performance inline data deduplication, highly available two-node clustering, and up to 1 petabyte (PB) of physical storage capacity per system. Combined with IBM storage, the ProtecTIER Gateway solution provides an optimal disk-based target for tape data.

See 10.6, “IBM TS7680 ProtecTIER Gateway for System z” on page 351 for more information.

TS3500 Tape Library

The IBM TS3500 Tape Library supports System z through the IBM 3953 Tape System (3953 tape system) or the IBM Virtualization Engine TS7740, which enable System z hosts to access the TS3500 Tape Library cartridge inventory and allow connection to TS1130, TS1120, and IBM TotalStorage 3592 Model J1A tape drives.

See 9.8, “IBM System Storage TS3500 Tape Library” on page 330 for more information.

TS1130 Tape Drive

The IBM TS1130 Tape Drive offers high-performance flexible data storage with support for data encryption. The TS1130 Tape Drive supports IBM System Storage TS3400 and TS3500 Tape Libraries, IBM TotalStorage 3494 Tape Libraries, IBM Virtualization Engine TS7700, IBM racks that enable stand-alone installation, and IBM 3952 Tape Frames Model C20 (3952C20 frame) attached to a Sun 9310 library.

See 8.7, “IBM System Storage TS1130 Tape Drive” on page 305 for more information.

IBM System Storage TS1120 Tape Drive

The IBM System Storage TS1120 Tape Drive offers a tape solution with high capacity, fast access to data and long-term data retention. It is supported in IBM tape libraries, or frames that support stand-alone installations.

See 8.5, “IBM System Storage TS1120 Tape Drive” on page 302 for more information.

1.5.2 Midrange tape systems

Whether a small or medium size business is expanding operations or experiencing rapid growth, IBM midrange tape products are designed to help meet the customer needs of data backup, archive, and management. Each tape product is designed to offer reliability, performance, and flexibility for today and the future.

TS3200 Tape Library Express Model

The IBM TS3200 Tape Library Express Model is an entry-level tape library designed to provide reliable, high capacity, high performance tape backup. It is designed to support up to two IBM LTO Ultrium Full Height Tape Drives or up to four IBM LTO Ultrium Half Height Tape Drives.

See 9.5, “IBM System Storage TS3200 Tape Library” on page 322 for more information.

TS7610 ProtecTIER Deduplication Appliance Express

The IBM System Storage TS7610 ProtecTIER Deduplication Appliance Express provides fast, reliable, and easy-to-deploy backup and recovery for midsized IT environments. Available in two configuration options (4 TB and 5.5 TB), the TS7610 ProtecTIER Deduplication Appliance Express provides capacity, price/performance, and RAS features required by midsized customers.

See 10.3, “TS7610 ProtecTIER Deduplication Appliance Express” on page 345 for more information.

TS7650 ProtecTIER Deduplication Appliance

The IBM System Storage TS7650 ProtecTIER Deduplication Appliance is a preconfigured solution of IBM storage, IBM server, and IBM revolutionary ProtecTIER data deduplication software designed to improve backup and recovery operations, making it easy to deploy data deduplication for your information infrastructure.

See 10.4, “TS7650 ProtecTIER Deduplication Appliance” on page 346 for more information.

IBM System Storage TS3310 Tape Library

The IBM System Storage TS3310 Tape Library is a modular, scalable tape library designed to address the tape storage needs of rapidly growing companies who find themselves space and resource constrained with tape backup and other tape applications. It is scalable from 2 to 18 drives and from 35 to 401 slots.

See 9.7, “IBM System Storage TS3310 Tape Library” on page 327 for more information.

IBM System Storage TS2340 Tape Drive Express Model

The IBM System Storage TS2340 Tape Drive Express Model is an external drive incorporating the fourth generation of IBM LTO technology. This is an external stand-alone or rack-mountable unit, similar to previous models of the IBM 3580 and is the entry point for the family of IBM Ultrium tape products. The TS2340 supports encryption of data and offers a 3 Gbps SAS connection. In addition, the TS2340 can read and write LTO Ultrium 3 Data Cartridges and read LTO Ultrium 2 Data Cartridges.

> **TS2340:** Effective November 26, 2010, the IBM System Storage TS2340 Tape Drive has been withdrawn from marketing. See the following link for more information.
>
> http://www-01.ibm.com/common/ssi/ShowDoc.jsp?docURL=/common/ssi/rep_ca/9/897/ENUS910-229/index.html&breadCrum=DET001PT022&url=buttonpressed=DET002PT005&specific_index=DET001PEF502&DET015PGL002=DET001PEF011&submit.x=7&submit.y=8&lang=en_US

See 8.3.4, “IBM System Storage TS2340 Tape Drive Express Model” on page 296 for more information.

IBM System Storage TS2350 Tape Drive Express

The IBM System Storage TS2350 Tape Drive Express is an external drive, incorporating the 5th generation of IBM Linear Tape-Open (LTO) technology in a full height form factor. This external stand-alone or rack-mountable unit is the entry point for the family of IBM Ultrium tape products. It is designed to provide greater capacity and improved data transfer rate with the capability of data encryption and media partitioning with a 6 Gbps SAS interface connection. In addition, the TS2350 can read and write LTO Ultrium 4 data cartridges and read LTO Ultrium 3 data cartridges.

See 8.3.5, “IBM System Storage TS2350 Tape Drive Express Model” on page 297 for more information.

IBM System Storage TS3100 Tape Library Express Model

The IBM TS3100 Tape Library Express Model is well-suited for handling backup, save and restore, and archival data storage needs for small to medium-size environments. With one full height tape drive or up to 2 half-height tape drives and 24 tape cartridge capacity, the IBM TS3100 model is designed to utilize Linear Tape-Open (LTO) technology to help cost effectively handle growing storage requirements.

See 9.4, “IBM System Storage TS3100 Tape Library Express Model” on page 320 for more information.

IBM System Storage TS3500 Tape Library

The IBM System Storage TS3500 Tape Library (TS3500 Tape Library) combines IBM automation and drive technology to provide a highly scalable, automated tape library for IBM System z and open systems backup and archive in midrange to enterprise environments.

See 9.8, “IBM System Storage TS3500 Tape Library” on page 330 for more information.

IBM TotalStorage 3580 Tape Drive

The IBM System Storage 3580 model L33 Tape Drive is an external drive incorporating the third generation of IBM LTO technology. This is an external stand-alone or rack-mountable unit, similar to previous models of the 3580, and is the entry point for the family of IBM Ultrium tape products. The 3580 Tape Drive provides an excellent migration path from digital linear tape (DLT or SDLT), 1/4-in., 4mm, or 8mm tape drives. The 3580 model L33 can read and write LTO Ultrium 2 Data Cartridges and read LTO Ultrium 1 Data Cartridges.

See 8.3.6, “IBM TotalStorage 3580 Tape Drive” on page 298 for more information.

IBM System Storage 7214 Storage Device Enclosure

The IBM System Storage 7214 Storage Device Enclosure features the latest technology options in tape drives and DVD optical drives. The 7214 Storage Enclosure is a low-profile design that is an excellent choice for mounting in your System p 19" rack.

1.5.3 Entry tape systems

IBM offers entry-level tape products that are designed to provide backup and protection of client data at an appealing cost to a company's budget.

TS2900 Tape Autoloader

The IBM System Storage TS2900 Tape Autoloader Express Model offers low profile, entry-level IBM LTO tape storage supported in open system platforms.

See 9.3, “IBM System Storage TS2900 Tape Autoloader Express” on page 318 for more information.

TS2230 Tape Drive Express

The IBM System Storage TS2230 Tape Drive Express Model offers high capacity and performance half-height Linear Tape-Open Tape Drive, with double the storage capacity of existing HH LTO2 drives in the market.

See 8.3.1, “IBM System Storage TS2230 Tape Drive Express Model” on page 293 for more information.

TS3100 Tape Library Express

The IBM TS3100 Tape Library Express Model offers large-capacity, high-performance tape backup for critical data. Designed to support one IBM LTO Ultrium Full Height Tape Drive or up to two IBM LTO Ultrium Half Height Tape Drives, to help increase capacity and performance. It is designed to offer outstanding capacity, performance, and reliability for midrange and network tape storage environments in a 2U form factor with 24 data cartridge slots and a mail slot.

See 9.4, “IBM System Storage TS3100 Tape Library Express Model” on page 320 for more information.

TS3200 Tape Library Express Model

The IBM TS3200 Tape Library Express Model is well-suited for handling backup, save and restore, and archival data-storage needs for small to medium-size environments. With up to two Ultrium full height tape drive(s) or up to four Ultrium Half-Height tape drive(s) and 48 tape cartridge capacity, the IBM TS3200 is designed to utilize Linear Tape-Open (LTO) technology to help cost effectively handle growing storage requirements.

See 9.5, "IBM System Storage TS3200 Tape Library" on page 322 for more information.

TS2240 Tape Drive Express

The IBM TS2240 Tape Drive Express Model offers a next generation, high capacity, half-high Linear Tape-Open Tape Drive. The TS2240 has a physical storage capacity of up to 1.6 TB (with 2:1 compression) in conjunction with the new IBM System Storage LTO Ultrium 800 GB data cartridge, which provides up to double the capacity of Ultrium 3 cartridges.

See 8.3.2, "IBM System Storage TS2240 Tape Drive Express Model" on page 294 for more information.

IBM System Storage TS2250 Tape Drive Express

The IBM System Storage TS2250 Tape Drive Express is an external drive, incorporating the 5th generation of IBM Linear Tape-Open (LTO) technology in a half height form factor. This external stand-alone or rack-mountable unit, is the entry point for the family of IBM Ultrium tape products. It is designed to provide greater capacity and improved data transfer rate with the capability of data encryption and media partitioning with a 6 Gbps SAS interface connection. In addition, the TS2250 can read and write LTO Ultrium 4 data cartridges and read LTO Ultrium 3 data cartridges.

See 8.3.3, "IBM System Storage TS2250 Tape Drive Express Model" on page 295 for more information.

IBM System Storage TS2340 Tape Drive Express Model

The IBM System Storage TS2340 Tape Drive Express Model is an external drive incorporating the fourth generation of IBM LTO technology. This is an external stand-alone or rack-mountable unit, similar to previous models of the IBM 3580 and is the entry point for the family of IBM Ultrium tape products. The TS2340 supports encryption of data and offers a 3 Gbps SAS connection. In addition, the TS2340 can read and write LTO Ultrium 3 Data Cartridges and read LTO Ultrium 2 Data Cartridges.

See 8.3.4, "IBM System Storage TS2340 Tape Drive Express Model" on page 296 for more information.

IBM System Storage TS2350 Tape Drive Express

The IBM System Storage TS2350 Tape Drive Express is an external drive, incorporating the 5th generation of IBM Linear Tape-Open (LTO) technology in a full height form factor. This external stand-alone or rack-mountable unit, is the entry point for the family of IBM Ultrium tape products. It is designed to provide greater capacity and improved data transfer rate with the capability of data encryption and media partitioning with a 6 Gbps SAS interface connection. In addition, the TS2350 can read and write LTO Ultrium 4 data cartridges and read LTO Ultrium 3 data cartridges.

See 8.3.5, "IBM System Storage TS2350 Tape Drive Express Model" on page 297 for more information.

IBM System Storage TS2900 Tape Autoloader

The IBM System Storage TS2900 Tape Autoloader is a single-drive, low profile automated tape solution and the first entry automation solution for small- to mid-market tape environments. The TS2900 utilizes the technology of IBM half-high LTO tape drives to help create a high-capacity tape storage solution suited for handling backup and archival data storage for the Windows, Linux and other open system environments.

IBM TotalStorage 3580 Tape Drive

The IBM System Storage 3580 model L33 Tape Drive is an external drive incorporating the third generation of IBM LTO technology. This is an external stand-alone or rack-mountable unit, similar to previous models of the 3580 and is the entry point for the family of IBM Ultrium tape products. The 3580 Tape Drive provides an excellent migration path from digital linear tape (DLT or SDLT), 1/4-in., 4 mm, or 8 mm tape drives. The 3580 model L33 can read and write LTO Ultrium 2 Data Cartridges and read LTO Ultrium 1 Data Cartridges.

See 8.3.6, "IBM TotalStorage 3580 Tape Drive" on page 298 for more information.

IBM System Storage 7214 Storage Device Enclosure

The IBM System Storage 7214 Storage Device Enclosure features the latest technology options in tape drives and DVD optical drives. The 7214 Storage Enclosure is a low-profile design that is an excellent choice for mounting in your System p 19" rack.

See 11.5.1, "IBM System Storage 7214 Storage Device Enclosure" on page 364 for more information.

IBM System Storage 7216 Multi-Media Storage Enclosure

The IBM System Storage 7216 Multi-Media Storage Device Enclosure features a low-profile design that can be configured with up to four storage devices.

See 11.5.2, "IBM System Storage 7216 Multimedia Enclosure" on page 365 for more information.

1.6 Storage Area Networks

IBM SAN products and solutions provide integrated SMB and enterprise SAN solutions with multi-protocol local, campus, metropolitan, and global storage networking.

1.6.1 Enterprise SAN directors

The Enterprise SAN directors are designed for the highest availability and scalability enterprise solutions.

IBM System Storage SAN768B

The IBM System Storage SAN768B fabric backbone is designed to be the premier platform for consolidation of your data center connectivity, providing high-performance and high-availability data networking. It provides new levels of performance with industry-leading 8 Gbps per second (Gbps) Fibre Channel (FC) and 10 Gbps Fibre Channel over Converged Enhanced Ethernet (FCoCEE) technologies.

See 13.5.3, "IBM System Storage SAN768B" on page 413 for more information.

IBM System Storage SAN384B

The IBM System Storage SAN384B fabric backbone is designed to be the premier platform for consolidation of your data center connectivity, providing high-performance and highly available data networking. It provides new levels of performance with industry-leading 8 Gbps Fibre Channel (FC) and 10 Gbps Fibre Channel over Converged Enhanced Ethernet (FCoCEE) technologies.

Built for large enterprise networks, the SAN768B has eight vertical blade slots to provide up to 512 8 Gbps Fibre Channel ports. The SAN384B is ideal for midsize core or edge deployments, providing four horizontal blade slots and up to 256 8-Gbps Fibre Channel ports. The flexible blade architecture also supports FCoE, fabric-based encryption for data-at-rest, and SAN extension advanced functionality for high-performance server I/O consolidation, data protection, and disaster recovery solutions.

See 13.5.2, "IBM System Storage SAN384B" on page 412 for more information.

IBM TotalStorage SAN256B

The IBM TotalStorage SAN256B is designed to provide outstanding performance, enhanced scalability, and a design ready for high-performance 4 Gbps, 8 Gbps, and 10 Gbps capable hardware and expanded capability features. The SAN256B is well suited to address enterprise SAN customer requirements for infrastructure simplification and improved business continuity.

> **SAN256B:** Effective December 18, 2010, IBM TotalStorage SAN256B had been withdrawn from marketing. See the following link for more details:
>
> http://www-01.ibm.com/common/ssi/ShowDoc.jsp?docURL=/common/ssi/rep_ca/7/897/ENUS910-187/index.html&breadCrum=DET001PT022&url=buttonpressed=DET002PT005&specific_index=DET001PEF502&DET015PGL002=DET001PEF011&submit.x=7&submit.y=8&lang=en_US

See 13.5.1, "IBM TotalStorage SAN256B" on page 409 for more information.

Cisco MDS 9513

The Cisco MDS 9513 for IBM System Storage provides 12 to 528 Fibre Channel ports, with 4 and 8 Gbps support and a high-availability design. It offers 4 to 44 10 Gbps ports for ISL connectivity across metro optical networks. It includes Virtual SAN (VSAN) capability for SAN consolidation into virtual SAN "islands" on a single physical fabric. The Cisco MDS 9513 provides network security features for large-enterprise SANs deployment. The director also offers intelligent networking services to help simplify mainframe FICON® and Fibre Channel SAN management and reduce total cost of ownership (TCO).

See 13.5.6, "Cisco MDS 9513 for IBM System Storage" on page 420 for more information.

Cisco MDS 9509

The Cisco MDS 9509 for IBM System Storage provides 1, 2, 4, 8, and 10 Gbps Fibre Channel switch connectivity and intelligent network services to help improve the security, performance, and manageability required to consolidate geographically dispersed storage devices into a large enterprise SAN. The 9509 has from 12 to 336 Fibre Channel ports, which are 1, 2, 4, and 8 Gbps autosensing ports.

See 13.5.5, "Cisco MDS 9509 for IBM System Storage" on page 418 for more information.

Cisco MDS 9506

The Cisco MDS 9506 for IBM System Storage supports 1, 2, 4, 8, and 10 Gbps Fibre Channel switch connectivity and intelligent network services to help improve the security, performance, and manageability required to consolidate geographically dispersed storage devices into a large enterprise SAN. The 9506 has from 12 to 192 Fibre Channel ports, which are 1, 2, 4, and 8 Gbps autosensing ports.

See 13.5.4, "Cisco MDS 9506 for IBM System Storage" on page 417 for more information.

1.6.2 Midrange SAN switches

IBM midrange SAN switches are scalable and affordable solutions ranging from SMB to an enterprise level.

IBM System Storage SAN32B-E4

The IBM System Storage SAN32B-E4 Encryption Switch is a high-performance stand-alone device designed for protecting data-at-rest in mission-critical environments. In addition to helping IT organizations achieve compliance with regulatory mandates and meeting industry standards for data confidentiality, the SAN32B-E4 Encryption Switch also protects them against potential litigation and liability following a reported breach.

See 13.3.3, “IBM System Storage SAN32B-E4” on page 405 for more information.

IBM System Storage SAN80B-4

The IBM System Storage SAN80B-4 SAN fabric switch provides 48, 64, or 80 active ports, and is designed for high performance with 8 Gbps link speeds and backward compatibility to support links running at 4, 2, and 1 Gbps link speeds. High availability features make it suitable for use as a core switch in midrange environments or as an edge-switch in enterprise environments.

See 13.3.2, “IBM System Storage SAN80B-4” on page 404 for more information.

IBM System Storage SAN40B-4

The IBM System Storage SAN40B-4 is a simple-to-use midrange and enterprise SAN fabric switch for IBM POWER Systems, System x, System z, and other server environments. They offer high port density design with up to 40 ports in an efficient, space saving 1U format, and non-disruptive capacity activation from 24 to 32 to 40 ports with Ports on Demand scalability.

See 13.3.1, “IBM System Storage SAN40B-4” on page 403 for more information.

Cisco MDS 9134

The Cisco MDS 9134 for IBM System Storage is designed to address the needs of medium-sized businesses and large enterprises with a wide range of Storage Area Network (SAN) capabilities. It can be used as part of a high performance simple SAN with single-switch or stacked switch configurations for business-class customers in support of IT simplification and business continuity solutions. It can also be used as an edge switch for device aggregation with 10 Gbps core director configurations for large enterprise customers.

See 13.3.4, “Cisco MDS 9134 for IBM System Storage” on page 407 for more information.

Cisco MDS 9148

The Cisco MDS 9148 for IBM System Storage Multilayer Fabric Switch (2417-C48) is designed to provide an affordable, highly capable, and scalable storage networking solution for small, midrange, and large enterprise customers. The switch provides line rate 8-Gbps ports with high-performance, high-density, and enterprise-class availability. The switch is designed to offer outstanding value by providing flexibility, high availability, security, and ease of use at an affordable price in a compact one-rack-unit (1RU) form factor. With the ability to expand from 16 to 48 ports in eight-port increments, the Cisco MDS 9148 can be used as the foundation for small, stand-alone SANs, as a top-of-rack switch, or as an edge switch in larger core-edge SAN infrastructures.

1.6.3 Entry SAN switches

Scalable, flexible storage infrastructure IBM SAN products and solutions provide integrated, simple, affordable SMB solutions with multi-protocol local, campus, metropolitan, and global storage networking.

IBM System Storage SAN24B-4 Express

The IBM System Storage SAN24B-4 Express fabric switch is designed specifically to address the needs of small to medium-sized SAN environments. It can be used to create a wide range of high-performance SAN solutions, from simple, single-switch configurations to larger, multi-switch configurations that support fabric connectivity and advanced business continuity capabilities.

See 13.2.1, “IBM System Storage SAN24B-4 switch” on page 401 for more information.

Cisco MDS 9124 Express

The Cisco MDS 9124 Express for IBM System Storage is designed to address the needs of small and medium-sized businesses with a wide range of SAN capabilities. It can be used as part of SAN solutions from simple single-switch configurations to larger multi-switch configurations in support of fabric connectivity and advanced business continuity capabilities.

See 13.2.2, “Cisco MDS 9124 Express for IBM System Storage” on page 402 for more information.

Cisco MDS 9148 for System Storage

The Cisco MDS 9148 for IBM System Storage Multilayer Fabric Switch (2417-C48) is designed to provide an affordable, highly capable and scalable storage networking solution for small, midrange and large enterprise customers. It can be used as part of SAN solutions from simple single-switch configurations to larger multiswitch configurations in support of fabric connectivity and advanced business continuity capabilities.

1.6.4 Multiprotocol routers

Multiprotocol routers are designed to connect two Storage Area Networks (SANs) over a wide distance using the Internet as the interconnection fabric (upgrades to enterprise-level functions are available). They are intended to support business continuity solutions between supported servers at one site and support servers or IBM System Storage disk or tape devices at a distant location.

IBM System Storage SAN04B-R

The IBM System Storage SAN04B-R is designed for high performance with 4 Gigabit per second (Gbps) Fibre Channel (FC) ports and hardware-assisted traffic processing for line-rate performance across Ethernet Internet Protocol (IP) ports. It utilizes existing Internet, IP-based Metropolitan Area Network (MAN) or Wide Area Network (WAN) infrastructures for metro and global SAN extension for business continuity solutions.

> **SAN04B-R:** Effective November 27, 2010, IBM System Storage SAN04B-R has been withdrawn from marketing. See the following link for more information:
>
> `http://www-01.ibm.com/common/ssi/ShowDoc.jsp?docURL=/common/ssi/rep_ca/7/897/ENUS910-167/index.html&breadCrum=DET001PT022&url=buttonpressed=DET002PT005&specific_index=DET001PEF502&DET015PGL002=DET001PEF011&submit.x=7&submit.y=8&lang=en_US`

See 13.6.1, “IBM System Storage SAN04B-R multiprotocol router” on page 423 for more information.

IBM System Storage SAN06B-R

The IBM System Storage SAN06B-R is designed for high performance with 8 Gigabit per second (Gbps) Fibre Channel (FC) ports and hardware-assisted traffic processing for line-rate performance across 1 GbE Ethernet Internet Protocol (IP) ports. It utilizes existing Internet, IP-based Metropolitan Area Network (MAN) or Wide Area Network (WAN) infrastructures for metro and global SAN extension for business continuity solutions.

See 13.6.2, “IBM System Storage SAN06B-R multiprotocol router” on page 425 for more information.

Cisco MDS 9222i

The Cisco MDS 9222i for IBM System Storage is designed to address the needs of medium-sized businesses and large enterprises with a wide range of Storage Area Network (SAN) capabilities. It can be used as a cost-effective high performance SAN extension over an IP router switch for midrange SMB customers in support of IT simplification and business continuity solutions. It can also provide remote site device aggregation and SAN extension connectivity to large customer data center directors.

See 13.6.3, “Cisco MDS 9222i for IBM System Storage” on page 426 for more information.

1.6.5 New Ethernet switches

Expanded network technology choices with the new IBM Ethernet switches and routers provide an integrated end-to-end resiliency and security framework. The big product range from IBM makes data center networking a cost efficient solution.

IBM b-type Ethernet switches and routers

IBM offers a versatile switch that supports both Fibre Channel (FC) and Ethernet LAN data in one fabric using FCoE to help data centers simplify their growing infrastructures. IBM b-type y-series Ethernet switches (4002BY2, 4002BY4, 4002CY2) are available in 24-port and 48-port models and designed for wire-speed, nonblocking performance in a compact 1U form factor. Available with Power over Ethernet Plus (PoE+) capabilities, these switches are designed to support next-generation campus convergence of video, voice, and data by providing a single-cable solution for devices such as Voice over IP (VoIP) phones, video surveillance cameras, and wireless access points. Additionally, multiple switches can be stacked and managed into a single logical switch to enable pay-as-you-grow expansion. The high-performance and reliability features also make the switch ideal for data center top-of-rack server and iSCSI storage connectivity.

See 14.1, “IBM b-type Ethernet products” on page 434 for more information.

IBM Converged Switch B32

The IBM Ethernet Switch B24X is a compact, high-performance, highly-available, and high-density 10 Gigabit Ethernet (GbE) solution designed for mission critical data centers, large enterprises, and High-Performance Computer (HPC) requirements. With an ultra-low latency, cut-through, non-blocking architecture, full wire-speed throughput, this switch provides a cost-effective solution for server or compute-node connectivity.

See 14.1.2, “IBM Converged Switch B32” on page 436 for more information.

IBM y-series Ethernet switches

The IBM y-series Ethernet switches are a high-performance, feature-rich, and easy-to-manage 1 GbE solution for network device access. Available in 24- and 48-port models in a compact 1 RU form-factor, these switches are designed to provide all-purpose network connectivity with Full Layer 2 and Enterprise Layer 3 features and the capability to unify the access layer utilizing IronStack technology, simplifying management and device deployment. These switches are available in two model families — purpose-built Data Center models featuring rack-friendly airflow and double the uplink bandwidth (4x10 Gbps, optional module) of standard 1 GbE switches, eliminating network bottlenecks in heavily virtualized environments, and Power over Ethernet Plus (PoE+) models to support the next generation of access devices such as 802.11n Access Points, tilt/pan surveillance cameras, and video teleconferencing systems in Enterprise Campus environments.

See 14.1.1, "IBM y-series Ethernet switches" on page 434 for more information.

IBM r-series Ethernet switches

The IBM r-series Ethernet switches are available in four chassis models, and allow network designers to standardize on a single product family for end-of-row, aggregation, and backbone switching. In addition, the switches, with their high-density and compact design, are an ideal solution for High-Performance Computing (HPC) environments and Internet Exchanges and Internet Service Providers (IXPs and ISPs) where non-blocking, high-density Ethernet switches are needed.

See 14.1.4, "IBM r-series Ethernet Switches" on page 438 for more information.

IBM c-series Ethernet switches

The IBM c-series Ethernet switches are powerful enablers of advanced converged enterprise backbones. Featuring state-of-the-art Quality of Service and wire-speed unicast/multicast routing, they enable the efficient rollout of converged backbones, providing reliable transport of Voice over IP (VoIP), video services, and mission critical data. IBM c-series Ethernet switches are compact 1 RU, multi-service edge/aggregation switches with a powerful set of capabilities that combine performance with rich functionality at the network edge. These switches offer network planners a broad set of high-performance IPv4 Full Layer 2 and Base Layer 3 functionalities with flexible software upgrade options in the same device, and come in four models.

See 14.1.5, "IBM c-series Ethernet Switches" on page 439 for more information.

IBM s-series Ethernet switches

The IBM s-series Ethernet switches meet today's demanding requirements to protect, optimize, and grow the enterprise from basic connectivity to much higher levels of intelligent service-based infrastructures, providing even greater value to organizations. A highly dense, resilient and flexible architecture allows scaling up to 384 10/100/1000 Mbps Class 3 (15.4 watts) PoE capable ports or 36 ports of high-speed 10 GbE. IBM s-series Ethernet switches have an extensive feature set, making them well suited for real-time collaborative applications, IP telephony, IP video, e-learning and wireless LANs to raise an organization's productivity. With wire-speed performance and ultra low latency, these systems are ideal for converged network applications such as VoIP and video conferencing.

See 14.1.8, "IBM s-series Ethernet Switch" on page 444 for more information.

IBM g-series Ethernet switches

The IBM g-series Ethernet access switches provide enterprise organizations with a flexible and feature-rich solution for building a secure and converged network edge. Upgradeable with 10-Gigabit Ethernet, PoE, and IronStack stacking technology, the switches provide enterprises with the cost and operational benefits of a “pay-as-you-grow” architecture.

See 14.1.6, “IBM g-series Ethernet Switches” on page 441 for more information.

IBM m-series Ethernet/IP routers

The IBM m-series Ethernet/IP routers are high performance multi-service IP/MPLS routers that help virtualize data center core routing and are available in four high density chassis. They feature state-of-the-art QoS and wire-speed unicast/multicast routing for IPv4, IPv6, and MPLS services.

See 14.1.7, “IBM m-series Ethernet/IP Routers” on page 442 for more information.

IBM x-series Ethernet switches

The IBM Ethernet Switch is a compact, high-performance, high-availability, and high-density 1 RU switch specifically designed for mission-critical data centers and High-Performance Computer (HPC) requirements. This switch provides twenty-four 10/1 GbE (SFP+) ports plus four 10/100/1000 MbE (RJ45) ports of connectivity in an ultra-low-latency, cut-through, non-blocking architecture.

See 14.1.3, “IBM x-series Ethernet switches” on page 437 for more information.

IBM j-type Ethernet routers and switches

The IBM j-type Ethernet switches and routers are designed to deliver the performance, scalability, and high availability required for today’s high-density data center and cloud computing environments. The IBM j-type family includes the following switches and router.

IBM Ethernet Switch J08E/J16E

The IBM Ethernet Switch J08E/J16E are high-performance 8-slot (J08E) and 16-slot (J16E) switches that support data center as well as campus LAN core and aggregation layer deployments.

See 14.2.1, “IBM Ethernet Switch J08E and IBM Ethernet Switch J16E” on page 447 for more information.

IBM Ethernet Switch J48E

The IBM Ethernet Switch J48E was designed for high-performance server access deployments, running Juniper Networks’ JUNOS Software operating system. A single switch can be deployed initially; as requirements grow, Virtual Chassis technology allows up to nine additional switches to be interconnected over a 128 gigabit-per-second (Gbps) backplane and managed as a single device.

See 14.2.2, “IBM Ethernet Switch J48E” on page 450 for more information.

IBM Ethernet Router J02M/J06M/J011M

The IBM Ethernet Routers J02M, J06M, and J11M deliver high-port density as well as performance of up to 960 Gbps throughput, scalability, and reliability in a space-efficient package. The routers offer fully redundant hardware that includes a redundant Switch Control Board (SCB) and Routing Engines (REs) plus fan trays and power supplies designed to increase system availability.

See 14.2.3, “IBM Ethernet Router J02M/J06M/J11M” on page 452 for more information.

IBM Ethernet Appliance J34S/JS6S

The IBM Ethernet Appliance J34S and IBM Ethernet Appliance J36S are next-generation security appliances that deliver market-leading scalability and service integration in a midsized form factor. These devices are ideally suited for medium-to-large enterprise data centers. The IBM J34S and J36S can be equipped with a flexible number of I/O cards (IOCs), network processing cards (NPCs) and service processing cards (SPCs)—allowing the system to be configured to support the ideal balance of performance and port density, enabling each deployment to be tailored to specific network security requirements. The IBM J3xS appliances can provide up to a 30 Gbps firewall, 2.25 million concurrent sessions and 175,000 new VPN connections per second, The IBM J3xS appliances are equipped with a robust list of features including firewall, denial of service (DoS), Network Address Translation (NAT), Virtual Private Network (VPN) support and quality of Service (QoS).

IBM Ethernet Appliance J56S/J58S

Based on the Dynamic Services Architecture, the J56S and J58S provide superior scalability. Each services appliance can support almost linear scalability, with each additional services processing card (SPC) enabling a fully equipped J58S to support up to120 Gbps firewall throughput and up to 10 million concurrent sessions with 350,000 new VPN connections per second. The SPCs are designed to support a wide range of services, enabling future support of new capabilities without the need for service-specific hardware. The IBM J5xS appliances are equipped with a robust list of features including firewall, denial of service (DoS), Network Address Translation (NAT), Virtual Private Network (VPN) support and quality of Service (QoS).

IBM c-type Ethernet switches

IBM c-series Ethernet switches are powerful enablers of advanced converged enterprise backbones. Featuring state-of-the-art Quality of Service and wire-speed unicast/multicast routing, they enable the efficient rollout of converged backbones, providing reliable transport of Voice over IP (VoIP), video services, and mission critical data. The platform's low latency, high-touch processing and deep buffering makes it an ideal fit for Data Center top-of-the-rack server access switch.

Cisco Nexus 4000

The Cisco Nexus 4001I Switch Module is a blade switch solution for the BladeCenter H and HT chassis providing the server I/O solution required for high-performance, scale-out, virtualized, and non-virtualized x86 computing architectures. It is a line rate, extremely low-latency, non-blocking, Layer 2, 10 Gigabit Ethernet blade switch that is fully compliant with Fibre Channel over Ethernet (FCoE) and IEEE Data Center Bridging standards.

Cisco Nexus 5000

The Cisco Nexus 5010 for IBM System Storage and Cisco Nexus 5020 for IBM System Storage FCoE switches help reduce costs through data center infrastructure simplification. A unified fabric over 10 Gigabit Ethernet (GbE) for server LAN and SAN traffic enables consolidation of server adapters, cables, and top-of-rack (TOR) switches by up to 50 percent.

Cisco Nexus 5020 provides up to 56 ports: 40 fixed 10 GbE and FCoE ports and 16 optional Fibre Channel, FC ports.

Cisco Nexus 5010 provides up to 28 ports: 20 fixed 10 GbE and FCoE ports and 8 optional FC ports.

See 14.3.2, "Cisco Nexus 5000" on page 462 for more information.

1.7 IBM NAS systems

IBM Network attached storage (NAS) products provide a wide range of network attachment capabilities to a broad range of host and client systems.

1.7.1 IBM N series hardware

IBM N series unified system storage solutions can provide customers with the latest technology to help them improve performance, virtualization manageability, and system efficiency at a reduced total cost of ownership.

IBM System Storage N3000 Express

The IBM N3000 Express systems are designed to provide primary and secondary storage for midsize enterprises. Consolidating all of their fragmented application-based storage and unstructured data into one unified, easily managed, and expandable platform can help IT generalists increase their effectiveness. N3000 Express systems offer integrated block-level and file-level data access, intelligent management software and data protection capabilities—such as higher-end N series systems—in a cost-effective package. IBM N3000 Express series innovations include internal controller support for Serial-Attached SCSI (SAS) or SATA drives, expandable I/O connectivity and onboard remote management.

The N3300 series squeezes 12 TB of internal raw capacity into a 2U enclosure and optional external expansion that can increase total system raw capacity to 68 TB. The new N3400 series can scale up to 12 TB of internal raw capacity and increase total raw capacity to 136 TB. The N3600 series scales up to 20 TB of internal raw capacity and can scale up to 104 TB by supporting up to 104 disk drives.

See 5.2.4, "IBM System Storage N3000 introduction" on page 217 for more information.

IBM System Storage N series Gateway

The IBM System Storage N series Gateway product line is a network-based unified storage solution designed to provide Internet Protocol (IP) and Fibre Channel (FC) protocol access to SAN-attached heterogeneous storage arrays. The N6000 and N7000 series ordered with a Gateway feature code can help you make the most of the dynamic provisioning capabilities of Data ONTAP® software across your existing Fibre Channel SAN infrastructure to support an expanded set of business applications.

This gateway is designed to enable organizations to consolidate UNIX, Linux, Windows, and web workloads with existing SAN storage, thereby helping to increase storage utilization.

See 5.3, "IBM System Storage N series Gateways" on page 227 for more information.

IBM System Storage N6000

The IBM System Storage N6000 series offers excellent performance and impressive scalability with a low total cost of ownership. The IBM N6000 systems support simultaneous host attachment by CIFS, NFS, iSCSI and Fibre Channel protocols. The IBM N6040 system supports up to 420 disk drives with a maximum raw capacity of 420 TB, and the IBM N6070 system supports up to 840 disk drives for a maximum raw capacity of 840 TB. The IBM N6060 system supports up to 672 disk drives for a maximum raw capacity of 672 TB. The IBM N6000 series supports attachment to a broad range of IBM, EMC, Hitachi, Fujitsu, 3PAR and HP storage subsystems, including the IBM Enterprise Storage Server® (ESS) series, IBM DS8000 and DS4000® series ordered through its Gateway feature.

See 5.2.5, "IBM System Storage N6000 introduction" on page 223 for more information.

IBM System Storage N7000

The IBM System Storage N7000 series systems are designed to help you tackle the challenge of effective data management using virtualization technology and a unified storage architecture. The N7000 series is designed to deliver high-end enterprise storage and data management capabilities with midrange affordability. Built-in serviceability and manageability features help support your efforts to increase reliability; simplify and unify storage infrastructure and maintenance; and deliver exceptional economy.

The IBM N7000 series can unify FC SAN, iSCSI SAN, NAS, primary, nearline, and regulatory compliance data retention and archival storage in an integrated architecture. The N7000 also offers massive scalability to support growth and consolidation. The combination of versatility and simplicity of N series systems is intended to help you respond quickly to changing business needs. The IBM System Storage N7000 Modular Disk Storage System is designed for non-disruptive expansion to more than 1.1 petabytes (1176 TB) storage capacity

In addition, the N7000 series ordered with a Gateway feature can help you get the most from your existing storage equipment.

See 5.2.6, “IBM System Storage N7000 introduction” on page 225 for more information.

1.7.2 IBM N series software

The IBM System Storage N series also provides a selection of features and functions designed to provide a comprehensive set of robust management and operational tools as well as high availability features, disaster recovery, and data copy services that help the system administration provide a high level of support for environments requiring IP attached storage solutions.

See 5.7, “Optional software” on page 240 for more information.

IBM System Storage N series with Performance Accelerator Module

IBM System Storage N series Performance Accelerator Module (PAM) was created to provide you with a new way to optimize storage performance. The N series PAM solution has been designed to help you improve performance for workloads that are random read-intensive without increasing drive counts.

IBM System Storage N series Provisioning Manager

IBM System Storage N series Provisioning Manager software provides operational efficiency by streamlining the provisioning process across enterprise-wide data sets. IT administrators can enter set provisioning policies, automate complex provisioning processes, check policy conformance, and pool storage resources for higher utilization. Provisioning Manager also allows server administrators the ability to provision storage within the confines set by the storage administrator.

IBM System Storage N series Open System SnapVault software

IBM N series Open System SnapVault® Software enables Windows, UNIX and Linux servers utilize N series Snapshot™ processes (block-level incremental backups) reduce the amount of backup data flowing over the WAN while maintaining data integrity and recoverability.

IBM System Storage N series Protection Manager Software

Protection Manager is designed as an intuitive backup and replication management software application for IBM N series unified storage disk-based data protection environments. The application is intended to support data protection and help increase productivity with automated setup and policy-based management.

Protection Manager is intended to help equip data center professionals with an innovative software solution to manage the enterprise's disk-based data protection environment. The application is designed to allow administrators to apply consistent data protection policies across the enterprise, automate complex data protection processes, and pool backup and replication resources to help improve utilization.

IBM System Storage N series with Operations Manager (formerly DataFabric Manager)

IBM System Storage N series with Operations Manager offers comprehensive monitoring and management for N series enterprise storage and content delivery environments. Operations Manager is designed to provide centralized alerts, reports, and configuration tools to help keep your storage and content delivery infrastructure in-line with your business requirements for high availability and low total cost of ownership.

Data ONTAP

IBM System Storage N series systems employ Data ONTAP, a highly scalable and flexible operating system for network storage appliances used in heterogeneous host environments. Data ONTAP is designed to deliver flexible management and support high availability and business continuance, thereby reducing storage management complexity in your enterprise.

FlexCache

IBM N series FlexCache™ software is designed to address some of the most difficult data access and data management problems. If storage infrastructure suffers from frequent read bottlenecks, if there is the need to efficiently support remote access, or if there is a need for tiered storage that can automatically adjust to changing usage patterns, then FlexCache software is an ideal solution.

IBM System Storage N series with SnapManager for Microsoft Exchange

IBM System Storage N series with SnapManager® for Microsoft Exchange is a comprehensive data management solution designed to streamline storage management by simplifying configuration, backup, and restore operations for Exchange databases.

IBM System Storage N series SnapManager For Hyper-V Software

SnapManager for Hyper-V provides an easy to use, quick and simple method to backup and restore virtual machines. SnapManager for Microsoft Hyper-V can help you to maximize your Microsoft virtual environment with elevated storage flexibility and innovative data protection solutions at a very low storage cost. This revolutionary management tool offers a comprehensive interface intended to provide an automated solution for managing backup, recovery, and replication of virtual machines in a virtualized environment.

IBM System Storage N series with Single Mailbox Recovery with SnapManager for Microsoft Exchange

The powerful combination of IBM System Storage N series, SnapManager for Microsoft Exchange and Single Mailbox Recovery functionality supports the fast, accurate, and cost-effective backup and recovery of Microsoft Exchange data. N series software is designed to take near-instantaneous online backups of Exchange databases, verify that the backups are consistent, and rapidly recover Exchange at almost any level of granularity-storage group, database, folder, single mailbox, or single message.

IBM System Storage N series with SnapManager for Microsoft SQL Server

IBM System Storage N series with SnapManager for Microsoft SQL Server is a comprehensive data management solution designed to enable storage consolidation and help simplify management across a SQL Server data farm. SnapManager features can help you streamline database storage while simplifying configuration, backup, and restore operations for SQL Server databases.

IBM System Storage N series SnapManager for Microsoft Office SharePoint Server 2007 Software

IBM System Storage N series with SnapManager for Microsoft Office SharePoint Server is designed to decrease the time spent on routine backup/recovery.

IBM System Storage N series with SnapManager for Oracle

IBM System Storage N series with SnapManager for Oracle is a comprehensive data management solution designed to help you streamline storage management while simplifying configuration, backup, and restore operations for Oracle databases.

IBM System Storage N series with SnapManager for SAP

IBM System Storage N series SnapManager for SAP software's integration and certification with SAP BRTools makes the full benefits of innovative N series technologies available for SAP data management. SnapManager is designed to automate complex and time-consuming tasks such as backup, recovery, and cloning—helping free IT personnel to focus more effort on value-added tasks. Administrators no longer have to worry about the underlying SAP data layout when performing routine data management tasks, because SnapManager for SAP is designed to understand and address the underlying complexity

SnapManager for Virtual Infrastructure

IBM System Storage N series SnapManager for Virtual Infrastructure is a comprehensive data management solution intended to streamline storage management in a VMware ESX environment. It can also help simplify backup, restore, and disaster recovery operations for virtual machines.

AutoSupport service for IBM System Storage N series

AutoSupport Service for IBM System Storage N series is designed to continuously monitor the health of your storage system using a sophisticated, event-driven logging agent featured in the Data ONTAP operating system inside each N series storage system.

IP SAN solution

The IBM System Storage N series IP SAN solution offers a comprehensive set of functions designed to help organizations easily consolidate data storage from dispersed systems into a single, high-performance storage pool. This consolidation can help improve data availability and application uptime, enable comprehensive data protection, simplify storage infrastructure and management, and utilize existing investments and resources.

1.7.3 Data management software

The data management software for the IBM System Storage N series includes the following features.

Clustered Failover

IBM System Storage N series with Clustered Failover is designed to deliver a robust and highly available data service for business-critical environments. Installed on a pair of N series filers, Clustered Failover can help improve data availability by transferring the data service of an unavailable filer to the other filer in the cluster. Often, the transfer of data service occurs without impacting end users and applications, and the data service can be quickly resumed with no detectable interruption to business operation.

FlexShare

IBM System Storage N series with FlexShare™ is a control-of-service tool designed to help reduce costs and simplify storage management. It allows storage administrators to host and prioritize different applications on a single storage system while avoiding impact to critical applications.

FlexVol and FlexClone

IBM System Storage N series systems with FlexClone® and FlexVol® technologies can help deliver storage virtualization solutions—solutions that support the sharing and pooling of enterprise data. Using FlexVol technology, system administrators can dynamically assign storage space to a user from the available pool of storage resources based on that user's space requirements. This flexibility can help your organization simplify operations, improve utilization and efficiency, and make changes quickly and seamlessly. FlexClone technology generates nearly instantaneous replicas of data sets and storage volumes that require no additional storage space. Each cloned volume is a transparent virtual copy that can be used for enterprise operations.

MetroCluster

IBM System Storage N series with MetroCluster is an integrated, high-availability and business continuance solution that is designed to expand the capabilities of the comprehensive IBM System Storage N series portfolio of high-availability and disaster recovery solutions. A simple-to-administer solution, MetroCluster is designed to extend failover capability from within a data center to a site located many miles away. It also helps support replication of data from a primary to a remote site to maintain data currency.

MultiStore

IBM System Storage N series with MultiStore® software is designed to let you quickly and easily create separate, private logical partitions in filer network and storage resources. Each virtual storage partition is designed to maintain separation from every other storage partition to prevent different enterprise departments that share the same storage resources from accessing or finding other partitions. MultiStore helps prevent information located on any virtual partition from being viewed, used or downloaded by unauthorized users.

NearStore

The IBM System Storage N series configured with SATA disk drives or an N series Gateway is designed to provide terabytes of near-primary storage performance at near-tape storage costs. Near-line storage can help organizations complement and improve existing tape backup, archiving and data protection schemes by inserting economical and simple-to-use disk-based storage or utilize SAN disk storage between application storage and tape libraries in a three-tier storage architecture.

SnapLock

The SnapLock® function is designed to deliver high performance and high security data function to disk-based nearline and primary IBM System Storage N series storage. An integrated element of the Data ONTAP operating system, the SnapLock function can help manage the permanence, accuracy, integrity, and security of data by storing business records in an inalterable form and allowing for their rapid online accessibility for long periods of time

SnapMirror

IBM System Storage N series systems with SnapMirror® technology can help deliver the disaster recovery and data distribution solutions that today's global enterprises need. By replicating data at high speeds over a LAN or a WAN, SnapMirror technology can support high data availability and quick recovery for mission-critical applications. SnapMirror technology can mirror data to one or more network filers and constantly update the mirrored data to keep it current and available.

SnapMover

SnapMover® technology is a fast and simple solution for migrating data among IBM System Storage N series systems while avoiding impact on data availability and disruption to users. Offering powerful and flexible data migration capabilities, SnapMover technology can help IT departments efficiently address evolving storage and performance requirements while maintaining user productivity.

SnapRestore

IBM System Storage N series systems with SnapRestore® capability is designed to help an enterprise recover data quickly in the case of a disaster. SnapRestore software can help recover data in amounts as small as an individual file up to a multiterabyte volume so that operations can quickly resume.

Snapshot

IBM System Storage N series systems with point-in-time Snapshot capability can help deliver data stability, scalability, recoverability and performance capabilities. IBM System Storage N series systems can utilize the Snapshot technology as a foundation for developing a range of data protection solutions to support advanced enterprise data protection

SnapDrive

IBM System Storage N series with SnapDrive® software can help reduce the cost and complexity of managing storage for your company by supporting the flexible and efficient utilization of storage resources. SnapDrive software offers a rich set of capabilities designed to virtualize and enhance storage management for Microsoft Windows and UNIX environments.

SnapVault

IBM System Storage N series with SnapVault capabilities can help you efficiently backup and restore critical data by supporting the frequent backup of data stored on IBM System Storage N series systems. SnapVault technology is designed to provide a centralized, disk-based backup solution for IBM N series systems. Storing backup data in multiple Snapshot copies on a SnapVault secondary storage system can let enterprises keep multiple backups online over a period of time for faster restoration.

SyncMirror

IBM System Storage N series systems with SyncMirror® is designed to keep data available and up-to-date by maintaining two copies of data online. When used with a high-availability solution, such as an IBM System Storage N series system with Clustered Failover, SyncMirror can help you support even higher levels of data availability.

1.7.4 Storage management and application integration software

The IBM System Storage N series includes the following software for Storage management and application integration

SecureAdmin

SecureAdmin™ is designed to enable authenticated, command-based administrative sessions between an administrative user and Data ONTAP over an intranet or the Internet. SecureAdmin supports authentication of both the administrative user and the filer, creating a secured, direct communication link to the filer. It helps protect administrative logins, passwords, and session commands from “cleartext” snooping by replacing rsh and telnet with the strongly encrypted SSH 1.0 protocol.

SnapValidator

IBM System Storage N series with SnapValidator® software is designed to provide a high level of protection for Oracle data, helping you to detect potential data corruption before it occurs. By adding intelligence and database awareness to modular storage systems—across iSCSI SAN, FC SAN, and NAS protocols—the software can help you extend the advantages of checksum functionality beyond monolithic storage environments.

> **N series:** For more comprehensive information about the full range of N series software products, see the website:
>
> `http://www.ibm.com/systems/storage/network/software`

1.8 Storage software

Here we describe IBM Storage software and Storage technologies for a Smarter Planet.

1.8.1 IBM System Storage SAN Volume Controller (SVC)

IBM System Storage SAN Volume Controller is designed to help increase the efficiency and flexibility of your storage infrastructure by pooling storage, centralizing management, and enabling changes to the physical storage while avoiding disruption to applications. SAN Volume Controller combines the capacity from multiple disk storage systems into a single storage pool, which can be managed from a central point in a consistent manner regardless of storage vendor. Now with tightly integrated support for solid-state drives (SSDs), numerous replication enhancements, dramatic performance improvements, and support for many non-IBM storage systems including EMC, HP, and HDS, SAN Volume Controller can help transform your storage environment into a tool to build a more dynamic infrastructure.

SAN Volume Controller software is delivered pre-installed on SVC Storage Engines so it is quickly ready for implementation after the engines are attached to your storage area network (SAN). SVC Storage Engines are based on proven IBM System x server technology and are always deployed in redundant pairs, which are designed to deliver very high availability.

SVC is designed to take control of existing storage, retaining all your existing information. This ability helps speed and simplify implementation while helping to minimize the need for additional storage. After SVC is implemented, you can make changes to the configuration quickly and easily as needed.

SAN Volume Controller Version 6.1 introduces a completely new graphic user interface modeled on the IBM XIV Storage System, which has been very well received by customers. The new user interface is designed to be much easier to use and includes many built-in IBM guidelines to help simplify storage provisioning and enable new users to get started quickly with a rapid learning curve.

See Chapter 16, “IBM System Storage SAN Volume Controller” on page 495 for more information.

1.8.2 IBM Information Archive

IBM Information Archive is the next-generation information retention solution designed as a universal archiving repository for all types of content to help midsize and enterprise clients reduce cost, manage risk and address clients complete information retention needs - business, legal, or regulatory.

With IBM Information Infrastructure solutions, you can utilize tiers of storage (disk and tape) with policy-based management that automatically moves less active information to a more cost-effective storage system, as well as deduplication and compression techniques to achieve storage capacity optimization and improved productivity.

To learn more about the IBM Information Archive, see the following website:

http://www-03.ibm.com/systems/storage/disk/archive/

1.8.3 IBM Tivoli Storage Productivity Center

IBM Tivoli Storage Productivity Center (TPC) is an integrated suite that includes a single user interface to manage capacity utilization of storage systems, file systems, and databases, and to automate file system capacity provisioning in both physical and virtual environments. IBM Tivoli Storage Productivity Center components can be ordered as a bundled suite or ordered separately based on specific needs.

The individual components include these:

- IBM Tivoli Storage Productivity Center Basic Edition
- IBM Tivoli Storage Productivity Center Standard Edition
- IBM Tivoli Storage Productivity Center for Data
- IBM Tivoli Storage Productivity Center for Disk
- IBM Tivoli Storage Productivity Center for Disk Midrange Edition
- IBM Tivoli Storage Productivity Center for Replication for System z

See Chapter 19, “IBM Tivoli Storage Productivity Center” on page 603 for more information.

1.8.4 IBM Tivoli Storage Manager

IBM Tivoli Storage Manager is the number one product of choice for an efficient and effective enterprise wide storage solution. It provides a data protection solution for backup, archiving, disaster recovery planning, space management, database and application protection, bare machine recovery, and record retention. More than 44 operating platforms are supported, using a consistent graphical user interface.

Tivoli Storage Manager provides the following capabilities:

- Centralized administration for data and storage management
- Fully automated data protection
- Efficient management of information growth
- High-speed automated server recovery
- Full compatibility with hundreds of storage devices, and local area network (LAN), wide area network (WAN), and storage area network (SAN) infrastructures
- Optional specifically designed backup solutions for major groupware, enterprise resource planning (ERP) applications, and database products.

Tivoli Storage Manager is the premier storage management solution for mixed platform environments. Coming with the latest version V6.2 new features such as client-side deduplication which reduces the network bandwidth impact during backup jobs and automatic update of Windows Backup/Archive Clients which simplifies administration, reduces risks of errors and more efficient backup of very large SAP databases (TSM for ERP v6.2).

See Chapter 18., "IBM Tivoli Storage Manager" for more information.

1.8.5 IBM Tivoli Key Lifecycle Manager

IBM Tivoli Key Lifecycle Manager helps IT organizations better manage the encryption key lifecycle by enabling them to centralize and strengthen key management processes throughout the enterprise.

- Simplify, centralize, and strengthen encryption key management for the enterprise
- Enhance data security while dramatically reducing the cost and complexity of managing encryption keys
- Simplify encryption key management with an easy to use and intuitive user interface for configuration and management
- Utilize the support for Key Management Interoperability Protocol (Released through OASIS) and consolidate key management in a single enterprise key management system hence reducing operational costs and enhancing data security
- Help minimize the risk of loss or breach of sensitive information
- Help facilitate compliance management of regulatory standards such as Health Insurance Portability and Accountability Act (HIPAA), HiTECH, and so on
- Enhance security of key management operations with support for role based access control
- Utilize open standards to help enable flexibility and facilitate vendor interoperability

See Chapter 20., "IBM Tivoli Key Lifecycle Manager" for more information.

1.8.6 IBM General Parallel File System

IBM General Parallel File System (GPFS) is a scalable, parallel cluster file system. In addition to high-speed parallel file access, GPFS provides fault tolerance, including automatic recovery from disk and node failures.

IBM General Parallel File System (GPFS) currently powers many of the world's largest scientific supercomputers and commercial applications requiring high-speed access to large volumes of data.

See Chapter 21, “IBM GPFS and SoFS” on page 679 for more information.

1.8.7 z/OS storage management tools

The z/OS storage management tools are a collection of products designed to provide a comprehensive menu of solutions in order to meet the storage management requirements of z/OS customers. The tools are positioned to complement and extend the storage management capabilities of DFSMS.

These products allow IBM to provide a more complete suite of storage management solutions:

- IBM Tivoli OMEGAMON XE
- IBM DB2® Cloning Tool
- IBM Tivoli Advanced Catalog Management for z/OS
- IBM Tivoli Advanced Backup and Recovery
- IBM Tivoli Advanced Audit for DFSMShsm
- IBM Tivoli Automated Tape Allocation Manager
- IBM Tivoli Storage Optimizer for z/OS
- IBM Tivoli Tape Optimizer for z/OS
- DFSMS Optimizer

See Chapter 23., “z/OS Storage Management Tools” for more information.

1.8.8 IBM System Storage Productivity Center

The IBM System Storage Productivity Center (SSPC) is an integrated hardware and software solution that can help you improve and centralize the management of your storage environment through the integration of products. It provides a single point from which to manage your storage systems.

See 19.10, “IBM System Storage Productivity Center” on page 658 for more information.

Strategies: Only IBM can provide a complete portfolio of solutions and services, innovative servers, storage, and systems software that facilitate combined business and IT.

To learn more about the IBM Dynamic Infrastructure and Smarter Planet strategies, see the following websites:

http://www-03.ibm.com/systems/dynamicinfrastructure
http://www-03.ibm.com/systems/dynamicinfrastructure/smarter_planet/index.html

Part 1

Disk systems

In Part 1 we describe disk products that either can be directly attached to a server by Direct Attached Storage (DAS), used in a Storage Area Network (SAN) infrastructure, or used with Network Attached Storage (NAS).

The IBM System Storage disk products portfolio covers the needs of a wide spectrum of possible implementations, from entry-level to large enterprise.

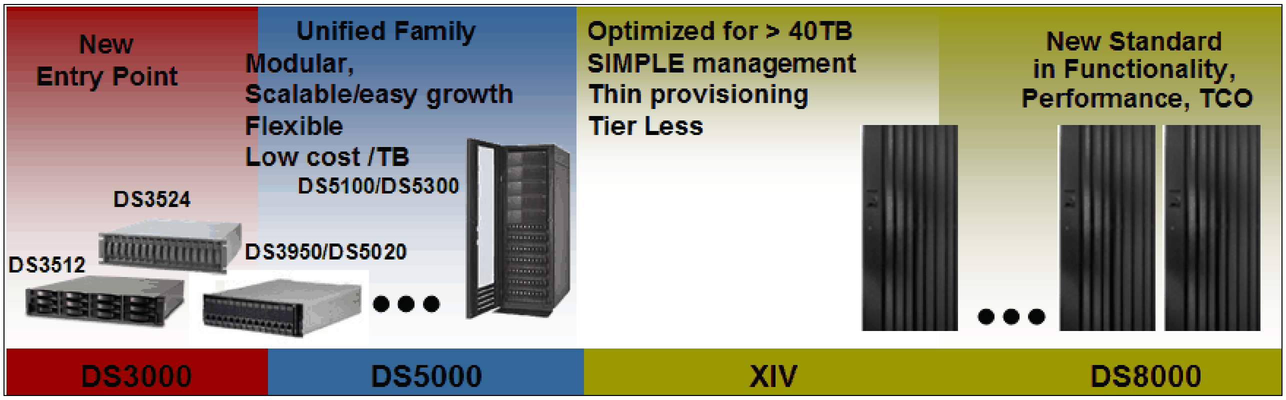
The IBM System Storage DS family combines the high-performance of the IBM System Storage DS8000 series and XIV enterprise servers with the IBM System Storage DS5000 series of midrange systems, and with DS3000 series low priced entry systems.

The family is further complemented by a range of expansion enclosures to expand the disk storage capacities of individual systems into hundreds of terabytes (TB), or even to a petabyte (PB).

Furthermore, a full range of IBM System Storage capabilities such as advanced copy services, management tools, and virtualization services are available to help protect data.

Types of storage

Here we show the extensive range of DS disk storage systems that we discuss in more detail in subsequent chapters.



IBM System Storage Disk systems

Enterprise storage

Under Enterprise disk storage, you find disk systems with the following characteristics:

- Excellent external storage solution for medium to large scale deployments
- Medium and large data centers
- Multi-workload mission critical environments
- Long distance disaster replication
- High performance, highly scalable, high function storage systems
- Designed to avoid any single points of failure for high availability; highly reliable architecture with hot-swap, redundant components
- Designed for non-disruptive upgrades in capacity, performance, and cache; long-term, highly expandable storage solutions to protect investment
- Flexible management including SMI-S compatible API
- Advanced business continuance solutions
- Excellent price/performance/value

Mid-level storage

IBM System Storage mid-level storage disks systems are characterized as follows:

- Ideal external storage solution for smaller deployments
- Often used in remote branch office locations
- Storage systems designed to offer low cost, scalability, high performance

In particular, the DS5000 series incorporates these characteristics:

- High reliability with hot-swap redundant power supplies, controllers and drives
- Fully redundant pathing from host to drive
- Current models are prepared for new iSCSI Host interfaces developments (10Gb iSCSI)
- High performance dual ported 4Gbps FC drives as well as SATA drives
- Easy to use, common DS Storage Manager

Near-line storage and reference data

For near-line storage and reference data, the IBM System Storage disk products in that category offer the following features:

- Excellent external storage solution for small to large scale deployments
- Data Protection with local snapshot and remote mirrors to help support rapid recovery and zero-time backup windows
- Fixed Content Support for those unchanging files and blocks that have light to moderate access profiles
- A design with no single point of failure for high availability, which offers high reliability with hot-swappable redundant components
- Designed to be non-disruptive for upgrades in capacity and performance, helping to protect investment
- Flexible management, including SMI-S compatible FSM API

Entry-level storage

IBM System Storage entry-level disk systems offer the following benefits:

- Excellent external storage solution for smaller deployments:
  - Smaller data center
  - Remote branch office locations
- Storage subsystems designed to provide low cost, scalability, high performance
- A design that offers high reliability with hot-swap redundant power supplies, controllers, and drives
- Easy to use Storage Manager helps remove complexity from SAN deployment and management

Network attached storage

IBM N series (NAS) products provide a wide-range of network attachment capabilities to a broad range of host and client systems. The range includes NAS gateways, providing heterogeneous access to Fibre Channel attached storage arrays, and NAS expandable storage systems, which come with Fibre Channel disks.

2

Entry-level disk storage

In this chapter, we describe the IBM System Storage entry-level family of external storage enclosures. The models are entry-level, cost-effective workgroup storage servers, and are flexible for use with the IBM System x, IBM system p, and IBM BladeCenter servers, and also for selected third party products.

There are new members to the entry-level disk storage family, the DS3500 and the EXP2500. The DS3500 is able to perform in SAS, iSCSI, and Fibre Channel environments. The EXP2500 provides storage expansion for selected System x servers. Both of them perform in the next-generation 6 Gbps SAS.

With a wide range of Advanced functions such as Partitioning, FlashCopy®, VolumeCopy, and Enhanced Remote Mirroring, the DS3500 disk solution is highly suitable for small to midsize companies.

Furthermore, the DS3500 disk systems are easy to deploy and manage through the IBM System Storage DS Storage Manager (also known as IBM DS Storage Manager).

DS3200, DS3300, DS3400: The DS3000 previous models (DS3200, DS3300, and DS3400) have been withdrawn from marketing on January 15, 2011, according to the withdrawal announcement letter number 910-217, available at the following URL. See the *IBM System Storage DS3000: Introduction and Implementation Guide*, SG24-7065 for information about those older models:

http://www.ibm.com/common/ssi/rep_ca/7/897/ENUS910-217/ENUS910-217.PDF

2.1 Overview of new entry-level series models

Designed to deliver advanced functionality at a breakthrough price, these entry-level systems provide an exceptional solution for workgroup storage applications such as email, file, print and web servers, as well as collaborative databases and remote boot for diskless servers.

2.1.1 IBM System Storage DS3500

The IBM System Storage DS3500 series models are entry-level, low-cost workgroup storage subsystems for IBM System x, IBM System p, IBM BladeCenter servers, and selected servers from other parties. They come in either single-controller or dual-controller configuration versions. The DS3500 series offer a solution for workgroup storage applications, such as file, print, and web serving, as well as remote boot storage for diskless servers.

The DS3500 is flexible about host connection options. It supports SAS direct connection, Fibre Channel direct connection, iSCSI connection through GbE switches, and Fibre Channel through SAN switches. The DS3500 supports intermixing four 1 Gbps iSCSI or four 8 Gbps FC host ports with its native 6 Gbps SAS interfaces. This flexible and multi-purpose dual protocol approach allows organizations to implement a single storage system to support all of their shared storage requirements, thereby maximizing productivity, reliability, and cost.

The modular and scalable design of the DS3500 Series can easily be upgraded to meet the growing needs of storage. Disk enclosures will enable flexible growth up to higher disk space requirement regions.

Availability of data is secured by common high availability features:

- Dual active RAID controllers
- Redundant hot-swappable components (controllers, drives, cables, and power/cooling)
- Automated IO path failover
- Online administration, expansion, configuration, and RAID level migration
- Unlimited Global Hot-Spares
- Battery backed cache with cache mirroring

Additional advanced (premium) software features are available on the DS3500 series:

- Storage partitions
- FlashCopy functionality
- VolumeCopy
- Enhanced Remote Mirroring (ERM)

Out of the box, the DS3500 series models include licenses for four partitions, two FlashCopy images, and Windows and Linux on Intel® host-attach license. The DS3500 can be expanded using EXP3500 expansion units.

2.1.2 IBM System Storage EXP2500

The EXP2500 is a cost-effective, fully integrated complement to System x servers. Offering substantial improvements at a price that will fit most budgets, the EXP2500 Express delivers superior price-to-performance ratios, functionality, scalability and ease of use for the entry-level storage user. EXP2500 highlights are as follows:

- Easy installation and management with storage expansion technology designed for IBM System x direct attachment by ServeRAID M5025 adapter
- Next-generation 6 Gbps Serial Attached SCSI (SAS) host and drive interfaces, which enable infrastructure simplification

- Support for flexible high-performance and nearline disk drive options
- High capacity, with support for multiple enclosures per configuration
- High-density 2U enclosure designed for supporting up to 12 3.5" disk drives on model EXP2512 Express and 24 2.5" disk drives on model EXP2524 Express
- High availability and reliability, with dual AC power supplies and fans

2.2 IBM System Storage DS3500

IBM has combined best-of-breed development with leading 6 Gbps host interface and drive technology in the IBM System Storage DS3500 Express.

The new IBM System Storage DS3500 series storage subsystems support up to two redundant RAID controllers in either a twelve or twenty four drive configuration. The models for the storage servers are DS3512 and DS3524. There are also two models of drive expansion chassis (a twelve drive and a twenty four drive) that can be attached to either of the storage subsystems, the EXP3512 and EXP3524. The new DS3500 models provide the following new capabilities from the previous generations:

- This capability allows for one storage subsystem to be able to perform in the environments of the three previous DS3000 family members, with support options for SAS, iSCSI, and Fibre Channel host connections.
- DS3500 shares the same management console, Storage Manager, and firmware releases from the DS5000 midrange family.
- This capability brings the Enhanced Remote Mirroring (ERM) premium feature to the DS3000 line (which was not supported in previous DS3000 models).
- New 6 Gbps SAS technology for host and drive attachments.
- Support for greater capacity with new larger capacity SAS drive offerings.
- Option to further enhance the performance of your dual controller DS3500 system with the Turbo Performance option. You choose the configuration to match your current performance requirements and budget, and IBM offers a way to protect your investment with an upgrade path to later add the options you need.

Figure 2-1 shows the 12 slot model and Figure 2-2 shows the 24 slot model.

Figure 2-1 DS3512 or EXP3512 subsystem assembly from the front view

Figure 2-2 DS3524 or EXP3524 servers assembly from the front view

Specifications: Table 2-1 lists the DS3500 specifications.

Table 2-1 IBM System Storage DS3500 specifications

Component	Description
Model	1746-A2S - DS3512 Express Single Controller Storage System 1746-A2D - DS3512 Express Dual Controller Storage System 1746-A4S - DS3524 Express Single Controller Storage System 1746-A4D - DS3524 Express Dual Controller Storage System 1746-A2E - EXP3512 Express Storage™ Expansion Unit 1746-A4E - EXP3524 Express Storage Expansion Unit
RAID controller	Dual active, hot-swappable controllers
Cache per controller	1 GB cache per controller with 2 GB upgrade (battery-backed)
Host interface	Three options: -Four or eight 6 Gbps SAS ports -Eight 8 Gbps FC ports and four 6 Gbps SAS ports -Eight 1 Gbps iSCSI ports and four 6 Gbps SAS port
Drive interface	Two 6 Gbps Serial Attached SCSI (SAS) ports
Supported drives	6 Gbps SAS 3.5" drives: -300 GB 15k rpm, 450 GB 15k rpm, 600 GB 15k rpm -1 TB 7.2k rpm Nearline, 2 TB 7.2k rpm Nearline -600 GB 15k rpm SED 6 Gbps SAS 2.5" drives: -146 GB 15k rpm -300 GB 10k rpm -600 GB 10k rpm -500 GB 7.2k rpm Nearline -300 GB 10k rpm SED
RAID	RAID 0, 1, 3, 5, 6, 10
Storage partitions	4 standard with upgrades to 8, 16, 32, and 64
Maximum drives supported	Up to 96 drives (high performance SAS drives, nearline SAS drives, and SED SAS drives) using EXP3512 (2U, 12 x 3.5-in drives) and EXP3524 (2U, 24 x 2.5-in drive) enclosures, which can be intermixed
Fans and power supplies	Dual redundant, hot-swappable
Rack support	19-inch, industry-standard rack

For the latest specification information about the DS3500, see the website:

http://www.ibm.com/systems/storage/disk/ds3500

2.2.1 DS3500 components

The DS3500 storage server is a 2U rack mountable enclosure, containing either one or two RAID controller modules, two power supplies, and up to twelve disk or twenty four disk modules. See Figure 2-3 for the component layouts.

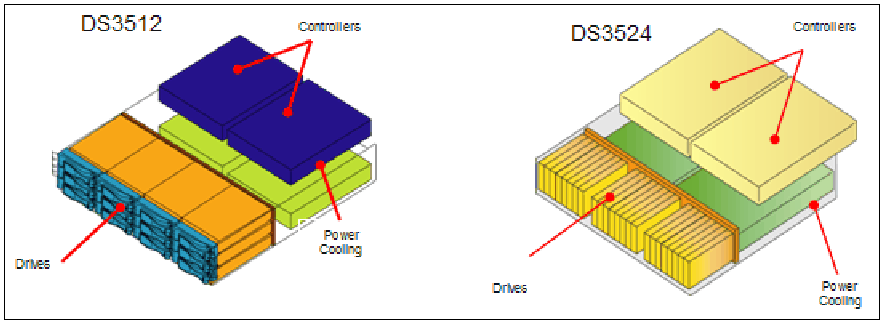


Figure 2-3 DS3500 components

DS3500 supported disk drives

The DS3500, similar to the DS3000, DS4000, and DS5000 storage systems, can cost-effectively support an organization's complete range of data capacity requirements, from near-line static data to highly utilized applications, through support for mixed drive types within a single storage system.

The DS3500 accomplishes this with the additional support for nearline SAS drives, SAS SED drives, and 2.5-inch SAS drives in addition to its traditional 3.5-in drives. Nearline SAS drives are also the clear replacement of SATA drives. Competitively priced to SATA drives, nearline SAS drives significantly outperform SATA and do so with greater reliability at a comparable price.

The DS3512 and EXP3512 support twelve drives in the 3.5 inch format and the DS3524, and EXP3524 supports twenty four drives in the 2.5 inch format.

Table 2-2 shows the available disk types for each DS3500 enclosure model.

Table 2-2 DS3500 family supported HDDs

Drives supported	DS3512/EXP3512	DS3524/EXP3524
SAS 15K rpm	300 GB, 450 GB, 600 GB	146 GB
SAS 15K rpm SED	600 GB	None
SAS 10K rpm	None	300 GB, 600 GB
SAS 10K rpm SED	None	300 GB
Nearline SAS 7.2K rpm	1 TB, 2 TB	500 GB
Maximum drives	12/96	24/96

Full Disk Encryption

In the life cycle of a hard drive, it will at some point be out of the user's control, either through theft, off-site service, repair, or disposal. The DS3500 combines local key management and drive-level encryption for comprehensive data security designed to protect data throughout the life of the drive without sacrificing storage system performance or ease of use.

Full Disk Encryption (FDE) provides data security at the most basic level, the hard drive. FDE protects against many exposures and vulnerabilities all at once. This drive-level encryption ensures data security in the event of a drive loss, theft or retirement. The FDE engine performs encryption without a performance penalty, which allows organizations to achieve the highest levels of data security while retaining optimal performance.

Fully integrated into the DS Storage Manager as a premium feature upgrade, the DS3500's local key management provides the necessary management and protection of self-encrypting disk (SED) drives by utilizing a single authorization scheme, or lock key, which can be set and applied to all SED drives within a DS3500. The DS Storage Manager maintains and controls the key linkage and communications with the SED drives, secures user-selected logical drive groups, and initiates the instant secure erase feature for customers desiring even more peace of mind when servicing, decommissioning, or repurposing drives. With local encryption services, FDE key management is transparent today-to-day storage administration, making SED drives as easy to manage as traditional drives.

2.2.2 Supported configurations

For its flexibility, DS3500 supports several configurations considering host attachment. In this section we present the most common ones. All the possible supported configurations are not represented in this document. Here we discuss several configurations:

- Fibre Channel direct connection:

  Figure 2-4 shows a direct connection between DS3500 FC ports and servers FC Host Bus Adapters (HBAs). In this example, each server has two FC HBAs. Each one of the server's HBAs is connected to a different DS3500 controller, making this a high availability connection, with no single point of failure (SPOF).

  This kind of connection is limited by the amount of the storage FC ports. When the ports end, there is no way to connect new servers but by using Fibre Channel SAN switches.

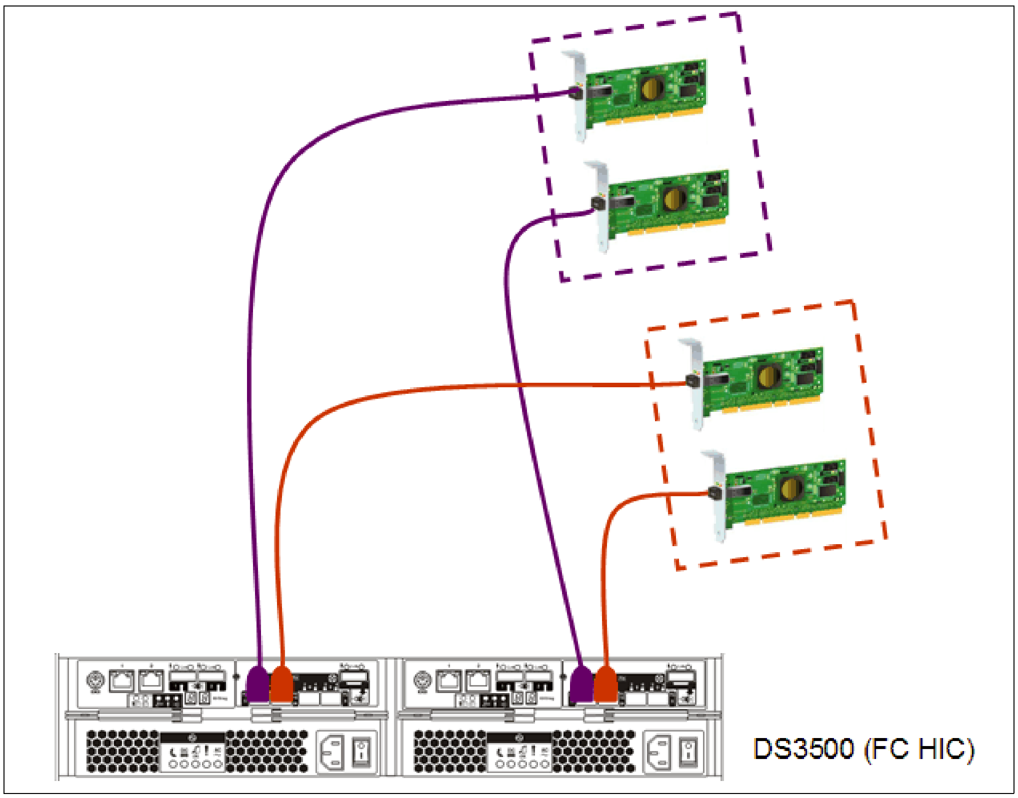


Figure 2-4 Fibre Channel direct connections

- Fibre Channel connection through SAN switches:

  Using Fibre Channel SAN switches, the number of connected servers is not limited by the number of storage ports anymore. Figure 2-5 shows a topology considering high availability and no SPOFs, that is why it has two switches instead of one.

  In this topology, each DS3500 controller (considering the dual controller models) is connected to both SAN switches. Each server has two FC HBAs, each one of which is connected to a different switch. That way, if something fails (FC HBA, switch, or storage controller), the service is not interrupted. If only one SAN switch was available, we then have an SPOF, the switch itself. If it fails, all the service is interrupted and all the connections are dropped.

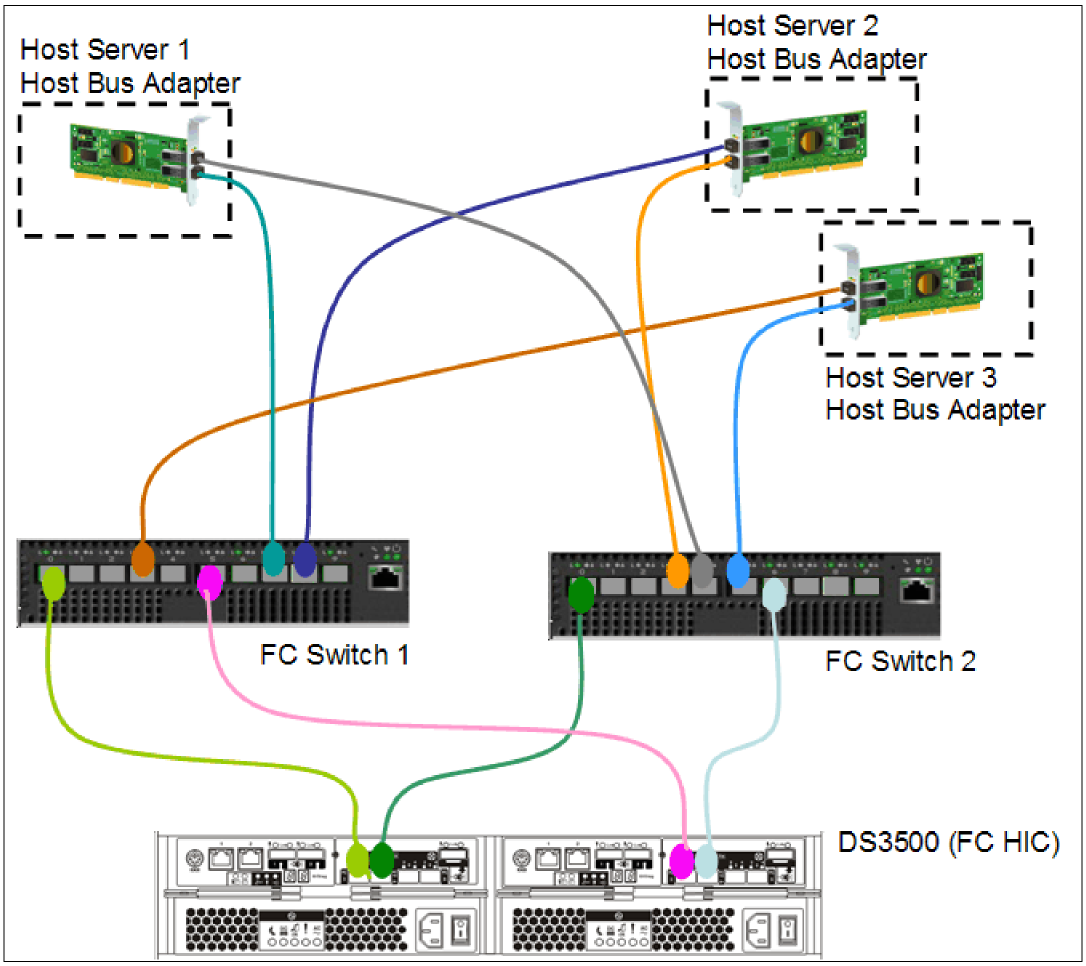


Figure 2-5 Fibre Channel connection through SAN switches

- iSCSI connection:

  With iSCSI, customers can use Ethernet switches, which are cheaper than Fibre Channel ones. The same discussion about high availability and SPOFs, considering one or two switches and HBAs from the previous topology, applies to this case.

  Figure 2-6 shows connections using one GbE switch. Although the two storage controllers are connected to the switch (and for that, if one of them fails, the service does not stop working), there is one switch only, and this is an SPOF.

  Support: Direct storage controller connection to an iSCSI HBA on a server is not supported. One or more GbE switches are necessary.

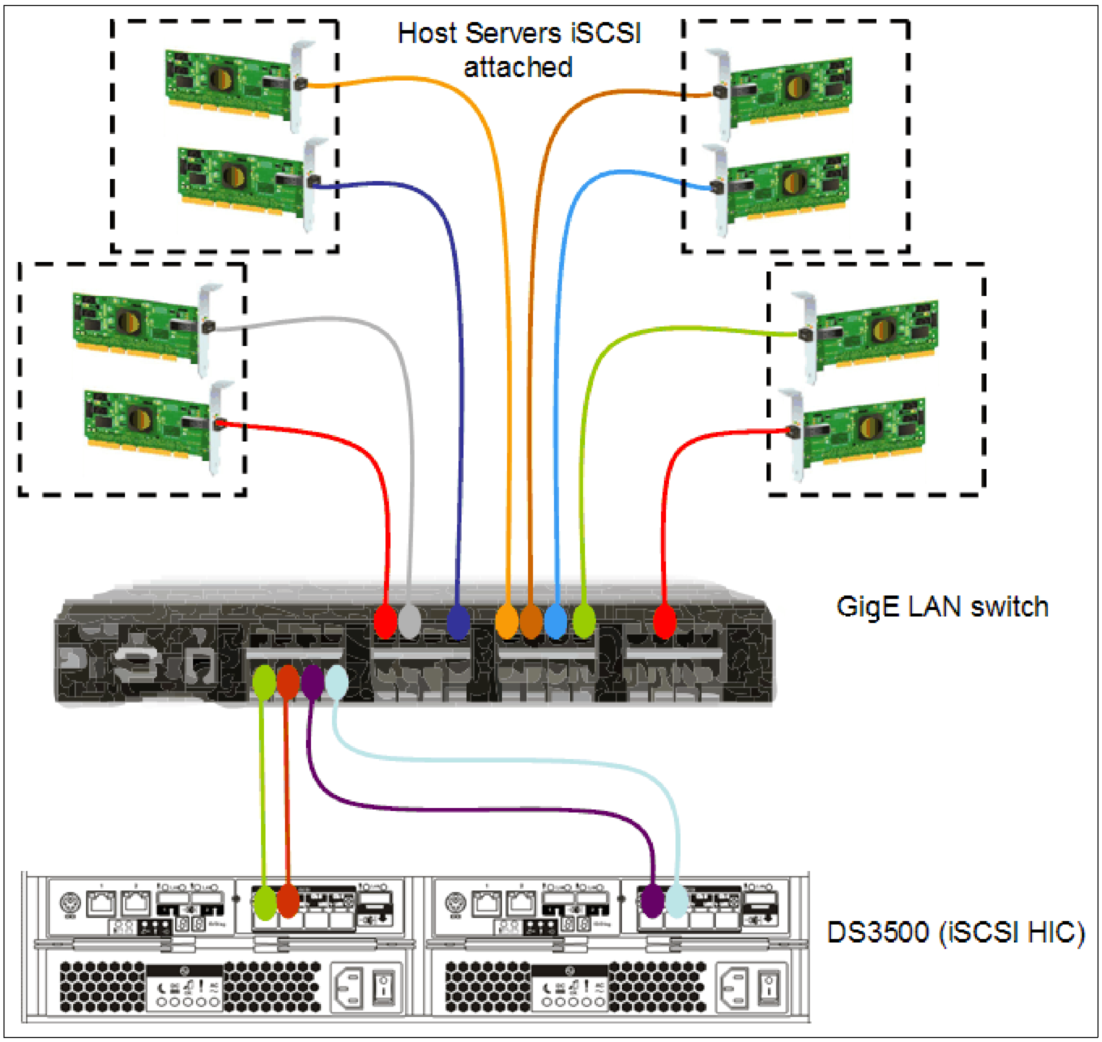


Figure 2-6 iSCSI connection using a GbE switch

- SAS connection:

  SAS is also supported by DS3500. It is possible to directly connect the storage SAS ports to SAS HBAs on servers or connect the storage SAS ports to a BladeCenter SAS switch connection, as shown in Figure 2-7.

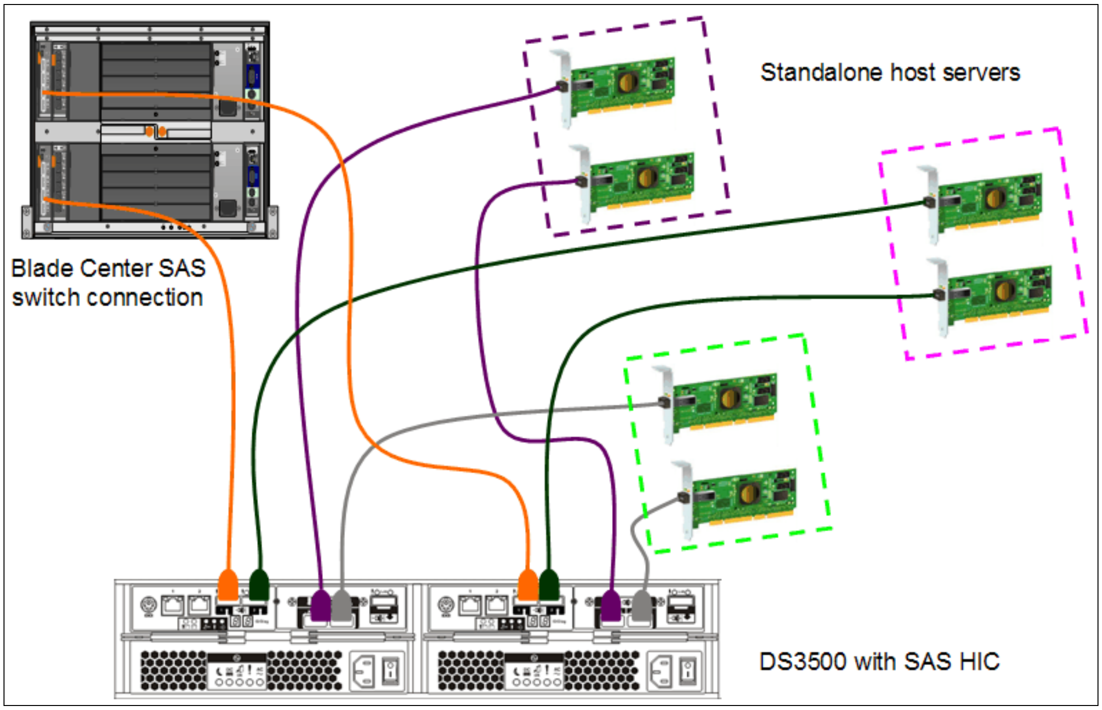


Figure 2-7 SAS connections

The DS3500 can use a mix of technologies too. Regarding its ports, there are three possible configurations:

- Four / Eight 6 Gbps SAS; or
- Eight 8 Gbps FC and four 6 Gbps SAS; or
- Eight 1 Gbps iSCSI and four 6 Gbps SAS

As example of hybrid connection is shown in Figure 2-8. In this example we are mixing SAS with either Fibre Channel or iSCSI networks.

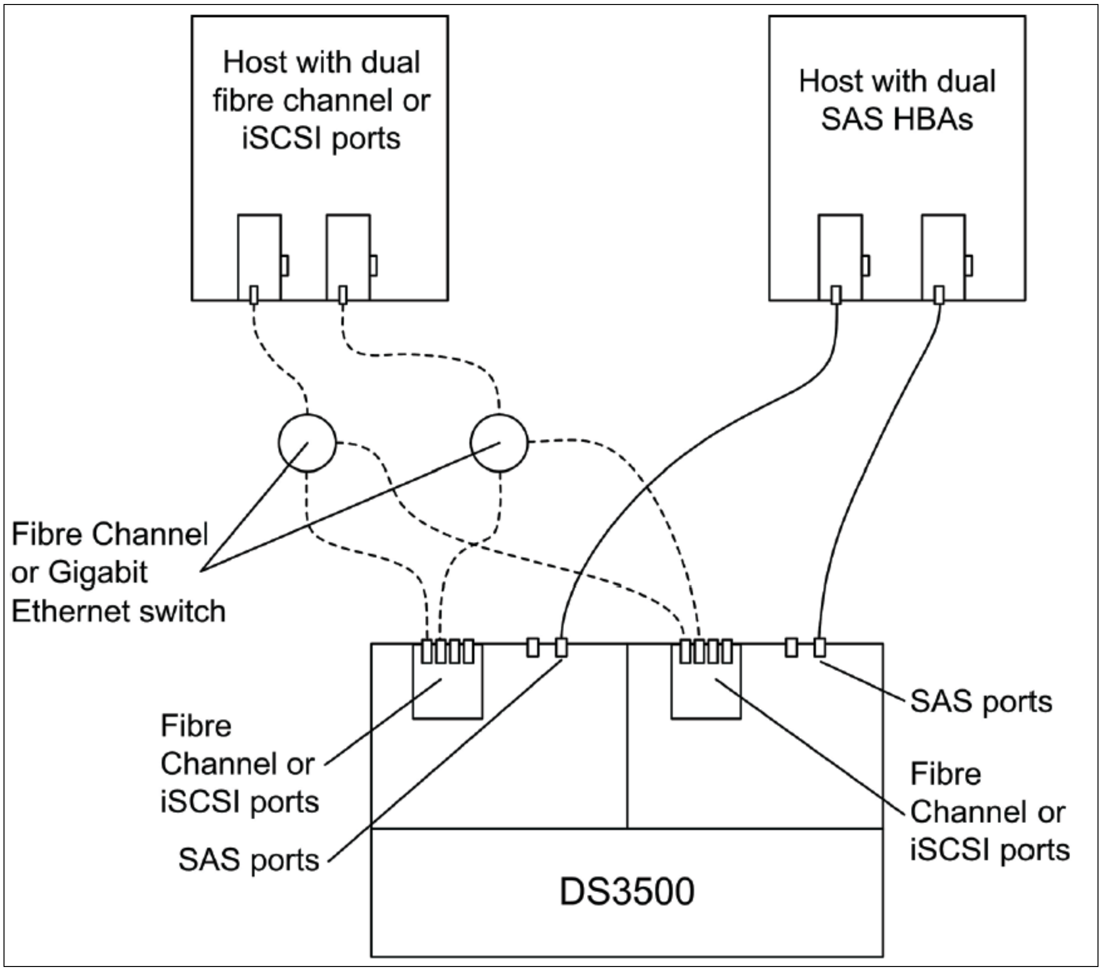


Figure 2-8 Hybrid DS3500 host connections example

2.3 EXP3500 storage expansion units

The EXP3512 and EXP3524 expansion subsystems allow DS3500 storage subsystem growth for up to the 96 drive, by adding either the twelve drive or twenty four drive chassis to the storage server's SAS drive expansion port. Any mix of the expansion models can be added up to the maximum allowed drive count.

The EXP3512 and EXP3524 differ from the DS3512 and DS3524 in that in place of the controller module, they are equipped with an Environmental Services Module (ESM) module. As with the DS3500 controllers, the expansions can be optionally upgraded with a second ESM module for redundant paths. Each ESM has a 6 Gbps SAS connection providing 600 MB/sec throughput.

Figure 2-9 shows the back view of a EXP3500. Each ESM has two SAS IN ports (although only one can be used) and a SAS OUT port.

Figure 2-9 EXP3512 and EXP3524 rear view

If you have a single controller DS3500 and three single ESM expansion units, your connection looks as shown in Figure 2-10. There is an SAS cable going from the expansion port on DS3500 to the SAS IN port on the EXP3500 ESM and then from each ESM SAS OUT port to the next expansion unit in its SAS IN port.

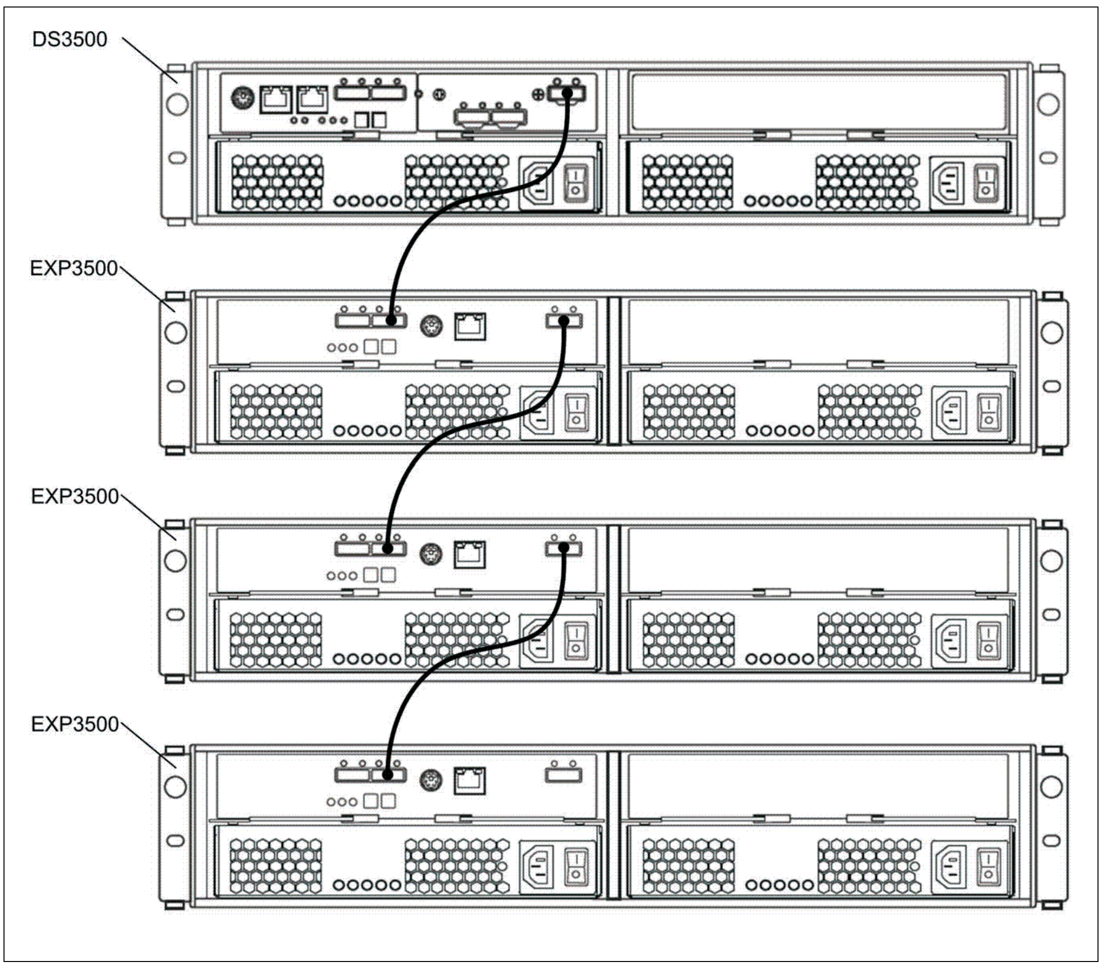


Figure 2-10 Single controller DS3500 connected to three single ESM EXP3500

Regarding the dual controller DS3500 and dual ESM EXP3500, the expansion cabling follows the top-down / bottom-up rule, making it redundant and without any SPOFs. That way, if an ESM fails, there is an alternative path, as shown in Figure 2-11.

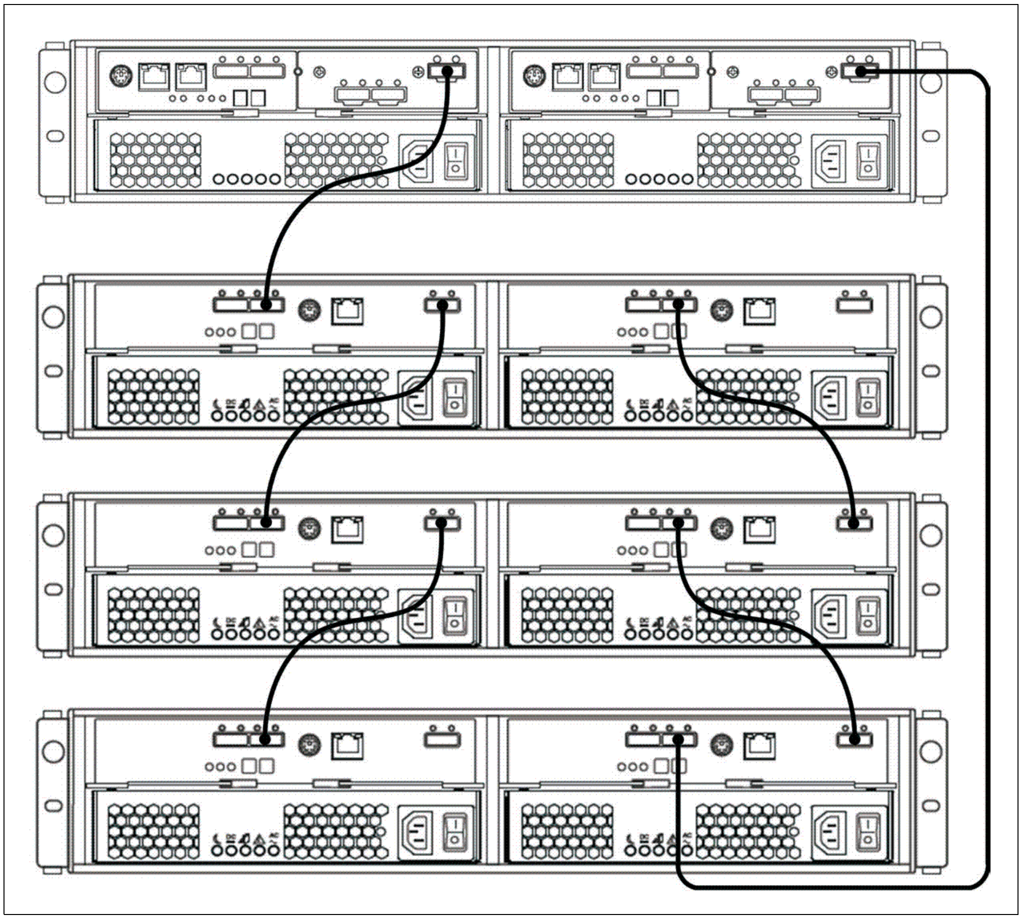


Figure 2-11 Dual controller DS3500 connected to three dual ESM EXP3500

It is not necessary to have more than one expansion unit to get a redundant and highly available connection. With a dual controller DS3500 and just one dual ESM expansion unit, the cabling is redundant too, as shown in Figure 2-12.

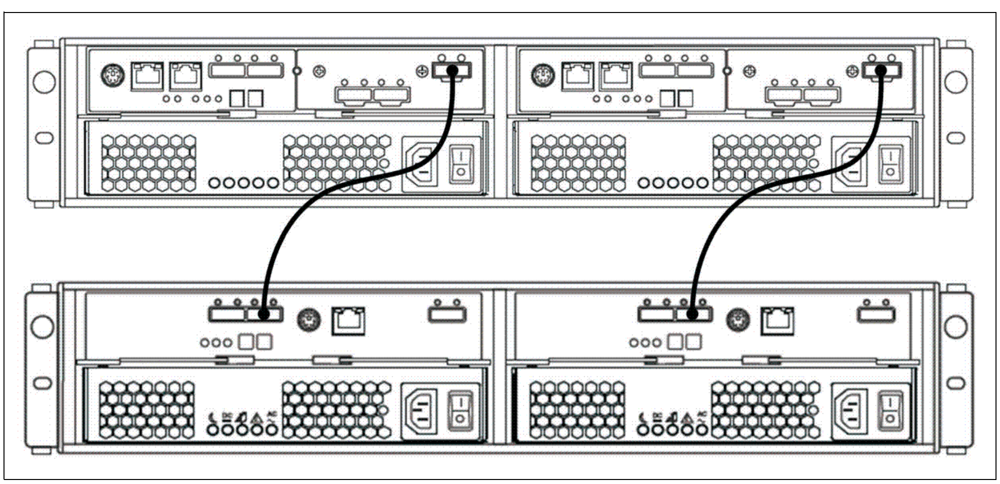


Figure 2-12 Dual controller DS3500 connected to one dual ESM EXP3500

2.4 IBM System Storage model DS3400

Model DS3400 fits the SMB market very well. You can start with a simple direct-attached FC solution, and as your storage demands grow, seamlessly transition to an FC SAN.

Growth will often lead you to a Fiber Channel SAN solution. The DS3400 is scalable, extremely fast, very reliable, congestion free, and fit for long distances. It is one of the world's best price-performance entry FC storage servers. It can support your remote sites, offices, and departments, while you can be self-sufficient due to its simple administration. The advantages of shared-storage are high; enablement of consolidation (storage and server), increased efficiencies within the infrastructure, and centralized single management.

The dual controller DS3400 storage subsystem (Model 1726-42x) contains the following components (Figure 2-13):

- A 2U rack-mountable enclosure with 12 easily accessible drive bays
- Two 4 Gbps FC host ports per controller
- Support for dual-ported and hot-swappable SAS (15k rpm) and SATA (7.2k rpm) disks
- Scalability of up to 7.2 TB of storage capacity with 600 GB hot-swappable SAS disks or 24.0 TB with SATA disks in the first enclosure
- Expands up to 96 TB physical storage capacity with attachment of three EXP3000 expansion units
- RAID 0, 1, 3, 5, 6 and 10 support
- Minimum 512 MB RAID cache memory
- Maximum 2 GB system memory, with battery backup
- Built-in reliability features with dual-redundant power-supplies standard

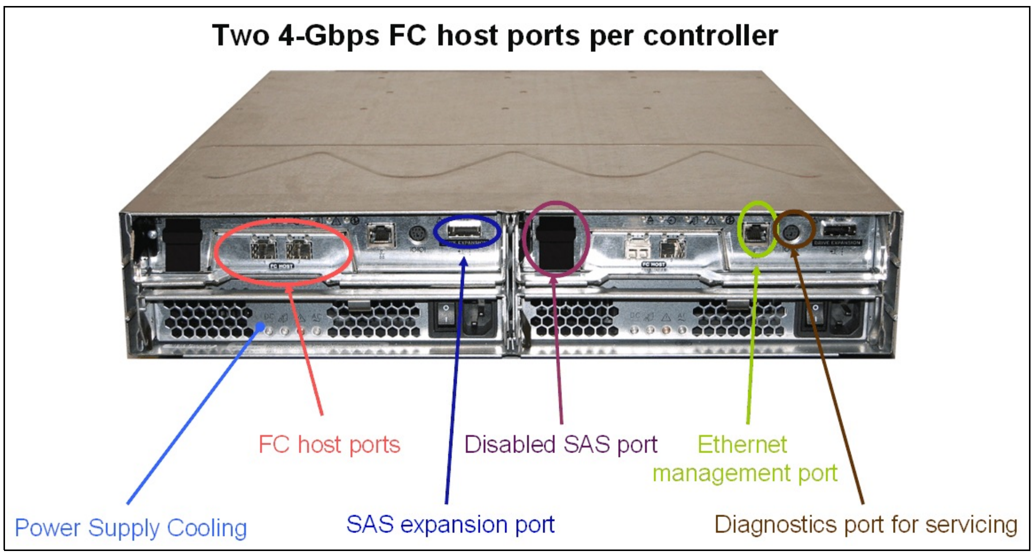


Figure 2-13 DS3400 storage subsystem model 1726-42x rear view

Specifications: Table 2-3 lists the DS3400 specifications.

Table 2-3 IBM System Storage DS3400 specifications

Component	Description
Model	1726-42X - dual controller 1726-42T - dual controller Telco
RAID controller	Dual active
Cache	512 MB battery-backed cache with 1 GB upgrade option
Host interface	Two host ports per controller, Fibre Channel (FC) 4 Gbps auto-sensing 1 Gbps/2 Gbps
Drive interface	Serial Attached SCSI (SAS)
Supported drives	Supports 6 Gbps SAS: 300 GB, 450 GB, 600 GB SAS drives at 15,000 rpm speeds 3 Gbps SATA: 1.0 TB, 2.0 TB SATA drives at 7,200 rpm speeds
RAID	RAID 0, 1, 3, 5, 6, 10
Storage partitions	4, 8, 16, 32
Maximum drives supported	48 SAS or SATA drives (using three EXP3000 Expansion Units)
Fans and power supplies	Dual redundant, hot-swappable
Rack support	19-inch, industry-standard rack

For the latest specification information, including the DS3400 Interoperability Matrix, see the website:

http://www.ibm.com/systems/storage/disk/ds3000/ds3400

2.5 IBM System Storage EXP3000

The EXP3000 is a 2U rack-mountable SAS disk drive enclosure. It supports up to 12 SAS or SATA 3.5-inch disk drives. If you use 2 TB SATA disk drives, the maximum storage capacity in a single EXP3000 will be 24 TB. You can attach up to three EXP3000 enclosures to a DS3400 storage subsystem, and this gives you a maximum storage capacity of 96 TB. Additionally, the 50 GB SATA Solid State Disk drives are supported in EXP3000 expansion units that are directly attached to System x servers by the ServeRAID MR10M SAS/SATA controller adapter installed in the System x server.

The EXP3000 enclosures connect to the drive side SAS port of the DS3400 through a 3 Gbps SAS interface. The main components of an EXP3000 are one or two Environmental Services Modules (ESMs), two power supply modules, and up to 12 SAS disk drives. ESMs and power supply modules are in the rear of the enclosure (as shown in Figure 2-14), whereas the SAS drives are installed in the front.

The EXP3000 comes with one ESM in the standard configuration, and another ESM can optionally be installed. Both ESMs must be installed in order to connect the EXP3400 to a dual controller DS3000 storage subsystem.

Each EXP3000 is also equipped with two hot-swappable and redundant power supply modules. Each power supply module contains two fans for cooling redundancy. If a power supply or a fan fails, you can replace it while the EXP3000 remains fully operational.

Figure 2-14 EXP3000 storage subsystem rear view

Specifications: Table 2-4 lists the EXP3000 specifications.

Table 2-4 IBM System Storage EXP3000 specifications

Component	Description
Model	1727-01X - IBM System Storage EXP3000 1727-02T - IBM System Storage EXP3000 with DC power supplies
Environmental Services Module	Single ESM with dual ESM upgrade SAS interface: Mini-SAS connectors
Drives supported	3 Gbps SAS: 146 GB, 300 GB, and 450 GB SAS drives at 15,000 rpm speeds 6 Gbps SAS: 300 GB, 450 GB, 600 GB SAS drives at 15,000 rpm speeds 3 Gbps SATA: 500 GB, 750 GB, 1.0 TB, 2.0 TB SATA drives at 7,200 rpm speeds Solid State Disk: 50 GB SATA (System x direct attach only by the ServeRAID MR10M SAS/SATA controller adapter)
Fans and power supplies	Two hot-swappable 515 watt (115 – 230 V AC) power supplies
Rack support	19-inch, industry-standard rack

For the latest specification information, including the EXP3000 dimensions, see the website:

http://www-03.ibm.com/systems/storage/disk/exp3000/index.html

2.6 IBM DS Storage Manager

The IBM DS Storage Manager provides a powerful, yet easy-to-use and intuitive graphical user interface (GUI) for DS3500 administrative activities, including configuration, reconfiguration, expansion, and routine maintenance, as well as performance tuning and management of advanced functions, such as data replication and Full Disk Encryption (FDE) keys.

The DS Storage Manager extends the robustness and functionality of storage management previously only available on the DS4000 and DS5000 products to the DS3500, while maintaining the ease-of-use and intuitive nature of the DS3000 Storage Manager. It provides a complete physical view of your DS3500, but with expertise built into the interface and automated policy decisions, you no longer have to contend with low-level activities. With DS Storage Manager, dynamic and other high functionality capabilities are now available for the DS3500 through the GUI functions available only through the Command Line Interface (CLI).

Along with your storage subsystem, you might get DS Storage Manager Software and Host Kit CDs; otherwise, you can download it from the IBM support website. Using DS Storage Manager software, you can perform tasks such as creating arrays and logical drives, assigning logical drives to the host servers, setting up premium features, capturing logs for troubleshooting, and so on.

2.6.1 Host server and management station

When discussing the DS Storage Manager, it is important to differentiate between the two terms, *host server* and *management station*.

Host server

The *host server* is a server attached to the DS3500 storage subsystem through the I/O path (SAS, iSCSI, or Fibre Channel). The host server has access to certain logical drives defined on the DS3500.

Management station

The *management station* is a system used for DS3500 management. The DS Storage Manager GUI runs on the management station. This management station can be based on Windows, Linux, AIX, or HP-UX operating systems. There might be slight screen shading differences between the different operating system version of the displays, but the fit and functions are the same for all. You need to establish a management connection between the management station and the DS3500 storage subsystem, which can be done in two ways:

- Out-of-band: With this method, also called *direct-attached management*, the management station is connected to the Ethernet management port in each DS3500 RAID controller. The management station in this case only requires an Ethernet connection to the DS3500.
- In-band: This method, also called *host-attached management,* utilizes the I/O path between a host server and the DS3500. In this case, the management station does not have a direct TCP/IP connection to the DS3500, but rather communicates with the DS3500 through an HBA, which acts as a gateway to the DS3500 storage subsystem.

Figure 2-15 shows the "look and feel" of the Storage Manager.

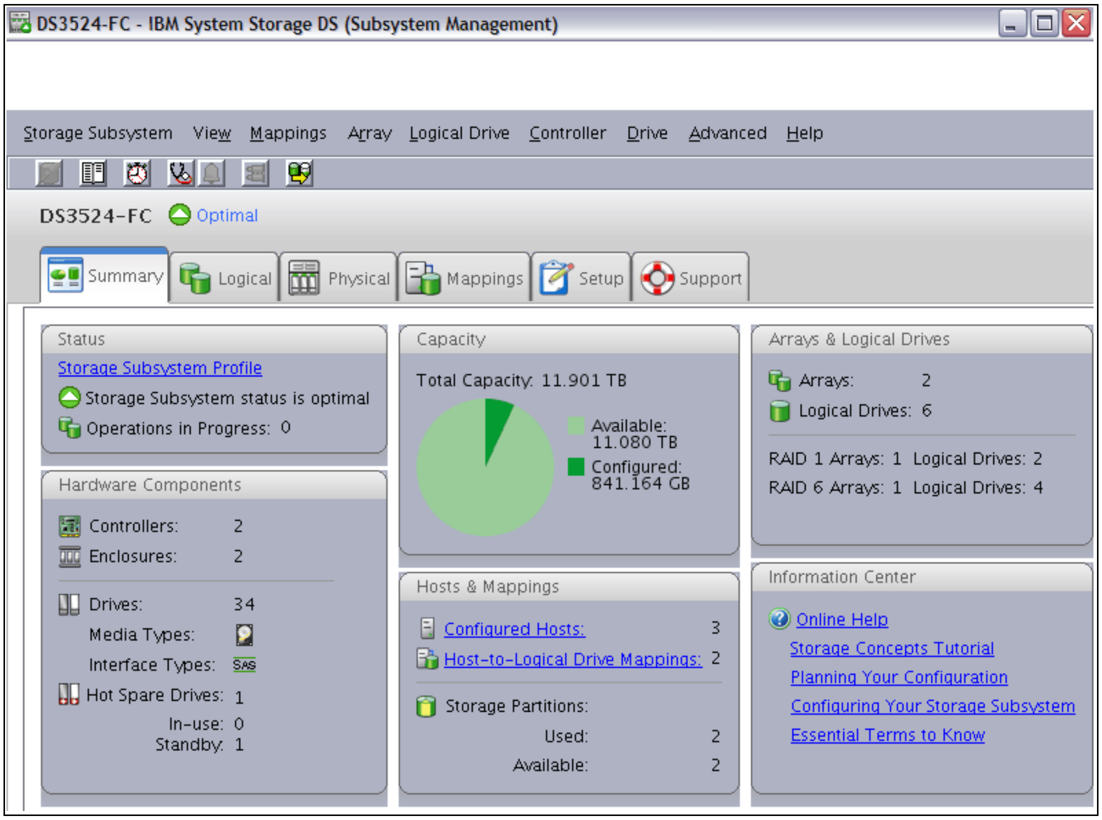


Figure 2-15 Storage Manager GUI

2.6.2 Premium features

In this section we describe the supported DS3500 premium features. For detailed information about Copy Services premium features, see *IBM System Storage DS Storage Manager Copy Services Guide*, SG24-7822.

Partition Expansion Licenses

As part of the standard configuration, four storage partitions are enabled on the DS3500 with Windows and Linux on Intel host attach license. The maximum number of storage partitions on the DS3500 is 64. Use the Partition Expansion Licenses to enable more storage partitions as needed.

FlashCopy Expansion Licenses

This feature enables FlashCopy, which is a point-in-time copy of a source logical drive. The FlashCopy logical drive becomes available almost instantaneously. FlashCopy requires the use of a defined FlashCopy *repository*, which contains the original content of the data that has since been altered. FlashCopy logical drives are often used as a source for a backup operation. They can also be used to simply and quickly roll back to an original data state, thus providing a restore point. However, if the source logical drive is lost, point-in-time FlashCopy will be lost as well. As part of the standard configuration, two FlashCopies are enabled on every DS3500 storage subsystem and this premium feature enables up to 64 FlashCopies. A maximum of eight FlashCopies can be created on a single logical drive.

VolumeCopy Licenses

VolumeCopy is a way to provide a complete point-in-time copy of a source logical drive. As opposed to FlashCopy (where only the original values of changed data are copied to the repository), the whole source logical drive is copied to target. You can use this functionality for data replication, relocation, backup, or to restore snapshot data to the original logical drive.

The time required to establish a copy will depend on the size of the source data and the operation priority settings. While establishing the copy, the source logical drive will be in read-only state. After all the data is copied to the target, the target will remain available if the source logical drive is lost. The VolumeCopy premium feature allows for up to 128 VolumeCopies. Be aware that FlashCopy is a prerequisite for VolumeCopy.

Enhanced Remote Mirroring

The Enhanced Remote Mirroring (ERM) option is used for online, real-time replication of data between storage subsystems over a remote distance. ERM mirrors by creating a full logical drive image on a secondary of the logical drive that is being mirrored from the primary. The DS3500 can have up to eight mirrored pair relationships and works on Fibre Channel only. The DS3500 can mirror to another DS3500 or another member of the IBM Midrange DS Storage System family running 7.70.xx code or higher.

Support: Enhanced Remote Mirroring is not supported on previous DS3000 models.

Operating modes for ERM

Enhanced Remote Mirroring (formerly named “Remote Volume Mirroring”) offers three operating modes:

- Metro mirroring:

  Metro mirroring is a synchronous mirroring mode. Any host write requests are written to the primary (local) storage subsystem and then to the secondary (remote) storage subsystem. The remote storage controller acknowledges the write request operation to the local storage controller, which reports a write completion to the host. This mode is called synchronous. The host application does not get the write request result until the write request has been executed on both (local and remote) storage controllers.

- Global copy:

  This mode copies a non-synchronous, remote copy function designed to complete write operations on the primary storage system before they are received by the secondary storage system. This capability is designed to prevent primary performance from being affected by wait time from writes on the secondary system. Therefore, the primary and secondary copies can be separated by long distances. This function is appropriate for remote data migration, offsite backups, and transmission of inactive database logs at virtually unlimited distances.

- Global mirroring:

  This mode is a two-site remote data mirroring function designed to maintain a complete and consistent remote mirror of data asynchronously at virtually unlimited distances with virtually no degradation of application response time. Separating data centers by longer distances helps provide protection from regional outages. This asynchronous technique can help achieve better performance for unlimited distances by allowing the secondary site to trail in data currency a few seconds behind the primary site. With Global Mirror, currency can be configured to be as little as three to five seconds with respect to host I/O. This two-site data mirroring function is designed to provide a high-performance, cost-effective global distance data replication and disaster recovery solution.

A minimum of two storage subsystems is required. One storage subsystem can have primary volumes being mirrored to arrays on other storage subsystems and hold secondary volumes from other storage subsystems. Also note that because replication is managed on a per-logical drive basis, you can mirror multiple individual logical drives from a primary storage subsystem to different appropriate secondary logical drives which are located on several separate remote storage subsystems. However, only one primary (source) and one secondary (target) member can exist in any mirrored pair relationship; and a logical drive cannot be a member of more than one mirror relationship at a time.

ERM: If a DS3500 is using ERM, controller host port 4 on both A and B controllers are dedicated to replication. This is required at both the source and target ends of the ERM solution. Additionally, Fibre Channel switches are required for the connection between storages.

2.7 IBM System Storage EXP2500

The IBM System Storage EXP2500 Express storage enclosures (Figure 2-16) enable flexible, low-cost storage capacity expansion of IBM System x servers to address growing storage needs. It is available in two models, EXP2512 (1747-12X) and EXP2524 (1747-24X).

Figure 2-16 IBM System Storage EXP2512 Express storage enclosure front view

The EXP2512 Express has twelve 3.5-inch SAS drive bays, and the EXP2524 Express has twenty-four 2.5-inch (small form factor) SAS drive bays. Both models support dual-port, 6 Gbps SAS high-performance and high-capacity nearline drives. Disk drives of the same form factor can be intermixed within the appropriate enclosure, and EXP2512 and EXP2524 enclosures can be intermixed in a daisy-chain configuration. RAID technology and other advanced functions are provided through the ServeRAID M5025 controller.

The EXP2500 has the following main features:

- 12 (3.5-inch) or 24 (2.5-inch) SAS drive bays in a compact 2U, 19-inch rack mount enclosure
- Dual port, hot-swappable 6 Gbps SAS high-performance and high-capacity nearline disk drive options
- Enterprise-grade RAID technology and other advanced functions provided by IBM ServeRAID M5025 SAS/SATA Controller
- Daisy-chain connection of multiple EXP2500 enclosures from a single ServeRAID M5025 controller port

Specifications: Table 2-5 lists the EXP2500 specifications.

Table 2-5 IBM System Storage EXP2500 specifications

Component	Description
Model	1747-HC1 (PN 174712X) - EXP2512 Express Storage Enclosure 1747-HC2 (PN 174724X) - EXP2524 Express Storage Enclosure
RAID controller	This expansion unit connects directly to selected System x servers using the IBM ServeRAID M5025 SAS/SATA Controller
Supported drives	EXP2512: 300 GB 15,000 rpm 6 Gb SAS 3.5" HDD 450 GB 15,000 rpm 6 Gb SAS 3.5" HDD 600 GB 15,000 rpm 6 Gb SAS 3.5" HDD 1 TB 7,200 rpm 6 Gb SAS NL 3.5" HDD 2 TB 7,200 rpm 6 Gb SAS NL 3.5" HDD EXP2524: 146 GB 15,000 rpm 6 Gb SAS 2.5" HDD 300 GB 10,000 rpm 6 Gb SAS 2.5" HDD 600 GB 10,000 rpm 6 Gb SAS 2.5" HDD 500 GB 7,200 rpm 6 Gb SAS NL 2.5" HDD
Fans and power supplies	Two hot-swappable 515 watt (115 - 230 V ac) power supplies
Rack support	19-inch, industry-standard rack, 2U

Each EXP3500 has two upstream and one downstream 6 Gbps SAS ports, as well as one 10/100 Mbps Ethernet enclosure management port.

Cables are required if the EXP2500 will be managed “out of band” using the 1 Gb Ethernet management port.

EXP2500 and EXP3000:

- EXP2500 and EXP3000 Expansion Unit enclosures cannot be intermixed in a daisy-chain connection to a single RAID controller port.
- EXP2500 is not supported for attachment to IBM System Storage DS3000 Storage Controllers or IBM System Storage DS3500 Express Storage Systems.

For the latest specification information, including the EXP2500 dimensions, see the website:

http://www.ibm.com/systems/storage/disk/exp2500

2.8 More information

For more information about the IBM System Storage entry-level disk systems, see the following Redbooks publications and websites:

- *IBM System Storage DS3000: Introduction and Implementation Guide*, SG24-7065
- *IBM System Storage DS3500: Introduction and Implementation Guide*, SG24-7914
- Product information for entry-level disk systems:

  http://www.ibm.com/systems/storage/disk/entry
- IBM/LSI Internet site for IBM employees and Business Partners (after subscription):

  http://www.ibmdsseries.com

3

Midrange disk systems

The introduction of the IBM Model DS5000 series offers a replacement path for the very successful range of DS4000 series systems. Whereas the midrange entry model DS5020 is the natural replacement for the model DS4700, the midrange model DS5100 is the natural replacement for the model DS4800.

In this chapter, we focus on the DS5000 models, also including the DS4000 series models for comparison when choosing an appropriate upgrade path.

The previous-generation DS4000 series systems are RAID controller devices that contain Fibre Channel (FC) interfaces to connect the host systems and the disk drive enclosures. All DS4000 series systems have dual, hot swappable RAID controllers, thereby providing excellent system availability even if one of the parts malfunctions. Furthermore, hot-swap and redundant power supplies and fans can also help with the availability.

The DS5000 series are dual RAID controller devices that support intermixing Fibre Channel and iSCSI interfaces to the host systems and FC interfaces to the disk drive enclosures. They deliver a tremendous balanced performance for IOPS and MB/s application behavior, while having all the availability features to keep your data safe and reachable.

The IBM System Storage model DCS9900 is designed for applications with high-performance streaming data requirements served by deep computing servers, high performing computers, and clustered systems. With its parallel storage solution architecture, the DCS9900 is especially designed to address such needs.

The IBM Storwize V7000 is a powerful midrange disk system that has been designed to be easy to use and enable rapid deployment without additional resources. Storwize V7000 offers IBM storage virtualization, SSD optimization and “thin provisioning” technologies built in to improve storage utilization and to enable the system to be reconfigured to meet changing needs quickly and easily. Storwize V7000 advanced functions also enable non-disruptive migration of data from existing storage, simplifying implementation and minimizing disruption to users. IBM Storwize V7000 also allows you to virtualize and reuse existing disk systems.

IBM offers the IBM System Storage DS3950 Express. As part of the DS series, the DS3950 Express offers high-performance 8 GBps capable FC connections, optional 1 GBps iSCSI interface for less demanding applications and lower cost implementation, up to 67.2 TB of FC physical storage capacity, 224 TB of SATA physical storage capacity, and powerful system management, data management, and data protection features. The DS3950 Express is designed to expand from workgroup to enterprise-wide capability with up to six FC expansion units with the EXP395 Expansion Unit.

In this chapter, we present the features and major characteristics of the various models that make up the current IBM Storwize V7000 and DS Midrange disk systems family, as known at the time of writing:

- IBM Storwize V7000
- IBM System Storage DS3950 Express
- IBM System Storage model DS5020 Express
- IBM System Storage model DS5100
- IBM System Storage model DS5300
- IBM System Storage model DCS9900
- IBM System Storage DS4000 EXP810 Expansion Unit
- IBM System Storage DS5020 EXP520 Expansion Unit
- IBM System Storage DS5100 and DS5300 EXP5000 Expansion Unit
- IBM System Storage EXP5060 High Density Drawer
- IBM TotalStorage EXP24

Technical descriptions and specifications are given for each model in the corresponding sections.

We also briefly discuss the IBM System Storage DS Storage Manager software that is used to manage the DS family series systems, and we give highlights of Full Disk Encryption and Solid State Disk. Then we close this chapter with a description of the Remote Support Manager product.

3.1 Overview of IBM Storwize V7000

IBM Storwize V7000 incorporates some of the IBM top technologies typically found only in enterprise-class storage systems, raising the standard for storage efficiency in midrange disk systems. This cutting-edge storage system extends the comprehensive storage portfolio from IBM and can help change the way organizations address the ongoing information explosion.

3.1.1 IBM Storwize V7000 highlights

Here we list highlights of the IBM Storwize V7000:

- Sophisticated enterprise-class storage function that is easy to use for midsized businesses
- Integrated IBM System Storage Easy Tier function provides up to 300 percent performance improvement with automatic migration to high-performing solid state drives (SSD)
- Thin provisioning allows you to purchase only the disk capacity you need
- Dynamic migration provides continuous availability of applications while migrating critical data
- Faster and more efficient data copies for online backup, testing or data mining with IBM FlashCopy
- IBM Systems Director provides flexible server and storage management capabilities
- Easy-to-use data management designed with a graphical user interface and point-and-click system management capabilities Metro Mirror and Global Mirror for replicating data synchronously or asynchronously between systems for backup efficiency Solid state drive (SSD) for applications that demand high speed and quick access to data RAID 0, 1, 5, 6 and 10

IBM Storwize V7000 provides unmatched performance, availability, advanced functions, and highly scalable capacity never seen before in midrange disk systems. IBM Storwize V7000 is a powerful midrange disk system that has been designed to be easy to use and enable rapid deployment without additional resources. Storwize V7000 offers IBM storage Virtualization, SSD optimization and “thin provisioning” technologies built in to improve storage utilization and to enable the system to be reconfigured to meet changing needs quickly and easily. Storwize V7000 advanced functions also enable non-disruptive migration of data from existing storage, simplifying implementation and minimizing disruption to users.

3.1.2 IBM Storwize V7000 product features

The IBM Storwize V7000 offers the following features:

- Automatic migration of frequently accessed data to high performing solid state disks (SSD)
- Provisioning support for business applications that need to grow dynamically but consume only the storage space they are actually using
- Migration capabilities that provide efficiency and business value in a non-disruptive migration
- Support for near instant data copies for backup or application testing
- Integrated instant copy capabilities for critical business needs
- Integrated tools and capabilities for server and storage management

3.1.3 IBM Storwize V7000 hardware summary

The IBM Storwize V7000 consists of the following hardware:

- 2U rack-mountable chassis
- Twenty four 2.5" drive bays (Model 124) or twelve 3.5" drive bays (Model 112)
- Up to 24 TB of physical storage using 2 TB near-line SAS disk drive modules on the 2076-112 model, or up to 14 TB physical storage using 600 GB SAS disk drive modules
- SAS disk drives, near-line SAS disk drives and SSDs
- Redundant dual-active intelligent RAID controllers
- 16 GB cache memory (8 GB per internal RAID controller) as a base feature
- Eight 8 Gbps FC host ports (four 8 Gbps Fibre Channel ports per RAID controller) and four 1 Gbps iSCSI host ports (two 1 Gbps iSCSI host ports per RAID controller), with an RJ-45 connector for each port
- RAID controller supports attachment of up to nine storage expansion units with configurations up to 240 TB physical storage capacities
- Dual power supplies and cooling components

See Chapter 17, “IBM Storwize V7000” on page 521 for detailed information about the IBM Storwize V7000.

3.2 Overview of IBM System Storage DS Models

In this section we present an overview of the current IBM System Storage DS Models.

3.2.1 IBM System Storage DS3950

Optimized data management requires storage solutions with high data availability, strong storage management capabilities, and powerful performance features. IBM offers the IBM System Storage DS3950 Express, designed to provide lower total cost of ownership, high performance, robust functionality, and unparalleled ease of use. As part of the IBM DS series, the DS3950 Express offers the following capabilities:

- High-performance 8 Gbps capable Fibre Channel connections.
- Model 98H offers 1 Gbps iSCSI interface.
- Up to 224 TB of physical storage capacity with 112 2 TB SATA disk drives.
- Powerful system management, data management, and data protection features.

3.2.2 IBM System Storage DS5000

IBM System Storage and System Storage DS5000 series are disk storage products using redundant array of independent disks (RAID) that contain 4 or 8Gbps Fibre Channel (FC) and 1 Gbps Internet SCSI (iSCSI) interface to connect to the host systems, thus enabling host tiering, and 4 Gbps FC to the disk drive enclosures. The DS5000 series of disk storage systems are an IBM solution for low to high-range departmental (and even low Enterprise) storage requirements.

The DS5000 series is equally adept at supporting transactional applications such as databases and OLTP, throughput-intensive applications such as HPC and rich media, and concurrent workloads for consolidation and virtualization. With its relentless performance and superior reliability and availability, the DS5000 series storage system can support the most demanding service level agreements (SLAs) for the most common operating systems, including Microsoft Windows, UNIX, and Linux. And when requirements change, you can add or replace host interfaces, grow capacity, add cache, and reconfigure the system on the fly, thus ensuring that it will keep pace with your growing company.

The IBM System Storage DS5000 series family consists of the following products:

- IBM System Storage DS5020 Express:

  The DS5020 Express offers high-performance 8 Gbps capable Fibre Channel connections, optional 1 Gbps iSCSI interface for less demanding applications and lower cost implementation, up to 67.2 TB of Fibre Channel physical storage capacity, 224 TB of SATA physical storage capacity, and powerful system management, data management and data protection features. The DS5020 Express is designed to expand from workgroup to enterprise-wide capability with up to six Fibre Channel expansion units with the EXP520 Expansion Unit.

- IBM System Storage DS5100 and DS5300:

  The IBM System Storage model DS5100 and DS5300 offer high performance 4 Gbps and 8 Gbps Fibre Channel and 1Gbps iSCSI connections to the Host and 4 Gbps FC drive interfaces to the EXP5000 and EXP810 (for migration purposes only) expansion units. Both can support up to 448 disk drives by 6 EXP5000 Expansion Drawers offering 268 TB FC or 448 TB SATA of physical storage capacity. Furthermore, they can support up to 8 EXP5060 High Density Drawers, which offers 480 TB of physical storage.

The DS5000 series is equally adept at supporting transactional applications such as databases and OLTP, throughput-intensive applications such as HPC and rich media, and concurrent workloads for consolidation and virtualization. With its relentless performance and superior reliability and availability, the DS5000 series storage system can support the most demanding service level agreements (SLAs) for the most common operating systems, including Microsoft Windows, UNIX, and Linux. And when requirements change, you can add or replace host interfaces, grow capacity, add cache, and reconfigure the system on the fly, thus ensuring that it will keep pace with your growing company.

The DS5100 can have the same performance as the DS5300 using the option of an enhanced performance key, so technically there is no difference. The difference is within the price setting. The DS5100 starts at a much lower price than the DS5300, but after full transition to a DS5300, it results in just a slightly higher price than an original DS5300. For the purposes of this chapter, we regard the DS5100 and the DS5300 as one.

3.3 IBM System Storage DS3950 Express

The new DS3950 storage subsystem is a version of the DS5020 storage subsystem, which is offered in the European and some Asian Pacific geographies. This subsystem has most of the same capabilities as the DS5020 with the major difference being the number of available host Fiber Channel attachments it can have. IBM offers the IBM System Storage DS3950 Express. As part of the DS series, the DS3950 Express offers high-performance 8 GBps capable FC connections, optional 1 GBps iSCSI interface for less demanding applications and lower cost implementation, up to 67.2TB of FC physical storage capacity, 224 TB of SATA physical storage capacity and powerful system management, data management, and data protection features. The DS3950 Express is designed to expand from workgroup to enterprise-wide capability with up to six FC expansion units with the EXP395 Expansion Unit.

3.3.1 IBM System Storage DS3950 highlights

- Next-generation 8 GBps FC interfaces that enable infrastructure simplification
- Mixed host interfaces support (FC/iSCSI), enabling Storage Area Network (SAN) tiering
- Balanced performance, well-suited for virtualization/consolidation
- Reduced cost of consolidation
- Support for intermixing FC/SATA drives, enabling cost effective tiered storage
- Trusted storage that protects and delivers your data when needed
- Flexibility to address wide range of storage needs
- Feature-rich management software that maximizes utilization and minimizes storage TCO
- Key application certifications to ensure confidence
- Central management of the DS series with the IBM System Storage DS Storage Manager
- Support of up to 112 disk drive modules with attachment of six EXP395 expansion units

3.3.2 IBM System Storage DS Series common features

- Dynamic Capacity Expansion (DCE)
- System Storage DS Storage Manager Software
- IBM FlashCopy to take point-in-time copies of logical volumes
- Dynamic Volume Expansion
- VolumeCopy feature designed to provide full replication of one logical volume to another
- Enhanced Remote Mirror to multi-Logical Unit Number (LUN) applications
- Hot-spare disk drives

3.3.3 IBM System Storage DS3950 Express Hardware summary

The IBM System Storage DS3950 Express consists of the following hardware components.

- Up to 4 GB cache battery-backed
- Up to eight host ports, four drive ports FC Switched and FC Arbitrated Loop (FC-AL) standard, Auto-sensing 2 GBps / 4 GBps, optional 1 GBps iSCSI interface
- Support for 4 GBps FC: 15k – 600 GB, 450 GB, 300 GB, E-DDM
- Support for 3 GBps SATA: 7.2K, 1 TB and 2 TB GB E-DDM
- Redundant Array of Independent Disk (RAID) level 0, 1, 3, 5, 6 and 10 support
- Up to 128 storage partitions
- 112 FC drives (using 6 EXP395 Expansion Units)
- Dual redundant, hot-swappable cooling fans
- 19-inch, industry-standard rack

The hot-swap features of the DS3950 enable you to remove and replace the hard disk drives without turning off the storage expansion enclosure. You can maintain the availability of your system while a hot-swap device is removed, installed, or replaced.

The DS3950 Express supports up to 16 disk drive modules (DDMs). Each drive bay also provides dual paths to each drive for path redundancy. The drives are customer replacement units (CRUs).

Several LED indicators and the FC Link speed selector are also visible from the front of the storage unit. For detailed description of all the LEDs and their usage, see the DS5020 section of the *IBM Midrange System Storage Hardware Guide*, SG24-7676.

Figure 3-1 shows a front view of the IBM System Storage DS3950 Express.

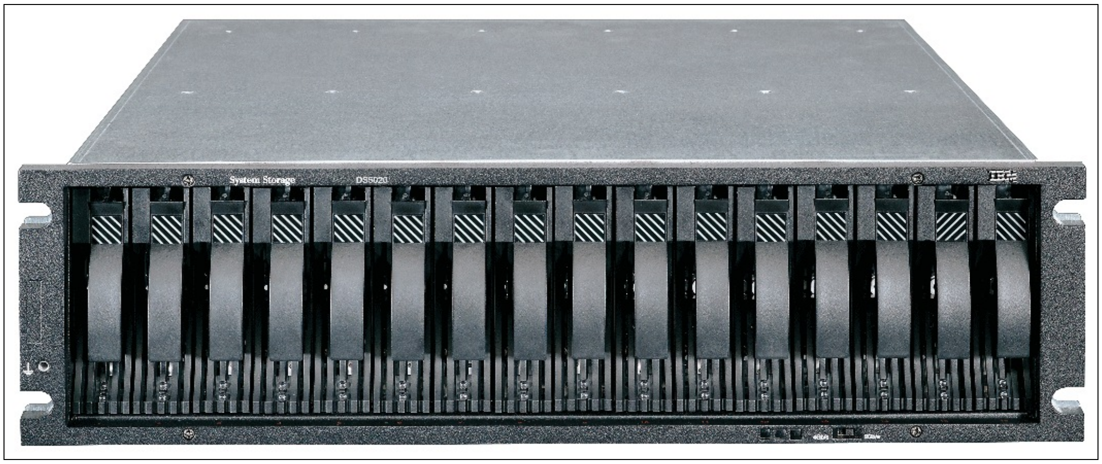


Figure 3-1 IBM System Storage DS3950 front view

> **Attention:** Never hot-swap an E-DDM CRU when its associated green activity LED is flashing. Hot-swap a drive CRU only when its associated amber fault LED light is not flashing or when the drive is inactive and its associated green activity LED light is not flashing. Wait 70 seconds before inserting the drive back into the bay.

The rear of the DS3950 can be ordered in two different versions, depending on what host port configuration is needed for the solution (see Figure 3-2 and Figure 3-3).

Figure 3-2 shows a rear view of the IBM System Storage DS3950.

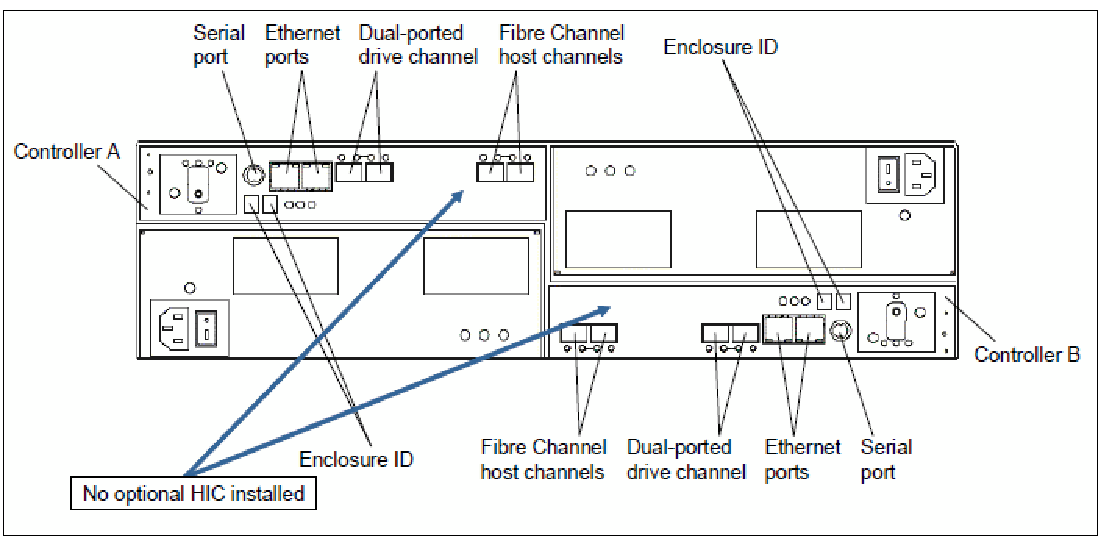


Figure 3-2 IBM System Storage DS950 rear view of base model

The base model does not have the optional Host Interface Cards (HICs). It comes with four 8 Gbps Fibre Channel host ports.

The optional configuration of the DS3950 has an additional four 1 Gbps iSCSI host ports added to the controllers with the optional FC HIC installed (Figure 3-3).

Figure 3-3 shows a rear view of the IBM System Storage DS3950 with the optional FC HIC installed.

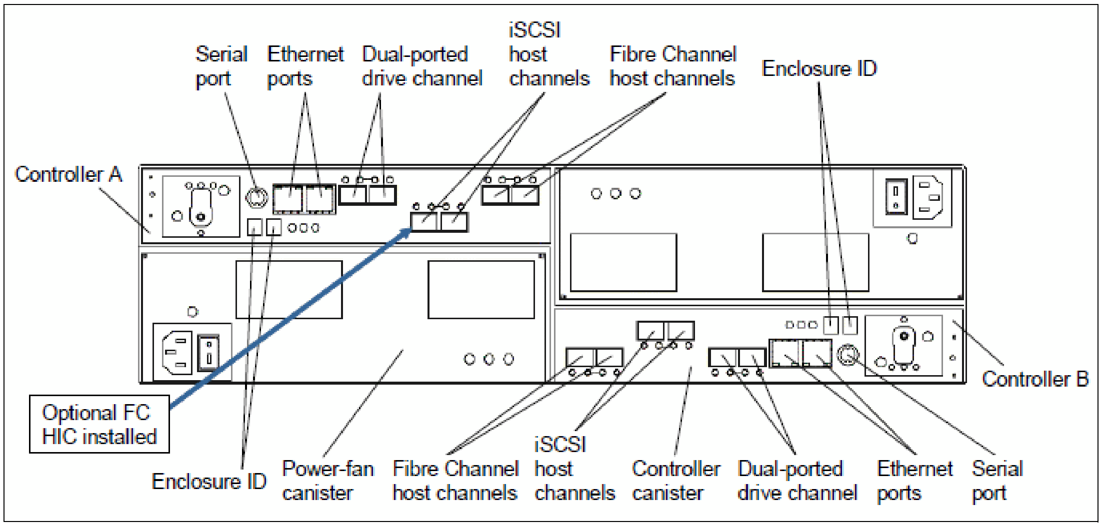


Figure 3-3 IBM System Storage DS950 with optional FC HIC installed

The DS3950 rear view shows four hot swappable parts:

- The two controllers with the Backup Battery Unit (BBU)
- The two Power Supply and Fan Units

The two controllers hold host and drive interfaces as well as the batteries. The left controller is controller A and the right controller is controller B. Note that controller A is upside-down relative to controller B. The same configuration applies to the power supply and fan unit. It is important to keep this information in mind when connecting the back-end ports to hosts and drive-side expansion enclosures.

The IBM System Storage DS3950 Express manages data more effectively with IBM System Storage DS3950 Express. Optimized data management requires storage solutions with high data availability, strong storage management capabilities and powerful performance features. IBM offers the IBM System Storage DS3950 Express, designed to provide lower TCO, high performance, robust functionality, and extreme ease of use. As part of the IBM DS series, the DS3950 Express offers the following capabilities:

- High-performance 8 GBps capable FC connections
- Model 98H offers 1 GBps iSCSI interface
- Up to 224 TB of physical storage capacity with 112 2 TB SATA disk drives
- Powerful system management, data management, and data protection features

Table 3-1 shows the IBM System Storage DS3950 features and benefits.

Table 3-1 DS3950 features and benefits

Features	Benefits
Host interface intermix	Support for intermixing FC and iSCSI interfaces allows for cost-effective SAN tiering.
Balanced performance	► Balanced performance. Equally adept at input/output operations per second (IOPS) and MegaBytes per second MBps, the DS3950 is able to support applications with wide-ranging performance requirements. ► Well suited for data warehousing, consolidation, and virtualization environments that have diverse workloads and application requirements. ► Designed to concurrently support transactional-applications, such as databases and OnLine Transaction Processing (OLTP) and throughput-intensive applications, such as high performance computing (HPC) and rich media.
Up to 112 intermixed drives	Ability to intermix FC and SATA disk drives enables tiered storage. FC disk is allocated to applications that demand high performance and have high I/O rates and less-expensive SATA disks are allocated to applications that require less performance. Enclosure-based intermixing maximizes efficiency.
Built-in efficiencies	► Modular design avoids over-configuration for an affordable entry-point while offering seamless “pay-as-you-grow” scalability as requirements change. ► Efficient utilization lowers raw capacity requirement, and support for intermixing high performance and high capacity drives enables tiered storage ► Exceptional per drive performance creates performance value by getting the most performance out of the fewest drives.
DS Storage Manager software	► Feature-rich storage management software enables maximum utilization and uninterrupted data availability. ► Configuration flexibility supports custom LUN tuning to ensure maximum performance or utilization. ► Centralized management of all local and networked based systems. ► Quickly configure and monitor storage from a centralized interface. ► Configure volumes, perform routine maintenance, and add new enclosures and capacity without interrupting access to data.
Dynamic Expansion capabilities	► Designed to offer ability to bring unused storage online for a new host group or an existing volume to provide additional capacity on demand (CoD). ► Designed to eliminate application interruptions due to growth, reconfigurations, or tuning.
Up to 128 partitions	Enough partitions to effectively support medium scale consolidation or virtualization environments; thus helping to reduce hardware and storage management costs
Fully-integrated replication features	► Multiple options allows administrators to best fit their replication needs ► Local or remote copies can be used for file restoration, backups, application testing, data mining or disaster recovery (DR)
Support for heterogeneous, open operating systems	Supports Microsoft Windows, UNIX, and Linux systems. Designed to enable the storage system to operate in any and all open system environments.
Custom XOR engine for RAID parity calculations	Efficiently handles compute-intensive parity calculations enabling exceptional disk-based performance that is ideally-suited for RAID 5 and RAID 6 configurations.

Features	Benefits
Support for multiple RAID levels; including RAID 6	► Designed to support high availability and security for mission-critical data. ► Designed to offer flexibility to configure the system to address varying service levels.
Redundant, hot-swappable components	Designed to maintain data availability by allowing components to be replaced without stopping I/O.
Persistent cache backup	Ensures that any data in cache is captured and safe in the event of a power outage.
Up to four 8 GBps FC host ports	► Designed to deliver high bandwidth for the most demanding applications. ► Designed to provide up to 3200 MBps cache burst rate for high throughput applications through the four channels.
Backward compatibility with 2 GBps and 4 GBps devices	► Plan for the future while leveraging current investments. ► Auto-negotiate connection speed to ease configuration in mixed environments.
Up to 112 FC drives	Upgrade from a workgroup SAN to an enterprise network storage system with a single DS3950 Express.
DCE Add EXP395 enclosures to an existing DS3950	► Express without stopping operations. ► Bring unused storage online for a new host group or an existing volume to provide additional capacity on demand.
Dynamic Volume Expansion	Expand logical volumes without disrupting operations.

For the latest specification information and Interoperability Matrix, see the website:

http://www-03.ibm.com/systems/hk/storage/disk/ds3950/index.html

3.4 IBM System Storage model DS5020

The DS5020 is the newest model within the DS5000 series and is designed to help address midrange or departmental storage requirements. The DS5020 delivers high performance, advanced function, high availability, and modular and scalable storage capacity. Equally adept at IOPS and MB/s, the DS5020 is able to support applications with wide-ranging performance requirements. It is well suited for data warehousing, consolidation, and virtualization environments that have diverse workloads and application requirements, and is designed to concurrently support transactional intensive applications, such as databases and OLTP, and throughput intensive applications, such as HPC and rich media at entry price level.

The DS5020's design avoids over-configuration for an affordable entry-point, while offering seamless "pay-as-you-grow" scalability as requirements change. Its efficient storage utilization lowers raw capacity requirement, and support for intermixing high-performance and high-capacity drives enables enclosure-based tiered storage. These unique capabilities reduce the number of drives needed to meet performance and/or capacity demands, thus lowering acquisition and operational expenditures.

3.4.1 DS5020 description

The DS5020 is a 3U rack-mountable enclosure, has four 4 Gbps FC drive interfaces, and can comprise a maximum of six EXP520 expansion units for a total of up to 112 disk drives. Through a specific activation feature, six EXP810 expansions can be used in place of the EXP520s, thus enabling investment protection.

The following model is available: DS5020 Disk Controller (1814-20A).

Figure 3-4 shows the Model DS5020.

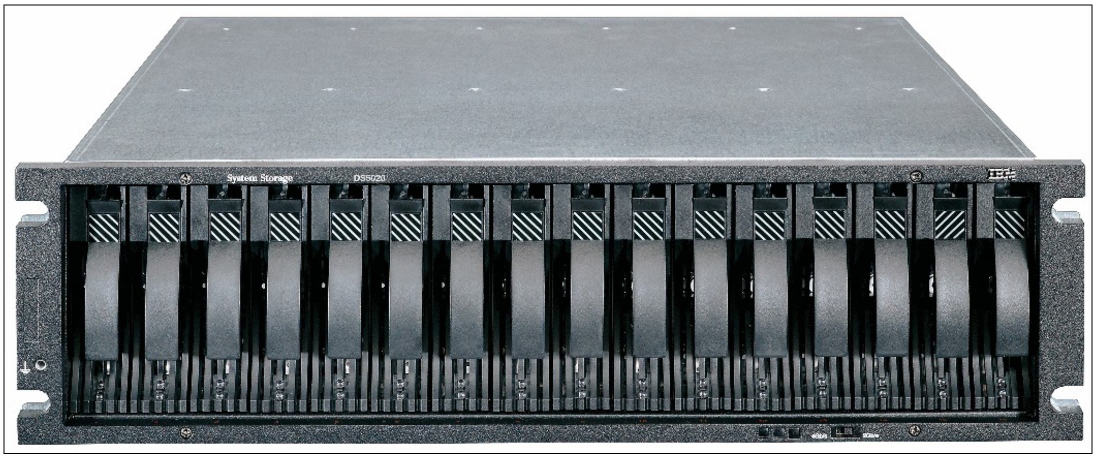


Figure 3-4 IBM System Storage DS5020

3.4.2 DS5020 features

Here we summarize the DS5020 features:

- Up to 112 TB physical storage capacity
- Comes with 2 GB cache memory (1 GB per internal RAID controller)
- Available with 4 GB cache memory (2 GB per RAID controller); feature is available as an initial plant order feature; there are no cache memory upgrades available as field (MES) features for the DS5020
- Accommodates up to 16 disk drives installed within the DS5020 enclosure
- Attachment support for up to six EXP520 expansion enclosures
- Attachment support for EXP810; this is supported with the Attach EXP810 to DS5020 Activation feature and is available only for migration purposes
- Supports intermix of SATA drives, FC drives, and encryption-capable FC drives (FDE) within the DS5020 and EXP520 enclosures
- Provides SAN-attached 8 Gbps Fibre Channel (FC) host connectivity, as well as optional 1GbE iSCSI host connectivity
- All DS5020s have four 8 Gbps FC ports (two per controller)
- Additionally, you can order initially either of the following options:
  - 2-Dual 8Gbps Host Interface Cards (HIC)
  - 2-Dual 1Gbps ISCSI HIC

- Drive options:
  - FC disks without encryption:
    - 146.8 GB/15K 4Gbps FC DDM
    - 300 GB/15K 4Gbps FC DDM
    - 450 GB/15K 4Gbps FC DDM
    - 600 GB/15k 4Gbps FC DDM
  - FC disk with encryption:
    - 146.8 GB/15K 4Gbps FC encryption-capable DDM
    - 300 GB/15K 4Gbps FC encryption-capable DDM
    - 450 GB/15K 4Gbps FC DDM encryption-capable DDM
    - 600 GB/15k 4Gbps FC DDM encryption-capable DDM
  - SATA disks:
    - 750 GB/7.2K SATA E-DDM
    - 1000 GB/7.2K SATA E-DDM
    - 2 TB/7.2K SATA E-DDM
- Supports RAID 0, 1, 3, 5, 6, and 10
- At the time of writing, one model is available: 1814-20A

3.4.3 DS5020 specifications

Table 3-2 shows the DS5020 specifications.

Table 3-2 IBM System Storage DS5020 specifications

Model	**1814-20A**
RAID controller	Dual active
Cache	Two GB battery-backed or four GB battery-backed initial option (no MES)
Host interface	Four 8 Gbps FC or eight 8 Gbps FC; or Four 4 Gbps FC and Four 1 Gb iSCSI
Drive interface	Four drive ports - Fibre Channel (FC) Switched and FC Arbitrated Loop (FC-AL) standard, Auto-sensing 2 Gbps/4 Gbps
Intermixed disk drives	Ability to intermix FC, FDE, SSD and SATA disk drives enables tiered storage
Supported drives	Supports 4 Gbps FC/FDE: 15k – 600 GB, 450 GB, 300 GB, 146.8 GB, E-DDM Supports 4 Gbps SATA: 7.2K 750 GB/1 TB and 2 TB E-DDM
Supported capacity	Up to 224 TB of physical storage capacity with 112 2 TB SATA disk drives
RAID	Levels 0, 1, 3, 5, 6, and 10
Storage partitions	4, 8, 16, 64, or 128 storage partitions
Maximum drives supported	112 FC or 112 SATA drives (using 6 EXP520 Expansion Units)
Fans and power supplies	Dual redundant, hot-swappable
Rack support	19-inch, industry-standard rack - 4U

For the latest specification information and Interoperability Matrix, see the website:

http://www.ibm.com/systems/storage/disk/ds5020/index.html

3.5 IBM System Storage Models 5100 and 5300

The first models of the DS5000 family that have been released offer increased performance compared to the family's DS4000 predecessors. It offers "Pay-as-you-grow" scalability up to 448 drives for both the DS5100 and the DS5300, thus enabling the most demanding capacity requirements, by utilizing the EXP5000 expansion enclosure. With the introduction of the EXP5060 Expansion Drawer, a configuration composed of a DS5100 or DS5300 controller attached to eight EXP5060 disk enclosures provide up to 960 TB of physical storage, all of which can be housed in a single IBM Storage Solutions 2101-200 rack system.

The DS5000 series is equally adept at supporting transactional applications such as databases and OLTP, throughput-intensive applications such as HPC and rich media, and concurrent workloads for consolidation and virtualization. With its relentless performance and superior reliability and availability, the DS5000 series storage system can support the most demanding service level agreements (SLAs). And when requirements change, you can add or replace host interfaces, grow capacity, add cache and reconfigure the system on the fly, ensuring that it will keep pace with your growing company.

The DS5000 series' also offers drive-level encryption, affordable data security with no performance penalty. And the DS5000 series' offers multiple replication options, drive level encryption, and persistent cache backup can help ensure that any detained cache is captured and safe in the event of a power outage.

3.5.1 DS5100/5300 storage subsystems

The following two models are available:

- DS5100 (1818-51A)
- DS5300 (1818-53A)

These two models differ in the number of host ports and amount of cache for data and performance.

Model DS5100 initially comes with eight host channels, 4 Gbps FC, and up to 64 GB cache for data with dedicated cache mirroring channels. and persistent cache backup in the event of a power outage. Upgrade path is available to DS5300 by using the optional full performance activation.

Model DS5300 comes with eight or sixteen host channels, 4 Gbps FC, and up to 64 GB cache for data and full performance activation.

Figure 3-5 shows the front view of the DS5000.

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Figure 3-5 IBM System Storage DS5000

3.5.2 DS5100 and DS5300 features

Models DS5100 (1818-51A) and DS5300 (1818-53A) have the following features:

- Compact 4U rack-mountable enclosure
- Utilize new 7th generation dedicated ZIP ASIC engines on RAID controllers
- Intel Xeon® 2.8 GHz processor
- Dual, redundant controllers
- PCI Express x8 bus technology
- Ability to attach up to Eight EXP5060 Enclosures feature
- New DS5000 IBM i Host Kit feature: The DS5000 IBM i Host Kit feature (#7735) is supported with DS5300 and DS5100 controllers at firmware level 07.60, or later operating with IBM Power Systems (rack/tower systems only, no Power Blade support) while hosting IBM iOS 6.1 with 6.1.1 machine code
- Dedicated cache for data (base model has 8 GB cache) with enhanced diagnostics; the architecture is designed to support a 64 GB cache
- Dedicated processor memory of 2 GB per controller
- Hot-swappable lithium-ion battery for backup and de-staging data from cache
- New flash memory to store data from cache during power outage
- Two dedicated PCI Express buses for cache mirroring
- Redundant, hot-swappable power supplies and fans
- Hot-swappable interconnect module acts as midplane
- Support for RAID 6, 5, 3, 10, 1, 0
- Support RAID 1 and 10 dedicated mirrored drive pair configurations
- Ability to create a RAID 10 or 0 group on all available drives to maximize performance for a LUN
- Flexible host interface modules that can be added, changed, or mixed as the infrastructure changes; quad-4 Gbps Fibre Channel (FC) Host Interface Cards (HIC) that can now be replaced with quad-8 Gbps FC HIC or a dual-1 Gbps iSCSI Host Interface Card; field replacements (MES) available

- Support an unlimited number of Global Hot Spare drives with the ability to enable/disable the copy back function (important for SATA drives)
- Host-side connections support:
  - Fibre Channel Switched Fabric
  - Arbitrated Loop and Fibre Channel Direct Connections
  - Ethernet Direct Connection and Ethernet Switched Network (with iSCSI HIC)
- Support sixteen 4 Gbps drive-side connections for both controllers, allowing a total of eight dual-redundant drive channel pairs to be implemented to support expansion enclosure additions
- Redundant drive-side connections designed to avoid any single-point of failure and maintain high availability
- Support up to 28 EXP5000 (or a mix of EXP5000 and EXP810 for migration purposes) for a total of 448 disks, thus allowing you to install up to 448 TB of raw capacity with 1 TB SATA disks or 268 TB of raw capacity with FC drives

  Migration: DS4800 running firmware version 6.60 or earlier can migrate its EXP810s into a DS5000 with at least one EXP5000.

- Up to 448 FC or SATA drives with EXP5000 and up to 480 drives when attaching 8 x EXP5060s.
- Support a maximum of 20 solid state drives (SSDs) within EXP5000:

  Fully support Fibre Channel/SATA/SSD intermix (premium feature) by allowing the simultaneous usage of SATA, Fibre Channel, and SSD behind one DS5000 controller, allowing user flexibility and increased storage capacity utilization; also possible to mix disks of various size and technology inside one enclosure
- Support up to 512 host storage partitions that isolate LUNs for various servers or groups of servers
- Support up to 2048 logical volumes
- Support up to 2048 host logins
- Support 4096 command queue depth (maximum drive queue depth is 16)
- Support logical volumes greater than 2 TB (when required and supported by the operating system)
- Support shortwave Fibre Channel 4 and 8 Gbps host attachment
- Support 1 Gbps copper iSCSI host attachment
- Multiple heterogeneous server and operating system support (host kits required)
- Powerful On Demand functions: Dynamic Volume Expansion, Dynamic Capacity Expansion, and Dynamic RAID Level Migration. Dynamic Segment Size allows users to modify storage configurations on-the-fly without incurring any downtime.
- Remote Support Manager notifies IBM if there is an issue; see 3.14, “IBM Remote Support Manager for Storage” on page 104.
- New dual 10/100/1000 Ethernet for out-of-band management to separate out-of-band management from service diagnostics for each controller
- FlashCopy (premium feature) for up to 16 copies per base volume. Two FlashCopies per default (without premium feature)
- VolumeCopy (premium feature)

- Remote Volume Mirroring: Metro Mirror, Global Mirror, and Global Copy (premium features) for up to 128 pairs
- Standard DB-9 serial connection for service purposes

The DS5000 series also helps to protect stored data as follows:

- DACstore technology stores configuration metadata on each drive.
- Proactive Drive Health Monitoring (PDHM) technology identifies faulty drives before they create problems.
- RAID 6 technology guards against concurrent drive failures and errors.
- Persistent cache backup ensures that data in the cache is captured and safe in the event of a power outage.

Additionally, the DS5100 offers further value in flexibility, scalability, and investment protection by providing the ability to upgrade to a DS5300. The DS5100 provides excellent performance for dynamic storage consolidation solutions in the deployment stage, with the full assurance that this model can be upgraded to a DS5300 performance level if required.

Table 3-3 shows the DS5000 specifications.

Table 3-3 IBM System Storage DS5000 specifications

Model	**DS5100 (1818-51A) and DS5300 (1818-53A)**
RAID controller	Dual active
Cache	Starts with 8 GB battery-backed Maximum 64 GB battery-backed
Host interface	4, 8 Gbps FC HICs or 1 Gbps iSCSI (sixteen total host ports)
Drive interface	16x 4Gbps drive ports - Fibre Channel (FC) Switched and FC Arbitrated Loop (FC-AL) standard
Supported drives	146 GB, 300 GB, 450 GB, 600 GB 15,000 rpm (Fibre Channel) 146 GB, 300 GB, 450 GB, 600 GB 15,000 rpm (Fibre Channel) FDE Also full 16 Encryption capable Disk packs and FC Disk packs available 750 GB, 1 TB SATAII 7,200 rpm, 2 TB SATAII 7,200 rpm 73 GB Solid State Disk (SSD)
RAID	Support for RAID 6, 5, 3, 10, 1, 0
Storage partitions	8, 16, 32, 64, 128, 256, 512 storage partitions - choice required Upgrades in steps available: 8–16, 16–64, and so on
Maximum drives supported	All models: 448 FC/FDE/SATA drives (using 28 EXP5000 Expansion Units) Maximum of 480 SATA drives (using 8 EXP5060 High Density Drawers Maximum of 20 Solid State Disks per Model
Fans and power supplies	Dual redundant, hot-swappable
Rack support	19-inch, industry-standard rack - 4U

For the latest specification information, including Interoperability Matrix, see the website:

http://www.ibm.com/systems/storage/disk/ds5000

For further details about the DS5000 storage subsystem and advice about how to configure it, see the *IBM Midrange System Storage Hardware Guide*, SG24-7676.

3.6 IBM System Storage Model DCS9900

The IBM System Storage DCS9900 Storage System is designed for applications with high-performance streaming data requirements served by Deep Computing systems, IBM System p High Performance Computing (HPC) systems, System x 1350 Linux Cluster systems, and Broadcast Video applications.

Applications such as those in HPC, rich media, life sciences, and government research require high-performance, reliable access to streaming data and extreme capacity and density to simplify management and reduce cost. Examples of such applications include weather forecasting, seismic processing, reservoir modeling, high definition (HD) creation and distribution, proteomics, structural analysis, fluid dynamics, and gene sequencing. With its parallel storage solution architecture, the DCS9900 is specifically designed to address those needs.

The DCS9900 brings many advantages:

- Performance: Industry leading streaming I/O performance (up to 5.7 Gbps)
- Dense packaging and capacity: Up to 1.2 PetaByte (PB) in a single rack and 2.4 PB in just two floor tiles
- Energy efficiency: Fewer Controller/Powersupplies/Fans and Sleep mode enabled
- Availability and Reliability: Hardware based RAID 6…8+2…with no performance penalty, Parity computed on every read – no SATA silent corruption errors, and all data remaining visible to all clients even in the case of a disk, enclosure or controller failure; parallel architecture at every level

3.6.1 New features

The DCS9900 provides the following new features.

- New – 2 TeraByte (TB) Serial Advanced Technology Attachment (SATA) disk drive — 7200 revolutions per minute (rpm)
- New 600 GB Serial Attached SCSI (SAS) disk drive (15000rpm)
- Support for SAS/SATA intermix in the same enclosure
- Support for 3-enclosure configuration
- High-performance sequential I/O: Reads and writes at up to 5.9 GigaBytes per second (GBps) with no Redundant Array of Independent Disk (RAID) 6 write penalty
- Dense packaging and capacity: Up to 1.2 PetaByte (PB) in a single rack and 2.4 PB in just two floor tiles
- High availability: Data access assured independent of disk, enclosure or controller failures
- Extreme reliability: Data transfer rates sustained independent of disk or enclosure failures, simultaneous detection and correction of SATA silent data-corruption errors and RAID 6 reliability

Orders: All orders for the DCS9900 Storage System, which includes the DCS9900 Controller Model CP2, DCS9900 Storage Expansion Units, and features, must first be approved by the mandatory I-listed RPQ 8S0870. Ask your IBM representative how to order the I-listed RPQ.

Figure 3-6 shows the front view of the DCS9900.

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Figure 3-6 IBM System Storage DCS9900

3.6.2 DCS9900 storage system

The following two models are available:

- DCS9900 Controller Model CP2 (1269-CP2)
- DCS9900 3S1 SAS/SATA Storage Expansion Unit (1269-3S1)

The DCS9900 Storage System initial offering consists of the DCS9900 Controller Model CP2 and the DCS9900 3S1 SAS/SATA Storage Expansion Unit. The DCS9900 Controller Model CP2 attaches to the DCS9900 Storage Expansion Units using twenty 3 Gbps SAS v1.0 disk expansion ports and is designed to scale up to 1200 disks, providing up to 1200 terabytes (TB) storage capacity in one DCS9900 controller system.

The DCS9900 Storage System consolidates and fully integrates a parallel, non-blocking architecture which enables industry leading data streaming performance. The DCS9900 is designed to provide optimal block level and file system performance with up to 6 gigabytes-per-second sustained data streaming bandwidth delivered to deep computing applications.

3.6.3 DCS9900 features

The DCS9900 controller model CP2 has the following features:

- The DCS9900 Controller Model CP2 (1269-CP2) comes in a 4U rack-mount enclosure containing dual controllers with 5 GB cache (2.5 GB cache per controller) and eight 8 Gbps Fibre Channel host ports. The DCS9900 controller attaches to DCS9900 3S1 SAS/SATA Storage Expansion Units using 3 Gbps SAS v1.0 disk expansion ports. The DCS9900 Model CP2 controller can support up to 1200 disks, yielding up to 1200 TB physical storage capacity, 64 thousand LUNs, and up to 4096 direct host logins per DCS9900 system.
- Infiniband host connectivity delivers high speed host connectivity option for attachment of host systems to the DCS9900 Storage System, it complements Fibre Channel host connectivity and offers host cables in several convenient lengths.
- Improved temperature reporting, fault handling, and ability to shut down all drives with one command are provided.
- The DCS9900 controller is designed to support managed Quality of Service to provide uninterrupted data delivery, as well as source all of its performance from multiple target LUNs or a single target “PowerLUN” reducing the need for host-based striping software.
- The DCS9900 controller incorporates enterprise-class data protection with on-the-fly parity checking on all read I/Os, as well as hardware-enabled RAID 6, which protects data in the event of double disk failure in the same redundancy group, without adversely affecting data availability or system performance.
- Additionally, the DCS9900 includes block level virtualization, to virtualize storage deployment and system management, through LUN aliasing, WWN masking/filtering, or port zoning.
- The DCS9900 Controller Model CP2 attaches to DCS9900 Storage Expansion Units to form the following supported, orderable configurations:
  - One DCS9900 Model CP2 Controller attached to five DCS9900 3S1 SAS/SATA Storage Expansion Units:
    - Range from 150 to 300 disk drives (in increments of 10 disk drives)
    - Scales from 21.9 to 300 TB physical storage capacity
  - One DCS9900 Model CP2 Controller attached to 10 DCS9900 3S1 SAS/SATA Storage Expansion Units:
    - Range from 150 to 600 disk drives (in increments of 10 disk drives)
    - Scales from 21.9 to 600 TB physical storage capacity
  - One DCS9900 Model CP2 Controller attached to 20 DCS9900 3S1 SAS/SATA Storage Expansion Units:
    - Range from 600 to 1200 disk drives (in increments of 10 disk drives)
    - Scales from 87.6 to 1200 TB physical storage capacity
- Each DCS9900 Storage System must be ordered with the minimum of number of disk drives, and then can be incremented an additional ten drives at a time, applied to the overall DCS9900 system configuration.

The DCS9900 3S1 SAS/SATA Storage Expansion Unit (1269-3S1) has the following features:

- The DCS9900 will support Intermix of SAS and SATA in the same enclosures.
- The DCS9900 will also support three disk enclosure configurations.
- The DCS9900 3S1 SAS/SATA Storage Expansion Unit comes in a 4U, rack-mounted, 60 SAS or 60 SATA disk enclosure. The Model 3S1 internally accommodates up to 60 SAS or 60 SATA disk drives logically configured as a 1x60 or 2x30 connection to the DCS9900 Model CP2 controller, dependent upon whether the configuration will contain five 3S1 expansion units or ten/twenty 3S1 expansion units. The Model 3S1 includes hot-swappable power supplies and hot-swappable cooling fans.
- The Model 3S1 disk expansion unit integrates into a 45U 1050mm deep rack, rack feature (#2003). A single DCS9900 system can consist of a configuration made up of either one or two racks. The first rack can contain either five 3S1 expansion units or ten 3S1 expansion units. The second rack must contain ten 3S1 expansion units for a maximum configuration of up to twenty 3S1 expansion units and up to 1200 disk drives.
- An order for a configuration made up of five 3S1 disk expansion units must be ordered with a minimum of 150 disk drives (30 drives per 3S1 expansion unit), and scales in increments of ten up to a maximum of 300 disk drives (60 drives per 3S1 expansion unit).
- Each group of five 3S1 disk expansion units ordered must contain the same number and same type of disk drives and ordered in increments of ten drives applied across the entire configuration. For example, each of the five 3S1 expansion units in the rack can contain either 30-, 32-, 34-, 36-,.......54-, 56-, 58-, up to 60-disk drives. But all 3S1 expansion units must contain the same number and type of drives.
- Additionally, when field upgrading from five 3S1 expansion units to ten 3S1 expansion units, specify feature 9231, the resulting rack of ten 3S1 expansion units must contain the same number and type of disk drives in each expansion unit.
- An order for a configuration made up of ten 3S1 disk expansion units must be ordered with a minimum of 150 disk drives (15 drives per 3S1 expansion unit), and scales in increments of ten drives up to a maximum of 600 drives (60 disk drives per 3S1 enclosure).
- Each group of ten 3S1 disk expansion units ordered must contain the same number and type of disk drives and ordered in increments of ten drives applied across the entire configuration. For example, each of the ten 3S1 expansion units in the rack can contain either 15-, 16-, 17-, 18-,.......57-, 58-, 59-, up to 60-disk drives. But all expansion units must contain the same number and type of drives.
- A configuration made up of two racks of ten 3S1 expansion units attached to a DCS9900 controller can have a unique disk drive feature in each rack. Therefore, disk drive features must not be intermixed within each rack of five 3S1s or each rack of ten 3S1s, however, configurations made up of two rack of ten 3S1 expansion units can have a unique SAS or SATA disk drive feature in each rack.
  - 500 GB SATA disk drive (#3201)
  - 750 GB SATA disk drive (#3202)
  - 1000 GB SATA disk drive (#3203)
  - 146 GB/15K SAS disk drive (#3231)
  - 300 GB/15K SAS disk drive (#3232)
  - 450 GB/15K SAS disk drive (#3233)
- Every DCS9900 system location which has a DCS9900 system configuration that uses the 45U 1050mm deep Rack Unit (#2003), must have access to one Service Ladder (#2011). The Service Ladder is mandatory for installation, service, and maintenance of components within the upper drawers of the 45U 1050mm deep Rack Unit. Failure to have at least one Service Ladder available in a required location can result in delayed or prolonged maintenance times.

Figure 3-7 shows the possible configurations of the DCS9900.

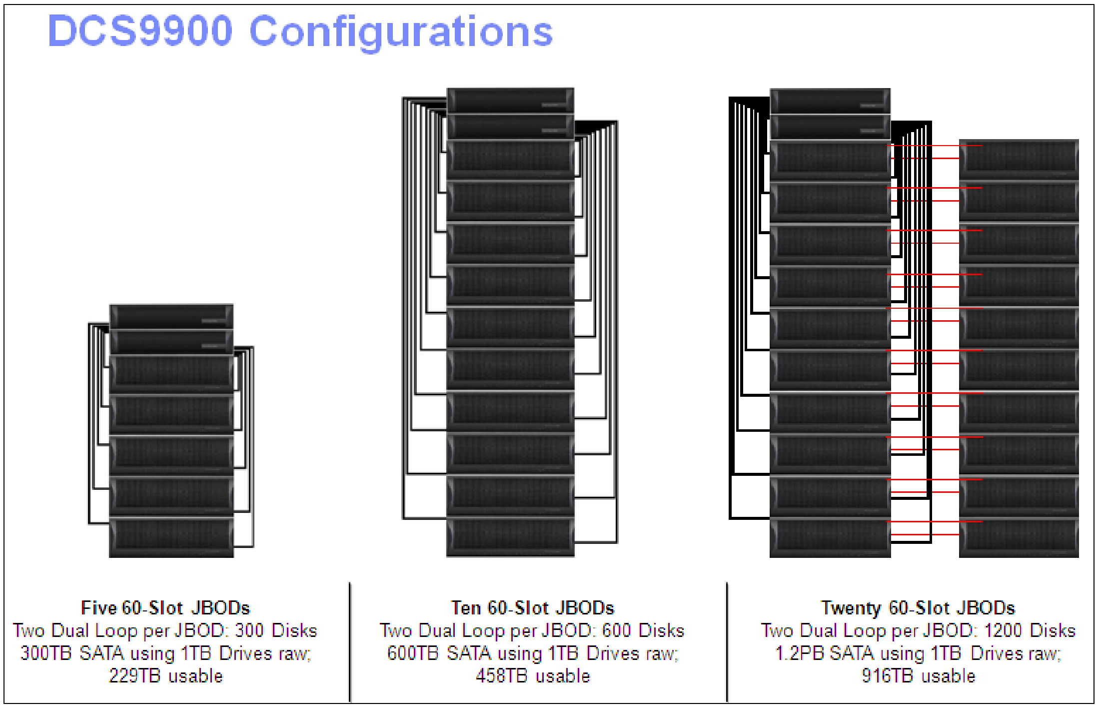

Figure 3-7 DCS9900 configurations

3.6.4 DCS9900 specifications

Table 3-4 shows the DCS9900 specifications.

Table 3-4 IBM System Storage DCS9900 specifications

Model	**1269-CP2 and 1269-3S1**
RAID controller	Dual active
Cache	Dual controller with 5 GB of RAID protected cache (2.5 GB cache per controller)
Host interface	Eight FC8 or IB 4X DDR host ports (4 ports per controller)
Drive interface	Twenty SAS 4-lane (3 Gbps) connections (10 per controller)
Supported drives	SAS: 450 GB and 600 GB SATA: 1 TB and 2 TB (7200 rpm) SATA: 2 TB (5400 rpm)
RAID	Hardware enabled RAID 6 (8+2)
Maximum # of supported LUN's	1024 LUNS, 512 concurrent logins (IB) and 1024 concurrent logins (FC) per DCS9900 couplet
Maximum drives supported	Maximum of 1200 SAS/SATA drives in 2 Racks
Fans and power supplies	2 redundant power supplies 3 redundant blowers with temp sensors, ensuring safe write-through and shutdown
Rack support	19-inch, industry-standard rack - 4U

Model	1269-CP2 and 1269-3S1
Management software	Standard features: LUN Mapping and Masking by WWN and/or Port Zoning; PowerLUNs; Real-Time Data Verification; Background Data Scrubbing; LUN in Cache; Place Holder LUNs; Intelligent Stream Detection, Read-only LUNs, Advanced A/V Modes, LUN Caching, DirectAPI Optional features: Java™ based Graphical User Interface (GUI) management software, Sleep mode MAID capability

For the latest specification information, see the website:

http://www-03.ibm.com/systems/storage/disk/dcs/dcs9900/index.html

3.7 IBM System Storage DS4000 EXP810 Expansion Unit

The EXP810 Expansion Unit is packaged in a 3U rack-mountable enclosure that supports up to 16 FC disk drives or E-DMM SATA drives. It contains 16 drive bays, dual-switched 4 Gbps ESMs, and dual power supplies and cooling components. Fully populated with 450 GB FC disk drive modules, this enclosure offers up to 7.2 TB of raw storage capacity or up to 16 TB when populated with the 1000 GB E-DDM SATA drives. This expansion unit is the only one that can be connected to every storage subsystem of the DS4000/DS5000 family. On the DS5000 family, the EXP810 can be attached for migration purposes only.

Through the proper firmware level, this expansion unit is able to host both FC and SATA Drives. Intermix of FC and SATA drives is supported within this expansion enclosure. The IBM System Storage DS4000 EXP810 storage expansion enclosure (Machine Type 1812, Models 81A and 81S) implements high-capacity, Fibre Channel disk storage. The expansion unit delivers fast, high-volume data transfer, retrieval, and storage functions for multiple drives to multiple hosts.

The EXP810 allows continuous, reliable service, using hot-swap technology for easy replacement without shutting down the system and support redundant, dual-loop configurations. Figure 3-8 shows the EXP810.

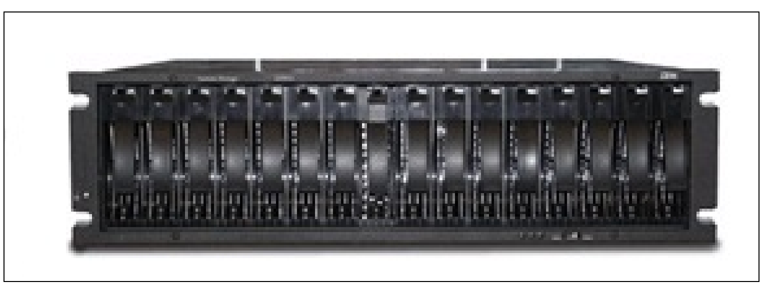

Figure 3-8 IBM DS4000 EXP810 Expansion Unit

3.7.1 EXP810 Expansion Unit features

The IBM System Storage DS4000 EXP810 expansion unit has the following features:

- Machine type:1812, Model number:81A/81S (Telco)
- 4 Gbps Fibre Channel and SATA drives currently available for the EXP810:
  - Supported drives, 2 Gbps FC: 15K rpm, 146 GB/73 GB/36 GB (E-DDM)
  - Supported drives, 2 Gbps FC: 10K rpm, 300 GB/146 GB/73 GB (E-DDM)
  - Supported drives, SATA drives: 7.2K rpm, 1000 GB[1]/750 GB[1]/500 GB (E-DDM)
  - Supported drives, 4 Gbps FC: 15K rpm, 600 GB[2]/450 GB[2]/300 GB/146 GB/73 GB (E-DDM)
- Attachment supported on models DS4300, DS4500, or DS4700 Express, DS4800 at V6.16 firmware and higher; attachment to DS5000 series for migration purposes only
- Can be intermixed with EXP710
- New design supporting up to 16 drives in 3U enclosure
- Up to 16 TB physical capacity per expansion unit using sixteen 1000 GB SATA disk drives
- Dual Environmental Service Modules (ESM) - 4 Gb FC
- Field replaceable components
- NEBS Level 3 certification and 48V dc Telco (model 1812-81S)
- Supported by IBM System p servers, IBM System x and selected Netfinity® servers, Selected Sun and HP UNIX servers, and Intel-based servers running Windows 2000, Windows Server 2003 SP2, Windows Server 2008 SP1, Linux, Novell NetWare, or VMware

For the latest configuration options, supported server models, supported operating system levels, supported system levels, and attachment capabilities, see the website:

http://www-03.ibm.com/systems/storage/disk/ds4000/exp810/index.html

Figure 3-9 shows the rear components of DS4000 EXP810.

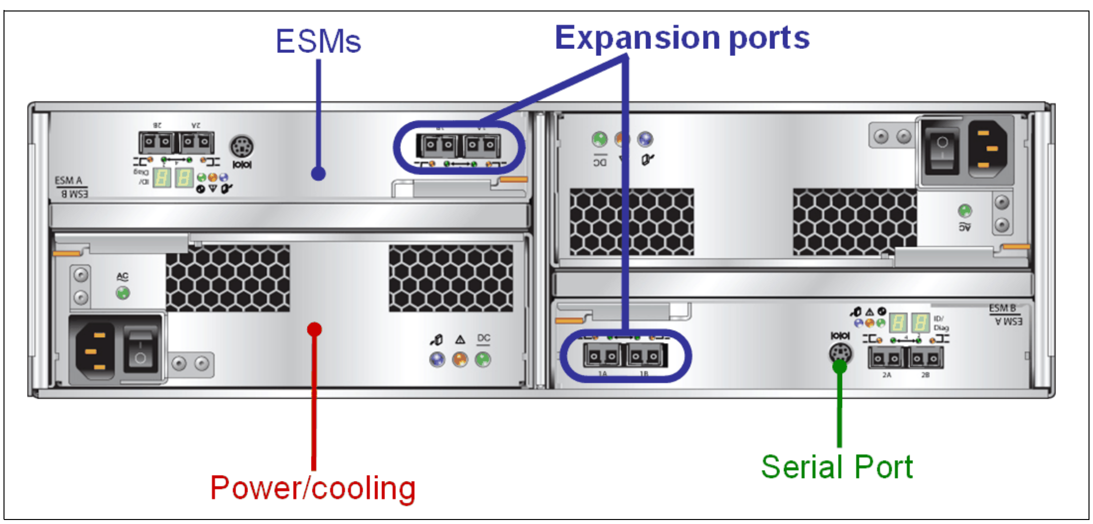

Figure 3-9 DS4000 EXP810 rear components

[1] Minimum required firmware level 06.23.05.00 or above
[2] Minimum required firmware level 06.23 and Storage Manager 9.23 or above

3.7.2 EXP810 Expansion Unit specifications

Table 3-5 shows specifications of the IBM System Storage DS4000 EXP810 expansion unit.

Table 3-5 IBM System Storage DS4000 EXP810 Expansion Unit

Model	**1812-81A/81S**
Number of drives supported	Up to 16 FC drives
Fans and power supplies	Dual redundant, hot-swappable
Dimensions	(With bezel) 12.95 cm H x 48.26 cm W x 57.15 cm D (5.1 in x 19 in x 22.5 in)
Weight	40 kg (88 lb)

3.8 IBM System Storage model EXP520 and EXP5000

The EXP520 and EXP5000 Drive enclosures are more than “just-a-bunch-of-disks.” They are designed to optimize performance, availability, and serviceability. Redundant 4 Gbps FC drive loops ensure complete accessibility to all drives in the event of a loop or cable failure, having redundant power supplies, cooling fans, and ESMs, while all primary components are hot-swappable CRUs and can be easily accessed and removed or replaced.

3.8.1 EXP520 and EXP5000 Drive features

The EXP5000 (1818-D1A) and EXP520 (1814-52A) storage expansion units are packaged in a 3U rack-mountable, high-capacity 16-drive bay enclosure containing dual switched 4 Gbps ESMs, dual power supplies, and redundant cooling. EXP5000s connect to DS5100 and DS5300 controllers through high-speed 4 Gbps FC disk expansion ports and have a physical storage capacity of up to 16 TB per enclosure, using 1000 GB SATA DDMs (disk drive modules) and up to 9.6 TB per enclosure, using 600 GB FC DDMs. It is also possible to mix SATA and FC drives in the same enclosure. The EXP520 uses the same disk types and sizes but only connects to DS5020 storage controllers.

The EXP5000 Expansion Unit (1818-D1A) and EXP520 (1814-52A) base model includes a 3U, rack-mount 16-bay disk enclosure, two SW SFP transceivers, dual power supplies, redundant cooling, rack mounting rails, soft copy documentation, and two rack PDU power cords (36L8886).

Figure 3-10 shows the EXP 520 unit.

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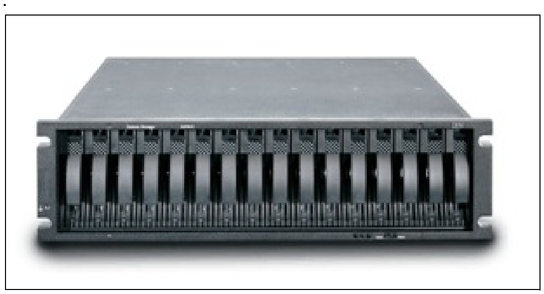


Figure 3-10 EXP520 front view

3.8.2 EXP520 and EXP5000 Drive support

Both expansion units support the following drives:

- 600 GB, 450 GB, 300 GB, 146 GB FC 4 Gbps, 15000 rpm (FDE and non-FDE)
- 2 TB SATAII, 1000 GB SATAII and 750 GB SATAII 4 Gbps 7,200 rpm
- 76 GB, FC, solid state drive (*only in EXP5000*)

For the latest specification information about the expansion units, see the website:

http://www.ibm.com/systems/storage/disk/

For the latest specification information for the DS5000, see the website:

http://www.ibm.com/systems/storage/disk/ds5000/specifications.html

3.9 IBM System Storage EXP5060

The IBM System Storage DS5000 series now offers an EXP5060 High Density Disk Enclosure. The EXP5060 can support up to 60 disk drives in a 4U unit, allowing a great reduction of footprint. Next to its lower infrastructure costs, with its high density format and amount of disks, it will deliver beneficial performance for HPC capacity intensive application environments, and with its efficient power supplies and variable speed cooling fans, it is a real energy saver.

Customers who will benefit most are the ones who have the following requirements:

- Have traditional HPC or GPC environments
- Have growing capacity needs
- Want to reduce power consumption
- Want to maximize density to reduce footprint in the data center

The EXP5060 comes in a 4U rack-mount enclosure and accommodates up to sixty 1000 GB 7.2K SATA DDMs. Up to eight EXP5060 Disk Enclosures are attachable to a DS5100 or DS5300 controller, providing up to 480 TB of physical storage.

3.9.1 EXP5060 overview

The EXP5060 is a 4U rack-mountable enclosure that supports up to 60 SATA Disk Drive Modules (DDMs), offering up to 60 TB of SATA disk space per enclosure using 1 TB SATA DDMs. The IBM System Storage EXP5060 storage expansion enclosure provides high-capacity SATA disk storage for the DS5100 and DS5300 storage subsystems. The storage expansion enclosure provides continuous and reliable service by using hot-swap technology for easy replacement, without shutting down the system, and supports redundant, dual-loop configurations. The expansion enclosure contains 60 drive bays (arranged on five stacked drawers with twelve drives for each drawer), dual-switched 4 Gbps ESMs, and dual power supplies and cooling components.

Coupled with a storage subsystem (DS5100 or DS5300), you can configure RAID-protected storage solutions of up to 480 TB when using 1 TB SATA DDMs and eight EXP5060 storage expansion enclosures, providing economical and scalable storage for your rapidly growing application needs. The “Attach up to 8 EXP5060s” feature pack must be purchased for the DS5100/DS5300 storage subsystem to enable it to be connected to up to eight EXP5060 storage expansion enclosures.

External cables and Small Form-Factor Pluggable (SFP) modules connect the DS5100 or DS5300 storage subsystem to the EXP5060 storage expansion enclosure. The EXP5060 uses redundant 4 Gbps Fibre Channel to make connections to the DS5100 or DS5300 storage subsystem and another EXP5060 storage expansion enclosure in a cascading cabling configuration, offering reliability and performance.

DS5100 and DS5300 models support attachment of up to eight EXP5060 enclosures. A configuration composed of a DS5100 or DS5300 controller attached to eight EXP5060 disk enclosures can provide up to 480 TB of physical storage, all of which can be housed in a single IBM 2101 Model 200 Storage Solutions rack system.

To help support the integration of EXP5060 enclosures into 2101-200 rack systems, new power cord features are offered for the 2101-200 rack. These power cords provide connections from the rack power distribution units (PDUs) within the rack enclosure to applicable 240 V ac power sources in the data center.

3.9.2 Key prerequisites for EXP5060

DS5100 and DS5300 controllers must be at firmware level 07.60, or later to support new EXP5060. Initial plant orders (IPOs) for the EXP5060 High Density Disk Enclosure must include a minimum of two 10-Pack EXP5060 1000 GB/7.2K SATA DDMs feature (#4740).

When EXP5060 enclosures are to be plant or field integrated into the IBM 2101 Model 200 Storage Solutions Rack, the rack must be configured with PDU power cords rated for 240 V AC electrical service using either of rack power cord options 9491, 9492, 6491, or 6492. See the *2101 Model 200 Rack Sales Manual* for details.

Storage expansion enclosures: A maximum of eight EXP5060 storage expansion enclosures (with 480 hard drives) can be attached only to the DS5100 and DS5300 storage subsystems, and only SATA disks are supported in the EXP5060 expansion.

Figure 3-10 shows the top view of the EXP5060 unit.

Figure 3-11 EXP5060 - High Density Drawer

For the latest specification information for the EXP5060, see the website:

http://www.ibm.com/systems/storage/disk/

3.10 IBM TotalStorage EXP24

The EXP24 is designed to interoperate with IBM eServer™ pSeries® servers. The EXP24 also includes management tools designed to help lower administration costs. And the cost benefits that come with the EXP24 are not at the expense of reliability—the Ultra 320 SCSI based EXP24 helps support increased reliability and performance compared to many older, non-redundant designed products.

The IBM TotalStorage EXP24 is designed to give cost-conscious businesses an entry-level server that can help meet storage and near-line application storage needs without undue expense, while leaving them room to grow. The EXP24 is scalable up to 7.2 TB of Ultra 320 SCSI physical disk storage with 24 internal 300 GB disks. The EXP24 is designed to provide ample yet scalable storage without the cost of extra expansion units. This storage server also is designed to help consolidate storage into a centrally managed environment.

Here we list highlights of the IBM TotalStorage EXP24:

- Well-suited for small to medium-sized enterprises that need affordable, entry-level storage
- Supports storage expansion of up to 24 Ultra 320 SCSI disk drives
- Expandable to over 7 Terabytes of storage capacity
- Offers high-availability features, including redundant power supplies, cooling, and hot swap DASD
- Provides up to four SCSI initiator host ports designed for economical attachment of up to 8 servers to a single EXP24 or for failover capabilities
- Configurable as either 4 groups of 6 drives or 2 groups of 12 drives with either single or dual connection any group of drives

For the latest specification information for the EXP24, see the website:

http://www.ibm.com/systems/storage/disk/

3.11 Solid State Disk and Full Disk Encryption

In this section we explain the high-level concepts and advantages of the relatively new products, Solid State Disk and Full Disk Encryption.

3.11.1 Solid State Disk

This section summarizes the major advantages offered by Solid State Disk (SSD) when compared to spinning, magnetic hard disk drives.

Figure 3-12 shows an SSD and its dimensions.

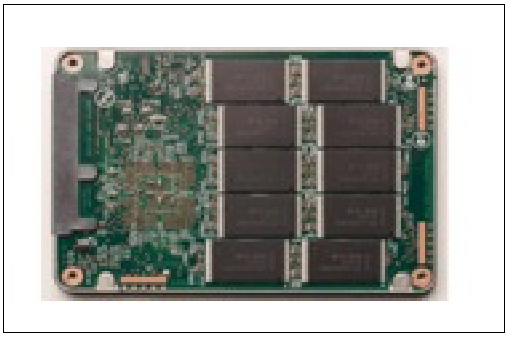


Figure 3-12 SSD

The simple fact that there are no moving parts (disk platters, magnetic heads, motor) in an SDD results in the following benefits:

- Faster data access and throughput:

  The access to the data with an SSD is faster because again, there is no read/write head to move and no magnetic platters need to spin up (no latency). On an SSD, the data can be read almost immediately. The SSD has up to 100x more throughput and 10x better response time than 15K RPM spinning disks. High transactional environments benefit most from SSD technology.

- Better reliability:

  Again, the lack of moving and rotating parts almost eliminates the risk of mechanical failure. SSDs have the ability to tolerate extreme shocks, higher altitude, vibration, and extremes of temperature. However, they can still fail and must be RAID protected like traditional drives.

- Less power consumption:

  Because there is no power for the motor required to spin up the magnetic platters and to move the heads, the drive uses less energy than a traditional hard disk drive. Each SSD uses about half of the power of a 15K RPM HDD. The savings can be substantial if a few SSDs can replace many HDDs to deliver the same performance. This is particularly true for applications that were forced, for performance reasons, to use large quantities of HDDs to get as many spindles as they can, while only using a small portion of the disk capacity. Besides power consumption savings, the overall system weighs much less because SSDs are already much lighter than HDDs.

Considerations for using SSDs

In this section we review special considerations and general usage guidelines to follow when SSDs are used:

- Copy Services:

  Copy Services operations are not specifically affected by SSD. However, it is best (as is the case with HDDs as well) not to use a slower device as the target of a copy services function.

- Sparing and rebuild time:

  The sparing algorithm is unchanged for storage systems equipped with SSDs. The rebuild time for an SSD is, however, much faster than with regular HDDs of the same capacity. For an idle 6+P SSD array, we have measured a rebuild time that is around 10-15% faster than a 6+P array with 15K RPM HDDs.

SSD usage

SSDs cost more per unit of storage than HDDs but the gap in price is expected to narrow over time. Also SDDs offer only relatively small capacity per drive in comparison to HDDs. You thus want to make sure that they are used (reserved) for the most business critical applications and that they are used under conditions that can guarantee optimum performance. Note that any update of the SSD firmware must be done in non-concurrent mode. This means that any application IO to the drives must be stopped prior to the upgrade.

Use the following guidelines when deciding:

- SSDs currently remain targeted at applications with high access workloads (IOPS). Applications with high IO rates and poor cache hit ratios are ideal candidates for SSDs while applications with a good cache hit ratios or low IO rates just remain on spinning drives.
- Also, sequential workloads (as opposed to random) stay on spinning disks.
- Given the current high cost per GB for SSDs, use a mix of SSDs and HDDs (not on the same DA), such that data from less critical applications can be stored on HDDs (you can use FC and SATA drives).
- Do not use SSDs as a source of a Remote Mirror or FlashCopy where the target is a regular HDD.
- If you run an I/O driver to a single SSD that is set up for direct attach, it can do up to 30k IOPS. The DS8000 for example can do about high IOPS across seven or eight disks on one device adapter. This is close to double on a device adapter pair. The throughput can scale up as more device adapter pairs are used for SSDs. Even the most active production data cannot exploit the range of 30k IOPS making use of 73 GB or 146 GB disk.

  In other words, the SSDs are so fast that the Device Adapter becomes the performance bottleneck on random workloads. For sequential workloads the DA was already the bottleneck with traditional HDDs (hence using SSDs for sequential IO is not a good investment).
- Use optimum host attachment options. The functionality provided by a storage server such as virtualization layers that make the particularities of disk hardware transparent to applications is critical for the usability of the system. However, this functionality adds to the response time that you normally get from an SSD. It is important not to further impact the response time that you use the host attachment options that guarantee the best performance.

Attention: You need sufficient amount of SSD to gain the best performance benefit. Indeed, applications such as databases can have high access rates, which makes them good candidates for deployment on SSD. However, the same database might require a large storage capacity. In this case you thus need a sufficient amount of SSD capacity to get the best performance improvement. To help customers get insight of their current Storage Data behavior and clarifying which data is expected to benefit from SSD, IBM has developed *"Smart Data Placement Tools."*

For specific information about SSD usage with DB2, see *Ready to Access DB2 for z/OS Data on Solid-State Drives*, REDP-4537.

For more SSD performance related information, see the website:

http://www.ibm.com/systems/storage/solutions/ssd/

3.11.2 Full Disk Encryption

This section summarizes the major advantages offered by Full Disk Encryption (FDE) when compared to regular hard disk drives.

Preventing data breaches is becoming more and more important, as they appear more frequently, making the headlines in newspapers or Internet. This can have a severe impact on companies.

The negative impact of data breaches are:

- Loss of customers and revenue
- Unplanned expenses of remedy a breach
- Legal implications, penalties, and fines
- Negative press and tarnished reputation
- Lost goodwill and undermining other corporate relationships

The difficulty today is to keep track of “data at rest” because eventually, the data will be out of the administrator’s control, and therefore vulnerable to a breach. When the storage system leaves the building, frequently sensitive client/partner data or intellectual capital resides on it.

Security technology efforts are fragmented across point products, leaving holes in the security system. Also, other current methods fall short. Because drive disposal methods are subject to human error, deleted files can be reinstated and password protected data can still be accessed by skilled individuals.

Because data security is now a common component of the corporate landscape due to necessity and regulatory compliance, there is a need for new technologies that can enable companies to comply. FDE provides such a solution.

FDE value propositions

FDE offers the following benefits:

- Data is secure at the most basic level – the hard drive:
  - It covers most data exposures and vulnerabilities all at once.
  - Security planning is simplified.
- Unparalleled security assurance with government-grade encryption is provided:
  - It is National Security Agency (NSA) qualified.
  - Advanced Encryption Standard (AES) 128 encryption algorithm is approved by the United States government for protecting secret-level classified data.
- Data is protected through the hardware life cycle:
  - FDE enables return of defective drives for servicing.
  - You can quickly decommission or re-purpose drives with instant secure erase.
- Performance is preserved:
  - FDE will not slow a system down.
  - The encryption engine matches the drive’s maximum port speed and scales as more drives are added.

In order for drive-level encryption to provide this value, the key that enables encryption must be protected and managed.

Figure 3-13 shows an FDE setup.

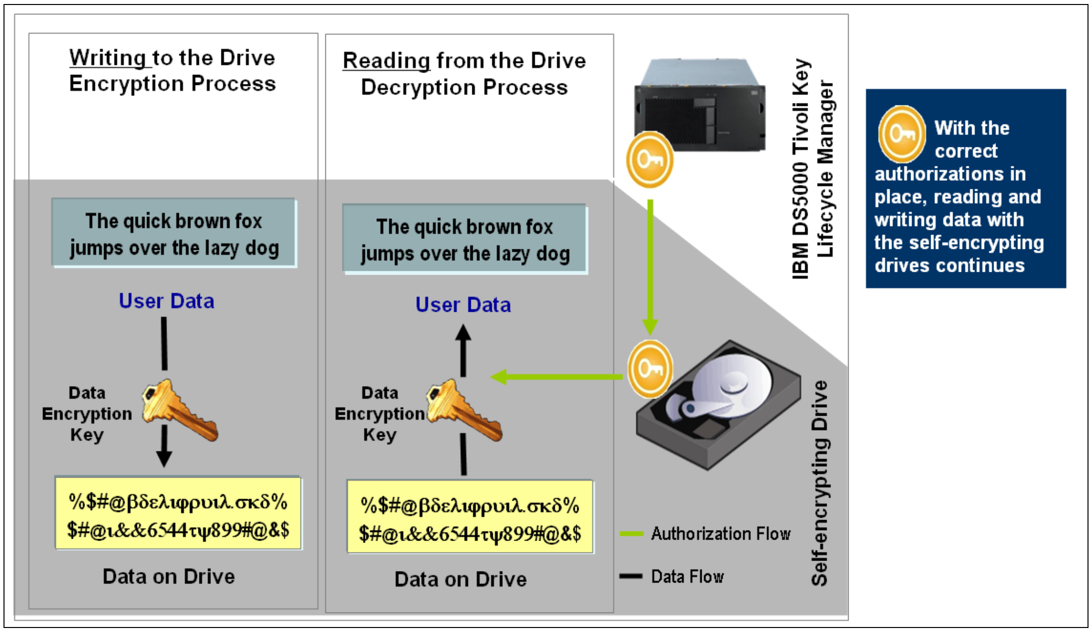


Figure 3-13 Locked, secured data with self encrypting drives

Components of FDE solution

The IBM Full Disk Encryption (FDE) solution has two components:

- FDE Hard Disk Drives (HW):
  - Encryption is performed at HDD level.
- Tivoli Key Lifecycle Manager (TKLM SW):
  - With the FDE drive, it generates and encrypts a security key.
  - It creates a unique security key ID that is paired with the security key.
  - It adds its WW identifier and a randomly generated number.
  - The security key ID is saved – this folder location will be needed whenever a security operation requires (such as when a drive powers up).
  - It creates a backup of the security key and the security key identifier.
  - A secure backup is provided in which the security key and the security key identifier are encrypted utilizing a user-selected pass phrase.

Figure 3-14 shows the classification of data levels.

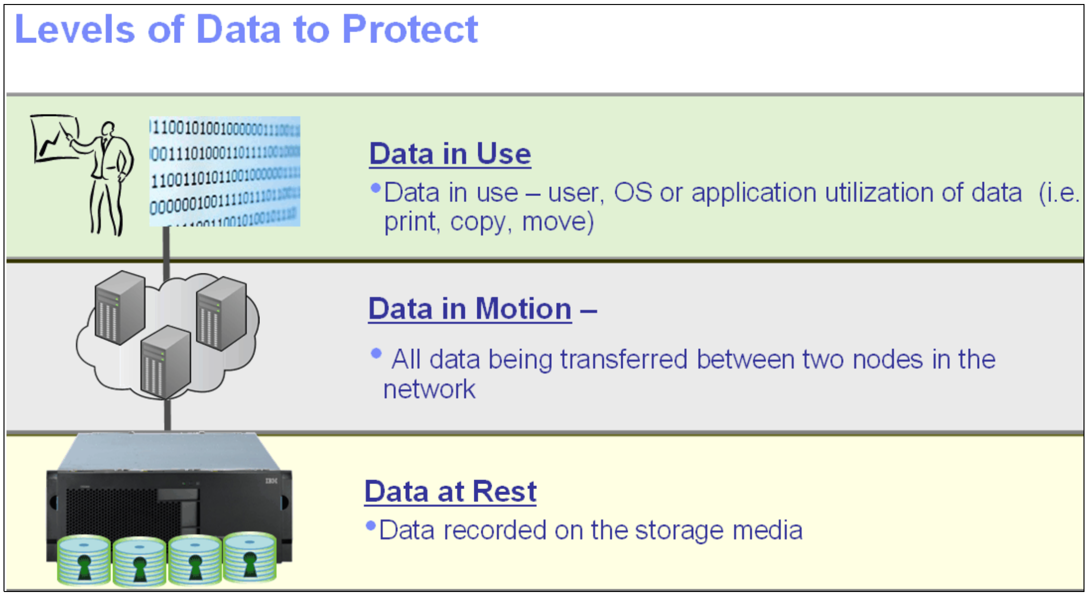


Figure 3-14 Levels of Data to protect

Reasons to classify data for encryption

Here are some reasons to classify data for encryption:

- Encryption of the entire data center requires a large investment:
  - Utilization of earlier investments of non-FDEs
  - Utilization of SATA drives
- Instead, utilize available FDEs for the most sensitive high-security data:
  - Determine the associated risk with the potential breach of that data.
  - Determine what data is regulated and must be encrypted.
  - Prioritize data accordingly.
  - Cut in FDE drives as storage is routinely replaced.
  - Enterprise businesses can choose to encrypt only their regulated data, because managing the keys and the overall encryption process remains complex.
  - Small and medium-size companies can consider encrypting just about everything to ease the management challenge of determining what to encrypt.

3.12 IBM System Storage DS Storage Manager

The IBM System Storage DS Storage Manager software is used to configure, manage, and troubleshoot the Disk System. Its front-end component, the Storage Manager client, is a Java based management tool that is available for various operating systems.

This tool is used primarily to configure RAID arrays and logical drives, assign logical drives into storage partitions, replace and rebuild failed disk drives, expand the size of the arrays and logical drives, and convert from one RAID level to another. It allows troubleshooting and management tasks, such as checking the status of the Disk System components, updating the firmware of the RAID controllers, and managing the Disk System. Finally, it offers advanced functions such as FlashCopy, Enhanced Remote Mirroring and VolumeCopy (these are premium features that need to be purchased).

IBM DS Storage Manager(SM)10.70 is the most recent version available at the time of writing this book. This version of the DS Storage Manager host software is required for managing the DS5300-all models, the DS5100-all models, the DS5020-all models, and the DS3950-all models with controller firmware version 07.70.xx.xx. In addition, it is also preferable for managing DS4000 storage subsystems with controller firmware version 05.40.xx.xx or higher installed.

Figure 3-15 and Figure 3-16 show the Summary tab and the Logical tab of the Storage Manager with a DS5000 storage subsystem.

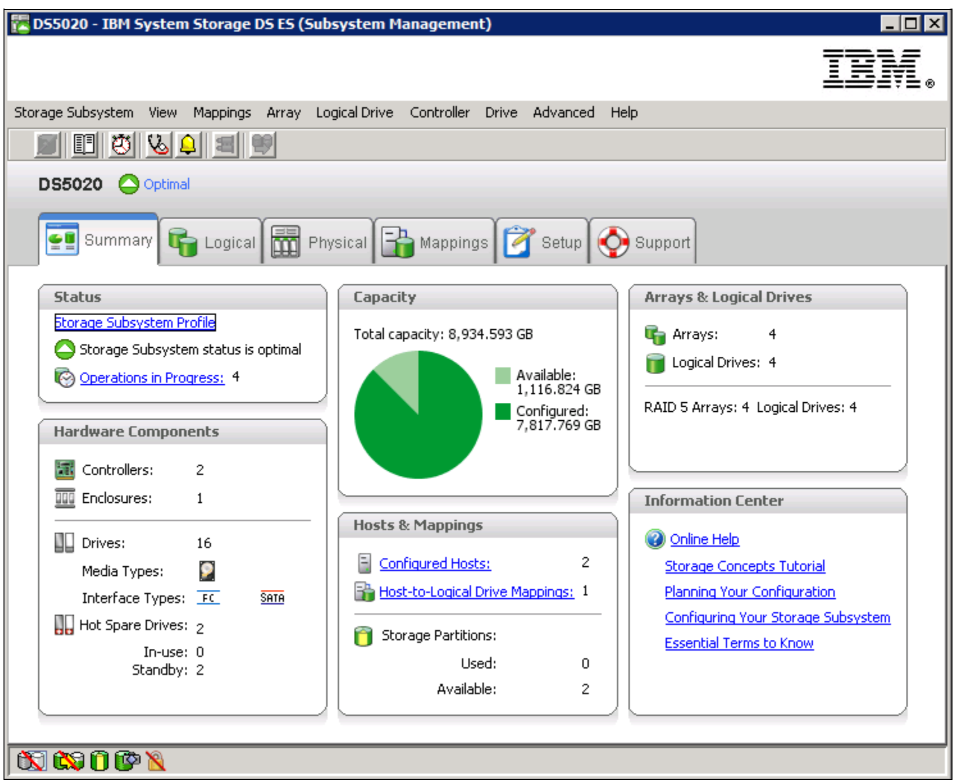


Figure 3-15 Storage Manager Example - Summary

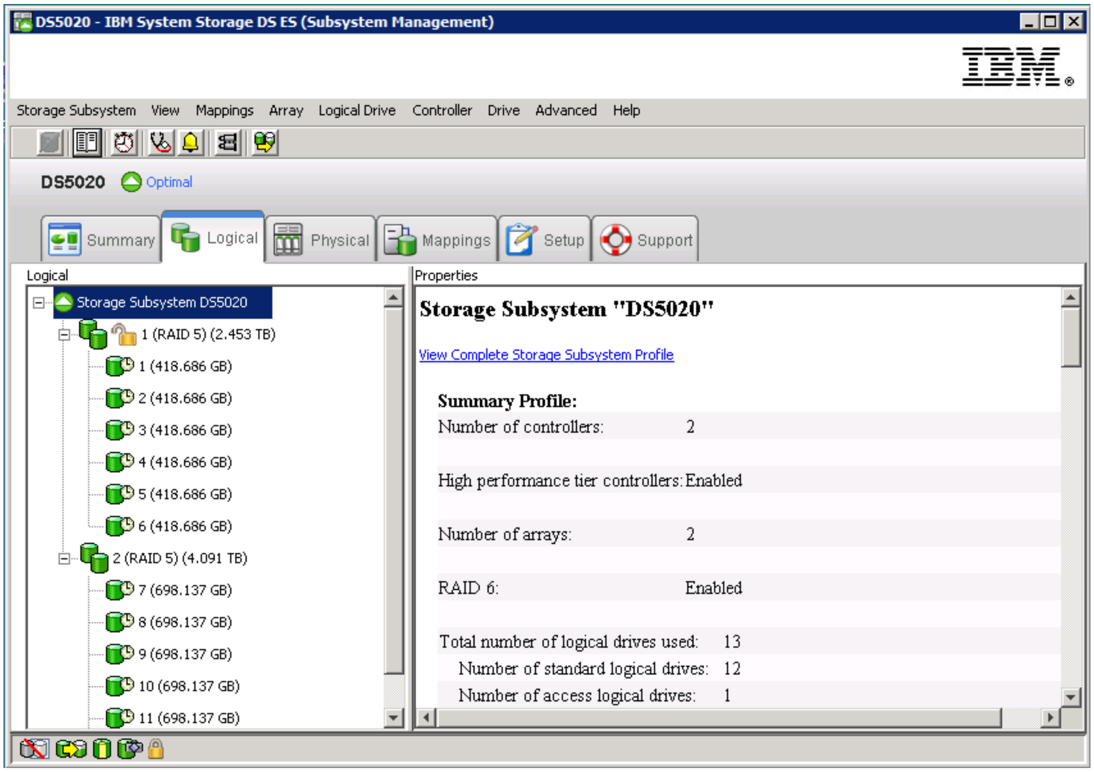


Figure 3-16 Storage Manager Example - Logical

Next we describe the latest enhancements to the Storage Manager:

- IBM DS Storage Manager Version 10.70 (controller code Version 7.70) includes all the functions already available in previous Storage Manager releases, and also offers several significant new features. The previous enhancements are listed at the end of this section.
- The controller code (firmware) Version 7.60(and above) is based on a new layered code design that provides better scalability and flexibility for future code enhancements. As part of the new design, the configuration database (DACStor region) has also been restructured. This new structure provides the foundation for supporting new features such as greater than 2 TB logical drives, RAID-6, and an increased number of logical partitions.
- The new 7.70 firmware is only supported on the DS4200, DS4700, DS4800, DS5020, and the DS5100/DS5300. Former DS4000 models (such as the DS4500 or DS4300) must remain at the latest compatible 6.xx firmware. Those former models can, however, be managed from Storage Manager V10.70 client.

3.12.1 New features

The DS Storage Manager version 10.70.xx.10 host software in conjunction with controller firmware version 7.70.23.xx provides support for:

- Support for SSD drives in the DS5020 storage subsystem.
- Storage subsystem password required for all subsystems running 7.70.xx.xx controller firmware.

Product details: See the DS4000/DS5000 README files for details on the Dependencies, Limitations, and Enhancements associated with your storage products.

3.12.2 Other features

In this section we describe the dynamic expansion features of Storage Manager:

- Dynamic Volume Expansion (DVE):

  DVE is a modification operation that you can use to increase the capacity of a standard logical drive or a FlashCopy repository logical drive. To increase the capacity, a DVE operation uses the free capacity that is available on the logical drive group of the logical drive. The operation is considered to be dynamic because you can continuously access data on logical drive groups, logical drives, and disk drives during the operation.

- Dynamic Capacity Expansion (DCE):

  DCE is the ability to increase the available free capacity on an array without needing to restart the host system, and is a very important feature. In today's IT environment, the need for storage space grows constantly. Many customers exhaust their existing space sooner or later and have to expand their storage capacity. It is essential that this process be non-disruptive and not cause any downtime. With DS4000 Storage Manager, you can simply add new disk drives to the Disk System and start the expansion procedure while the system remains fully operational. After the procedure starts, you cannot stop it. Be aware that you might see a performance impact because the expansion process competes with normal disk access.

Further dynamic volume/array reconfiguration such as changing the logical drive segment size (DSS) and changing the RAID level (DRM) are discussed in more detail in the following Redbooks publications

- *IBM System Storage DS4000 and Storage Manager V10.30*, SG24-7010
- *IBM Midrange System Storage Hardware Guide*, SG24-7676
- *IBM System Storage DS3500: Introduction and Implementation Guide*, SG24-7914

3.13 Introduction to IBM Midrange Storage Copy Services

This section provides a high-level overview of the difference in functionality between FlashCopy, VolumeCopy, and Enhanced Remote Mirror features, which are supported on all of the midrange storage servers mentioned in this Redbooks publication.

Customers in today's IT world require good archives of their data as well as the ability to create these archives with minimal interruptions. The IBM Midrange Storage Subsystem helps to fulfill these requirements by offering three premium features for Copy Services: *FlashCopy, VolumeCopy, and Enhanced Remote Mirroring (ERM)*.

All of these three premium features can be used individually, or can be combined together to help with providing a solution to customers for designing a disaster recovery answer for their critical data protection needs. All of these premium features require license keys for activation. FlashCopy and ERM can be purchased individually, however VolumeCopy requires the purchase of a combined FlashCopy and VolumeCopy license key.

In the following section, we present a brief overview of these premium features and their capabilities. For more information, see the *IBM System Storage DS Storage Manager Copy Services Guide*, SG24-7822.

3.13.1 FlashCopy premium feature

When customers are in need of doing their backups, they frequently want to do so without requiring long application backup windows. With the IBM Midrange Storage Subsystem, this capability is handled by using the FlashCopy feature.

A FlashCopy can be used to create a virtual logical drive that is a point-in-time (PiT) image of a real logical drive. The FlashCopy is the logical equivalent of its complete physical source copy, at the time created, but it is created in seconds and requires much less physical resources than a full copy of the source to another logical drive might take. Flashcopies can be used for performing backup images, to create a temporary test image and to create a source image for a VolumeCopy operation that can be copied without extended impacts to the production operations.

Using the FlashCopy also requires the use of less physical disk space, because it makes use of a repository logical drive for storing only data change operations that have been made since its creation. Because the FlashCopy is not a full physical copy, if the source logical drive is damaged, the FlashCopy logical drive itself cannot be used to recover it.

Figure 3-17 shows how FlashCopy works.

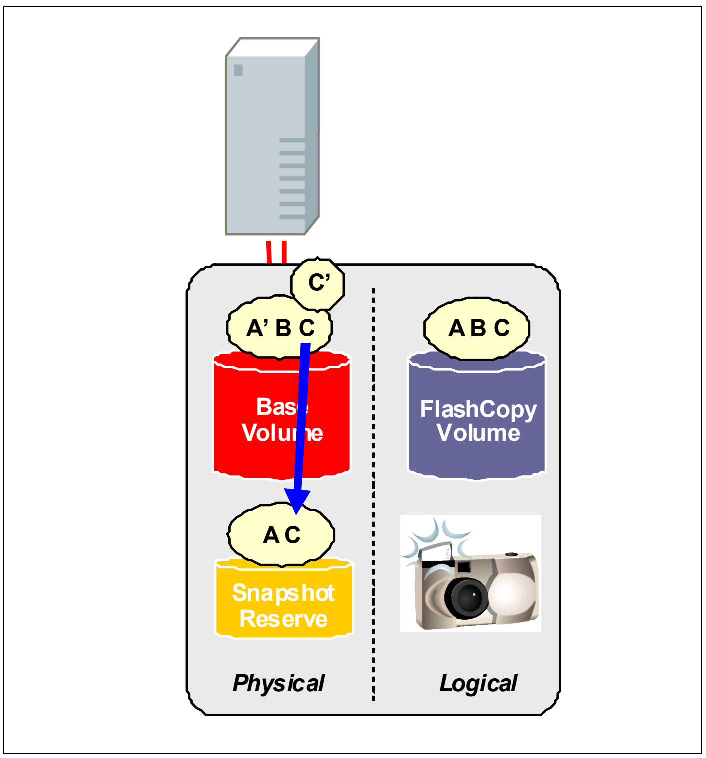


Figure 3-17 FlashCopy

The Storage Management software issues a warning message when the FlashCopy repository logical drive nears a user-specified threshold (a percentage of its full capacity; the default is 20 percent). When this condition occurs, you can use the Storage Manager software to expand the capacity of your FlashCopy repository logical drive from free capacity on the array.

3.13.2 VolumeCopy

The VolumeCopy premium feature is used to copy data from one logical drive (source) to another logical drive (target) to create a complete PiT image copy to a target logical drive within a single IBM Midrange Storage Subsystem. The target logical drive is an exact copy or clone of the source logical drive. This feature can be used to migrate data from one array to another. There is no requirement that the arrays be of a common RAID type, physical drive type or size, only that the target logical drive be of at least the same size in capacity as the source.

VolumeCopy is a full PiT replication of the source; which enables its use for the creation of a logical drive image to be used in analysis, data mining, and testing without placing additional overhead on the source production logical drives.

Figure 3-18 shows how VolumeCopy works.

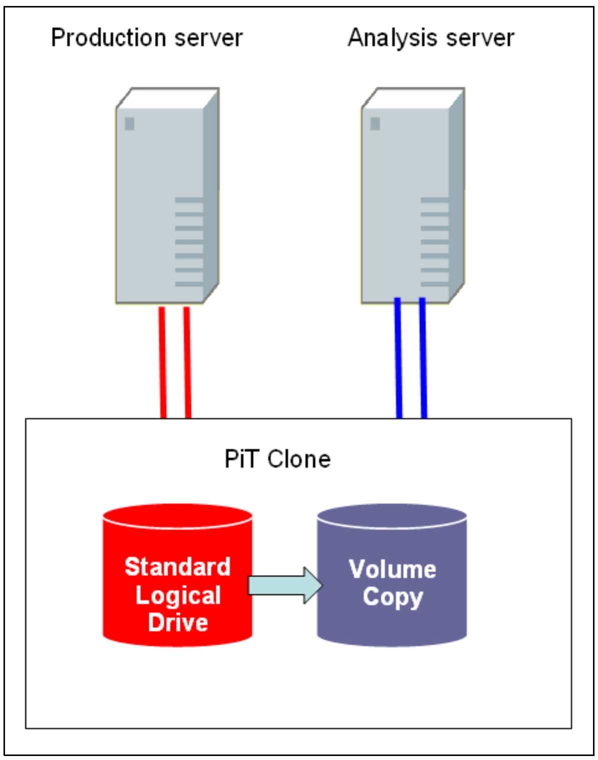


Figure 3-18 VolumeCopy

VolumeCopy does require the source logical drive to be quiesced while the target is being created so the image is not being changed while the copy is being done. To enable minimal impact here, this is best performed in conjunction with the FlashCopy feature.

Figure 3-19 shows how this process works.

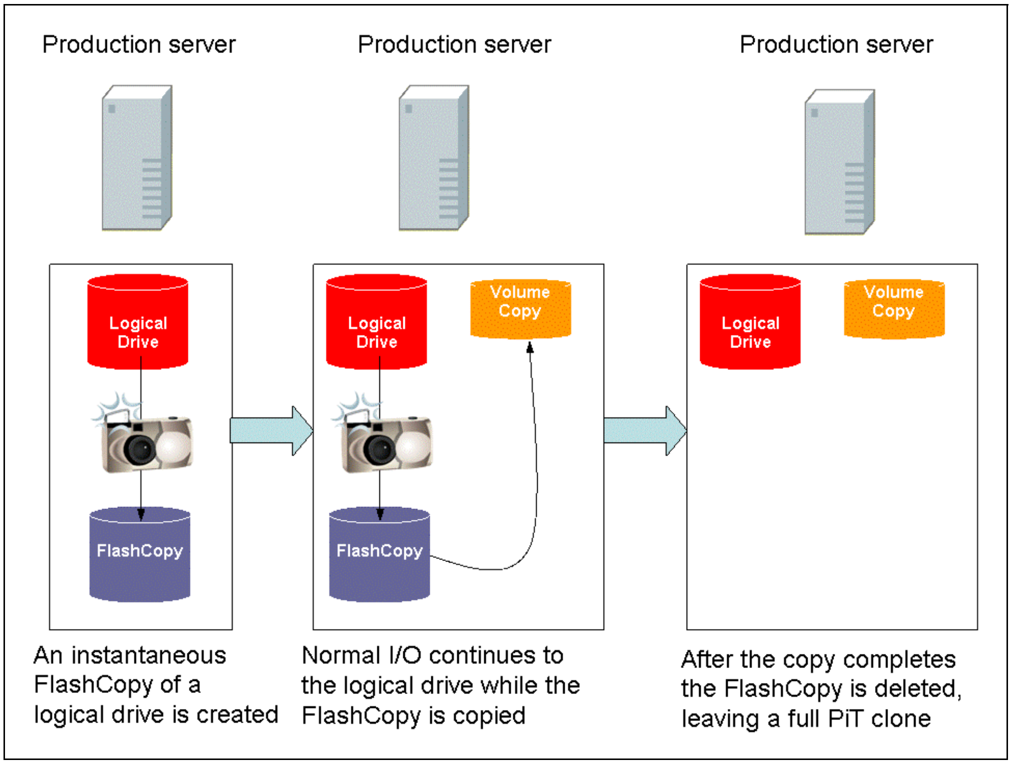


Figure 3-19 VolumeCopy integration with FlashCopy

3.13.3 Enhanced Remote Mirroring

Enhanced Remote Mirroring (ERM) or Remote Mirroring is the premium feature that enables the IBM Midrange Storage Subsystem to create a full image mirror of its logical drives on a second IBM Midrange Storage Subsystem, and keep both images synchronized with each other.

ERM is generally used by customers to migrate their data from one subsystem to another, or it is used as the remote mirroring engine for their disaster recovery solution (DR) between two site locations over varying distances.

The ERM option is used for online, real-time replication of data between storage subsystems over a remote distance (Figure 3-20). In the event of disaster or unrecoverable error at one storage subsystem, you can promote the second storage subsystem to take over responsibility for normal I/O operations. Currently, a high number of mirror relationships are supported per DS storage subsystem.

Figure 3-20 shows how ERM works.

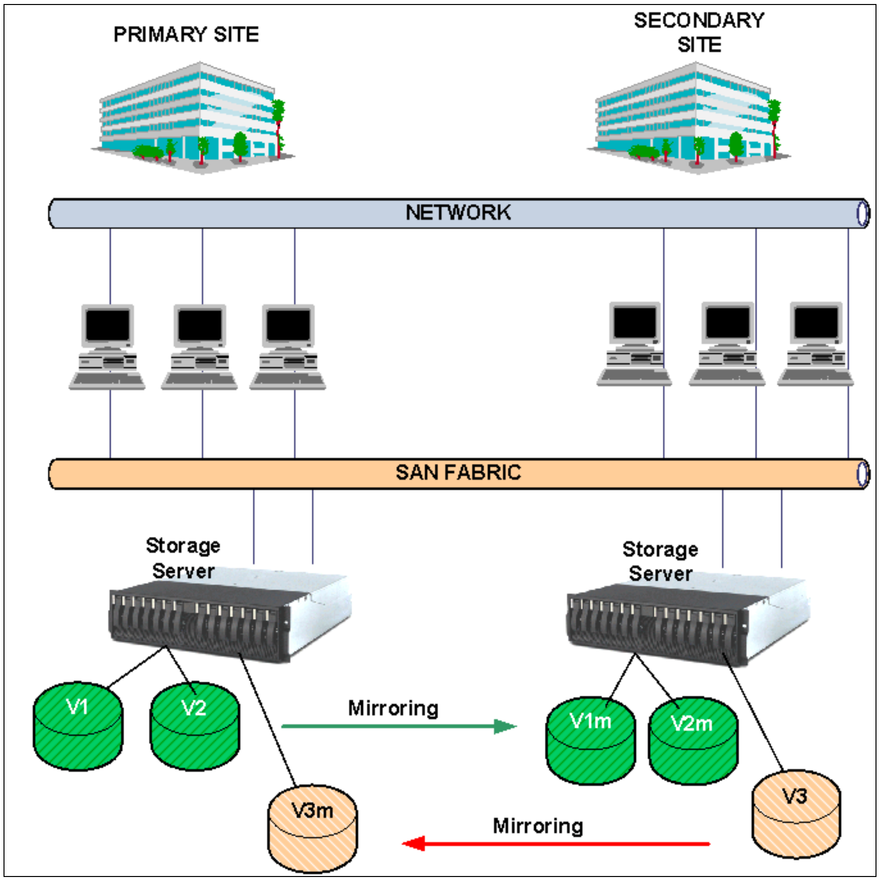


Figure 3-20 ERM

ERM supports three methods of creating the target images over various distances and networks. In the following topics, we describe the mirroring methods that are supported.

Metro Mirror method

Metro mirroring is a synchronous mirroring method, generally used for campus or local (up to 10 mile) distances. Any host write request is written to the primary (local) storage subsystem and then transferred to the secondary (remote) storage subsystem. The host application must wait until receiving acknowledgement that the write request has been executed on both (local and remote) storage controllers.

Global mirror method

Global mirroring is an asynchronous method of mirroring that also uses write order consistency (WOC) to ensure that the IO changes are sent to the secondary in the same sequence as they were processed on the primary. This method must be used when the host application has critical data to be mirrored, spread across several logical drives. This method writes all requests from a host to the primary (local) storage subsystem and immediately reports them as completed to the host. Doing this ensures that the inter-dependent write requests are carried out in the same order at the remote site as they were performed at primary (local) site so that it performs the mirroring writes in the same order that they were received. This is accomplished through the use of a consistency group that tracks the order in which the member logical drives' IOs were received and processed.

Global copy method

Global copy is a second asynchronous ERM write method. With this method, all write requests from a host are written to its primary (local) storage subsystem and immediately reported as completed back to the host system as is done with global mirroring as just described. The secondary (target) is also written to at a later time however, there is no inter-dependency check done to any of the other logical drives to determine if there are any relationships there. This method of mirroring can be used to copy static logical drives that have no IO being performed to them; or to mirror LUNs which are totally independent from all other logical drives that are being mirrored.

For information about the Copy Services, see the following Redbooks publications:

- *IBM System Storage DS4000 and Storage Manager V10.30*, SG24-7010
- *IBM System Storage DS Storage Manager Copy Services Guide*, SG24-7822
- *IBM System Storage DS3500: Introduction and Implementation Guide*, SG24-7914
- *IBM Midrange System Storage Hardware Guide*, SG24-7676
- *IBM Midrange System Storage Implementation and Best Practices Guide*, SG24-6363
- *IBM System Storage DS3000: Introduction and Implementation Guide*, SG24-7065

3.14 IBM Remote Support Manager for Storage

The storage challenges facing businesses are very demanding. Faster response times are needed for alerts, more detailed information is needed from these alerts in order to resolve the potential issue, and they need to be resolved in a timely manner. DS Remote Support Manager (DS-RSM) Model RS3 is an integrated solution designed to help address these challenges.

3.14.1 Overview

DS-RSM is designed to manage problem reporting and resolution for the IBM entry and midrange disk systems by providing the following capabilities:

- Fast response time to alerts
- Detailed information about each alert for analysis and accuracy
- Management for up to 50 storage systems per implementation and with no annual fees for lower IT costs
- Security designed to give control of remote access and notifications when remote users connect
- Compatibility with your existing IBM Storage Manager client application to help detect events
- Fast problem resolution by sending log and status with the initial alert to IBM
- Ability for IBM service to remotely connect and obtain additional information and logs to aid problem determination and speed problem resolution

What Remote Support Manager for Storage does

The IBM Remote Support Manager for Storage (RSM for Storage) software installs on an IBM System x server running Novell SUSE Linux Enterprise Server 9, SUSE Linux Enterprise Server 10, Red Hat Enterprise Linux 4 Advanced Server, or Red Hat Enterprise Linux 5 and provides problem reporting and remote access for IBM Service for the DS3000, DS4000, and DS5000 families of IBM storage subsystems.

The problem reporting provided by RSM for Storage automatically creates an entry in the IBM call management system for each subsystem that reports a problem. This is the equivalent of placing a voice call to IBM Service for a problem. After being entered into the IBM call management system, problems are responded to with the same priority as specified by the maintenance agreement in place for the product.

RSM for Storage controls security for remote access by managing hardware and software components of the server it is installed on. After being installed, the server has to be considered a single purpose appliance for problem reporting and remote access support for your storage subsystems. Only applications approved by IBM and specified in this document are to be installed. (Management of the internal firewall and other configuration changes made by the software might prevent other applications from working.) There is no guarantee that applications that work with the current version of RSM for Storage will continue to work with future releases.

Remote access to the RSM for Storage system by IBM Support is provided by either an external modem attached to the server or by an external SSH connection. This connection provides IBM Service with a command-line interface to the server. All bulk data transfers for logs and other problem determination files are sent to IBM by email using the server's Ethernet interface. Isolation of remote and local users of the system from other devices on your intranet is performed by an internal firewall that is managed by the RSM for Storage software. Local and remote IBM users of the system do not have the ability to change any security features of the software.

Figure 3-21 shows the RSM for Storage layout.

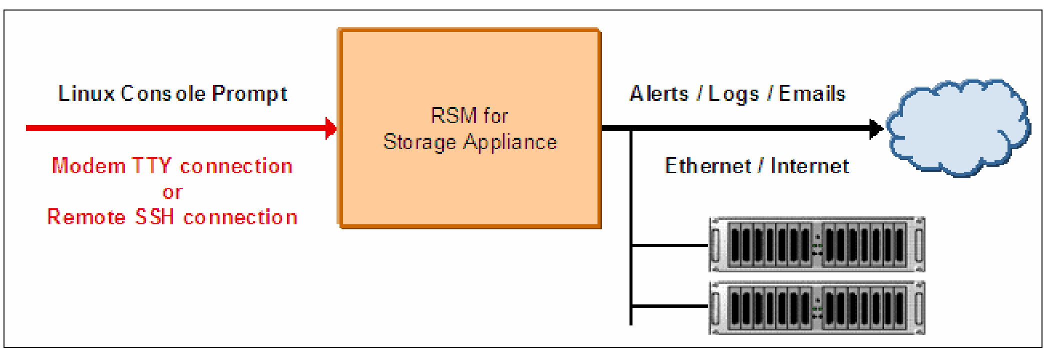


Figure 3-21 RSM for Storage layout

Monitoring of storage subsystems is performed by your existing IBM DS Storage Manager software, which is configured to send SNMP traps to the Remote Support Manager when critical events are detected. Configuration of the management application is addressed later in this document.

The RSM for Storage user interface allows you to control and view status of four management areas:

- System configuration
- Reporting
- Remote access
- Internal firewall

Your configured contact person for RSM for Storage will also receive emails of status changes in these areas.

Supported products

The RSM for Storage software supports the subsystems, management applications, and other SAN devices outlined in the following sections.

Storage subsystems

The RSM for Storage software supports the DS3000, DS4000, and DS5000 families of mid-range storage subsystems. The storage subsystems must be covered under warranty or a current IBM maintenance agreement to be eligible to use the RSM for Storage software.

Storage management applications

The RSM for Storage software works with the Event Monitor of IBM DS Storage Manager. While you can use other applications for routine management of your storage subsystems, DS Storage Manager's Event Monitor must be running.

Other SAN devices

While RSM for Storage does not support problem reporting for other SAN devices (such as switches), you can specify other devices in the RSM for Storage configuration in order to permit IBM Service to access the management ports of these devices for problem determination. Remote access to these devices must be enabled by the administrator of RSM for Storage when access is required.

3.14.2 Hardware and software requirements

RSM for Storage has the following hardware and software requirements.

Hardware requirements

IBM internal databases that support RSM for Storage use the IBM Machine Type and Serial Numbers of the servers, and therefore an IBM System x server must be used. This is required in order to properly register heartbeat records from the RSM for Storage system in IBM tracking databases. RSM for Storage can be run on a dedicated System x server or in a VMware client running on a System x server.

For the minimum server requirements and a list of the specific servers that have been tested with the RSM software, see the *IBM RSM for Storage Compatibility Guide*, available at:

http://www.ibm.com/support/docview.wss?uid=psg1MIGR-66062&rs=594

Suggested servers

The following servers have been tested with the RSM for Storage software, and installation instructions are available for configuring and using them with RSM for Storage software:

- IBM System x3250 4364
- IBM System x306m 8849
- IBM System x3550 7978
- IBM System x3550m2 7946
- IBM System x3550m3 7944
- IBM DS-RSM Model RS3 (1818-RS3)

The DS-RSM Model RS3 solution includes the following components:

- IBM System x3550 M3 (Type 7944) server configured with 2.13GHz IntelXeon processor, 4 GB system memory, two 146 GB 10,000 rpm SAS disk drives (configured as RAID 1) and dual power supplies
- Novell SUSE Linux Enterprise Server (SLES) 10 SP3 operating system (preinstalled)
- IBM Remote Support Manager software (preinstalled)

The following optional features are available with the DS-RSM solution:

- Keyboard/Video/Mouse (KVM) assembly (feature number 2510)
- Internal Modem (feature number 2512)

For specific information about the BIOS configuration and device drivers that might be required to install the Linux OS on the foregoing servers, see the document *IBM Remote Support Manager for Storage: Installation Hints and Tips* , available at this website

http://www.ibm.com/support/docview.wss?uid=psg1MIGR-66062&rs=594

DS-RSM Model RS3 (1818-RS3) replaces the DS-RSM Model RS2 (1818-RS2), and provides the same functional capabilities with comparable performance. DS-RSM Model RS3 includes IBM Remote Support Manager Software preinstalled on an IBMSystem x3550 M3 server.

Additionally, the DS-RSM Model RS3 is designed to enable the following capabilities:

- IBM to establish communication with the attached supported storage systems
- Faster response time on processing alerts
- The ability to transfer detailed information to assist error analysis
- Enhanced problem resolution

The DS RSM can help improve and facilitate service and support for DS series disk storage systems. Additionally, for each data center with a DS employed, it is desirable to install at least one DS RSM that will be operational with all of the DS5000/DS4000/DS3000 controllers located at the site. Each DS RSM unit has the capability to manage up to 50 DS5000/DS4000/DS3000 storage systems.

Figure 3-22 shows the DS RSM Model RS3.

Figure 3-22 DS RSM Model RS3

RSM requires a service contract. You can contact your IBM representative for further information regarding the service offering.

Installing on other IBM servers

You can use other System x servers that meet the following requirements:

- Memory: 512 MB memory is required.
- Disk space: 20 GB disk space is required.
- Serial port: The serial port must be on the server system board. Some servers have a build-in Remote Supervisor Adapter (RSA) that also includes a serial port. The serial port on the RSA cannot be accessed by the RSM for Storage software.
- Ethernet port: Note that if your SAN devices are on a private management LAN, a second Ethernet port for accessing your company's SMTP server and the Internet will be required if your selected server has only a single Ethernet port.

Other servers: To use servers other than those specifically tested with RSM for Storage, you will need to see the System x server support website for technical information about BIOS configuration and device drivers that might be required to install the Linux OS or configure the server's internal RAID capability.

The *IBM RSM for Storage Compatibility Guide* also contains the setup required for a VMware client that will host the Linux operating system running RSM for Storage.

RSM for Storage in a VMware virtual client

RSM for Storage has been tested for operation in a VMware virtual client. For specific configurations, see the *IBM RSM for Storage Compatibility Guide*.

In setting up the virtual client, allocate the following resources:

- Storage: 20 GB HDD.
- Memory: 512 MB.
- Assign exclusive physical ownership of the host system's first serial port to the virtual client as /dev/ttyS0.

The client must be configured to automatically start when the host reboots.

RSM for Storage has been tested on both SLES 10 and RHEL 5 running on an System x server with the following servers:

- VMware Server 1.05, 2.0
- VMware ESX Server 3

Software requirements

The RSM for Storage software requires the following prerequisite software to monitor an IBM System Storage DS subsystem:

- IBM System Storage DS Storage Manager V10.70 or later (the latest version is suggested) with Event Monitor installed on a management station in a different server.
- Storage subsystems with controller firmware supported by Storage Manager V10.70 or later. The latest supported firmware version is suggested.
- One of the following operating systems to install the RSM for Storage software:
  - Novell SUSE Linux Enterprise Server 9 (SP3 or SP4)
  - Novell SUSE Linux Enterprise Server 10 (Base, SP1, SP2, SP3)
  - Red Hat Enterprise Linux 4 AS (Update 4, 5, or 5)
  - Red Hat Enterprise Linux 5 (Base, Update 1, 2, 3, 4)

RSM for Storage software receives SNMP traps from the Event Monitor included with the Storage Manager. RSM for Storage software cannot be installed on the same system used to manage your storage network.

Support: See the *IBM RSM for Storage Compatibility Guide* for the latest update of supported servers, modem, and operating systems. The document can be downloaded from the following web page:

http://www.ibm.com/support/docview.wss?uid=psg1MIGR-66062&rs=594

3.14.3 DS-RSM Model RS3

The IBM System Storage DS Remote Support Manager for Storage (DS-RSM) Model RS3 server is available to simplify the task of obtaining the hardware and software components required for running the RSM for Storage software. The DS-RSM Model RS3 (Figure 3-23) can be ordered as an appliance with your IBM DS3500 System Storage storage subsystem.

The DS-RSM Model RS3 is designed to help manage problem reporting and analyze alert notifications for IBM System Storage DS subsystems. The DS-RSM Model RS3 contains more advanced processor and memory technology for enhanced processing capabilities. The DS-RSM Model RS3 can attach to the LAN and collects alerts from IBM System Storage DS subsystems within the data center and expedite forwarding of the alerts to an IBM Service center.

Figure 3-23 DS-RSM Model RS3

Additionally, the DS-RSM Model RS3 is designed to enable the following capabilities:

- IBM to establish communication with the attached supported storage systems
- Faster response time on processing alerts
- The ability to transfer detailed information to assist error analysis
- Enhanced problem resolution

The DS-RSM Model RS3 can help improve and facilitate service and support for the DS storage subsystems. Additionally, IBM suggest that, for each data center with a DS storage subsystem present, that you install at least one DS-RSM Model RS3 that can interoperate with all of the DS5000/DS4000/DS3000 controllers located at the site. Each DS-RSM Model RS3 unit has the capability to manage up to 50 DS5000/DS4000/DS3000 storage systems.

DS-RSM Model RS3 is compatible with the following IBM System Storage DS subsystems:

- DS3000 series
- DS4000 series
- DS5000 series

The DS-RSM model RS3 is based on the System x3550 M3 Type 7944 server. The server is preloaded with Novell SLES 10 and RSM for Storage software. An internal modem is available as an option if you choose to use a modem to provide remote access for IBM Service. The internal modem might not be compatible in all countries or regions. In that case, you can provide an external modem appropriate for your phone system. As an alternative to using a modem, you can allow remote access using an external SSH connection. A keyboard, mouse, and monitor are required by IBM Service for installation and troubleshooting of the DS-RSM Model RS3 server. An optional, rack-mounted KVM drawer can be ordered with the DS-RSM Model RS3 server in order to meet this requirement.

3.14.4 Installation choices for RSM for Storage

Various options exist for how RSM for Storage can be set up, as shown in Figure 3-24.

For the latest information related to these options, see the *IBM RSM for Storage Compatibility Guide* and the *IBM Remote Storage Manager for Storage Planning, Installation and Users Guide,* found at the following address:

http://www.ibm.com/support/docview.wss?uid=psg1MIGR-66062&rs=594

Installation Choices

Hardware choices	Build your own	Use existing hardware	Use your own server and obtain a supported version of the Linux. The system act as a gateway for IBM Support with limited scope of access to your network.	RSM documentation has step by step procedures for installing the Linux OS and the RSM for Storage software. Decide if you will allow IBM support to connect via a modem or SSH
		Order a new System x server	Order a new System x server for use with RSM for Storage and get the Linux OS as a drop in the box option	
		Run in a VMware guest OS	Install a supported OS distribution in a VMware system and reduce your hardware costs.	Consider hosting your SAN Management Station and the RSM for Storage on the same VMware platform.
	DS-RSM	Purchase a RSM ready appliance	DS-RSM is reloaded with SLES 10 and RSM software and optional internal modem.	DS-RSM is installed and supported by IBM. You will need to complete the installation worksheet and have networking infrastructure in place in order for IBM to complete the configuration.
Remote Access	Problem reports are sent to IBM via email. You must choose a method of remote access.	SSH	Requires configuration of your external firewall	The use of an authentication server adds another layer of access control.
		Modem	Requires an analog phone line and modem.	You can use most external modems or if using the DS-RSM, order it with an internal modem adapter.
OS	RSM for Storage is a collection of software elements that integrates with a Linux OS	SLES	9.3 & 9.4 10.0, 10.1, 10.2 & 10.3	The DS-RSM is preloaded with Novell SLES 10.3
		RHEL	4.4, 4.5 & 4.6 5.0, 5.1, 5.2, 5.3 & 5.4	RHEL is only available on "build your own" systems.
KVM	RSM requires an attached monitor, mouse and keyboard for some tasks		As the system can be anywhere in your network, you can connect to a KMV switch with other severs.	The DS-RSM can be ordered with a rack mounted KVM kit.

Figure 3-24 RSM Installation choices

3.15 More information

More detailed information about the DS4000 and DS5000 families can be found in the following publications and websites:

- *Deployment Guide Series: IBM TotalStorage Productivity Center for Data*, SG24-7140
- *IBM i and Midrange External Storage*, SG24-7668
- *IBM Midrange System Storage Hardware Guide*, SG24-7676
- *IBM Midrange System Storage Implementation and Best Practices Guide*, SG24-6363
- *IBM System Storage DS Storage Manager Copy Services Guide*, SG24-7822
- *IBM System Storage DS3000: Introduction and Implementation Guide*, SG24-7065
- *IBM System Storage DS3500: Introduction and Implementation Guide*, SG24-7914
- *IBM System Storage DS4000 and Storage Manager V10.30*, SG24-7010
- *IBM System Storage FlashCopy Manager and PPRC Manager Overview*, REDP-4065
- Interoperability matrix:

  http://www.ibm.com/servers/storage/disk/ds4000/interop-matrix.html
  http://www-03.ibm.com/systems/storage/disk/ds5000/interop-matrix.html
- Servers and storage:

  http://www.ibm.com/servers/storage/disk/index.html

4

Enterprise Disk Systems

The family of IBM Enterprise Disk Systems offers a broad range of scalable solutions to address various enterprise storage needs. By making use of IBM leading technology, the Enterprise Disk Systems provide a significant choice in functionality, performance, and resiliency.

In this chapter, we discuss the features and major characteristics of the following enterprise disk storage products:

- IBM System Storage DS8000 Series:
  - IBM System Storage DS8700 (type 242x model 941 and 94E)
  - IBM System Storage DS8800 (type 242x model 951 and 95E)
- IBM System Storage XIV (type 281x model A14)

The previous DS8000 series models, DS8100 and DS8300 (types 2107 and 242x, models 931, 932, and 9B2), have been withdrawn from marketing and are not covered in this chapter.

4.1 Enterprise Disk Family: Overview

The IBM Enterprise Disk Systems deliver high-performance, high-availability storage, with flexible configurations for various business requirements. The IBM System Storage DS8000 and XIV deliver an enterprise storage continuum of systems designed to help simplify the storage infrastructure, support business continuity, and optimize information lifecycle management. See Figure 4-1 for an overview of the Enterprise Disk Family.

Figure 4-1 Enterprise Disk Systems

For a quick overview of storage solutions, see the *IBM System Storage Product Guide* at this website:

http://www.ibm.com/systems/storage/resource/pguide/

The enterprise disk products are listed at the website.

http://www.ibm.com/systems/storage/disk/enterprise

4.1.1 DS8000 series overview

The IBM System Storage DS8000 series is designed for the most demanding, mission critical environments requiring the highest level of availability. The DS8000 series is designed to set an entirely new industry standard for high performance and high capacity by delivering a dramatic leap in performance and scalability.

All DS8000 series models consist of a storage unit and one or two management consoles, two being the preferred configuration. The hardware has been optimized to provide enhancements in performance, connectivity, and reliability. The DS8000 series features several models in a new, higher-density footprint, while re-using much of the fundamental architecture of the previous IBM Enterprise Storage Server (ESS) models. This ensures that the DS8000 benefits from a very stable and well-proven operating environment.

During recent years, the DS8000 series were developed and improved; this process is still ongoing and brings new solutions and technologies to the DS Family. In the following sections we describe innovations and new implementations for the DS8700 and DS8800.

For more information about the DS8000, see the following references:

- In this book, see 4.3, “DS8000 series” on page 117.
- *IBM System Storage DS8000: Architecture and Implementation*, SG24-6786

- *IBM System Storage DS8700 Architecture and Implementation*, SG24-8786
- *IBM System Storage DS8800 Architecture and Implementation*, SG24-8886

4.1.2 XIV series overview

The XIV Storage System architecture is designed to deliver performance, scalability, and ease of management while harnessing the high capacity and cost benefits of Serial Advanced Technology Attachment (SATA) drives. The system employs off-the-shelf products as opposed to traditional offerings that use proprietary designs and therefore require more expensive components. The main idea of this machine is the Modules architecture based on the massive parallelism: The system architecture ensures full exploitation of all system components.

The IBM XIV Storage System is a next-generation high-end open disk storage system. An integral part of the IBM broad spectrum of system storage and SAN offerings, the XIV system is based on a grid of standard, off-the-shelf hardware components connected in any-to-any topology by means of massively paralleled, non-blocking Gigabit Ethernet. Its innovative architecture is designed to deliver the highest levels of reliability, performance, scalability, and functionality at low overall cost, while providing unprecedented ease of management.

For more information about the XIV, see 4.4, “IBM XIV Storage System” on page 177, and the book, *IBM XIV Storage System: Architecture, Implementation, and Usage*, SG24-7659.

4.2 Enterprise Disk Solutions

IBM Enterprise Disk Systems are designed for high performance that takes advantage of IBM leading technologies. In today’s world, enterprises need business solutions that can deliver high levels of performance continuously every day, day after day. They also need a solution that can handle various workloads simultaneously, so they can run business intelligence models, large databases for enterprise resource planning (ERP), and online and Internet transactions alongside each other. In this section we present some of the business solutions addressed by IBM Enterprise Disk systems.

4.2.1 Infrastructure simplification

The IBM System Storage DS Family and XIV offers the opportunity to simplify your IT infrastructure through consolidation and streamlined storage management.

Consolidating storage assets

Consolidation begins with interoperability. The IBM System Storage DS Family and XIV can be connected across a broad range of server environment, including AIX, i5/OS®, Linux, HP-UX, Sun SOLARIS, Novell NetWare, UNIX, and Microsoft Windows. IBM DS8000 series also support IBM z/OS, z/VM®, and OS/400®. You can easily split storage capacity among the attached servers, reducing the total number of storage systems required.

Streamlining storage management

The IBM System Storage DS Family and XIV incorporates streamlined management tools with an easy-to-use and straightforward GUI based on open Storage Management Initiative Specification (SMI-S) interfaces. The GUI allows users to manage multiple subsystems and controllers, perform logical configurations, and administer copy service management functions, all by a web browser.

There is a set of common functions for storage management, including the IBM System Storage DS Command-Line Interface (DS CLI) and the IBM System Storage DS open application programming interface (API). The XIV Storage System offers a comprehensive set of Extended Command Line Interface (XCLI) commands to configure and monitor the system. All the functions available in the GUI are also available in the XCLI.

Advanced copy functions and storage management tools are described later in this chapter.

4.2.2 Business continuity

The IBM Enterprise Family offers the capability to increase your IT continual operation tolerance by data protection and compatible copying service.

Data protection

Many design characteristics and advanced functions of the IBM Enterprise Disk Systems contribute to protect data effectively:

- Fault-tolerant:

  The IBM System Storage DS8000 and XIV series are designed with no single point of failure. They are fault-tolerant storage subsystems that can be maintained and upgraded concurrently with user operations.

- RAID and mirroring protected storage:

  The IBM DS Family Systems support RAID 5, RAID 6, and RAID 10 configurations, or a combination of them. This gives more flexibility when selecting the redundancy technique for data protection. RAID 6 protection provides more fault tolerance than RAID 5 in the case of disk failures and uses less raw disk capacity than RAID 10.

  The XIV systems use no regular RAID. XIV mirrors every 1 MB data chunk in two different modules. That way there are always two copies of data in two different and redundant parts of the system.

Copy Services

IBM FlashCopy point-in-time copy functions support higher application availability and continuity of operations because they are designed to shrink backup window time. Metro and Global Mirror functions allow for creation of duplicate copies of application data at remote sites for rapid recovery purposes.

The IBM System Storage DS Family also supports open standards. As a result, you can mirror a DS8000 series system with an existing DS6000™ series system to help lower the total cost of the disaster recovery solution.

XIV supports business continuity through synchronous and asynchronous differential mirroring that offers flexible backup and restore options between remote sites for rapid recovery.

Copy Services can be managed and automated with Tivoli Storage Productivity Center for Replication. For information regarding supported systems and functions, see Chapter 19, “IBM Tivoli Storage Productivity Center” on page 603 and *IBM Tivoli Storage Productivity Center V4.1 Release Guide*, SG24-7725.

4.2.3 Green Data Center

Faced with increasingly urgent warnings about the consequences of the projected rise in both energy demands and greenhouse gas emissions, governments and businesses alike are now focusing more attention than ever on the need to improve energy efficiency. Corporate data centers are well known as significant power users.

IBM launched the Green Data Center environment in a very responsible *green* way, which is catching the attention of many companies. IBM Enterprise products can provide huge increases in processing, with dramatically less power consumption and lower carbon output.

For more information about creating a Green Data Center, call your IBM representative or visit following web page:

`http://www.ibm.com/cio`

4.3 DS8000 series

Organizations in nearly every industry are facing the challenge of exponential data growth. Storage systems are being stretched and multiple system architectures combined to meet these demands. The IBM System Storage DS8000 series offers high-performance, high capacity, secure storage systems that are designed to deliver the highest levels of performance, flexibility, scalability, resiliency and total overall value for the most demanding, heterogeneous storage environments.

The DS8000 series offers a unique combination of flexibility, resiliency, performance, and scalability, which can help address the many challenges stemming from the exponential growth of data across the enterprise. As organizations evolve their data centers to become smarter, they are looking for innovative ways to manage and adapt in today's increasingly competitive, global business environment, and the DS8000 series is designed to meet this challenge.

The physical storage capacity of the DS8000 series systems can range from 2.3 TB to 2048 TB. The system can start small and easily scale to large levels of storage by adding DS8000 expansion enclosures to your environment. A DS8000 system is shown in Figure 4-2.

The DS8000 delivers robust, flexible, and cost-effective disk storage for mission-critical workloads and helps to ensure exceptionally high system availability for continuous operations in 24x7 environments.

Figure 4-2 DS8000 base frame with covers removed (left) and with expansion (right)

4.3.1 DS8000 concepts

In this section we present some explanation about DS8000 concepts, data types, storage hierarchy, and a mainframe capability called Parallel Access Volumes.

Fixed block and count key data

The DS8000 series is compatible with mainframes and open systems. In this chapter and other DS8000 related books, you will see the Fixed Block (FB) and Count Key Data (CKD) denominations. Next we provide a brief explanation for better understanding.

In fixed block (FB) architecture, the data (the logical volumes) are mapped over fixed-size blocks or sectors. With an FB architecture, the location of any block can be calculated to retrieve that block. This architecture uses tracks and cylinders. On a physical disk there are multiple blocks per track, and a cylinder is the group of tracks that exists under the disk heads at one point in time without performing a seek operation.

In count-key-data (CKD) disk data architecture, the data field stores the user data. Because data records can be variable in length, in CKD they all have an associated count field that indicates the user data record size. The key field enables a hardware search on a key. The commands used in the CKD architecture for managing the data and the storage devices are called channel command words.

Open systems utilize FB architecture and mainframes use CKD architecture.

DS8000 storage hierarchy

The DS8000 series implement a virtualized storage hierarchy as discussed in “Virtualization and configuration flexibility” on page 126. This offers great flexibility in LUN creation and use. In this section we present some concepts that are important for understanding DS8000 configurations.

Extent pools

An extent pool is a logical construct that is used to manage a set of extents of the same type that are associated with a given rank group.

When an extent pool is defined, it must be assigned a rank group and an extent type. One or more ranks with the same extent type can be assigned to an extent pool, but a rank can be assigned to only one extent pool. There can be as many extent pools as there are ranks. There are no constraints on the number or size of ranks assigned to the extent pool. All extents of the ranks assigned to an extent pool are independently available for allocation to logical volumes that are associated with the extent pool.

Typically, all the ranks within an extent pool have the same characteristics relative to RAID type, disk-drive module (DDM) RPM, and DDM interface rate. This allows for a differentiation of logical volumes by assigning them to the appropriate extent pool for the desired characteristics. Different extent sizes for the same device type (for example, count-key-data or fixed block) can be supported on the same storage image, but these different extent types must be in different extent pools.

Logical control unit

A logical control unit (LCU) represents a logical subsystem for System z hosts.

For System z hosts, a logical subsystem represents an LCU. Each LCU is associated with only one logical subsystem and groups logical volumes in groups of up to 256 logical volumes.

Logical volumes

A logical volume is the storage medium that is associated with a logical disk. It typically resides on one or more hard disk drives.

For the storage unit, the logical volumes are defined at logical configuration time. For count-key-data (CKD) servers, the logical volume size is defined by the device emulation mode and model. For fixed block (FB) hosts, you can define each FB volume (LUN) with a minimum size of a single block (512 bytes) to a maximum size of 2^{32} blocks or 2 TB.

A logical device that has nonremovable media has one and only one associated logical volume. A logical volume is composed of one or more extents. Each extent is associated with a contiguous range of addressable data units on the logical volume.

Logical configuration overview

In the storage hierarchy, you begin with a physical disk. Logical groupings of eight disks form an array site. Logical groupings of one array site form an array. After you define your array storage type as CKD or FB, you can create a rank. A rank is divided into a number of fixed-size extents. If you work with an open-systems host, an extent is 1 GB. If you work in an IBM System z environment, an extent is the size of an IBM 3390 Mod 1 disk drive.

After you create ranks, your physical storage can be considered virtualized. Virtualization dissociates your physical storage configuration from your logical configuration, so that volume sizes are no longer constrained by the physical size of your arrays.

The available space on each rank is divided into extents. The extents are the building blocks of the logical volumes. An extent is striped across all disks of an array.

Extents of the same storage type are grouped together to form an extent pool. Multiple extent pools can create storage classes that provide greater flexibility in storage allocation through a combination of RAID types, DDM size, DDM speed, and DDM technology. This allows a differentiation of logical volumes by assigning them to the appropriate extent pool for the desired characteristics. Different extent sizes for the same device type (for example, CKD or FB) can be supported on the same storage unit, but these different extent types must be in different extent pools.

A logical volume is composed of one or more extents. A volume group specifies a set of logical volumes. By identifying different volume groups for different uses or functions (for example, SCSI target, FICON/ESCON® control unit, remote mirror and copy secondary volumes, FlashCopy targets, and Copy Services), access to the set of logical volumes that are identified by the volume group can be controlled. Volume groups map hosts to volumes. Figure 4-3 shows a graphic representation of the logical configuration sequence.

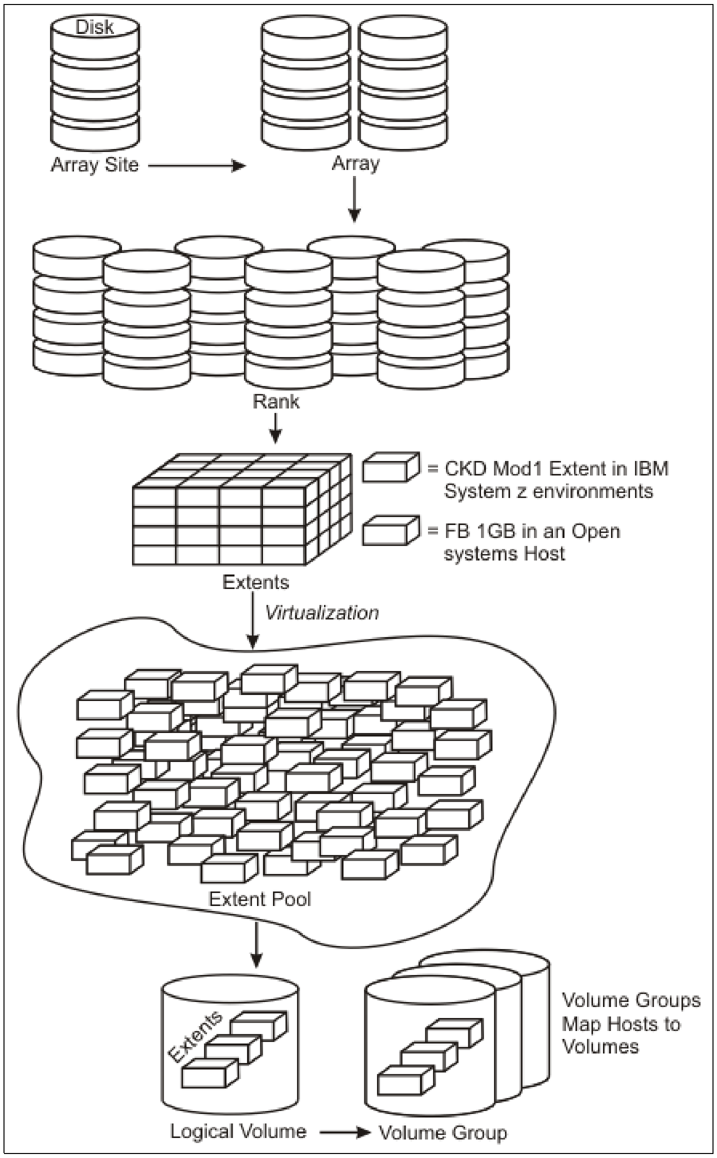


Figure 4-3 DS8000 storage hierarchy

Parallel access volumes

Parallel access volumes (PAVs) provide your system with access to volumes in parallel when you use a System z or S/390® host.

A PAV capability represents a significant performance improvement by the storage unit over traditional I/O processing. With PAVs, your system can access a single volume from a single host with multiple concurrent requests.

You must configure both your storage unit and operating system to use PAVs. You can use the logical configuration definition to define PAV-bases, PAV-aliases, and their relationship in the storage unit hardware. This unit address relationship creates a single logical volume, providing concurrent I/O operations.

Static PAV associates the PAV-base address and its PAV aliases in a predefined and fixed method. That is, the PAV-aliases of a PAV-base address remain unchanged. Dynamic PAV, however, dynamically associates the PAV-base address and its PAV aliases. The device number types (PAV-alias or PAV-base) must match the unit address types as defined in the storage unit hardware.

You can further enhance PAV by adding the IBM HyperPAV feature. IBM HyperPAV associates the volumes with either an alias address or a specified base logical volume number. When a host system requests IBM HyperPAV processing and the processing is enabled, aliases on the logical subsystem are placed in an IBM HyperPAV alias access state on all logical paths with a given path group ID.

Support: The IBM HyperPAV feature is only supported on FICON channel paths.

PAVs can improve the performance of large volumes. You get better performance with one base and two aliases on a 3390 Model 9 than from three 3390 Model 3 volumes with no PAV support. With one base, it also reduces storage management costs that are associated with maintaining large numbers of volumes. The alias provides an alternate path to the base device. For example, a 3380 or a 3390 with one alias has only one device to write to, but can use two paths.

The storage unit supports concurrent or parallel data transfer operations to or from the same volume from the same system or system image for System z or S/390 hosts. PAV software support enables multiple users and jobs to simultaneously access a logical volume. Read and write operations can be accessed simultaneously to different domains. (The domain of an I/O operation is the specified extents to which the I/O operation applies.)

4.3.2 The DS8000 series design keys

The DS8000 series incorporates performance, resiliency, and scalability features. In this section we discuss key architectural basics of DS8000 and improvements of DS8700 and DS8800. From an architectural point of view, the DS8700 and DS8800 have not changed much with respect to the fundamental architecture of the predecessor DS8100 and DS8300 models. This ensures that the new models can benefit from a very stable and well-proven operating environment, offering the optimum in availability. Their hardware have been optimized to provide higher performance, connectivity, and reliability.

Server-based design

The design decision to use processor memory as I/O cache is a key element of the IBM Enterprise storage architecture. Performance improvements can be traced to the capabilities of the processor speeds, the L1/L2 cache sizes and speeds, the memory bandwidth and response time, and the PCI bus performance. This architecture is used since the first ESS E models, using PowerPC® based RS6000 H50 servers, to the actual POWER6+™ based servers on the DS8800 model.

With the DS8000 series, the cache access has been accelerated further by making the non-volatile storage (NVS) a part of the main memory. Part of the memory is used for the operating system and another part in each controller card acts as non-volatile storage (NVS), but most of the memory is used as cache. This design to use processor memory makes cache accesses very fast.

IBM POWER processor technology

The DS8100 and the DS8300 used the IBM POWER5™ server technology. They used 64-bit POWER5 microprocessors in dual 2-way or dual 4-way processor complexes, with up to 256 GB of cache.

The DS8700 uses the IBM POWER6®, and the DS8800 uses the IBM POWER6+ processor. They both run symmetric multiprocessor (SMP) system featuring 2-way or 4-way processor configuration.

Compared to the POWER5+™ processor in previous models, the POWER6 processor can enable over a 50% performance improvement in I/O operations per second in transaction processing workload environments. Additionally, sequential workloads can receive as much as 150% bandwidth improvement. Compared to the POWER6 processor in DS8700 models, the DS8800 POWER6+ processor offers up to over a 40 percent performance improvement.

Multipathing software

IBM Multipath Subsystem Device Driver (SDD) provides load balancing and enhanced data availability in configurations with more than one I/O path between the host server and the storage server. Most vendors' priced multipathing software selects the preferred path at the time of initial request. IBM free of charge preferred path multipathing software dynamically selects the most efficient and optimum path to use at each data interchange during read and write operations.

Multi-tiered storage environments

The DS8000 series is ideally suited to a multi-tiered storage environment. This helps minimize storage costs by retaining frequently accessed or high-value data on higher performance disk and archiving less frequently accessed or less valuable information about less-costly and high-capacity disk.

Switched Fibre Channel Arbitrated Loop (Switched FC-AL)

There is a switched FC-AL implementation in the DS Family (Figure 4-4). This switching technology uses a point-to-point connection to each disk drive and adapter, which allows maximum bandwidth for data movement, eliminates the bottlenecks of loop designs, and allows for specific disk drive fault indication and isolation in the same time. Each disk is attached to both switches. Whenever the device adapter connects to a disk, it uses a switched connection to transfer data. This means that all data travels by the shortest possible path.

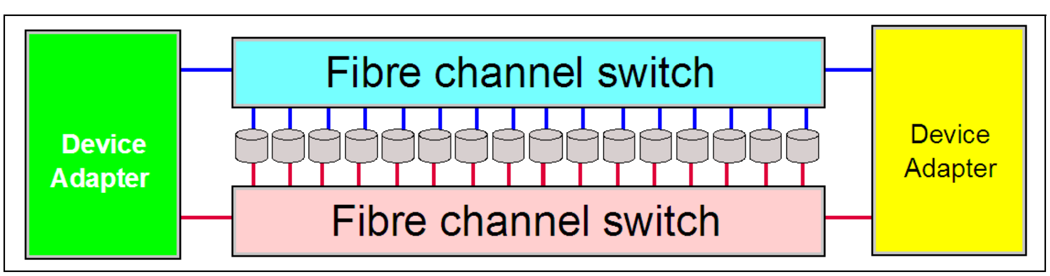


Figure 4-4 Disk enclosure switched connections (considering DS8700 Fibre Channel connections)

Features of FC-AL technology

Key features of switched FC-AL technology are as follows:

- Standard FC-AL communication protocol from DA to DDMs
- Direct point-to-point links are established between DA and DDM
- Isolation capabilities in case of DDM failures, providing easy problem determination
- Predictive failure statistics
- Simplified expansion: No cable rerouting is required when adding another disk enclosure

The DS8000 architecture employs dual redundant switched FC-AL access to each of the disk enclosures. The key benefits of doing this are as follows:

- Two independent networks to access the disk enclosures
- Four access paths to each DDM
- Each device adapter port operating independently
- Double the bandwidth over traditional FC-AL loop implementations

Figure 4-5 shows the connections in a DS8700.

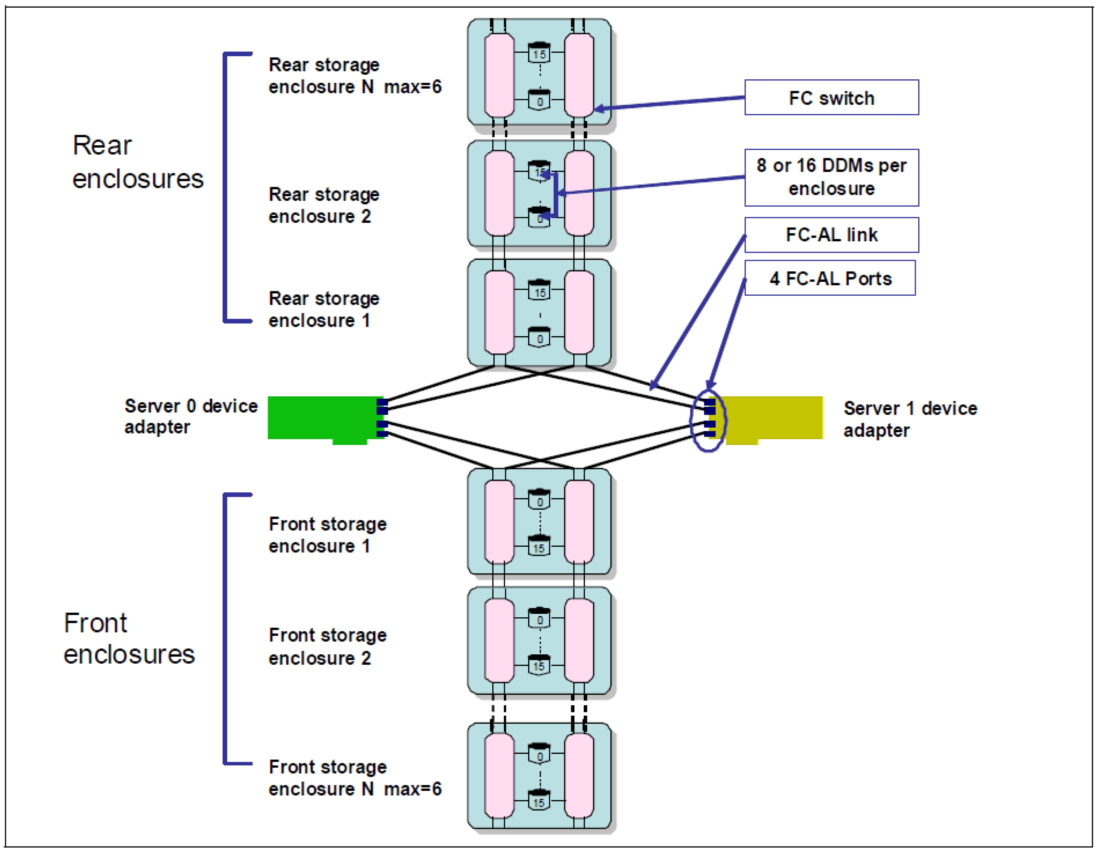


Figure 4-5 DS8700 switched disk expansion

Figure 4-6 shows how each DS8800 DA connects to the two disk networks (*loops*).

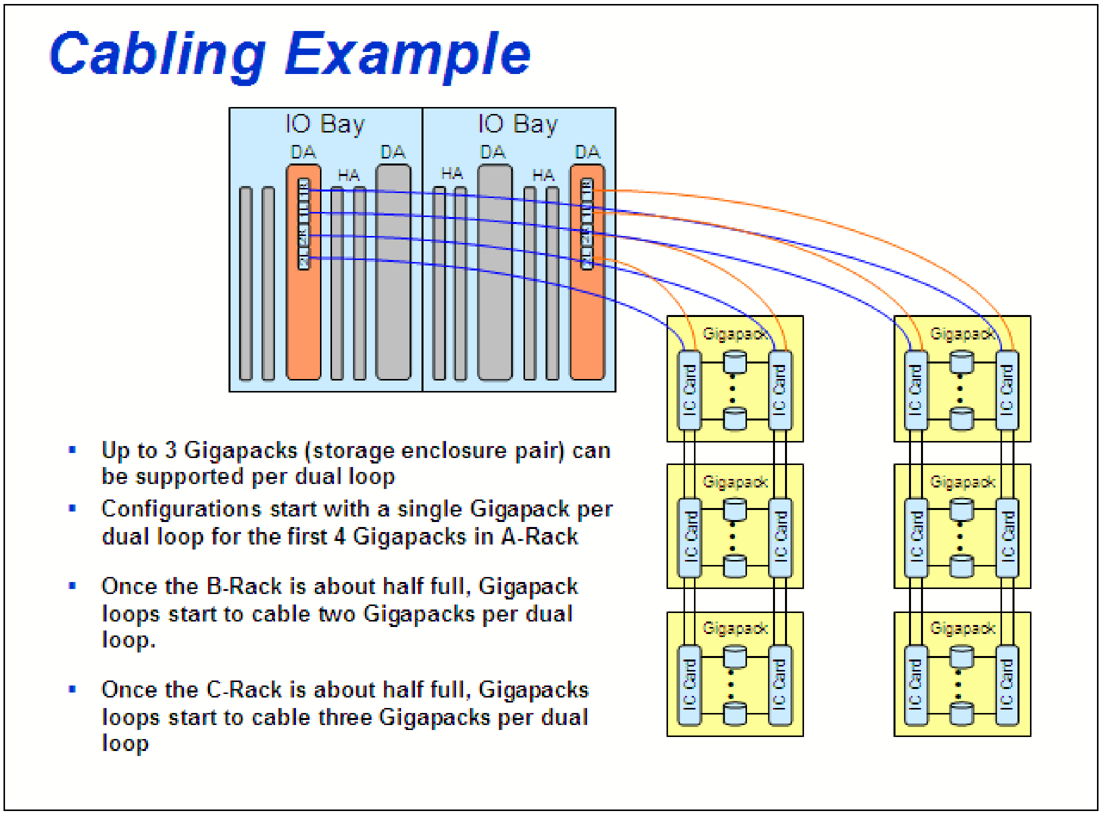


Figure 4-6 DS8800 switched disk expansion

Expansion is achieved by adding enclosures to the expansion ports of each switch. Each loop can potentially have up to six enclosures.

Arrays across loops

Each array site consists of eight DDMs. Four DDMs are taken from the upper enclosure in an enclosure pair, and four are taken from the lower enclosure in the pair. This means that when a RAID array is created on the array site, half of the array is on each enclosure. Because the front enclosures are on one switched loop, and the rear enclosures are on a second switched loop, this splits the array across two loops. This is called *array across loops* (AAL).

Four path switched drive subsystem

There are four paths from the device adapters to each disk drive to provide greater data availability in the event of multiple failures along the data path (Figure 4-7). The four paths provide two FC-AL device interfaces, each with two paths such that either path can be used to communicate with any disk drive on that device interface (in other words, the paths are redundant). One device interface from each device adapter connects to a set of FC-AL devices such that either device adapter has access to any disk drive through two independent switched fabrics (in other words, the device adapters and switches are redundant).

In normal operation, however, disk drives are typically accessed by one device adapter and one server. Each path on each device adapter can be active concurrently, but the set of eight paths on the two device adapters can all be concurrently accessing independent disk drives. This avoids any contention between the two device adapters for access to the same disk, and means that all eight ports on the two device adapters can be concurrently communicating with independent disk drives.

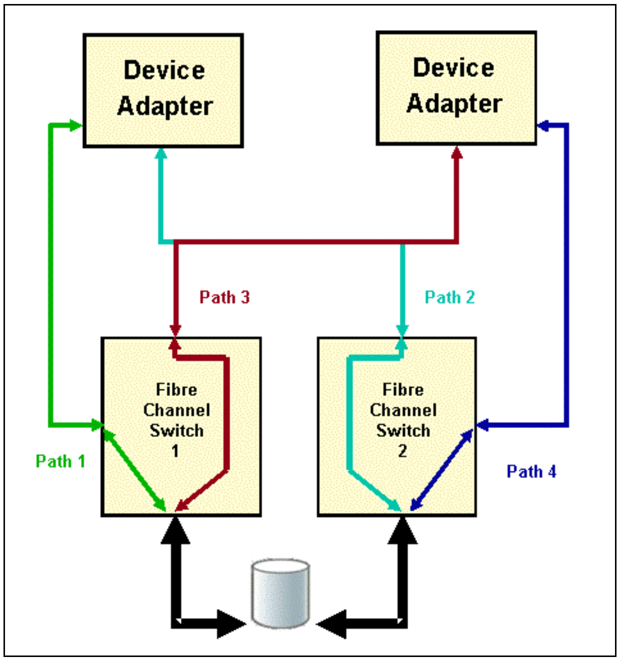


Figure 4-7 Four paths to each disk drive

Self-learning cache algorithms: SARC

The DS8000 use the Sequential Prefetching in Adaptive Replacement Cache (SARC) algorithm, developed by IBM Storage Development in partnership with IBM Research. It is a self-tuning, self-optimizing solution for a wide range of workloads with a varying mix of sequential and random I/O streams. SARC is inspired by the Adaptive Replacement Cache (ARC) algorithm and inherits many features from it.

When a host performs a read I/O, the DS8000 fetch the data from the disk arrays through the high performance switched disk architecture. The data is then cached in volatile memory in case it is required again. The DS8000 attempt to anticipate future reads by the SARC algorithm. Data is held in cache as long as possible using this smart algorithm. If a cache hit occurs where requested data is already in cache, then the host does not have to wait for it to be read from the disks.

SARC provides the following benefits:

- Sophisticated algorithms to determine what data is to be stored in cache based upon the recent access and frequency needs of the hosts.
- Pre-fetching, which anticipates data prior to a host request and loads it into cache.

Predictive Failure Analysis

The DS Enterprise Family uses Predictive Failure Analysis (PFA) to monitor disk drive operations. PFA takes preemptive and automatic actions before critical drive failures occur. The disk drives can anticipate certain forms of failures by keeping internal statistics of read and write errors. If the error rates exceed predetermined threshold values, the drive will be nominated for replacement. Because the drive has not yet failed, data can be copied directly to a spare drive. This avoids using RAID recovery to reconstruct all of the data onto the spare drive.

Virtualization and configuration flexibility

The DS8000 use virtualization techniques to separate the logical view of hosts from the underlying physical layer, as discussed in "Logical configuration overview" on page 119. On the old ESS, there was a fixed association between logical subsystems (LSS) and device adapters. With the DS8000, these limitations no longer apply (Figure 4-8).

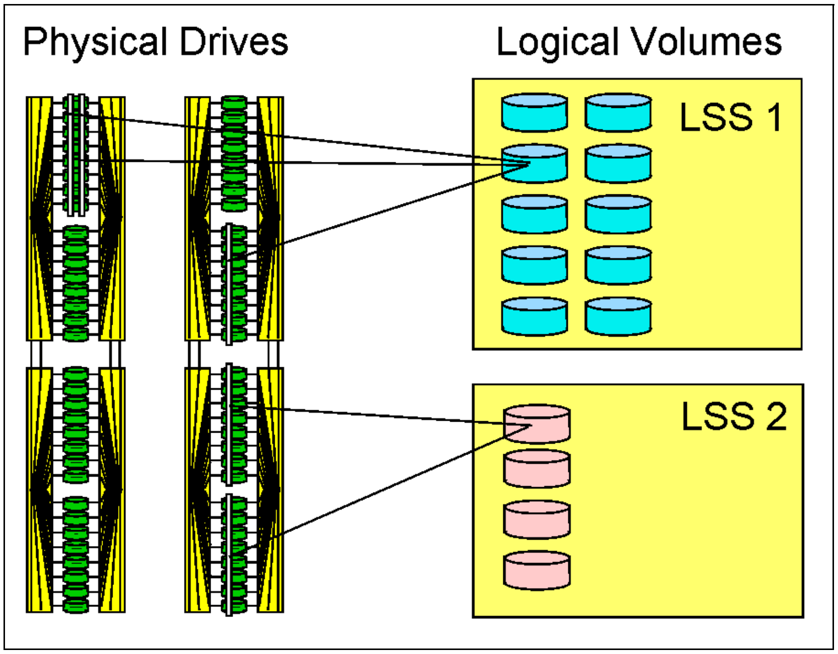


Figure 4-8 Grouping of volumes in LSSs

Through virtualization, organizations can allocate system resources more effectively and better control application quality of service. With no predefined association of arrays to LSSs on the DS8000 series, users are free to put LUNs or CKD volumes into LSSs and make best use of the 256 address range, overcoming previous ESS limitations, particularly for System z.

The DS8000 series provide a high configuration flexibility with the following virtualization techniques:

- Dynamic Logical Unit (LUN) or Volume creation and deletion:

  LUNs can be created and deleted without having to reformat a whole array.

- Large LUN and large CKD volume support:

  LUNs and volumes can be configured to span arrays, which allows for large LUN sizes.

- Flexible LUN to LSS association:

  There is no predefined association of arrays to logical subsystems (LSS).

- Simplified LUN masking:

  The access to LUNs by the host systems is controlled by volume groups. Hosts or disks in the same volume group share access to data.

4.3.3 Overview of DS8000 recent features and technology

In this section we present an overview of the most recent DS8000 features and technology.

Thin provisioning or space efficient volumes

The Thin Provisioning feature provides over-provisioning capability for more efficient usage of the storage capacity and reduced storage management requirements, hence improving cost efficiency and reducing the Total Cost of Ownership (TCO).

The DS8700 provides two different types of Space Efficient volumes: Track Space Efficient volumes and Extent Space Efficient volumes. Both of these features enable over-provisioning capabilities that provide the customers with benefits in terms of more efficient usage of the storage capacity and reduced storage management requirements.

> **Support:** At the time of writing, thin provisioning is not yet supported on DS8800.

A Space Efficient (or thin-provisioned) volume does not occupy physical capacity when it is created. Space gets allocated when data is actually written to the volume. The amount of space that gets physically allocated is a function of the amount of data written to or changes performed on the volume. The sum of capacities of all defined Space Efficient volumes can be larger than the physical capacity available.

For more information, see *DS8000 Thin Provisioning*, REDP-4554 or the announcement letter, available at:

http://www.ibm.com/common/ssi/rep_ca/1/897/ENUS109-431/ENUS109-431.PDF

Space Efficient FlashCopy

The FlashCopy SE capability enables more Space Efficient utilization of capacity for FlashCopy operations, improving cost effectiveness.

How it works

FlashCopy Space Efficient (SE) uses Space Efficient volumes as FlashCopy target volumes. A Space Efficient target volume has a virtual size that is equal to or greater than the source volume size. However, space is not allocated for this volume when the volume is created and the FlashCopy initiated. Only when updates are made to the source volume will any original tracks of the source volume (that will be modified) are copied to the Space Efficient target volume. Space in the repository is allocated for just these tracks or for any write to the target itself.

For more information, see *IBM System Storage DS8000 Series: IBM FlashCopy SE*, REDP-4368.

Limitations

Most options available for standard FlashCopy (as discussed in “IBM System Storage FlashCopy: Point-in-Time Copy feature” on page 166) are also available for FlashCopy SE. Only the options that differ are discussed in this section.

- Incremental FlashCopy:

  Because Incremental FlashCopy implies an initial full volume copy, and a full volume copy is not possible in an IBM FlashCopy SE relationship, Incremental FlashCopy is not possible with IBM FlashCopy SE.

- Data Set FlashCopy:

  FlashCopy SE relationships are limited to full volume relationships. As a result, data set level FlashCopy is not supported within FlashCopy SE.

- Multiple Relationship FlashCopy SE:

  Standard FlashCopy supports up to 12 relationships and one of these relationships can be incremental. There is always some impact when doing a FlashCopy or any kind of copy within a storage subsystem. A FlashCopy onto a Space Efficient volume has more impact because additional tables have to be maintained. All IBM FlashCopy SE relations are nocopy relations; incremental FlashCopy is not possible. Therefore, the practical number of IBM FlashCopy SE relationships from one source volume will be lower than 12. You need to test in your own environment how many concurrent IBM FlashCopy SE relationships are acceptable from a performance standpoint.

- Consistency Group FlashCopy:

  With IBM FlashCopy SE, consistency groups can be formed in the same way as with standard FlashCopy, as discussed in "IBM System Storage FlashCopy: Point-in-Time Copy feature" on page 166. Within a consistency group, there can be a mix of standard FlashCopy and IBM FlashCopy SE relationships.

Quick Initialization

IBM now supports Quick Initialization for open (FB) volumes as an enhancement to device provisioning technology on DS8700 platforms. Quick initialization improves initialization speeds up to 2.6 times over previous versions of the DS8700 and allows a copy services relationship to be established after a device is created, while the provisioning of storage is in progress. These improvements can help allow users to create an enterprise storage environment, quickly provision new logical devices, and move the devices into production while utilizing the new thin provisioning technology in less time than ever before on DS8700 systems.

> **Support:** At the time of writing, the Quick Initialization feature is not supported on DS8800.

Remote Pair FlashCopy

The Remote Pair FlashCopy feature (not in Licensed Machine Code 5.4.3x.xx) enables more effective two-site business continuity with FlashCopy and Metro Mirror. It allows you to establish a FlashCopy relationship where the target is a remote mirror Metro Mirror primary volume keeping the pair in the full duplex state. This significantly reduces the recoverability time that exists when a FlashCopy background copy and Metro Mirror Resync are in progress. The Remote Pair FlashCopy provides a solution for data replication, data migration, remote copy, and disaster recovery tasks.

For business continuity, the Remote Pair FlashCopy operations are non-disruptive, allowing the primary device of each FlashCopy pair to remain available to all hosts for both read and write I/O operations. After being established, Remote Pair FlashCopy operations continue unattended to support continuous data backup to the secondary device. z/OS support of Remote Pair FlashCopy is available on z/OS V1.9, or later, using the name FlashCopy Preserve Mirror.

> **Support:** At the time of writing, Remote Pair FlashCopy is not yet supported on DS8800.

See *IBM System Storage DS8000: Remote Pair FlashCopy (Preserve Mirror)*, REDP-4504 for more information.

Multiple Global Mirror sessions

This allows creation of separate global mirror sessions so that separate applications can fail over to remote sites at different times. The support for this feature is available by RPQ only.

> **Support:** At the time of writing, the Multiple Global Mirror sessions feature is not yet supported on DS8800.

LDAP authentication support

The DS8000 provides support for both unified sign-on functions (available through the DS Storage Manager), and the ability to specify an existing Lightweight Directory Access Protocol (LDAP) server.

The LDAP server can have existing users and user groups that can be used for authentication on the DS8000. Setting up unified sign-on support for the DS8000 is achieved using the Tivoli Storage Productivity Center. The LDAP authentication support allows single sign-on functionality. This can simplify user management by allowing the DS8000 to rely on a centralized LDAP directory rather than a local user repository.

For more information, see *IBM System Storage DS8000: LDAP Authentication*, REDP-4505.

Data encryption

The DS8700 and DS8800 support data encryption with the use of Tivoli Key Lifecycle Manager (TKLM) and the IBM Full Disk Encryption feature. The IBM Tivoli Key Lifecycle Manager implements a key server application and integrates with certain IBM storage products. The Tivoli Key Lifecycle Manager can be installed on a set of servers to implement a set of redundant key servers.

Encryption capable storage devices that require key services from the key server are configured to communicate with one or more key servers and the key servers are configured to define the devices to which they are allowed to communicate. The storage device does not maintain a persistent copy of the data key. Therefore, the storage device must access the Tivoli Key Lifecycle Manager to encrypt or decrypt data. To enable encryption, the DS8000 must be configured to communicate with two or more Tivoli Key Lifecycle Manager key servers. The physical connection between the DS8000 HMC and the key server is through a TCP/IP network.

> **Encryption:** To use data encryption, a DS8000 must be ordered from the factory with all IBM Full Disk Encryption drives. At this time, DS8000 does not support intermix of FDE and non-FDE drives so additional drives added to a DS8000 must be consistent with the drives that are already installed.

Enhancements to disk encryption key management that can help address PCI-DSS (Payment Card Industry Data Security Standard) requirements:

- Encryption deadlock recovery key: Supports the ability for IBM to restore access to a DS8700 when the encryption key for the storage is unavailable due to an encryption deadlock scenario.
- Dual platform key server support: DS8000 requires an isolated key server in encryption configurations. The isolated key server currently defined is an IBM System x server. Dual platform key server support allows two different server platforms to host the key manager with either platform operating in either “clear key” or “secure key” mode.

Deadlock recovery

The DS8000 family of storage servers with Full Disk Encryption drives can utilize a System z key server running the Tivoli Key Lifecycle Manager (TKLM) solution. A TKLM server provides a robust platform for managing the multiple levels of encryption keys needed for a secure storage operation. System z mainframes do not have local storage; their operating system, applications, and application data are often stored on an enterprise-class storage server, such as a DS8000 storage subsystem. So it becomes possible, due to a planning error or even the use of automatically-managed storage provisioning, for the System z TKLM server storage to end up residing on the DS8000 that is a client for encryption keys. After a power interruption event, the DS8000 becomes inoperable because it must retrieve the Data Key (DK) from the TKLM database on the System z server. The TKLM database becomes inoperable because the System z server has its OS or application data on the DS8000. This represents a deadlock situation.

Recovery key

The DS8700 mitigates this problem by implementing a recovery key (RK). The recovery key allows the DS8700 to decrypt the Group Key (GK) that it needs to come up to full operation. A new customer role is defined in this process: the Security Administrator. This must be a different person from the Storage Administrator so that no single user can perform recovery key actions. Setting up the recovery key and use of the recovery key to boot a DS8700 requires both people to take action. Usage of a recovery key is entirely within the customer's control; no IBM service representative needs to be involved. The DS8700 never stores a copy of the recovery key on the encrypted disks and it is never included in any service data.

> **Support:** At the time of writing, encryption deadlock recovery disable key is not supported on DS8800.

For more information about encryption, see the following references:

- Chapter 20, "IBM Tivoli Key Lifecycle Manager" on page 667
- *IBM System Storage DS8700 Disk Encryption Implementation and Usage Guidelines*, REDP-4500
- *IBM System Storage DS8800 Architecture and Implementation*, SG24-8886
- IBM Encrypted Storage Overview and Customer Requirements website:

  http://www.ibm.com/support/techdocs/atsmastr.nsf/WebIndex/WP101479

Solid state drives

To improve data transfer rate (IOPS) and response time, IBM DS8000 series provides support for solid state drives (SSDs), which have improved I/O transaction-based performance over traditional platter-based drives. SSDs are a high-IOPS class enterprise storage device targeted at Tier 0 applications that can use a high level of fast-access storage. SSDs offer a number of potential benefits over hard disk drives, including up to 100 times the throughput and 10 times lower response time than 15K rpm spinning disks, lower power consumption, less heat generation, and lower acoustical noise.

> **Support:** SSDs are limited to 256 drives per the DS8700 system and 384 drives per DS8800 system. RAID 6 and RAID 10 are not supported for SSD arrays.

For more information about SSDs, see *DS8000: Introducing Solid State Drives*, REDP-4522.

Easy Tier

The IBM System Storage Easy Tier is a DS8000 built-in dynamic data relocation feature that allows a host transparent movement of data among the storage subsystem resources. This improves significantly the configuration flexibility and the performance tuning and planning.

Easy Tier feature helps enable more effective storage consolidation by taking the guesswork out of deploying solid-state drives. Easy Tier can automatically and dynamically move the appropriate data to the appropriate drive tier in the system, based on ongoing performance monitoring. The performance attributes of solid state drives are attractive but they remain considerably more expensive than traditional spinning disks. Without the tools to manage the effective placement of data across the various drive tiers in the system, you might have been unwilling to pay high premiums for SSDs without knowing exactly which data to place on them. For some organizations this is acceptable; for many others, the inefficient use of these expensive drives limits their appeal.

Automatic mode or manual mode

Easy Tier can operate in two modes:

- Easy Tier Automatic Mode:

  Easy Tier automatic mode is a facility that autonomically manages the capacity allocated in a DS8000 Extent Pool containing mixed disk technology (HDD + SSD) in order to place the most demanding pieces of data (hot data) on the appropriate storage media. The data relocation is at the extent level. This significantly improves the overall storage cost-performance ratio and simplifies the performance tuning and management. This is shown in Figure 4-9.

- Easy Tier Manual Mode:

  Easy Tier manual mode allows a set of manual initiated actions to relocate data among the storage subsystem resources in dynamic fashion, that is, without any disruption of the host operations. The Easy Tier Manual Mode capabilities are Dynamic Volume Relocation and Dynamic Extent Pool Merge. Dynamic Volume Relocation allows a DS8700 volume to be migrated to the same or different Extent Pool. Dynamic Extent Pool Merge allows an Extent Pool to be merged to another Extent Pool. By combining these two capabilities, we can significantly improve the configuration flexibility of the DS8000.

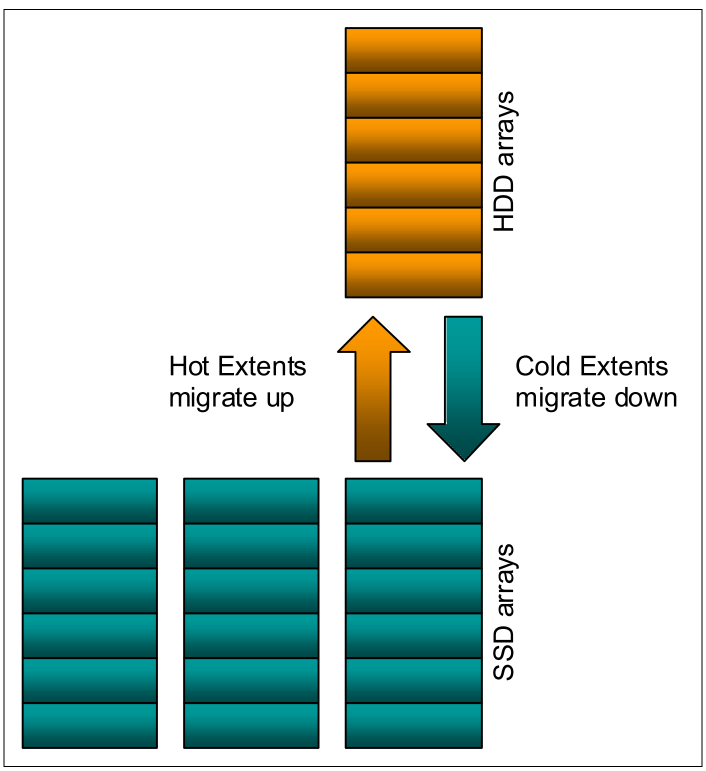


Figure 4-9 DS8000 Easy Tier

Today, you have “extent pools” that can be either SSD-only or HDD-only. With Easy Tier announcement, IBM introduced “mixed” SSD+HDD extent pools. The hottest extents are moved to SSD, and cooler extents are moved down to HDD. The support applies to both Fixed block architecture (FBA) LUNs as well as Count-Key-Data (CKD) volumes. In other words, an individual LUN or CKD volume can have some of its 1 GB extents on SSD and other extents on HDD.

Easy Tier feature:

- Easy Tier is a DS8000 firmware function available with LMC level 6.5.1.xx or later. An additional no-cost LIC feature must be ordered and installed.
- At the time of writing, Easy Tier is not supported on DS8800.

Easy Tier provides a performance monitoring capability whether or not the licensed feature is activated. This monitoring capability enables workload data collection that can be off loaded and further processed with the Storage Tiering Advisor Tool. Providing a graphical representation of hot data distribution at the volume level, this powerful tool allows you to analyze the workload characteristics and evaluate the benefits of the higher performance possible with the solid state drive technology.

See *IBM System Storage DS8700 Easy Tier*, REDP-4667 for more information.

High Performance FICON for System z

High Performance FICON for System z (zHPF) is a new FICON protocol and system I/O architecture that results in improvements for small block transfers (a track or less) to disk using the device independent random access method. Instead of Channel Command Word (CCWs), Transport Control Words (TCWs) can be used. I/O that is using the Media Manager, like DB2, PDSE, VSAM, zFS, VTOC Index (CVAF), Catalog BCS/VVDS, or Extended Format SAM, will benefit from zHPF.

zHPF reduces the impact associated with supported commands on current adapter hardware, thereby improving FICON throughput on the DS8000 I/O ports. The DS8700 also supports the new zHPF I/O commands for multi-track I/O operations. With LMC level 6.5.1.xx.xx, the zHPF feature has been further enhanced by the implementation of the zHPF Disable Transfer Ready protocol. This introduces the High Performance FICON Multi-track Extended Distance capability, which provides higher throughput for longer distances.

Optional licensed feature

High Performance FICON for z (zHPF) is an optional licensed feature. In situations where this is the exclusive access in use, it can improve FICON I/O throughput on a single DS8000 port by 100%. Realistic workloads with a mix of data set transfer sizes can see 30 - 70% of FICON IOs utilizing zHPF, resulting in up to a 10-30% channel utilization savings.

Although customers can expect to see I/Os complete faster as the result of implementing zHPF, the real benefit is expected to be obtained by using fewer channels to support existing disk volumes, or increasing the number of disk volumes supported by existing channels. Additionally, the changes in architecture offer end-to-end system enhancements to improve reliability, availability, and serviceability (RAS).

Support: Only the System z10® processors support zHPF, and only on the FICON Express8, FICON Express 4, or FICON Express2 adapters. The FICON Express adapters are not supported. The required software is z/OS V1.7 with IBM Lifecycle Extension for zOS V1.7 (5637-A01), z/OS V1.8, z/OS V1.9, or z/OS V1.10 with PTFs.

IBM Laboratory testing and measurements are available at the following website:

http://www.ibm.com/systems/z/hardware/connectivity/ficon_performance.html

zHPF is transparent to applications. However, z/OS configuration changes are required.

High Performance FICON for System z (zHPF) Extended Distance

This new feature enhances zHPF write performance by supporting the zHPF “Disable Transfer Ready” protocol.

zHPF Extended Distance allows clients to achieve equivalent FICON write performance at a distance, because some existing customers running multiple sites at long distances (10-100 km) cannot exploit zHPF due to the large impact to the write I/O service time.

Support: At the time of writing, zHPF Extended Distance is not yet supported on DS8800.

4.3.4 DS8000 series architecture

This section describes the architecture of the DS8000 systems and provides information about the following components:

- Processor complexes
- Disk subsystems (switched FC-AL loops)
- I/O enclosures (device and host adapters)
- Power and cooling
- Battery backup units
- Hardware Management Console (HMC)
- Network switches
- Frames and expansion frames

The DS8700 storage facility consists of two POWER6 servers and the DS8800 uses two POWER6+ servers. The servers form a processor complex that utilizes a RIO-G loop for processor communication and an PCIe infrastructure to communicate to the I/O subsystem, as seen in Figure 4-15 on page 139.

When a host performs a read operation, the servers (also called CECs) fetch the data from the disk arrays using the high performance switched disk architecture. The data is then cached in volatile memory in case it is required again. The servers attempt to anticipate future reads by an algorithm known as Sequential prefetching in Adaptive Replacement Cache (SARC). Data is held in cache as long as possible using this smart algorithm. If a cache hit occurs where requested data is already in cache, then the host does not have to wait for it to be fetched from the disks. The cache management has been enhanced by breakthrough caching technologies from IBM Research, such as the Adaptive Multistream Prefetching (AMP) and Intelligent Write Caching (IWC).

On a DS8700 and DS8800, the data traffic is isolated from the processor complex communication that utilizes the RIO-G loop.

DS8000 physical view

A DS8000 base frame provides the rack and packaging that contain a dual processor complex, I/O enclosures, host adapters, device adapters, power supplies, batteries, and cooling, as well as space for disk drive sets in storage enclosures. It has also the capability to attach expansion units. Figure 4-10 shows the components used to create the DS8000 primary frame.

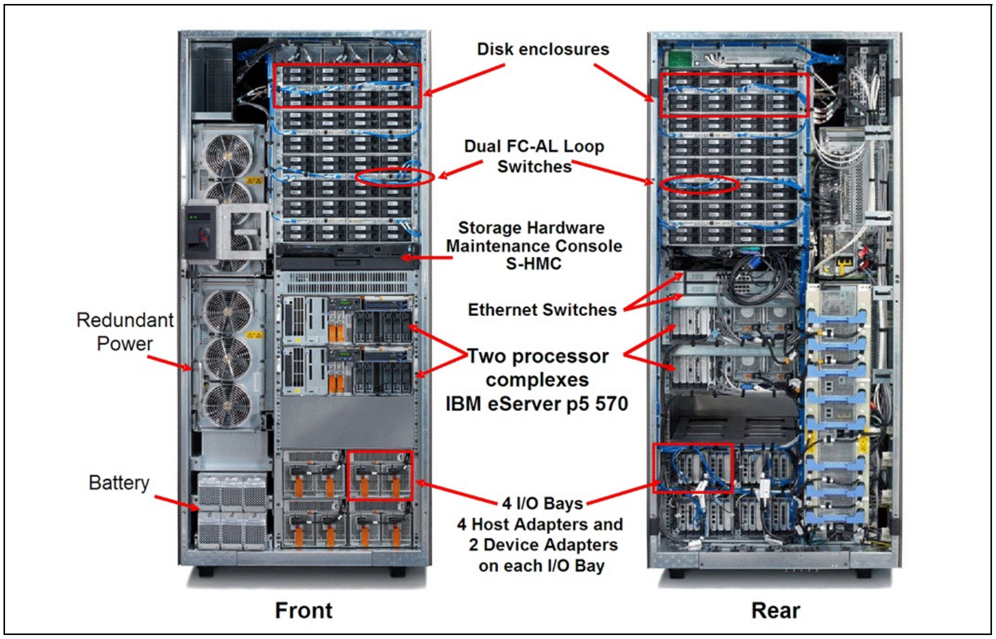


Figure 4-10 DS8000 base frame

The DS8700 base frame can contain up to eight disk enclosures, each can contain up to 16 disk drives. They are described as 16-packs because each enclosure can hold 16 disks. In a maximum configuration, the base frame can hold 128 disk drives. Each expansion frame can hold up to 16 disk enclosures which contain the disk drives. In a maximum configuration, an expansion frame can hold 256 disk drives.

The DS8800 base frame can contain up to ten disk enclosures, each can contain up to 24 disk drives. Each HD Disk enclosure pair can hold 48 disks (or three 16-disk drive sets). In a maximum configuration, the base frame can hold 240 disk drives. The DS8800 expansion frame 95E provides the rack and packaging for an additional 21 drive sets of 16 drives (in the second position) or 30 drive sets (in the third position).

The left side of the base frame (viewed from the front of the machine) is the frame power area. Only the base frame contains rack power control cards (RPC) to control power sequencing for the storage unit. It also contains a fan sense card to monitor the fans in that frame. The base frame contains two primary power supplies (PPSs) to convert input AC into DC power. The power area also contains two or three battery backup units (BBUs), depending on the model and configuration. Expansion frames also contain their own set of power supplies, batteries, and cooling.

Between the disk enclosures and the processor complexes are two Ethernet switches and a Storage Hardware Management Console (HMC).

The base frame contains two processor complexes. These POWER6/6+ servers contain the processor and memory that drive all functions within the DS8000.

Finally, the base frame contains two or four I/O enclosures. These I/O enclosures provide connectivity between the adapters and the processors. The adapters contained in the I/O enclosures can be either device adapters (DAs) or host adapters (HAs), or both.

The inter processor complex communication still utilizes the RIO-G loop as in previous models of the DS8000 Family. However, this RIO-G loop no longer has to handle data traffic, which improves reliability to a great extent.

DS8000 expansion units provide the rack and packaging for an additional disk drive sets. They also contain their own set of power supplies, batteries, and cooling. Expansion frames in the second position can also contain additional host adapters, device adapters, and I/O enclosures. A DS8700 base frame and two expansion frames are shown in Figure 4-11.

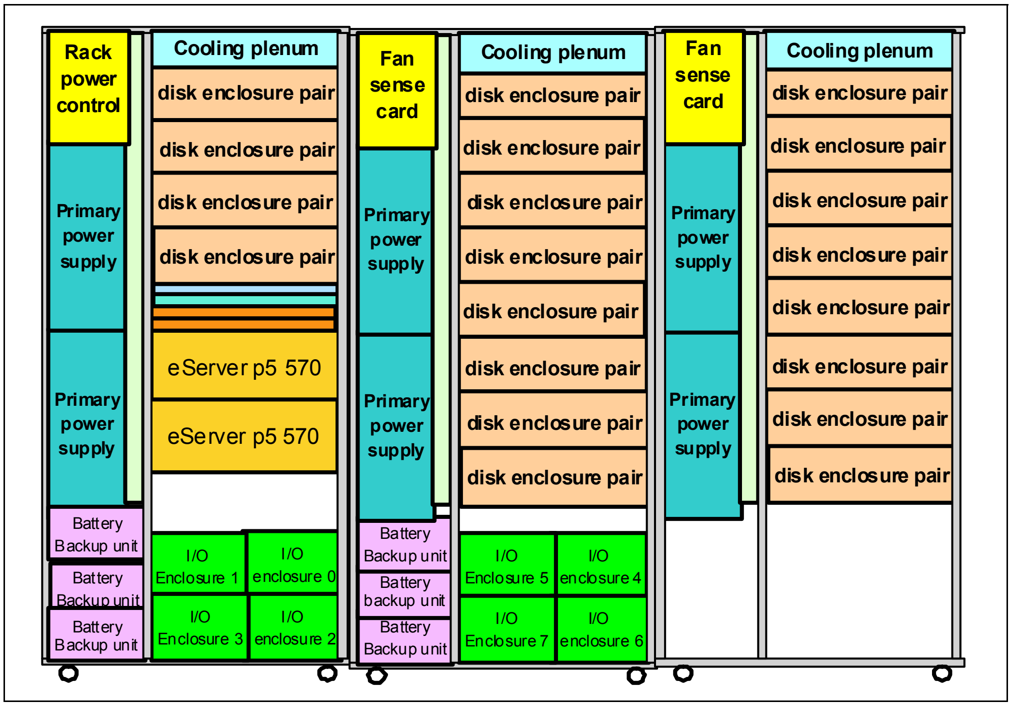


Figure 4-11 DS8700 frame types

A DS8800 scenario with two expansion frames is shown in Figure 4-12.

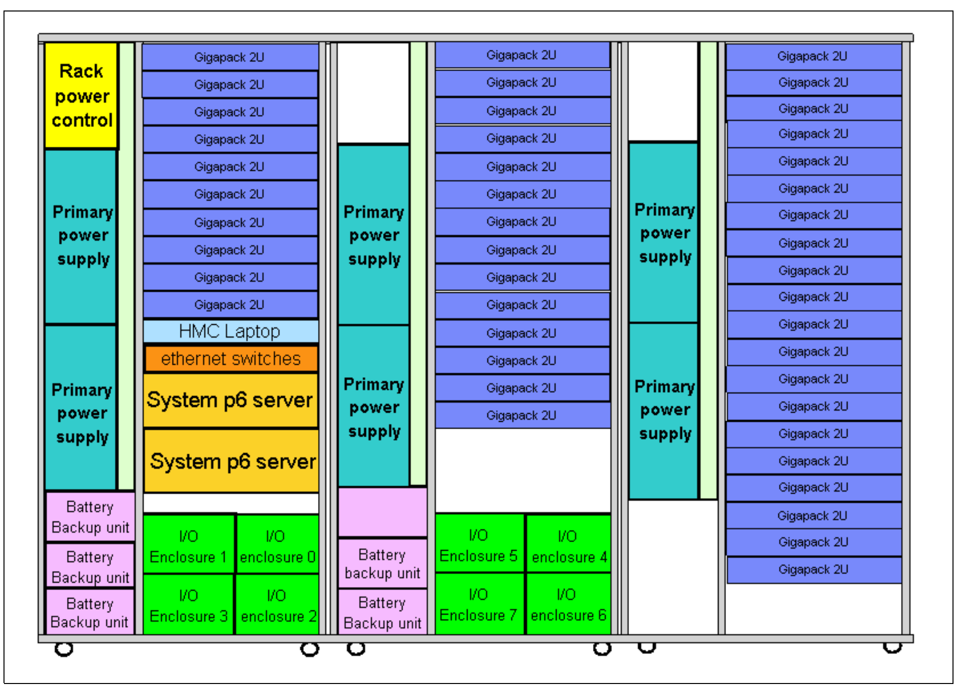


Figure 4-12 DS8800 frame types

Processor complex

The DS8000 base frame contains two symmetric multiprocessor IBM POWER Systems processor complexes, which contain the processor and memory that drive all functions in the DS8000.

The DS8700 base frame contains two processor complexes, based on POWER6 microprocessors running at 4.7 GHz. The 941 model can have the 2-way processors feature or the 4-way processors feature. There can be two or four I/O enclosures. In this case, at least four I/O enclosures are required. More might be necessary depending on the number of disk drives.

The DS8800 high-performance flagship model features two processor complexes as well, using the IBM POWER6+ server technology running at 5.0 GHz to help support high performance. Compared to the performance of the previous DS8000 system, DS8700, the new processor aids the DS8800 in achieving sequential read throughput performance improvement of up to 20% and sequential write throughput performance improvement of up to 40%. The DS8800 offers either a dual 2-way processor complex or a dual 4-way processor complex and has been built on a proven and reliable code base, as seen in Figure 4-13.

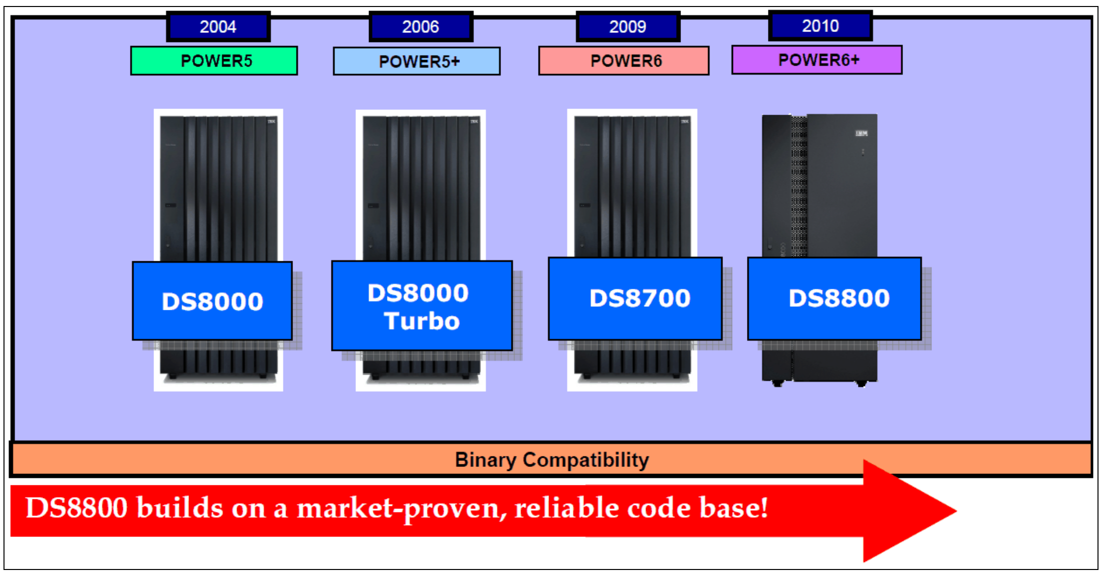


Figure 4-13 DS8000 and POWER processors

Using SMPs as the primary processing engine sets the DS8000 apart from other disk storage systems on the market. Additionally, the POWER Systems POWER6/6+ processors used in the DS8700 series and DS8800 series support the execution of two independent threads concurrently. This capability is referred to as *simultaneous multi-threading (SMT)*. The two threads running on the single processor share a common L1 cache. The SMP/SMT design minimizes the likelihood of idle or overworked processors, while a distributed processor design is more susceptible to an unbalanced relationship of tasks to processors.

The design decision to use SMP memory as I/O cache is a key element of IBM storage architecture. Although a separate I/O cache can provide fast access, it cannot match the access speed of the SMP main memory.

The inter processor complex communication still utilizes the RIO-G loop as in previous models of the DS8000 family. However, this RIO-G loop no longer has to handle data traffic, which greatly improves reliability.

All memory installed on any processor complex is accessible to all processors in that complex. The addresses assigned to the memory are common across all processors in the same complex. Alternatively, using the main memory of the SMP as the cache leads to a partitioned cache. Each processor has access to the processor complex's main memory but not to that of the other complex. Keep this in mind with respect to load balancing between processor complexes.

Processor memory

The DS8700 and DS8800 offer up to 384 GB of processor memory. Half of this will be located in each processor complex. In addition, the Non-Volatile Storage (NVS) scales to the processor memory size selected, which can also help optimize performance.

Service processor and SPCN

The service processor (SP) performs predictive failure analysis based on any recoverable processor errors. The SP can monitor the operation of the firmware during the boot process, and it can monitor the operating system for loss of control. This enables the service processor to take appropriate action. The system power control network (SPCN) is used to control the power of the attached I/O subsystem.

A redundant pair of rack power control (RPC) cards coordinate the power management within the storage unit. The RPC cards are attached to the service processors in each processor complex, the primary power supplies in each rack, and indirectly to the fan/sense cards and storage enclosures in each rack.

I/O enclosures

An I/O enclosure provides a way to interconnect one or more external I/O adapters to the processor complex I/O interface. The DS8000 base frame contains I/O enclosures and adapters. There can be two or four I/O enclosures in a DS8700 or DS8800 base frame. The I/O enclosures hold the adapters and provide connectivity between the adapters and the processors. Device adapters and host adapters are installed in the I/O enclosure.

The I/O enclosure supports the following types of external I/O adapters:

- Host adapters:

  A host adapter supports the attachment of host systems to the storage facility device adapters.

- Device adapters:

  A device adapter supports the attachment of storage devices to the storage facility through one or more I/O ports. The attachment is a PCIe point to point connection in a DS8700 or a DS8800 system. Each DS8700 Model 941 (2-way) or DS8800 Model 951 (2-way) system can have up to four device adapter pairs and each DS8700 Model 941 (4-way) or DS8800 Model 951 (4-way) system can have up to eight device adapter pairs.

An I/O enclosure pair supports up to two device adapter pairs and up to eight host adapters in a DS8700 or four host adapters in a DS8800.

In previous generations of the DS8000, the I/O enclosures were on the RIO-G loops between the two CECs. The RIO-G interconnect is a high speed loop between the two CECs. Each RIO-G port can operate at 1 GHz in bidirectional mode and is capable of passing data in each direction on each cycle of the port. The RIO-G bus carried the CEC-to-DDM data (host I/O) and all CEC-to-CEC communications. This is shown in Figure 4-14.

The attached hosts interact with software running on the complexes to access data on logical volumes. Each complex hosts at least one instance of this software (which is called a *server*), running in an LPAR. The servers manage all read and write requests to the logical volumes on the disk arrays. During write requests, the servers use fast-write where the data is written to volatile memory on one complex and persistent memory on the other complex. The server then reports the write as complete before it has been written to disk. This provides much faster write performance.

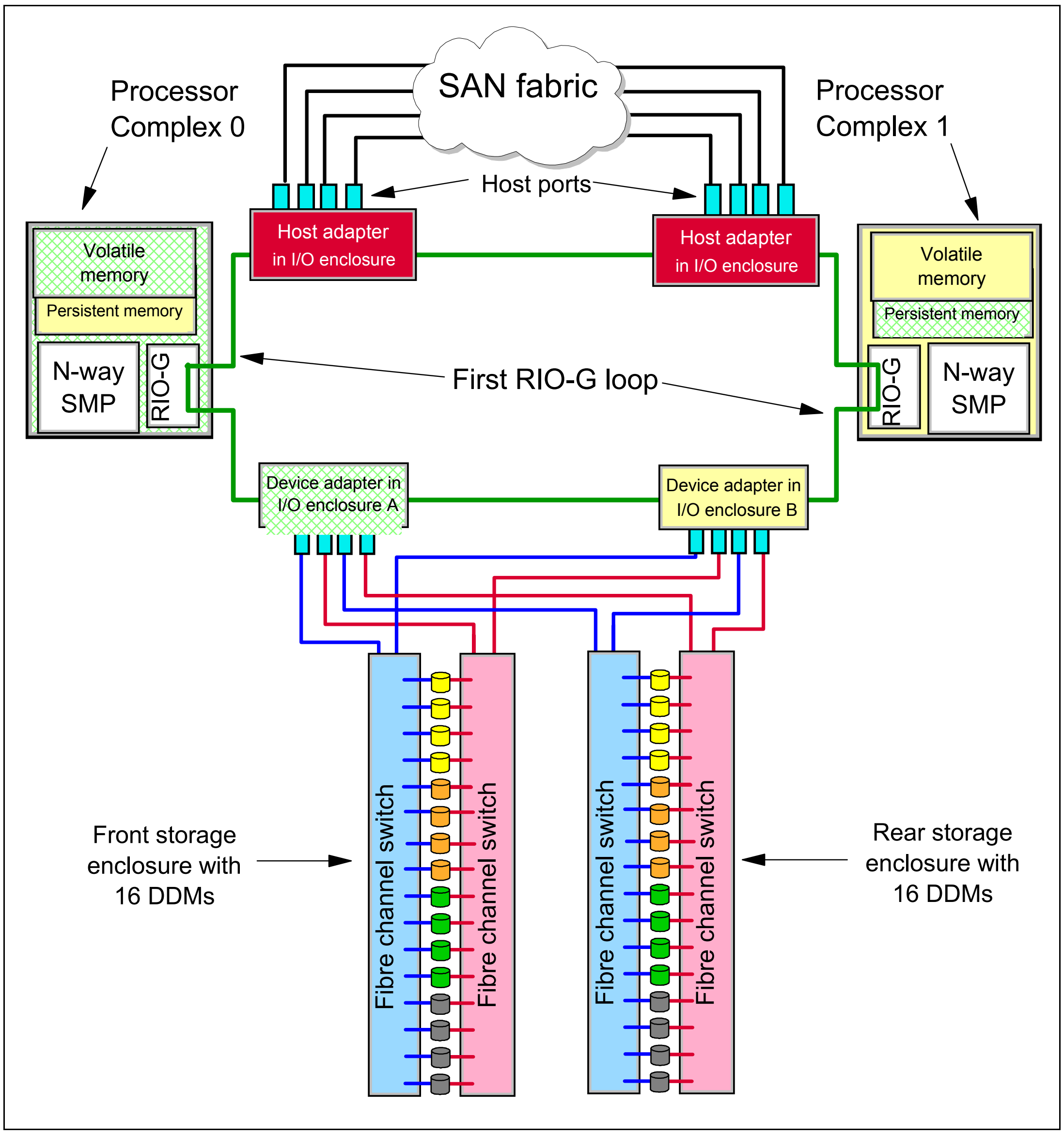


Figure 4-14 The DS8000 previous architecture

On a DS8700 or DS8800, the RIO-G ports are used for inter processor communication only, and the I/O enclosures are wired point-to-point with each CEC using a PCI Express architecture. This means that only the CEC-to-CEC communications are now carried on the RIO-G, and the RIO loop configuration is greatly simplified. This is shown in Figure 4-15.

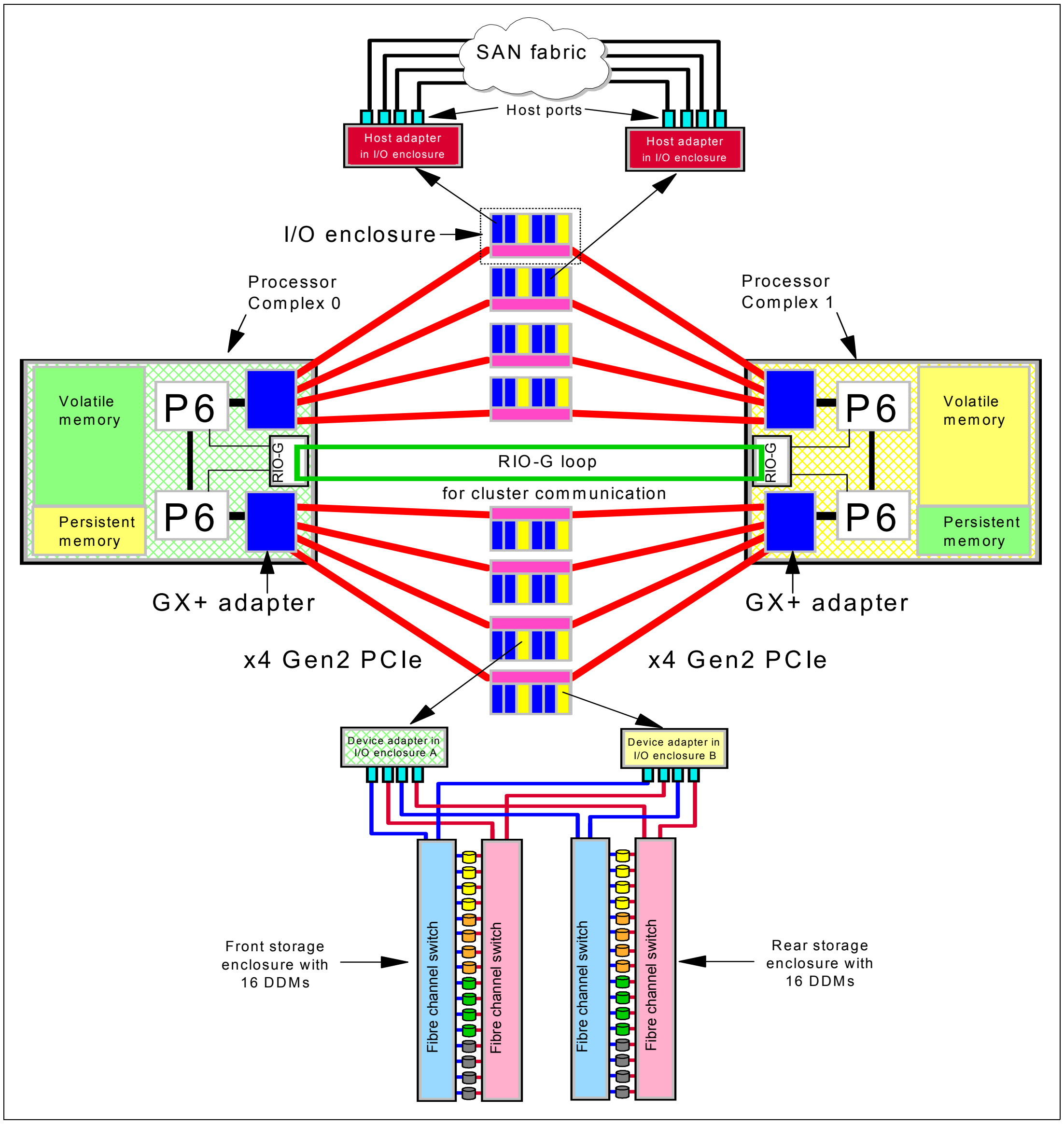


Figure 4-15 DS8000 series new architecture

Figure 4-16 shows this new fabric design. The DS8700 and DS8800 processor complex uses a PCIe infrastructure to access I/O enclosures. PCIe is a standard-based replacement to the general-purpose PCI expansion bus. PCIe is a full duplex serial I/O interconnect. Transfers are bi-directional, which means data can flow to and from a device simultaneously. The PCIe infrastructure uses a non-blocking switch so that more than one device can transfer data. The communication path used for adapter-to-processor complex communication consists of four, 8 lane (x8) PCI-e Generation 2 connections.

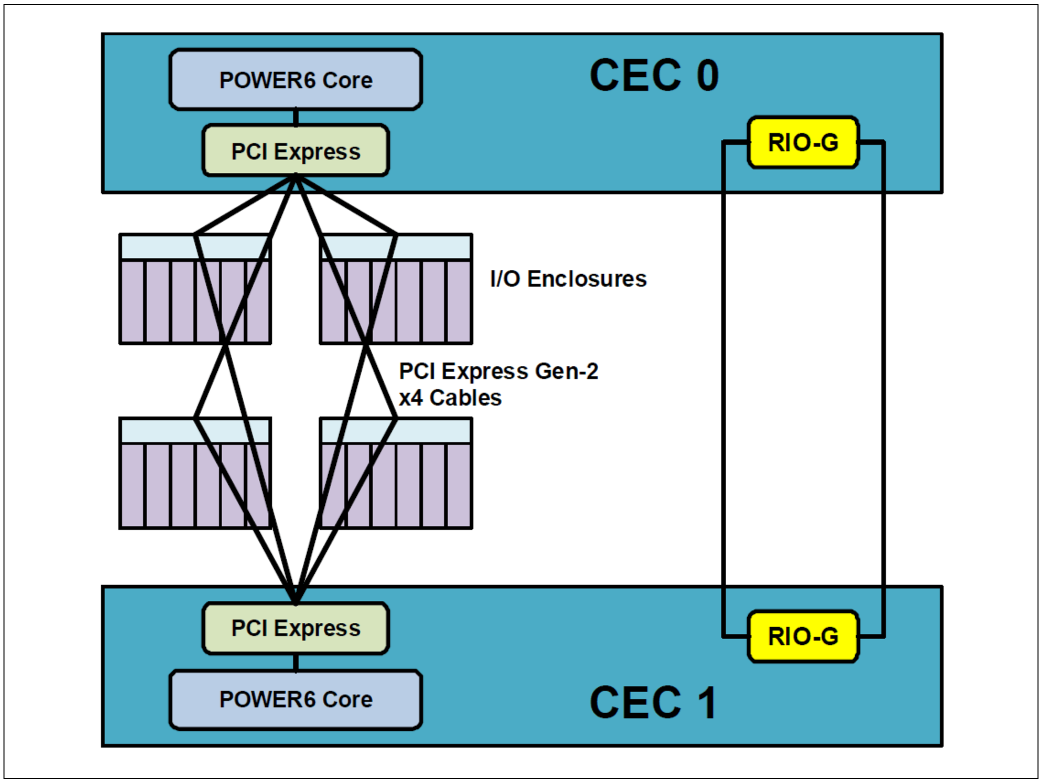


Figure 4-16 DS8700 and DS8800 new design of RIO-G loop and I/O enclosures

The communication path used for adapter to processor complex communication in DS8700 or DS8800 are now four lane (x4) PCIe Generation 2 connections providing a bandwidth of 2 Gbps for each connection. To translate the x8 Gen 1 lanes from the processor to the x4 Gen 2 lanes used by its I/O enclosures, a bridge is used, as shown in Figure 4-17.

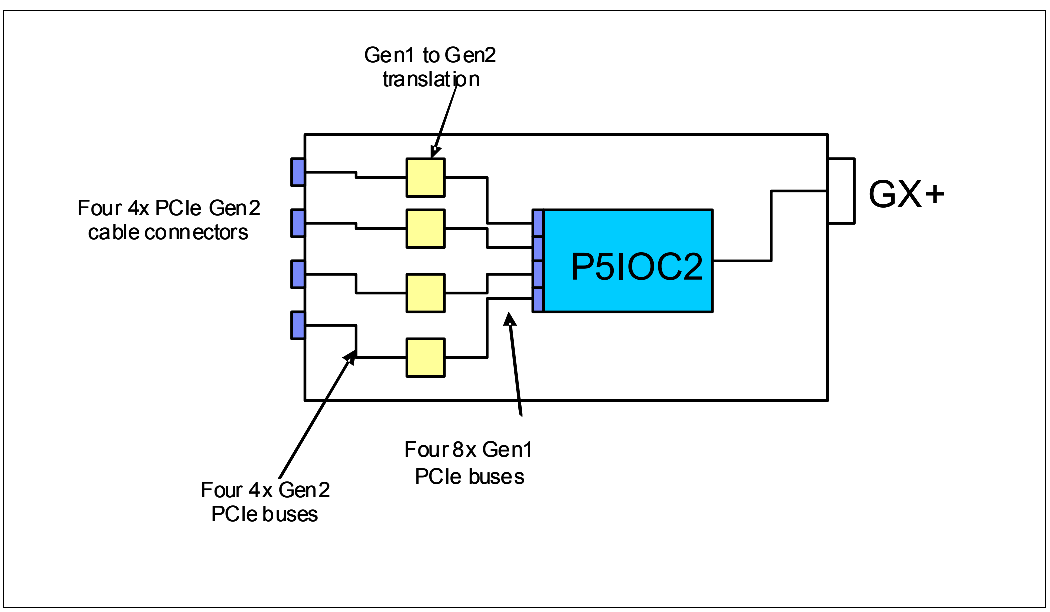


Figure 4-17 GX+ to PCI Express adapter

Host adapters

The DS8000 series offers host connectivity with Fibre Channel/FICON Host Adapters. Fibre Channel is a technology standard that allows data to be transferred from one node to another at high speeds and great distances (up to 10 km and beyond). The DS8000 uses Fibre Channel protocol to transmit SCSI traffic inside Fibre Channel frames. It also uses Fibre Channel to transmit FICON traffic, which uses Fibre Channel frames to carry System z I/O.

The DS8700 supports 4-port 4 Gbps, and the DS8800 supports 4-port and 8-port 8 Gbps Fibre Channel/FICON host adapters.

The Fibre Channel/FICON Host Adapters are offered in longwave and shortwave. The 4 Gbps DS8700 Host Adapters auto-negotiate to either 4 Gbps, 2 Gbps, or 1 Gbps link speeds. The 8 Gbps DS8800 Host Adapters auto-negotiate to either 8 Gbps, 4 Gbps, or 2 Gbps link speeds.

Each port on the adapter can be individually configured to operate with Fibre Channel Protocol (FCP) (also used for mirroring) or FICON. The DS8800 8 Gbps Fibre Channel/FICON host adapter supports FICON attachment to FICON Express8 on zEnterprise 196 (z196) and System z10 (z10 EC, z10 BC).

The DS8700 model with 2-way configuration offers up to 16 host adapters and the DS8700 model with 4-way configuration offers up to 32 host adapters, which provide up to 128 Fibre Channel/FICON ports.

Up to 8 Fibre Channel (SCSI-FCP and FICON host adapters) can be installed in any combination in a DS8800 Model 951 (2-way). Up to 16 Fibre Channel (SCSI-FCP and FICON) host adapters can be installed in a DS8800 Model 951 (4-way) system in any combination (8 in DS8800 base unit and another 8 in the first DS8800 expansion unit), which provide up to 128 Fibre Channel/FICON ports as well.

Support: Only Fibre Channel/FICON adapters are supported for both DS8700 and DS8800. ESCON adapters are no longer supported.

The card itself is a PCI-X 64 Bit 133 MHz for DS8700 configuration. The card is driven by a new high function, high performance ASIC. To ensure maximum data integrity, it supports meta data creation and checking. Each Fibre Channel port supports a maximum of 509 host login IDs and 1,280 paths. This allows for the creation of very large storage area networks (SANs). The design of the card is depicted in Figure 4-18.

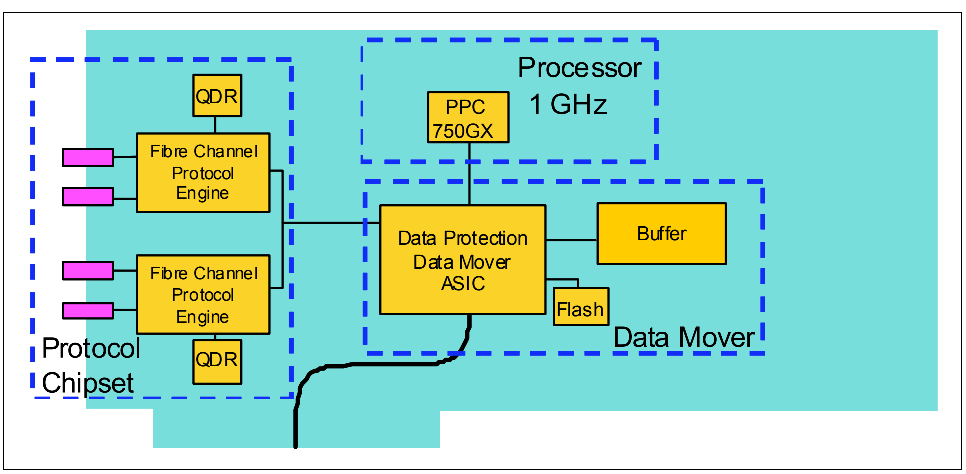


Figure 4-18 DS8700 Fibre Channel/FICON host adapter

The DS8800 features new host cards as well. It is a PCIe Gen 2 card. The card is driven by a new high function, that is, high performance ASIC. To ensure maximum data integrity, it supports metadata creation and checking. Each Fibre Channel port supports a maximum of 509 host login IDs and 1,280 paths. This allows for the creation of very large storage area networks (SANs). For more information about the design of the card, see *IBM System Storage DS8800 Architecture and Implementation*, SG24-8886.

Device adapters

Device adapters provide the connection between storage devices and the storage facility images through I/O ports.

Device adapters are ordered and installed in pairs. A device adapter pair supports two independent paths to all of the disk drives served by the pair. The two paths connect to two different network fabrics to provide fault tolerance and to help ensure availability. The physical links allow two read operations and two write operations to be performed simultaneously around the fabric.

Each DS8000 device adapter (DA) card offers four FC-AL ports, 2 Gbps for DS8700 and 8 Gbps for DS8800. These ports are used to connect the processor complexes to the disk enclosures. The adapter is responsible for managing, monitoring, and rebuilding the RAID arrays. The adapter provides remarkable performance thanks to a high function/high performance ASIC. To ensure maximum data integrity, it supports meta data creation and checking.

The DS8700 device adapter design is shown in Figure 4-19.

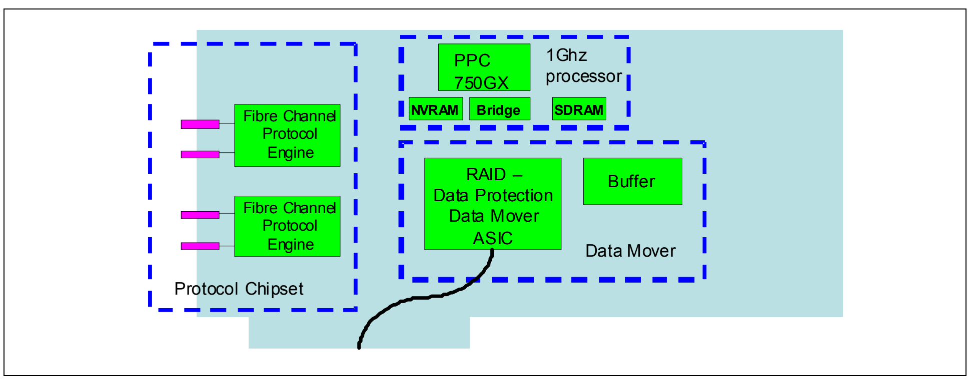


Figure 4-19 New DS8700 device adapter with 1 Ghz processor

In the DS8800, a faster application-specific integrated circuit (ASIC) and a faster processor is used on the device adapter cards compared to adapters of other members of the DS8000 family, which leads to higher throughput rates. The DS8800 replaces the PCI-X device and host adapters with native PCIe 8 Gbps FC adapters. This is an improvement from all previous DS8000 models. For more information about the new DS8800 device adapter design, see *IBM System Storage DS8800 Architecture and Implementation*, SG24-8886.

The DAs are installed in pairs because each storage partition requires its own adapter to connect to each disk enclosure for redundancy. This is why we call them *pairs*.

The DS8000 implements the concept of Array Across Loops (AAL) which splits each array site into two halves. Half of the site is located on the first disk loop of a device adapter (DA) pair and the other half is located on the second disk loop of that DA pair. It is implemented primarily to maximize performance; however it also provides higher level of redundancy with RAID-10 configurations, as shown in Figure 4-20.

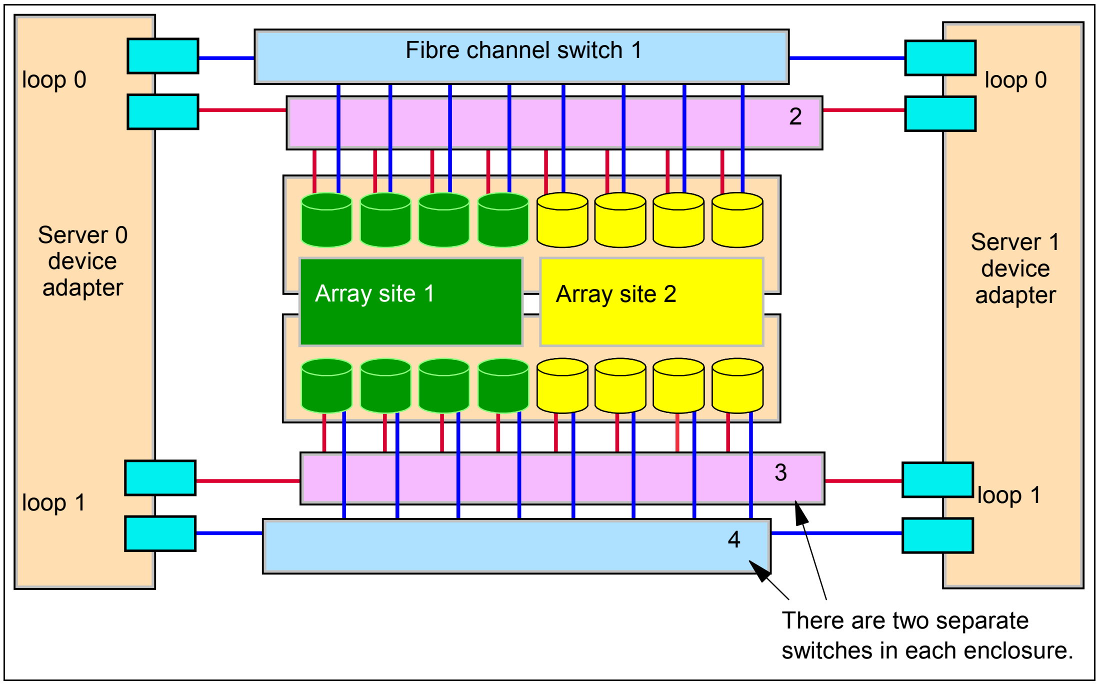


Figure 4-20 Array across loops

Considering the SAS disks in the DS8800, the Figure 4-21 shows that each disk drive is depicted as being attached to two separate interface connectors with bridges to the SAS disk drivers. This means that with two device adapters, we have four effective data paths to each disk. Each DA can support two networks.

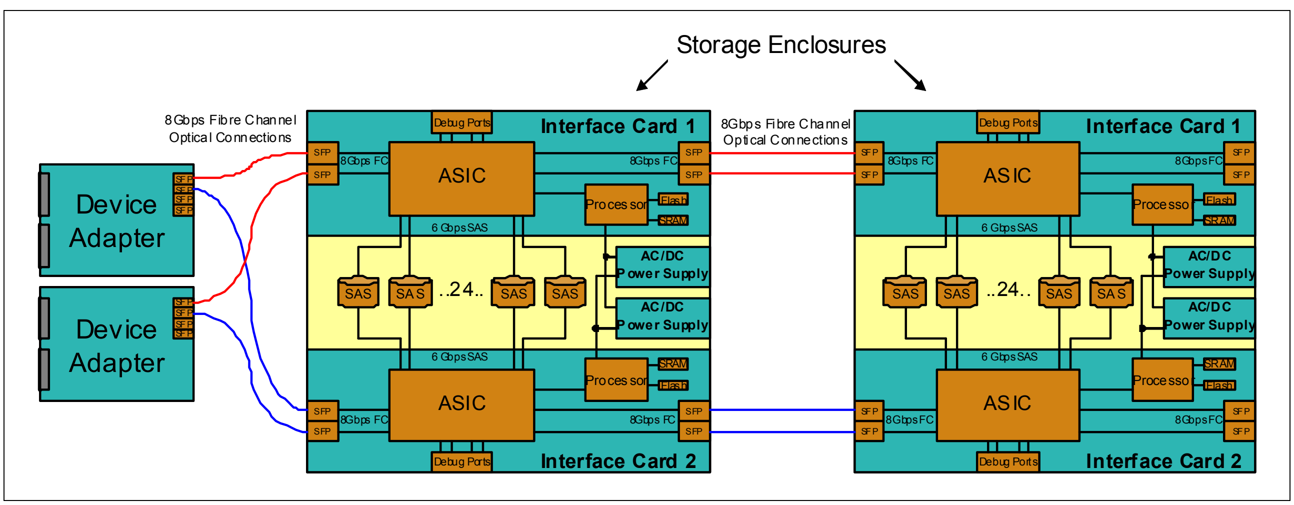


Figure 4-21 DS8800 Storage enclosure

For detailed information about PCI buses, host adapters, and device adapters, see the Redbooks publications, *IBM System Storage DS8700 Architecture and Implementation*, SG24-8786 and *IBM System Storage DS8800 Architecture and Implementation*, SG24-8886.

Storage enclosures

A storage enclosure provides a way to interconnect disks to the I/O interface attached to a device adapter I/O port. Each storage enclosure contains a redundant pair of storage enclosure services cards and disk slots.

Table 4-1 provides a comparison between DS8700 and DS8800 storage enclosures.

Table 4-1 DS8700 and DS8800 storage enclosures comparison

Characteristic	DS8700 megapack	DS8800 gigapack
Disk technology	3.5' LFF Fibre Channel	2.5' SFF SAS
Throughput	2 Gbps FC interconnect backbone and 2 Gbps FC to disks	8 Gbps FC interconnect backbone and 6 Gbps SAS-2 to disks
Density	16 disks per enclosure	24 disks per enclosure
Rack vertical space	3.5U	2U
Cabling	passive copper interconnect	optical short wave multimode interconnect
Modularity	rack level power and cooling	integrated power and cooling

In the following sections we present an overview of each storage enclosure.

DS8700 storage enclosures

A storage enclosure interconnects the DDMs to the Fibre Channel switch cards that connect to the device adapters. Each storage enclosure contains a redundant pair of Fibre Channel switch cards. Figure 4-22 shows a sketch of a Storage Enclosure.

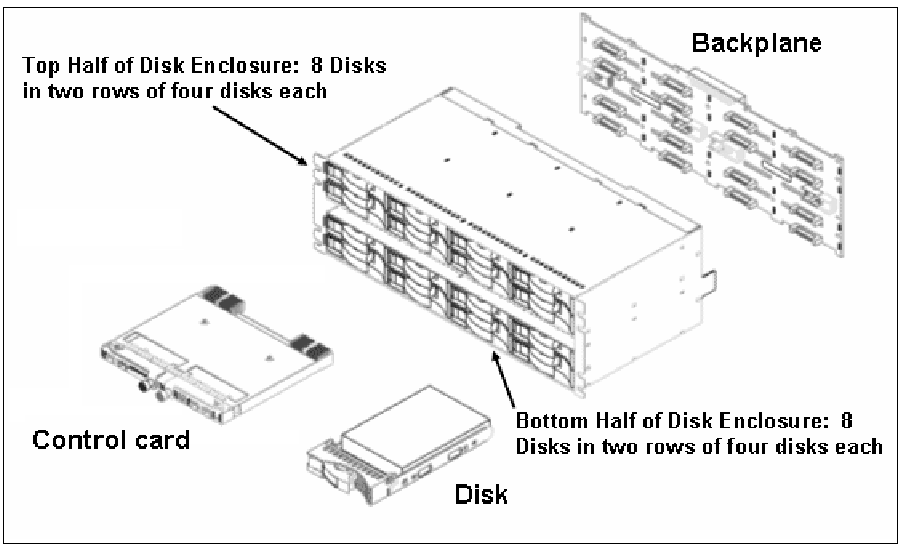


Figure 4-22 DS8700 storage enclosure

The storage enclosures are always installed in pairs, one enclosure in the front of the unit and one enclosure in the rear. A storage enclosure pair can be populated with one or two disk drive sets (16 or 32 DDMs), or in the case of SSDs, a half disk drive set (eight DDMs). All DDMs in a disk enclosure pair must be of the same type (capacity and speed). Most commonly, each storage enclosure is shipped full with 16 DDMs, meaning that each pair has 32 DDMs. If a disk enclosure pair is populated with only eight or 16 DDMs, disk drive filler modules called baffles are installed in the vacant DDM slots. This is to maintain the correct cooling airflow throughout the enclosure.

Each storage enclosure attaches to two device adapters (DAs). The DAs are the RAID adapter cards that connect the CECs to the DDMs. The DS8700 DA cards are always installed as a redundant pair, so they are referred to as DA pairs.

For example, if a DS8700 has six disk enclosures total, it has three at the front and three at the rear. If all the enclosures are fully populated with disks, and an additional order of 16 DDMs are purchased, then two new disk enclosures are added, one at the front and one at the rear. The switched networks do not need to be broken to add these enclosures. They are simply added to the end of the loop; eight DDMs go in the front enclosure and the remaining eight DDMs go in the rear enclosure. If an additional 16 DDMs get ordered later, they will be used to fill up that pair of disk enclosures. These additional DDMs added have to be of the same type as the eight DDMs residing in the two enclosures already.

To access the disk subsystem, each complex (CEC) uses several four-port Fibre Channel arbitrated loop (FC-AL) device adapters. A DS8700 can have up to sixteen of these adapters arranged into eight pairs. Each adapter connects the complex to two separate switched Fibre Channel networks. Each switched network attaches disk enclosures that each contain up to 16 disks. Each enclosure contains two 20-port Fibre Channel switches. Of these 20 ports, 16 are used to attach to the 16 disks in the enclosure and the remaining four are used to either interconnect with other enclosures or to the device adapters. Each disk is attached to both switches. Whenever the device adapter connects to a disk, it uses a switched connection to transfer data. This means that all data travels through the shortest possible path.

Mixing: SSDs and other disks cannot be intermixed within the same enclosure. SSDs can be intermixed with HDDs within the same DA pair, but not on the same disk enclosure pair. FDE drives cannot be intermixed with other drive types in the same storage facility image.

DS8800 storage enclosures

The DS8800 includes the new high-density storage enclosure, a small form factor (SFF) drive enclosure which retains Fibre Channel (FC) cable connection. A high performance 8 Gbps optical FC-AL fabric attachment is provided from the device adapter to the storage expansion enclosure. The enclosure control card provides the FC to SAS bridge, matching industry standards. Device adapter (DA) attachment supports dual-trunked Fibre Channel, which allows for higher bandwidth and an extra layer of redundancy.

Figure 4-23 shows front and back views of the storage enclosure. This supports 24 SFF, 2.5” SAS drives. The storage enclosure is 2U (EIA units) or 3.5” in height.

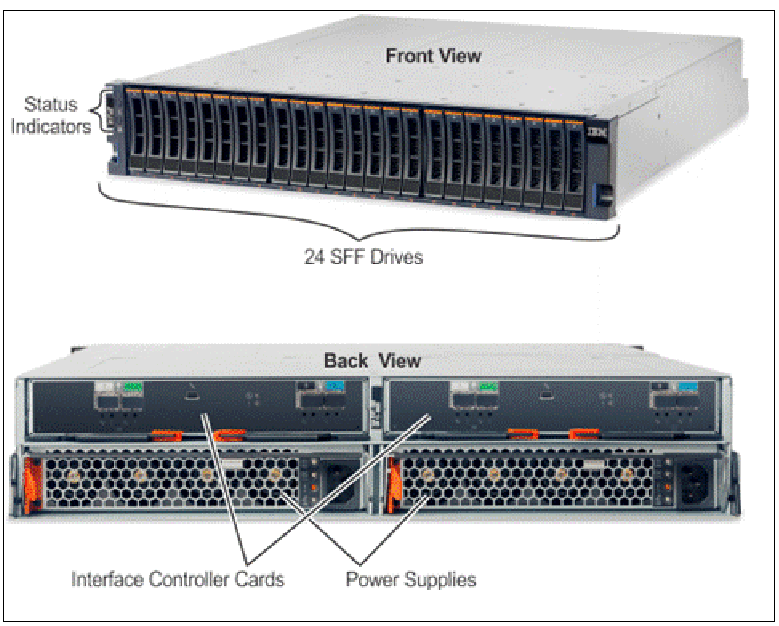


Figure 4-23 Front and back view of DS8800 storage enclosure

The front of the enclosure contains slots for 24 drives, and also contains enclosure-level status indicators. The back of the enclosure contains the following components:

- Two power supplies, N+1 for redundancy, each with four cooling elements at the drawer-level.
- Two interface controller (IC) cards, N+1 for redundancy.

All power and signal cables exit from the back of the enclosure.

The following features are included in the expansion storage enclosure:

- Support for up to four enclosures per loop
- Redundant, integrated power and cooling
- 6 Gbps SAS data transfer rate to the disk drives

The power and cooling systems are composed of two redundant power supply units. Each power supply contains fans to supply cooling for the entire enclosure.

There are two types of frame configurations supported, which are commonly designated as A and B frames. An A frame is the base configuration (Mode 951) and contains not just power and storage but also the CECs, Ethernet switch, HMC, and I/O Bays. If more storage is needed than the A frame (base Model 951) can provide, the next step is to add a B frame, or expansion (Model 95E). The 95E contains more storage and more I/O Bays, increasing the number of DA cards you can select.

Each disk plugs into the disk enclosure backplane. The *backplane* is the electronic and physical backbone of the disk enclosure.

The enclosure has a redundant pair of interface control cards (IC) that provides the interconnect logic for the disk access and a SES processor for enclosure services. The ASIC is an 8 Gbps FC-al switch with a Fibre Channel (FC) to SAS conversion logic on each disk port. The FC and SAS conversion function provides speed aggregation on the FC interconnection ports. The FC trunking connection provides full 8 Gbps transfer rates from a group of drives with lower interface speeds.

Intermixing: The design of this enclosure assumes that all drives used are homogeneous, possessing the same interface speed, type (all native SAS or all SSD) and capacity. However, drives with differing speeds can be combined if the capacity is the same. An exception to this is that intermixing encrypting and non-encrypting drives is not supported.

Hardware Management Console (HMC)

The Hardware Management Console (HMC) is the focal point for maintenance activities. This dedicated laptop is physically located (installed) inside your DS8700 or DS8800 and can proactively monitor the state of your system, notifying you and IBM when service is required. It can also be connected to your network to enable centralized management of your system using the IBM System Storage DS Command Line Interface or storage management software utilizing the IBM System Storage DS Open API. For more information regarding the HMC and other management features, see 4.3.6, “DS8000 management” on page 160.

Ethernet switches

The DS8000 base frame contains two 8-port Ethernet switches. Two switches are supplied to allow the creation of a fully redundant management network. Each processor complex has multiple connections to each switch to allow each server to access each switch. This switch cannot be used for any equipment not associated with the DS8700. The switches get power from the internal power bus and thus do not require separate power outlets. The switches are shown in Figure 4-24.

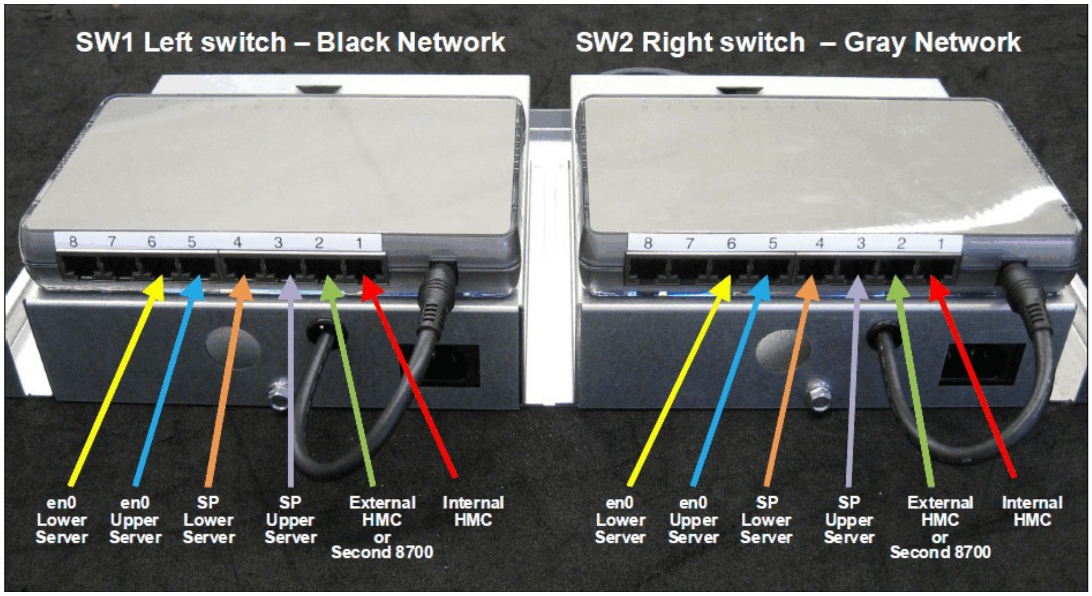


Figure 4-24 DS8700 and DS8800 Ethernet switches

Power supplies, batteries, and cooling

The DS8000 power and cooling system is highly redundant. There are two redundant primary power supplies (PPSs) in each frame of the DS8000, and each PPS can power the frame by itself. Furthermore, each processor and I/O enclosure has dual redundant power supplies.

The disk enclosures do not have separate power supplies because they draw power directly from the PPSs. They do however have cooling fans located in a plenum above the DS8700 enclosures and in the back of the DS8800 enclosures.

The backup battery assemblies help protect data in the event of a loss of external power. In the event of a complete loss of input AC power, the battery assemblies are used to allow the contents of NVS memory to be written to a number of DDMs internal to the processor complex, prior to power off.

The data DDMs are not protected from power loss unless the extended power line disturbance (Extended PLD) feature has been purchased.

4.3.5 DS8000 series products

The DS8000 Family technical specifications are shown in Table 4-2.

Table 4-2 DS8000 Family technical specifications

Models	DS8100 (931) - withdrawn	DS8300 (932, 9B2) - withdrawn	DS8700 (941, 94E)	DS8800 (951, 95E)
Shared SMP processor configuration	POWER5+ dual 2-way	POWER5+ dual 4-way	POWER6 dual 2-way or 4-way	POWER6 dual 2-way or 4-way
Other major processors	PowerPC, ASICs	PowerPC, ASICs	PowerPC, ASICs	PowerPC, ASICs
Processor memory for cache and NVS (min/max)	16 GB/128 GB	32 GB/256 GB	32 GB/384 GB	32 GB/384 GB

Models	DS8100 (931) - withdrawn	DS8300 (932, 9B2) - withdrawn	DS8700 (941, 94E)	DS8800 (951, 95E)
Host adapter interfaces	4-port 4 Gbps or 2 Gbps Fibre Channel/FICON, 2-port ESCON	4-port 4 Gbps or 2 Gbps Fibre Channel/FICON, 2-port ESCON	4-port 4 Gbps Fibre Channel/ FICON	4-port and 8-port 8 Gbps Fibre Channel/ FICON
Host adapters (min/max)	2/16	2/32	2/32	2/16
Host ports (min/max)	4/64	4/128	8/128	8/128
Drive interface	FC-AL	FC-AL	4 Gbps Switched FC-AL	6 Gbps serial-attached SCSI (SAS-2, connected to 8 Gbps switched FC-AL)
Number of disk drives (min/max)	16/384	16/1024	8/1024	16/1056
Device adapters	Up to eight 4-port FC-AL	Up to 16 4-port FC-AL	Up to 16 4-port 2 Gbps FC-AL	Up to 16 4-port 8 Gbps FC-AL
Maximum physical storage capacity	384 TB	1024 TB	2048 TB	634 TB

DS8700 overview

The IBM System Storage DS8700 is designed to support the most demanding business applications with its exceptional all-around performance and data throughput. Combined with its world-class business resiliency and encryption features, it provides a unique combination of high availability, performance, and security. Its tremendous scalability, broad server support, and virtualization capabilities can help simplify the storage environment by consolidating multiple storage systems onto a single DS8700.

The IBM System Storage DS8700 provides new functional capabilities, allowing you to choose the combination of price and efficiency that is right for your application needs. New capabilities include these:

- IBM POWER6 processor technology: The DS8700 features the IBM POWER6 server technology to help support high performance. Compared to the POWER5+ processor in previous models, the POWER6 processor can enable over a 40% performance improvement in I/O operations per second in transaction processing workload environments. Additionally, sequential workloads can receive as much as 150% bandwidth improvement. The DS8700 offers either a dual 2-way processor complex or a dual 4-way processor complex.
- PCI-e IO enclosures: To improve IOPS (I/O Operations Per Second) and sequential read/write throughput, the new IO enclosures are directly connected to the servers by point-to-point PCI-e cables. IO enclosures no longer share common “loops”; they connect directly to each internal server by separate cables and link cards.
- Four-port device adapters: Device adapter processor hardware has been upgraded to twice as fast processors for more IOPS performance to enable better utilization of SSD drives.
- Non-disruptive upgrade path for the DS8700 Model 941 and additional Model 94E expansion frames allows processor, cache, and storage enhancement to be performed concurrently without disrupting applications.

- Enhancements to disk encryption key management that can help address PCI-DSS (Payment Card Industry Data Security Standard) requirements:
  - Encryption deadlock recovery key: This feature supports the ability for IBM to restore access to a DS8700 when the encryption key for the storage is unavailable due to an encryption deadlock scenario.
  - Dual platform key server support: DS8000 requires an isolated key server in encryption configurations. The isolated key server currently defined is an IBM System x server. Dual platform key server support allows two separate server platforms to host the key manager with either platform operating in either *clear key* or *secure key* mode.
- Value based pricing/licensing: Operating Environment License is now priced based on the performance, capacity, speed, and other characteristics that provide value in customer environments.

Besides these new functions, the DS8700 inherits most of the features of its predecessors.

DS8700 Models 941 and 94E

The DS8700 series currently has one model available: the DS8700 model 941. You can also order Expansion Frames with the base frame: 94E.

In the following sections, we describe these models further:

- DS8700 Model 941:

  This model features a dual two-way processor complex with only 64 DDMs and 8 FC Adapter cards, a dual two-way processor complex with 128 DDMs and 16 FC Adapter cards and a dual four-way processor complex with 128 DDMs and 16 FC Adapter cards.
- DS8700 Model 94E:

  This model represents the Expansion Frame for the 941 model and includes additional FC Adapter cards to allow a maximum configuration of 32 FC Adapter cards.

Frames: The 3th, 4th, and 5th frame from a DS8300 (92E) can be reused in the DS8700.

The DS8700 Model 941 has the following features:

- Two processor complexes, each with a System p6 POWER6 4.7GHz two-way or four-way Central Electronics Complex (CEC).
- A two-way configuration requires two battery packs; a four-way configuration requires three battery packs.
- Base frame with up to 128 DDMs for a maximum base frame disk storage capacity of 128 TB with SATA DDMs.
- Up to 128 GB (two way) or 384 GB (four way) of processor memory, also referred to as the *cache*. Note that the DS8700 supports concurrent cache upgrades.
- Up to 16 four-port Fibre Channel/FICON host adapters (HAs) of 4 Gbps. Each port can be independently configured as either:
  - FCP port to open systems hosts attachment.
  - FCP port for Metro Mirror, Global Copy, Global Mirror, and Metro/Global Mirror connectivity.
  - FICON port to connect to System z hosts.
  - FICON port for z/OS Global Mirror connectivity.
  - This totals up to 64 ports with any mix of FCP and FICON ports.

- The DS8700 Model 941 can connect up to four Expansion Frame Model 94E/92E. Figure 4-2 on page 118 depicts a front view of a DS8700 Model 941 and 94E with the covers off. The base and Expansion Frame together allow for a maximum capacity of 384 DDMs: 64 DDMs minimum or 128 DDMs maximum in the base frame and 256 DDMs in the Expansion Frame. With all of these being 1 TB enterprise DDMs, this results in a maximum disk storage subsystem capacity of 384 TB.

Figure 4-25 shows the maximum configuration of a DS8700 with the 941 base frame plus a 94E Expansion Frame and provides the front view of the basic structure and placement of the hardware components within both frames.

> **Upgrades:** A model 941 supports non-disruptive upgrades from a 64 DDM install to a full four expansion rack unit.

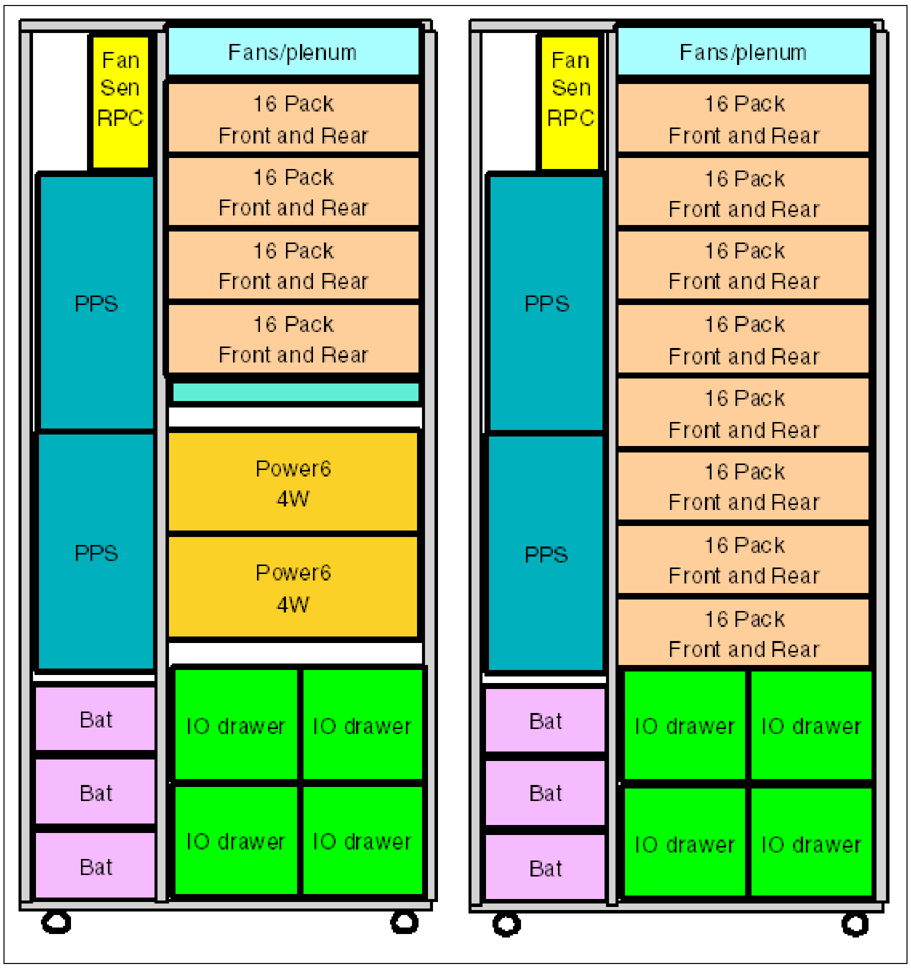


Figure 4-25 Maximum DS8700 configuration: 941 base unit and 94E expansion

DS8700 models vary in processor type, maximum disk storage capacity, processor memory, and maximum host adapters. Table 4-3 provides a comparison of the DS8700 model 941 and its available combination of resources.

Table 4-3 DS8700 series model comparison 941 and additional resources

Base models	Expansion models	Processor types	DDMs	Processor memory	Max. host adapters
941	None	2-way 4.7 GHz	<= 64	<= 128 GB	<= 8
941	None	2-way 4.7 GHz	<= 128	<= 128 GB	<= 16
941	None	4-way 4.7 GHz	<= 64	<= 384 GB	<= 16
	1 x 94E		<= 384		<= 32
	2 x 94E		<= 640		
	3 x 94E		<= 896		
	4 x 94E		<= 1024		

Depending on the DDM sizes, which can vary within a 941 or 94E and the number of DDMs, the total capacity is calculated accordingly.

DS8700 disk drives

The DS8700 offers a selection of Fibre Channel and SATA disk drives as well as SSD. This way it is possible to consolidate multiple workloads in a single storage system, with different tiers of performance and cost. The DS8700 uses 3.5 inch form factor disks only.

- Fibre Channel disk drives:

  The DS8700 offers a selection of industry standard Fibre Channel disk drives, including 300 GB (15K rpm), 450 GB (15K rpm), and 600 GB (15K rpm). The 600 GB 15K rpm Fibre Channel Disk Drive provides capacity, allowing a single system to scale up to 614 TB of Fibre Channel capacity. The DS8700 also allow customers to install 300 GB 15K rpm and 450 GB 15K rpm Full Disk Encryption drive sets.

- Serial ATA drives:

  With the 2 TB (7,200) Serial ATA (SATA) drives, the DS8700 capacity scales up to 2 PB (2048 TB = 2 petabytes = 2 PB). These SATA drives offer a cost-effective option for lower priority data.

- Solid state drives:

  With solid state drives (SSDs), which are available in 73 GB, 146 GB, and 600 GB, the DS8700 offers new opportunities for ultra high performance applications.

DS8800 overview

The IBM System Storage DS8000 series encompasses the flagship disk enterprise storage products in the IBM System Storage portfolio. The DS8800 represents the latest in this series designed for high-performance, high-capacity, and resilient series of disk storage systems.

The DS8800 family includes the DS8800 Model 951 base frame and the associated DS8800 Expansion Unit Model 95E.

The DS8800 is available in either of the following configurations:

- DS8800 Model 951 Standard Cabling:

  This model is available as either a dual 2-way processor complex with installation enclosures for up to 144 DDMs and 4 FC adapter cards or a dual 4-way processor complex with enclosures for up to 240 DDMs and 8 FC adapter cards. Standard cabling is optimized for performance and highly scalable configurations, allowing large long-term growth

- DS8800 Model 951 Business Class Cabling:

  This configuration of the Model 951 is available as a dual 2-way processor complex with installation enclosures for up to 240 DDMs and 4 FC adapter cards. The business class option allows a system to be configured with more drives per device adapter, reducing configuration cost and increasing adapter utilization. Scalability is limited with this option.

  Upgrades: Model 951 supports non-disruptive upgrades from dual 2-way to dual 4-way.

  For more details on Business Class Cabling, see “DS8800 Business Class cabling feature” on page 157.

- DS8800 Model 95E:

  This expansion frame for the 951 model includes enclosures for additional DDMs and additional FC adapter cards to allow a maximum configuration of 16 FC adapter cards. The Expansion Unit 95E can only be attached to the 951 4-way processor complex. Up to two expansion frames can be attached to a Model 951. FC adapter cards can only be installed in the first expansion frame.

Requirements:

- Former 92E and 94E expansion frames cannot be reused in the DS8800
- A model 951 supports non-disruptive upgrades from a 48 DDM install to a full two expansion rack unit.
- Only one expansion frame can be added concurrently to the business class configuration.
- Addition of a second expansion frame to a business class configuration requires recabling as standard class, is disruptive, and is available by RPQ only.

Table 4-4 provides a comparison of the DS8800 model 951 and its available combinations of resources.

Table 4-4 DS8800 series model comparison 951 and additional resources

Base model	Cabling	Expansion model	Processor type	Max DDMs	Max processor memory	Max host adapters
951	Standard	None	2-way 5.0 GHz	<==144	<==128 GB	<==4
951	Business	None	2-way 5.0 GHz	<==240	<==128 GB	<==4
951	Standard	None	4-way 5.0 GHz	<==240	<==384 GB	<==8

Base model	Cabling	Expansion model	Processor type	Max DDMs	Max processor memory	Max host adapters
951	Standard	1 x 95E	4-way 5.0 GHz	<==576	<==384 GB	<==16
951	Standard	2 x 95E	4-way 5.0 GHz	<==1056	<==384 GB	<==16
951	Business	1 x 95E	4-way 5.0 GHz	<==576	<==384 GB	<==12

Depending on the DDM sizes, which can be different within a 951or 95E, and the number of DDMs, the total capacity is calculated accordingly.

Each Fibre Channel/FICON host adapter has four or eight Fibre Channel ports, providing up to 128 Fibre Channel ports for a maximum configuration. Machine type 242*x*

DS8800 models are associated to machine type 242*x,* exclusively. This machine type corresponds to the “Enterprise Choice” length of warranty offer that allows a 1 year, 2 year, 3 year, or 4 year warranty period (x=1, 2, 3, or 4, respectively). The 95E expansion frame has the same 242*x* machine type as the base unit.

The DS8800 features up to 90% more drives in a single frame. Compared to the DS8700, the DS8800 offers more drives in 60% the floor space when fully-configured, as seen in Figure 4-26.

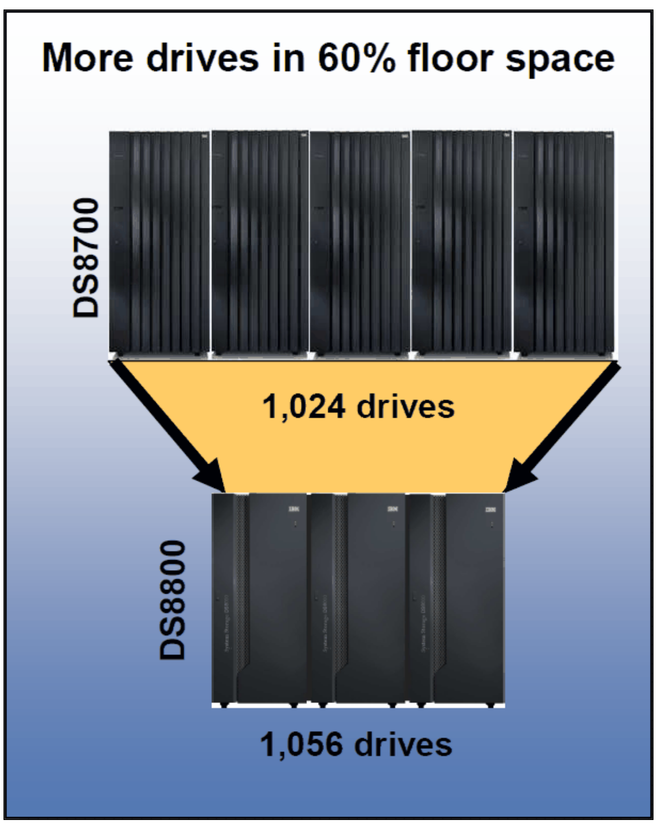


Figure 4-26 Fully configured DS8800 and DS8700 floor space comparison

Energy efficiency

The previous models of DS8000 series were designed to take in cold air from both front and back, and route the hot air out the top, known as chimney design. However, many companies are re-arranging their data centers into separate cold aisles and hot aisles to optimize energy efficiency. The new DS8800 has front-to-back cooling to help accommodate this design with a complete front-to-back airflow, as shown in Figure 4-27.

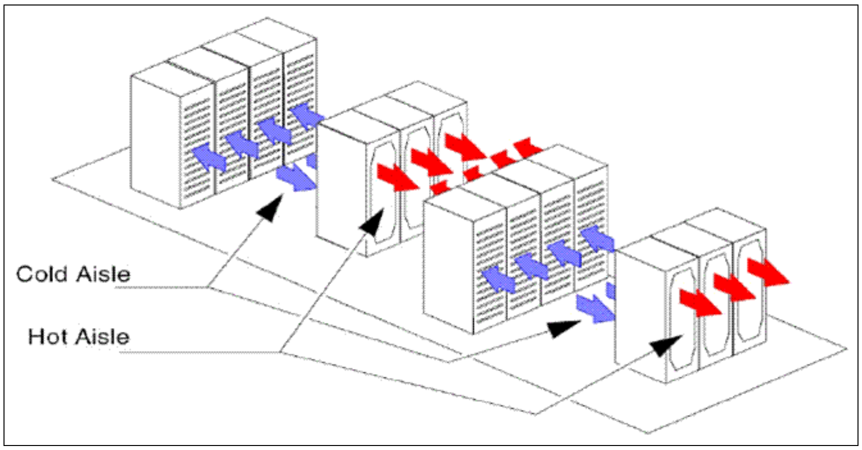


Figure 4-27 DS8800 front-to-back cooling design

DS8800 Models 951 and 95E

The DS8800 Model 951, shown in Figure 4-28, has the following features:

- A base frame with up to 240 DDMs for a maximum base frame disk storage capacity of 140 TB in high density storage enclosures. **1**
- Two processor complexes, each with a IBM System p POWER6+ 5.0 GHz 2-way or 4-way Central Electronic Complex (CEC). **2**
- Up to 128 GB (2-way) or 384 GB (4-way) of processor memory, also referred to as the *cache*. Note that the DS8800 supports concurrent cache upgrades.
- Up to 8 four-port or eight-port Fibre Channel/FICON host adapters (HAs) of 8 Gbps. **3** Each port can be independently configured as either:
  - FCP port to open systems hosts attachment
  - FCP port for Metro Mirror, Global Copy, Global Mirror, and Metro/Global Mirror connectivity
  - FICON port to connect to System z hosts
  - FICON port for z/OS Global Mirror connectivity
  - This totals up to 64 ports with any mix of FCP and FICON ports
- A 2-way configuration requires two battery packs. A 4-way configuration requires three battery packs. **4**
- The DS8800 has redundant Primary power supplies (PPS) **5** are on the side of the frame. They provide a redundant 208 VDC power distribution to the rack. The processor nodes, I/0 drawers, and storage enclosures have dual power supplies that are connected to the rack power distribution units (PDU) **6**
- The DS8800 Model 951 can connect up to two expansion frames (Model 95E). Figure 4-28 depicts a front and rear view of a DS8800 Model 951 with the covers off, displaying the components as shown.

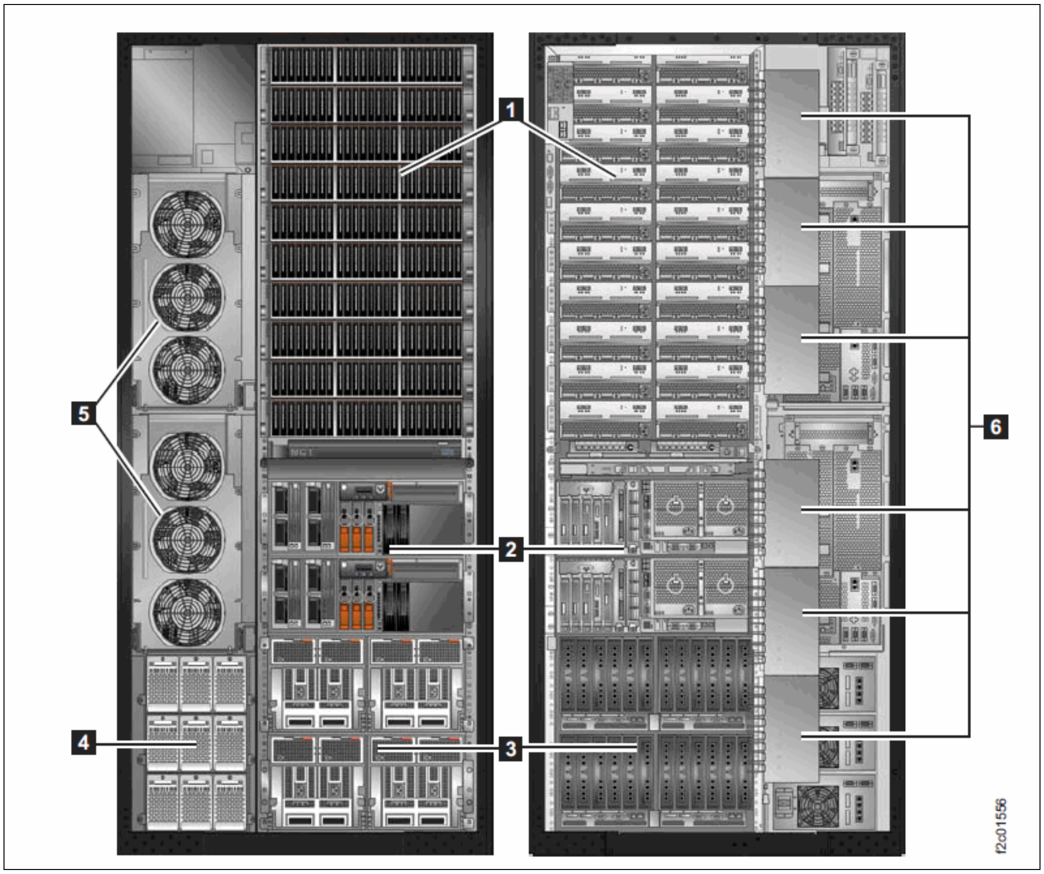


Figure 4-28 DS8800 base frame with covers removed: Front and rear

Example 4-29 shows the maximum configuration for a DS8800 Model 951 base frame with one 95E expansion frame.

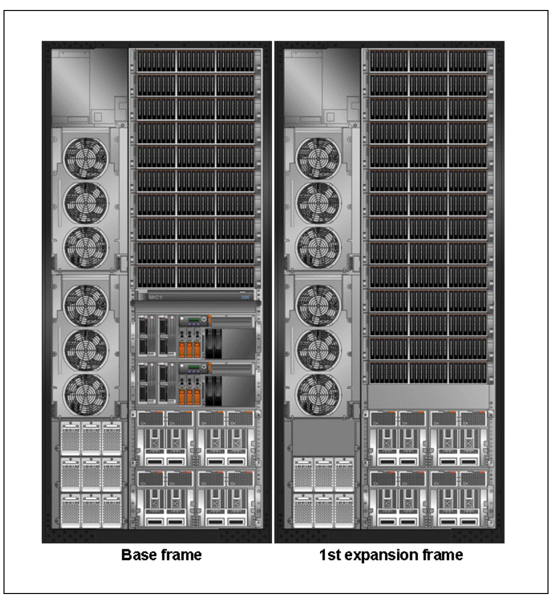


Figure 4-29 DS8800 configuration: 951 base unit with one 95E expansion frame: Front

There are no additional I/O enclosures installed for the second expansion frame. The result of installing all possible 1056 DDMs is that they will be distributed nearly evenly over all the device adapter (DA) pairs. The second 95E expansion frame is depicted in Figure 4-30.

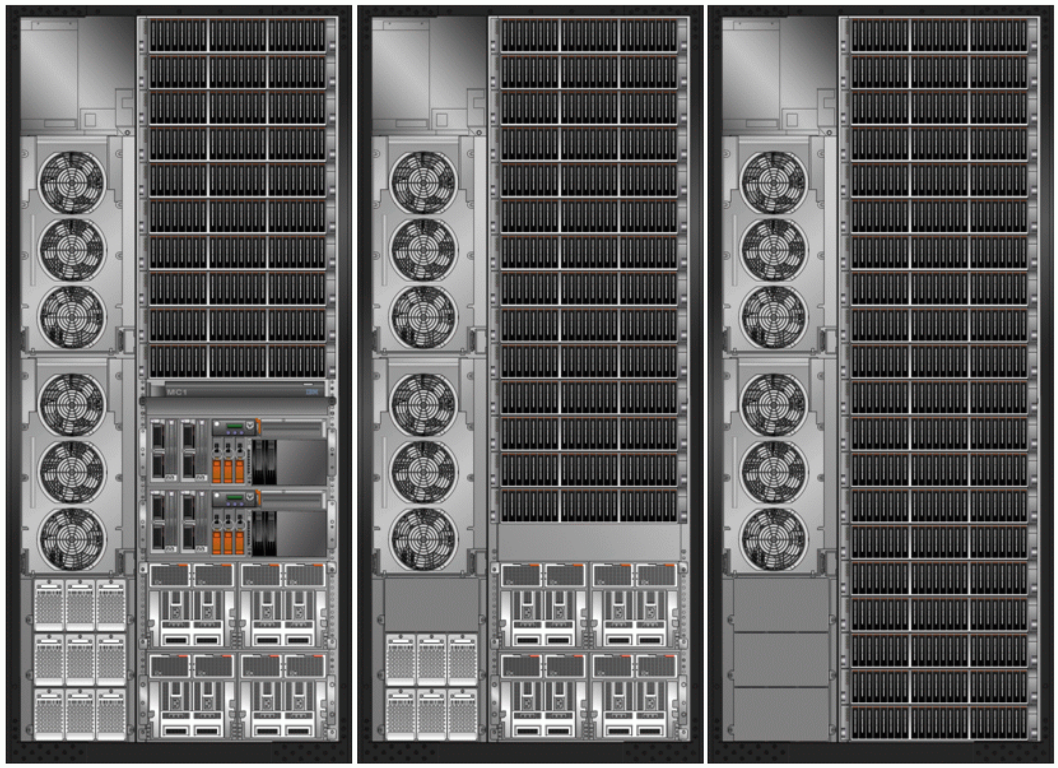


Figure 4-30 DS8800 models 951/95E maximum configuration with 1056 disk drives: Front

Here we list considerations for scalability of the DS8800 disk drive modules (DDMs):

- The DS8800 model 951 can have up to 144 DDMs and 4 FC adapter cards in the 2-way standard configuration.
- The DS8800 model 951 can have up to 240 DDMs and 4 FC adapter cards in the 2-way business class configuration.
- The DS8800 model 951 can have up to 240 DDMs and 8 FC adapter cards in the 4-way configuration in the base frame. The DS8800 model 951 4-way configuration supports up to 1056 DDMs and 16 FC adapter cards with two expansion frames.

A summary of the capacity characteristics is given in Table 4-5.

Table 4-5 Capacity comparison of device adapters, DDMs, and storage capacity

Component	2-way base frame with one I/O enclosure pair	2-way base frame, business class cabling	4-way base with two I/O enclosure pairs	4-way (one expansion frame)	4-way (two expansion frames)
DA pairs	1 or 2	1 or 2	1 to 4	1 to 8	1 to 8
HDDs	Up to 144 increments of 16	Up to 240 increments of 16	Up to 240 increments of 16	Up to 576 increments of 16	Up to 1056 increments of 16

Component	2-way base frame with one I/O enclosure pair	2-way base frame, business class cabling	4-way base with two I/O enclosure pairs	4-way (one expansion frame)	4-way (two expansion frames)
SSDs	Up to 96 increments of 16	Up to 96 increments of 16	Up to 192 increments of 16	Up to 384 increments of 16	Up to 384 increments of 16
Maximum physical capacity	86 TB	144 TB	144 TB	346 TB	633 TB

DS8800 disk drives

The DS8800 provides storage enclosure support for 24 small form factor (SFF, 2.5") SAS drives in 2U of rack space. This option helps improve the storage density for disk drive modules (DDMs) as compared to previous enclosures, which only supported 16 DDMs in 3.5U of rack space.

- Serial Attached SCSI (SAS) disk drives:

  The DS8800 offers a selection of industry standard SAS-2 disk drives, including 146 GB (15K rpm), 450 GB (10K rpm), and 600 GB (10K rpm). The DS8800 also allow customers to install 450 GB 10K rpm and 600 GB 10K rpm with Full Disk Encryption.

- Solid state drives:

  The DS8800 offers 300 GB SSD SAS attached disk drives. SSDs are a high-IOPS class enterprise storage device targeted at Tier 0 applications that can use a high level of fast-access storage. SSDs offer a number of potential benefits over hard disk drives, including better IOPS performance, lower power consumption, less heat generation, and lower acoustical noise.

Device adapters and performance

By default, the DS8800 comes with an additional pair of device adapters per 48 DDMs. If you order a system with, for example, 96 drives, you will get two Device Adapter (DA) pairs. When ordering 432 disk drives, you get eight DA pairs, which is the maximum number of DA pairs. Adding more drives will not add DA pairs. Having many DA pairs is important to achieving a higher throughput level required by some sequential workloads, such as data warehouse installations requiring a throughput of 1 GBps or more.

DS8800 Business Class cabling feature

The IBM System Storage DS8800 business class cabling feature offers a streamlined, lower cost configuration than the standard configuration. The DS8800 business class cabling feature reconfigures the Model 951, reducing the number of installed device adapters and I/O enclosures while increasing the number of storage enclosures attached to the remaining device adapters. The business class option allows a system to be configured with more drives per device adapter, thereby reducing configuration cost and increasing adapter usage.

The DS8800 Model 951 with business class cabling has the following features:

- Cost-optimized cabling
- Dual two-way processor complex
- Up to 128 GB of processor memory on a two-way processor and up to 384 GB on a four-way.
- Up to 4 host adapters or up to 32 host ports, FCP (Fibre Channel protocol) or FICON, and up to 12 host adapters on a four-way configuration.

With one Model 95E expansion unit, the DS8800 Model 951 business class supports up to 576 disk drives, for a maximum capacity of up to 346 TB, and up to 12 host adapters. An expansion model 95E is added after reaching 240 drives, and as with a standard Model 951 with expansion frame, provides 576 drives. The cabling of the expansion frame remains the same for both the standard and business class.

Cable: The DS8800 high-density business class disk drive cable option is an optional feature (feature code 1250).

Figure 4-31 shows the business class cabling configuration for a Model 951 used with an expansion model (95E).

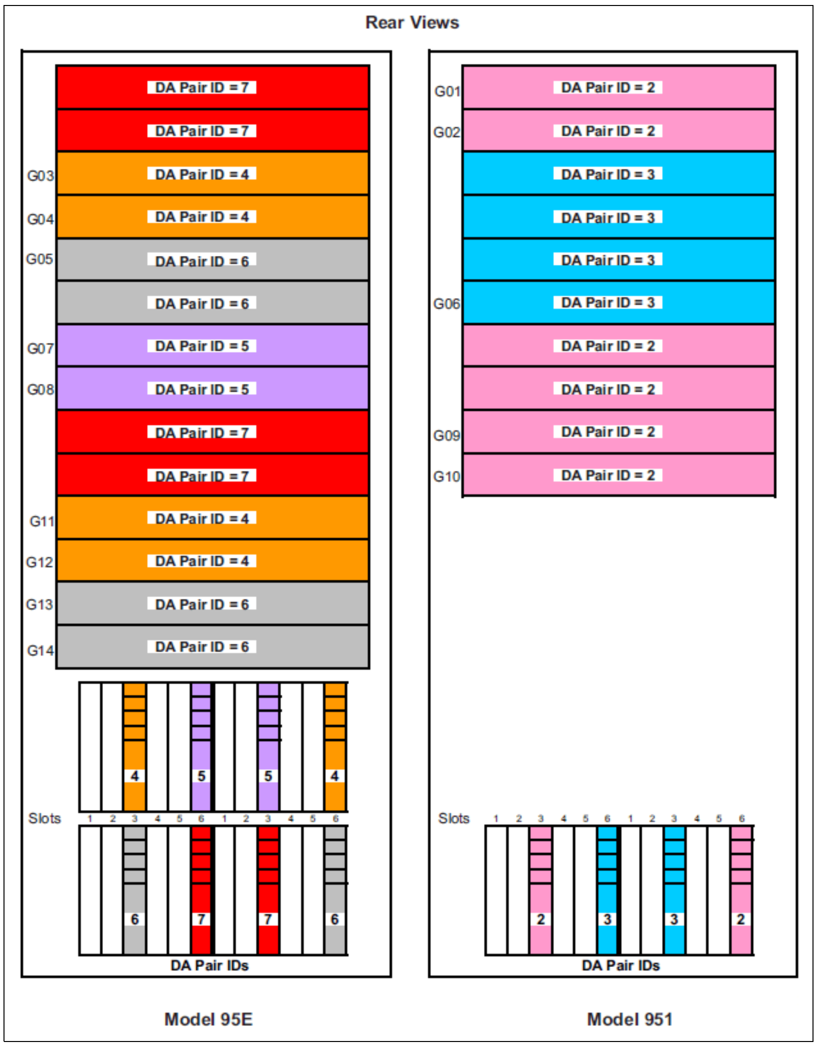


Figure 4-31 Cabling configuration for Model 951 (business class) with expansion Model 95E

As explained before, the DS8800 business cabling class option of the Model 951 is available as a dual 2-way processor complex with installation enclosures for up to 240 DDMs and 4 FC adapter cards. Figure 4-32 shows the maximum configuration of 2-way standard versus 2-way business class cabling.

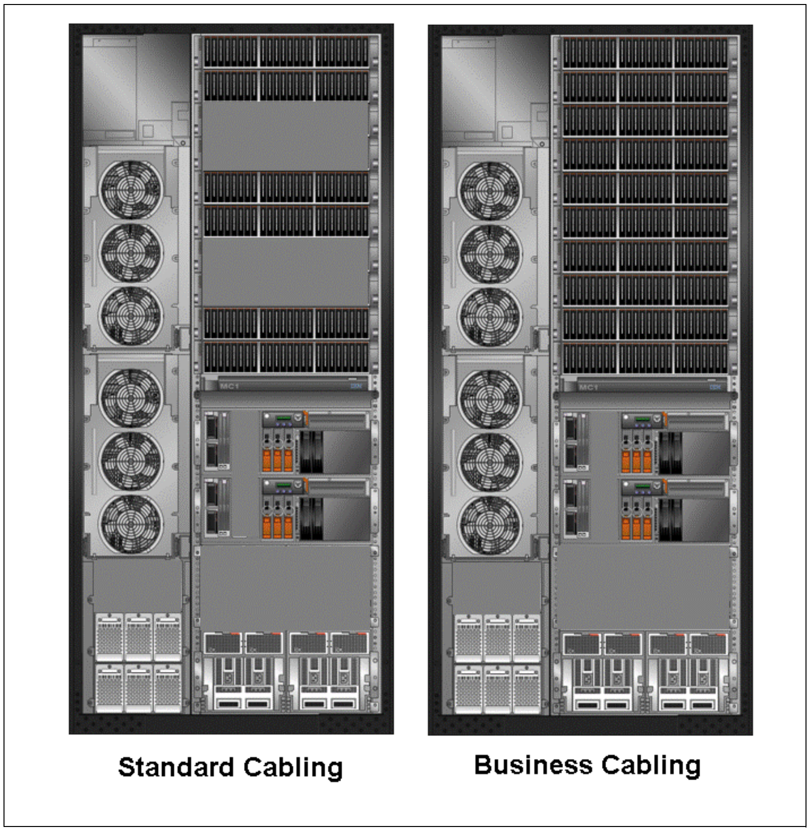


Figure 4-32 DS8800 2-way Processor standard cabling versus business cabling: Front

In order to connect an expansion frame to the business cabling configuration, an upgrade from a 2-way to 4-way processor complex is a pre-requisite. The upgrade of the processor complex and the addition of the expansion frame are both concurrent operations. Figure 4-33 shows the maximum configuration of business class cabling.

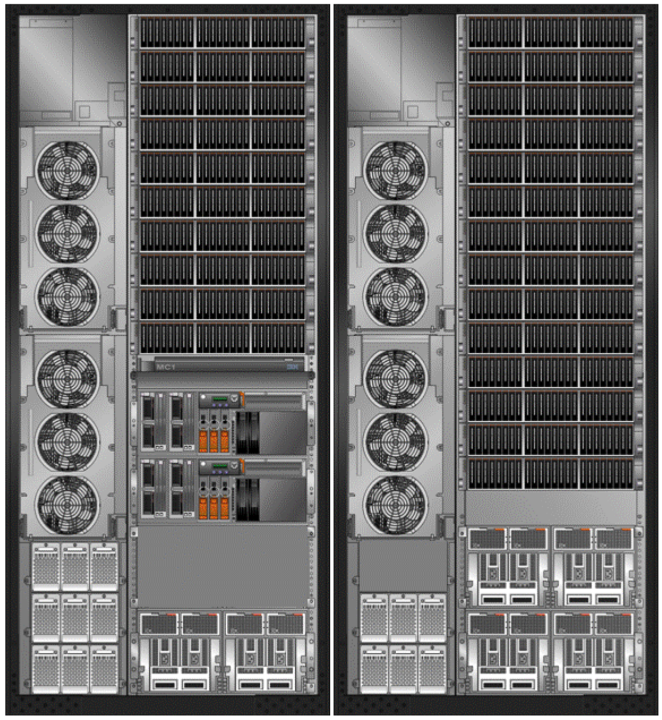


Figure 4-33 Business Class Cabling with expansion frame: Front

4.3.6 DS8000 management

The IBM DS8000 series offers the following management interfaces:

- IBM System Storage DS Storage Manager GUI
- IBM System Storage DS Command-Line Interface (CLI)
- IBM System Storage DS Open application programming interface
- IBM Tivoli Storage Productivity Center
- IBM Tivoli Storage Productivity for Replication Manager

> **Attention:** For DS8000, you can have a maximum of 256 clients connected to a single storage unit server at the same time. Clients include all DS Storage Managers, DS command-line interfaces, DS open application interfaces, and IBM Tivoli Storage Productivity Center for Replication sessions. However, you must not simultaneously start more than 100 client sessions including DS CLI sessions. Starting more than 100 sessions simultaneously can result in connection problems.

In this section, we discuss each one of the interfaces.

Hardware Management Console

The IBM System Storage Hardware Management Console (HMC) is the focal point for configuration, copy services management, and maintenance activities. The HMC is a dedicated notebook that is physically located (installed) inside your DS8800 and can automatically monitor the state of your system, notifying you and IBM when service is required.

The HMC management features include these:

- DS8000 power control
- Storage provisioning
- Advanced Copy Services management
- Interface for on-site service personnel
- Call Home and problem management
- Remote support
- TKLM encryption functions

The HMC is the point where the DS8000 is connected to the customer network. It provides the services that the customer needs to configure and manage the storage, and it also provides the interface where service personnel will perform diagnostics and repair actions. The HMC is the contact point for remote support, both modem and VPN.

Access to the IBM DS8000 Storage Manager interface is embedded in the management console. All base model ships with one internal Management Console. An external Management Console is available as a optional feature and can be used as a redundant management console for environments with high-availability requirements.

Internet Protocol: The DS8000 HMC supports IPv6, the next generation of the Internet Protocol. The Hardware Management Console (HMC) continues to support the IPv4 standard as well as mixed IPV4 and IPv6 environments.

The graphical user interface (GUI) of the IBM System Storage DS8000 Storage Manager is accessible from IBM System Storage Productivity Center (SSPC) through the IBM Tivoli Storage Productivity Center GUI.

IBM System Storage DS Storage Manager GUI

The DS Storage Manager is a web based GUI that is used to perform logical configurations and Copy Services management functions. It is accessed by a web browser invoked from the SSPC, as shown in Figure 4-34.

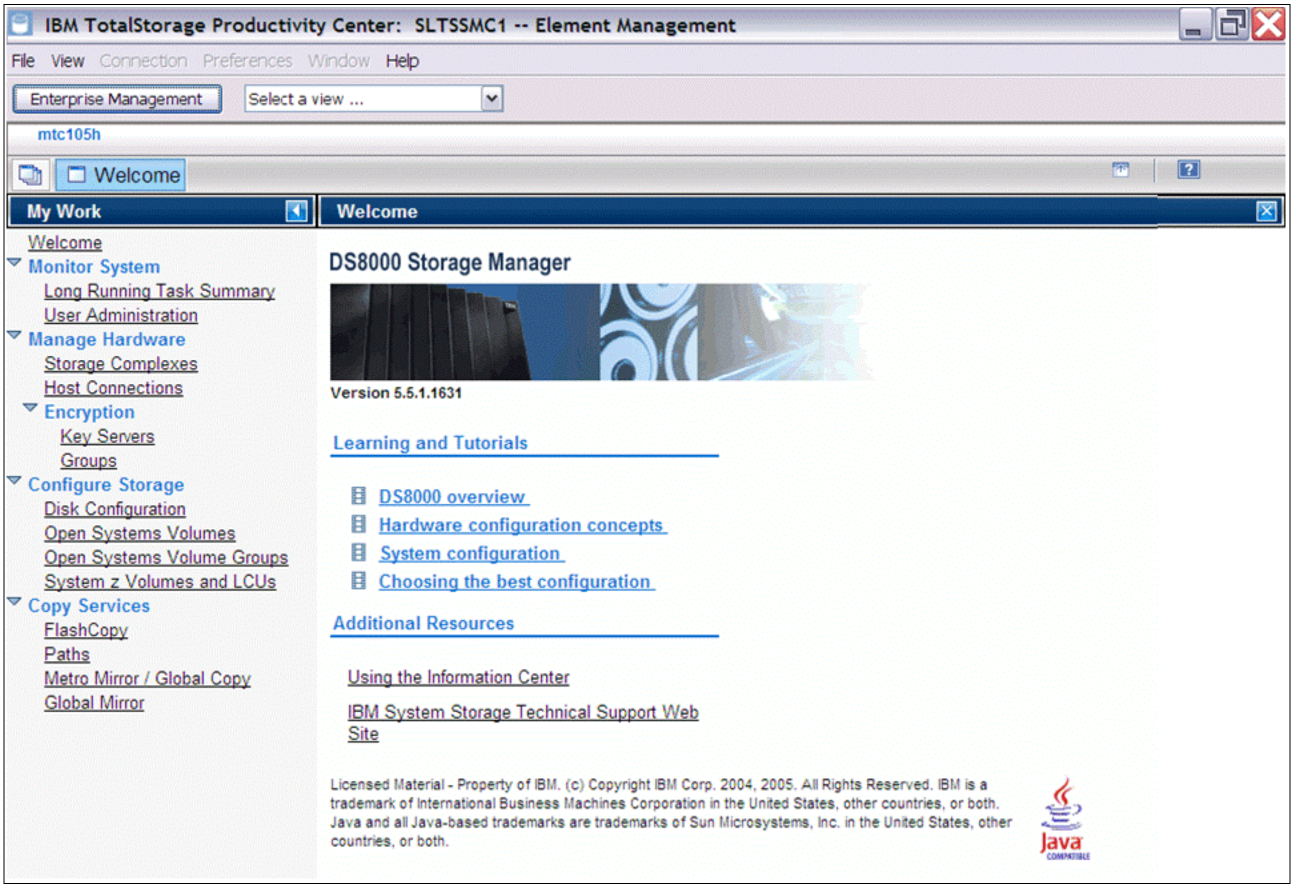


Figure 4-34 IBM DS Storage Manager GUI invoked from SSPC

You have the following options to use the DS Storage Manager:

- Simulated (Offline) Configuration:

  With this option, you can create or modify logical configurations when disconnected from the network. After creating the configuration, you can save it and then apply it to the storage system later when connected to the network.

- Real-time (Online) Configuration:

  This option provides real-time management support for logical configuration and Copy Services features for a network attached storage system.

The DS Storage Manager provides a graphical user interface (GUI) to configure the IBM System Storage DS8000 series and manage Copy Services. The DS Storage Manager GUI (DS GUI) is invoked from SSPC.

The Tivoli Storage Productivity Center is required to remotely access the DS Storage Manager GUI. The DS Storage Manager can be accessed through the Tivoli Storage Productivity Center Element Manager from any network-connected workstation with a supported browser. It can also be accessed directly from the management console by using the browser on the hardware management console.

For DS GUI changes related to disk encryption, see *IBM System Storage DS8700 Disk Encryption Implementation and Usage Guidelines*, REDP-4500.

IBM System Storage Productivity Center management console

The DS8000 series utilizes the IBM System Storage Productivity Center (SSPC), an advanced management console that can provide a view of both IBM and non-IBM storage environments. SSPC can enable a greater degree of simplification for organizations grappling with the growing number of element managers in their environment. The SSPC provides preloaded software including IBM Tivoli Storage Productivity Center (previously known as TotalStorage Productivity Center) Basic Edition and the enhanced DS Storage Manager.

The enterprise edition of the SSPC also supports the option to install the IBM Tivoli Storage Productivity Center for Replication, designed to support hundreds of replication sessions across thousands of volumes, supporting both open and z/OS attached volumes.

> **Important:** The SSPC is a separately purchased product (using Machine type 2805) for the DS8000. Any new DS8000 shipped requires a minimum of one SSPC per data center to enable the launch of the DS8000 Storage Manager other than from the HMC. Clients with currently installed DS8000 machines are not required to purchase the SSPC.

Utilizing IBM Tivoli Storage Productivity Center Basic Edition software, SSPC extends the capabilities available through the IBM DS Storage Manager. SSPC offers the unique capability to manage a variety of storage devices connected across the storage area network (SAN). The rich, user-friendly graphical user interface provides a comprehensive view of the storage topology, from which the administrator can explore the health of the environment at an aggregate or in-depth view.

Moreover, the pre-installed Tivoli Storage Productivity Center Basic Edition can be optionally licensed and used to enable more in-depth performance reporting, asset and capacity reporting, and automation for the DS8000, as well as being able to manage other resources, such as server file systems, tape drives, and libraries, with the full licensed Tivoli Storage Productivity Center modules:

- IBM Tivoli Storage Productivity Center for Disk
- IBM Tivoli Storage Productivity Center for Data
- IBM Tivoli Storage Productivity Center for Fabric
- IBM Tivoli Storage Productivity Center for Replication

This can provide an integration point for storage and fabric management and replication. For more information about the IBM Tivoli Storage Productivity Center, see Chapter 19, “IBM Tivoli Storage Productivity Center” on page 603.

IBM System Storage DS Open Application Programming Interface (API)

The DS Open API supports routine LUN management activities, such as LUN creation, mapping, and masking, and the management of point-in-time copy and remote mirroring. It supports these activities through the use of a standard interface as defined by the Storage Networking Industry Association (SNIA) Storage Management Initiative Specification (SMI-S). It is implemented through the IBM System Storage Common Information Model Agent (CIM Agent) for the DS series, a middleware application that provides a CIM-compliant interface.

You can implement the DS Open API without using a separate middleware application, like the IBM System Storage Common Information Model (CIM) agent, which provides a CIM-compliant interface. The DS Open API uses the CIM technology to manage proprietary devices as open system devices through storage management applications. The DS Open API is used by storage management applications to communicate with a storage unit.

The DS Open API and CIM Agent are provided with the DS8000.

For additional information, see the *IBM System Storage DS Open Application Programming Interface Reference* at the following website:

http://www.ibm.com/support/docview.wss?uid=ssg1S7001160

IBM System Storage DS Command-Line Interface

The IBM System Storage DS Command-Line Interface (DS CLI) is a single CLI that can perform a full set of commands for logical configuration and/or Copy Services activities. These tasks can be performed either interactively, in batch processes (operating system shell scripts), or in DS CLI script files. A DS CLI script file is a text file that contains one or more DS CLI commands and can be issued as a single command. Scripts can enhance productivity because it eliminates the previous requirement (on ESS) to create and save a task using the GUI (Example 4-1).

The following list highlights a few of the functions that you can perform with the DS CLI:

- Create user IDs that can be used with the GUI and the DS CLI.
- Manage user ID passwords.
- Install activation keys for licensed features.
- Manage storage complexes and units.
- Configure and manage storage facility images.
- Create and delete RAID arrays, ranks, and extent pools.
- Create and delete logical volumes.
- Manage host access to volumes.
- Check the current Copy Services configuration that is used by the storage unit.
- Create, modify, or delete Copy Services configuration settings.
- Integration of LDAP policy usage and configuration.
- Implement encryption functionality.

> **Internet Protocol:** For DS8000 with Licensed Machine Code (LMC) level 5.40xx.xx or later, you have the possibility to access the HMC over the newest Internet Protocol IPv6, IPv4, or both. Remember to have the DSCLI version corresponding to the LMC level installed on your system.

Example 4-1 DS CLI

```
dscli> lssi
Date/Time: 27 June, 2005 9:47:23  IBM DSCLI Version: 5.1.0.276
Name ID           Storage Unit     Model WWNN           State  ESSNet
============================================================================
IBM.2107-75ABTV1 IBM.2107-75ABTV0 9A2   5005076303FFC663 Online Enabled
IBM.2107-75ABTV2 IBM.2107-75ABTV0 9A2   5005076303FFCE63 Online Enabled
dscli> lsarray
Date/Time: 27 June 2006 9:48:27 IBM DSCLI Version: 5.1.0.276 DS: IBM.2107-7ABTV1
Array State Data RAIDtype    arsite Rank DA Pair DDMcap (10^9B)
=====================================================================
A0 Assigned Normal 5 (6+P+S) S1     R0   0             146.0
A1 Assigned Normal 5 (6+P+S) S2     R1   0             146.0
dscli>
```

The DS CLI provides a full-function set of commands to manage logical configurations and Copy Services configurations. The DS CLI can be installed on and is supported in many different environments (for example, IBM AIX, IBM i operating system, HP-UX, Linux, NetWare, OpenVMS, Solaris, and Microsoft Windows). Batch processes and task schedulers (for example, cron), can be used to automate many DS CLI common tasks (such as data replication).

For more information, see the *IBM System Storage DS8000: Command-Line Interface User´s Guide*, SC26-7916.

For DS CLI commands related to disk encryption, see the *IBM System Storage DS8700 Disk Encryption Implementation and Usage Guidelines*, REDP-4500.

4.3.7 IBM Standby Capacity on Demand offering for the DS8000

IBM Standby Capacity on Demand (Standby CoD) solutions are designed to meet the changing storage needs of rapidly growing e-businesses. IBM Standby CoD for the DS8000 offering allows inactive disk drives to be installed and easily activated as business needs require.

The Standby CoD provides the ability to tap into additional storage and is particularly attractive for rapid or unpredictable growth, or just for the knowledge that extra storage will be there when needed.

With this offering, up to for Standby CoD disk drive sets (64 disks drives) for DS8700 or up to six Standby CoD disk drive sets (96 disk drives) in DS8800 can be factory or field installed into the system. For activation, the disk drives have to be logically configured. This is a non-disruptive activity that does not require intervention from IBM.

Upon activation of any portion of a Standby CoD disk drive set, an order must be placed with IBM to initiate billing for the activated set. At that time, replacement Standby CoD disk drive sets can also be ordered.

This offering allows licensed functions to be purchased based upon the machine's physical capacity, excluding unconfigured Standby CoD capacity.

This offering does not have an offering fee premium. A Standby CoD disk drive set must be activated within a 12-month period from the date of installation and all activation is permanent. For more information about the CoD offering, see *IBM System Storage DS8700 Architecture and Implementation*, SG24-8786 and *IBM System Storage DS8800 Architecture and Implementation*, SG24-8886.

4.3.8 DS8000 Copy Services

Advanced Copy Services are enterprise-level, leading-edge functions that address an organization’s needs for disaster recovery, data migration, and data duplication.

Copy Services in the DS Family includes the following optional licensed functions:

- IBM System Storage FlashCopy and IBM FlashCopy SE, which are point-in-time copy functions
- Remote mirror and copy functions, which include these:
  - IBM System Storage Metro Mirror, previously known as synchronous PPRC
  - IBM System Storage Global Copy, previously known as PPRC Extended Distance
  - IBM System Storage Global Mirror, previously known as asynchronous PPRC
  - IBM System Storage Metro/Global Mirror, a 3-site solution to meet the most rigorous business resiliency needs

- Additionally for the System z users, the following options are available:
  - z/OS Global Mirror, previously known as Extended Remote Copy (XRC)
  - z/OS Metro/Global Mirror, a 3-site solution that combines z/OS Global Mirror and Metro Mirror

Many design characteristics of the DS systems and its data copy and mirror capabilities and features contribute to the protection of your data, 24 hours a day and seven days a week.

In this section we present an overview on DS8000 Copy Services. For more detailed information, see *IBM System Storage DS8000: Copy Services in Open Environments*, SG24-6788 and *DS8000 Copy Services for IBM System z*, SG24-6787.

IBM System Storage FlashCopy: Point-in-Time Copy feature

IBM System Storage FlashCopy (Figure 4-35) helps reduce or eliminate planned outages for critical applications. FlashCopy enables data to be copied in the background while making both source and copied data available to users almost immediately. The point-in-time copy created by FlashCopy is typically used when a copy of production data must be produced with minimal application downtime. It can be used for online backup, testing of new applications, or for copying a database for data mining purposes.

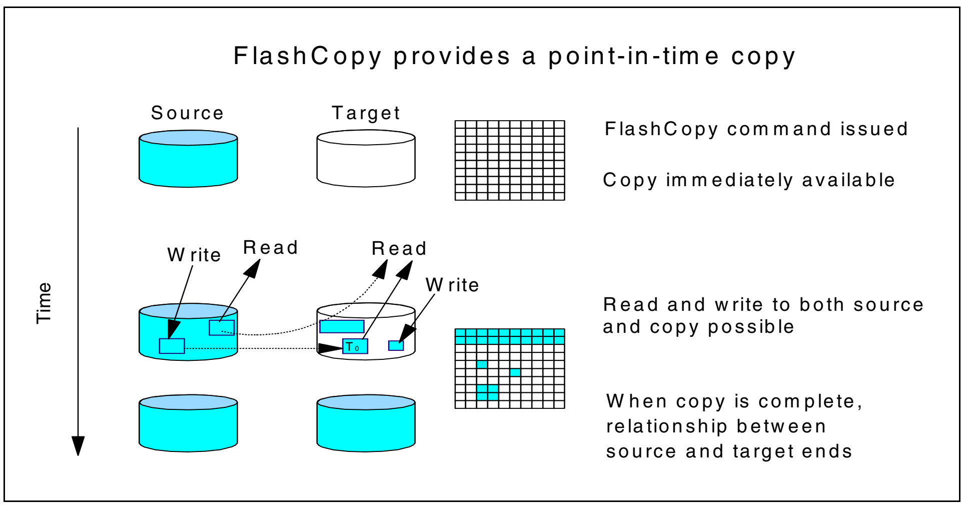


Figure 4-35 FlashCopy

FlashCopy is an additional charged feature. You must order the Point-in-Time Copy feature, which includes FlashCopy.

FlashCopy supports many advanced capabilities, including these:

- Data Set FlashCopy:

  This feature allows a FlashCopy of a data set in a System z environment.

- Multiple Relationship FlashCopy:

  This feature allows a source volume to have multiple targets simultaneously. A source volume or extent can be FlashCopied to up to 12 target volumes or target extents.

- Incremental FlashCopy:

  This feature allows update of a FlashCopy target without having to recopy the entire volume. When a subsequent FlashCopy is initiated, only the data required to make the target current with the source's newly established point-in-time is copied.

  In many cases, at most 10 to 20 percent of the entire data is changed in a day. In this situation, if you use this function for daily backup, you can save the time for the physical copy of FlashCopy.

- Consistency group function:

  This feature is used to help create a consistent point-in-time copy across multiple LUNs or volumes, and even across multiple DS8000, DS6000, ESS800, and ESS750 systems.

  If a consistent point-in-time copy across many logical volumes is required, and you do not want to quiesce host I/O or database operations, then you can use consistency group FlashCopy to create a consistent copy across multiple logical volumes in multiple storage units.

  In order to create this consistent copy, issue a set of establish FlashCopy commands with the freeze option, which will freeze host I/O to the source volumes. In other words, Consistency Group FlashCopy provides the capability to temporarily queue at the host I/O level, not at the application level, subsequent write operations to the source volumes that are part of the consistency group. During the temporary queuing, Establish FlashCopy is completed. The temporary queuing continues until this condition is reset by the **`Consistency Group Created`** command or the timeout value expires.

  After all of the Establish FlashCopy requests have completed, a set of **`Consistency Group Created`** commands must be issued using the same set of DS network interface servers. The **`Consistency Group Created`** commands are directed to each logical subsystem (LSS) involved in the consistency group. The **`Consistency Group Created`** command allows the write operations to resume to the source volumes.

  > **Important:** Consistency Group FlashCopy can create host-based consistent copies; they are not application-based consistent copies. The copies have power-fail or crash level consistency. This means that if you suddenly power off your server without stopping your applications and without destaging the data in the file cache, the data in the file cache can be lost and you might need recovery procedures to restart your applications. To start your system with Consistency Group FlashCopy target volumes, you might need the same operations as the crash recovery.

- In-band commands over remote mirror link:

  In a remote mirror environment, commands to manage FlashCopy at the remote site can be issued from the local or intermediate site and transmitted over the remote mirror Fibre Channel links. This eliminates the need for a network connection to the remote site solely for the management of FlashCopy.

- Persistent FlashCopy:

  Persistent FlashCopy allows the FlashCopy relationship to remain even after the copy operation completes. You must explicitly delete the relationship.

- FlashCopy to a Remote Mirror Primary:

  This feature allows a FlashCopy target volume to be used also as a remote mirror primary volume. This process allows you to create a point-in-time copy and then make a copy of that data at a remote site with Metro Mirror or Global Copy (Figure 4-36).

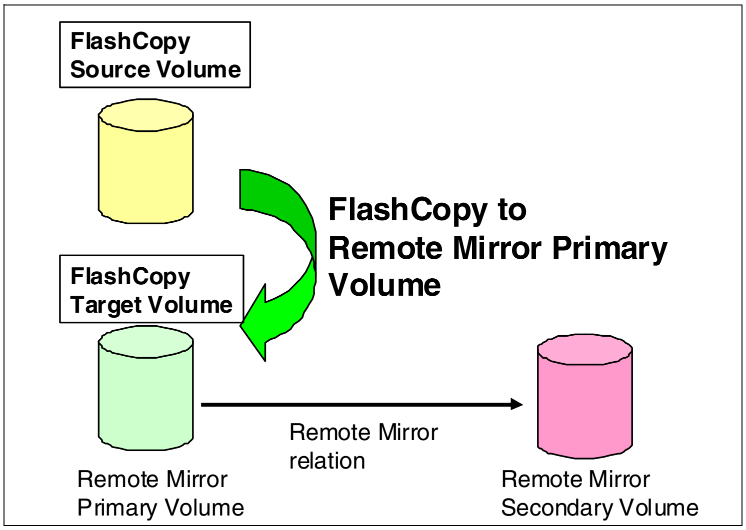


Figure 4-36 Establish FlashCopy on existing Remote Mirror and Copy Primary

This process keeps the local and remote site consistent which facilitates recovery, supports HyperSwap®, and reduces link bandwidth utilization. See *IBM System Storage DS8000: Remote Pair FlashCopy (Preserve Mirror)*, REDP-4504 for more information.

Remote Mirror and Copy feature

Remote Mirror and Copy is another separately orderable priced feature, which includes Metro Mirror, Global Copy, and Global Mirror. The local and remote storage systems must have a Fibre Channel connection between them. The Fibre Channel ports used for Remote Mirror and Copy can be configured either as a dedicated remote mirror link or as a shared port between remote mirroring and Fibre Channel Protocol (FCP) data traffic.

The DS6000 and DS8000 series systems can participate in remote mirror and copy solutions with each other as well with other systems which support this service.

IBM supports the following remote mirror and copy solutions.

IBM System Storage Metro Mirror (Synchronous PPRC)

Metro Mirror is a remote-mirroring technique for all supported servers, including z/OS and open systems, providing mirroring of logical volumes between two DS8000s or any other combination of DS8000, DS6000, and ESS800. It is designed to constantly maintain an up to date copy of the local application data at a remote site which is within the metropolitan area (typically up to 300 Km away using DWDM). With synchronous mirroring techniques, data currency is maintained between sites, though the distance can have an impact on performance.

Metro Mirror is used primarily as part of a business continuance solution for protecting data against disk storage system loss or complete site failure (Figure 4-37).

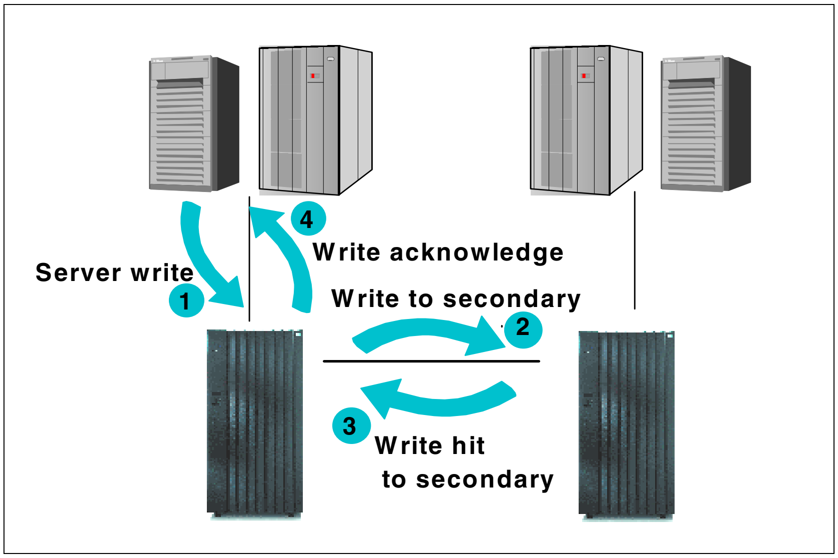


Figure 4-37 Metro Mirror

IBM System Storage Global Copy (Asynchronous PPRC-XD)

Global Copy (Figure 4-38) is an asynchronous remote copy function for z/OS and open systems for longer distances than are possible with Metro Mirror. With Global Copy, write operations complete on the primary storage system before they are received by the secondary system. This capability is designed to prevent the primary system's performance from being affected by wait-time from writes on the secondary system. Therefore, the primary and secondary copies can be separated by any distance. This function is appropriate for remote data migration, off-site backups, and transmission of inactive database logs at virtually unlimited distances.

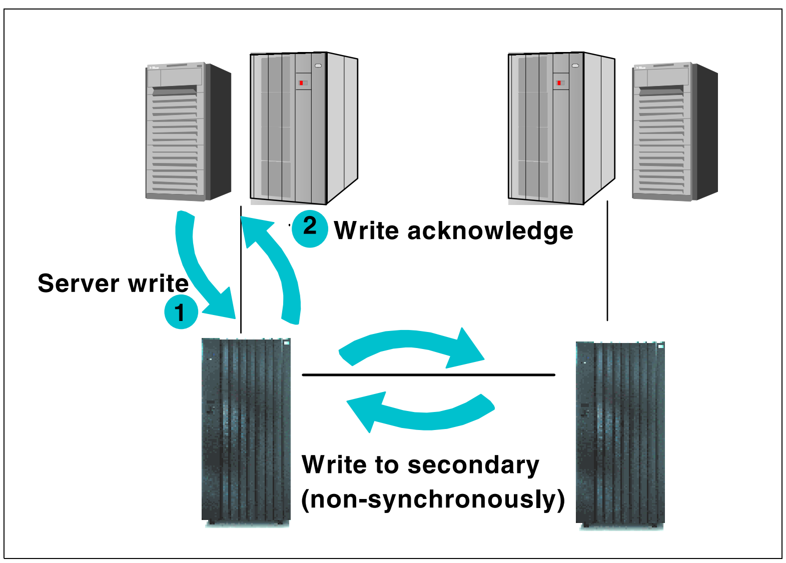


Figure 4-38 Global Copy

Global Copy does not keep the sequence of write operations. Therefore, the copy is a fuzzy copy, but you can make a consistent copy through synchronization called a go-to-sync operation. After the synchronization, you can issue FlashCopy at the secondary site to make the backup copy with data consistency. After the establishment of the FlashCopy, you can change the mode back to the non-synchronous mode.

IBM System Storage Global Mirror (Asynchronous PPRC)

Global Mirror (Figure 4-39) copying provides a two-site extended distance remote mirroring function for z/OS and open systems servers. With Global Mirror, the data that the host writes to the storage unit at the local site is asynchronously shadowed to the storage unit at the remote site. A consistent copy of the data is then automatically maintained on the storage unit at the remote site. This two site data mirroring function is designed to provide a high-performance, cost-effective global distance data replication and disaster recovery solution.

Global Mirror provide the following benefits:

- Support for virtually unlimited distances between the local and remote sites. The distances are typically limited only by the capabilities of the network and channel extension products.
- A consistent and restartable copy of the data at the remote site, created with minimal impact to applications at the local site.
- Dynamic selection of the desired recovery point objectives.
- Efficient synchronization of the local and remote sites with support for failover and failback modes.

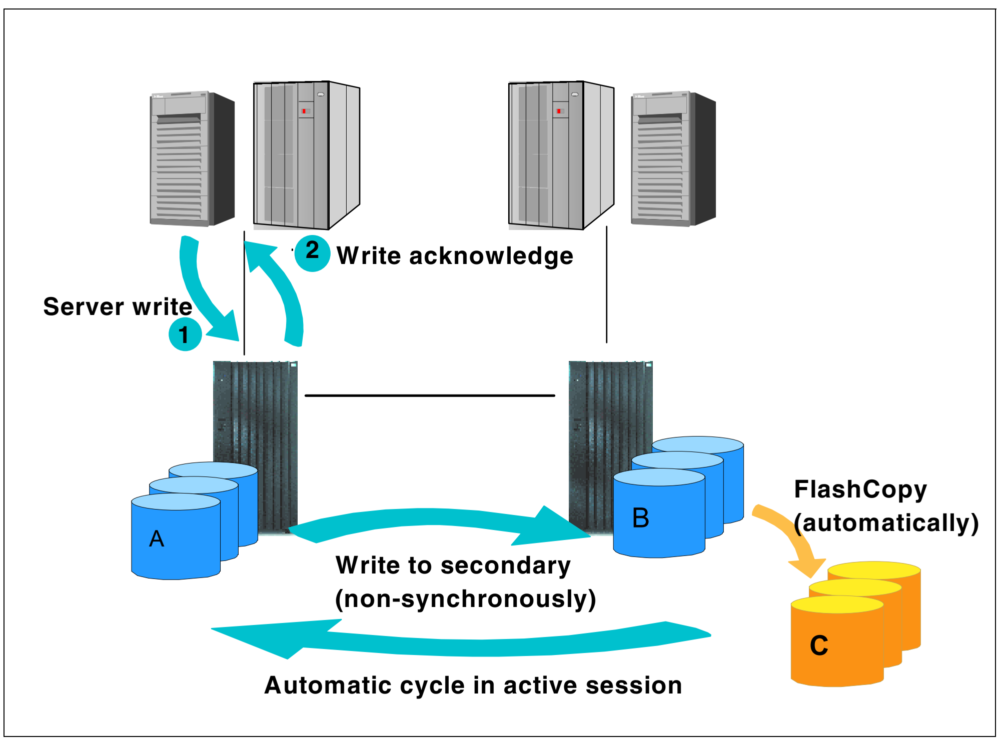


Figure 4-39 Global Mirror

IBM System Storage Metro/Global Mirror

Metro/Global Mirror is a three-site, multi-purpose, replication solution for both System z and Open Systems data. Local site (site A) to intermediate site (site B) provides high availability replication using Metro Mirror, and intermediate site (site B) to remote site (site C) supports long distance disaster recovery replication with Global Mirror. Figure 4-40 illustrates this feature.

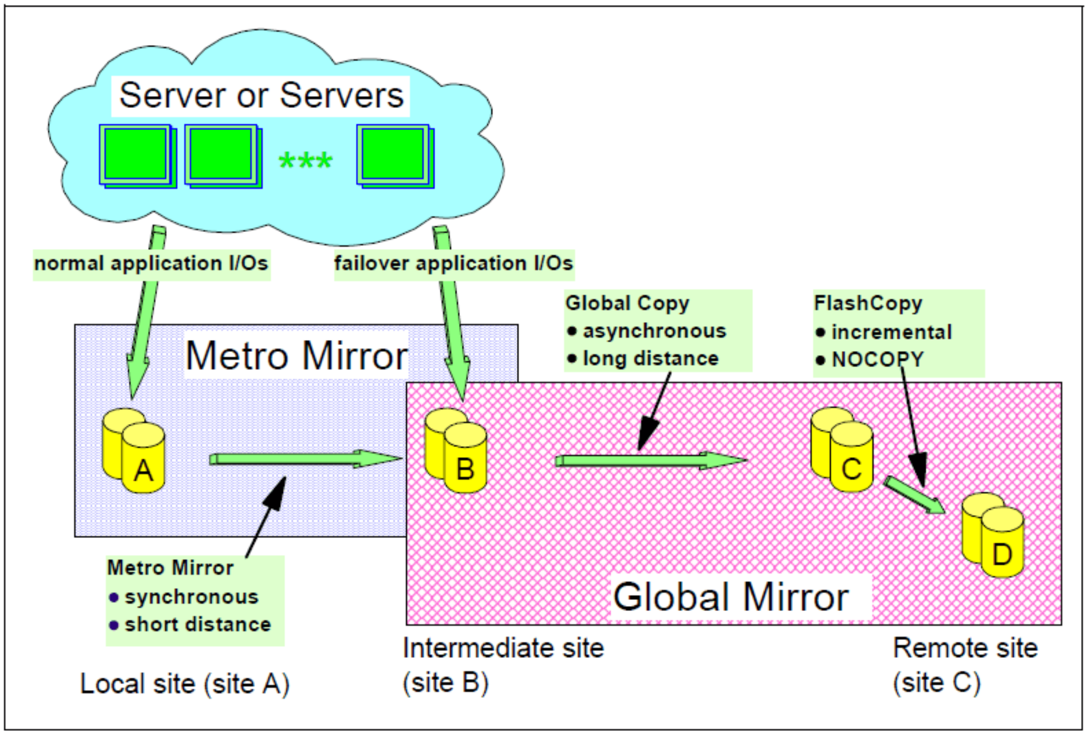


Figure 4-40 Metro/Global Mirror elements

The Metro Mirror provides the opportunity to locate the intermediate site disk subsystems close to the local site allows use of intermediate site disk subsystems in a high availability configuration. Then the Global Mirror provides a recoverable, restartable, and consistent image at the remote site with an RPO typically in the 3 to 5 second range.

IBM System Storage z/OS Global Mirror (Extended Remote Copy XRC)

z/OS Global Mirror (Figure 4-41) is a remote data mirroring function available for the z/OS and OS/390® operating systems. It maintains a copy of the data asynchronously at a remote location over unlimited distances. z/OS Global Mirror is well suited for large System z server workloads and can be used for business continuance solutions, workload movement, and data migration.

Attention: DS6000 series systems can only be used as a target system in z/OS Global Mirror operations.

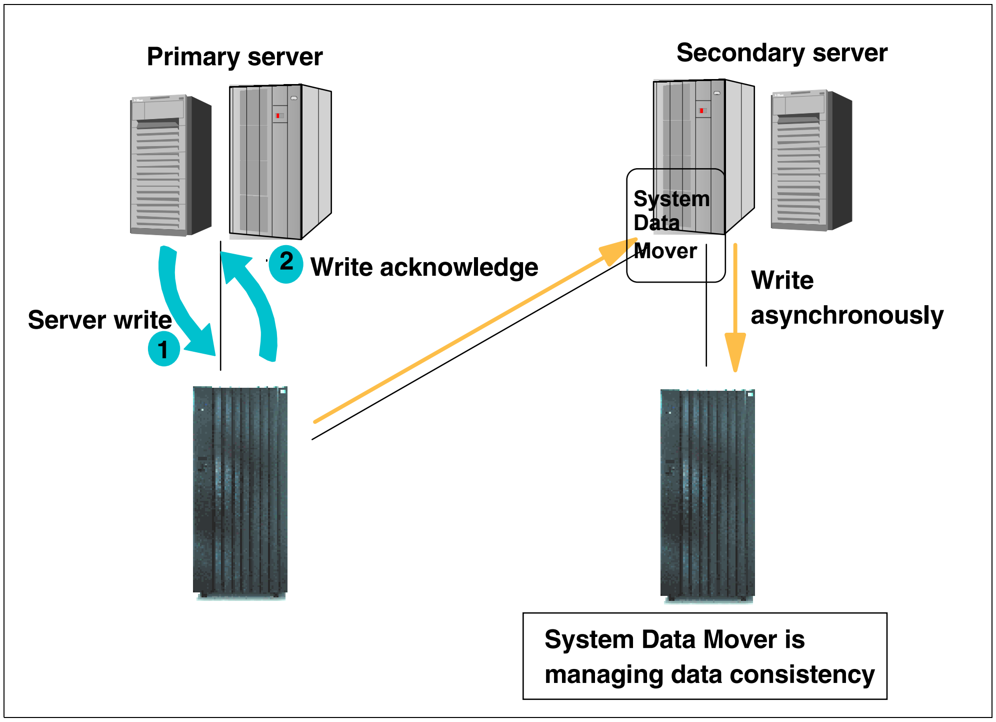


Figure 4-41 z/OS Global Mirror

IBM System Storage z/OS Metro/Global Mirror

This mirroring capability utilizes z/OS Global Mirror to mirror primary site data to a location that is a long distance away and also uses Metro Mirror to mirror primary site data to a location within the metropolitan area. This enables a 3-site high availability and disaster recovery z/OS solution for even greater protection from unplanned outages (Figure 4-42).

Support: z/OS Metro/Global Mirror is not supported on DS6000 series.

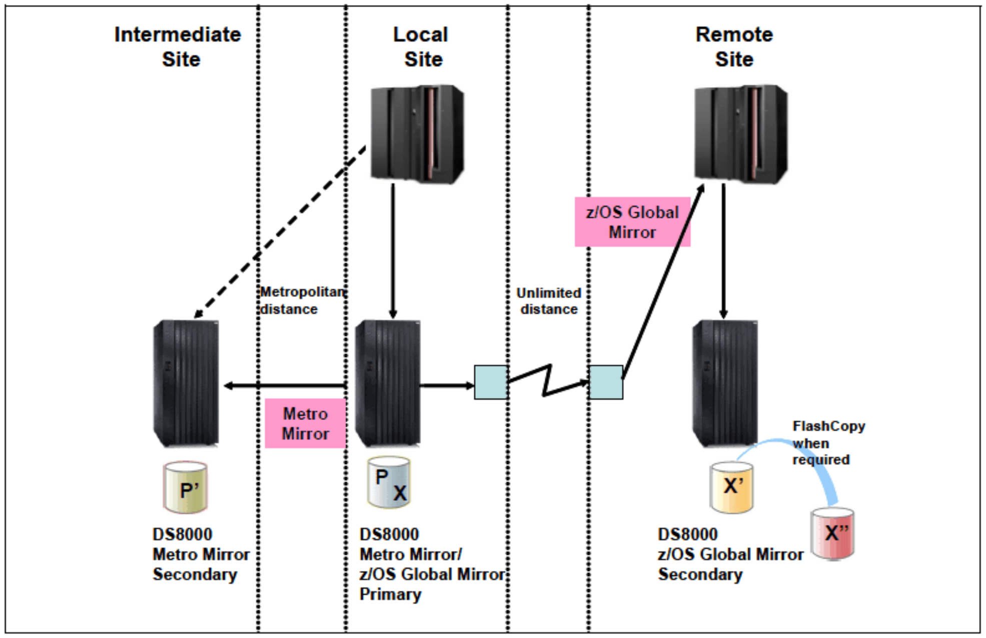


Figure 4-42 z/OS Metro/Global Mirror

For more up to date information, see *DS8000 Copy Services for IBM System z*, SG24-6787.

4.3.9 DS8000 licensing overview

Licensed functions are purchased as DS8000 function authorization features. After you decide which licensed functions to use with your storage unit, you are ready to order the functions.

The procedure is simple:

1. Order the operating environment license (OEL) features that support the total physical capacity of your storage unit.
2. Order optional licensed functions for your storage unit.

> **CoD:** Standby Capacity on Demand (CoD) disk drive features do not count toward the physical capacity. It is not necessary to order an OEL license for standby CoD physical capacity unless you want to activate it.

The operating environment model and features establish the extent of IBM authorization for the use of the IBM System Storage DS operating environment.

For all licensed functions, you can combine feature codes to order the exact capacity that you need. For example, if you determine that you need 23 TB of point-in-time capacity, you can order two 10 TB features and three 1 TB features.

Operating environment license

For every storage unit, you must order an operating environment license (OEL). This operating environment license support function is called the 239x Model LFA, OEL license on the 242x hardware machine type. The OEL licenses the operating environment and is based on the total physical capacity of the storage unit (base model plus any expansion models). It authorizes you to use the model configuration at a given capacity level.

After the OEL has been activated for the storage unit, you can configure the storage unit. Activating the OEL means that you have obtained the feature activation key from the DSFA website and entered it into the DS Storage Manager.

The operating environment license (OEL) must cover the full physical capacity of your storage unit, which includes the physical capacity of any expansion models within the storage unit. The license must cover both open systems data (fixed block data) and System z data (count key data). Standby CoD drives are not included in this calculation.

As you add additional disk drives to your storage unit, you must increase the OEL authorization level for the storage unit by purchasing additional license features (otherwise, you cannot logically configure the additional disk drives for use).

Optional licensed functions

The following ordering rules apply when you order point-in-time licenses for FlashCopy or Remote Mirror and Copy licenses:

- If the function is used with only open systems data, a license is required for only the total physical capacity that is logically configured as fixed block (FB).
- If the function is used with only System z data, a license is required for only the total physical capacity that is logically configured as count key data (CKD).
- If the function is used for both open systems and System z data, a license is required for the total configured capacity.

For better understanding, we provide an example: suppose you have a 120 TB physical capacity DS8000 and you want 20 TB for the Mainframe, 100 TB for Open Systems (30 TB for AIX servers, 50 TB for Linux servers and 20 TB for Windows servers). Suppose you need FlashCopy for the Windows servers only and you are doing Metro Mirror for all the Linux and Mainframe servers. Your licensing needs will be as follows:

- 120 TB of OEL license, to activate ALL the physical capacity
- 100 TB of PTC license for FlashCopy (considering all the FB data)
- 120 TB of MM license for Metro Mirror (considering ALL data, that is, FB + CKD)

Note that you cannot license only the Windows part or Linux part. The licensing is divided into Open Systems data (FB), Mainframe data (CKD), or both (ALL).

Point-in-time copy functions: PTC and SE

The PTC features (239x Model LFA, PTC) license FlashCopy function. The SE features (239x Model LFA, SE) license FlashCopy SE function.

The point-in-time copy licensed function model and features establish the extent of IBM authorization for the use of the point-in-time copy licensed function on your storage unit. The IBM System Storage FlashCopy function is a point-in-time licensed function.

Remote copy functions: MM, GM, MGM

The remote mirror and copy (242x Model RMC and 239x Model LFA) licensed function model and features establish the extent of IBM authorization for the use of the remote mirror and copy licensed functions on your storage unit.

The following functions are remote mirror and copy licensed functions:

- Metro Mirror (formerly Synchronous PPRC)
- Global Mirror (formerly Asynchronous PPRC)
- Global Copy (formerly PPRC Extended Distance)
- Metro/Global Mirror

You must purchase features for both the source (primary) and target (secondary) DS8000 storage units.

If you use the Metro/Global Mirror solution in your environment, the following rules apply:

- Site A: You must have a Metro/Global Mirror license, and a remote mirror and copy license.
- Site B: You must have a Metro/Global Mirror license, and a remote mirror and copy license.
- Site C: You must have a Metro/Global Mirror license, a remote mirror and copy license, and a point-in-time copy license.

If you use Global Mirror, you must follow these additional rules:

- A point-in-time copy function authorization (239x Model LFA, PTC license, 242x machine type) must be purchased for the secondary storage unit.
- If Global Mirror is to be used during failback on the secondary storage unit, a point-in-time copy function authorization must also be purchased on the primary system.

Remote mirror for z/OS: RMZ

The remote mirror for z/OS (242x Model RMZ and 239x Model LFA) licensed function model and features establish the extent of IBM authorization for the use of the z/OS remote mirroring licensed function on your storage unit. It is licensed for CKD capacity only.

Parallel access volumes: PAV

The parallel access volumes (239x Model LFA, PAV license) features establish the extent of IBM authorization for the use of the parallel access volumes licensed function. It is licensed for CKD capacity only.

IBM HyperPAV: HyperPAV license

You can add the optional IBM HyperPAV feature (242x Model PAV and 239x Model LFA) to any licensed parallel access volume (PAV) feature.

IBM HyperPAV can be enabled only if PAV is enabled on the storage image. The IBM HyperPAV feature is available for a single charge (flat fee) regardless of the extent of IBM authorization that you have for the corresponding PAV feature.

License activation

All licenses are activated through the IBM website. Activation refers to the retrieval and installation of the feature activation code into the DS8000 system. The feature activation code is obtained using the DSFA website and is based on the license scope and license value.

You perform these activities at the following times:

- After the IBM service representative has installed your storage unit and before you configure it
- When you increase the extent of the function authorization for a licensed function (that is, you add additional capacity to your license)
- When you reallocate function authorizations between images on Model

To perform these activities, you must access the DSFA website:

http://www.ibm.com/storage/dsfa

4.3.10 DS8000 supported environments

The IBM System Storage DS8000 series can be connected across a broad range of server environments such as these:

- System z
- System i®
- System p
- System x
- Servers from SUN Microsystems
- Servers from Hewlett-Packard
- Other non-IBM based server platforms

New versions of operating systems, servers, file systems, host bus adapters, clustering products and SAN components are constantly announced in the market. Information about the supported environments changes frequently. Therefore you are strongly advised always to consult the online resources.

The System Storage Interoperation Center (SSIC) always provides the latest information about supported platforms, operating systems, host adapters and SAN infrastructure solutions. It contains detailed specifications about models and versions. SSIC also lists special support items, such as boot support, and exceptions:

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

4.3.11 DS8000 series: More information

For more information about the DS8000 series, see the following Redbooks publications and websites:

- *The IBM TotalStorage DS8000 Series: Concepts and Architecture*, SG24-6452
- *IBM System Storage DS8000: Architecture and Implementation*, SG24-6786
- *DS8000 Copy Services for IBM System z*, SG24-6787
- *IBM System Storage DS8000: Copy Services in Open Environments*, SG24-6788
- *DS8000 Copy Services for IBM System z*, SG24-6787
- *DS8000 Performance Monitoring and Tuning*, SG24-7146
- *IBM System Storage DS8000 Series: IBM FlashCopy SE*, REDP-4368
- *IBM System Storage DS8700 Architecture and Implementation*, SG24-8786
- *IBM System Storage DS8800 Architecture and Implementation*, SG24-8886
- IBM System Storage DS8000 website:

  http://www.ibm.com/systems/storage/disk/ds8000/index.html
- IBM System Storage DS8000 Information Center:

  http://publib.boulder.ibm.com/infocenter/dsichelp/ds8000ic/index.jsp
- IBM System Storage DS8800 Introduction and Planning Guide:

  http://www.ibm.com/support/docview.wss?uid=ssg1S7001073

4.4 IBM XIV Storage System

The IBM XIV Storage System is a fully scalable enterprise storage system that is based on a grid of standard, off-the-shelf hardware components. It has been designed with an easy to use and intuitive GUI that allows administrators to become productive in a very short time.

The XIV Storage System architecture is designed to deliver performance, scalability, and ease of management while harnessing the high capacity and cost benefits of Serial Advanced Technology Attachment (SATA) drives. The system employs off-the-shelf products as opposed to traditional offerings that use proprietary designs thus requiring more expensive components.

Here are some key properties of this ground breaking solution:

- Superior architecture boasting massive parallelism and sophisticated distributed algorithms that yield superior power and value
- Superior performance through maximized utilization of all disks, true distributed cache implementation coupled with more effective cache bandwidth, and practically zero overhead incurred by snapshots
- Superior reliability through distributed architecture, redundant components, self-monitoring and auto-recovery processes; ability to sustain failure of a complete disk module and three more disks with minimal performance degradation
- Market leading auto-restoration of system redundancy in case of disk failure (less than 30 minutes for 1 TB drives – compared to several hours for the closest competitor)
- Superior administration and zero management overhead: no need to ever tune the system in order to attain high-end performance, even after adding or removing disks; no need to make compromises when utilizing snapshots; non-restricted creation and management of unlimited snapshots with practical zero overhead

4.4.1 System models and components

The IBM XIV Storage System Family consists of two machine types, the XIV Storage System (Machine type 2812) Model A14 and the XIV Storage System (Machine type 2810) Model A14. The 2812 Model A14 supports a 3-year warranty to complement the 1-year warranty offered by the existing and functionally equivalent, 2810 Model A14.

New orders for both machine types feature a new low voltage CPU (dual CPU in interface modules), for less power consumption.

Both machine types are available in the following configurations:

- 6 modules (including 3 Interface Modules)
- 9 -15 modules (including 6 Interface Modules)

Both machine types include the following components (Figure 4-43):

- 3-6 Interface Modules, each with 12 SATA disk drives
- 3-9 Data Modules, each with 12 SATA disk drives
- An Uninterruptible Power Supply (UPS) module complex comprising three redundant UPS units
- Two Ethernet switches and an Ethernet Switch Redundant Power Supply (RPS)
- A Maintenance Module
- An Automatic Transfer Switch (ATS) for external power supply redundancy

- A modem, connected to the Maintenance Module for externally servicing the system (note that the modem, feature number 910, is not available in all countries).

All of the modules in the system are linked through an internal redundant Gigabit Ethernet network, which enables maximum bandwidth utilization and is resilient to at least any single component failure.

The system and all of its components come pre-assembled and wired in a lockable rack.

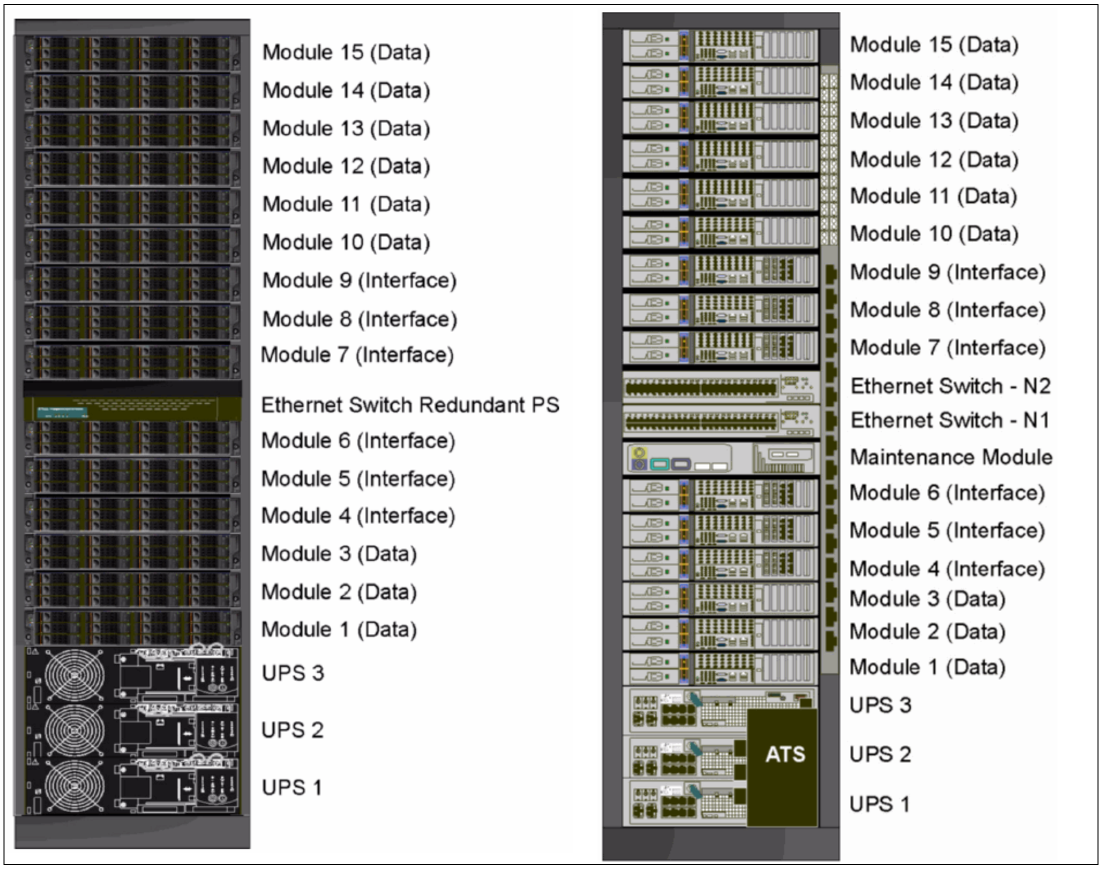


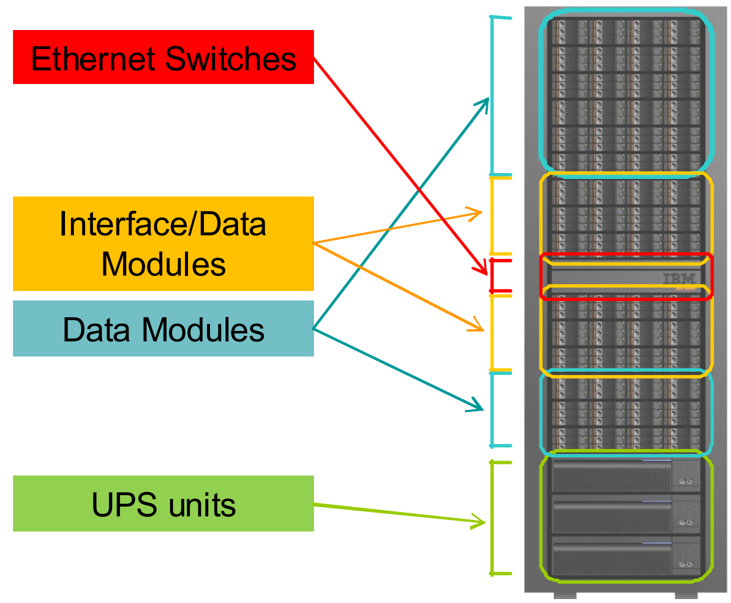
Figure 4-43 Components of XIV system

The XIV Storage System architecture incorporates a variety of features designed to uniformly distribute data across internal resources. This unique data distribution method fundamentally differentiates the XIV Storage System from conventional storage subsystems, thereby offering numerous availability, performance, and management benefits across both physical and logical elements of the system.

Hardware elements

In order to convey the conceptual principles that comprise the XIV Storage System architecture, it is useful to first provide a glimpse of the physical infrastructure.

The primary components of the XIV Storage System are known as *modules*. Modules provide processing, cache, and host interfaces and are based on “off the shelf” Intel based systems. They are redundantly connected to one another through an internal switched Ethernet network, as shown in Figure 4-44. All of the modules work together concurrently as elements of a grid architecture, and therefore, the system harnesses the powerful parallelism inherent in such a distributed computing environment.



Although externally similar in appearance, Data and Interface/Data Modules differ in functions, interfaces, and in how they are interconnected.

Figure 4-44 IBM XIV Storage System major hardware elements

Figure 4-44 summarizes the main hardware characteristics of the IBM XIV Storage System 2810-A14 and 2812-A14.

All XIV hardware components come pre-installed in a standard 19” data center class rack. At the bottom of the rack, an Uninterruptible Power Supply (UPS) module complex, which is made up of three redundant UPS units, is installed and provides power to the various system components.

Fully populated configurations

A fully populated rack contains 9 Data Modules and 6 Interface Modules for a total of 15 modules. Each module is equipped with the following connectivity adapters:

- USB ports
- Serial ports
- Ethernet adapters
- Fibre Channel adapters (Interface Modules only)

Each module also contains twelve 1 TB or 2 TB Serial Advanced Technology Attachment (SATA) disk drives. This design translates into a total usable capacity of 79 TB (180 TB raw) using 1 TB drives, or 161 TB (360 TB raw) using 2 TB drives for the complete system.

Data Modules

At a conceptual level, the Data Modules function as the elementary "building blocks" of the system, providing storage capacity, processing power, and caching, in addition to advanced system-managed services. The Data Module's ability to share and manage system software and services are key elements of the physical architecture, as depicted in Figure 4-45.

Interface Modules

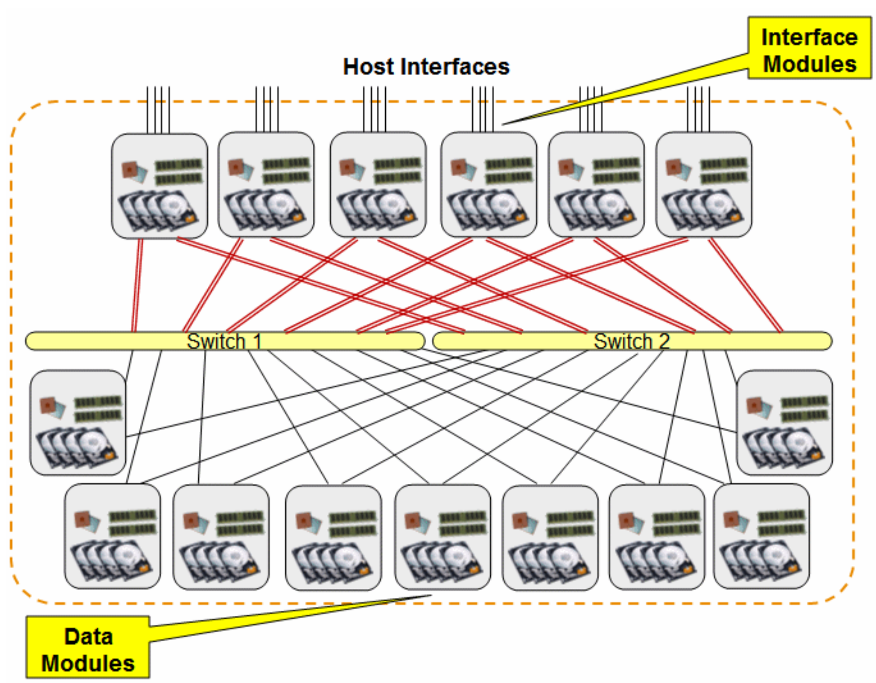
Interface Modules are equivalent to Data Modules in all aspects, with the following exceptions:

- In addition to disk, cache, and processing resources, Interface Modules are designed to include both Fibre Channel and iSCSI interfaces for host system connectivity, Remote Mirroring, and Data Migration activities. Figure 4-45 conceptually illustrates the placement of Interface Modules within the topology of the XIV IBM Storage System architecture.
- The system services and software functionality associated with managing external I/O reside exclusively on the Interface Modules.

Ethernet switches

The XIV Storage System contains a redundant switched Ethernet network that transmits both data and metadata traffic between the modules. Traffic can flow in any of the following ways:

- Between two Interface Modules
- Between two Data Modules
- Between an Interface Module and a Data Module



Interface and Data Modules are connected to each other through an internal IP switched network.

Figure 4-45 Architectural overview

> **Architecture:** Figure 4-45 depicts the conceptual architecture only. Do not misinterpret the number of connections and such as a precise hardware layout.

4.4.2 Key design features

This section describe the key design features of the XIV Storage System architecture.

Massive parallelism

The system architecture ensures full exploitation of all system components. Any I/O activity involving a specific logical volume in the system is always inherently handled by all spindles. The system harnesses all storage capacity and all internal bandwidth, and it takes advantage of all available processing power, which is as true for host-initiated I/O activity as it is for system-initiated activity, such as rebuild processes and snapshot generation. All disks, CPUs, switches, and other components of the system contribute to the performance of the system at all times.

Workload balancing

The workload is evenly distributed over all hardware components at all times. All disks and modules are utilized equally, regardless of access patterns. Despite the fact that applications might access certain volumes more frequently than other volumes, or access certain parts of a volume more frequently than other parts, the load on the disks and modules will be balanced perfectly.

Pseudo-random distribution ensures consistent load-balancing even after adding, deleting, or resizing volumes as well as adding or removing hardware. This balancing of all data on all system components eliminates the possibility of a hot-spot being created.

Self-healing

Protection against double disk failure is provided by an efficient rebuild process that brings the system back to full redundancy in minutes. In addition, the XIV Storage System extends the self-healing concept, resuming redundancy even after failures in components other than disks.

True virtualization

Unlike other system architectures, storage virtualization is inherent to the basic principles of the XIV Storage System design. Physical drives and their locations are completely hidden from the user, which dramatically simplifies storage configuration, letting the system lay out the user’s volume in the optimal way. The automatic layout maximizes the system’s performance by utilizing system resources for each volume, regardless of the user’s access patterns.

Thin provisioning

The system supports thin provisioning, which is the capability to allocate actual storage to applications on a just-in-time and as needed basis, allowing the most efficient use of available space and as a result, significant cost savings compared to traditional provisioning techniques. This is achieved by defining a logical capacity that is larger than the physical capacity and utilizing space based on what is consumed rather than what is allocated.

Processing power

The IBM XIV Storage System open architecture benefits from the latest processor technologies and is more scalable than solutions that are based on a closed architecture. The IBM XIV Storage System avoids sacrificing the performance of one volume over another, and therefore requires little to no tuning.

4.4.3 IBM XIV Storage System software

The IBM XIV system software 10.2 (or later) provides the functions of the system, which include these:

- Bundled advanced features:

  All the features of the XIV including advanced features such as migration and mirroring are included free of charge and apply to the entire storage capacity.

- Non-Disruptive Code Load (NDCL):

  System software code can be upgraded without requiring downtime. This enables ‘non-stop’ production environments to remain running while new code is upgraded.

  The code upgrade is run on all modules in parallel and the process is fast enough to minimize impact on hosts applications.

  No data migration or rebuild process is allowed during the upgrade. Mirroring, if any, will be suspended during the upgrade and automatically reactivated upon completion.

  Storage management operations are also not allowed during the upgrade, although the status of the system and upgrade progress can be queried. It is also possible to cancel the upgrade process up to a point of no return.

  Note that the NDCL does not apply to specific components firmware upgrades (for instance, module BIOS and HBA firmware). Those require a phase in / phase out process of the impacted modules.

- Support for 16000 snapshots:

  The snapshot capabilities within the XIV Storage System Software utilize a metadata, redirect-on-write design that allows snapshots to occur in a sub-second time frame with little performance overhead. Up to 16000 full or differential copies can be taken. Any of the snapshots can be made writable, and then snapshots can be taken of the newly writable snapshots. Volumes can even be restored from these writable snapshots.

- Remote Mirroring:

  The IBM XIV Storage System enables mirroring for business continuity, as well as to distribute workloads across the organization’s various data centers, improving efficiency by utilizing existing assets for more diverse uses, such as backup, decision support, testing, and application development.

  The system offers mirroring with broad support:

  – Replication on volume-based granularity, with up to 16 target XIV systems supported
  – All mirroring based on differential snapshot technology; allows moving of minimal amounts of data, avoiding the high cost of communications
  – Synchronous and asynchronous mirroring
  – Mirroring of volumes and/or consistency groups
  – Ability to specify Recovery Point Objectives (RPOs) per mirror
  – Flexible replication schedules
  – Concurrent and bidirectional mirroring
  – FC and iSCSI-based mirroring, with the mirroring protocol agnostic to the host protocol (mirroring by iSCSI volumes served by FC and vice versa)
  – Flexible RPO per volume from 30 seconds to 24 hours, enabling flexible planning and priority setting based on business needs

The XIV asynchronous mirroring function enables data replication over extended distances between two sites. Asynchronous mirroring complements the XIV synchronous mirroring function which was already available. Both provide solutions for business continuity and disaster recovery.

The XIV system's remote mirroring capability provides a flexible, cost effective, simple to implement, and simple to test solution for a disaster recovery site.

- Support for thin provisioning:

  Thin provisioning allows administrators to over-provision storage within storage pools; this is done by defining logical volume sizes that are larger than the physical capacity of the pool. Unlike other approaches, the physical capacity only needs to be larger than the actual written data, not larger than the logical volumes. Physical capacity of the pool needs to be increased only when actual written data increases.

- Instant space reclamation:

  A new instant space capability enhances the existing XIV Thin Provisioning space reclamation capability. The new capability is designed to enable XIV users to optimize capacity utilization, thus saving costs, by allowing supporting applications, such as Symantec's Veritas Storage Foundation product, to instantly regain unused file system space in thin-provisioned XIV volumes.

- Support for in-band data migration of heterogeneous storage:

  The XIV Storage System is also capable of acting as a host, gaining access to volumes on an existing legacy storage system. The XIV is then configured as a proxy to respond to requests between the current hosts and the legacy storage while migrating all existing data in the background. In addition, XIV supports thick-to-thin data migration, which allows the XIV Storage System to reclaim any allocated space that is not occupied by actual data.

- Authentication using Lightweight Directory Access Protocol (LDAP):

  LDAP can be used to provide user logon authentication allowing the XIV Storage System to integrate with Microsoft Active Directory (AD) or Sun Java Systems Directory Server (formerly Sun ONE Directory). Multiple directory servers can be configured to provide redundancy if one becomes unavailable.

- Robust user auditing with access control lists:

  The XIV Storage System Software offers the capability for robust user auditing with Access Control Lists (ACLs) in order to provide more control and historical information.

- Support for Tivoli Storage Productivity Center:

  Tivoli Storage Productivity Center (TPC) can now discover XIV Storage Systems and all internal components, manage capacity for storage pools including allocated, unallocated, and available capacity with historical trending on utilization. It can also receive events and define policy-based alerts based on user-defined triggers and thresholds.

IBM XIV Storage Manager GUI

The XIV Storage Manager GUI acts as the management console for the XIV Storage System. A simple and intuitive GUI enables storage administrators to manage and monitor all system aspects easily, with almost no learning curve. Figure 4-46 shows one of the top level configuration panels.

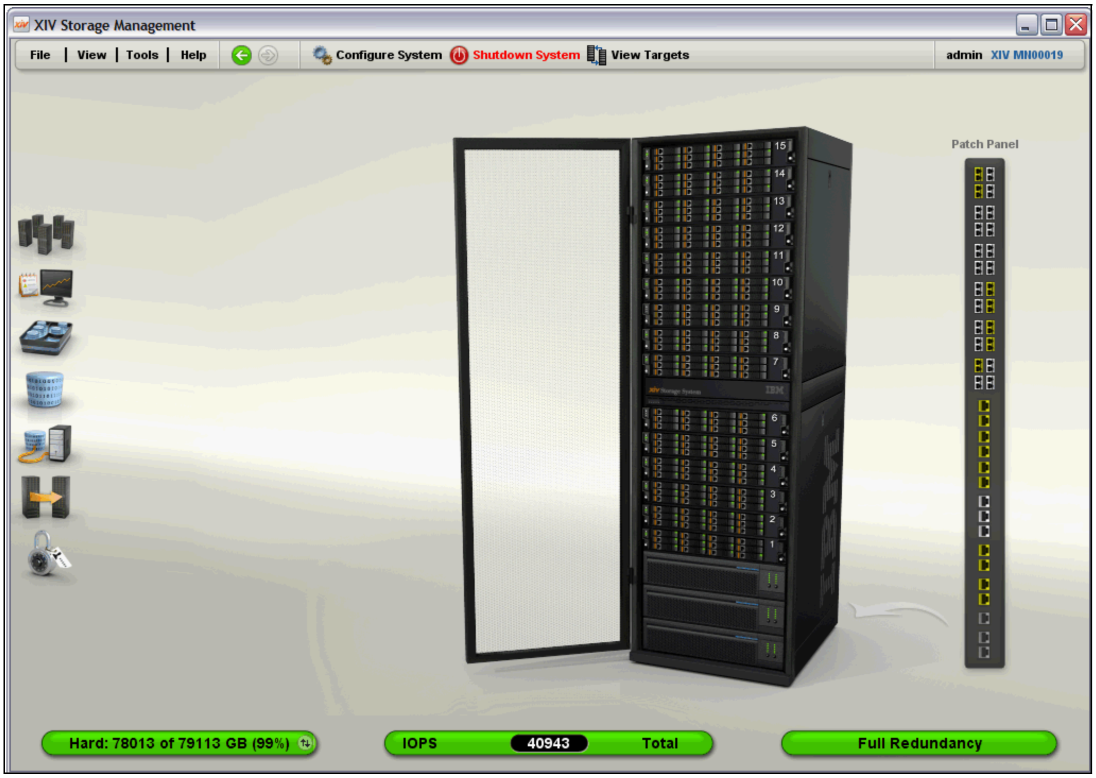


Figure 4-46 The IBM XIV Storage Manager GUI

The GUI is also supported on the following platforms:

- Microsoft Windows 2000, Windows ME, Windows XP, Windows Server 2003, and Windows Vista
- Linux (Red Hat 5.x or equivalent)
- AIX 5.3, AIX 6.1
- Solaris v9, Solaris v10
- HPUX 11i v2, HPUX 11i v3

The GUI can be downloaded at the following site:

ftp://ftp.software.ibm.com/storage/XIV/GUI/

The XIV system's virtualization and simplicity, together with its powerful GUI management, significantly reduce the time and effort required for managing storage resources. Note that GUI and XCLI (command line interface) are packaged together.

Here we list the GUI enhancements:

- You can use the organization's LDAP (Lightweight Directory Access Protocol) server to manage users, passwords and access lists.
- Cluster private mapping: You can define private LUNs for hosts even if they are members of a cluster.
- Additional statistics filters:
  - System statistics per host ports
  - System capacity usage over time
- Up to 15 systems can be managed with a single GUI (up from 9 systems).

- Demo mode provides the ability to run the GUI without connecting to any live system, using predefined sample data and configuration. To access Demo mode, login with the user name “P10DemoMode”.
- Snapshots Tree and Snapshot Groups Tree views can now be used to actively manage snapshots (for example, create, delete, map, and so on.)
- You can execute tasks for multiple objects at once, for example, delete volumes, activate mirroring, and so on.
- Capacity usage thresholds: You can adjust the thresholds that determine the alert level for capacity usage by pool volumes and snapshots.
- Gradual events retrieval: Events are retrieved from the system gradually, to allow better performance as well as the ability to retrieve any number of events that match the used filter (up to a maximum of 10,000).

These are the advanced support features:

- Support logs: You can automatically collect all the system logs required by IBM-XIV support for timely analysis of the system status and health.
- Customer contact information forms: Use these forms to facilitate communication.
- VPN setup: VPN allows secure connectivity to IBM-XIV Remote Support Center.

IBM XIV Storage System XCLI

The XIV Storage System offers a comprehensive set of Extended Command Line Interface (XCLI) commands to configure and monitor the system. All the functions available in the GUI are also available in the XCLI. The XCLI can be used in a shell environment to interactively configure the system or as part of a script to perform lengthy and/or complex tasks. Example 4-2 shows a command being run in the XCLI interactive mode (XCLI session).

Example 4-2 The XCLI interactive mode

```
>> config_get
Name                     Value
dns_primary
dns_secondary
email_reply_to_address
email_sender_address
email_subject_format     {severity}: {description}
iscsi_name               iqn.2005-10.com.xivstorage:000019
machine_model            A14
machine_serial_number    MN00019
machine_type             2810
ntp_server
snmp_community           XIV
snmp_contact             Unknown
snmp_location            Unknown
snmp_trap_community      XIV
support_center_port_type Management
system_id                19
system_name              XIV MN00019
```

The XCLI is supported on the following platforms:

- Microsoft Windows 2000, Windows ME, Windows XP, Windows Server 2003, and Windows Vista
- Linux (Red Hat 5.x or equivalent)

- AIX 5.3, AIX 6.1
- Solaris v9, Solaris v10
- HPUX 11i v2, HPUX 11i v3

The XCLI can be downloaded at the following site:

ftp://ftp.software.ibm.com/storage/XIV/GUI/

4.4.4 Parallelism

Here we provide an overview of the concept of *parallelism.* Complete information about the XIV System can be found in the IBM Redbooks publication, *IBM XIV Storage System: Architecture, Implementation, and Usage*, SG24-7659.

The concept of parallelism pervades all aspects of the XIV Storage System architecture by means of a balanced, redundant data distribution scheme in conjunction with a pool of distributed (or grid) computing resources. In order to explain the principle of parallelism further, it is helpful to consider the ramifications of both the hardware and software implementations independently. We subsequently examine virtualization principles in 4.4.5, "Full storage virtualization" on page 188.

> **Important:** The XIV Storage System exploits parallelism at *both* the hardware and software levels.

Hardware parallelism and grid architecture

The XIV grid design in Figure 4-47 involves the following characteristics:

- Both Interface Modules and Data Modules work together in a distributed computing sense. However, the Interface Modules also have additional functions and features associated with host system connectivity.
- The modules communicate with each other through the internal, redundant Ethernet network.
- The software services and distributed computing algorithms running within the modules collectively manage all aspects of the operating environment.

Design principles

The XIV Storage System grid architecture, by virtue of its distributed topology and "off the shelf" Intel components, ensures that the following design principles are possible:

- Performance:
  - The relative effect of the loss of a module is minimized.
  - All modules are able to participate equally in handling the total workload.
- Compatibility:
  - Modules consist of standard "off the shelf" components.
  - Because components are not specifically engineered for the system, the resources and time required for the development of newer hardware technologies are minimized.
- Scalability:
  - Computing resources can be dynamically changed.
  - "Scaled out" by adding new modules to accommodate both new capacity and new performance demands.
  - "Scaled up" by upgrading modules.

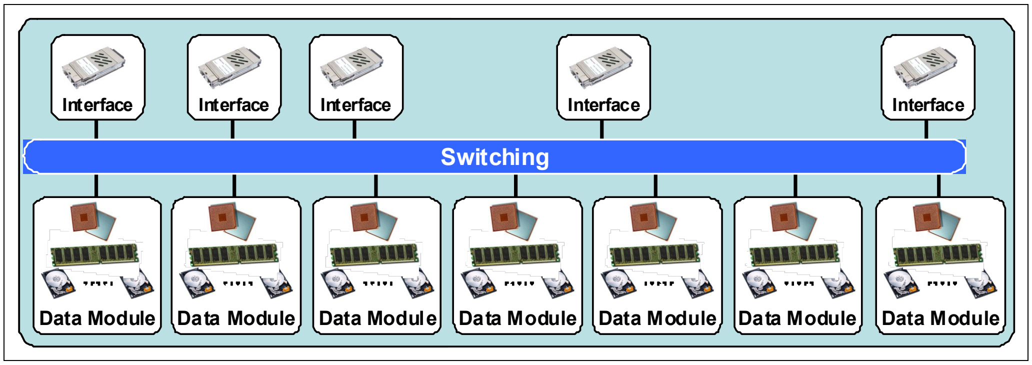


Figure 4-47 IBM XIV Storage System scalable conceptual grid architecture

Proportional scalability

Within the XIV Storage System, each module contains all of the pertinent hardware elements that are necessary for a grid topology (processing, caching, and storage). All modules are connected through a scalable network. This aspect of the grid infrastructure enables the relative proportions of cache, processor, disk, and interconnect bandwidth to remain optimal even in the event that modules are added or removed:

- Linear cache growth: The total system cache size and cache bandwidth increase linearly with disk capacity, because every module is a self-contained computing resource that houses its own cache (in terms of both host-to-cache and cache-to-disk).
- Proportional interface growth: Interface Modules house Ethernet and Fibre Channel host interfaces and are able to access not only the local resources within the module, but the entire system. With every Interface Module added, the system proportionally scales both the number of host interfaces and the bandwidth to the internal resources.
- Constant switching capacity: The internal switching capacity is designed to scale proportionally as the system grows, preventing bottlenecks regardless of the number of modules.
- Embedded processing power: Because each module incorporates its own processing power in conjunction with cache and disk components, the ability of the system to perform processor-intensive tasks, such as aggressive prefetch caching, sophisticated cache updates, snapshot management, and data distribution, is always maintained regardless of of the system capacity.

Software parallelism

In addition to the hardware parallelism, the XIV Storage System also employs sophisticated algorithms to achieve optimal parallelism.

Modular software design

The XIV Storage System internal operating environment consists of a set of software functions that are loosely coupled with the hardware modules. These software functions reside on one or more modules and can be redistributed among modules as required, thus ensuring resiliency under changing hardware conditions.

An example of this modular design resides specifically in the interface modules. All six interface modules actively manage system services and software functionality associated with managing external I/O. Also, three of the interface modules deliver the system's management interface service for use with the XIV Storage System.

Data distribution algorithms

Data is distributed across all drives in a *pseudo-random* fashion. The patented algorithms provide a uniform yet random spreading of data across all available disks to maintain data resilience and redundancy. Figure 4-48 on page 190 provides a conceptual representation of the pseudo-random data distribution within the XIV Storage System.

4.4.5 Full storage virtualization

In this part we give the overview for concept of *virtualization.* See *IBM XIV Storage System: Architecture, Implementation, and Usage*, SG24-7659 for complete information about the XIV System.

The data distribution algorithms employed by the XIV Storage System are innovative in that they are deeply integrated into the system architecture itself, instead of at the host or storage area network level. The XIV Storage System is unique in that it is based on an innovative implementation of full storage virtualization within the system itself.

IBM XIV Storage System virtualization design

The implementation of full storage virtualization employed by the XIV Storage System eliminates many of the potential operational drawbacks that can be present with conventional storage subsystems, while maximizing the overall usefulness of the subsystem.

The XIV Storage System virtualization offers the following benefits:

- Easier volume management:
  - Logical volume placement is driven by the distribution algorithms, which manage all of the data in the system collectively without deference to specific logical volume definitions.
  - Any interaction, whether host or system driven, with a specific logical volume in the system is inherently handled by all resources; it harnesses all storage capacity, all internal bandwidth, and all processing power currently available in the system.
  - Logical volumes are not exclusively associated with a subset of physical resources (can be dynamically resized and thinly provisioned).
- Consistent performance and scalability:
  - Hardware resources are always utilized equally, because all logical volumes always span all physical resources and are therefore able to reap the performance potential of the full system and maintain data integrity.
  - There are no “pockets” of capacity, “orphaned” disk space, or resources that are inaccessible due to array mapping constraints or data placement.
- Flexible snapshots:
  - Full storage virtualization incorporates snapshots that are differential in nature; only updated data consumes physical capacity:
    - Many concurrent snapshots are used (up to 16000 volumes and snapshots can be defined).
    - Multiple concurrent snapshots are possible because a snapshot uses physical space only after a change has occurred on the source.
    - Multiple snapshots of a single master volume can exist independently of each other.
    - Snapshots can be cascaded, in effect, creating snapshots of snapshots.
  - Creation and deletion of snapshots do not require data to be copied and hence occur immediately.

- When updates occur to master volumes, the system's virtualized logical structure enables it to preserve the original point-in-time data associated with any and all dependent snapshots by redirecting the update to a new physical location on disk. This process, which is referred to as *redirect on write,* occurs transparently from the host perspective and uses the virtualized remapping of the updated data to minimize any performance impact associated with preserving snapshots, regardless of the number of snapshots defined for a given master volume.

> **Snapshot:** The XIV snapshot process uses "redirect on write," which is more efficient than the "copy on write" that is used by many other storage subsystems.

- Data migration efficiency:
  - XIV supports thin provisioning. When migrating from a system that only supports regular (or thick) provisioning, XIV allows thick-to-thin provisioning of capacity.
  - Due to the XIV pseudo-random distribution of data, the performance impact of data migration on production activity is minimized, because the load is spread evenly over all resources.

Logical system concepts

In this section, we elaborate on the logical system concepts, which form the basis for the system full storage virtualization.

Logical constructs

The XIV Storage System logical architecture incorporates constructs that underlie the storage virtualization and distribution of data, which are integral to its design. The logical structure of the system ensures that there is optimum granularity in the mapping of logical elements to both modules and individual physical disks, thereby guaranteeing an equal distribution of data across all physical resources.

Partitions

The fundamental building block of logical volumes is known as a *partition*. Partitions have the following characteristics on the XIV Storage System:

- All partitions are 1 MB (1024 KB) in size.
- A partition contains either a primary copy or secondary copy of data:
  - Each partition is mapped to a single physical disk:
    - This mapping is dynamically managed by the system through innovative data distribution algorithms in order to preserve data redundancy and equilibrium.
    - The storage administrator has no control or knowledge of the specific mapping of partitions to drives.
  - Secondary copy partitions are always placed in another *Module* than the one containing the primary copy partition.

> **Important:** In the context of the XIV Storage System logical architecture, a partition consists of 1 MB (1024 KB) of data. Do not confuse this definition with other definitions of the term "partition."

The diagram in Figure 4-48 illustrates that data is uniformly, yet randomly distributed over all disks. Each 1 MB of data is duplicated in a primary and secondary partition. For the same data, the system ensures that the primary partition and its corresponding secondary are not located within the same module.

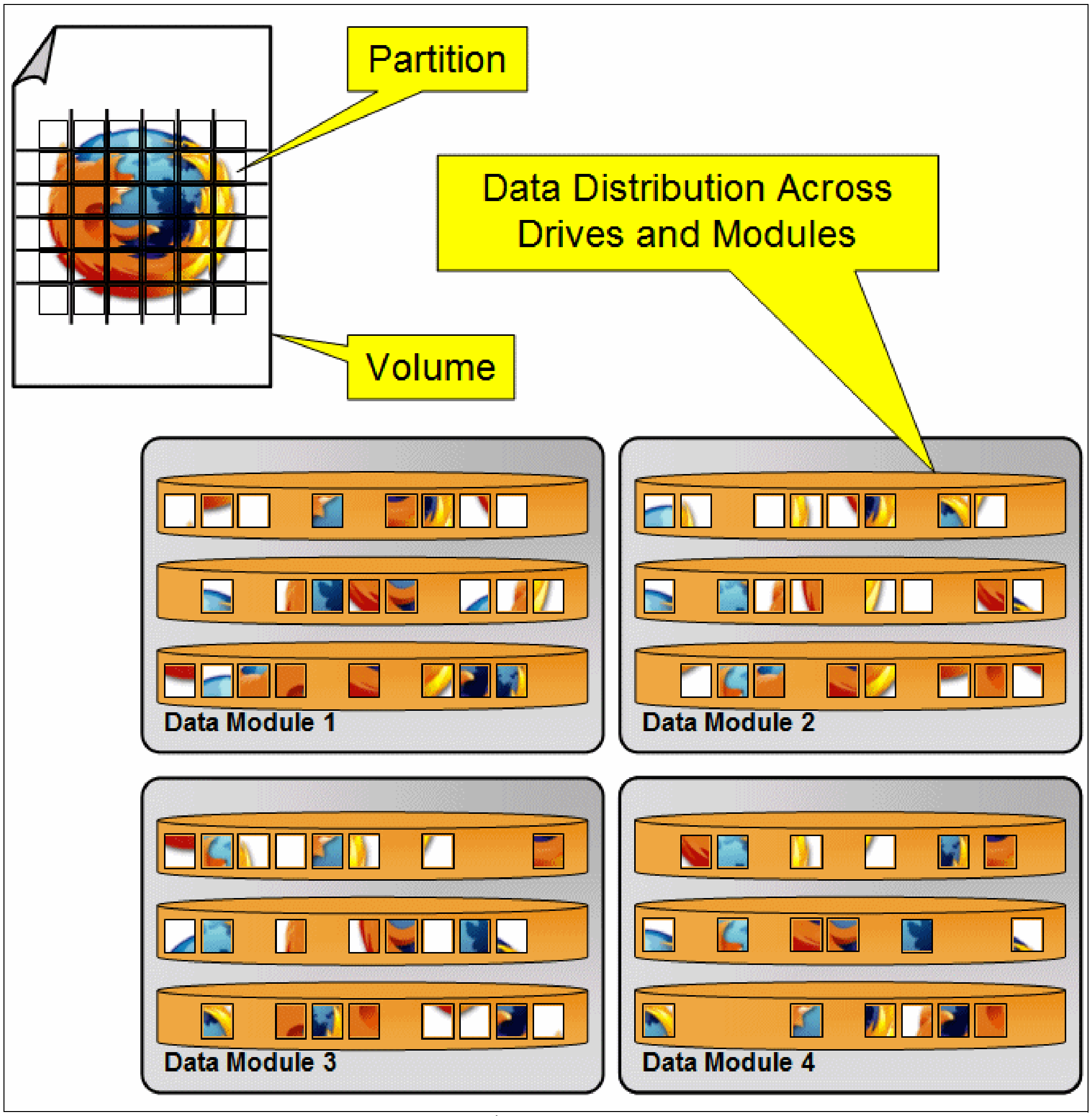


Figure 4-48 Pseudo-random data distribution[1]

Logical volumes

The XIV Storage System presents logical volumes to hosts in the same manner as conventional subsystems; however, both the granularity of logical volumes and the mapping of logical volumes to physical disks differ:

- As discussed previously, every logical volume is comprised of 1 MB (1024 KB) constructs of data known as partitions.
- The physical capacity associated with a logical volume is *always a multiple of 17 GB (decimal).*

  Therefore, while it is possible to present a block-designated logical volume to a host that is *not* a multiple of 17 GB, the *actual physical space* that is allocated for the volume will always be the sum of the minimum number of 17 GB increments needed to meet the block-designated capacity.

[1] Copyright 2005-2008 Mozilla. All Rights Reserved. All rights in the names, trademarks, and logos of the Mozilla Foundation, including without limitation, Mozilla, Firefox, as well as the Firefox logo, are owned exclusively by the Mozilla Foundation.

> **Physical capacity:** The initial physical capacity actually allocated by the system upon volume creation can be less than this amount.

- The maximum number of volumes that can be concurrently defined on the system is limited by the following constraints:
  - The logical address space limit:
    - The logical address range of the system permits up to 16 377 volumes, although this constraint is purely logical, and therefore, is not normally a practical consideration.
    - Note that the same address space is used for both volumes and snapshots.
  - The limit imposed by the logical and physical topology of the system for the minimum volume size.

    The physical capacity of the system, based on 180 drives with 1 TB of capacity per drive (considering the 1 TB drives) and assuming the minimum volume size of 17 GB, limits the maximum volume count to 4 605 volumes. Again, a system with active snapshots can have more than 4 605 addresses assigned collectively to both volumes and snapshots, because volumes and snapshots share the same address space.

> **Important:** The logical address limit is ordinarily not a practical consideration during planning, because under most conditions, this limit will not be reached; it is intended to exceed the adequate number of volumes for all conceivable circumstances.

Storage Pools

Storage Pools are administrative boundaries that enable storage administrators to manage relationships between volumes and snapshots and to define separate capacity provisioning and snapshot requirements for such uses as separate applications or departments. Storage Pools are not tied in any way to physical resources, nor are they part of the data distribution scheme.

Snapshots

A *snapshot* represents a point-in-time copy of a volume. Snapshots are like volumes except snapshots incorporate dependent relationships with their source volumes, which can be either logical volumes or other snapshots. Because they are not independent entities, a given snapshot does not necessarily wholly consist of partitions that are unique to that snapshot. Conversely, a snapshot image will not share all of its partitions with its source volume if updates to the source occur after the snapshot was created.

Logical volume layout on physical disks

The XIV Storage System manages the distribution of logical volumes over physical disks and modules by means of a dynamic relationship between primary data partitions, secondary data partitions, and physical disks. This virtualization of resources in the XIV Storage System is governed by the data distribution algorithms.

Distribution table

The Distribution table is created at system startup, and contains a mapping of every primary and secondary partition, as well as the Module and physical disk they reside on. When hardware changes occur, a new Distribution table is created and delivered to every module. Each module retains redundant copies of the Distribution table.

Volume layout

At a conceptual level, the data distribution scheme can be thought of as an mixture of mirroring and striping. While it is tempting to think of this scheme in the context of RAID 1+0 (10) or 0+1, the low-level virtualization implementation precludes the usage of traditional RAID algorithms in the architecture.

As discussed previously, the XIV Storage System architecture divides logical volumes into 1 MB partitions. This granularity and the mapping strategy are integral elements of the logical design that enable the system to realize the following features and benefits:

- Partitions that make up a volume are distributed on all disks using what is defined as a *pseudo-random distribution function*, as introduced in "Software parallelism" on page 187:
  - The distribution algorithms seek to preserve the equality of access among all physical disks under all conceivable conditions and volume access patterns. Essentially, while not truly random in nature, the distribution algorithms in combination with the system architecture preclude the occurrence of "*hot-spots*":
    - A fully configured XIV Storage System contains 180 disks, and each volume is allocated across at least 17 GB (decimal) of capacity that is distributed evenly across all disks.
    - Each logically adjacent partition on a volume is distributed across another disk; partitions are *not* combined into groups before they are spread across the disks.
    - The pseudo-random distribution ensures that logically adjacent partitions are never striped sequentially across physically adjacent disks. See "Software parallelism" on page 187 for a further overview of the partition mapping topology.
  - Each disk has its data mirrored across all other disks, *excluding the disks in the same module.*
  - Each disk holds approximately one percent of any other disk in other modules.
  - Disks have an equal probability of being accessed regardless of aggregate workload access patterns.

> **Goal distribution:** When the number of disks or modules changes, the system defines a new data layout that preserves redundancy and equilibrium. This target data distribution is called the *goal distribution*.

- As discussed previously in "IBM XIV Storage System virtualization design" on page 188:
  - The storage system administrator does *not* plan the layout of volumes on the modules.
  - Provided that there is space available, volumes can always be added or resized instantly with negligible impact on performance.
  - There are no unusable pockets of capacity known as "orphaned spaces."
- When the system is scaled out through the addition of modules, a new *goal distribution* is created whereby just a minimum number of partitions are moved to the newly allocated capacity to arrive at the new distribution table.

  The new capacity is fully utilized within several hours and with no need for any administrative intervention. Thus, the system automatically returns to a state of equilibrium among all resources.
- Upon the failure or phase-out of a drive or a module, a new goal distribution is created whereby data in non-redundant partitions is copied and redistributed across the remaining modules and drives.

The system rapidly returns to a state in which all partitions are again redundant, because all disks and modules participate in achieving the new goal distribution.

System usable capacity

The XIV Storage System reserves physical disk capacity for the following purposes:

- Global spare capacity
- Metadata, including statistics and traces
- Mirrored copies of data

Global spare capacity

The dynamically balanced distribution of data across all physical resources by definition obviates the inclusion of dedicated spare drives that are necessary with conventional RAID technologies. Instead, the XIV Storage System reserves capacity on each disk in order to provide adequate space for the redistribution or rebuilding of redundant data in the event of a hardware failure.

This global spare capacity approach offers advantages over dedicated hot spare drives, which are used only upon failure and are not used otherwise, therefore reducing the number of spindles that the system can utilize for better performance. Also, those non-operating disks are typically not subject to background scrubbing processes, whereas in XIV, all disks are operating and subject to examination, which helps detect potential reliability issues with drives.

The global reserved space includes sufficient capacity to withstand the failure of a full module and a further three disks, and will still allow the system to execute a new *goal distribution,* and to return to full redundancy.

Failures: The system will tolerate multiple hardware failures, including up to an entire module in addition to three subsequent drive failures *outside of the failed module*, provided that a new goal distribution is fully executed before a subsequent failure occurs. If the system is less than 100% full, it can sustain more subsequent failures based on amount of unused disk space that will be allocated at the event of failure as a spare capacity.

Snapshots: The XIV Storage System does not manage a global reserved space for snapshots. We explore this topic in the next section.

Metadata and system reserve

The system reserves roughly 4% of the physical capacity for statistics and traces, as well as the distribution table.

Net usable capacity

The calculation of the *net usable capacity* of the system consists of the total disk count, less disk space reserved for sparing (which is the equivalent of one module plus three more disks), multiplied by the amount of capacity on each disk that is dedicated to data (that is 96% because of metadata and system reserve), and finally reduced by a factor of 50% to account for data mirroring achieved by the secondary copy of data.

Storage Pool concepts

While the hardware resources within the XIV Storage System are virtualized in a global sense, the available capacity in the system can be administratively portioned into separate and independent Storage Pools. The concept of *Storage Pools* is purely administrative. Essentially, Storage Pools function as a means to effectively manage a related group of similarly provisioned logical volumes and their snapshots.

Improved management of storage space

Storage Pools form the basis for controlling the usage of storage space by imposing a capacity quota on specific applications, a group of applications, or departments, enabling isolated management of relationships within the associated group of logical volumes and snapshots.

A *logical volume* is defined within the context of one and only one Storage Pool. As Storage Pools are logical constructs, a volume and any snapshots associated with it can be moved to any other Storage Pool, as long as there is sufficient space.

As a benefit of the system virtualization, there are no limitations on the size of Storage Pools or on the associations between logical volumes and Storage Pools. In fact, manipulation of Storage Pools consists exclusively of metadata transactions and does not trigger any copying of data. Therefore, changes are completed instantly and without any system overhead or performance degradation.

Consistency groups

A *consistency group* is a group of volumes of which a snapshot can be made at the same point in time, thus ensuring a consistent image of all volumes within the group at that time. The concept of a consistency group is common among storage subsystems in which it is necessary to perform concurrent operations collectively across a set of volumes, so that the result of the operation preserves the consistency among volumes. For example, effective storage management activities for applications that span multiple volumes, or for creating point-in-time backups, is not possible without first employing consistency groups.

This consistency between the volumes in the group is paramount to maintaining data integrity from the application perspective. By first grouping the application volumes into a consistency group, it is possible to later capture a consistent state of all volumes within that group at a given point-in-time using a special snapshot command for consistency groups.

Issuing this type of a command results in the following process:

1. Complete and destage writes across the constituent volumes.
2. Instantaneously suspend I/O activity simultaneously across all volumes in the consistency group.
3. Create the snapshots.
4. Finally, resume normal I/O activity across all volumes.

The XIV Storage System manages these suspend and resume activities for all volumes within the consistency group.

Consistency: Additional mechanisms or techniques, such as those provided by the Microsoft Volume Shadow copy Services (VSS) framework, might still be required to maintain full application consistency.

Storage Pool relationships

Storage Pools facilitate the administration of relationships among logical volumes, snapshots, and consistency groups.

The following principles govern the relationships between logical entities within the Storage Pool:

- A logical volume can have multiple independent snapshots. This logical volume is also known as a *master volume*.

- A *master volume* and all of its associated snapshots are always a part of only one Storage Pool.
- A volume can only be part of a single consistency group.
- All volumes of a consistency group must belong to the same Storage Pool.

Storage Pools have the following characteristics:

- The size of a Storage Pool can range from 17 GB (the minimum size that can be assigned to a logical volume) to the capacity of the entire system.
- *Snapshot reserve capacity* is defined within each Storage Pool and is effectively *maintained separately* from logical, or master, volume capacity. The same principles apply for thinly provisioned Storage Pools, with the exception that space is not *guaranteed* to be available for snapshots due to the potential for hard space depletion, which is discussed in *IBM XIV Storage System: Architecture, Implementation, and Usage*, SG24-7659:
  - Snapshots are structured in the same manner as logical, or master, volumes.

    > **Attention:** The snapshot reserve needs to be a minimum of 34 GB. The system preemptively deletes snapshots if the snapshots fully consume the allocated available space.

  - As mentioned before, snapshots will only be automatically deleted when there is inadequate physical capacity available within the context of each Storage Pool. This process is managed by a snapshot deletion priority scheme. Therefore, when the capacity of a Storage Pool is exhausted, only the snapshots that reside in the affected Storage Pool are deleted in order of the deletion priority.
- The space allocated for a Storage Pool can be dynamically changed by the storage administrator:
  - The Storage Pool can be increased in size. It is limited only by the unallocated space on the system.
  - The Storage Pool can be decreased in size. It is limited only by the space that is consumed by the volumes and snapshots that are defined within that Storage Pool.
- The designation of a Storage Pool as a regular pool or a thinly provisioned pool can be dynamically changed even for existing Storage Pools. Thin provisioning is discussed in-depth in “Capacity allocation and thin provisioning” on page 196.
- The storage administrator can relocate logical volumes between Storage Pools without any limitations, provided there is sufficient free space in the target Storage Pool:
  - If necessary, the target Storage Pool capacity can be dynamically increased prior to volume relocation, assuming there is sufficient unallocated capacity available in the system.
  - When a logical volume is relocated to a target Storage Pool, sufficient space must be available for all of its snapshots to reside in the target Storage Pool as well.

> **Notes:**
>
> - When moving a volume into a Storage Pool, the size of the Storage Pool is not automatically increased by the size of the volume. Likewise, when removing a volume from a Storage Pool, the size of the Storage Pool does not decrease by the size of the volume.
> - The system defines capacity using decimal metrics. Using decimal metrics, 1 GB is 1 000 000 000 bytes. Using binary metrics, 1 GB is 1 073 741 824 bytes.

Capacity allocation and thin provisioning

Thin provisioning is a central theme of the virtualized design of the XIV system, because it uncouples the virtual, or apparent, allocation of a resource from the underlying hardware allocation.

Capacity allocation

The following benefits emerge from the XIV Storage System's implementation of thin provisioning:

- Capacity associated with specific applications or departments can be dynamically increased or decreased per the demand imposed at a given point in time, without necessitating an accurate prediction of future needs. Physical capacity is only committed to the logical volume when the associated applications execute writes, as opposed to when the logical volume is initially allocated.
- Because the total system capacity is architected as a globally available pool, thinly provisioned resources share the same "buffer" of free space, which results in highly efficient aggregate capacity utilization without pockets of inaccessible unused space.

  With the static, inflexible relationship between logical and physical resources commonly imposed by traditional storage subsystems, each application's capacity must be managed and allocated independently. This situation often results in a large percentage of the total system capacity remaining unused, because the capacity is confined within each volume at a highly granular level.
- Capacity acquisition and deployment can be more effectively deferred until actual application and business needs demand additional space, in effect facilitating an on demand infrastructure.

Thin provisioning

The idea behind thin provisioning is simple. Users define volumes with any logical size, and acquire and install only the physical capacity needed for data that is actually written.

This simple idea is similar to others used widely in other IT areas, for example:

- Virtual memory in a computer gives each process the perception of a huge memory space, while physical memory is much smaller.
- File systems allocate user quotas that can total more than the available space.
- Communication infrastructure paradigms have switched from dedicating capacity per user or application to statistical multiplexing of multiple users or applications.

With the XIV system, thin provisioning functions similarly to the aforementioned concepts. Thin provisioning principles are as follows:

- For a system, two types of capacities are defined:
  - Hard capacity. The physical disk capacity available to applications (net capacity, after taking into account redundancy and spares)
  - Soft capacity. The logical capacity of the entire system. Volumes are defined out of this capacity.
- When defining a volume, its size is only limited by the remaining soft capacity of the system.
- At the time of provisioning, the new volume is defined as formatted, meaning all zeros, and does not consume any hard capacity. As applications start to write data, the written areas consume hard capacity.

Soft capacity: Any system must potentially be expanded to its soft capacity. When defining the soft capacity, the customer must pre-plan how storage capacity will be added, reserve the required floor space, and ensure that the future power and cooling requirements can be met.

Thin provisioning conceptual examples

It is helpful to examine the following basic examples, because they incorporate all of the concepts inherent to the XIV Storage System's implementation of thin provisioning.

System-level thin provisioning conceptual example

Figure 4-49 depicts the incremental allocation of capacity to both a regular Storage Pool and a thinly provisioned Storage Pool within the context of the global system soft and hard sizes. This example assumes that the soft system size has been defined to exceed its hard size. The unallocated capacity shown within the system's soft and hard space is represented by a discontinuity in order to convey the full scope of both the logical and physical view of the system's capacity. Each increment in the diagram represents 17 GB of soft or hard capacity.

When a regular Storage Pool is defined, only one capacity is specified, and this amount is allocated to the Storage Pool from *both the hard and soft global capacity within the system*.

When a thinly provisioned Storage Pool is defined, both the soft and hard capacity limits for the Storage Pool must be specified, and these amounts are deducted from the system's global available soft and hard capacity, respectively.

In the next example we focus on the regular Storage Pool introduced in Figure 4-49.

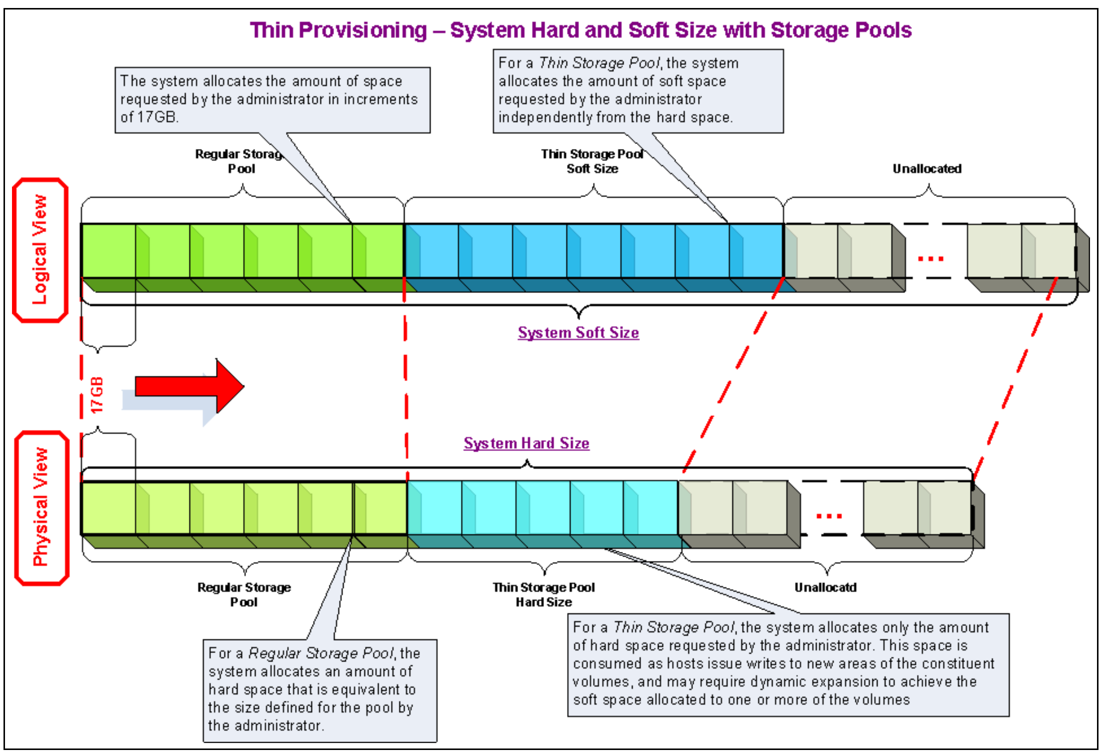


Figure 4-49 Thin provisioning at the system level

Regular Storage Pool conceptual example

Figure 4-50 represents a focused view of the regular Storage Pool that is shown here in Figure 4-49 and depicts the division of both soft and hard capacity among volumes within the pool. Note that the regular pool is the same size (102 GB) in both diagrams.

First, consider Volume 1. Although Volume 1 is defined as 19,737,900 blocks (10 GB), the soft capacity allocated will nevertheless be comprised of the minimum number of 17 GB increments needed to meet or exceed the requested size in blocks, which is in this case only a single 17 GB increment of capacity. The host will, however, see exactly 19,737,900 blocks. When Volume 1 is created, the *system does not initially allocate any hard capacity.* At the moment that a host writes to Volume 1, even if it is just to initialize the volume, the system will allocate 17 GB of hard capacity. The hard capacity allocation of 17 GB for Volume 1 is illustrated in Figure 4-50 on page 199, although clearly this allocation will never be fully utilized as long as the host-defined capacity remains only 10 GB.

Unlike Volume 1, Volume 2 has been defined in terms of gigabytes and has a soft capacity allocation of 34 GB, which is the amount that is reported to any hosts that are mapped to the volume. In addition, the hard capacity consumed by host writes has not yet exceeded the 17 GB threshold, and hence, the system has thus far *only allocated one increment of 17 GB hard capacity*. However, because the hard capacity and the soft capacity allocated to a regular Storage Pool are equal by definition, the remaining 17 GB of soft capacity assigned to Volume 2 is effectively preserved and will remain available within the pool's hard space until it is needed by Volume 2. In other words, because the pool's soft capacity does not exceed its hard capacity, there is no way to allocate soft capacity to effectively "overcommit" the available hard capacity.

The final reserved space within the regular Storage Pool shown in Figure 4-50 is dedicated for the snapshot usage. The diagram illustrates that the specified snapshot reserve capacity of 34 GB is effectively deducted from both the hard and soft space defined for the regular Storage Pool, thus guaranteeing that this space will be available for consumption collectively by the snapshots associated with the pool. Although snapshots consume space granularly at the partition level, as discussed in "Storage Pool relationships" on page 194, the snapshot reserve capacity is still defined in increments of 17 GB.

The remaining 17 GB within the regular Storage Pool have not been allocated to either volumes or snapshots. Note that all soft capacity remaining in the pool is "backed" by hard capacity; the remaining unused soft capacity will always be less than or equal to the remaining unused hard capacity.

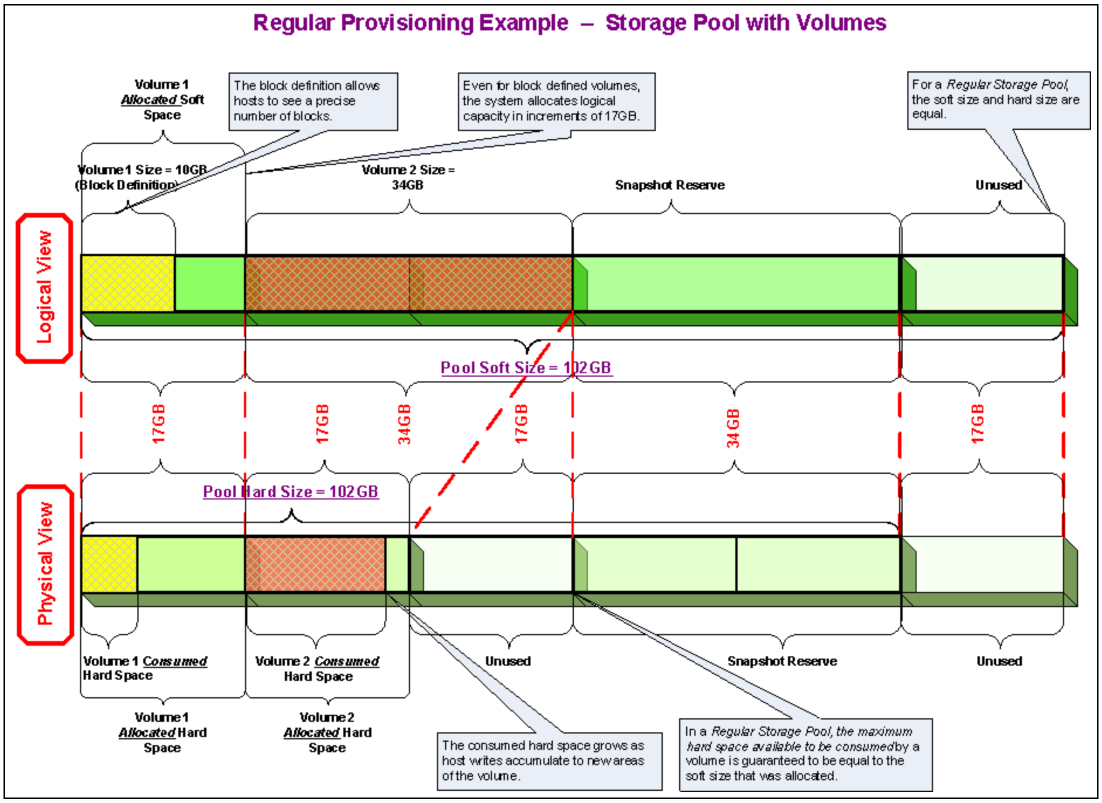


Figure 4-50 Volumes and snapshot reserve space within a regular Storage Pool

Thinly provisioned Storage Pool conceptual example

The thinly provisioned Storage Pool that was introduced in Figure 4-49 on page 197 is explored in detail in Figure 4-51. Note that the hard capacity and the soft capacity allocated to this pool are the same in both diagrams: 136 GB of soft capacity and 85 GB of hard capacity are allocated. Because the available soft capacity exceeds the available hard capacity by 51 GB, it is possible to thinly provision the volumes collectively by *up to* 66.7%, assuming that the snapshots are preserved and the remaining capacity within the pool is allocated to volumes.

Consider Volume 3 in Example 4-51. The size of the volume is defined as 34 GB; however, less than 17 GB has been consumed by host writes, so only 17 GB of hard capacity have been allocated by the system. In comparison, Volume 4 is defined as 51 GB, but Volume 4 has consumed between 17 GB and 34 GB of hard capacity and therefore has been allocated 34 GB of hard space by the system. It is possible for either of these two volumes to require up to an additional 17 GB of hard capacity to become fully provisioned, and therefore, at least 34 GB of additional hard capacity must be allocated to this pool in anticipation of this requirement.

Finally, consider the 34 GB of snapshot reserve space depicted in Figure 4-51. If a new volume is defined in the unused 17 GB of soft space in the pool, or if either Volume 3 or Volume 4 requires additional capacity, the system will sacrifice the snapshot reserve space in order to give priority to the volume requirements. Normally, this scenario does not occur, because additional hard space must be allocated to the Storage Pool as the hard capacity utilization crosses certain thresholds.

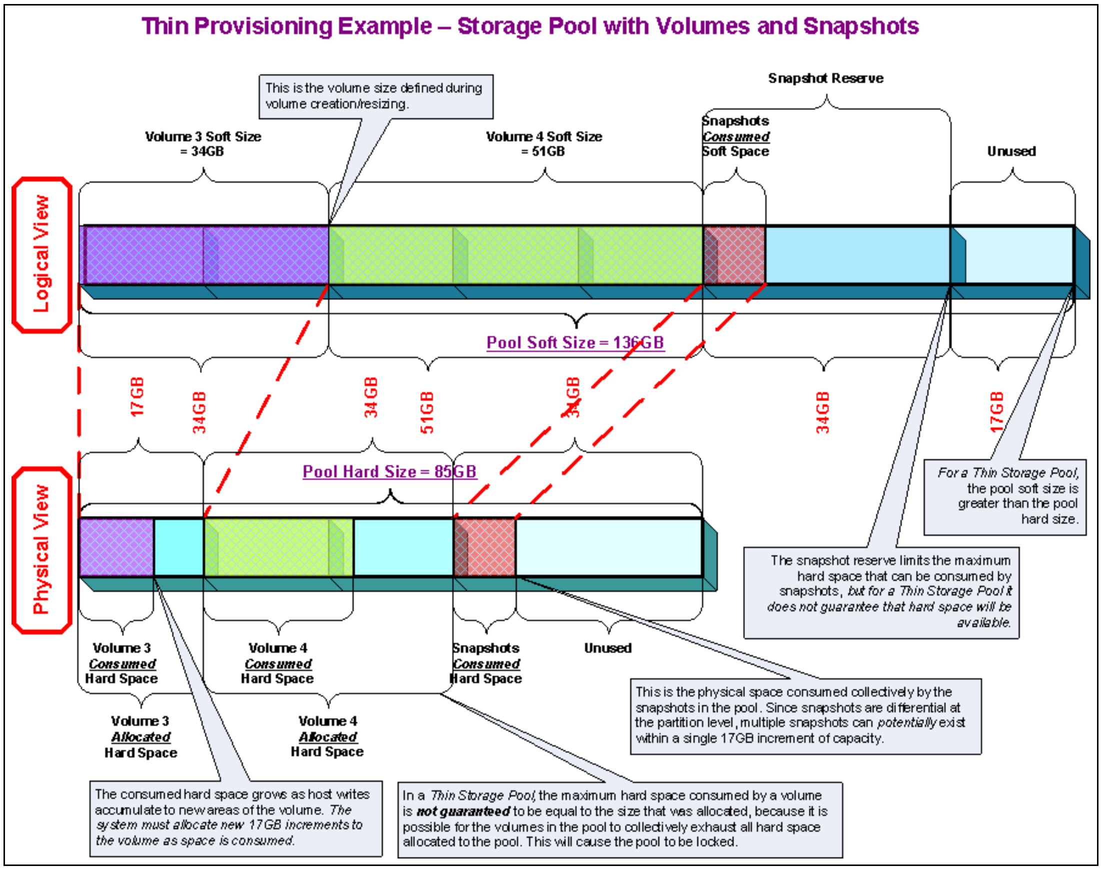


Figure 4-51 Volumes and snapshot reserve space within a thinly provisioned Storage Pool

Depletion of hard capacity

Using thin provisioning creates the inherent danger of exhausting the available physical capacity. If the soft system size exceeds the hard system size, the potential exists for applications to fully deplete the available physical capacity.

Important: Upgrading the system beyond the full 15 modules in a single frame is currently not supported.

- Snapshot deletion:

  As mentioned previously, snapshots in regular Storage Pools can be automatically deleted by the system in order to provide space for newer snapshots, or in the case of thinly provisioned pools, to permit more physical space for volumes.

- Volume locking:

  If more hard capacity is still required after all the snapshots in a thinly provisioned Storage Pool have been deleted, *all the volumes in the Storage Pool are locked, thereby preventing any additional consumption of hard capacity.* There are two possible behaviors for a locked volume: read only (the default behavior) or no I/O at all.

Important: Volume locking prevents writes to all volumes in the Storage Pool.

It is very important to note that thin provisioning implementation in the XIV Storage System manages space allocation within each Storage Pool, so that hard capacity depletion in one Storage Pool will never affect the hard capacity available to another Storage Pool. There are both advantages and disadvantages:

- Because Storage Pools are independent, thin provisioning volume locking on one Storage Pool never cascades into another Storage Pool.
- Hard capacity cannot be reused across Storage Pools, even if a certain Storage Pool has free hard capacity available, which can lead to a situation where volumes are locked due to the depletion of hard capacity in one Storage Pool, while there is available capacity in another Storage Pool. Of course, it is still possible for the storage administrator to intervene in order to redistribute hard capacity.

4.4.6 Reliability, availability, and serviceability

The XIV Storage System's unique modular design and logical topology fundamentally differentiate it from traditional monolithic systems, and this architectural divergence extends to the exceptional reliability, availability, and serviceability aspects of the system. In addition, the XIV Storage System incorporates autonomic, proactive monitoring and self-healing features that are capable of not only transparently and automatically restoring the system to full redundancy within minutes of a hardware failure, but also taking preventive measures to preserve data redundancy even before a component malfunction actually occurs.

For further reading about the XIV Storage System's parallel modular architecture, see 4.4.4, "Parallelism" on page 186.

Resilient architecture

As with any enterprise class system, redundancy pervades every aspect of the XIV Storage System, including the hardware, internal operating environment, and the data itself. However, the design elements, including the distribution of volumes across the whole of the system, in combination with the loosely coupled relationship between the underlying hardware and software elements, empower the XIV Storage System to realize unprecedented resiliency.

The resiliency of the architecture encompasses not only high availability, but also excellent maintainability, serviceability, and performance under non-ideal conditions resulting from planned or unplanned changes to the internal hardware infrastructure, such as the loss of a module.

Availability

The XIV Storage System maximizes operational availability and minimizes the degradation of performance associated with non-disruptive planned and unplanned events, while providing for the capability to preserve the data to the fullest extent possible in the event of a disaster.

Write path redundancy

Data arriving from the hosts is temporarily placed in two separate caches before it is permanently written to disk drives located in separate modules. This design guarantees that the data is always protected against possible failure of individual modules, even before the data has been written to the disk drives.

Figure 4-52 illustrates the path taken by a write request as it travels through the system. The diagram is intended to be viewed as a conceptual topology, so do not interpret the specific numbers of connections and so forth as literal depictions. Also, for purposes of this discussion, the Interface Modules are depicted on a separate level from the Data Modules.

However, in reality the Interface Modules also function as Data Modules. The following numbered steps correspond to the numbers in Figure 4-52:

1. A host sends a write request to the system. Any of the Interface Modules that are connected to the host can service the request, because the modules work in an active-active capacity. Note that the XIV Storage System does not load balance the requests itself. Load balancing must be implemented by storage administrators to equally distribute the host requests among all Interface Modules.
2. The Interface Module uses the system configuration information to determine the location of the primary module that houses the referenced data, which can be either an Interface Module, including the Interface Module that received the write request, or a Data Module. The data is written only to the local cache of the primary module.
3. The primary module uses the system configuration information to determine the location of the secondary module that houses the copy of the referenced data. Again, this module can be either an Interface Module or a Data Module, but it will not be the same as the primary module. The data is redundantly written to the local cache of the secondary module.

After the data is written to cache in both the primary and secondary modules, the host receives an acknowledgement that the I/O is complete, which occurs independently of copies of either cached, or dirty, data being destaged to physical disk.

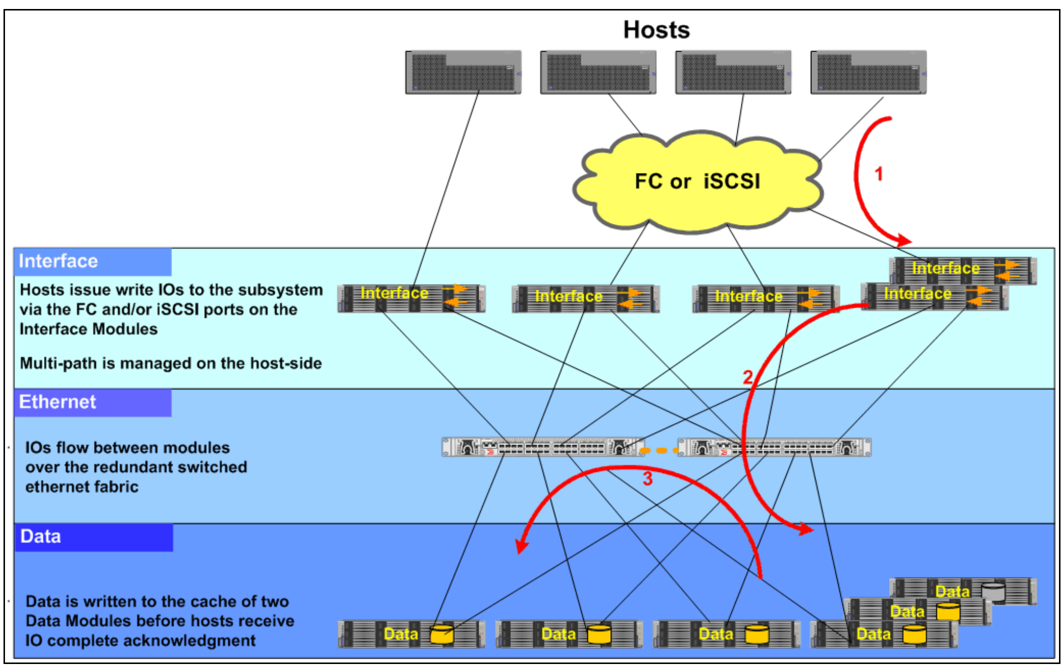


Figure 4-52 Write path

System quiesce and graceful shutdown

When an event occurs that compromises both sources of power to the XIV Storage System's redundant uninterruptible power supplies, the system executes the graceful shutdown sequence. Full battery power is guaranteed during this event, because the system monitors available battery charge at all times and takes proactive measures to prevent the possibility of conducting write operations when battery conditions are non-optimal.

Due to the XIV Storage System's grid topology, a system quiesce event essentially entails the graceful shutdown of all modules within the system. Each module can be thought of as an independent entity that is responsible for managing the destaging of "dirty" data, that is, written data that has not yet been destaged to physical disk. The dirty data within each module consists of equal parts primary and secondary copies of data, *but will never contain both primary and secondary copies of the same data.*

- Write cache protection:

  Each module in the XIV Storage System contains a local, independent space reserved for caching operations within its system memory.

  Each module contains 8 GB of high speed volatile *memory* (a total of 120 GB), from which 5.5 GB (and 82.5 GB overall) is dedicated for caching data.

  > **Destage:** The system does *not* contain non-volatile memory space reserved for write operations. However, the close proximity of the cache and the drives, in conjunction with the enforcement of an upper limit for dirty, or non-destaged, data on a per-drive basis, ensures that the full destage will occur while operating under battery power.

- Graceful shutdown sequence:

  The system executes the graceful shutdown sequence under either of these conditions:

  – The battery charge remaining in two or more universal power supplies is below a certain threshold, which is conservatively predetermined in order to provide adequate time for the system to fully destage all dirty data from cache.

  – The system detects the loss of external power for more than 30 seconds.

- Power on sequence:

  Upon startup, the system will verify that the battery charge levels in all uninterruptible power supplies exceed the threshold necessary to guarantee that a graceful shutdown can occur. If the charge level is inadequate, the system will halt the startup process until the charge level has exceeded the minimum required threshold.

  > **I/O activity:** If the battery charge is inadequate, the system will remain fully locked until the battery charge has exceeded the necessary threshold to safely resume I/O activity.

Rebuild and redistribution

As discussed in "Data distribution algorithms" on page 188, the XIV Storage System dynamically maintains the pseudo-random distribution of data across all modules and disks while ensuring that two copies of data exist at all times *when the system reports Full Redundancy*. Obviously, when there is a change to the hardware infrastructure as a result of a failed component, data must be restored to redundancy and distributed, or when a component is added, or *phased-in,* a new data distribution must accommodate the change.

Goal distribution

The process of achieving a new goal distribution while simultaneously restoring data redundancy due to the loss of a disk or module is known as a *rebuild*. Because a rebuild occurs as a result of a component failure that compromises full data redundancy, there is a period during which the *non-redundant data* is both restored to full redundancy and homogeneously redistributed over the remaining disks.

The process of achieving a new goal distribution (only occurring when redundancy exists) is known as a *redistribution*, during which all data in the system (including both primary and secondary copies) is redistributed, when it is a result of the following events:

- The replacement of a failed disk or module following a rebuild, also known as a "phase-in"
- When one or more modules are added to the system, known as a "scale out" upgrade

Following the completion of goal distribution resulting from a rebuild or phase-out, a subsequent redistribution must occur when the system hardware is fully restored through a phase-in.

> **Goal distribution:** The goal distribution is transparent to storage administrators and cannot be changed. In addition, the goal distribution has many determinants depending on the precise state of the system.
>
> **Important:** Never perform a phase-in to replace a failed disk or module until after the rebuild process has completed. These operations must be performed by the IBM XIV technician anyway.

Preserving data redundancy

Whereas conventional storage systems maintain a static relationship between RAID arrays and logical volumes by preserving data redundancy only across a subset of disks that are defined in the context of a particular RAID array, the XIV Storage System dynamically and fluidly restores redundancy and equilibrium across all disks and modules in the system during the rebuild and phase-out operations.

See "Logical volume layout on physical disks" on page 191 for a detailed discussion of the low-level virtualization of logical volumes within the XIV Storage System. The proactive phase-out of non-optimal hardware through autonomic monitoring and the modules' cognizance of the virtualization between the logical volumes and physical disks yield unprecedented efficiency, transparency, and reliability of data preservation actions, encompassing both rebuilds and phase-outs.

Rebuild examples

When the full redundancy of data is compromised due to a module failure, as depicted in Figure 4-53, the system immediately identifies the non-redundant partitions and begins the rebuild process. Because none of the disks within a given module contain the secondary copies of data residing on any of the disks in the module, the secondary copies are read from the remaining modules in the system. Therefore, during a rebuild resulting from a module failure, there will be concurrently 168 disks (180 disks in the system minus 12 disks in a module) reading, and 168 disks writing, as is conceptually illustrated in Figure 4-53.

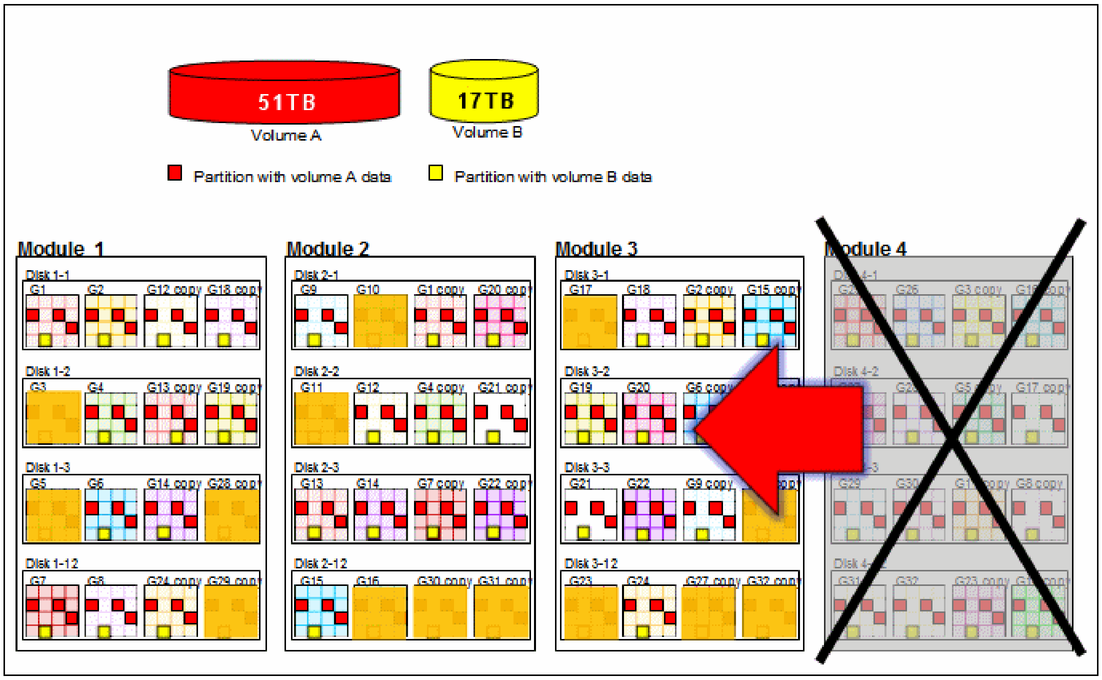


Figure 4-53 Non-redundant group of partitions following module failure

Figure 4-54 depicts a denser population of redundant partitions for both volumes A and B, thus representing the completion of a new goal distribution, as compared to Figure 4-53, which contains the same number of redundant partitions for both volumes distributed less densely over the original number of modules and drives.

Finally, consider the case of a single disk failure occurring in an otherwise healthy system (no existing phased-out or failed hardware). During the subsequent rebuild, there will be only 168 disks reading, because there is no non-redundant data residing on the other disks within the same module as the failed disk. Concurrently, there will be 179 disks writing in order to preserve full data distribution.

Attention: Figure 4-53 and Figure 4-54 conceptually illustrate the rebuild process resulting from a failed module. *The diagrams are not intended to depict in any way the specific placement of partitions within a real system, nor do they literally depict the number of modules in a real system.*

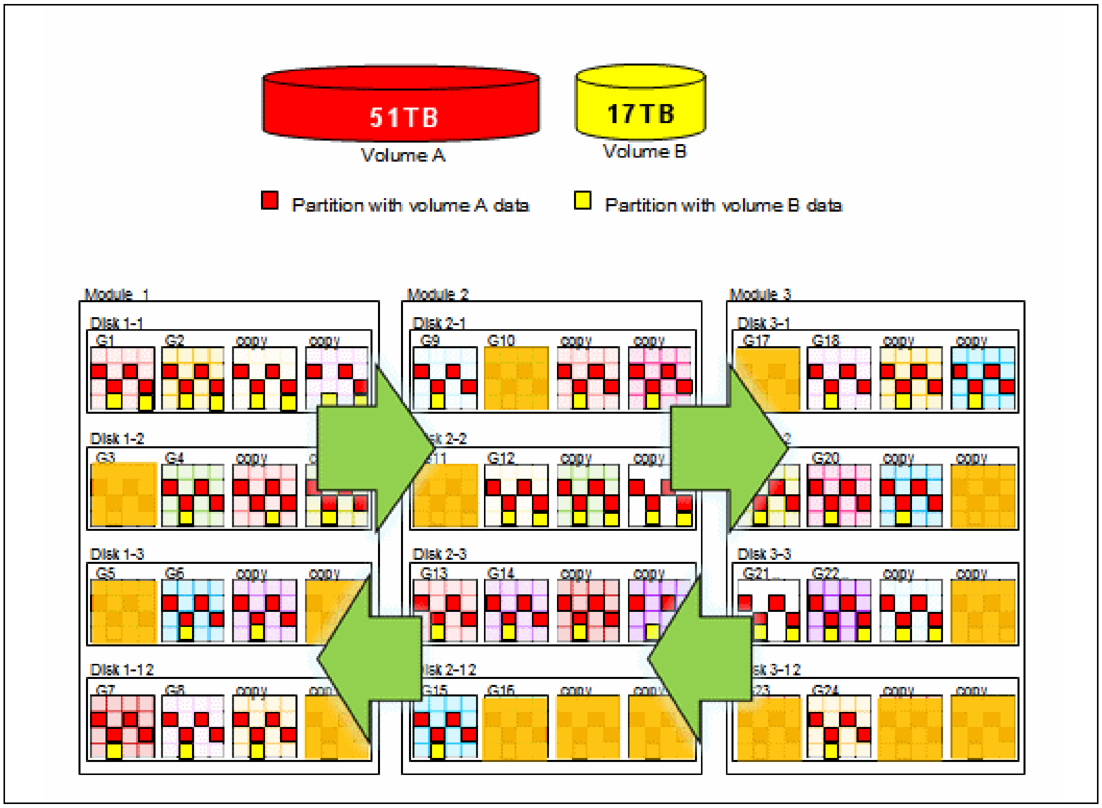


Figure 4-54 Performing a new goal distribution following module failure

Transient soft and hard system size

The capacity allocation that is consumed for purposes of either restoring non-redundant data during a rebuild, or creating a tertiary copy during a phase-out, will be sourced based on availability.

In the event that sufficient unallocated hard capacity is available, the system will withhold allocating reserve spare space to complete the rebuild or phase-out process in order to provide additional protection. As a result, it is possible for the system to report a maximum soft size that is temporarily less than the allocated soft capacity. The soft and hard system sizes will not revert to the original values until a replacement disk or module is phased-in, and the resultant redistribution completes.

Important: While it is possible to resize or create volumes, snapshots, or Storage Pools while a rebuild is underway, we strongly discourage these activities until the system has completed the rebuild process and restored full data redundancy.

Redistribution

The XIV Storage System homogeneously redistributes all data across all disks whenever new disks or modules are introduced or phased in to the system. This redistribution process is not equivalent to the “striping volumes on all disks” employed in traditional systems. when new capacity is added and new volumes are allocated, ordinary RAID striping algorithms do not intelligently redistribute data to preserve equilibrium for all volumes through the pseudo-random distribution of data. Thus, the XIV Storage System employs dynamic volume-level virtualization, obviating the need for ongoing manual volume layout planning.

The redistribution process is triggered by the “phase-in” of a new drive or module and differs from a rebuild or phase-out in the following respects:

- The system does not need to create secondary copies of data to reinstate or preserve full data redundancy.
- The distribution density, or the concentration of data on each physical disk, decreases instead of increasing.
- The redistribution of data performs differently, because the concentration of write activity on the new hardware resource is the bottleneck.

Minimized exposure

In this section we describe other features that contribute to the XIV Storage System reliability and availability.

Disaster recovery

All high availability SAN implementations must account for the contingency of data recovery and business continuance following a disaster, as defined by the organization’s recovery point and recovery time objectives. The provision within the XIV Storage System to efficiently and flexibly create nearly unlimited snapshots, coupled with the ability to define consistency groups of logical volumes, constitutes integral elements of the data preservation strategy. In addition, the XIV Storage System’s synchronous data mirroring functionality facilitates excellent potential recovery point and recovery time objectives as a central element of the full disaster recovery plan.

Proactive phase-out and self-healing mechanisms

The XIV Storage System can seamlessly restore data redundancy with minimal data migration and overhead. A further enhancement to the level of reliability standards attained by the XIV Storage System entails self-diagnosis and early detection mechanisms that autonomically phase out components before the probability of a failure increases beyond a certain point. In real systems, the failure rate is not constant with time, but rather increases with service life and duty cycle. By actively gathering component statistics to monitor this trend, the system ensures that components will not operate under conditions beyond an acceptable threshold of reliability and performance. Thus, the XIV Storage System’s self-healing mechanisms dramatically increase the already exceptional level of availability of the system, because they virtually preclude the possibility of data redundancy from ever being compromised along with the associated danger, however unlikely, of subsequent failures during the rebuild process.

The autonomic attributes of the XIV Storage System cumulatively impart an enormous benefit to not only the reliability of the system, but also the overall availability, by augmenting the maintainability and serviceability aspects of the system. Both the monetary and time demands associated with maintenance activities, or in other words, the total cost of ownership (TCO), are effectively minimized by reducing reactive service actions and enhancing the potential scope of proactive maintenance policies:

- Disk scrubbing:

  The XIV Storage System maintains a series of scrubbing algorithms that run as background processes concurrently and independently scanning multiple media locations within the system in order to maintain the integrity of the redundantly stored data. This continuous checking enables the early detection of possible data corruption, alerting the system to take corrective action to restore the data integrity before errors can manifest themselves from the host perspective. Thus, redundancy is not only implemented as part of the basic architecture of the system, but it is also continually monitored and restored as required.

In summary, the data scrubbing process has the following attributes:

– Verifies the integrity and redundancy of stored data

– Enables early detection of errors and early recovery of redundancy

– Runs as a set of background processes on all disks in parallel

– Checks whether data can be read from partitions and verifies data integrity by employing checksums

– Examines a partition approximately every two seconds

- Enhanced monitoring and disk diagnostics:

  The XIV Storage System continuously monitors the performance level and reliability standards of each disk drive within the system, using an enhanced implementation of Self-Monitoring, Analysis and Reporting Technology (SMART) tools. As typically implemented in the storage industry, SMART tools simply indicate whether certain thresholds have been exceeded, thereby alerting that a disk is at risk for failure and thus needs to be replaced.

  However, as implemented in XIV Storage System, the SMART diagnostic tools, coupled with intelligent analysis and low tolerance thresholds, provide an even greater level of refinement of the disk behavior diagnostics and the performance and reliability driven reaction. For instance, the XIV Storage System measures the specific values of parameters including, but not limited to:

  – Reallocated sector count: If the disk encounters a read or write verification error, it designates the affected sector as "reallocated" and relocates the data to a reserved area of spare space on the disk. Note that this spare space is a parameter of the drive itself and is *not* related in any way to the system reserve spare capacity that is described in "Global spare capacity" on page 193. The XIV Storage System initiates phase-out at a much lower count than the manufacturer says.

  – Disk temperature: The disk temperature is a critical factor that contributes to premature drive failure and is constantly monitored by the system.

  – Raw read error: The raw read error count provides an indication of the condition of the magnetic surface of the disk platters and is carefully monitored by the system to ensure the integrity of the magnetic media itself.

  – Spin-up time: The spin-up time is a measure of the average time that is required for a spindle to accelerate from zero to 7,200. The XIV Storage System recognizes abnormal spin-up time as a potential indicator of an impending mechanical failure.

  Likewise, for additional early warning signs, the XIV Storage System continually monitors other aspects of disk-initiated behavior, such as spontaneous reset or unusually long latencies. The system intelligently analyzes this information in order to reach crucial decisions concerning disk deactivation and phase-out. The parameters involved in these decisions allow for a very sensitive analysis of the disk health and performance.

- Redundancy-supported reaction:

  The XIV Storage System incorporates *redundancy-supported reaction*, which is the provision to exploit the distributed redundant data scheme by intelligently redirecting reads to the secondary copies of data, thereby extending the system's tolerance of above average disk service time when accessing primary data locations. The system will reinstate reads from the primary data copy when the transient degradation of the disk service time has subsided. Of course, a redundancy-supported reaction itself might be triggered by an underlying potential disk error that will ultimately be managed autonomically by the system according to the severity of the exposure, as determined by ongoing disk monitoring.

- Flexible handling of dirty data:

  In a similar manner to the redundancy-supported reaction for read activity, the XIV Storage System can also make convenient use of its redundant architecture in order to consistently maintain write performance. Because intensive write activity directed to any given volume is distributed across all modules and drives in the system, and the cache is independently managed within each module, the system is able to tolerate sustained write activity to an under-performing drive by effectively maintaining a considerable amount of "dirty," or unwritten, data in cache, thus potentially circumventing any performance degradation resulting from the transient, anomalous service time of a given disk drive.

Non-disruptive code load

Non-disruptive code load (NDCL) enables upgrades to the IBM XIV Storage System software from a current version (starting with Version 10.1) to a later version without disrupting the application service.

The code upgrade is run on all modules in parallel and the process is fast enough to minimize impact on the host applications.

No data migration or rebuild process is allowed during the upgrade. Mirroring, if any, will be suspended during the upgrade and automatically reactivated upon completion.

Storage management operations are also not allowed during the upgrade, although the status of the system and upgrade progress can be queried. It is also possible to cancel the upgrade process up to a point of no return.

Note that the NDCL does not apply to specific components firmware upgrades (for instance, module BIOS, HBA firmware). Those require a phase in / phase out process of the impacted modules.

4.4.7 More information about the IBM XIV Storage System

For more information about the DS8000 series, see the following Redbooks publications and websites:

- *IBM XIV Storage System: Architecture, Implementation, and Usage*, SG24-7659
- *IBM XIV Storage System: Copy Services and Migration*, SG24-7759
- *IBM XIV Storage System with the Virtual I/O Server and IBM i*, REDP-4598
- IBM XIV Storage System website:

  http://www.ibm.com/systems/storage/disk/xiv/index.html
- IBM XIV Storage System Information Center:

  http://publib.boulder.ibm.com/infocenter/ibmxiv/r2/index.jsp
- *White Paper IBM XIV Storage System: Thin Provisioning Reinvented*:

  ftp://service.boulder.ibm.com/storage/disk/xiv/ibm_xiv_thin_provisioning_paper.pdf

4.5 Comparison of Enterprise products

In this section we show a feature comparison between DS8000 series models and XIV. See Table 4-6.

Table 4-6 Enterprise products feature comparison

Characteristic	XIV	DS8700	DS8800
Product	IBM XIV Storage System	IBM System Storage DS8000	IBM System Storage DS8000
Machine/model	2810-A14, 2812-A14	242x-941/94E	242x-951/95E
Platform support	AIX, Solaris, HP-UX, Windows, Linux for Intel, Linux for POWER, Linux for System z, VMware, Mac OS	z/OS, Z/VM, OS/400, VSE/ESA, TPF, i5/OS, AIX, Solaris, HP-UX, OpenVMS, TRU64, Windows, Linux for Intel, Linux for POWER, Linux for System z, VMware, Mac OS, Netware, SGI IRIX, Fujitsu PRIMEPOWER	z/OS, Z/VM, OS/400, VSE/ESA, TPF, i5/OS, AIX, Solaris, HP-UX, OpenVMS, TRU64, Windows, Linux for Intel, Linux for POWER, Linux for System z, VMware, Mac OS, Netware, SGI IRIX, Fujitsu PRIMEPOWER
Host connectivity	4 Gbps Fibre Channel, iSCSI	4 Gbps Fibre Channel, FICON	8 Gbps Fibre Channel, FICON
Copy services	Synchronous mirror, asynchronous mirror, snapshot	FlashCopy, FlashCopy SE, Metro Mirror, Global Mirror, Global Copy, Metro/Global Mirror	FlashCopy, FlashCopy SE, Metro Mirror, Global Mirror, Global Copy, Metro/Global Mirror
Advanced features	thin provisioning	thin provisioning, Easy Tier, deadlock recovery	-
Mainframe features	-	z/OS Global Mirror, PAV, HyperPAV	z/OS Global Mirror, PAV, HyperPAV
Controllers	Multiple active-active	Dual active-active	Dual active-active
Cache (min, max)	48/270 GB	32/384 GB	32/384 GB
RAID support	Data mirroring	5, 6, 10	5, 6, 10
Raw capacity (min, max)	72/360 TB	584 GB/2048 TB	2.3 TB/634 TB
Drive interface	SATA	2 Gbps Fibre Channel	8 Gbps Fibre Channel
Supported drives	SATA	SSD, Fibre Channel, SATA	SSD, 6 Gbps SAS-2

For detailed comparison information, see the IBM System Storage product guide, available at the following website:

http://www.ibm.com/systems/storage/resource/pguide

5

IBM System Storage N series

In this chapter, we introduce the IBM System Storage N series and describe its hardware and software. The IBM System Storage N series provides a range of reliable, scalable storage solutions for a variety of storage requirements.

All IBM N series systems utilize a single operating system across the entire portfolio to help minimize the IT storage skills required. A combination of multiple advanced function software features provide one of the industry's most versatile storage platform solutions ranging from comprehensive system management, storage management, onboard and outboard copy services, virtualization technologies and disaster recovery and backup solutions. The N series products provide a wide range of network attachment capabilities to a broad range of host and client systems using a multitude of network access protocols including file system protocols (CIFS, NFS, HTTP, FTP); and block I/O protocols including iSCSI and FCP, utilizing built-in Redundant Array of Inexpensive Disks (RAID) technologies.

All data is well protected with options to enhance protection through mirroring, replication, Snapshots, virtualization technologies, and disaster recovery and backup solutions. The N series systems are also characterized by simple management interfaces that make installation, administration, and troubleshooting straightforward. The IBM System Storage N series is designed from the ground up as a stand-alone storage system.

Advantages of using this type of flexible storage solution include the following capabilities:

- Tune the storage environment to a specific application while maintaining flexibility to increase, decrease, or change access methods with minimal disruption.
- React easily and quickly to changing storage requirements. If additional storage is required you can expand it quickly and non-disruptively. If existing storage is deployed incorrectly you have the capability to reallocate available storage from one application to another quickly and simply.
- Maintain availability and productivity during upgrades. If outages are necessary, they can be kept to the shortest time possible.
- Create effortless backup and recovery solutions that operate in a common manner across all data access methods.
- Simplify your infrastructure with file- and block-level services in a single system.

- Tune the storage environment to a specific application while maintaining its availability and flexibility.
- Change the deployment of storage resources non-disruptively, easily, and quickly. Online storage resource redeployment is possible.
- Easily and quickly implement the upgrade process. Non-disruptive upgrade is possible.
- Achieve strong data protection solutions with support for online backup and recovery.
- Include added value features such as deduplication to optimize space management.

5.1 IBM N series storage systems functionality

The IBM System Storage N series storage systems offer multiprotocol connectivity using internal storage or storage provided by expansion units (Figure 5-1). IBM System Storage N series systems are designed to provide integrated block-level and file-level data access, allowing concurrent operation in IP SAN (iSCSI), FC SAN, NFS, and CIFS environments. Other storage vendors might require the operation of multiple systems to provide this functionality, thus this makes the N series a perfect storage consolidation system. IBM System Storage N series storage systems are designed to avoid costly downtime, both planned and unplanned, and improve your access to mission-critical data, thereby helping you gain a competitive advantage.

Figure 5-1 shows the ability to connect multiple data access methods.

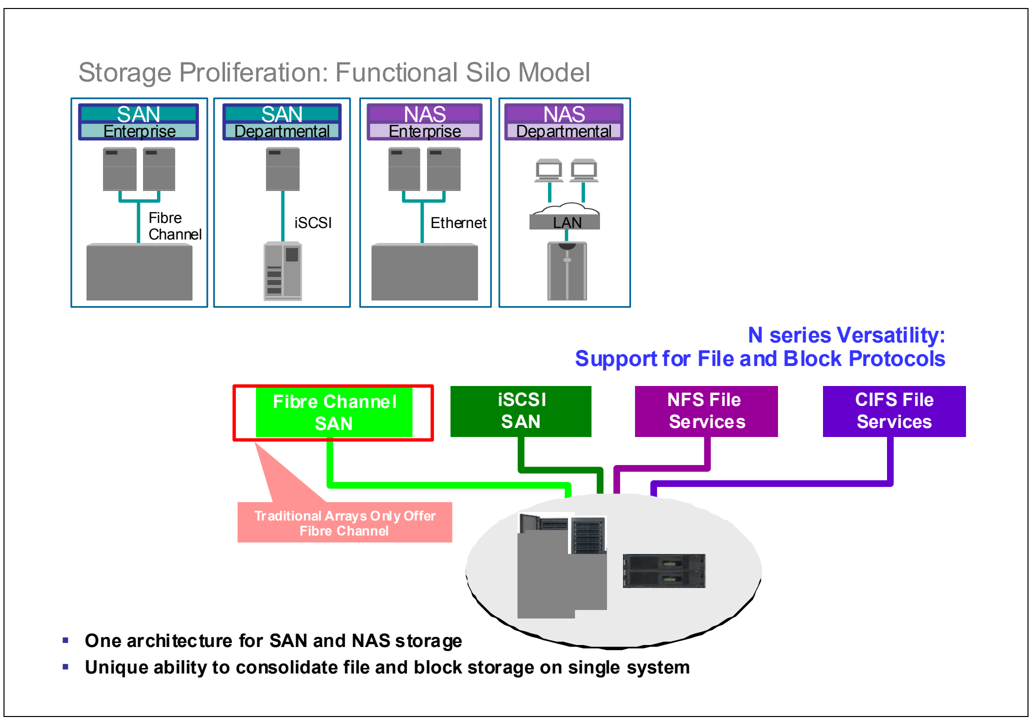


Figure 5-1 IBM System Storage N series A models

The N series is a specialized, *thin server* storage system with a customized operating system, similar to a stripped-down UNIX kernel, hereafter referred to as Data ONTAP. With this customized operating system, many of the server operating system functions that you are familiar with are not supported. Data ONTAP improves performance and reduces costs by eliminating unnecessary functions that do not pertain to a storage system.

The N series systems come with preconfigured software and hardware, and with no monitor or keyboard for user access. This is commonly called a *headless* system. A storage administrator accesses the systems and manages the disk resources from a remote console using a web browser or command line.

One of the typical characteristics of an N series storage systems product is its ability to be installed rapidly, using minimal time and effort to configure the system. N series is integrated seamlessly into the network, making it especially attractive when limited resources of time and skills are of consideration in the decision process.

5.1.1 Drive flexibility

IBM System Storage N series products are designed to provide network-attached storage for environments where customers have a need to utilize their storage investment in a multifaceted environment. IBM System Storage N series storage systems provide customers with a tremendous amount of versatility by allowing this solution to be populated with both Fibre Channel disk drives and SATA disk drives. An N series populated with Fibre Channel disk drives might be suitable for mission-critical high-performance data transaction environments, whereas an N series populated with SATA disk drives might be attractive to customers who wish to use the platform for disk-to-disk backup scenarios, disaster recovery scenarios, archive data, or data such as home directories, which do not have the demands of high-performance transactional environments. See Table 5-1.

Table 5-1 Drive positioning

Requirement	Fibre Channel drives	SAS drives	SATA drives
Online, high-performance, mission-critical production data repository	X	X	
Near-line storage used for tiered storage or infrequently accessed data	X	X	X
Data retention to help meet the needs of customers required to store data in non-erasable and non-rewritable (WORM) formats		X	X

5.1.2 Near-line storage solution

IBM System Storage N series with SATA drives offers near-line storage. Figure 5-2 shows an example of traditional disk-based backup and recovery. The left side shows the primary storage characterized by a higher cost and very fast performing system. On the far right, the archive targets are represented traditionally by tape or optical jukeboxes.

The N series secondary with SATA drives reduces access times to read and write data. A few years ago the concept of near-line storage in the middle for disk staging was introduced and enabled organizations to do daily backups to disk. Additionally, backups to tape can be done weekly or bi-weekly, thereby reducing the amount of data that needed to be written to tape. Moreover, data that is online is available for faster recovery. The other advantage that this provides is that you can profit from your existing investment in primary storage, your backup application, and tape libraries.

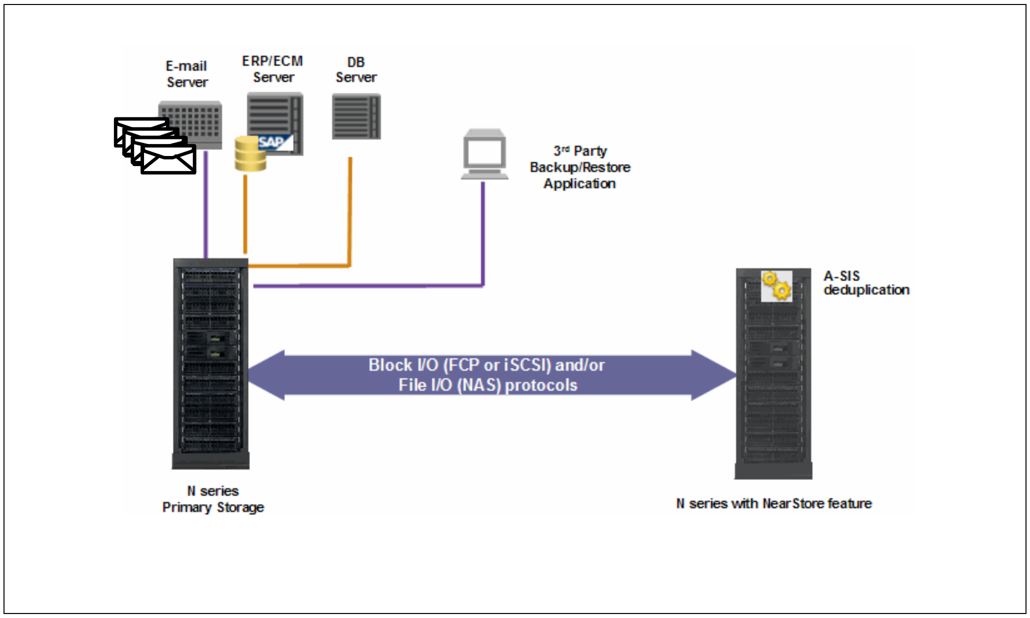


Figure 5-2 Near-line storage solution

5.2 IBM System Storage N series hardware

In the following sections we discuss the N series models available today:

- N3000 series
- N6000 series
- IBM System Storage Gateway
- N7000 series

Table 5-2 provides details about these models.

Table 5-2 IBM System Storage N series storage systems and their disk capacity

A1X and A2X models	Maximum number of drives	Maximum raw capacity in TB
N3300	68	68
N3400	136	136
N3600	104	104
N6040[a]	420	420
N6060[a]	672	672
N6070[a]	840	840
N7700	840	840
N7900	1176	1176

a. The N6000 models series also act as a gateway with Data ONTAP 7.3 and later.

5.2.1 Maximum number of network interfaces

Beginning with Data ONTAP 7.3, storage systems (except for the smallest models) are no longer limited to 128 interfaces per storage system. Larger storage systems can accommodate from 256 to 1,024 network interfaces per system depending on the system's memory and whether they are in a clustered, active/active configuration.

Table 5-3 shows the new maximum number of network interfaces allowed for each system. The total number of interfaces can include physical, Virtual Interface (VIF), virtual local area network (VLAN), vh, and loopback interfaces.

The number of physical interfaces depends on the storage system model. Up to 16 VIFs can be supported by each storage system. The maximum number of VLANs that can be supported equals the maximum number of network interfaces shown in Table 5-3 minus the total number of physical interfaces, VIFs, vh, and loopback interfaces supported by the storage system.

Table 5-3 Storage system memory and maximum number of interfaces

Storage system memory	Maximum number of interfaces
2 GB or less	128
2 GB or less in an active/active configuration	256
6 GB or less	256
6 GB or less in an active/active configuration	512
More than 6 GB	512
More than 6 GB in an active/active configuration	1024

5.2.2 IBM System Storage N series A models hardware reference

Table 5-4 provides a quick reference for N series (A) models.

Table 5-4 A quick reference for N series A model hardware.

Feature	N3300	N3400	N3600	N6040	N6060	N6070	N7700	N7900
Maximum raw capacity in TB A1X models	68	136	104	420	672	840	840	1176
Maximum raw capacity in TB A2X models	68	136	104	420	672	840	840	1176
Fibre Channel disk drives	10 K RPM - 300 GB 15 K RPM - 144 GB, 300 GB, 450 GB, 600 GB							
Serial Advanced Technology Attachment (SATA) disk drives	7.2 K RPM - 500 GB, 1 TB, 2 TB							
Serial Attached SCSI (SAS) disk drives	15K RPM - 300 GB, 450 GB, 600 GB (SAS drives) 7,2K RPM 500 GB, 1 TB, 2 TB (SATA drives)							
Maximum number of disks	68	136	104	420	672	840	840	1176
Expansion units supported	EXN1000 (SATA), EXN2000 (FC 2 Gbps), EXN4000 (FC 4 Gbps), EXN3000 (SAS 3 Gbps)[a]							

a. EXN3000 supports only SAS drives and 500 GB, 1 TB, 2 TB SATA drives

Table 5-5 provides a quick reference for N series Gateway (G) models.

Table 5-5 N series G models quick reference

Function	N7700	N7900
Maximum raw capacity in TB G10/G20 models	840	1176
Max. number of logical units (LUNs) on back-end disk storage array	840	1176
Max LUN size in GB	1024	2048
Maximum volume size in TB	16	16

5.2.3 IBM System Storage N series A and G models hardware quick reference

Table 5-6 provides a quick reference for the storage systems.

Table 5-6 Storage system reference

Function	N3300	N3400	N3600	N6040	N6060	N6070	N7700	N7900
Network protocol support	NFS V2/V3/V4 over UDP or TCP, PCNFSD V1/V2 for (PC) NFS client authentication, Microsoft CIFS, iSCSI, FCP, VLD, HTTP 1.0, HTTP1.1 virtual host							
Other protocol support	SNMP, NDMP, LDAP, NIS, DNS,							
Onboard I/O ports per node	4 x GbE 4 x FC	8 x GbE 4 x FC 2 x SAS	4 x GbE 4 x cal FC	4 x GbE 8 x FC		4 x Gbe 8 x FC	6 x GbE 8 x FC	6 x GbE 8 x FC
PCI expansion slots per node	N/A	N/A	1 x PCI-E	4 x PCI-E	4 x PCI-E	4 x PCI-E	3 x PCI-x5 10 x PCI-E	3 x PCI-E 10 x PCI-E
Non-volatile RAM (NVRAM) in MB per node	128	256	256	512	2048	2048	2048	4096
Memory in GB per node	1	4	2	4	8	16	16	32
Rack space per node	2U for two nodes	2U for two nodes	4U for two nodes	6U for two nodes	6U for two nodes	6U for two nodes	6U	6U
Processors (A1X)	One 2.2 GHz Mobile Celeron®	One 1.66 GHz Intel DUal Core Xeon	One 2.2 GHz Mobile Celeron	2.4 GHz AMD dual-core 64-bit Opteron	Two 2.6 GHz AMD dual-core 64-bit Opteron	Two 2.6 GHz AMD dual-core 64-bit Opteron	Two 2.6 GHz AMD dual-core Opteron	Four 2.6 GHz AMD dual-core Opteron
Processors (A2X)	Two 2.2 GHz Mobile Celeron	Two 1.66 GHz Intel Dual-core Xeon	Two 2.2 GHz Mobile Celeron	Two 2.4 GHz AMD dual-core 64-bit Opteron	Four 2.6 GHz AMD dual-core 64-bit Opteron	Four 2.6 GHz AMD dual-core 64-bit Opteron	Four 2.6 GHz AMD dual-core Opteron	Eight 2.6 GHz AMD dual-core Opteron

5.2.4 IBM System Storage N3000 introduction

The N3000 systems are designed to provide primary and secondary storage for midsize enterprises. IT administrators can consolidate fragmented application-based storage and unstructured data into one unified, easily managed, expandable platform. N3000 systems offer integrated block-level and file-level data access, intelligent management software, and data protection capabilities (similar to those offered in higher-end N series systems) in a cost-effective package. N series innovations include Serial-Attached SCSI (SAS) disk drive support, expandable I/O connectivity, and onboard remote management.

N3000 systems

The N3000 systems are designed as the entry point to the entire N series family. These systems can provide the following key advantages:

- High availability: Utilizes proven features including a high-performing and scalable operating system, data management software, and redundancy features
- Backup and recovery features: Designed to support disk-based backup, with file or application-level recovery with Snapshot and SnapRestore software features
- Simple replication and disaster recovery: Designed to provide an easy-to-deploy mirroring solution that is highly tolerant of wide area network (WAN) interruptions
- Management simplicity: Self-diagnosing systems designed to enable on-the-fly provisioning
- Versatile, single, integrated architecture: Designed to support concurrent block I/O and file serving over Ethernet and Fibre Channel SAN infrastructures

The N3000 series is compatible with the entire family of N series unified storage systems, which feature a comprehensive line-up from top-to-bottom of hardware and software designed to address a variety of possible deployment environments:

- N3300:
  - 2859-A10 Single Node
  - 2859-A20 Clustered
- N3400
  - 2859-A11 Single Node
  - 2859-A21 Clustered
- N3600:
  - 2862-A20 Clustered

The N3000 series supports Ethernet and Fibre Channel environments, enabling economical NAS, FC, and iSCSI deployments. The N3000 system functions as a *unification engine*, which is designed to allow you to simultaneously serve both file-level and block-level data across a single or multiple networks demanding procedures that, for certain solutions, require multiple separately managed systems.

N3000 storage systems can offer significant advantages for distributed enterprises with remote and branch office sites. These organizations and others can utilize the SnapVault and SnapMirror software functions to implement a cost-effective data protection strategy by mirroring data to a central corporate data center.

There are no additional PCI adapter slots in the N3300 storage system. On the other hand, the N3600 storage system has one available PCIe adapter slot per node. For an A20 model, identical adapters must be added in pairs, one to each node, so that both nodes are populated with identical types of PCIe adapters.

N3300 and N3600

The N3300 and 3600 systems (Figure 5-3 and Figure 5-4) provide multiple I/O connectivity options, a small footprint to hold high-density Serial-Attached SCSI (SAS) drives, and external expansion using either low-cost SATA drives or Fibre Channel disks for production applications while using Data ONTAP's Snapshot technology. SAS is the next generation of SCSI that combines the advantages of parallel SCSI and serial FC.

For further systems administration time and cost advantages, the systems come standard with Remote Onboard Management capabilities to simplify remote system monitoring, cycle power, execute firmware upgrades, enter console commands, and run diagnostics to maintain the reliability of the system as well as business-critical data.

Figure 5-3 N3300

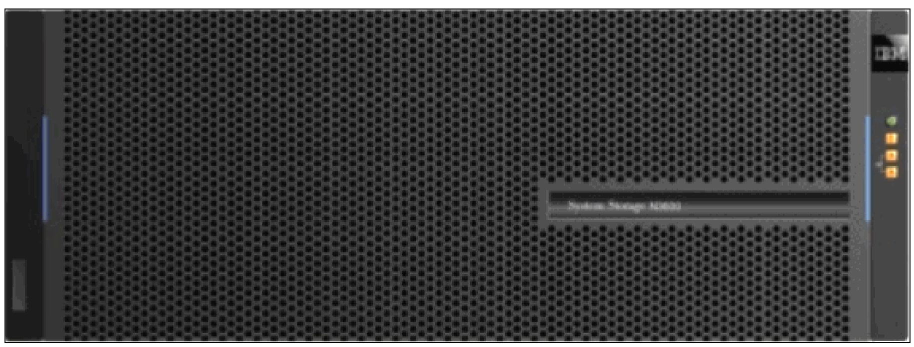


Figure 5-4 N3600

Figure 5-5 and Figure 5-6 show the rear views of N3300 and N3600, respectively. The single node models (A10) use a single control unit, while the dual-node clustered models (A20) use two control units.

Figure 5-5 N3300 rear view

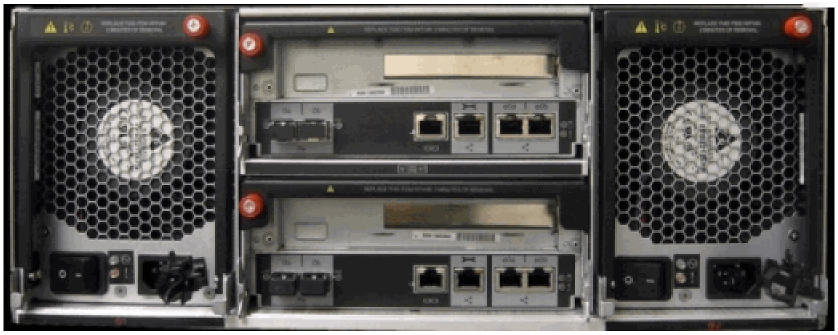


Figure 5-6 N3600 rear view

N3300 is a 2U-high device with capacity for 12 internal SAS drive bays and supports up to two external disk expansion units. Each controller has dual gigabit Ethernet ports, dual 4 Gbps Fibre Channel ports (Figure 5-7), one console port, and one remote management port.

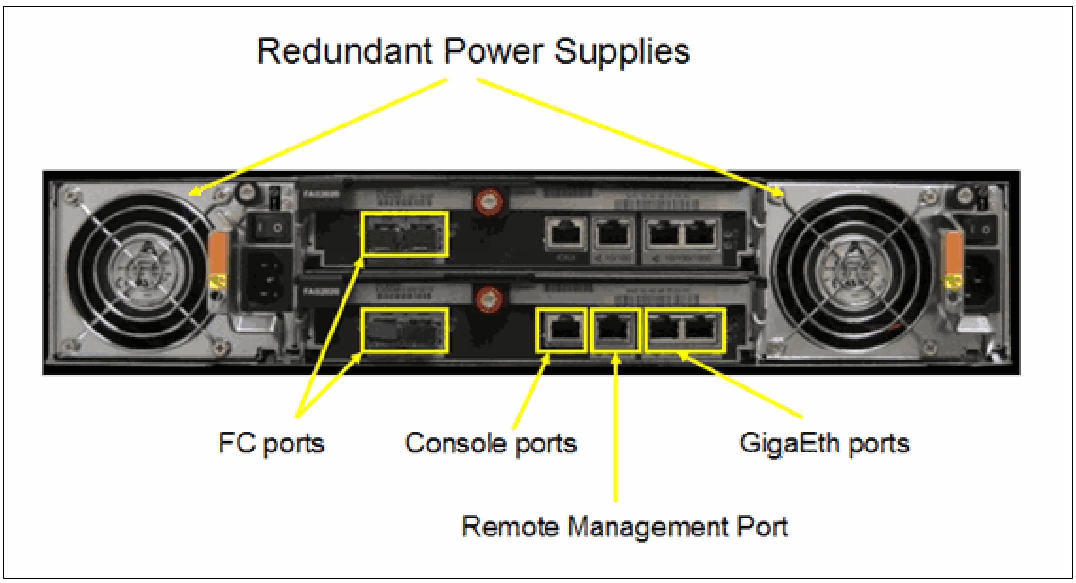


Figure 5-7 External ports on N3300

Tips: The N3300 series supports SAS, FC, and SATA disk technologies. The N3300 controller chassis supports from 6 to12 SAS or SATA disk drives. All disks must be of the same type. The N3300 controller can be configured with 0 disk drives and storage in disk expansion units such as EXN1000/SATA or EXN4000/FC.

The N3600 has redundant power supplies (Figure 5-8).

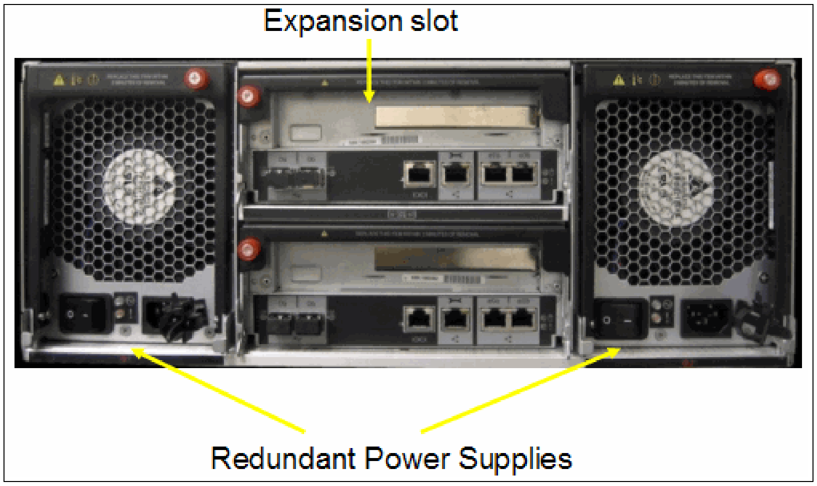


Figure 5-8 N3600 power supplies and expansion slot

The N3600 is a 4U-high device with capacity for 20 internal SAS drive Bays. N3600 can support up to six external disk expansion units. Each controller has dual gigabit Ethernet ports and dual 4 Gbps Fibre Channel ports (Figure 5-9). It also has one console port and one remote management port, as well as one PCIe slot on each controller for an expansion card.

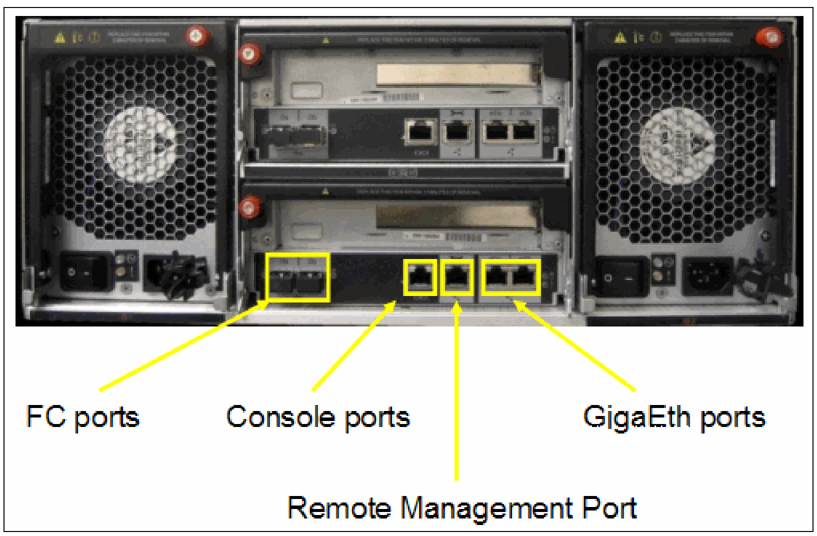


Figure 5-9 External ports on N3600

Tips: The N3600 series supports SAS, FC, and SATA disk technologies. The controller chassis supports either 20 SAS or 20 SATA disk drives. The N3600 requires a minimum of six SAS drives in the controller chassis.

The N3000 series is a small form-factor appliance that conserves scarce and valuable space in data centers or remote office locations and it is engineered for small to medium-sized enterprises.

Specifications: For an N3000 quick reference of model specifications, see Table on page 215 through Table 5-6 on page 216.

For detailed specifications of N3000 series models, see the website:

`http://www-03.ibm.com/systems/storage/network/n3000/appliance/specification.html`

N3400

The IBM System Storage N3400 is the newcomer of the N3000 family and can provide primary and secondary storage for the midsize enterprise. It enables the IT department of such an organization to consolidate all of their distributed application-based storage and unstructured data into one unified, easily managed and expandable platform, thereby increasing their effectiveness. N3400 offers integrated block-level and file-level data access, intelligent management software, and data protection capabilities in a cost-effective package. The IBM System Storage N3400 and the other N3000 models provide innovation with internal controller support for Serial-Attached SCSI (SAS) or SATA drives, expandable I/O connectivity, and onboard remote management.

The new N3400 series can scale up to 24 TB of internal raw capacity and increase total raw capacity to 104 TB. Using 2 TB SATA drives will the lower maximum spindle count in the system.

Figure 5-10 and Figure 5-11 show front and back views of the N3400 controller module. In the rear panel both clustered controllers and stand-alone controller options are available.

Figure 5-10   Front views of 3400 controller modules

N3400 is a 2U box with the capability to host up to 12 drives in the controller enclosure. If more capacity is needed the N3400 can be attached to external EXN1000 and EXN4000 units with SATA and FC drives. It is also possible to connect the controllers to the new EXN3000 shelf.

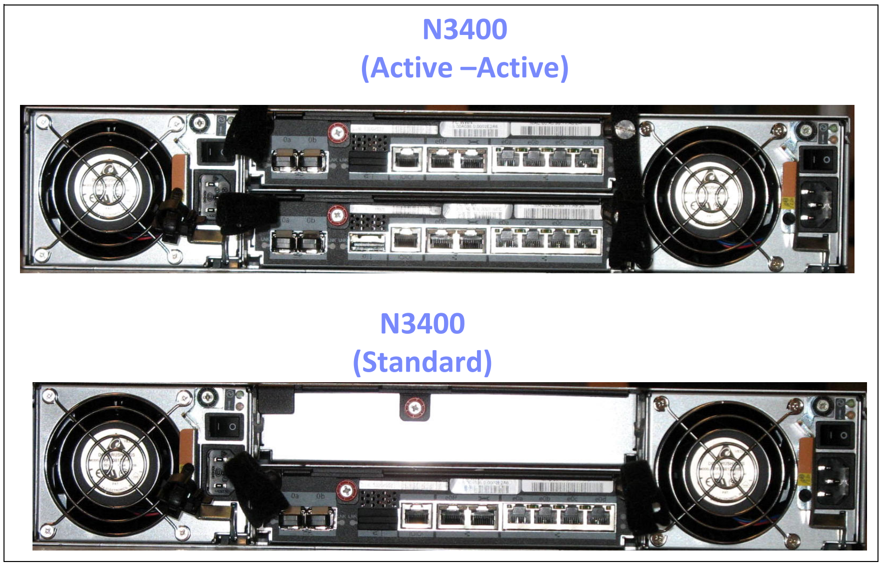


Figure 5-11 Comparison of N3400 configurations

The N3400 has one SAS expansion port per controller with one Alternate Control Path (ACP). If you need to attach the EXN3000 shelf to the controller you can configure the shelf Alternate Control Path during the setup process. This will enable Data ONTAP to manage the EXN3000 on a separate network in order to increase availability and stability. The ACP is shown in Figure 5-12.

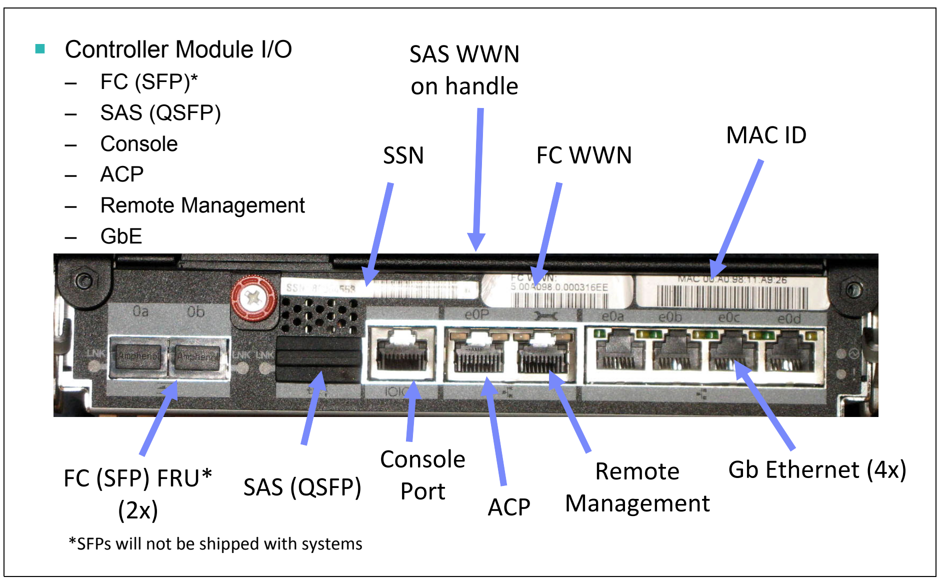


Figure 5-12 N 3400 communication ports

The N3400 has the following key specifications:

- 2U high
- Up to eight external EXN1000, EXN4000 expansion units (up to 6 in stack)
- High-performance SAS infrastructure
- Single controller or dual controller (for HA)
- Unified storage: iSCSI, NAS, Fibre Channel
- Each controller: Up to 8 gigabit Ethernet ports and two dual 4 Gbps Fibre Channel ports
- Onboard remote platform management
- Internal SAS drive bays

Starting from SAS firmware 0500, it is possible to perform a Non Disruptive Update (NDU) so disk I/Os are uninterrupted while SAS firmware is being updated.

5.2.5 IBM System Storage N6000 introduction

IBM N6000 series systems offer a versatile storage platform for handling the large amounts of diverse data moving through your business. With an N6000 series system, you can consolidate these varied data sets onto a unified storage platform supporting simultaneous block and file services for business and technical applications. The N6000 systems enable you to connect your heterogeneous server environment (including Windows, UNIX, and Linux servers) and clients to one storage system by using standard storage protocols and interfaces.

The IBM N6000 A series comes in the following models:

- N6040:
  - 2858-A10 Single Node
  - 2858-A20 Clustered
- N6060:
  - 2858-A12 Single Node
  - 2858-A22 Clustered
- N6070:
  - 2858-A11 Single Node
  - 2858-A21 Clustered

Figure 5-13 shows the front view of the N6000 series.

Figure 5-13 N6000 front view

Figure 5-14 shows the rear view of the N6000 series.

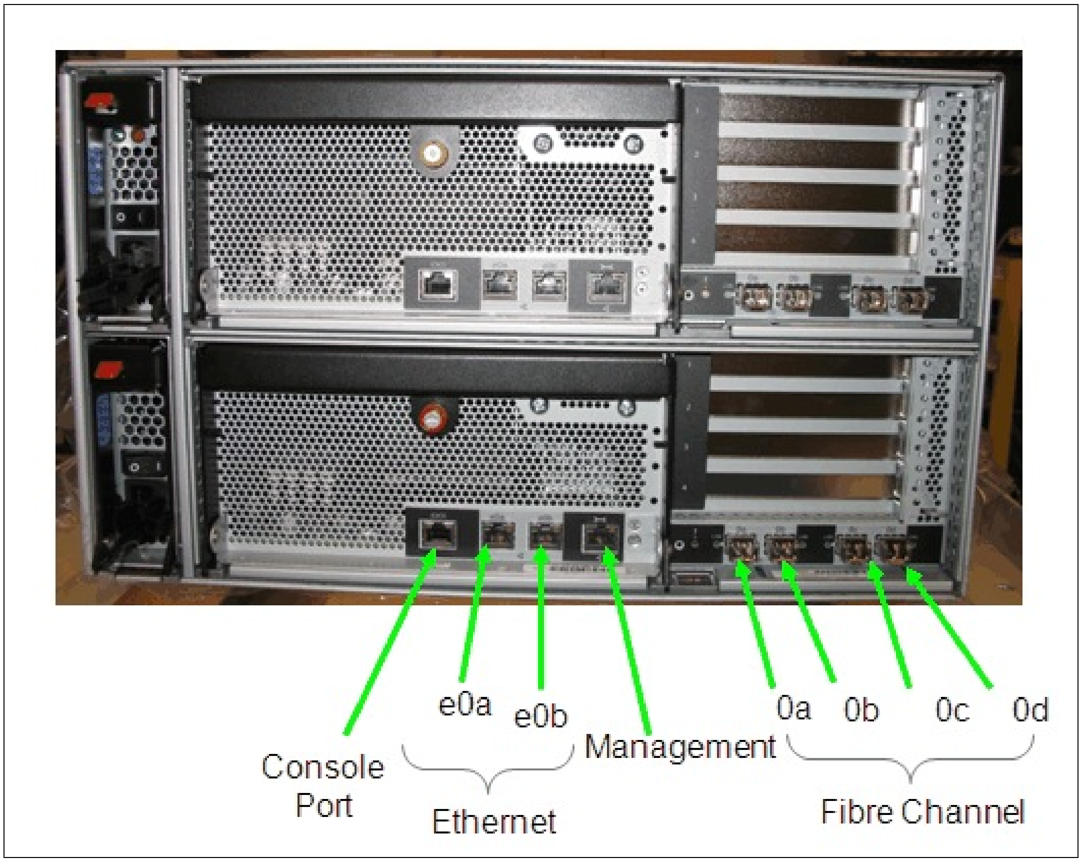


Figure 5-14 N6000 rear view

Specifications: For an N6000 quick reference of model specifications, see Table on page 215 through Table 5-6 on page 216.

For detailed specifications of N6000 series models, see the website:

`http://www.ibm.com/systems/storage/network/n6000/appliance/specifications.html`

5.2.6 IBM System Storage N7000 introduction

The IBM System Storage N7000 series offers additional choices to organizations facing the challenges of enterprise data management. The IBM System Storage N7000 series is designed to deliver high-end enterprise storage and data management value with midrange affordability. Built-in enterprise serviceability and manageability features help support your efforts to increase reliability, simplify and unify storage infrastructure and maintenance, and deliver exceptional economy.

- The IBM N7000 A series comes in two models:
  - N7700:
    - 2866-A11
    - 2866-A21 Clustered
  - N7900:
    - 2867-A11
    - 2867-A21 Clustered
- FC or SATA (both can be used behind a single controller but not in the same drawer)

Like its N5000 predecessor, the front of the N7000 series unit has the LCD display and the three standard LEDs indicating system activity, status, and power (Figure 5-15).

Figure 5-15 N7000 front view

From the rear of the N7000, you can see the redundant power supplies marked, the NVRAM card, the gigabit Ethernet interfaces, and the Fibre Channel interfaces. The console port and RLM port are also located on the rear (Figure 5-16).

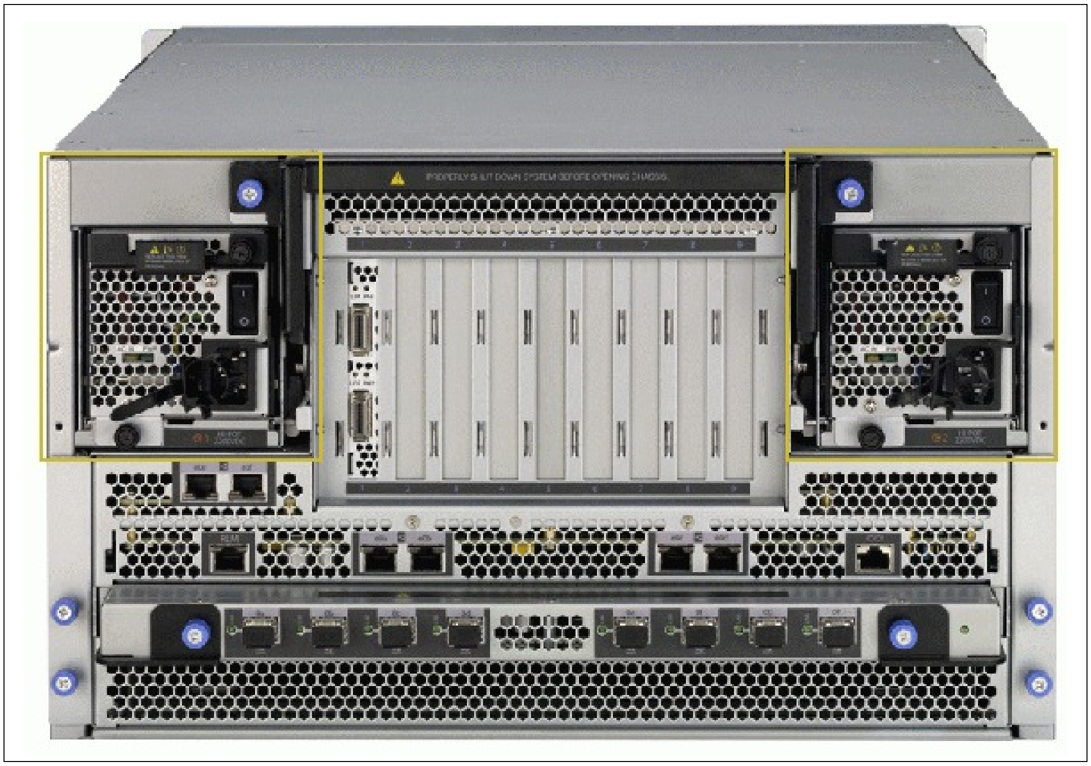


Figure 5-16 N7000 rear view

Each N7000 node requires 6U of rack space. Each expansion unit requires 3U of rack space. Each N7000 node requires at least one expansion unit (Figure 5-17).

Figure 5-17 N7000 racked

A dual-node N7900 supports a maximum of 84 storage expansion units. Each rack holds a maximum of 12 expansion units. The N7000 products are installed by IBM Service or by a qualified IBM Business Partner. These systems are not for customer setup.

Figure 5-18 shows the N7000 with multiple expansion units.

Figure 5-18 Clustered N7000 with multiple expansion units

> **Specifications:** For an N7000 quick reference of model specifications, see Table on page 215 through Table 5-6 on page 216.
>
> For detailed specifications of N7000 series models, see the website:
>
> `http://www.ibm.com/systems/storage/network/n7000/appliance/specification.html`

5.3 IBM System Storage N series Gateways

The IBM System Storage N series Gateway family, an evolution of the N5000 series product line, is a network-based virtualization solution that virtualizes tiered, heterogeneous storage arrays, allowing customers to utilize the dynamic virtualization capabilities available in Data ONTAP across multiple tiers of IBM and vendor-acquired storage (Figure 5-19).

Like all IBM System Storage N series storage systems, the IBM System Storage N series Gateway family is based on the industry-hardened Data ONTAP microkernel operating system, which unifies block and file storage networking paradigms under a common architecture and provides a complete suite of IBM System Storage N series advanced data management capabilities for consolidating, protecting, and recovering mission-critical data for enterprise applications and users.

Figure 5-19 shows the N series gateway in a heterogeneous SAN environment.

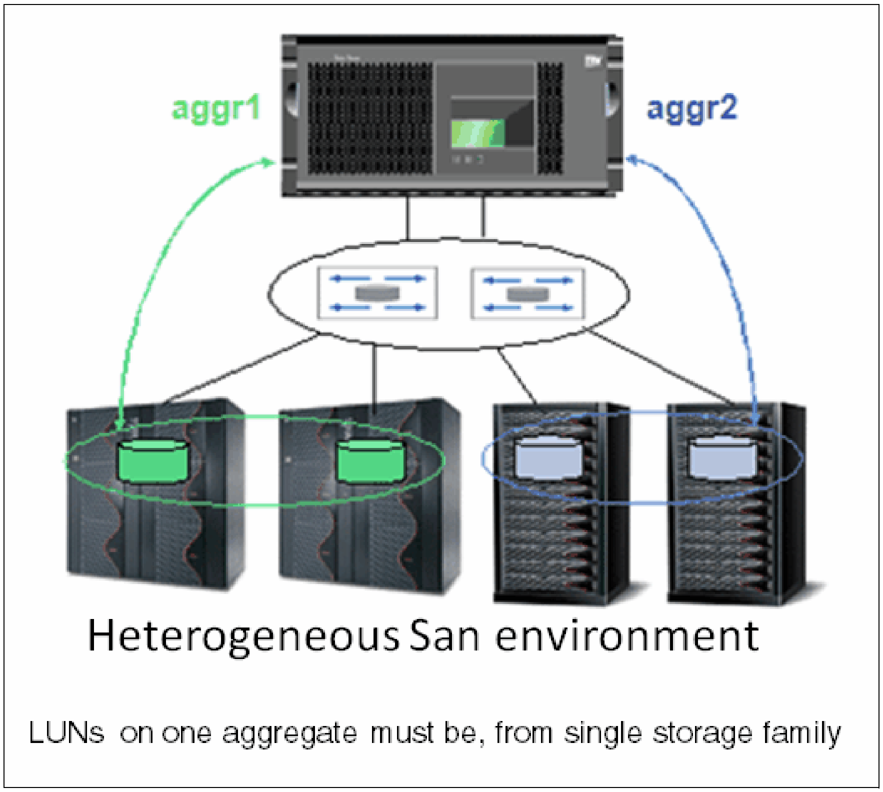


Figure 5-19 Heterogeneous storage

The industry's most comprehensive virtualization solution, the N series Gateway provides proven and innovative data management capabilities for sharing, consolidating, protecting, and recovering mission-critical data for enterprise applications and users and seamlessly integrates into mission-critical enterprise-class SAN infrastructures. These innovative data management capabilities, when deployed with disparate storage systems, simplify heterogeneous storage management (Figure 5-19).

The IBM System Storage N series Gateway presents shares, exports, or LUNs that are built on flexible volumes that reside on aggregates. The N series Gateway is also a host on the storage array SAN. N series Gateways can take storage array LUNs (which are treated as disks) and virtualize them through Data ONTAP, presenting a unified management interface.

The IBM System Storage N series Gateway offers customers new levels of performance and scalability and a robust portfolio of proven data management software for sharing, consolidating, protecting, and recovering mission-critical data.

IBM System Storage N series storage systems seamlessly integrate into mission-critical SAN environments and provide a simple, elegant data management solution by decreasing management complexity, improving asset utilization, and streamlining operations to increase business agility and reduce total cost of ownership for organizations that are looking for ways to utilize SAN-attached storage to create a consolidated storage environment for the various classes of applications and storage needs throughout their enterprise. These customers are looking for ways to increase utilization, simplify management, improve consolidation, enhance data protection, enable rapid recovery, increase business agility, deploy heterogeneous storage services, and broaden centralized storage usage by provisioning SAN capacity for business solutions requiring NAS, SAN, or IP SAN data access.

Figure 5-20 shows the Gateway topology for N series gateways.

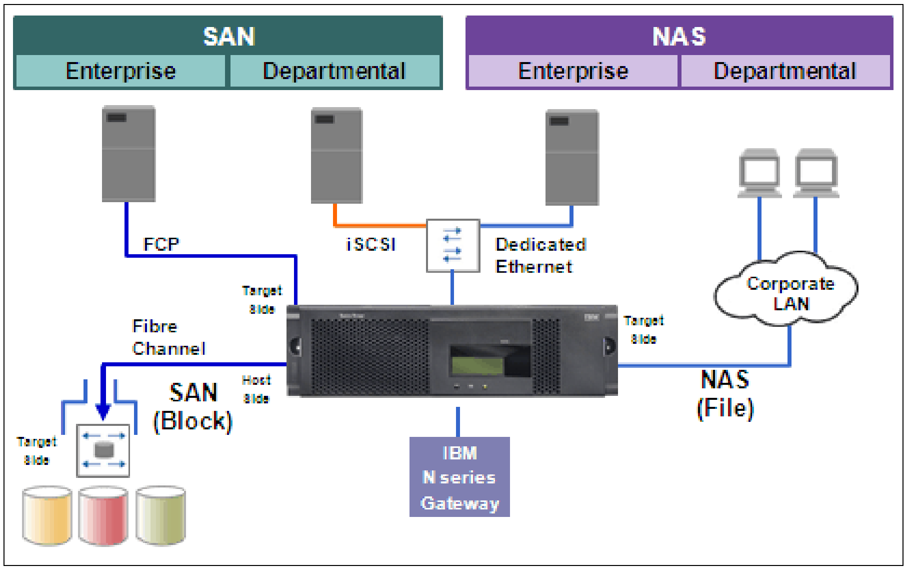


Figure 5-20 Gateway topology

These customers have the following requirements:

- Significant investments or a desire to invest in a SAN architecture
- Excess capacity or an attractive storage cost for SAN capacity expansion
- Increasing requirements for both block access (FCP, iSCSI) and file access (NFS, CIFS, and so on)
- Increasing local or remote shared file services and file access workloads

They are seeking solutions for the following purposes:

- Cost-effectively increase utilization
- Consolidate distributed storage, Direct Access Storage, and file services to SAN storage
- Simplify storage management
- Improve storage management business practices

With Data ONTAP, the N series Gateway now supports attachment of heterogeneous storage systems as well as IBM expansion units of the type used with N series storage systems.

When implementing an N series Gateway, there are two halves to set up.

An N series Gateway implementation can be thought of as a front-end implementation and a back-end implementation:

- The front-end setup includes configuring the N series Gateway for all protocols (NAS or FCP), implementing any snap features (Snapshot, SnapMirror, SnapVault, and so on), and setting up backup including NDMP dumps to tapes.
- The back-end implementation includes all tasks required to set up the N series Gateway system up to the point where it is ready for Data ONTAP installation. These include array LUN formatting, port assignment, cabling, switch zoning, assigning LUNs to the N series Gateway system, creating aggregates, and loading Data ONTAP.

5.3.1 IBM System Storage N series Gateway highlights

The IBM System Storage N series Gateway provides a number of key features that enhance the value and reduce the management costs of utilizing a storage area network (Figure 5-21). An N series Gateway offers the following benefits:

- Simplifies storage provisioning and management
- Lowers storage management and operating costs
- Increases storage utilization
- Provides comprehensive, simple-to-use data protection solutions
- Improves business practices and operational efficiency
- Transforms conventional storage systems into a better managed storage pool

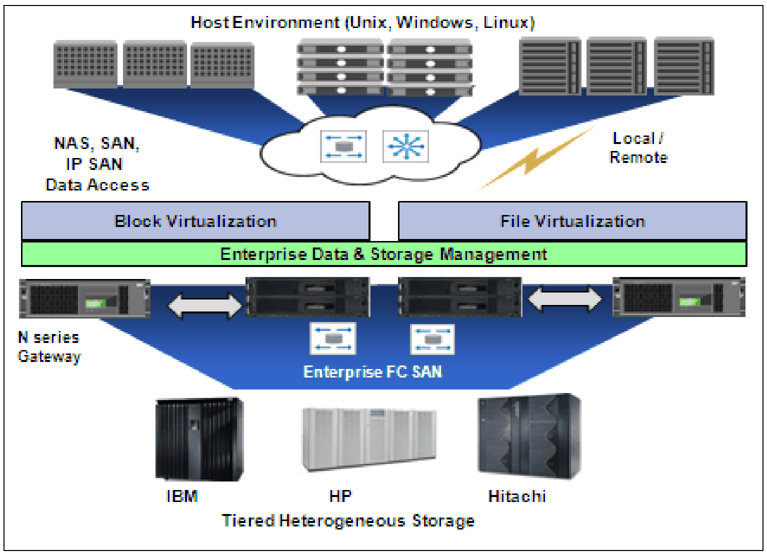


Figure 5-21 Tiered heterogeneous storage

5.3.2 IBM System Storage N6040, N6060, and N6070 Gateway models

The N6000 Appliance models when provided with feature code 9551 are Gateway models. For more details, see this website:

http://www-03.ibm.com/systems/storage/network/

This means that the system can be attached to both EXNx000 shelves and other disk systems (if qualified). To determine whether your disk system (IBM or not) is certified check the compatibility matrix at this website:

ftp://public.dhe.ibm.com/storage/nas/nseries/nseries_gateway_interoperability.pdf

The Gateway models of the N6000 family are as follows:

- N6040
  - 2858-A10 Single Node
  - 2858-A20 Clustered
- N6060
  - 2858-A22 Clustered
- N6070
  - 2858-A21 Clustered

5.3.3 IBM System Storage N7700 and N7900 Gateway models

The IBM System Storage N7000 series Gateway models offer additional choices to organizations facing the challenges of enterprise data management. The IBM System Storage N7000 series is designed to deliver high-end enterprise storage and data management value with midrange affordability. Built-in enterprise serviceability and manageability features help support your efforts to increase reliability, simplify and unify storage infrastructure and maintenance, and deliver exceptional economy.

The IBM System Storage N series Gateway models N7700 and N7900 deliver all the feature function that the N5000 series did, but with increased processing, memory, NVRAM, and total storage capacity. The N7700 and N7900 are designed with the high-end of the enterprise environments. The N7000 series Gateway hardware is identical to the A10 and A20 models, the difference being in the enabled features and disk attachment by Data ONTAP.

The IBM System Storage N7000 G series comes in two models:

- N7700:
  - 2866-G11
  - 2866-G21 Clustered
- N7900:
  - 2867-G11
  - 2867-G21 Clustered

LUN sizing

Gateway support for LUN sizes is as follows:

- Maximum LUN size: 1024 GB
- Minimum LUN size: 100 MB

> **Data ONTAP definition:** One GB is equal to 1000 x 1024 x 1024 bytes.
>
> Therefore, the maximum LUN size that Data ONTAP supports means
> 1024* 1000 * 1024 * 1024 = 1,048,576,000,000 bytes.

LUN mapping

Storage subsystem LUNs are converted to disks for the IBM System Storage N series Gateway (Figure 5-22). When external storage is used, the logical disk count equals the physical LUN count associated with the N series. The diagram shows an example of an array LUN mapped to a gateway disk.

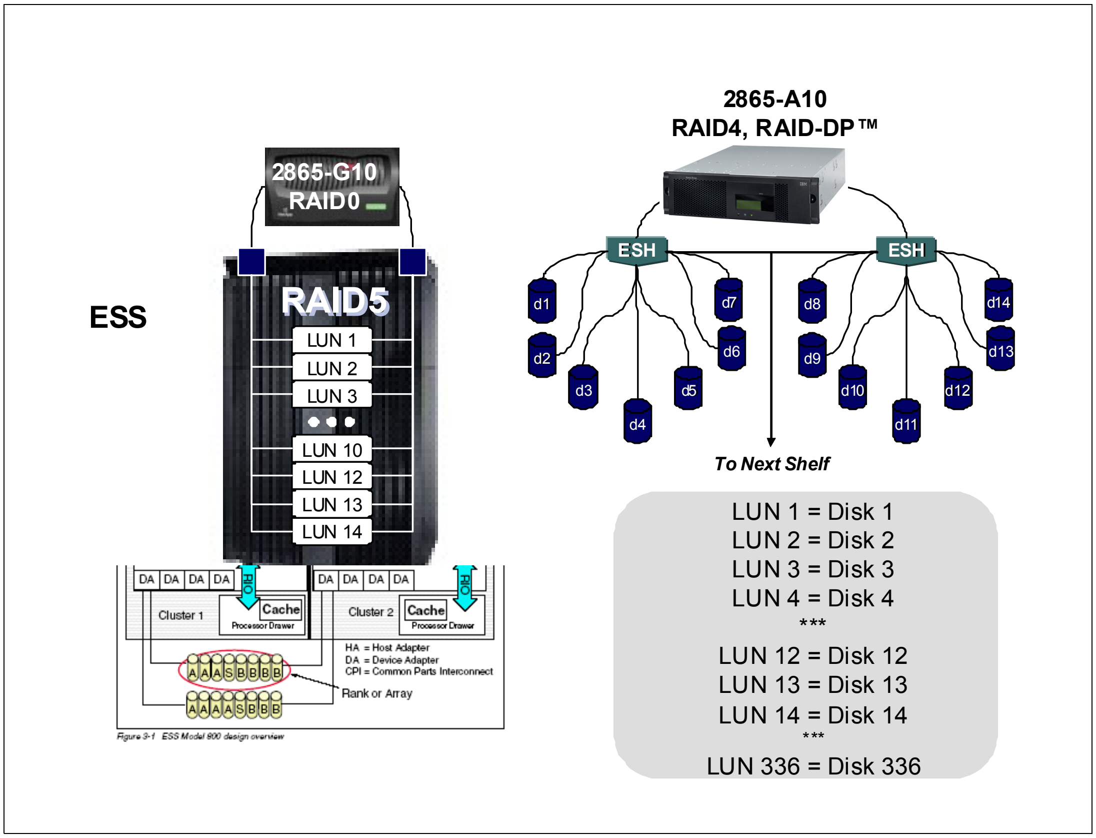


Figure 5-22 LUN to N series Gateway disk relationship

LUNs are added to the Gateway through the same volume wizard that we use on the N series A models (Figure 5-23).

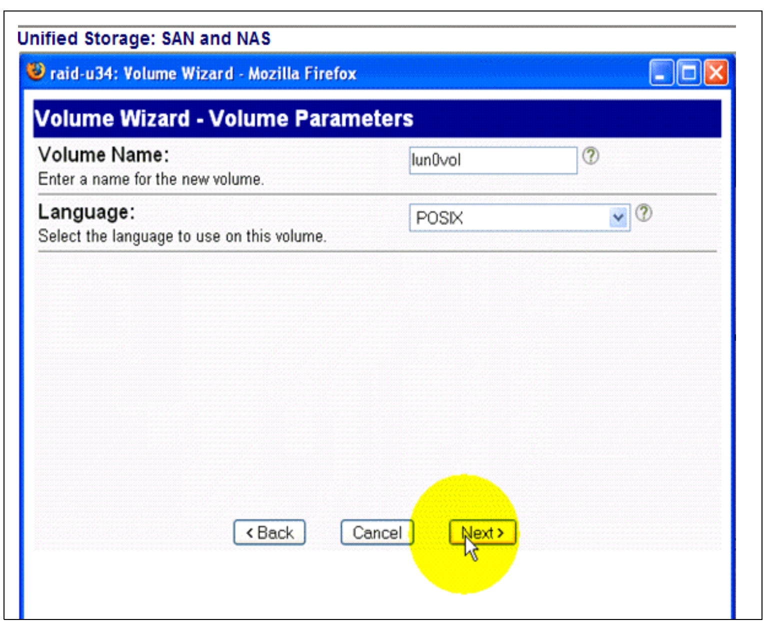


Figure 5-23 Volume wizard

Important: Do not map LUN 0 to gateway systems, even if LUN 0 is a storage LUN.

For all N7000 model specifications, see Table on page 215 through Table 5-6 on page 216.

5.4 N series expansion units

There are currently two disk storage expansion units specifically designed for the IBM System Storage N series storage systems:

- IBM EXN4000 Fibre Channel disk storage expansion unit with 4 Gbps interfaces
- IBM EXN1000 Serial Advanced Technology Attachment storage expansion unit
- IBM EXN3000 Serial Attached SCSI expansion unit

Units: EXN expansion units can be used for attachment to a gateway with Data ONTAP 7.3 and later.

Multiple EXN1000s, each having unique SATA disk drive feature codes, can be attached to the same N series storage system on the same Fibre Channel loop. Multiple EXN4000s, each having unique Fibre Channel disk drive feature codes, can be attached to the same N series storage system on the same Fibre Channel loop.

For the latest storage expansion unit support information, see the following website:

http://www.ibm.com/storage/support/nas/

5.4.1 Intermixing EXN units with N series A models

EXN4000s are Fibre Channel disk storage expansion units. Intermixing Fibre Channel and SATA disk drives in a supported N series storage system configuration is supported as follows:

- Intermixing Fibre Channel disk expansion units with SATA disk expansion units on the same loop is not supported.
- EXN4000s (Fibre Channel disk drives) and EXN1000s (SATA disk drives) can be attached to the same N series storage system only if the Fibre Channel disk expansion units (EXN4000s) are on separate loops from the SATA disk expansion units (EXN1000s).
- Intermixing SAS disk expansion units with SATA disk expansion units on the same loop is not supported.

Figure 5-24 shows the Speed switches on the EXN4000.

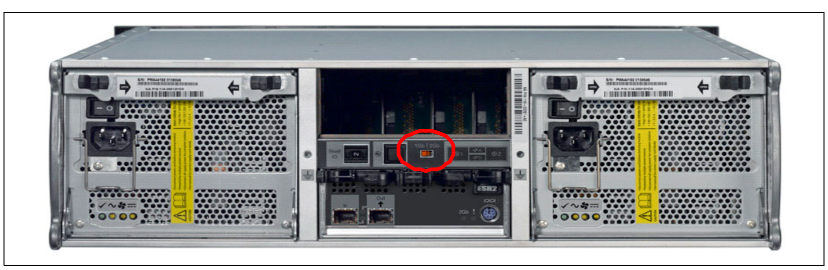


Figure 5-24   Speed switches

5.4.2 EXN1000

The EXN1000 uses the same shelf and hardware as the EXN4000 so it has the same dimensions. It also supports the same number of disks per shelf (14). The main differences are as follows:

- Drive type supported: SATA versus Fibre Channel
- Interface module: AT-FCX versus ESH2

Figure 5-25 shows the EXN1000 front view.

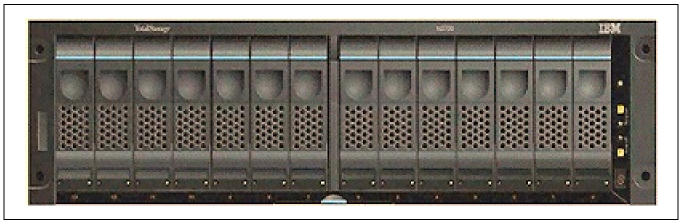


Figure 5-25 EXN1000 expansion unit: front view

Data ONTAP supports up to 400 RAID groups per storage system or cluster. When configuring your aggregates, keep in mind that each aggregate requires at least one RAID group and that the total of all RAID groups in a storage system cannot exceed 400.

5.4.3 EXN4000

The EXN4000 uses the same shelf and hardware as the EXN1000, so it has the same dimensions. EXN4000 also supports the same number of disks per shelf (14). EXN4000 uses ESH4 as its controller module. ESH4 refers to the third-generation, multiloop speed ESH module. ESH4 can function at 1 Gb, 2 Gb, or 4 Gb loop speed when it works with EXN4000. The ESH4 has LEDs that indicate whether the module is functioning normally, whether there are any problems with the hardware, and the loop speed operation of the EXN4000. The main differences are as follows:

- The following drive type is supported: Fibre Channel versus SATAI.
- The EXN4000 FC storage expansion unit will run at 2 Gbps FC when attached to systems that do not have 4 Gbps capability.
- ENX4000 can also be added to loops with existing EXN2000 loops.
- Higher bandwidth is available for heavy sequential workload.
- Fewer HBAs or slots are used to achieve higher bandwidth needs.

Figure 5-26 shows the EXN4000 front view.

Figure 5-26 EXN 4000 front view

Figure 5-27 shows the EXN4000 rear view.

Figure 5-27 EXN4000 rear view

5.4.4 EXN3000

The IBM N series EXN3000 SAS Expansion Disk Shelf (Figure 1-54 on page 48) can host up to 48 TB of raw capacity in only 4U and 24 drives, and it is available with performance-optimized (SAS) drives or capacity-optimized (SATA) drives. N3400 and N3600 can be connected to up to four EXN3000.

The EXN3000 provides the following benefits:

- Offers a greater capacity density and new resiliency features such as the ACM and point-to-point SAS technology.
- Can offer greater bandwidth with up to 12 Gbps SAS (with 4 wide SAS ports x 3 Gbps) versus the current 4 Gbps of FC.
- Reduces power consumption with more than 10% Watt consumed per TB of storage. Can be attached to new or to already installed N6000 and N7000 series systems and can be attached to N3400 and N3600 systems.
- Disk drives can be of 300 GB, 450 GB, 500 GB, and 1 TB physical capacity. SAS and SATA drives cannot be intermixed; the EXN3000 is either a SAS storage controller or a SATA storage controller.

The EXN3000 SAS/SATA expansion unit is a 4U disk storage expansion unit. It can be mounted in any industry standard 19-inch rack. The EXN3000 contains the following components:

- Dual redundant hot-pluggable integrated power supplies and cooling fans
- Dual redundant disk expansion unit switched controllers
- 24 hard disk drive slots
- Diagnostic and status LEDs

Figure 5-28 shows the EXN3000 front view.

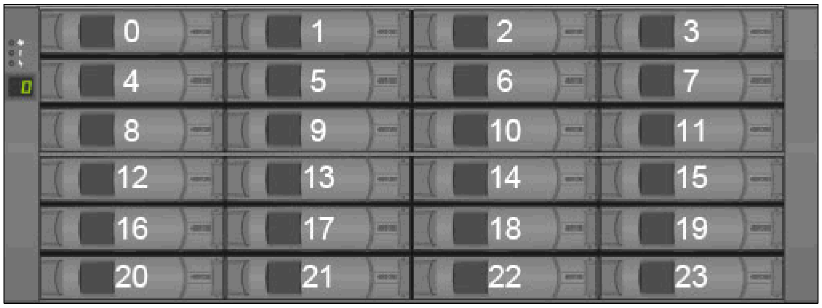


Figure 5-28 EXN3000 front view

5.5 Overview of Data ONTAP for IBM System Storage N series

In this section we present an overview of Data ONTAP for the IBM System Storage N series.

5.5.1 Background

Data ONTAP for IBM System Storage N series is a highly scalable and flexible operating system for IBM System Storage N series systems that is designed to support the use of network filers, such as those in the IBM System Storage N series, in heterogeneous host environments.

5.5.2 Benefits

Data ONTAP offers flexible management and high availability options to support business continuance, thereby helping to reduce storage management complexity in your enterprise. Data ONTAP is designed for use in UNIX, Windows, and web (http) environments, providing the foundation to build your storage infrastructure.

Robust scalability and flexible management

The innovative Data ONTAP architecture is designed to deliver scalable performance and support a flexible storage environment, allowing IBM System Storage N series systems to serve a range of needs, from small workgroups to enterprise data centers. N series systems can store and serve applications, consolidate data and support reliable data access throughout the enterprise.

The Data ONTAP operating system can help simplify management and improve storage utilization by combining innovative file-system technology and a microkernel design to enable features such as:

Flexible data management

Data ONTAP supports the implementation of efficient storage environments with flexible volumes that don't require pre-partitioning. These capabilities can enable you to tailor data management to the requirements of each data set, respond quickly to changing needs of the enterprise, and help reduce implementation and management overhead.

Impressive scalability

Data ONTAP takes advantage of multiple processors to help deliver attractive performance. You can consolidate multiple terabytes of data onto a single appliance, making IBM System Storage N series systems a good fit for a variety of database, messaging, web and other applications.

Heterogeneous access

Data ONTAP provides data access using block- and file-level protocols from the same hardware platform. IBM System Storage N series systems provide block-level data access over a Fibre Channel SAN fabric using FCP and over an IP-based Ethernet network using iSCSI. File access protocols such as NFS, CIFS, HTTP or FTP provide file-level access over an IP-based Ethernet network. Additionally, SecureShare® cross-protocol locking provides heterogeneous data sharing while supporting security, compatibility and performance.

Flexibility, availability, and reliability

IBM System Storage N series systems can help reduce costly downtime and improve access to mission-critical data. A combination of standard features and optional software capabilities allows Data ONTAP to support high availability for mission-critical applications.

Write Anywhere File Layout file system

The Write Anywhere File Layout (WAFL) file system supports a high-level of data availability while providing dynamic and flexible data storage volumes using FlexVol technology, as well as data protection using integrated, nonvolatile RAM and block-level checksum capability.

Support for business continuance and data retention

In today's business environment, lengthy disruptions to information access, as well as noncompliance with records retention regulations, are of increasing concern. Data ONTAP incorporates several innovative features to support disaster-tolerant data protection and recovery to help improve business continuance. It also provides disk-based, non-erasable, non-rewritable (WORM) data for the retention of reference data.

Integrated RAID

Data ONTAP is designed to provide cost-effective protection against disk failures and errors using double-parity RAID to help reduce disruption of service to users.

Lowered total cost of ownership

Data ONTAP can help reduce the complexity of deploying, administering and managing the storage infrastructure in your enterprise, enabling greater efficiency and productivity within your organization.

Ease of deployment

Data ONTAP can integrate into existing UNIX and Windows environments by utilizing standard naming and authentication services. Additionally, Data ONTAP incorporates a setup wizard to quickly complete basic configuration and installation.

Ease of management

Wizard-based tools guide you through common management operations. DataFabric® Manager supports centralized, multi-appliance management throughout your network.

Table 5-7 lists the benefits and features for Data ONTAP.

Table 5-7 Benefits and features for Data ONTAP

Features	Benefits
Integrates into UNIX, Windows, and web environments	► Provides the foundation to build a storage infrastructure across your enterprise ► Provides a platform that has been optimized for storing and serving files, supports consolidation of data and data access throughout the enterprise
Flexible volumes, no pre-partitioning	► Tailors data management to the requirements of each data set ► Can help respond quickly to changing needs of the enterprise ► Reduce implementation and management overhead
Takes advantage of multiple processors	► Consolidates multiple terabytes of data onto a single appliance ► Improves performance for a variety of database, messaging, web and other data intensive applications
Transport-independent, data access	► Provides file-level access over an IP-based, Ethernet network using standard protocols ► Provides block-level data access over a Fibre Channel SAN fabric using FCP and over an IP-based Ethernet network using iSCSI
WAFL® (Write Anywhere File Layout) file system	► Contributes to a high level of data availability ► Provides dynamic and flexible data storage containers using FlexVol technology ► Offers data protection using integrated, nonvolatile RAM and a patent-pending, block-level checksum capability
Integrated RAID	► Helps provide cost-effective protection against disk failures and errors ► Can help reduce disruption of service to users
Wizard-based tools	► Guides administrators through common management operations ► Eases management of your storage infrastructure

5.6 IBM System Storage N series standard software features

Table 5-8 lists no-charge features that are available with the IBM System Storage N series.

Table 5-8 Standard software features

Feature	Description
Data ONTAP	Operating system software that optimizes data serving and allows multiple protocol data access.
FTP	File Transfer Protocol (FTP), a standard Internet protocol, is a simple way to exchange files between computers on the Internet.
Telnet	The Telnet protocol provides a general, bi-directional communications facility. It provides user-oriented command-line login sessions between hosts.
Snapshot	This enables online backups, providing near instantaneous access to previous versions of data without requiring complete, separate copies.
FlexVol	FlexVol creates multiple flexible volume on a large pool of disks; dynamic, non-disruptive (thin) storage provisioning; and space and time efficiency. These flexible volumes can span multiple physical volumes without regard to size.
FlexShare	FlexShare gives administrators the ability to utilize existing infrastructure and increase processing utilization without sacrificing the performance of critical business needs. With the use of FlexShare, administrators can confidently consolidate various applications and data sets on a single storage system. FlexShare gives administrators the control to prioritize applications based on how critical they are to the business.
Disk sanitization	Disk sanitization is the process of physically obliterating data by overwriting disks with specified byte patterns or random data in a manner that prevents recovery of current data by any known recovery methods. This feature enables you to carry out disk sanitization by using three successive byte overwrite patterns per cycle. By default, six cycles are performed.
FilerView®	This is a web-based administration tool that allows IT administrators to fully manage N series storage systems from remote locations. It provides simple and intuitive web-based single-appliance administration.
SnapMover	This migrates data among N series clusters with no impact on data availability and no disruption to users.
AutoSupport	AutoSupport is a sophisticated, event-driven logging agent featured in the Data ONTAP operating software and inside each N series system. It continuously monitors the health of your system and issues alerts if a problem is detected. These alerts can also be in the form of email.
SecureAdmin	SecureAdmin is a Data ONTAP module that enables authenticated, command-based administrative sessions between an administrative user and Data ONTAP over an intranet or the Internet.
Domain Name System (DNS)	The N series supports using a host naming file or a specified DNS server and domain.
Network Information Service (NIS)	The N series provides NIS client support and can participate in NIS domain authentication.

Feature	Description
Integrated automatic Redundant Array of Independent Disks (RAID) manager	The IBM System Storage N series and Data ONTAP provide integrated RAID management with RAID-Double Parity (default) and RAID 4.
iSCSI Host Attach Kit for AIX, Windows, Linux	A host support kit includes support software and documentation for connecting a supported host to an iSCSI network. The support software includes programs that display information about storage and programs to collect information needed by customer support to diagnose problems.
Systems Manager	The basic idea behind the System Manager (SM) is to provide comprehensive management and capability of one of more arrays by way of a simple, easy-to-use, intuitive GUI.
SyncMirror	SyncMirror is the synchronous mirror of a volume. It maintains a strict physical separation between the two copies of your mirrored data. In case of an error in one copy, the data is still accessible without any manual intervention.
Open System SnapVault (OSSV) software	Enables Windows, UNIX, and Linux servers to take advantage of the N series Snapshot processes (for example, block-level incremental backups) to reduce the amount of backup data flowing over the WAN while maintaining data integrity and irrecoverably.
NearStore® option	Provides enhanced performance in a disk-based, secondary storage device used for enterprise applications.
Advanced Single Instance Storage (ASIS)	Significantly improves physical storage efficiency and network efficiency by enabling the sharing of duplicate data blocks. ASIS provides a data solution native to N series.

5.7 Optional software

Table 5-9 provides information about optional chargeable features.

Table 5-9 Optional software

Feature	Description
Common Internet File System (CIFS)	This provides file system access for Microsoft Windows environments.
NFS	This provides file system access for UNIX and Linux environments.
Hypertext Transfer Protocol (HTTP)	Hypertext Transfer Protocol allows a user to transfer displayable web pages and related files.
FlexCache for NFS	This provides efficient caching of files/volumes in a local N series storage system when the source volume resides in a remote location N series storage system, thus avoiding inefficient use of bandwidth resources.
FlexClone	This is designed to provide instant replication of data volumes/sets without requiring additional storage space at the time of creation.
FlexScale	This is used exclusively to improve performance by managing the additional cache provided by Performance Accelerator Modules. These modules can be added as an option to an N series storage system.

Feature	Description
Multistore	This permits an enterprise to consolidate a large number of Windows, Linux, or UNIX file servers onto a single storage system. Many virtual N series storage systems on one physical appliance ease migration and multi-domain failover scenarios.
SnapLock	This provides non-erasable and non-rewritable data protection that helps enable compliance with government and industry records retention regulations. Snaplock is not available starting in DATA ONTAP 7.3.0. It is available in Data ONTAP 7.3.1.
SnapMirror	This is remote mirroring software that provides automatic block-level incremental file system replication between sites. It is available in synchronous, asynchronous, and semi-synchronous modes of operation.
SnapRestore	This allows rapid restoration of the file system to an earlier point in time, typically within a few seconds.
SnapVault	This provides disk-based backup for N series systems by periodically backing up a Snapshot copy to another system
SnapDrive	SnapDrive enables Windows and UNIX applications to access storage resources on N series storage systems, which are presented to the Windows 2000 or later operation system as locally attached disks. For UNIX it allows you to create storage on N series storage systems in the form of logical unit numbers (LUNs), file systems, logical volumes, or disk groups.
SnapManager	Host software for managing Snapshots for backup and restore operations. There are various versions of SnapManager that integrate easily with critical applications, in particular: ► SnapManager for MS Exchange ► SnapManager for SQLServer ► SnapManager for MS SharePoint ► SnapManager for Oracle ► SnapManager for SAP ► SnapManager for Virtual Infrastructures, which automates and simplifies backup and recovery of primary storage used by VMWare Virtual Infrastructure ► SnapManager for Hyper-V
SnapValidator	For Oracle deployments, SnapValidator can be used to provide an additional layer of integrity checking between the application and N series storage. SnapValidator allows Oracle to create checksums on data transmitted to N series storage for writes to disk and include the checksum as part of the transmission.
Single Mailbox Recovery for Exchange (SMBR)	SMBR is a software option from SnapManager that is designed to take near-instantaneous online backups of Exchange databases, verify that the backups are consistent, and rapidly recover Exchange within levels (storage group, database, folder, single mailbox, or single message). The potential results are improved service to internal clients, reduced infrastructure expenses, and significant time savings for Exchange administrators.
Operations Manager FSRM	The File Storage Resource Manager (FSRM) feature of Operations Manager provides monitoring and management of storage resources, including applications, files, file systems, and networks.
Operations Manager Core	Operations Manager provides remote, centralized management of IBM System Storage N series data storage infrastructure, including global enterprise, storage network, and so on.

Feature	Description
Provisioning Manager	Allows IT administrators to enter set provisioning policies, automate complex provisioning processes, check policy conformance, and pool storage resources for higher utilization. Provisioning Manager also enables server administrators to provision storage within the confines set by the storage administrator.
MetroCluster	MetroCluster software provides an enterprise solution for high availability over wide-area networks between two clustered nodes of a single N series storage system.
Virtual File Manager (VFM®)	A comprehensive solution for managing unstructured file data. It is designed to provide data management functionality for server and storage consolidation, migration, remote office data management, and disaster recovery features, all while avoiding disruption to users. It provides all of this functionality through automated policy-based data management using a global namespace.
Cluster failover (CFO)	Ensures high data availability for business-critical requirements by eliminating a single point of failure. It must be ordered for A2X clustered configurations or upgrades from A1X to A2X. Its active/active pairing delivers even more “nines to the right of the decimal point.”

5.8 Performance Accelerator Module

The performance of a disk system is heavily dependent on disk count as well as RPM of each disk. While a greater disk count and higher RPM provide better performance, this also increases the power consumption and space usage in the data center. The Performance Accelerator Module (PAM) has been introduced in the N6000, and N7000 series as a means of improving performance by adding modules with additional cache memory.

Each PAM module provides an additional 16 GB (PAM I), 256 GB, or 512 GB (PAM II) of extended cache for your IBM System Storage N series storage subsystem, depending on the model, and it is possible to add more than one PAM to an N series storage system. Up to five modules can be installed. Each module must be installed on a PCI express slot and only consumes an additional 18 W of power (per module). Extra rack space and ventilation is not required, thus making it an environmentally friendly option (Figure 5-29).

Each Performance Accelerator Module currently consists of:

- 256 GB of SLC flash memory per module (PAM II)
- 512 GB of SLC flash memory per module (PAM II)

IBM System Storage N series Performance Accelerator Module (PAM) software and caching adapters were created to offer performance improvements comparable to SSD without creating another storage tier. With this solution, you do not need to move data from tiers in order to gain the best performance.The PAM caching modules help you to put active data blocks in the storage controller, speeding access significantly. The PAM can be tuned to match your specific workload by using software policies that let you choose from three different modes of operation.

PAMs can be configured to operate in three modes:

- Mode 1: Behaves more like main memory
- Mode 2: Preferentially caches meta data
- Mode 3: Caches what otherwise might have been flushed

Figure 5-29 shows a photograph of the PAM.

Figure 5-29 IBM System Storage N series PAM

Here we describe the advantages offered by the PAM:

- Provides an alternative to adding more disk drives as a means of reducing latency and increasing response time and throughput
- PAM device functions as an intelligent read cache
- Automatically puts active data where access can be fast
- Provides greater I/O throughput without adding high-performance disk drives to a disk-bound storage system
- Effective for random read intensive workloads such as file services, OLTP databases, messaging, and virtual infrastructure (Exchange and virtual environments)
- Results that can be predicted for an existing storage system

Using tools based on predictive cache statistics it is possible to determine the optimal settings and the number of modules to deploy.

Performance Accelerator Modules are available as optional adapters in N5000, N6000, and N7000 N series systems. When including Performance Accelerator Modules it is necessary to add the FlexScale licensed software.

PAM II cards are available for N6070 and N7000 systems.

5.9 References

To learn more about NAS, see the following references:

- Redbooks publications:

  IBM System Storage N series, SG24-7129.
  IBM System Storage N Series Hardware Guide, SG24-7840

- Websites:

  http://www.ibm.com/systems/storage/network/
  http://www-03.ibm.com/systems/storage/network/hardware/index.html

6

IBM Scale Out Network Attached Storage

IBM Scale Out Network Attached Storage (SONAS) is a highly scalable system designed to provide a clustered NAS system with a single name space for CIFS, NFS, FTP, and HTTP services. In this chapter, we describe SONAS and its use.

The system consists of two to thirty Interface nodes (2851-SI1), one to thirty Storage pods consisting of the Storage node (2851-SS1), Storage controller (2851-DR1) and attached disks, and one to two Management nodes (2851-SM1). The maximum configuration provides up to 14.4 PB of storage capacity in a single clustered, highly-redundant system, and it supports up to 256 file systems.

The storage used in the SONAS system can be high performance 15K RPM SAS hard disk drives or high capacity 7.2K RPM SATA hard disk drives, allowing users to tune the configuration to suit their needs.

There are three rack configurations (2851-RXA, -RXB, and -RXC) that can be populated with the systems and switches needed to configure according to the needs of the environment.

6.1 Overview of SONAS

SONAS is designed to address the new storage challenges posed by the continuing explosion of data. Utilizing mature technology from the IBM High Performance Computing experience, and based upon the IBM General Parallel File System (GPFS), SONAS is an easy-to-install, turnkey, modular, scale out NAS solution that provides the performance, clustered scalability, high availability, and functionality that are essential to meeting strategic Petabyte Age and cloud storage requirements.

The high-density, high-performance SONAS system can help organizations consolidate and manage data affordably, reduce crowded floor space, and reduce management expense associated with administering an excessive number of disparate storage systems. With its advanced architecture, SONAS virtualizes and consolidates multiple filers into a single, enterprise-wide file system, which can translate into reduced total cost of ownership, reduced capital expenditure, and enhanced operational efficiency.

6.1.1 SONAS features

SONAS provides a global namespace that enables your storage infrastructure to scale to extreme amounts of data, from terabytes to petabytes. Within the solution, centralized management, provisioning, control, and automated Information Lifecycle Management (ILM) are integrated as standard features to provide the foundation for a truly cloud storage-enabled solution.

SONAS provides extreme scale out capability, a globally clustered NAS file system built upon IBM GPFS. The global namespace is maintained across the entire global cluster of multiple Storage pods and multiple Interface nodes. All Interface nodes and all Storage nodes share equally in the cluster to balance workloads dynamically and provide parallel performance to all users and storage, while also assuring high availability and automated failover.

SONAS supports a full complement of standards-based network protocols, including Common Internet File System (CIFS), Network File System (NFS), Hypertext Transfer Protocol (HTTP) and File Transfer Protocol (FTP).

6.1.2 SONAS highlights

Here is a summary of the highlights from SONAS:

- Multiple petabytes of storage and up to a billion files managed in a single file system
- Operational efficiency achieved with automated, policy-driven tiered storage
- Lower TCO with automated life cycle management and migration to tape
- Scale-out performance to satisfy bandwidth hungry applications
- Asynchronous replication for disaster recovery and business continuity

6.2 How SONAS works

SONAS is a scale out NAS offering designed to manage vast repositories of information in enterprise environments requiring very large capacities, high levels of performance, and high availability. The system supports multiple petabytes of storage and up to a billion files in a single file system and supports up to 256 file systems per system. Data access to the system from client computers is provided using industry standard network file protocols NFS v2/v3, CIFS, and FTP (including z/OS NFS client support).

In addition, the system supports traditional NAS features and functions, including these:

- Snapshots
- Quotas (user, group, and fileset level)
- Integration with user directory servers such as Microsoft Active Directory (AD) and Lightweight Directory Access Protocol (LDAP)
- Command line interface (CLI) and browser-based graphical user interface (GUI)
- Call home and remote support capabilities

In addition to these traditional features, the system supports advanced features, including integrated Tivoli Storage Manager backup client.

The advanced architecture of SONAS virtualizes and consolidates the file space into a single, enterprise-wide file system as shown in Figure 6-1.

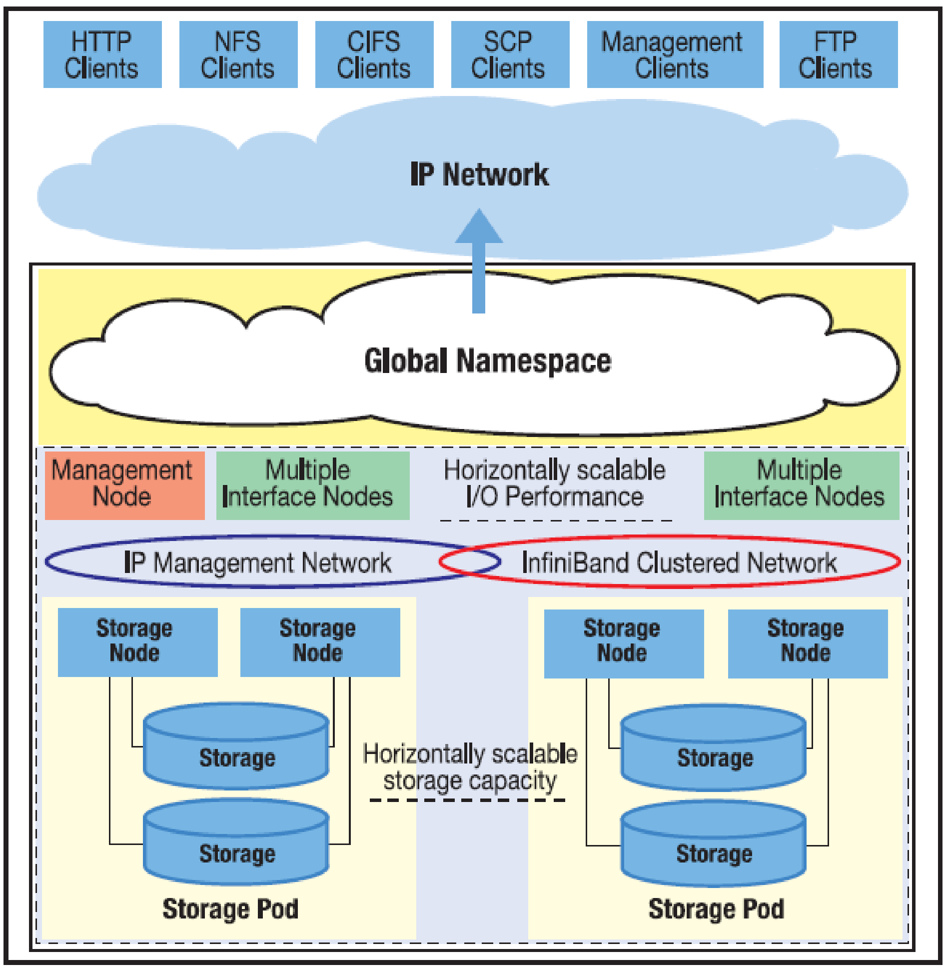


Figure 6-1 SONAS architecture

The SONAS system consists of the following components:

- Management node
- Interface nodes
- Storage nodes
- Storage controllers
- Disk storage expansion units
- Ethernet and InfiniBand switches and racks

The Management node provides a central point for the system administrator to configure, monitor, and manage the system. The Management node supports both a browser-based graphical user interface (GUI) and a command line interface (CLI). It also provides a System Health Center for monitoring the overall health of the system.

The Interface node provides the network port connection and the file services for the IBM SONAS system. These nodes can operate at up to 10 Gb speeds with optional adapters to providing extremely fast access to data. They are connected to the rest of the SONAS system by a redundant high speed InfiniBand data network.

The system has the concept of a Storage pod. Each Storage pod consists of a pair of Storage nodes and one or two Storage controllers. Each Storage controller contains 60 disks, and can have one storage expansion attached for 60 additional disks per controller. Each Storage pod supports a maximum of 240 hard disk drives. A maximum of 30 Storage pods are supported for a maximum of 7200 hard disk drives in a single system.

These systems are configured within three pre-defined, customizable rack configurations. The Base Rack (2851-RXA) contains the Management node, the InfiniBand switches, and from two to six Interface nodes with up to one Storage pod. Each Storage Expansion Rack (2851-RXB) contains up to two Storage pods, for a maximum of 480 disks. The Interface Expansion Rack (2851-RXC) contains up to twenty additional Interface nodes.

6.3 SONAS features

SONAS provides extreme scale out capability, a globally clustered NAS file system built upon IBM GPFS. The global namespace is maintained across the entire global cluster of multiple Storage pods and multiple Interface nodes. All Interface nodes and all Storage nodes share equally in the cluster to balance workloads dynamically and provide parallel performance to all users and storage, while also assuring high availability and automated failover.

SONAS is a scalable virtual file storage platform that grows as data grows. It meets demanding performance requirements as new processors can be added independently or as storage capacity is added, eliminating a choke point found in traditional scale-up systems. SONAS is designed for high availability 24x7 environments with a clustered architecture that is inherently available and, when combined with the global namespace, allows for much higher utilization rates than found in scale-up environments. Next we discuss important features of SONAS.

6.3.1 Centrally managed, centrally deployed storage

SONAS enables you to cluster and centrally deploy and manage a large scale out NAS storage environment, in order to gain a unified centralized management capability for security, provisioning, and configuration (Figure 6-2).

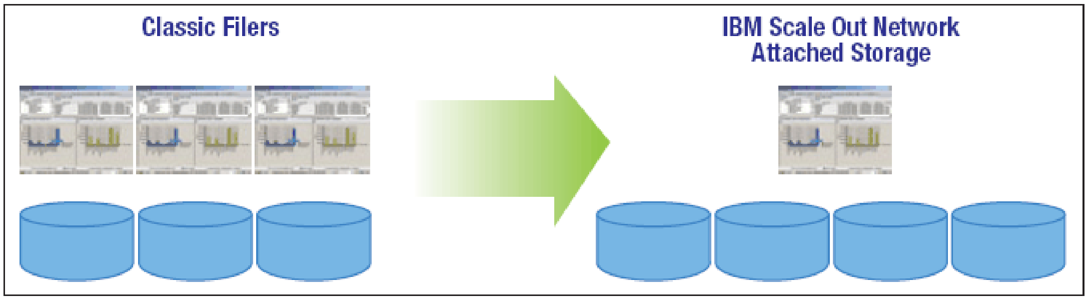


Figure 6-2 SONAS unified management view

The global cluster provides intelligent load balancing, dynamic thin provisioning, geographical distribution, performance optimization, and advanced replication, all globally applied and centrally managed.

6.3.2 Automated, integrated tiered storage and information lifecycle management

SONAS supports end users across the organization with a comprehensive suite of storage capabilities, including tiered storage and ILM.

When file systems grow from terabytes to petabytes and to millions and billions of files, the task of managing and migrating this scale of data can become an immense challenge. Backup and archive becomes complex, expensive, and slow because of the large amount of data that must be scanned to identify what must be backed up. SONAS is designed to solve these problems by providing extreme scale out capability in a single global namespace, with automated, integrated policy-driven ILM and hierarchical storage management built in.

The integrated ILM capability allows you to manage a petabyte-level global namespace in logical storage pools instead of individual disks. The architecture enables easy dynamic growth and transparent data migration, supporting the ability to make changes to your storage infrastructure without having to plan weeks in advance. You can centrally provision storage nearly instantaneously, on a quota basis, by user, group or location. Extensive global reporting and global access control capabilities are standard features.

SONAS provides a powerful high-performance scan engine that makes ILM possible at the level of petabytes of data with millions and billions of files. The high-performance scan engine enables fast searches, with ILM data movement, back-ups, and restores done in parallel by all nodes in the system (Figure 6-3).

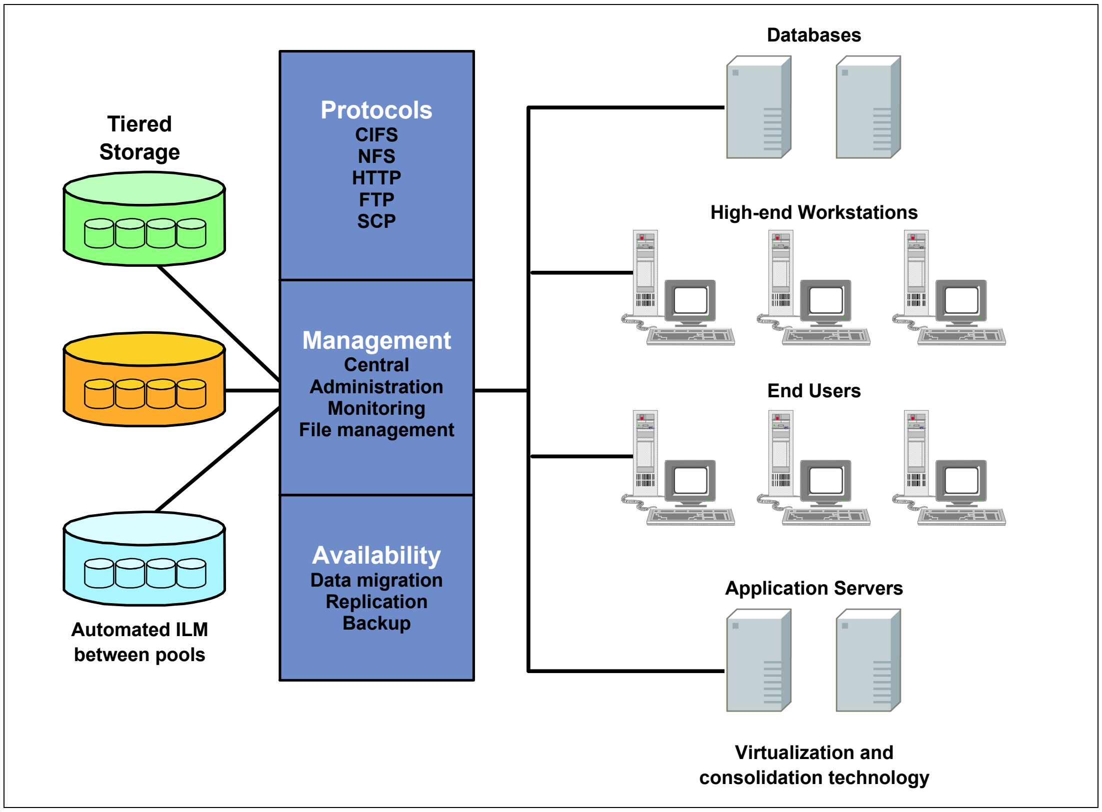


Figure 6-3 SONAS Tiered storage and ILM

The clustered architecture means all nodes share in performing the high-performance scan, and all nodes can participate in the transparent movement of ILM data or backup data to other storage pools or external removable media. ILM is performed at the individual file level, thus greatly optimizing storage usage while enabling maximum business flexibility. Physical data movement between pools, or migration and recall to and from tape, is transparent to the global namespace and to the logical user paths, directory locations, and applications.

6.3.3 Protecting data and replicating between sites

SONAS offers data protection through space-efficient snapshots that protect against accidental deletion or modification of files and that enable you to restore at the file level. The solution also provides for synchronous replication as well as bandwidth-optimized asynchronous replication to multiple sites.

6.3.4 Utilizing unique capabilities and modular hardware

In addition to extreme scale out capability and integrated ILM, SONAS enables your organization to utilize an array of uniquely scalable, globally clustered hardware capabilities. For instance, it has wide area network (WAN) capabilities that enable local caching of remote files for fast service.

The solution is self-tuning, with all data automatically striped across all disks in a logical storage pool for high performance. All nodes share equally in the reading and writing of files in parallel from all disks, thus providing intelligent load balancing, eliminating of hot spots, and ensuring very high performance. Storage capacity is only allocated when written, providing dynamic thin provisioning.

The solution is also self-healing, providing automatic failover, failback, and fully dynamic load balancing. The modular configuration of Interface nodes and Storage node building blocks can be upgraded or downgraded dynamically, giving you the ability to scale in real time (Figure 6-4).

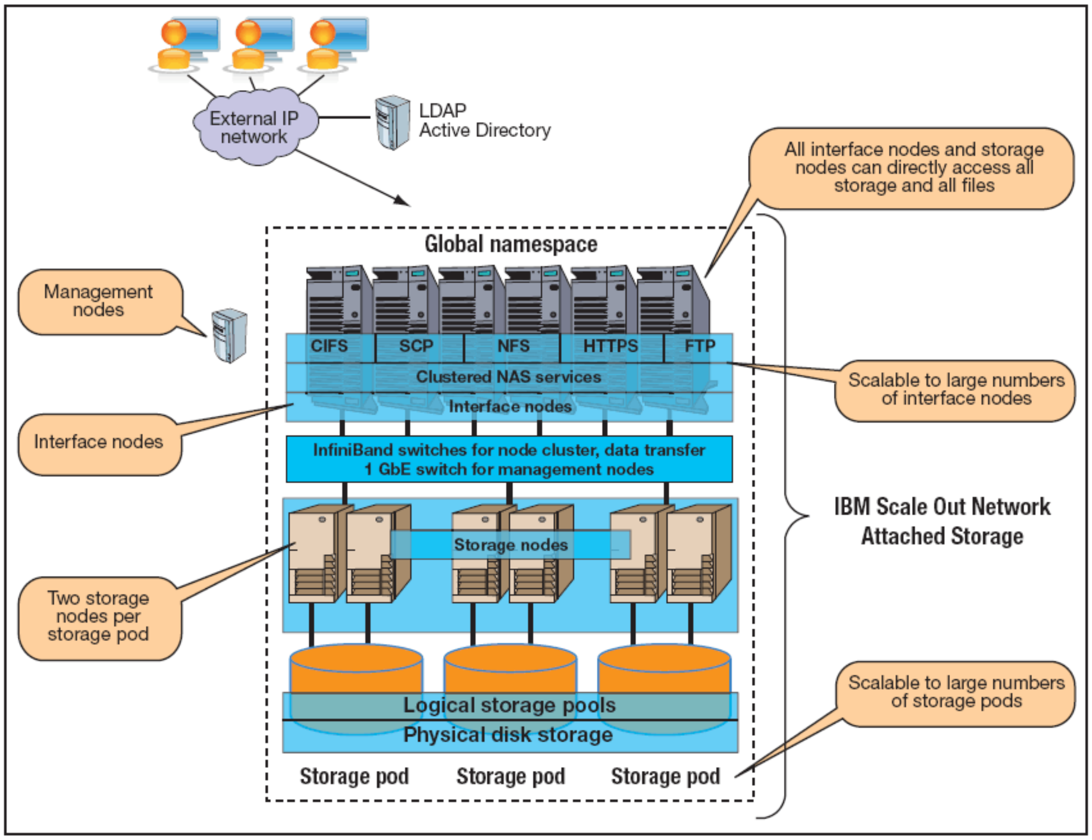


Figure 6-4 SONAS - Storage performance, scalability, and flexibility

Organizations can take advantage of numerous flexible, modular, hardware configuration possibilities. The initial versions of SONAS will support any combination of up to 30 Interface nodes and 30 Storage pods, flexibly configured to suit your requirements.

Storage pods range from 4U to 16U in size. Each pod can provide reliable storage from 27 to 480 terabytes of data. Storage pods and Interface nodes can be combined into one globally clustered scale out NAS system, storing up to 14.4 petabytes of data. This provides extreme flexibility in configuring, adding and subtracting Interface nodes and Storage nodes in any way your workload requires.

For example, a system for archival might be configured with 2 Interface nodes and 20 Storage pods, whereas a system for email might be configured with 20 Interface nodes and 2 Storage pods. SONAS provides extreme high density storage, and exploits leading-edge technology such as InfiniBand.

6.3.5 Driving a dynamic infrastructure

SONAS supports the most dynamic infrastructures, including remote office and disaster recovery infrastructures. Organizations in every industry can gain significant competitive advantages by implementing dynamic infrastructures that enable them to improve service, reduce cost and manage risk.

IBM Scale Out Network Attached Storage (SONAS) is designed to serve as a highly dynamic, flexible, elastic storage element of your infrastructure, driving greater levels of responsiveness through consolidation, resiliency, and scalability (Figure 6-5).

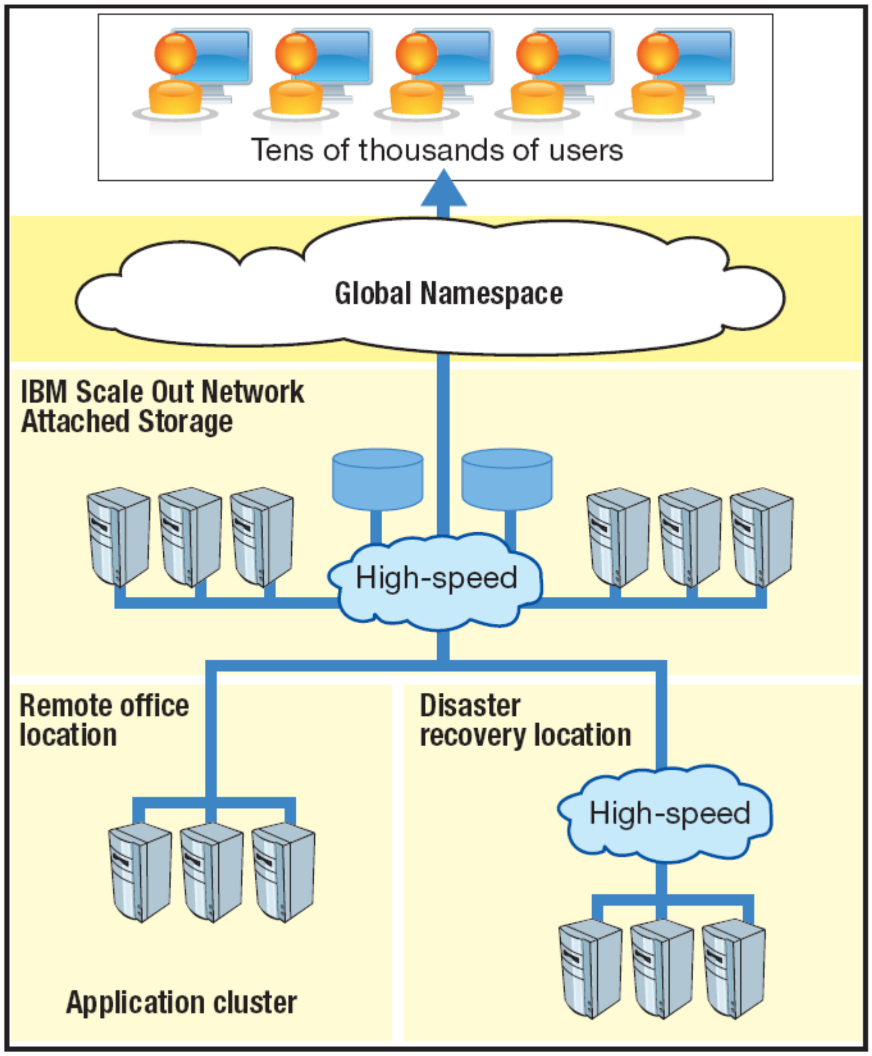


Figure 6-5 SONAS - Dynamic Infrastructure

6.4 Components within a SONAS solution

The main components of the IBM Scale Out Network Attached Storage (SONAS) system are the Interface node (2851-SI1), Management node (2851-SM1), Storage node (2851-SS1), Storage controller (2851-DR1), and Disk Storage expansion unit (2851-DE1). These components are assembled into one of three rack configurations with Ethernet and InfiniBand (IB) switches.

The minimum SONAS system configuration consists of the following components:

- Two Interface nodes
- Two 36-port 4X DDR InfiniBand switches
- One Management node
- Two Storage nodes with one Storage controller

The maximum size of a SONAS system, in terms of Interface nodes and Storage pods, depends on whether the 36-port or 96-port InfiniBand switch is selected. Each of the following major components requires one IB port on each IB switch:

- Management node
- Interface node
- Storage node

Three InfiniBand ports of each IB switch are reserved for the following components:

- Two ports are reserved for future use.
- One port is for the required Management node.
- The remaining IB ports are available for Interface nodes and Storage nodes.

6.4.1 Interface node

The Interface node provides the connections to the customer's IP network for attaching to the SONAS system for network file serving capabilities (CIFS, NFS, FTP). A SONAS system contains a minimum of two Interface nodes and a maximum of 30.

The Interface node (2851-SI1) is a 2U server containing the following components:

- Two Intel Xeon E5530 (Nehalem EP) quad-core processors
- 32 GB of DDR3 memory standard, with feature to add an additional 32 GB of memory
- Four onboard 10/100/1000 Ethernet ports (two available for customer use)
- Two 300 GB 2.5-inch SFF 10K RPM SAS Slim-HS hard disk drives with mirroring between the two HDDs
- Four PCIe Gen 2.0 x8 adapter slots (two available for customer use)
- Integrated Baseboard Management controller (IBMC)
- Two redundant hot-swappable power supplies
- Six redundant hot-swappable cooling fans

The Interface node contains two redundant hot-swappable 300 GB 2.5-inch 10K RPM SAS HDDs with mirroring between them for high-availability. The HDDs contain the SONAS System Software product which hosts the operating system and all other software needed for an operational SONAS system.

Two of the PCIe adapter slots are already populated with two single-port 4X Double Data Rate (DDR) InfiniBand Host Channel Adapters (HCA). The two HCAs attach to two independent InfiniBand switches in the SONAS system and interconnect the Interface nodes to the Management node(s) and the Storage nodes.

Two of the PCIe adapter slots are available for customer use to add more adapters for host IP interface connectivity.

Each Interface node comes standard with two 10/100/1000 Ethernet ports available to connect to the customer's IP network. Additional Ethernet connectivity can be achieved by adding one of the following features:

- 1100 (Quad-port 1GbE NIC)
- 1101 (Dual-port 10 Gb Converged Network Adapter)

Each Interface node is connected to the two InfiniBand switches by one InfiniBand cable to each switch, a total of two cables. The InfiniBand Host Channel Adapters (HCA) in the Interface nodes have an X4 port. The 36-port InfiniBand switches have QSFP connectors and the 96-port IB switches have X4 connects.

For an Interface node (2851-SI1) in the base rack (2851-RXA), no InfiniBand cables need to be ordered. Copper InfiniBand cables are automatically provided for all Interface nodes in the base rack. The length of the copper InfiniBand cables provided is based on the position of the Interface node in the rack.

6.4.2 Management node

The Management node provides the user interface for configuring, administering, and monitoring the SONAS system. A single Management node is required. The Management node contains two redundant hot-swappable 300 GB 2.5-inch 10K RPM SAS HDDs with mirroring between them for high-availability. The hard disk drives contain the SONAS System Software product which hosts the operating system and all other software needed for an operational SONAS system.

The Management node (2851-SM1) is a 2U server containing the following components:

- Two Intel Xeon E5530 (Nehalem EP) quad-core processors
- 32 GB of DDR3 memory
- Four onboard 10/100/1000 Ethernet ports (two for connecting to customer network for management access)
- Two 300 GB 2.5-inch SFF 10K RPM SAS Slim-HS hard disk drives with mirroring between the two HDDs
- One non-mirrored 300 GB 2.5-inch SFF 10K RPM SAS Slim-HS hard disk drive for centralized log/trace file collection
- Four PCIe Gen 2.0 x8 adapter slots
- Integrated Baseboard Management Controller (IBMC)
- Two redundant hot-swappable power supplies
- Six redundant hot-swappable cooling fans

Two of the PCIe x8 adapter slots are already populated with two single-port 4X Double Data Rate (DDR) InfiniBand Host Channel Adapters (HCA). The two HCAs attach to two independent InfiniBand switches in the SONAS system and interconnect the Management node to the other components of the SONAS system.

The Management node comes with two InfiniBand copper cables to connect it to the two InfiniBand switches in the base rack. Both the primary Management node and the optional redundant Management node are assumed to be in the SONAS base rack with the two InfiniBand switches.

SONAS Management node software

SONAS software utilizes a powerful cross-platform access to the same files with locking for data integrity. In addition, SONAS provides high availability Linux, UNIX, CIFS (Windows) sessions with no client side changes (see Figure 6-6 on page 255). Deploying SONAS allows users to reduce the overall number of disk drives and file storage systems that need to be housed, powered, cooled, and managed relative to scale-up systems.

Figure 6-6 shows SONAS software functionality.

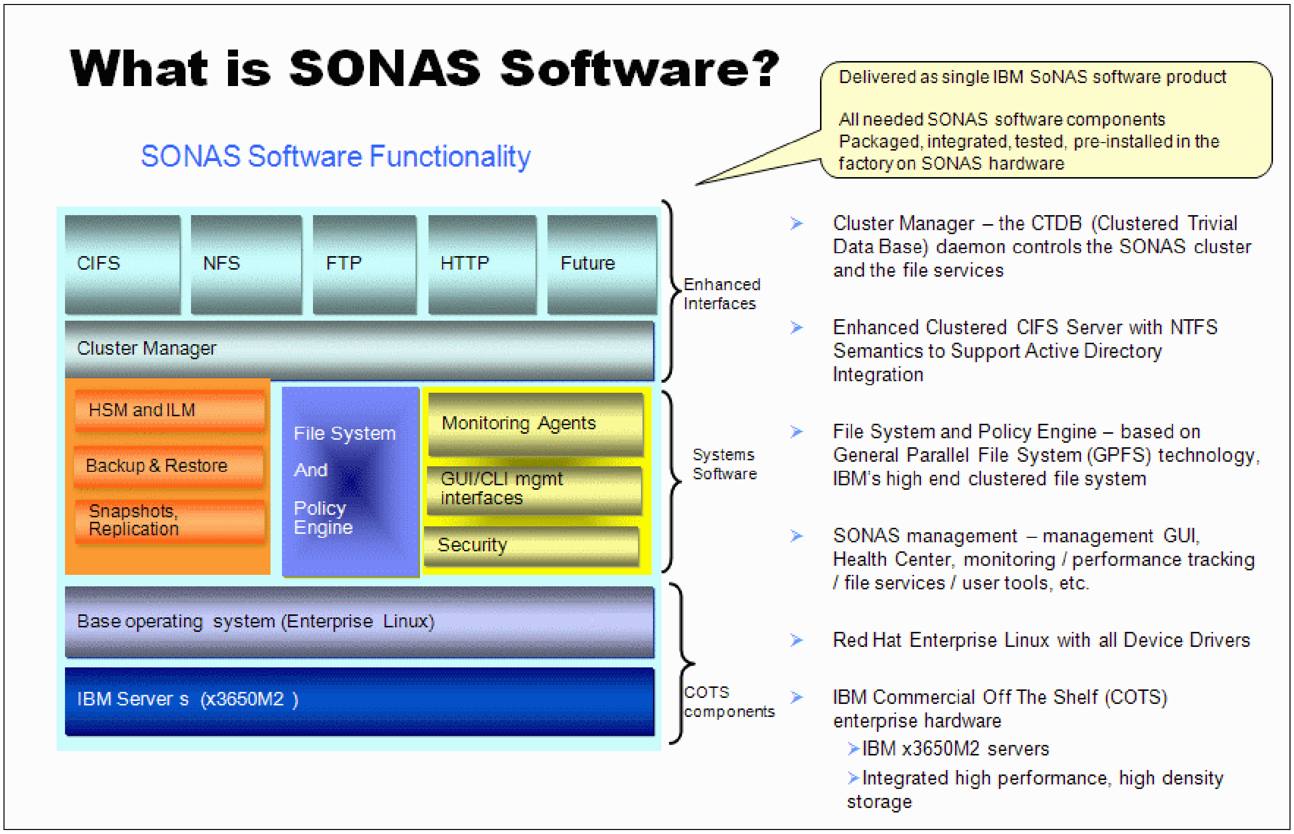


Figure 6-6 SONAS software functionality

The benefits of SONAS Storage Management provide integrated support of policy-based automated placement and subsequent tiering and migration of data. Customers can provision storage pools and store file data according to its importance to the organization. For example, a user can define multiple storage pools with different drive types and performance profiles. They can create a higher performance storage pool with SAS drives and define a less expensive (and lower performance) pool with SATA drives.

Rich, sophisticated policies are built into SONAS which can transparently migrate data between pools based on many characteristics, such as capacity threshold limits and age of the data. This helps to address business critical performance requirements. Leveraging automated storage tiering, users can finally realize the cost savings and business benefits of Information Lifecycle Management (ILM) at an immense scale.

Management GUI

SONAS provides a centralized web-based graphical user interface and Health Center for configuration and monitoring tasks. Users access the GUI / Health Center by a standard web browser. There is a command line interface (CLI) as well.

SONAS Management GUI runs on the SONAS Management Node, and is web-based (https). It provides role-based authorization for users, and enables the administrator to maintain the SONAS cluster. These roles are used to segregate GUI administrator users according to their working scope within the Management GUI. These roles are as follows:

- Administrator: This role has access to all features and functions provided by the GUI. This role is the only one that can manage GUI users and roles.

- Operator: The operator can do the following tasks:
  - Check the health of the cluster.
  - View the cluster configuration.
  - Verify the system and file system utilization.
  - Manage to set thresholds and notifications settings.
- Export administrator: The export administrator is allowed to create and manage shares, as well as performing the tasks that the operator can execute.
- Storage administrator: The storage administrator is allowed to manage disks and storage pools, as well as performing the tasks that the operator can execute.
- System administrator: The system administrator is allowed to manage nodes and tasks, as well as performing the tasks that the operator can execute.

SONAS has a central database that stores configuration information and events. This information is partly pulled by the Management node and partly pushed to the Management node by the other nodes in the cluster.

The SONAS Management GUI and Health Center provides panels for most major functions:

- Storage management
- File system management
- Pool management
- Fileset management
- Policy management
- Access control list (ACL) management
- Synchronous replication management
- Hierarchical Storage management
- Tivoli Storage Manager backup management
- Asynchronous replication management
- Snapshot management
- Quota management
- Cluster management
- Protocol management (CIFS, NFS, HTTPS, FTP)
- Export management
- Event log
- Node availability
- Node utilization (CPU, memory, I/O)
- Performance management (CPU, memory, I/O)
- File system utilization (capacity)
- Pool / disk utilization (capacity)
- Notifications / call-home
- Hardware monitoring
- File access services such as NFS, HTTPS, FTP, and CIFS
- File system services
- Nodes including CPU's, memory DIMM's, VRM, disk drives, power supplies, fans and onboard network interface ports
- I/O adapters including storage and network access
- Storage utilization

Command Line Interface

The SONAS Command Line Interface (CLI) runs on the SONAS Management Node. The CLI provides the ability to perform SONAS administrative tasks, and implements about 110 CLI commands. The focus is on enabling scripting of administrative tasks. The CLI is used primarily for installation and setup commands, with additional configuration functionality.

The CLI includes commands for the following capabilities:

- Cluster configuration
- Authentication
- Network
- Files
- File Systems
- Exports
- File Sets
- Quotas
- Snapshots
- Replication
- ILM automatic tiered storage
- Hierarchical storage management
- Physical management of disk storage
- Performance and Reports
- System Utilization
- SONAS Console Settings
- Scheduled Tasks

The SONAS CLI is designed to be familiar to the standard UNIX, Windows, and NAS administrator.

6.4.3 Storage node

The Storage node provides the InfiniBand connection to the InfiniBand cluster interconnect and direct Fibre Channel attachment to the SONAS Storage controller. Storage nodes must be configured in high-availability (HA) pairs. The two Storage nodes in the HA pair are connected to one or two SONAS Storage controllers. Four PCIe adapters are attached to the internal network and the Scale Out NAS Storage controller.

The Storage node (2851-SS1) is a 2U server containing the following components:

- Two Intel Xeon E5530 (Nehalem EP) quad-core processors
- 2.26 Ghz, 8 MB L2 cache, 80 W
- 8 GB of DDR3 memory
- Four onboard 10/100/1000 Ethernet ports
- Two 300 GB 2.5-inch SFF 10K RPM SAS Slim-HS hard disk drives with mirroring between the two HDDs
- Four PCIe Gen 2.0 x8 adapter slots
- Integrated Baseboard Management Controller (IBMC)
- Two redundant hot-swappable power supplies
- Six redundant hot-swappable cooling fans

Two of the onboard Ethernet ports connect the Storage node to the internal private management network, and two for a NULL Ethernet connection to the SONAS Disk Storage controllers.

The Storage node contains two redundant hot-swappable 300 GB 2.5-inch 10K RPM SAS HDDs with mirroring between them for high-availability. The hard disk drives contain the SONAS System Software product which hosts the operating system and all other software needed for an operational SONAS system.

All of the PCIe x8 adapter slots in the Storage node are already populated with adapters. Two of the PCIe adapter slots are populated with two single-port 4X DDR InfiniBand HCAs for attaching to the two InfiniBand switches in the SONAS system. The other two PCIe x8 adapter slots are populated with two dual-port 8 Gbps Fibre Channel Host Bus Adapters (HBAs) for attaching to the SONAS Storage controller.

The SONAS Storage controller (2851-DR1) is a high-performance 4U Storage controller with the following components:

- Dual redundant hot-swappable RAID controllers
- Dual redundant hot-swappable power supply and cooling modules
- Support for 60 3.5-inch SAS/SATA HDDs

Each RAID controller contains the following components:

- Cache of 4 GB
- Two 8 Gbps FC host ports
- One drive-side SAS expansion port

The Storage controller supports RAID 1, 5 and 6. One high-density disk Storage expansion unit can be attached to the Storage controller. The Storage controller comes with four FC optical cables for attaching the Storage controller to the two Storage nodes.

All sixty hard disk drives in the Storage controller must be the same, therefore a quantity of six of feature #1300, #1301, or #1310 must be ordered.

Table 6-1 shows the total raw storage capacity of the Storage controller when populated with the various hard disk drive features.

Table 6-1 Raw storage capacity of the Storage controller

Quantity	Feature	Description	Total raw storage capacity
6	1300	10-pack of 7.2K RPM 1 TB SATA	60 TB
6	1301	10-pack of 7.2K RPM 2 TB SATA	120 TB
6	1310	10-pack of 15K RPM 450 GB SAS	27 TB

Features #9011, #9012, #9013, and #9014 are plant-only feature and are used to indicate into which Storage controller location (1-4) this particular Storage controller is to be placed during manufacturing. The rack must be populated from the bottom of the rack (EIA position 1) to the top of the rack (EIA position 42) for stability reasons. Therefore, the following rules apply to the placement of Storage controllers within the rack:

- You cannot have a Storage controller in location #4 (EIA positions 29-32) unless you have a Storage controller in location #3 (EIA positions 21-24).
- You cannot have a Storage controller in location #3 (EIA positions 21-24) unless you have a Storage controller in location #2 (EIA positions 9-12).
- You cannot have a Storage controller in location #2 (EIA positions 9-12) unless you have a Storage controller in location #1 (EIA positions 1-4).

Also, features #9013 and #9014 are not valid when plant-merging the Storage controller into the Base Rack (2851-RXA), because the Base Rack only holds two Storage controllers.

The SONAS disk Storage expansion unit (2851-DE1) is a 4U high-density disk enclosure supporting 60 3.5 inch SATA or SAS hard disk drives. One disk Storage expansion unit might be attached to a single SONAS Storage controller. Each disk Storage expansion unit contains the following features:

- Two SAS switch modules that provide SAS connections to the Storage controller
- Two redundant hot-swappable power supply and cooling units
- Support for 60 3.5-inch SAS or SATA HDDs

The Disk Storage expansion unit must be physically located in the same rack and in adjacent EIA positions as the SONAS Storage controller to which it is attaching. All sixty hard disk drives in the disk Storage expansion unit must be the same, therefore a quantity of six of feature #1300, #1301, or #1310 must be ordered.

Table 6-2 shows the total raw storage capacity of the disk Storage expansion unit when populated with the various types of hard disk drive features.

Table 6-2 Raw storage capacity of the disk Storage expansion unit

Quantity	Feature	Description	Total raw storage capacity
6	1300	10-pack of 7.2K RPM 1 TB SATA	60 TB
6	1301	10-pack of 7.2K RPM 2 TB SATA	120 TB
6	1310	10-pack of 15K RPM 450 GB SAS	27 TB

Features #9021, #9022, #9023, and #9024 are plant-only features and are used to indicate into which disk Storage expansion unit location (1-4) this particular disk Storage expansion unit is to be placed during manufacturing. A disk Storage expansion unit must be attached to a Storage controller. The Storage controller attached to a disk Storage expansion unit must be in the EIA position immediately adjacent and below the disk Storage expansion unit.

Therefore, the following rules apply to the placement of Storage controllers within the rack:

- You cannot have a disk Storage expansion unit in disk Storage expansion unit location #1 (EIA positions 5-8) unless you have a Storage controller in Storage controller location #1 (EIA positions 1-4).
- You cannot have a disk Storage expansion unit in disk Storage expansion unit location #2 (EIA positions 13-16) unless you have a Storage controller in Storage controller location #2 (EIA positions 9-12)
- You cannot have a disk Storage expansion unit in disk Storage expansion unit location #3 (EIA positions 25-28) unless you have a Storage controller in Storage controller location #3 (EIA positions 21-24)
- You cannot have a disk Storage expansion unit in disk Storage expansion unit location #4 (EIA positions 33-36) unless you have a Storage controller in Storage controller location #4 (EIA positions 29-32)

Additionally, features #9023 and #9024 are not valid when plant-merging the Storage controller into the Base Rack (2851-RXA), because the Base Rack only holds two disk Storage expansion units.

6.4.4 InfiniBand switches

The major components of a SONAS system (Interface node, Storage node, and Management node) are interconnected by a high-performance low-latency InfiniBand 4X Double Data Rate (DDR) fabric. Two redundant InfiniBand switches are incorporated inside each SONAS system.

For small and medium configurations, a 1U 36-port 4X DDR InfiniBand switch is available. For larger configurations, a 7U 96-port 4X DDR InfiniBand switch is available. Two identical IB switches must be ordered for a SONAS system, either two 36-port IB switches or two 96-port IB switches. These IB switches are described in the following sections.

36-port IB switch

The SONAS 36-port IB switch (2851-I36) is a 4X DDR InfiniBand switch providing 36 QSFP ports, with each port operating at 20 Gbps. This IB switch provides a maximum backplane bandwidth of 1.44 Tbps and contains an embedded IB fabric manager. The switch provides two redundant hot-swap power supplies.

96-port IB switch

The 96-port IB switch (2851-I96) provides a 96-port 4X DDR InfiniBand switch providing up to 96 4X DDR X4 switch ports. The 96-port IB switch is intended for large SONAS system configurations. The IB switch provides a maximum backplane bandwidth of 3.84 Tbps.

The 96-port IB switch comes standard with the following features:

- Two 96-port InfiniBand Switch Fabric boards
- One 24-port 4X DDR Line Board
- One Hi-Memory Management board containing an embedded IB fabric manager
- Two Power Supply Units (PSU)
- All fan assembles

The 96-port switch comes standard with one 24-port 4X DDR line board providing 24 4X DDR (20 Gbps) IB ports. Up to three additional SLB-2024 24-port 4X DDR line boards can be added for a total of 96 ports.

The 96-port IB switch comes standard with two SLB-2004 Switch Fabric boards. Up to two additional SLB-2004 Switch Fabric boards can be added to provide additional backplane bandwidth.

The 96-port IB switch comes standard with two power supplies. Up to two additional PSUs can be added for redundancy. The two standard power supplies are capable of powering a fully configured 96-port IB switch with the following boards:

- Four SFV-2004 Switch Fabric boards
- Four SLB-2024 24-port 4X DDR line boards
- Two SMB-HM Hi-Memory Management boards

The following options can be added to the 96-port InfiniBand switch:

- FC 1500 96-port InfiniBand Switch Fabric board
- FC 1501 24-port 4X DDR InfiniBand Line Board
- FC 1502 Hi-Memory Management Board
- FC 1503 Power Supply

6.5 Summary of features and benefits

Here we provide a summary of the features and benefits of SONAS.

Massive scalability:

- Supports multiple petabytes of storage for organizations that need billions of files in a single file system.
- Supports the ability to rapidly add massive amounts of storage capacity. Supports up to 256 file systems per system.

Flexibility:

- Access your data in a single global namespace allowing all users a single, logical view of files through a single drive letter such as a Z drive.
- Offers internal (SAS, SATA) and external (Tape) storage pools. Automated file placement and file migration are based on policies. It can store and retrieve any file data in/out of any pool transparently and quickly without any administrator involvement.
- Tiered storage for highly available primary data and secondary storage for less accessed data.
- Industry standard protocols: CIFS, NFS, FTP, HTTP.
- High-performance metadata: IBM SONAS stores metadata in a very efficient format which allows scanning of metadata for millions of files, very fast searches, and custom queries.

Consolidation:

- Your organization can consolidate and manage data to avoid problems associated with administering an array of disparate storage systems.
- It is highly scalable, helps conserve floor space, and can help to reduce your capital expenditure and enhance your operational efficiency.
- Its advanced architecture virtualizes and consolidates your file space into a single, enterprise-wide file system, which can translate into reduced total cost of ownership.

GPFS:

- GPFS integrates into organizational environments by bringing together mixed server and storage components to provide a common view to enterprise file data.
- It also provides online storage management, scalable access and information lifecycle tools to manage large volumes of data.

Data protection:

- Snapshots, up to 256 per file system
- Supports RAID 5, 6

Cloud storage:

- In a cloud environment, applications and services are not tethered to specific hardware components. Instead, processing is handled across a distributed, globally accessible network of resources, which are dispensed on demand.
- Self-managing, autonomic system that enables capacity, provisioning and other IT service management decisions to be made dynamically, without human intervention or increased administrative costs.
- Seamless elasticity to scale computing resources up or down, as required, to fulfil changing organizational needs without service interruption.

- Highly resilient and secure applications, and an underlying infrastructure capable of meeting expected levels of availability, reliability and integrity.
- A highly standardized environment that facilitates simultaneous service deployment and upgrades for all users, no matter where they reside.
- Lowers the cost of service access by economies of scale.
- Preserves capital.
- Clouds can provide rapid access to computing capacity at a lower cost of ownership enabling companies to perform operations that might have previously been unaffordable or impractical.

Management software:

- SONOS Software

Interface:

- Supports both Command line interface (CLI) and browser-based graphical user interface (GUI).

Advanced features:

- Integrated Tivoli Storage Manager backup/archive client.

Drive drive support:

- Supports both SAS and SATA drives (15K RPM 450 GB or 600 GB SAS drives and 7.2K RPM 1 TB or 2 TB SATA drives.)

Maximum drives supported:

- 7,200

6.6 More information

For further information about SONAS, see the following references:

Websites:

- `http://www-03.ibm.com/systems/storage/network/sonas/index.html`
- `http://publib.boulder.ibm.com/infocenter/sonasic/sonas1ic/index.jsp`
- `http://publib.boulder.ibm.com/infocenter/sonasic/sonas1ic/index.jsp?topic=/com.ibm.sonas.doc/pln_f2c_featurecode_storage_dr1.html`

Redbooks publications:

- *IBM Scale Out Network Attached Storage Concepts*, SG24-7874
- *IBM Scale Out Network Attached Storage Architecture and Implementation*, SG24-7875

7

IBM Information Archive

In this chapter, we discuss the IBM Information Archive, which represents the next generation information and data retention solution. It is designed as an archiving repository for all types of content (structured or unstructured) to help organizations of any size address complete information retention needs - business, legal, or regulatory.

IBM Information Archive is the unique part of the complete solution of *IBM Smart Archive* - Information Archive for Email, Files and eDiscovery. This solution contains three components:

- Content Collector Discovery Analytics
- Information Archive
- Content Manager Enterprise Edition

To help you meet the growing challenge of efficiently managing and protecting business information, IBM offers IBM Information Archive, an integrated storage repository solution for archiving multiple types of data from multiple sources. Designed to help you store, retrieve, manage, share, and secure regulated and non-regulated data, the Information Archive is designed to be highly secured and offers extraordinary cost efficiency.

As you address your information retention needs: whether keeping valuable content for long periods of time, meeting industry retention regulations or addressing corporate governance, you need an archiving solution that is secure, scalable, but also cost-effective.

For complete information about the IBM Information Archive, see the product page at the following website:

http://www.ibm.com/systems/storage/disk/archive/

> **Product name:** Although IBM Information Archive is sometimes shortened to "IA", in this chapter we are using the full name to avoid confusion with other possible products thusly abbreviated.

7.1 IBM Smart Archive strategy

The IBM Smart Archive strategy, a broad strategy unifying the power and value of IBM software, systems and services offers specific solutions in a unified, integrated, and coherent information aware strategy that maximizes customer value.

As part of the IBM Smart Archive strategy, Information Archive for Email, Files and eDiscovery is a specific solution that helps to simplify and accelerate the implementation of an end-to-end archiving and eDiscovery solution from weeks to days. With this solution, IBM is delivering a specific Smart Archive strategy solution that will ensure the success of information archiving projects.

This solution consists of pre-configured software, hardware, and implementation services from a single vendor. The total solution configuration utilizes IBM experience in customer archiving deployments, simplifying implementation and providing quick time to value. Additionally, proven service packages are available to manage ongoing administration and maintenance.

This solution is ideal for organizations that have the following requirements:

- Capture and retain email and file system content
- Demonstrate compliance with retention mandates
- Bring soaring storage costs under control
- Quickly and efficiently respond to eDiscovery requests

The new solution utilizes IBM experience and best practices in customer archiving deployments, simplifying implementation and providing quick time to value. It is built on a highly scalable, secure, high performance infrastructure with the flexibility to meet multiple requirements in a single solution. As a result, customers can improve their ability to locate, collect, organize, analyze, trust, and utilize information across the organization.

7.1.1 Utilizing IBM archiving offerings

Three main components of the IBM Smart Archive strategy help to utilize archiving offerings:

- *Optimized and unified ingest capabilities* enable a deeper understanding of what information to archive through discovery and analytics based assessment technologies. They reduce solution complexity and costs by unifying data and content archiving through common collection and classification technologies. This phase is also known as *Content Collection and Archiving*
- *Flexible and secure infrastructure* allows you to easily implement and enforce policies, and protect the integrity of your business records throughout its lifecycle. Speed time to value through multiple modular, yet integrated solutions, including choice of management and delivery models such as traditional on-premise software, preconfigured appliance, cloud-based and hybrid options. The component includes:
  - Content repositories
  - Storage repositories
  - Archive services
- *Integrated software, supporting compliance, analytics, and eDiscovery* reduces the risk, responds more quickly to legal inquiries, establishes trust, and utilizes information using integrated software to support your information lifecycle governance, analytics, and eDiscovery requirements. The main feature of the component is called *Compliance Management.*

7.1.2 Solution elements

As already mentioned, the IBM Smart Archive strategy and its Information Archive for Email, Files and eDiscovery solutions consists of three crucial elements:

- Content Collector Discovery Analytics Starter pack, which includes Content Collector for Email, Content Collector for File Systems, eDiscovery Manager, eDiscovery Analyzer
- IBM Information Archive
- Content Manager Enterprise Edition

In the following text we mainly focus on IBM Information Archive as a key storage repository for archived data identified and collected by Content Collectors and managed by Content Manager.

For detailed information about IBM Smart Archive, visit the site:

http://www.ibm.com/software/data/smart-archive/

7.2 Data retention and compliance

There is a rapidly growing class of data that is best described by the way in which it is managed rather than the arrangement of its bits. The most important attribute of this kind of data is its retention period, hence it is called retention managed data, and it is typically kept in an archive or a repository. In the past it has been variously known as archive data, fixed content data, reference data, unstructured data, or other terms implying its read-only nature. It is often measured in terabytes and is kept for long periods of time, sometimes forever.

Not only are there numerous state and governmental regulations that must be met for data storage, but there are also industry-specific and company-specific ones as well. And of course these regulations are constantly being updated and amended. Organizations need to develop a strategy that must ensure that the correct records are kept for the correct period of time. Needless to say these records must be readily accessible when they need to be retrieved at the request of regulators or auditors. It is easy to envisage the exponential growth in data storage that will result from these regulations and the concomitant requirement for a means of managing this data. Overall, the management and control of retention managed data is a significant challenge for the IT industry when taking into account factors such as cost, latency, bandwidth, integration, security, and privacy.

7.2.1 Characteristics of retention managed data

When considering the safekeeping of retention managed data, companies also need to consider storage and data characteristics that differentiate it from transactional data.

Storage characteristics of retention managed data include these:

- Variable data retention period: This is usually a minimum of a few months, up to forever.
- Variable data volume: Many customers start with 5 TB to 10 TB of storage in an enterprise. It also usually consists of a large number of small files.
- Data access frequency: Write Once Read Rarely or even Write Once Read Never.
- Data read/write performance: Write handles volume; Read varies by industry and application.
- Data protection: Requirement for non-erasability, non-rewritability, and deletion when the retention policy expires

Data characteristics of retention managed data include these:

- Data lifecycle: Typically, the data is frequently accessed near its creation, then the access frequency diminishes exponentially, near zero. Certain industries have peaks that require access, such as check images in tax season.
- Data rendering: Ability to view or use data in a very old data store. There is a risk that the data format used to store the data might no longer be supported in 25 years.
- Data mining: With all this data being saved, there is intrinsic value in the content of the archive that can be exploited using data mining. But this implies indexing and categorization of the data when it is initially written.

For additional information about managing data, see the following Redbooks publications:

- *ILM Library: Information Lifecycle Management Best Practices Guide*, SG24-7251
- *ILM Library: Techniques with Tivoli Storage and IBM TotalStorage Products*, SG24-7030
- *IBM Enterprise Content Management and DR550 for E-mail Archiving and Records Management Overview*, REDP-4284

7.2.2 IBM strategy and positioning

Regulations and other business imperatives, as briefly outlined before, stress the need for an Information Lifecycle Management process and tools to be in place. The unique experiences that IBM has had with the broad range of ILM technologies, and its broad portfolio of offerings and solutions, can help businesses address this particular need and provide them with the best solutions to manage their information throughout its lifecycle.

IBM provides a comprehensive, open, set of solutions to help. IBM has products that provide content management, data retention management, and sophisticated storage management, along with the storage systems to house the data. To specifically help companies with their risk and compliance efforts, the IBM Risk and Compliance framework is another tool designed to illustrate the infrastructure capabilities needed to help address the myriad of compliance requirements. Using the framework, organizations can standardize on the use of common technologies to design and deploy a compliance architecture that can help them deal more effectively with compliance initiatives.

IBM has identified six key industry sectors with specific set of retention and data management requirements:

- Financial Services
- Health Care/Life Sciences
- Insurance
- Manufacturing
- Transportation
- Government

Based on the analysis of each of those industry sectors, IBM has been able to develop and prepare concrete industry-adapted archiving solution with specific sets of data management policies, which are part of strategic IBM Information Archive and which significantly help customers to identify their archiving requirements as they are part of pre-configured solution.

7.3 IBM Information Archive

IBM Information Archive (as seen in Figure 7-1), is a consolidated hardware and software offering built with the latest IBM technologies enabling the archive of data with scalability to multiple petabytes.

IBM Information Archive offers' policy-based, data retention capabilities designed to support non-erasable, nonrewritable (NENR)/write Once Read Many (WORM) data storage protection and help address the needs of regulated and non-regulated industries with long-term data retention and protection requirements.

In addition to data encryption capabilities, each collection within the IBM Information maintains a set of tamper-proof audit logs, which provide an immutable and retention-protected provenance record for documents in the collection. Audit logs track document ownership and system lifecycle events including document creation and deletion, changes to retention policies, and system software upgrades.

Figure 7-1 IBM Information Archive

IBM Information Archive is designed to archive and retain records in nonerasable, nonrewritable formats. It supports businesses requirements for retaining and protecting information from premature deletion or malicious modifications. IBM Information Archive is a universal storage repository for all types of archived information that can help midsize and enterprise customers reduce storage costs and improve operational efficiencies within their data center.

IBM Information Archive can help reduce the need for primary storage by enabling archiving applications to move inactive or unnecessary information off the primary storage tier to lower-cost storage tiers. When your primary storage tier has less information, applications can run faster and backup and recovery operations can be completed more quickly. In addition, IBM Information Archive can help reduce your business risk by providing a storage repository in which stored information cannot be altered or deleted until the compliance retention period has elapsed. Information Archive features the option to use the retention policies from archiving applications or to assign your own retention policies.

There are three retention policy enforcement options:

- *Basic* enables applications and users to delete documents before the retention period or retention hold expires. Users can also increase or decrease a retention policy and modify the collection’s protection level if warranted. This option can be used when information is archived for general business reference purposes or to meet broad corporate governance requirements.
- *Intermediate* allows users to increase or decrease retention periods, but prevents deletion before the expiration of the retention period or the retention hold requirements. Users can increase the protection level to Maximum, but cannot decrease it to Basic. Customers looking to save important project information or enforce strict corporate governance requirements are likely to use this protection level.
- *Maximum* only allows users to increase retention periods and prevents information from being deleted until the retention period or retention hold has expired. This protection level cannot be altered and is ideal for companies that have to archive data to meet strict regulatory compliance requirements. This protection level can be compared to storage systems configured in WORM format.

IBM Information Archive is the next generation information retention solution that brings together off-the-shelf IBM hardware and software products along with customized applications for ease of management and use. It is a universal, scalable, and secure storage repository for structured and unstructured information as a compliant or non-compliant integrated archive appliance.

IBM Information Archive is an integrated IBM software and hardware solution that retains and protects data by enforcing the industry's most stringent data retention laws and addresses the complete information retention needs of midsize and enterprise clients.

7.3.1 IBM Information Archive appliance

The IBM Information Archive appliance is an integrated information-retention solution. The appliance includes preinstalled servers, disk storage, and the Information Archive software. The appliance can be used to store and manage multiple billions of documents over its deployment lifetime.

The Information Archive appliance provides policy-managed storage for compliance, archiving, and content management applications. Both time-based and event-based retention options are available. Stored data can be compressed and deduplicated. Optional features include Enhanced Remote Mirroring for disaster recovery, high-availability server configurations, and migration from disk to tape storage.

Depending on the configuration you choose, files can be archived using the Network File System (NFS) protocol, and retrieved using either NFS or HTTP. Another option is to use the IBM Tivoli Storage Manager archive client or application programming interface (API) to archive and retrieve files.

Data: If you use the Tivoli Storage Manager archive client or API client, a different process is used for storing data in the appliance.

The base appliance frame (2231-IA3) has a drawer with a 16-drive capacity, and comes with one disk controller. For more storage, the controller can be attached to a maximum of six expansion drawers; each with the capacity for another 16 disk drives. You can configure each drawer in half-drawer increments (eight hard disk drives at a time). A fully populated base frame of one controller and six expansion drawers yields a capacity of 112, 2 terabyte (TB) Serial Advanced Technology Attachment (SATA) disks.

The 2231-IA3 base rack can be supplemented with a 2231-IS3 expansion rack that has the capacity for two additional disk controllers plus a maximum of 10 expansion drawers. Each document collection requires another disk controller, so two additional controllers represents two additional document collections. Each expansion drawer is configured in half-drawer increments (eight hard disk drives at a time). A fully populated expansion rack has a capacity of 192 disks (two controllers with 192 TB of total physical storage each), and provides 254.6 TB of total usable storage space. This space is divided up into 127.3 TB each for the two collections. A primary rack, combined with an expansion rack, provides the total physical storage capacity of 304 2 TB hard disks.

The hard disk drives operate in a Redundant Array of Independent Disks (RAID) 6 configuration to maintain data integrity. Because of the RAID 6 configuration, two of every eight drives are reserved for parity. A spare drive is set aside in the disk controller drawer the third expansion drawer in each controller string. An additional drive is allocated in the first rack for a special all-appliance utility file system. This drive configuration yields a maximum of 81 usable 2 TB drives in the primary rack, and 70 usable 2 TB drives for each of the two possible collections in the expansion rack.

Archiving processing and data management

The data information lifecycle within IBM information Archive consists of three phases as shown in Figure 7-2.

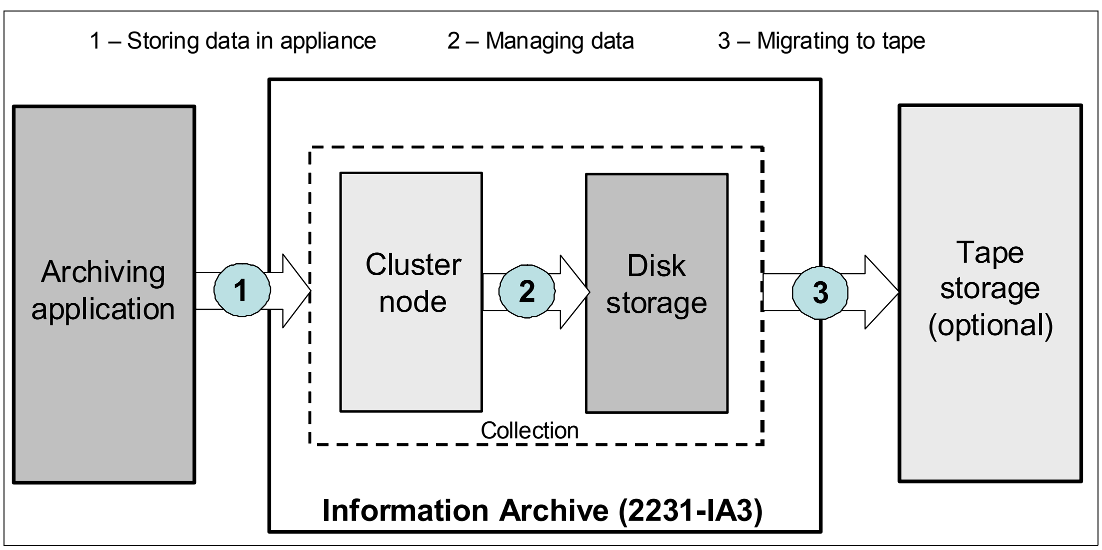


Figure 7-2 Data processing within IBM Information Archive

Those three steps can be described the following way:

- Storing Data in the Appliance: Information Archive uses a logical object called a *collection* to manage archived data. Each collection is represented by a file system. To begin the process of storing data, an archiving application (for example, IBM Content Manager) writes a new file to the collection file system. The file is then *committed* to the archive by one of several available methods. Committing a file starts the process of *ingestion*. During ingestion, the file is added to the collection, along with a set of descriptive *metadata*. This metadata includes information about when the file was created, who owns the file, and other identifying information. You can extend the metadata by adding custom fields to the metafile schema. Files and their accompanying metadata are referred to as *documents*.
- Managing Archived Data: The Information Archive appliance includes up to three servers for ingesting and managing documents. These servers are called *cluster nodes* because they use a clustered file system to provide workload balancing and high-availability through failover. Each collection is associated with a dedicated pool of disk-based storage. Each collection has its own policy domain, which includes rules for managing security, for setting document retention periods, and for managing storage resources. During the ingestion process, the retention policies that are defined for the collection are applied to the newly ingested document. These policies determine how long the document is retained in the archive, and whether the document can be deleted before its retention period expires. After a document has been ingested, it is migrated to the next level in the disk storage hierarchy. During the migration process, documents can be compressed and deduplicated to make the most efficient use of the available storage capacity.
- Migration to tape storage (optional): By default, all documents that are stored in the appliance are protected by a RAID6 storage configuration. A remote replication option is also available. To provide an additional level of disaster recovery protection, archived data can be automatically copied to tape storage and transferred to an off-site location. The Information Archive solution includes an integrated storage management application that provides policy-based management of this migrated data. Attaching a tape library to the appliance can significantly increase its overall storage capacity, while still providing the ability to access the documents through the Information Archive interface.

Conceptual model

The IBM Information Archive can be described conceptually as follows:

- The next generation information retention solution
- A universal storage repository for all types of content of structured (database) and unstructured (files, email, images, and docs)
- A robust, scalable, secure information retention, fully integrated hardware, software, and services solution
- A solution that addresses the complete business, legal, or regulatory information retention needs of midsize and enterprise clients

IBM Information Archive is easy to implement, configure, and manage, allowing you to start archiving the next day. It looks like a file server; just simply drag and drop files to IBM Information Archive. Built to industry standards, IBM Information Archive works with any archiving application that supports standard NAS interface. There is no additional integration work required.

IBM Information Archive allows you to optimize your storage infrastructure immediately. You can do this by offloading your production files to IBM Information Archive right away and gain storage efficiencies, utilizing tape, and automatically migrating to tape for cost and energy savings, and storing a single instance of the same files creating storage space savings.

IBM Information Archive allows you to quickly archive, locate, and retrieve information and offers index / search on data and metadata. IBM Information Archive automates "file" lifecycle (from ingestion to deletion) by policy driven administration and enforces retention policies set forth by the application, or allows administrators set retention policies (time or event based).

Retain your data with confidence and protect, secure, and tamper-proof your information with customizable retention policies to meet your organization's needs.

IBM Information Archive scales up to 604 TB (raw) with disk only repository and petabytes with attached external tape library allowing you to consolidate your data and be ready for growth.

Because the IBM Information Archive solution allows the usage of multiple collections per IBM Information Archive, you can handle multiple archive applications at once under one management point and with it, being a cloud ready smart business system, you have a unified and simplified smart business system infrastructure which will adapt as business needs evolve.

As you can see in Figure 7-3, IBM Information Archive allows input by NFS and supported applications that can write to the Tivoli Storage Manager API client. After the data is stored in the appropriate secured collection on internal disk, you have the capability to migrate them to the external tape or other supported device, bringing further options of overall scalability.

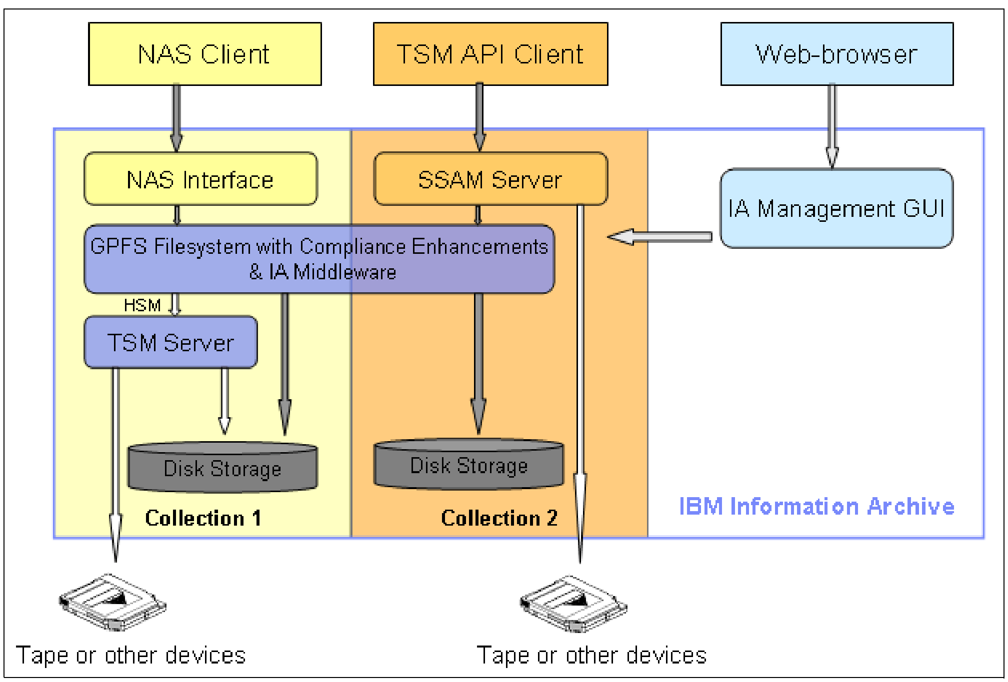


Figure 7-3 Information Archive High Level Architecture

Partitioning by collections

A single Information Archive can be partitioned into three archive collections, and each collection is assigned to a storage node. The IBM Information Archive can have up to three storage nodes thus, up to three archive collections and each collection can be customized to support various protection levels. Each collection is accessible by Network for File System (NFS) or System Storage Archive Manager (SSAM) protocols. IBM Information Archive supports multiple ingest and input models including custom applications, as shown in Figure 7-4.

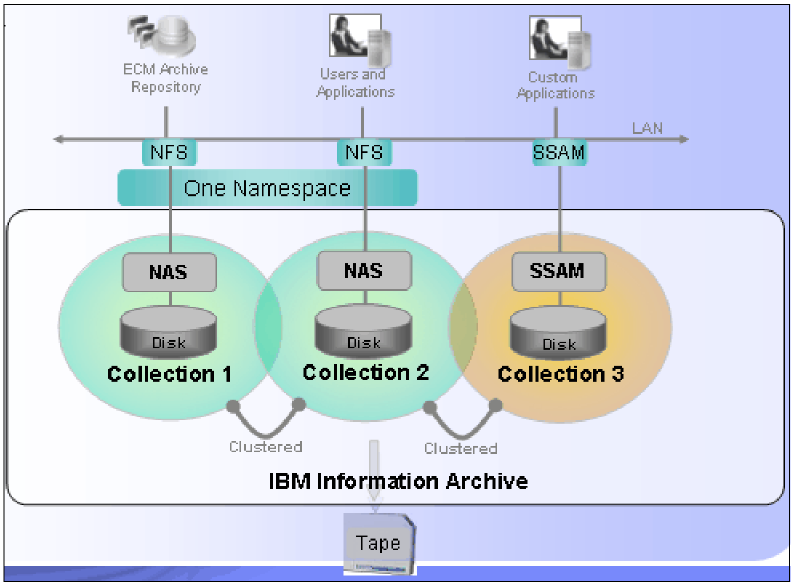


Figure 7-4 IBM Information Archive Advanced 3x3 Collection Architecture

Appliance administration

Information Archive includes a web-based user interface called the *administrative interface*. Customers can use this interface to configure and manage the appliance. The administrative interface provides wizards to guide you through common tasks. Properties notebooks allow you to modify settings and perform advanced management tasks. The administrative interface is only used to configure and manage the appliance, and to download audit logs. This interface is not used to archive or retrieve documents.

Interface: The Information Archive administrative interface is installed as a component of the IBM Integrated Solutions Console (ISC).

The IBM Information Archive administrative interface can be used to control the following features:

- Archive Management:
  - Document collection configuration (creation, modification, deletion)
  - Reporting (documents and capacity)
- System Management:
  - System configuration
  - System monitoring and alerting (SNMP and email)
- Services:
  - Retrieve logs from all servers and SW components
  - Launch Director and RSM GUIs

- Auditing:
  - Download audit logs per document collection
  - Configure access to audit logs for feeding into TCIM, and so on

In addition to the web-based administrative interface, Information Archive provides a command-line interface. This interface runs on the management console server in the appliance and can be accessed locally from the keyboard video mouse (KVM) console or from a remote computer using an SSH client. The command-line interface is keyboard accessible and supports command automation through scripting. System administrators can use the command-line interface to perform most of the same tasks that can be done using the administrative interface.

7.3.2 Enhanced Remote Mirroring

IBM Information Archive (Information Archive) exploits the Enhanced Remote Mirroring feature available with the DS family of storage controllers. This feature provides the technology that enables business continuity in the event of a disaster or unrecoverable error at one appliance, accomplished by maintaining copies of the data at two locations, enabling a second appliance to take over responsibility.

The optional Enhanced Remote Mirroring feature allows data synchronization between two Information Archive appliances installed at a primary and a secondary site. The secondary Information Archive appliance can take over I/O responsibility when the primary appliance becomes unavailable. Enabling the feature reduces the chances of data loss and system down time.

The remote replication is enabled by manufacturing, when you order two Information Archive appliances, one being specified as primary and the other one as secondary appliance. The Enhanced Remote Mirroring feature must be installed on each of the 2231-D1A storage controllers installed in the appliance. Therefore, if one storage controller is mirrored, all of the other storage controllers potentially installed in the same IBM Information Archive appliance must be mirrored too.

When you order two Information Archive systems with the Enhanced Remote Mirroring option, several additional components are installed in both the primary and secondary appliances. These components include shortwave or longwave SFP transceivers in the SAN switches and additional Fibre Channel cables. Enabling Enhanced Remote Mirroring for the storage controllers and the Ports on Demand feature to enable eight additional ports in the Fibre Channel (FC) switches is already taken care of by manufacturing.

The detail description and step-by-step procedure how to configure and enable Enhanced Remote Mirroring between two sites with IBM Information Archives, see *IBM Information Archive Architecture and Deployment*, SG24-7843.

7.3.3 Migration from DR550 to Information Archive

Customers can migrate the archived data from an IBM System Storage DR550 into a System Storage Archive Manager collection on an IBM Information Archive. Use the information in this section to understand the process and requirements for System Storage DR550 migration.

A System Storage DR550 migration is a one-time service action that moves archived data and compliance settings from an existing System Storage DR550 over a local area network to the newly created System Storage Archive Manager collection. The management classes and copy groups are moved to Information Archive to ensure that the expiration date of each document is preserved after the migration.

Data is migrated from System Storage DR550 to Information Archive at approximately 10 - 20 Terabytes (TB) per day. The System Storage DR550 appliance can receive and respond to archive requests while the data is being migrated. You can stop the migration at any point and resume it later.

> **Migration:** The migration is performed by an IBM service representative. A log tracks the migration status so that customers can audit the process and ensure that all the data and policies from the System Storage DR550 were successfully received by the Information Archive appliance.

The System Storage DR550 migration has the following restrictions:

- The migrated documents must be stored in a System Storage Archive Manager collection on Information Archive.
- The documents must be exported to a System Storage Archive Manager collection that was created as part of the migration procedure. You cannot use a collection that was created before this procedure, even if the collection is empty.
- You cannot migrate the contents of two System Storage DR550s into a single System Storage Archive Manager collection.
- You must migrate all the data on a System Storage DR550 to a System Storage Archive Manager collection. Migrating a portion of the archive can impact the compliance of the archive.
- The System Storage DR550 archive must be smaller than the maximum capacity of a System Storage Archive Manager collection. The first collection has a capacity of 148 TB and two additional collections can be added with a capacity of 127 TB each.
- A System Storage DR550 containing File System Gateway data cannot be migrated to Information Archive.
- To migrate the data from an IBM System Storage DR450, you must upgrade it to a System Storage DR550 before this procedure.

7.3.4 IBM Information Archive components

There are various configurations of IBM Information Archive available. The standard 2231-IA3 base frame includes the following hardware and software components.

Hardware

The frame integrates the following IBM hardware components:

- At least one cluster node 2231-S2M (IBM System x 3560 M2 server)
- One Management Console server - IBM System x 3550 M2
- One Remote Support Manager (RSM) server - IBM System x 3550 M2
- One console kit (Keyboard, Video, Mouse) and KVM switch
- Two 1 Gbps Ethernet switches
- Two 4 Gbps IBM SAN switches (2498-B24, optional)
- One Storage Controller 2231-D1A (IBM System Storage DS4200)
- Up to six Expansion Drawers 2231-D1B (IBM System Storage EXP420)

The base frame can be extended by one expansion frame 2231-IS3 to provide storage for up to two additional collections.The optional expansion unit consists of the following hardware components:

- Up to two Storage Controllers 2231-D1A (DS4200)
- Up to ten Expansion Drawers 2231-D1B (EXP420)

Both frames of IBM Information Archive can be equipped by either 1 TB or 2 TB Serial Advanced Technology Attachment (SATA) disk. There are limitations and restrictions when one needs to use a combination of 1 TB and 2 TB disks, thus we do not advise such installations.

Software

The frame integrates the following IBM software components:

- IBM System Storage Archive Manager
- IBM Tivoli Storage Manager for Hierarchical Storage Management (HSM)
- Scale Out File System - General Parallel File System (GPFS)
- IBM Systems Director
- RSM for Information Archive
- DS Storage client for Information Archive
- Content Manager
- DB2 and Net Search Extender
- CommonStore
- eDiscovery Manager

7.3.5 Summary of features and benefits

In order to meet the widest range of retention demands, the IBM Information Archive allows the IT Administrator to customize retention policies based on unique and dynamically changing business requirements.

It provides three information protection levels with up to three archive collections within a single system. This 3x3 combination provides you the greatest flexibility of protection levels to help your organization meet unique data retention requirements. With various collections, you have the flexibility to assign customized levels of protection, and retention policies for various kinds of data based on business rules.

These customizable retention policies include time-based and event-based information retention policies to protect information from intentional or accidental deletions or modifications. They also include a retention hold and deletion hold feature to set indefinite period of retention on a file during circumstances such as legal discovery.

Backward compatibility with IBM System Storage DR550 allows the data migration to the newly deployed IBM Information Archive without risk of data loss and according to the compliance requirements.

Enhanced Remote Mirroring allows customers to build highly available, disaster resistant solution across primary and secondary (disaster) sites for reasonable time and material investment.

There are many additional features and benefits of the IBM Information Archive. Here we list and summarize the majority of them and the most important features:

- Designed to offer quick time-to-value; can be installed and configured quickly and easily
- Ease of use:
  - Ability to manage the archive from a single point
  - Ability to manage data with fewer resources
  - Designed to help reduce cost
- Information Protection Levels and Retention policies that address unique data retention needs with flexible information protection levels:
  - Ability to store data in up to three collections per system and assign various levels of protection, and retention policies for various kinds of data
  - Allows compliant and non-compliant storage within the same appliance footprint
  - Offers Enhanced Tamper protection
  - Accepts retention policies from applications or creates them
  - Accepts time-based and event-based information retention policies to protect information from intentional or accidental deletions or modifications
  - Accepts retention hold and deletion hold policies to set an indefinite period of retention for a file, such as during legal discovery
- Grows with your needs; can add storage to increase capacity and nodes for performance
- Industry standard interfaces:
  - Eliminates the need for customized application programming interface (API) or add on feature requirements
  - Helps to manage the operational costs
- Data deduplication and compression:
  - Helps lower total cost of ownership (TCO) by providing embedded deduplication and compression capabilities
  - Designed to optimize storage capacity and to improve productivity
- Tiered storage management:
  - Designed to allow a cost-effective mix on nearline and offline storage (disk and/or tape)
  - Contains costs while utilizing storage technology for optimum usage
- Universal storage repository for all types of content; structured and unstructured; compliant and non-compliant
- Numerous other capabilities:
  - Provides up to three information protection levels offering maximum flexibility
  - Stores information by multiple access methods
  - Scales up to 608 TB (raw capacity)
  - Maintains data integrity until deletion is permitted by retention policy
  - Enhanced security and protection with data encryption option
  - Helps optimize storage consumption with data deduplication and compression features
  - Lowers Total Cost of Ownership (TCO) by allowing use of mixed media (disk and tape)
  - Increases data security through Enhanced Tamper Protection feature

7.3.6 Additional information

For additional information about the IBM Information Archive topics, see these websites:

- IBM Information Archive:

  http://www.ibm.com/systems/storage/disk/archive
- IBM Information Archive V1.2 Information Center:

  http://publib.boulder.ibm.com/infocenter/tivihelp/v37r1/index.jsp
- *IBM Information Archive Architecture and Deployment*, SG24-7843:

  http://www.redbooks.ibm.com/abstracts/sg247843.html
- *IBM Information Archive V1.2 - Introduction and Planning Guide*, SC27-2324-02:

  http://www.ibm.com/support/docview.wss?rs=1328&uid=ssg1S7003200
- *IBM Information Archive, V1.2 - Installing and Configuring IBM Information Archive*, GC27-2326-02:

  http://www.ibm.com/support/docview.wss?rs=1328&uid=ssg1S7003240
- *IBM Information Archive V1.2 - User's Guide*, SC27-2325-02:

  http://www.ibm.com/support/docview.wss?rs=1328&uid=ssg1S7003239
- *IBM Information Archive V1.2 - Service Guide*, SC27-2327-02:

  http://www.ibm.com/support/docview.wss?rs=1328&uid=ssg1S7003241

Part 2

Tape Systems

In Part 2 we review IBM TotalStorage and System Storage Tape Drives, IBM Tape Automation products, and IBM Tape Virtualization products.

8

IBM TotalStorage and System Storage Tape Drives

In this chapter, we provide information about IBM tape drives starting from the entry-level TS2230 Tape Drive Express model all the way to the enterprise capable IBM System Storage TS1130 Tape Drive.

We briefly discuss Linear Tape-Open (LTO) technology and related Ultrium specifications, as well as TS1100 (formerly 3592) tape technology.

We also briefly consider the IBM midrange and enterprise storage media used in LTO and TS1130 tape drives.

Finally, we supply comprehensive information about the strategic IBM tape systems and briefly summarize the next steps in the development of tape technology.

8.1 LTO technology

Linear Tape-Open (LTO) is an open format technology. This means that users can have multiple sources of products and media. The LTO technology establishes a new open format specification for high-capacity, high-performance storage products and addresses a growing customer need for improved data interchange across platforms.

LTO technology was developed jointly by IBM, Hewlett Packard (HP), and Seagate in 1997 to provide a clear and viable choice in an increasing complex array of tape storage options. The consortium created two specifications, Accelis and Ultrium.

The current technology provider companies are IBM, HP, and Certance LLC (owned by Quantum). The Accelis technology has not been pursued by manufacturers because it is apparent that Ultrium meets the market needs.

Here we describe technical standards defined for LTO technology:

- The cartridge dimensions (approximate) are 4.1 x 4.0 x 0.8 inches (105 x 102 x 21 mm).
- The single-hub design allows for the cartridge to be optimally packed with media. High capacity is further enhanced by the use of an LTO technology data compression algorithm with two control modes to maximize compression efficiency.
- Dedicated Dual Servo means that the servo bands are pre-written on the tape during the tape cartridge manufacture process. If one servo element becomes defective, the head will continue to track as a result of the second “redundant” servo system.
- There are currently five available Ultrium formats:
  - Ultrium format generation 1: This has 100 GB native capacity (up to 200 GB using 2:1 compression) per cartridge. Ultrium 1 drives are no longer being actively sold, although the media can still be purchased; those are fully compatible with Ultrium 2 tape drives and readable by Ultrium 3 drives. Only SCSI interface available for direct attachment to the systems.
  - Ultrium format generation 2: This has 200 GB native capacity (up to 400 GB using 2:1 compression) per cartridge. The product is withdrawn from the market, nevertheless LTO2 media are still available for purchase as fully compatible with Ultrium 3 tape drives. SCSI and 2 Gbps FC connection usable.
  - Ultrium format generation 3: This has 400 GB native capacity (up to 800 GB using 2:1 compression) per cartridge. SCSI, SAS and 4 Gbps FC interface feasible.
  - Ultrium format generation 4: This has 800 GB native capacity (up to 1.6 TB with 2:1 compression) per cartridge (3 Gbps SAS and 4 Gbps FC interface). Additional features include 256-bit AES encryption and Write Once, Read-Many (WORM) technology
  - Ultrium format generation 5: This has 1.5 TB native capacity (up to 3 TB using 2:1 compression) per cartridge (6 Gbps SAS and 8 Gbps FC interfaces). Ultrium 5 technology offers 256-bit AES application manageable encryption, WORM, and tape partitioning.

LTO technology delivers the following benefits:

- High capacity for improved Total Cost of Ownership (TCO) is provided.
- LTO easily integrates into current operating environments.
- The roadmap protects investment today and in the future as each new generation reads the previous two generations format and offers full compatibility with previous generation (read/write).

- Migration paths are focused on increasing maximum transfer rates to reduce the backup window. In addition, native capacity will double in each successive generation.
- Simplified product planning means faster cycle time for new features.
- Compliance testing ensures that LTO Ultrium drives and media cartridges conform to the specification to deliver data interchange among multiple vendors' products.
- Instant access to data; this is made possible by LTO Cartridge Memory (CM), which is a passive, contactless silicon storage device that is physically a part of the cartridge. Strong algorithm using CM and low level encoding prevent data tampering in case the WORM feature is enabled.

Figure 8-1 shows technical details of Ultrium LTO2 tape cartridge. The other generations have the same structure and disposition of all components, only their functional parameters are slightly different.

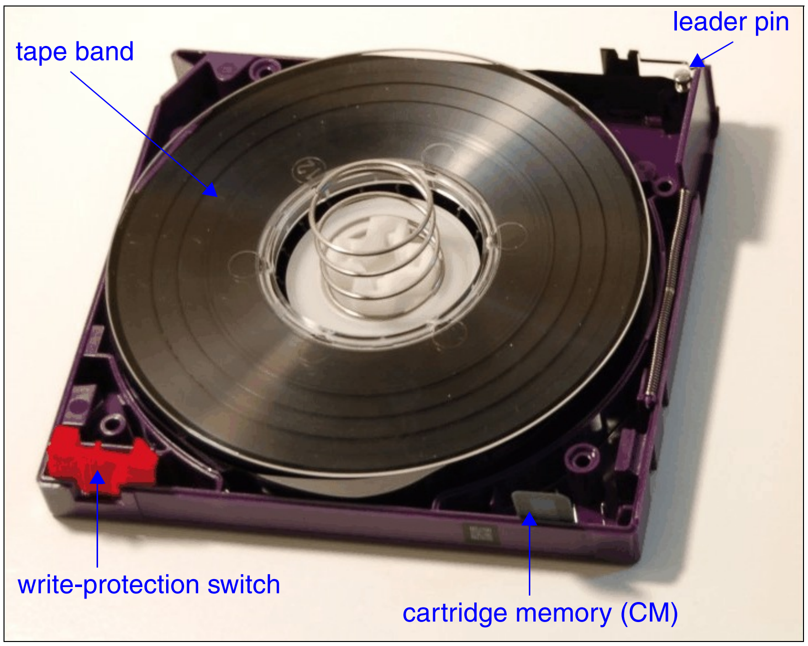


Figure 8-1 Technical details of Ultrium LTO2 tape cartridge

For details about the LTO or Ultrium, see the following websites:

http://www.lto-technology.com
http://www.ultrium.com

8.1.1 Interleaved recording

The LTO drive uses an interleaved, serpentine, longitudinal recording format. The first set of 8 or 16 data tracks is written from near the physical beginning of the tape to near the physical end of the tape. The head then repositions to the next set of tracks for the return. This process continues until all tracks are written and the tape is full.

The format of the recording of the data and servo tracks is defined as part of the LTO specification in order to meet the requirement for interchange between various manufacturers' implementations.

8.1.2 Servo tracks

Servo tracks (also called servo bands) enable accurate positioning of the tape drive head over the data track, ensuring that the head does not stray onto an adjacent track. They are necessary to support high-data densities on the tape where the tracks are very close together. The servo bands are written at time of cartridge manufacture, before the cartridge is usable for data storage and retrieval. If the servo bands are erased, the tape becomes unusable.

Servo tracks are like lane markings on a multi-lane highway. Imagine the difficulty of driving on the highway without any lane markings. Lane markings help by positioning you on the lane, just as servo tracks support the drive recording head to position on the data tracks (Figure 8-2).

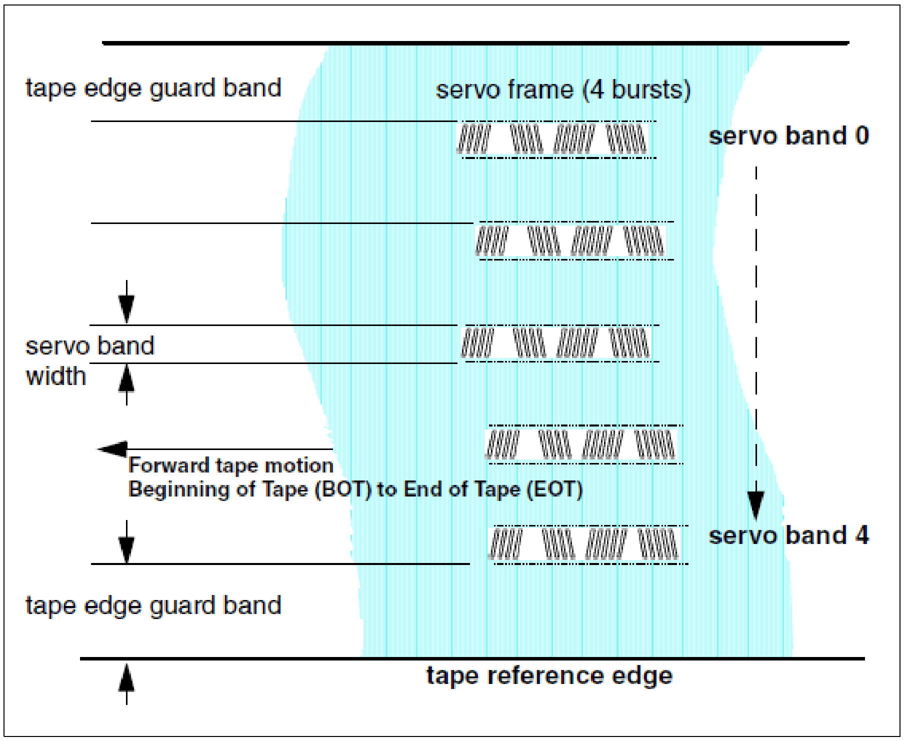


Figure 8-2 Servo band position and nomenclature

8.1.3 Track following

Each pair of servo bursts is at an angle to each other, and the servo heads move such that they keep a constant value for the distance between the bursts. In this way the servo is able to follow a straight line within the servo band; any small deviation away from the correct path causes a variation (plus or minus) in the gap between the bursts (Figure 8-3). Provided that the servo head element follows a straight line along the servo band, then the distance “x” shown in the figure remains constant. IBM LTO drives use two servo bands simultaneously during write operations to provide two sources of servo information, and therefore increased accuracy.

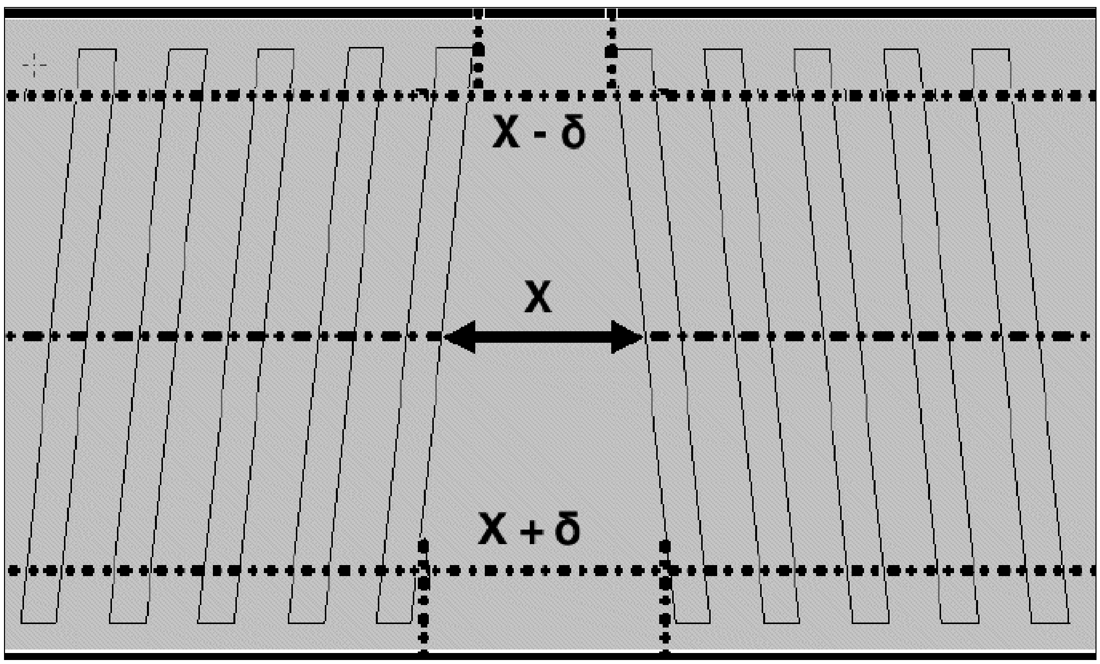


Figure 8-3 Magnified servo band showing a pair of servo bursts

Longitudinal positioning

The LTO servo band is designed not only for track following, but also for recording the longitudinal position (LPOS). The absolute location down the length of the tape and the manufacturer data are recorded in LPOS *words* approximately every quarter-inch (.7 cm) along the tape. The LPOS word consists of symbols constructed from bit sequences (ones and zeros); these bits are encoded within the servo frames. Each servo frame encodes one bit using the first pair of servo bursts. When servo stripes 2 and 3 (out of the five) are shifted inward (Figure 8-4), this encodes a zero; when servo stripes 2 and 3 are shifted outward, this encodes a one.

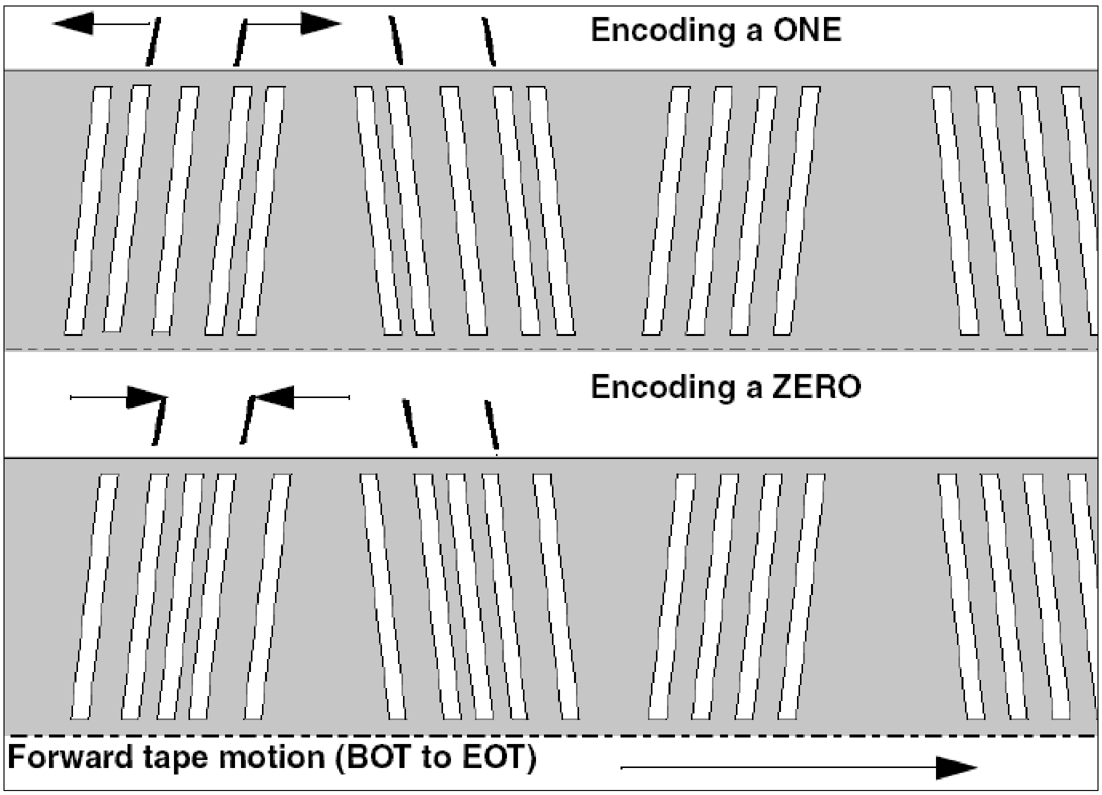


Figure 8-4 Encoding bits using the servo stripes within the servo bursts

The LPOS word contains 36 bits and therefore has a length of 36 servo frames. Each of the 5 servo bands on the tape can be uniquely identified by the relative positions of the frames down the tape, in adjacent servo bands. The offset of the frames between servo band *n* and servo band *n+1* are specific to each servo band (0 and 1, 1 and 2, 2 and 3, or 3 and 4). Therefore, the drive can move the head directly from the physical beginning of the tape to a specific logical position for reading or writing.

Data tracks

The area between adjacent servo bands is a data band. There are four data bands numbered 2, 0, 1, and 3, where data band number 2 is nearest the reference edge of the tape and data band 3 is farthest away, as in Figure 8-5. The data bands are written in sequence beginning with 0 (in the center of the tape) and ending with 3.

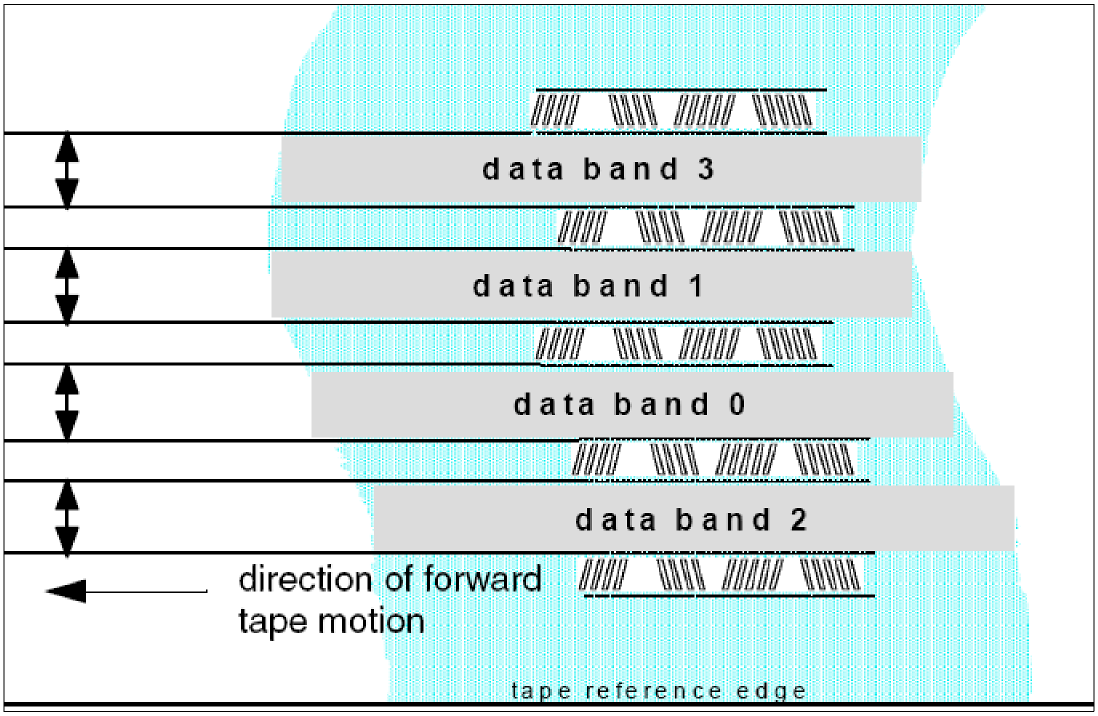


Figure 8-5 Four data bands written between the servo tracks

Each data band consists of numbers of tracks that are recorded eight tracks at a time (for Ultrium 1 and Ultrium 2) from one end of the tape to the other end. For Ultrium 3 and Ultrium 4, the tracks are recorded 16 tracks at a time. The process is as follows:

1. The head is positioned over data band 0, and the first set of eight (16) tracks is written from the physical beginning of the tape (BOT) to the physical end of the tape (EOT).
2. The head physically repositions (using a separate servo position within the same servo bands) and switches electronically3 to a second set of eight (16) write elements in order to write eight (16) tracks in the reverse direction back to the physical beginning of the tape.
3. The head physically repositions again, and, switching back to the first set of write elements, writes another set of tracks to the physical end of the tape.
4. The head continues to switch and index in this manner until all the tracks are written, and the head is back at the physical beginning of the tape (Ultrium 1 and 2) or at the end of the tape for Ultrium 3.
5. The head moves to data band 1 to continue writing the data.

For Ultrium 1, 96 data tracks (8 tracks times 6 forward and backward writes) coexist in one data band. For Ultrium 2, there are 128 data tracks in one data band (8 tracks times 8 forward and backward writes), and for Ultrium 3 there are 176 tracks in one data band (16 tracks times 6+5 forward or backward writes). For Ultrium 4, 224 data tracks (16 tracks times 14 forward and backward writes) are in one data band.

A group of tracks recorded concurrently in the physical forward or the physical backward direction is called a wrap. Wraps recorded while the tape is moving from BOT to EOT are forward wraps; wraps recorded while the tape is moving from EOT to BOT are reverse wraps. The wraps are recorded in a serpentine fashion, as described: a forward wrap, then a reverse wrap. They are numbered sequentially in the order that they are processed, starting with wrap 0. Therefore, for Ultrium 1 six forward wraps and six reverse wraps make up a data band. For Ultrium 2, eight forward and eight reverse wraps make up a data band. The individual tracks within a wrap are interleaved with tracks from other wraps; in other words, adjacent tracks are not part of the same wrap (Figure 8-6).

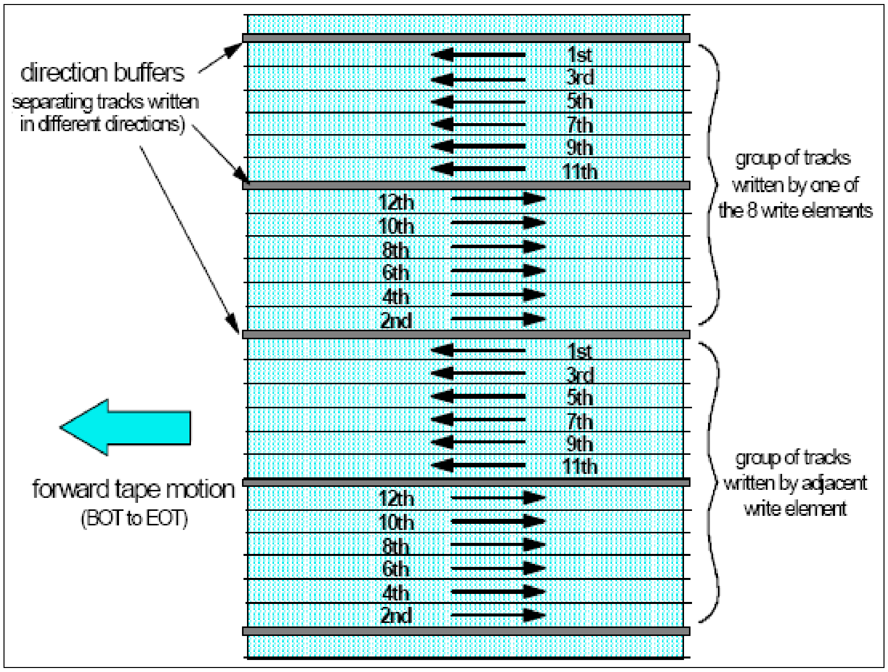


Figure 8-6 Portion of data band showing Ultrium 1 track-writing sequence

Backwards compatibility

The LTO standard specifies a backwards compatibility of writing one generation backwards and reading two generations backwards. To make this possible, LTO uses a technique called *shingling*. When using shingling, a write track can overlap the bottom of a previously written track. LTO Generation 2 uses shingling when writing data to an LTO Generation 2 Cartridge.

The very first two passes write to the tape in the normal way. The following passes can partially overwrite previously written data tracks. The IBM LTO Generation 2 write head width is that of the LTO Generation 1. Therefore the LTO Generation 2 drives can write an LTO 1 cartridge in full track width, and when writing to an LTO 2 cartridge it uses the shingling write function. To read the residual LTO generation 2 data tracks, the read head must of course be narrower than the LTO generation 1 read head.

Figure 8-7 shows the shingling process used for writing to tape.

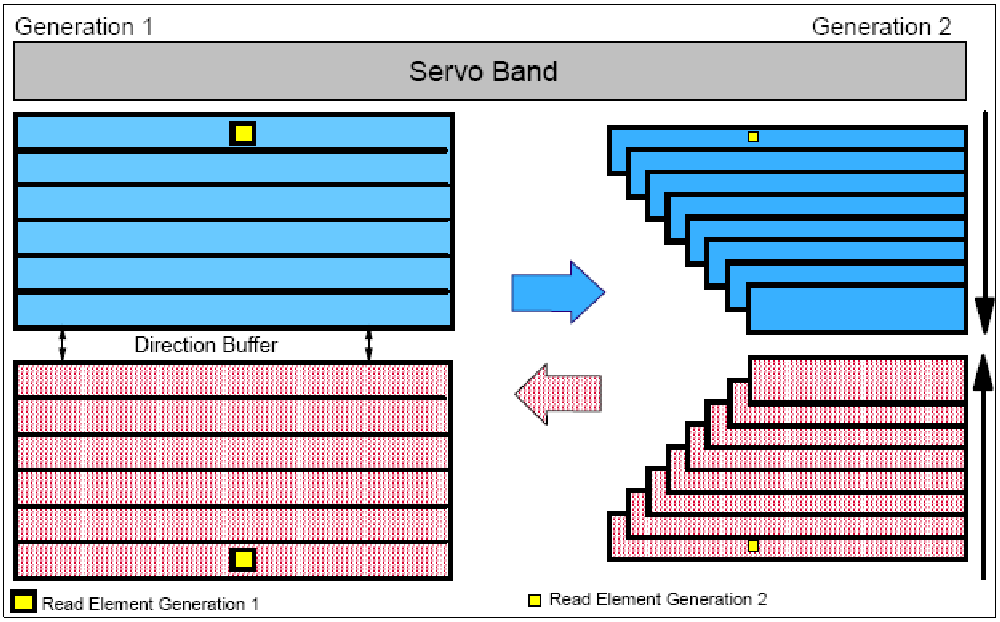


Figure 8-7 Shingling - writing to tape generation 1 versus generation 2

Again, newer generations are conceptually the same, but with small technical differences. For example, the Ultrium 3 data is written in 16 tracks at the same time, using the shingling technique. To achieve compatibility, the write heads are equal to the residual track width of the Generation 2 format, and the spacing between alternate (every second) Generation 3 write heads is the same as between the Generation 2 write heads. Thus Generation 3 data is written using the shingling method, but Generation 2 data is written using only every second write head and writing the full Generation 2 data width. Generation 1 data can similarly be read by every other read head.

8.2 IBM Ultrium 1, 2, 3, 4, and 5 highlights

In this section, we show highlights of all available IBM Ultrium Tape Drives, such as drive and cartridge compatibility, LTO drive performance, drive operations, reliability, and cleaning the drive. We also illustrate the IBM LTO Ultrium family of tape drives and libraries and provide an overview of the multipath architecture.

There are five generations of LTO data cartridges as specified in the following tables. Here are the rules describing the compatibility among the various LTO cartridge generations:

- Data cartridges one generation prior are read/write compatible.
- Data cartridges two generations prior are read only.
- Data cartridges three generations prior are not supported.

However, the Ultrium 5 drive only allows an Ultrium 4 cartridge to be written at the LTO Generation 4 operating point (800 GB). More specifically, the Ultrium 5 drive does not allow an Ultrium 4 cartridge (800 GB) to be reformatted to the Ultrium 5 format (1.5 TB), which is the generally rule for all previous generations of cartridges. Easily said, the maximum usable capacity is specified by the generation of tape cartridge, no matter in what (compatible) tape drives is written.

Table 8-1 shows the compatibility among the five generations of LTO data cartridges.

Table 8-1 IBM Ultrium Tape Compatibility

IBM Ultrium Tape Drive	IBM TotalStorage LTO Ultrium Data Cartridge (native capacity)				
	1.5 TB (Ultrium 5)	800 GB (Ultrium 4)	400 GB (Ultrium 3)	200 GB (Ultrium 2)	100 GB (Ultrium 1)
Ultrium 5	Read/Write	Read/Write	Read only	N/A	N/A
Ultrium 4	N/A	Read/Write	Read/Write	Read only	N/A
Ultrium 3	N/A	N/A	Read/Write	Read/Write	Read only
Ultrium 3	N/A	N/A	N/A	Read/Write	Read/Write
Ultrium 1	N/A	N/A	N/A	N/A	Read/Write

Table 8-2 briefly lists technical specifications for all generations of Ultrium LTO media:

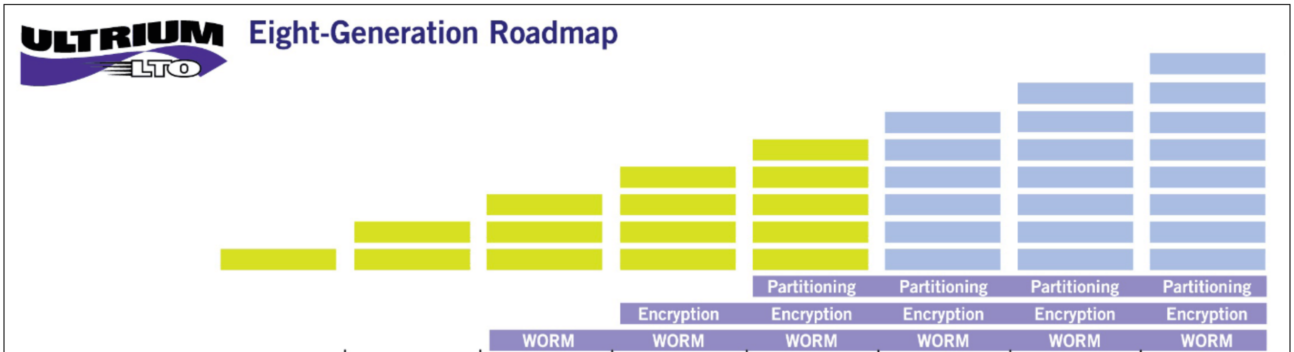
Table 8-2 Technical parameters of Ultrium LTO generations

Attribute	LTO1	LTO2	LTO3	LTO4	LTO5	LTO6	LTO7	LTO8
Release date	2000	2003	2005	2007	2010	TBA	TBA	TBA
Native Capacity [GB]	100	200	400	800	1500	3200	6400	12800
Max Speed [MBps]	15	40	80	120	140	270	315	472
Compression Capable?	Yes 2:1					Planned 2.5:1		
WORM Capable?	No		Yes			Planned		
Encryption Capable?	No			Yes		Planned		
Partition Capable?	No				Yes	Planned		
Tape Thickness [µm]	8.9		8	6.6	6.4			
Tape Length [m]	609		680	820	846			
Tape Tracks	384	512	704	896	1280			
Write Elements	8		16					
Wraps per Band	12	16	11	14	20			
Linear Density [bit/mm]	4880	7398	9638	13250	15142			
Encoding Type	RRL	PRML						

8.2.1 Ultrium generation roadmap

The development path of Ultrium technology consists of eight generations with clearly defined technical details and expectations. Figure 8-8 provides further details. You can also see the following website:

http://www.lto.org/technology/roadmap.html



	Generation 1	Generation 2	Generation 3	Generation 4	Generation 5	Generation 6	Generation 7	Generation 8
Compressed Capacity	200 GB	400 GB	800 GB	1.6 TB	3 TB	8 TB	16 TB	32 TB
Native Capacity	100 GB	200 GB	400 GB	800 GB	1.5 TB	3.2 TB	6.4 TB	12.8 TB
Compressed Data Rate	up to 40 MB/s	up to 80 MB/s	up to 160 MB/s	up to 240 MB/s	up to 280 MB/s	up to 525 MB/s	up to 788 MB/s	up to 1180 MB/s
Native Data Rate	up to 20 MB/s	up to 40 MB/s	up to 80 MB/s	up to 120 MB/s	up to 140 MB/s	up to 210 MB/s	up to 315 MB/s	up to 472 MB/s

Figure 8-8 Ultrium generation roadmap

Compressed capacity for Ultrium generation 1-5 assumes maximum compression ratio 2:1, while higher generations 6-8 introduce the ratio 2.5:1 being achieved with a larger compression history buffer.

8.2.2 WORM tape format

IBM Ultrium Write Once Read Many (WORM) cartridges (machine type 3589) were designed for applications requiring an audit trail, such as those mentioned in the data management categories specified in the Sarbanes-Oxley Act of 2002, Health Insurance Portability and Accountability of 1996 (HIPAA), and many other legal regulations in different countries.

The IBM Ultrium 3, 4, and 5 tape drives provide WORM support for these types of applications. The IBM Ultrium WORM cartridges work with the IBM System Storage LTO Ultrium Tape Drive to help prevent the alteration or deletion of user data. In addition, IBM has taken several steps to reduce the possibility of tampering with the information:

- The bottom of the cartridge is molded in a color other than that used for rewritable cartridges.
- The special cartridge memory algorithm protects the WORM nature of the media.
- A unique format is factory-written on each WORM cartridge.

The native and compressed capacity of Ultrium WORM tape cartridges is identical with the standard LTO rewritable media. The same statement is valid for the compatibility between Ultrium WORM generations of tape drives and cartridges as described in Table 8-1.

8.2.3 IBM Long Term File System

IBM Long Term File System (LTFS) utilizes the latest generation of Ultrium tape cartridges in conjunction with dedicated tape drives and operating systems. LTFS is a low-cost, self-describing, tape file system that provides an easy tape storage and distribution solution without additional database applications.

Here we list the main features of LTFS:

- The file system is implemented on dual partition of LTO 5 media.
- There is fast file system access to tape data; drag and drop files; to and from tape.
- Files and directories appear on desktop, directory listing.
- Data exchange is supported.
- A simple, one-time intuitive installation is provided.

The following hardware and software are supported:

- IBM System Storage TS2250 or TS2350 tape drive with LTO 5 media
- x86 or x86_64bit platforms
- SAS interface supported by IBM Ultrium 5 tape drives
- 1 GB of available RAM for each 1 million files stored on tape
- Red Hat Enterprise Linux Server version 5.4 and higher

When using LTFS, the raw capacity of LTO 5 tape media is 1325.25 GiB (1 GiB = 0.93 GB) or 1425 GB (1 GB = 1 × 10^9 bytes). However, the actual usable capacity is greater because LTO drives compress data while writing. For example, when the LTO compression ratio is 2:1, the capacity of LTO 5 tape media with LTFS is 2650.5 GiB (2850 GB).

8.2.4 Reliability

The IBM LTO Ultrium tape format differs from earlier IBM products, and the following reliability and availability features are included:

- Data integrity: The drive performs a read after write, for verification.
- Power loss: No recorded data is lost as a result of normal or abnormal power loss while the drive is reading or writing data.
- Error correction: Two levels of error correction can provide recovery from longitudinal media scratches.
- Integrated head cleaner: During the load process, a brush integrated into the drive mechanism cleans the head before it is used with the tape. Additionally, IBM tape libraries introduce the dedicated slots for special LTO cleaning cartridges, increasing the data lifecycle together with the automatic cleaning functions of tape drives and libraries.
- Surface control guiding: This feature guides the tape along the tape path using the surface of the tape rather than the edges to control tape motion.
- Flat lap head: This feature improves contact between the read and write recording elements and the tape, giving higher quality recording and readback of data.
- Statistical Analysis and Reporting System (SARS): Only IBM LTO drives provide this level of preventive diagnostic reporting to assist in isolating failures between media and hardware.

For more information, see the website:

http://www.ibm.com/servers/storage/tape/lto/

8.3 IBM LTO Tape Drives

The IBM LTO Ultrium family of tape drives is comprised of the following products:

- IBM System Storage TS2230 Tape Drive Express Model
- IBM System Storage TS2240 Tape Drive Express Model
- IBM System Storage TS2250 Tape Drive Express Model
- IBM System Storage TS2340 Tape Drive Express Model
- IBM System Storage TS2350 Tape Drive Express Model
- IBM TotalStorage 3580 Tape Drive

8.3.1 IBM System Storage TS2230 Tape Drive Express Model

The IBM System Storage TS2230 Tape Drive Express LTO3 HH Mode is the entry-level IBM System Storage tape product family offering. By utilizing advanced Linear Tape-Open technology and the half-high format, the TS2230 Tape Drive is suited for handling the backup, save and restore, and archival data storage needs of a wide range of small systems. See Figure 8-9.

The TS2230 has a storage capacity of up to 800 GB (with 2:1 compression) in conjunction with the IBM TotalStorage LTO Ultrium 400 GB data cartridge, which is double the capacity of the Ultrium 2 technology. Along with its higher capacity, the performance of the TS2230 Tape Drive has more than doubled over the previous generation of half-high LTO drives in the market for a native data transfer rate of up to 60 MBps. The TS2230 Tape Drive provides an excellent alternative to slower and smaller capacity 1/4-inch, 4 mm and 8 mm DLT/SDLT tape drives.

The TS2230 Tape Drive houses the Half-High Ultrium 3 Tape Drive. The TS2230 came available at the end of 2006 and might be an ideal tape drive for small clients who want a reliable tape drive with LTO technology. The TS2230 Tape Drive provides an excellent migration path from digital linear tape (DLT or SDLT), 1/4-inch, 4mm, or 8mm tape drives. The TS2230 Tape Drive Express Model incorporates third-generation IBM LTO Ultrium technology. The maximum tape drive throughput data rate performance is up to 60 MB/s native data transfer rate. IBM Ultrium 3 Tape Drives can read and write LTO Ultrium 2 Data Cartridges and can read LTO Ultrium 1 Data Cartridges.

The TS2230 can be attached to IBM System i, IBM System p, IBM System x, Microsoft Windows, Hewlett-Packard UNIX (HP-UX), Sun Solaris, UNIX, Linux, and PC servers. To determine the latest update of the supported servers, see the website:

http://www-03.ibm.com/systems/storage/tape/library.html

TS2230 highlights: The IBM System Storage TS2230 Tape Drive Express Model has the following features (Figure 8-9):

- Half-high LTO 3
- Lower list price than full-high LTO 3 tape drives
- LVD Ultra160 SCSI attach
- 3 Gbps SAS attach
- WORM capable
- Up to 800 GB compressed; 400 GB native capacity per cartridge based on 2:1 compression
- Up to 60 MBps native sustained data transfer rate based on 2:1 compression

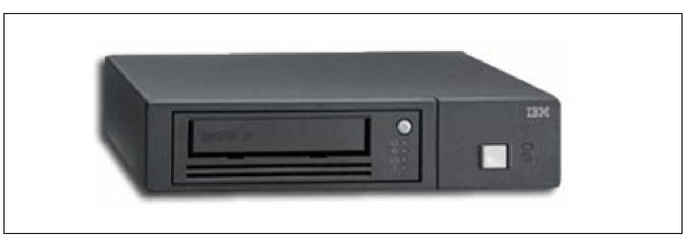


Figure 8-9 Front view of IBM System Storage TS2230 Tape Drive Express Model

8.3.2 IBM System Storage TS2240 Tape Drive Express Model

The System Storage TS2240 Tape Drive, as seen in Figure 8-10, is an excellent tape storage solution for businesses requiring backup or low-cost, real-time archival storage of their data. The TS2240, with a half-high form factor, offers the same high capacity of full-high LTO 4 tape drives. The TS2240 has a physical storage capacity of up to 1.6 TB (with 2:1 compression) in conjunction with the new IBM System Storage LTO Ultrium 800 GB data cartridge, which provides up to double the capacity of Ultrium 3 cartridges.

The native data transfer performance of the TS2240 Tape Drive has increased over the previous LTO half-high generation to up to 120 MBps. The TS2240 Tape Drive continues to provide an excellent alternative to slower and smaller capacity 1/4-inch, 4 mm, and 8 mm DLT/SDLT tape drives.

The IBM System Storage TS2240 Tape Drive (3580 Model H4S) is an external stand-alone or rack-mountable shelf unit, designed for the family of IBM Ultrium Tape products. The TS2240 Tape Drive is a high-capacity data storage device that offers high performance and is designed for backup and restore by midrange Open Systems applications. The TS2240 Tape Drive incorporates the Linear Tape-Open (LTO) IBM System Storage Ultrium 4 Half-High Tape Drive.

The TS2240 Tape Drive Model H4S is encryption-capable and supports Application-Managed Encryption (AME). The TS2240 Tape Drive can use the T10 encryption method. Encryption is only supported with the LTO Ultrium 4 Data Cartridge. The TS2240 is a Customer Replaceable Unit (CRU). In case the TS2240 has a failure, IBM provides you a replacement rather than repairing the tape drive.

TS2240 highlights: The IBM System Storage TS2240 Tape Drive Express Model has the following features (Figure 8-10):

- New IBM Ultrium 4 Tape Drive in a half-high form factor
- IBM Ultrium 4 technology that is designed to support encryption of data and continues to support write once, read many (WORM) operation
- Hardware encryption available
- 3 Gbps SAS attach
- Up to 1.6 TB compressed; 800 GB native capacity per cartridge based on 2:1 compression
- Up to 120 MBps native sustained data transfer rate based on 2:1 compression
- Large internal data transfer buffer
- Backwards compatibility with previous generations of LTO Ultrium cartridges

Figure 8-10 Front View of IBM System Storage TS2240 Tape Drive Express Model

8.3.3 IBM System Storage TS2250 Tape Drive Express Model

TS2250, incorporating the latest available generation of industry leading LTO technology - Ultrium 5 tape drive, is the logical step in offerings of IBM entry-level tape drive systems. Tape Drive is suited for handling backup, save and restore, and archival data storage needs with higher capacity and higher data transfer rate than previous generation. In addition, the IBM Ultrium 5 technology is designed to support media partitioning, and the new IBM Long Term File System technology. It also continues to support encryption of data and WORM media.

The TS2250 provides a physical storage capacity of up to 3.0TB (with 2:1 compression) in conjunction with the new IBM Ultrium 5 (1.5TB) data cartridge, nearly double of the capacity of previous Ultrium 4 cartridges. The data transfer performance of the TS2250 Tape Drive has increased over the previous LTO half-height generation with a transfer rate of up to 140MBps with 6 Gbps SAS interface connectivity. It also now offers two SAS and one Ethernet port per drive to improve availability. SCSI and FC interface is no longer supported as SCSI connection does not offer

TS2250 is delivered with an extended 3 year warranty as a Customer Replaceable Unit.

TS2250 highlights: The tape drive features include these:

- IBM Ultrium 5 Tape Drive in a half-high form factor with reduced power consumption and smart stand-by mode
- IBM Ultrium 5 technology that supports application managed data encryption and WORM cartridges
- Maximum storage capacity up to 3 TB with 2:1 compression rate, 1.5 TB native capacity
- Dual 6 Gbps SAS interface and 1 Gbps Ethernet port available
- Native data transfer rate up to 140 MBps
- Introduces partitioning on LTO 5 tape media and new IBM Long Term File System (LTFS)
- Compatible with major operating systems and software vendor independent (ISV) applications
- New design (see Figure 8-11) allowing two units to be mounted side-by-side in 19” rack

Figure 8-11 IBM System Storage TS2250 Tape Drive Express Model

8.3.4 IBM System Storage TS2340 Tape Drive Express Model

The IBM System Storage TS2340 Tape Drive features SCSI Ultra160 Low Voltage Differential (LVD) as well as 3 Gbps SAS interface for connection to a wide spectrum of open system servers. The TS2340 is intended to exceed your most demanding backup and restore needs. The IBM Ultrium 4 technology is designed to support encryption of data. The hardware encryption and decryption core and control core resides in the IBM Ultrium 4 tape drive (available to the TS2340 with the 3 Gbps SAS interface).

A larger internal data buffer helps improve data access rates and reduce cartridge fill and rewind times along with dynamic channel calibration to help increase data throughput. In addition to reading and writing to LTO Ultrium 3 tape cartridges, the TS2340 can read LTO Ultrium 2 cartridges as seen in Figure 8-12.

The TS2340 Tape Drive is available in two models, which are determined by the attachment interfaces. The TS2340 Tape Drive Model L43 uses a Small Computer Systems Interface (SCSI) Ultra160 Low Voltage Differential (LVD) attachment, and Model S43 uses a 3 Gbps Serial-Attached SCSI (SAS) interface for connecting to Open Systems servers.

The TS2340 Model S43 has two SFF-8088 interfaces for connecting to Open Systems servers. Write Once Read Many (WORM) cartridges are supported and recognized when loaded.

The TS2340 Tape Drive Model S43 is encryption-capable and supports Application-Managed Encryption (AME). The TS2340 Tape Drive uses the T10 encryption method. Encryption is only supported with the LTO Ultrium 4 Data Cartridge. The TS2340 is client-replaceable unit (CRU). In case the TS2340 has a failure, IBM provides you a replacement.

For error codes and messages, there is a Single Character Display (SCD) at the front of the TS2340 Tape Drive. The TS2340 Tape Drive can be attached to IBM System i, IBM System p, IBM System x, Microsoft Windows, Hewlett-Packard UNIX (HP-UX), Sun Solaris, UNIX, Linux, and PC servers.

To determine the latest supported servers, see the website:

http://www.ibm.com/servers/storage/tape/compatibility/pdf/

TS2340 highlights: The IBM System Storage TS2340 Tape Drive Express Model has the following features (see Figure 8-12):

- Model L43 – One IBM Ultrium 4 Tape Drive, LVD Ultra160 SCSI attached
- Model S43 – One IBM Ultrium 4 Tape Drive, 3 Gbps SAS attached
- Next generation of LTO technology
- Hardware encryption available
- WORM capable
- Up to 1.6 TB compressed; 800 GB native capacity per cartridge based on 2:1 compression
- Up to 120 MBps native sustained data transfer rate based on 2:1 compression
- Large internal data transfer buffer
- Backwards compatibility with previous generations of LTO Ultrium cartridges

Figure 8-12 Front View of IBM System Storage TS2340 Tape Drive Express Model

8.3.5 IBM System Storage TS2350 Tape Drive Express Model

The TS2350 Tape Drive is suited for handling backup, save and restore, and archival data storage needs with a higher capacity and higher data transfer rate than that for the previous generation. Also, the IBM Ultrium 5 technology is designed to support media partitioning as well as the new IBM Long Term File System (LTFS) technology. It also continues to support encryption of data using application managed encryption (AME) in conjunction with 256-bit AES coding, and of course WORM media for long term archiving of the business critical and legal information.

The TS2350 incorporates the Linear Tape-Open (LTO) IBM System Storage Ultrium 5 Full-High tape drive, which writes a cartridge with native physical capacity 1.5 TB and up to 3 TB using 2:1 compression. The dual 6 Gbps Serial-attached SCSI (SAS) interface (model 3580-S53) allows customers to utilize the tape drive with the native data transfer rate of 140 MBps, which significantly helps to address the demands to reduce the needed backup window. With the maximum capacity of 3 TB, it also cuts down the physical storage requirements for written media (especially WORM tapes written only once); this is clearly visible on the storage bills from third party outsourcing companies, keeping your media in a secured place.

Partitioning of the LTO5 tape cartridge, enabled by IBM Long Term File System, improves the ability to reference smaller sections of data on tape. LTFS helps with interchange of data between different platforms. At the time of writing this book, two partitions can be created on a single LTO5 tape cartridge.

Because the TS2350 is delivered with the SAS interface only, the Data Path Failover feature is supported for the LTO5 tape drive. SCSI and Fibre Channel connections are not supported any longer because they do not show the benefit in this entry-level segment of IBM tape drives in conjunction with Ultrium 5 technology (standard low-voltage and high-voltage SCSI suffer from the optimal data transfer rate, thus the 8 Gbps FC connection brings additional cost to the host system). Also, a 1 Gbps Ethernet interface is available for environments where the data transfer rate (and thus the eventual backup window) is not the crucial parameter of the concrete backup/archive solution.

A new enclosure design with reduced width to 8.4 inch (21.3 cm) allows customers to mount two TS2350 units side-by-side into an industry standard 19” rack (the rack mount kit has to be ordered separately). See Figure 8-13 for details.

TS2350 highlights:

- Model S53 – One IBM Ultrium 5 Tape Drive, dual 6 Gbps SAS port, single Ethernet port
- The newest generation of LTO technology
- Hardware encryption available
- WORM capable
- 1.5 TB native capacity per cartridge, up to 3 TB based on 2:1 compression
- Up to 140 MBps native sustained data transfer rate
- Tape partitioning available using IBM Long Term File System (LTFS)
- Large internal data transfer buffer
- Backwards compatibility with previous generations of LTO Ultrium cartridges
- External stand alone or rack mountable unit
- Compatible with all major platforms and software vendor independent (ISV) applications
- Benefits from Full-High Ultrium 5 tape drive with optimized power consumption

Figure 8-13 New enclosure of IBM TS2350 Tape Drive Express model

8.3.6 IBM TotalStorage 3580 Tape Drive

The IBM TotalStorage 3580 Tape Drive is the smallest in the family of IBM Ultrium tape solutions. It is an external, stand-alone, Small Computer System Interface (SCSI)-attached tape drive that attaches to System i, System p, System x, RS/6000® SP, and other UNIX and PC servers supporting OS/400, IBM AIX, Sun Solaris, HP-UX, Microsoft Windows NT®, Microsoft Windows 2000 Server, Microsoft Windows Server 2003, and Red Hat and SUSE LINUX using a supported SCSI adapter. See Figure 8-14.

The IBM TotalStorage 3580 model L33 Tape Drive is an external drive incorporating the third generation of IBM LTO technology. This is an external stand-alone or rack-mountable unit, similar to previous models of the 3580, and is the entry point for the family of IBM Ultrium tape products as seen in Figure 8-14. The 3580 Tape Drive provides an excellent migration path from digital linear tape (DLT or SDLT), 1/4-in., 4mm, or 8mm tape drives. The 3580 model L33 can read and write LTO Ultrium 2 Data Cartridges and read LTO Ultrium 1 Data Cartridges.

For additional information regarding the IBM TotalStorage 3580 Tape Drive, see the website:

http://www.ibm.com/systems/storage/tape/3580/index.html

3580 product details: The IBM TotalStorage 3580 Tape Drive has the following features (Figure 8-14):

- Integrates into the following storage environments: Server (non-IBM and IBM), automated library, and SAN-attached

- Adheres to the widely supported LTO specification that promotes standardization and allows for multiple media and drive providers
- Provides superior performance and capacity attributes for unattended backup within midrange and enterprise server environments
- Is compatible with major operating systems and ISV applications
- Uses advanced technologies that optimize throughput, increase cartridge capacity, and provide superior data protection

Figure 8-14   3580 Model L33/L3H

8.4 IBM System Storage TS1100 Tape Drive Family

The IBM System Storage TS1120 and TS1130 tape drives (machine types 3592-E05 and 3592-E06/EU6) offer a design focused on high capacity, performance, and high reliability for storing mission critical data. With the September 2003 introduction of the first generation of the new family of tape drives, IBM advanced its high-end half-inch cartridge tape technology to a new level. The second generation of the 3592 family enhanced the capacity and performance characteristics, which have now become increased by the IBM System Storage TS1130 Model E06/EU6 Tape Drive, the third generation of the 3592 family, which provides the unprecedented capacity of 1 TB of uncompressed data.

The following key features are included:

- Virtual backhitch, which is the optimum adaptive format and algorithm designed for improved start/stop write synchronize performance
- High performance and robust dual microprocessor architecture; one microprocessor operates the host attachment interface (running what is essentially proven 3590 host attach microcode), while the other microprocessor is allowed to focus strictly on writing data and reading data from tape; each microprocessor is designed to reset the other microprocessor to act as a fail-safe
- S/390 and System z attachment through ESCON and FICON by means of the existing J70 controller, as well as the TS1120 Tape Controller
- Statistical Analysis Recording System (SARS) algorithm with extended mount count
- Fast random access performance when operating on any of the Short Length Cartridge (SLC) types

- Support of an enhanced capacity scaling and segmentation format when operating on the full length Read/Write (R/W) cartridge type JA and JB, enabling very fast locate and read times
- Streaming Lossless Data Compression (SLDC) algorithm (enhancement of the Limply-Ziv class 1 (LZ-1) data compression algorithm)
- Cartridge memory of 4 K designed for the 3592 to support advanced features
- An advanced interleaved bidirectional serpentine recording technique that writes 16 data tracks at a time on a 3592 cartridge
- Timing-based servo technique that guarantees the most accurate positioning of the Read/Write heads
- Improved reliability and availability are achieved by:
  - Single Field Replaceable Unit (FRU)
  - Redundant, hot-pluggable power supplies
  - Retention of Fibre Channel Worldwide Name ID during service action
- Advanced technology by:
  - Robust loader mechanism
  - Elimination of drive pneumatics and mechanical adjustments
  - Straighter and shorter tape path for better tape tracking
  - Speed matching to reduce backhitching
  - Channel calibration to optimize performance and data integrity
- The drive has a large data buffer with read-ahead buffer management
- Speed matching for medium data rates when operating from a host that cannot sustain the maximum 3592 data rate
- Cartridge memory chip, which holds information about that specific cartridge, the media in the cartridge, and the data on the media
- High-resolution tape directory for improved nominal and average access times for locate operations
- Performance/capacity scaling that lets clients trade off capacity for improved access times

8.4.1 Milestone: 1 TB on tape

On 5 April 2002, IBM achieved an unprecedented feat—1 TB of data was recorded, without compression, to a tape containable in a half-inch format tape cartridge. This was a technological accomplishment that set the foundation for the 3592 Tape Drive family. By using the evolutionary progression of technology building blocks that IBM had set in place over the preceding five years, an Enterprise Tape Drive roadmap was laid out that can ultimately reach and exceed 1 TB in native cartridge capacity over several tape drive generations.

The 3592 Model J1A became the first tape drive generation of the Enterprise Tape family. It enabled storage of 300 GB of data to a cartridge even if it is incompressible (900 GB with 3:1 compressible data). An even more innovative achievement was that these same cartridges are designed to be reused by the second generation of 3592 tape drives, the TS1120 Model E05 to store significantly more data; using the JA media, we can store 500 GB and with the high capacity cartridge, 700 GB without compression. Now, with the third generation of IBM 3592 Tape Drive, IBM kept its promise documented in the roadmap for 3592 tape drives. The TS1130 Tape Drive is not just a new drive but the IBM commitment to further tape technology development.

8.4.2 Recording format

The IBM 3592 Tape Drive uses an advanced interleaved bidirectional serpentine recording technique that writes eight or 16 (depending on the drive) data tracks at a time on a 3592 cartridge. The 3592 cartridge is a half-inch, advanced metal particle, dual layer tape, and the tape layout consists of five servo bands (which are prerecorded on the tape) and four data bands where the data is written (Figure 8-15). The servo bands provide location information to control the positioning of the head as it writes and reads data within the data band. This design is explained in detail in 8.1.2, "Servo tracks" on page 284.

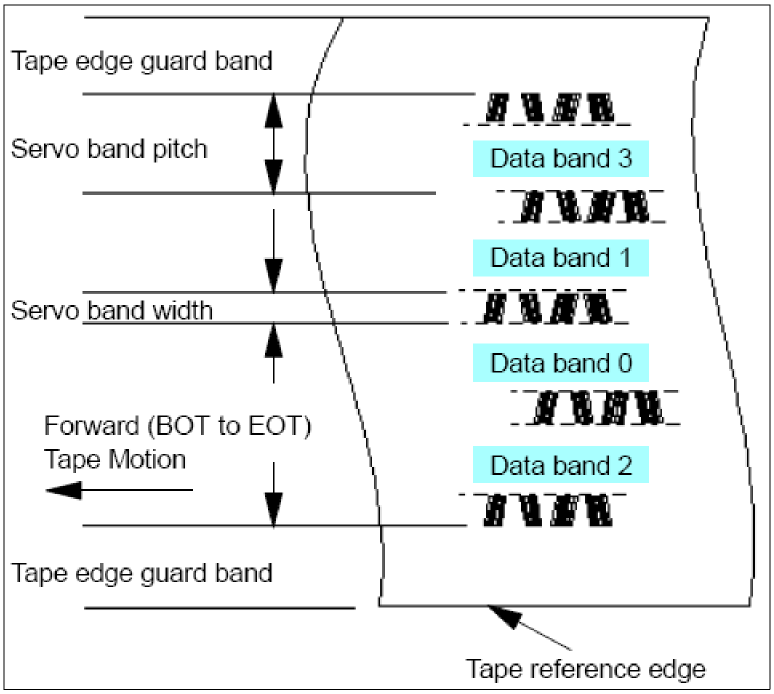


Figure 8-15 The layout of the servo and data bands on the 3592 media

As shown in Figure 8-15, the area between adjacent servo bands is a data band. There are four data bands, each with a number of data tracks (128 - 288, which is unique for each model), on the 3592 media. The data bands are numbered 2, 0, 1, and 3, with data band 2 nearest the Tape Reference Edge and data band 3 farthest from the Tape Reference Edge.

As shown in Figure 8-16 (here, for example, is a J1A written cartridge), each data band is actually composed of eight data sub-bands, one for each of the eight write heads. Each sub-band is written by a given write-head position in a technique called a linear serpentine, which means that the tape moves back and forth longitudinally while the head is indexed up or down laterally at each pass. This technique makes it possible to write multiple distinct tracks in a given data sub-band.

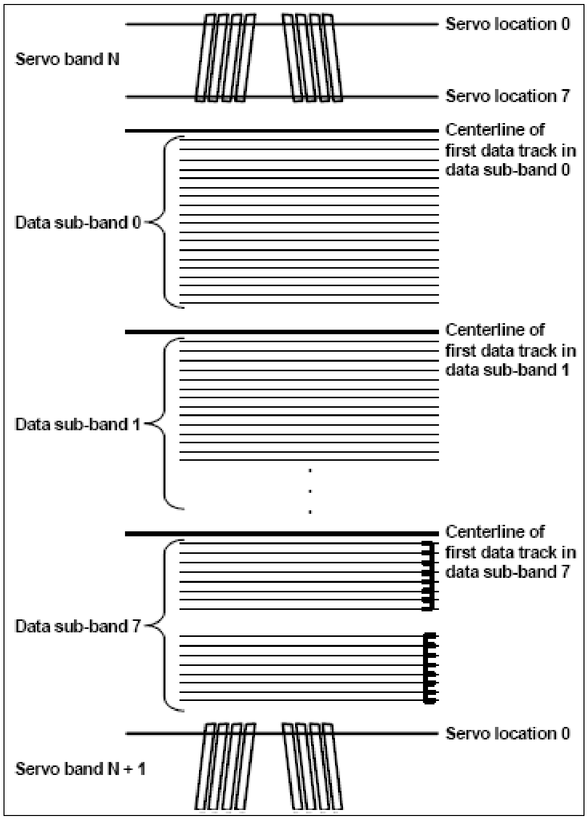


Figure 8-16 Section of tape showing one data band and its surrounding servo bands

8.5 IBM System Storage TS1120 Tape Drive

The IBM System Storage TS1120 Tape Drive (machine type 3592-E05) is the second generation 3592-type drive. It is supported in IBM tape libraries, IBM frames that support stand-alone installation, and in an IBM TotalStorage 3592 Model C20 (3592 C20 frame) attached to a Sun StorageTek 9310 library.

The TS1120 tape drive uses the existing 3592 media, which is available in rewritable or WORM format to store 100 GB, 500 GB, and 700 GB native capacity depending on cartridge media. The 3592 JA/JW media helps reduce resources to lower total costs, whereas the 3592 JJ/JR media is designed to support applications that require rapid access to data.

TS1120 tape drives can be shared among supported open system hosts on a SAN, or between FICON and ESCON mainframe hosts when attached to an IBM System Storage TS1120 Tape Controller Model C06 (TS1120 tape controller). Sharing drives optimizes drive utilization and helps reduce infrastructure requirements. Figure 8-17 shows the TS1120 tape drive. The TS1120 features dual-port 4 Gbps Fibre Channel interfaces.

Figure 8-17 IBM TS1120 tape drive

8.5.1 Highlights

The TS1120 tape drive offers the following features:

- Supports IBM Systems and selected open system platforms
- Supported on existing IBM and Sun StorageTek automation
- Offers native data transfer rate of up to 104 MBps - over 2.5 times as fast as the IBM TotalStorage 3592 Tape Drive and over seven times as fast as the 3590
- Data transfer rate up to 260 MBps with 3:1 compression
- Up to 700 GB native cartridge capacity, a 1.6 times increase over the IBM TotalStorage 3592 Tape Drive and a five times as much as the 3590 H Models
- Supports up to 1.5 TB (uncompressed in a System z9® environment) on a 3592 JA/JW cartridge
- Supports fast access with a 3592 JJ/JR cartridge
- Helps support regulatory compliance requirements for records retention with WORM media
- Stores up to 2.1 TB on a 3592 JB/JX cartridge
- Supports encryption and key management:
  - Supports a single encryption key management approach, which can help reduce audit and compliance costs
  - Helps to avoid the need for host-based encryption of data or the use of specialized encryption appliances

8.5.2 Media support

The TS1120 tape drive can initialize short length JJ cartridges to 60 GB or 100 GB and initialize (or re-initialize) standard length JA cartridges to 60, 100, 300, or 500 GB to support fast access to data or to help address data growth and facilitate interchange. At typical compression ratios, the 3592 JA cartridge can provide usable capacity of up to 1 TB in an open system environment, and up to 1.5 TB in an IBM System z9 environment when used with a TS1120 tape drive.

8.5.3 More information

For additional product details, see the following website:

http://www.ibm.com/systems/storage/tape/drives

8.6 IBM System Storage TS1120 Tape Controller Model C06

The IBM System Storage TS1120 Tape Controller Model C06 (model type 3592-C06) provides performance and reliability for IBM System z customers. The IBM System Storage TS1120 Tape Controller Model C06, has up to four 4 Gbps FICON attachments. The TS1120 Tape Controller also has up to eight ESCON attachments, or an intermix of ESCON and FICON attachments. Up to 16 IBM System Storage TS1120 Tape Drives or IBM TotalStorage 3592 Tape Drives can be attached to a single TS1120 Tape Controller.

8.6.1 Overview

The controller can be installed in an IBM System Storage 3952 Tape Frame Model F05 , an IBM 3953 Tape Frame Model F05, or in a stand-alone rack, supporting 3592 Tape Drives installed in IBM 3494 frames, IBM 3584 frames, IBM 3592 Model C20 frames, and stand-alone racks.

TS1120 tape drives can be shared among supported open system hosts on a Storage Area Network (SAN), or between FICON and ESCON mainframe hosts when attached to an IBM System Storage TS1120 Tape Controller (TS1120 tape controller). Sharing drives optimizes drive utilization and helps reduce infrastructure requirements.

The TS1120 Tape Controller provides up to 1.7 times the throughput of the IBM TotalStorage 3592 Tape Controller Model J70, with 4 Gbps FICON attachment using the 3592 Model J1A Tape Drive.

The TS1120 Tape Controller has many of the reliability and availability characteristics that the 3592 Model J70 offered, such as redundant power supplies with automatic failover and hot swap capabilities, redundant cooling, and support for the IBM TS3000 System Console (TSSC) attachment, previously known as the IBM TotalStorage Master Console (TSMC).

The TS1120 Tape Controller also includes application performance and capacity enhancements that are available with the 3592 Model J70, such as capacity scaling commands. The effect of capacity scaling is to potentially reduce the average locate time to a random record (from load point) to as little as 30% of the normal locate time. Figure 8-18 shows the IBM TS1120 Tape Controller.

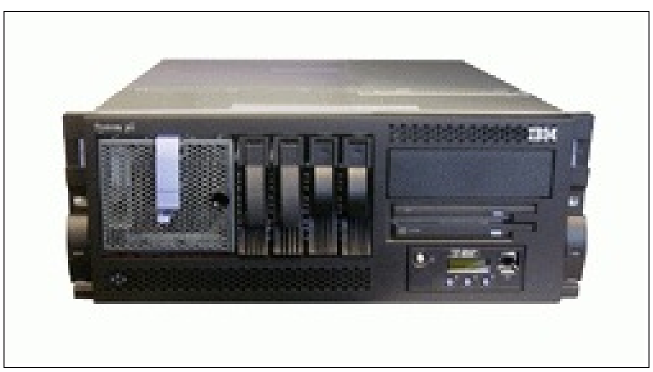


Figure 8-18 IBM TS1120 Tape Controller

8.6.2 Highlights

Here is a summary of IBM System Storage TS1120 Tape Controller features:

- Enables System z attachment for the IBM System Storage TS1120 Tape Drive
- Supports the IBM System Storage TS3400, TS3500, and TotalStorage 3494 Enterprise Tape Libraries, StorageTek 9310 Powderhorn Tape Library; and stand-alone rack and frame environments
- Designed to fully exploit the high performance, capacity, and reliability of the TS1120 tape drive
- Designed to support the 700GB extended capacity, 500GB standard capacity and 100 GB fast-access formats of the IBM 3592 tape cartridges
- Enables tape drive and tape cartridge sharing between ESCON and FICON enabled System z servers
- Supports TS1120 tape drive encryption

8.7 IBM System Storage TS1130 Tape Drive

The IBM System Storage TS1130 Tape Drive (also referred to as the 3592 Model E06 and EU6) is the third tape drive generation of the IBM 3592 tape family (see Figure 8-19). This generation provides higher capacity and performance compared to the predecessor 3592 Model E05.

8.7.1 Overview

The TS1130 records in two recording formats supporting both encryption and non-encryption. Enterprise format 3 (EFMT3) is used to represent the non-encrypted recording format, and enterprise encrypted format 3 (EEFMT3) is used to denote the encrypted recording format. With these recording formats, the non-compressed capacity of the extended length MEDIA9 and MEDIA10 cartridges is increased from 700 GB to 1 TB.

The 3592 Model E06 is downward read compatible (n-2) to the 3592 Model J1A format (EFMT1) and is downward write compatible (n-1) to the 3592 Model E05 formats (EFMT2/EEFMT2). All current media types are supported.

Figure 8-19 Front View of TS1130 Tape

The 3592-E06 supports all of the same subsystems and automation environments as the previous models. The 3592-E06 and 3592 cartridges support multiple automation libraries and can be easily transported between environments (consider the compatibility requirements for silo-attached 3592 tape drives).

The TS1120 tape controller offers ESCON and FICON attachment of TS1130 tape drives in a TS3400, TS3500 or 3494 tape library, 3952 C20 frame or rack to support drives in a 3494 tape library the tape controller must reside in an IBM 3952 Tape Frame Model F05.

To help optimize drive utilization and reduce infrastructure requirements, the TS1130 tape drives can be shared among supported open system hosts on a Storage Area Network (SAN) or between IBM FICON and ESCON mainframe hosts when attached to an IBM System Storage TS1120 Tape Controller.

To further protect mission-critical data, the TS1130 tape drive provides advanced technology, such as error correction code and factory-written servo tracks on the tape cartridge, to provide precise head positioning. In addition, unique functions such as virtual backhitch and a high-resolution directory help improve small file write performance and improve recall access to data, respectively.

The IBM 3592 cartridges used in the TS1130 tape drive are available in short, standard, and extended lengths and in rewritable and WORM formats. Cartridges can be ordered in packs of 20 and can be labeled and initialized, initialized only, or unlabeled and uninitialized. An RFID label option is also available.

8.7.2 Highlights

The following features are included:

- Provides information security with support for encryption and key management
  - Supports a single encryption key management approach, which can help reduce audit and compliance costs
  - Helps to avoid the need for host-based encryption of data or the use of specialized encryption appliances
- Optimizes information retention with support for existing IBM tape automation
- Supports Write Once Read Many (WORM) cartridges to help satisfy compliance requirements
- Offers high performance and high capacity for storage consolidation
- Up to 3 TB on a 3592 JB/JX cartridge:
  - High capacity helps reduce the need for additional tape drives and cartridges
  - Use fewer drives to reduce complexity of your tape infrastructure
- 320 MBps in open system environments where data typically compresses at 2:1
- 350 MBps in a mainframe environment where data typically compresses at 3:1
- Virtual backhitch and high resolution directory which will improve access to data and reduce wear and tear on media
- IBM Power Systems, System i, System p, System z, and System x support

8.8 IBM Midrange and Enterprise Storage Media

There are dedicated tape media for each type of tape drive: LTO, 3592, and 3590. Each drive type only supports its own media; for example, you cannot use an LTO cartridge in a 3592 tape drive. When IBM Tape Library is ordered, it is supplied with one Ultrium data cartridge or one 3592 data cartridge and one cleaning cartridge at no additional charge. Each member of the IBM 35xx and TS3xxx Tape Library family has unique media features and rules that apply when placing the order. Use the following information when ordering additional media.

If you want to order media for your Ultrium, 3590, or 3592 tape drives, go to this website:

http://www.ibm.com/servers/storage/media/distributors/index.html

Select your geographic location and your country, and a list of authorized distributors is presented.

For a tape media compatibility matrix, follow the link:

http://www.ibm.com/systems/storage/media/tape_compatibility.html

8.8.1 LTO cartridge

IBM is delivering high-capacity media that provides clients the ability to meet the demanding growth in data storage. The increase in cartridge capacity reduces the amount of equipment, space, and human intervention required for daily tape operations. In addition, it reduces the number of cartridges needed for backup and restore operations, and helps to lower operational costs throughout the enterprise.

For additional information about IBM LTO media, referred as midrange tape media, see the website:

http://www.ibm.com/systems/storage/media/

The Ultrium cartridge is a single-reel cartridge. This means that the whole tape is wrapped around a single reel when the cartridge is not loaded in a drive. During the loading process, the threader of the drive catches the leader pin of the tape and threads it through the drive and the machine reel. During the read/write process, the tape is stored on the machine reel and the cartridge.

Each generation of Ultrium tape cartridges is manufactured with the different color for easier identification:

- Ultrium LTO1 - black
- Ultrium LTO2 - purple
- Ultrium LTO3 - slate blue, WORM cartridge with platinum or silver bottom
- Ultrium LTO4 - green, WORM cartridge with platinum or silver bottom
- Ultrium LTO5 - red, WORM cartridge with platinum or silver bottom

LTO colors: The colors of LTO Ultrium cartridge shells are somewhat standardized. Nevertheless there are certain manufacturers who do not completely follow that convention. Thus our advice is to only utilize vendors following the same scheme to avoid having a confusing assortment of conflicting colors in your tape library and storage room.

A top and rear view of the tape cartridge is shown in Figure 8-20.

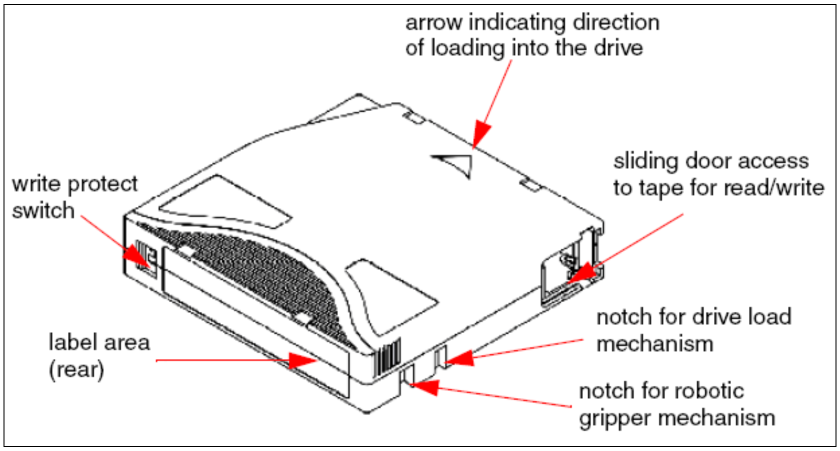


Figure 8-20 Ultrium cartridge view from top and rear

A top and front view of the tape cartridge is shown in Figure 8-21.

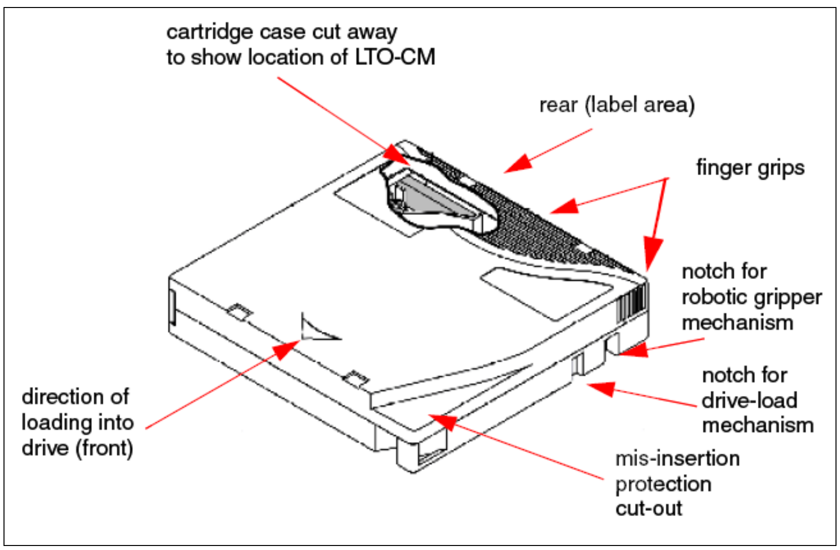


Figure 8-21 Ultrium cartridge view from top and front

IBM TotalStorage LTO Ultrium 100 GB Data Cartridge

This data cartridge offers the following features:

- Provides the capacity, performance, and reliability for midrange and network tape storage environments
- Contains half-inch metal particle tape that features a native data capacity of 100 GB and a compressed data capacity of 200 GB
- Includes a Linear Tape-Open Cartridge Memory (LTO - CM) chip that contains cartridge specific information to communicate with Ultrium tape drives during loading/unloading by a radio frequency component
- Adheres to widely supported Linear Tape-Open (LTO) design specifications

IBM TotalStorage LTO Ultrium 200 GB Data Cartridge

This data cartridge offers the following features:

- Provides capacity, performance and reliability for midrange and network tape automated storage environments
- Contains half-inch metal particle tape; cartridges feature a native data capacity of 200GB and a compressed data capacity of 400GB (2:1 compression)
- Includes a Linear Tape-Open Cartridge Memory (LTO - CM) chip that contains cartridge specific information to communicate with Ultrium tape drives during loading/unloading by a radio frequency component
- Adheres to widely supported Linear Tape-Open (LTO) Ultrium 2 design specifications

IBM TotalStorage LTO Ultrium 400 GB Data Cartridge

This data cartridge offers the following features:

- High-capacity, high-reliability tape cartridge for LTO Generation 3 storage environments
- Provides 400 GB storage physical capacity (800 GB with 2:1 compression)
- Available in rewritable and Write Once Read Many (WORM) cartridge models
- Designed to help improve read/write reliability by storing the IBM statistical media read/write analysis on every use of the cartridge
- Designed to adhere to widely supported Linear Tape-Open (LTO) Ultrium 3 design specifications

IBM TotalStorage LTO Ultrium 800 GB Data Cartridge

This data cartridge offers the following features:

- High-capacity, high-reliability tape cartridge for LTO Ultrium Generation 4 storage environments
- Provides 800 GB storage physical capacity (1.6 TB with 2:1 compression)
- Available in rewritable and write once, read many cartridge (WORM) models
- Data that is encrypted by LTO Ultrium 4 drives can be stored on both rewritable and WORM media to securely maintain data integrity
- Designed to help improve read/write reliability by storing the IBM statistical media read/write analysis on every use of the cartridge when using IBM LTO tape drives

IBM TotalStorage LTO Ultrium 1.5 TB Data Cartridge

This data cartridge offers the following features:

- High-capacity, high-reliability tape cartridge for LTO Ultrium Generation 5 storage environments
- Provides 1.5 TB storage physical capacity (3 TB with 2:1 compression)
- Available in rewritable and write once, read many cartridge (WORM) models
- Data that is encrypted by LTO Ultrium 5 drives can be stored on both rewritable and WORM media to securely maintain data integrity
- Designed to help improve read/write reliability by storing the IBM statistical media read/write analysis on every use of the cartridge when using IBM LTO tape drives

8.8.2 IBM 3590 and 3590E Cartridge

IBM 3590 Extended High-Performance Cartridge Tape continues the IBM focus on tape technology by doubling the length and providing twice the capacity of IBM 3590 High-Performance Cartridge Tape. These tape products increase the data storage capacity of half-inch cartridge tape. In addition, both types of cartridges can reside in the same physical space as IBM 3490 cartridges; they can also coexist in an IBM TotalStorage Enterprise Tape Library 3494.

- Designed to provide outstanding capacity, performance and reliability in 128-track, 256-track or 384-track formats
- Helps protect existing investments by residing in the IBM TotalStorage Enterprise Tape Library 3494 with IBM 3490 cartridges
- Supports flexibility with a choice of native media capacities: 10 GB/20 GB, 20 GB/40 GB, or 30 GB/60 GB

For more information about IBM 3590 media, see the website:

http://www.ibm.com/systems/storage/media/3590/index.html

8.8.3 IBM 3592 Cartridge

IBM 3592 Tape Cartridges are designed to work with the first-generation IBM TotalStorage Enterprise Tape Drive 3592 Model J1A (3592 J1A tape drive) and the second-generation IBM System Storage TS1120 Tape Drive (TS1120 Tape Drive). 3592 tape media can be seen in Figure 8-22.

The 3592-J1A uses four media cartridge types: JA, JJ, JW, and JR. The 3592-E05 and the 3592-E06 use six media cartridge types: JA, JJ, JW, JR, JB, and JX. All six cartridge types contain the same dual-coat, advanced-particle media. Capacity on these media types depends on whether the cartridge is used by Model 3592-J1A, 3592-E05, or 3592-E06.

Cartridges are available in three lengths and in either re-writeable or Write Once, Read Many (WORM) formats. The short length 3592 JJ/JR cartridges provide rapid access to data and the standard length 3592 JA/JW cartridges provide high capacity. The 3592 Extended Data JB and Extended WORM JX 700GB high capacity cartridges support TS1120 tape drives only.

The first-generation 3592 J1A tape drive can initialize short length JJ cartridges to 60 GB and initialize (or re-initialize) standard JA length cartridges to either 60 GB (to support fast time to data) or 300 GB (to support high capacity).

The second-generation TS1120 tape drive can initialize short length JJ cartridges to 60 GB or 100 GB and initialize (or re-initialize) standard length JA cartridges to 60 GB, 100 GB, 300 GB, or 500 GB to support fast access to data or to help address data growth and facilitate interchange. 3592 Extended Data JB cartridges can be initialized to 140 GB for fast access to data, and can be segmented to 609 GB or used at full 700 GB capacity.

Highlights: The following features are included (Figure 8-22):

- Designed for the first generation IBM TotalStorage Enterprise Tape Drive 3592 or the second generation IBM System Storage TS1120 Tape Drive
- Available in rewritable and write once, read many (WORM) cartridge models
- The JJ and JR cartridges provide fast access to application information
- The JA/JW and JB/JX cartridges support high capacity requirements
- Memory chip tracks cartridge and tape drive usage

For more information about IBM 3592 media, see the website:

http://www.ibm.com/systems/storage/media/3592/index.html

Figure 8-22 IBM 3592 Tape Media

8.8.4 More information

Additional information about how the 3592 can be used in your environment can be found in the following materials:

- *IBM System Storage Tape Library Guide for Open Systems*, SG24-5946
- *IBM TotalStorage 3494 Tape Library: A Practical Guide to Tape Drives and Tape Automation*, SG24-4632

9

IBM Tape Automation products

In this chapter, we describe the IBM Midrange and Enterprise Tape Automation products, which provide the highest levels of performance and reliability of any IBM tape subsystem.

The chapter covers the following products:

- IBM System Storage:
  - IBM System Storage TS2900 Tape Autoloader Express
  - IBM System Storage TS3100 Tape Library
  - IBM System Storage TS3200 Tape Library
  - IBM System Storage TS3400 Tape Library
  - IBM System Storage TS3310 Tape Library
  - IBM System Storage TS3500 Tape Library
- IBM TotalStorage 3593 Tape System:
  - The TS7740 includes the functionality of the previously required IBM 3593 Tape System consisting of one or more frames and the Library Manager.
  - The 3953 Tape System is still required for attachment of TS1100 tape drives installed in the TS3500 Tape Library and connected to a System z host through tape controllers.
- Other models:
  - IBM TotalStorage 3581 Tape Autoloader: The IBM TotalStorage 3581 Tape Autoloader has been replaced by the IBM System Storage TS3100 Tape Library Express Model.
  - IBM TotalStorage 3582 Tape Library: The IBM TotalStorage 3582 Tape Library has been replaced by the IBM System Storage TS3200 Tape Library Express Model.
  - IBM TotalStorage 3583 Tape Library: The IBM TotalStorage 3583 Tape Library has been replaced by the IBM System Storage TS3310 Tape Library.
  - IBM TotalStorage 3584 Tape Library: The IBM TotalStorage 3584 Tape Library is known as IBM System Storage TS3500 Tape Library. The TS3500 is offered as an alternative to the IBM TotalStorage 3494 Tape Library.

9.1 Valuable IBM tape library features

With continued development of IBM tape products, device drivers, and management tools, various new features and components have been introduced by IBM. Here we describe the most important of these.

9.1.1 IBM High Density function

The IBM High Density function of specific IBM System Storage tape libraries and expansion frames is the IBM patented technology that allows multiple cartridges to be stored in a tiered architecture. The depth of a cartridge location in a high-density slot is known as a tier. High-density slots are designed to contain multiple cartridges in up to 5 tiers depending on type and the model of tape library or expansion module.

Here is how it works. Each column has a spring-loaded mechanism that pushes a tape cartridge into Tier 1 when it is the only cartridge in that column. A single cartridge in a column takes on the Tier 2 (or higher) element address even though it is physically located in Tier 1. A storage element address is assigned to each cartridge at the time the cartridge is inserted into the library. Figure 9-1 illustrates the basic principle of the IBM High Density feature.

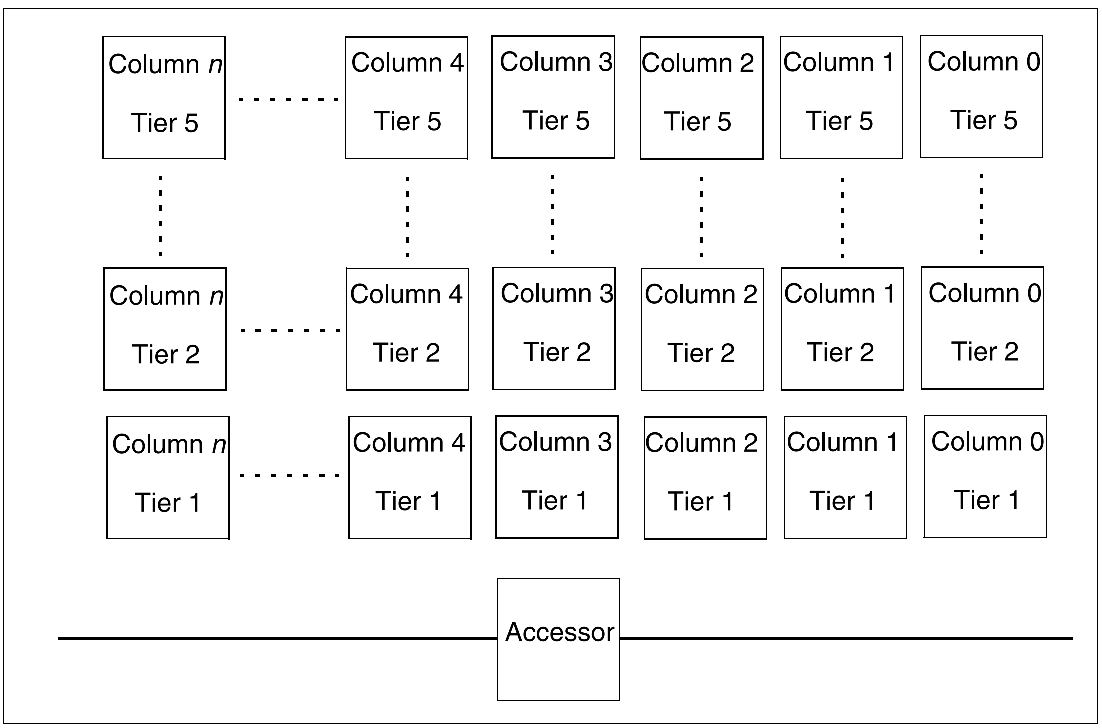


Figure 9-1 The principle of the IBM High Density feature

As might be expected, the IBM High Density feature is used in very large enterprise business tape solutions. This significantly reduces the overall tape library footprint within the data centers and increases the total capacity of the tape solution for a reasonable price.

We pay special attention to the IBM High Density feature in 9.8, “IBM System Storage TS3500 Tape Library” on page 330. We further describe the IBM System Storage TS3500 Tape Library as an enterprise tape storage solution using base control frame (Lx3) in configuration with High Density expansion frames (S24 and S54).

Caution: The HD slots have a constant force spring for maintaining forward pressure on the tape cartridges. Therefore, use caution when inserting or removing cartridges into or from the HD slots.

9.1.2 SNMP Messaging and SNMP traps

Occasionally, the tape library might encounter a situation that you want to know about, such as an open magazine or library door or a fault that causes the library to stop. IBM tape libraries provide a standard TCP/IP protocol called Simple Network Management Protocol (SNMP) to send alerts about conditions (such as a need for operator intervention) over a TCP/IP LAN network to an SNMP monitoring station. These alerts are called *SNMP traps*. Using the information supplied in each SNMP trap, the monitoring station (together with customer-supplied software) can alert operations personnel of possible problems or operator interventions that occur.

SNMP traps are alerts or status messages that can be collected, monitored and used to proactively manage attached libraries using SNMP protocol with the SNMP monitoring station(s). In summary, each trap provides the following information:

- *Product Identification* such as product name, description, manufacturer, model number, firmware level, and the URL that the trap is designated for.
- *Product Status* such as the severity of the trap, status (current and previous) and the time the trap occurred.
- *Library State* (physical device status) such as identification and status of devices that are monitored. In the case of the library, it includes enclosure, power supply, controller, magazine status, drive count, cartridge slot count, and I/O station count. Also included are certain library statistics, and where appropriate, the fault symptom code (FSC) including the severity and description of that fault.
- *Drive Status* such as the identification of each drive in the library, firmware level, serial number and other address and status information.
- *Trap Definitions* such as library status change, open magazine, I/O accessed, hard fault information, drive cleaning requests, excessive retries and library returning to normal operations.
- *The library's Management Information Base* (MIB) contains units of information that specifically describe an aspect of the system, such as the system name, hardware number or communications configuration

See the principal diagram of the SNMP configuration in Figure 9-2.

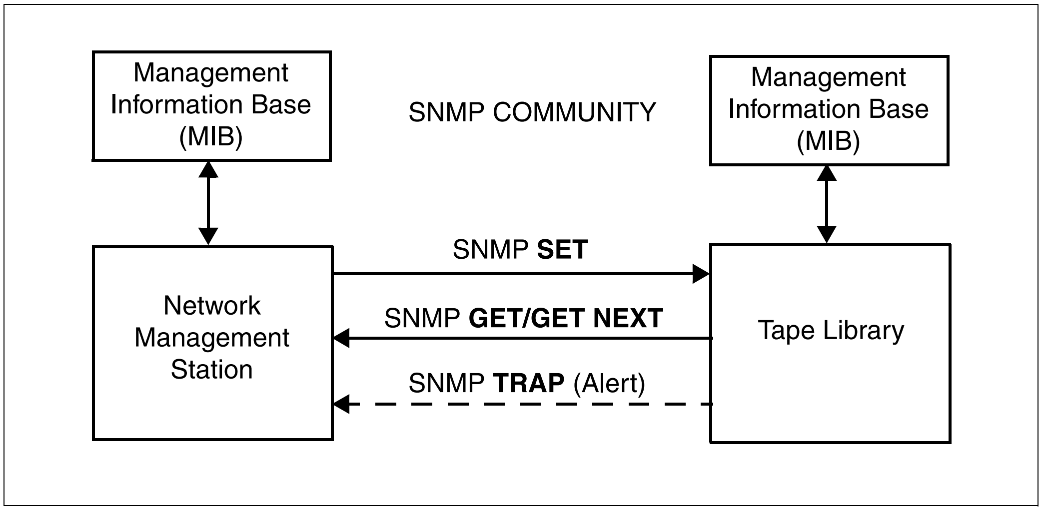


Figure 9-2 SNMP Community and its functions

9.1.3 Control Path and Data Path failover

Here we present a brief overview of the Control Path and Data Path failover.

Control Path Failover

This feature, currently available for AIX, Linux, Solaris, HP-UX, and Windows hosts, configures multiple physical control paths to the same logical library within the device driver and provides automatic failover to an alternate control path when a permanent error occurs on one path. This is transparent to the running application.

For example, consider a simple multi-path architecture connection consisting of two HBAs in a host that are connected to a library with two or more drives. Two drives have the control ports enabled. The two HBAs are connected to the first and second control port drives, respectively. This simple configuration provides two physical control paths to the library for redundancy if one path from an HBA to the library fails. When the server boots, each HBA detects a control port to the library, and two medium changer devices (in AIX smc0 and smc1) are configured. Each logical device is a physical path to the same library; however, an application can open and use only one logical device at a time, either smc0 or smc1.

When the alternate pathing support is enabled on both smc0 and smc1, the device driver configures them internally as a single device with multiple paths. The application can still open and use only one logical device at a time (either smc0 or smc1). If an application opens smc0 and a permanent path error occurs, the current operation continues on the alternate path without interrupting the application.

Requirements: Control path failover can work only with IBM tape libraries containing at least two tape drives. The license key needs to be ordered separately and the appropriate host device driver is crucial.

Data Path Failover

This function provides a failover mechanism in the IBM device driver, so that you can configure multiple redundant paths in a SAN environment. If a path or component fails, the failover mechanism is designed to provide automatic error recovery to retry the current operation using an alternate, preconfigured path without stopping the current job in progress. This improves flexibility in SAN configuration, availability, and management.

When accessing a tape drive device that has been configured with alternate pathing across multiple host ports, the IBM device driver automatically selects a path through the HBA that has the fewest open tape devices and assigns that path to the application. This autonomic, self-optimizing capability is called *load balancing*.

The dynamic load balancing support is designed to optimize resources for devices that have physical connections to multiple HBAs in the same machine. The device driver is designed to dynamically track the usage on each HBA as applications open and close devices, and balance the number of applications using each HBA in the machine. This can help optimize HBA resources and improve overall performance. Further, the data path failover provides autonomic self-healing capabilities similar to control path failover, with transparent failover to an alternate data path in the event of a failure in the primary host-side path.

Data Path Failover is enabled automatically when Control Path Failover license keys are installed within the supported IBM tape libraries and the appropriate device drivers are correctly configured on the host machine.

9.2 Overview of available tape libraries

IBM System Storage provides a complete spectrum of tape libraries highlighting high performance and capacity for entry, midrange and enterprise systems. The IBM libraries handle backups, save and restore, and archival data storage needs with minimal or even none manual intervention of on-site personnel.

9.2.1 IBM System Storage TS2900 Autoloader

The IBM System Storage TS2900 Tape Autoloader is a single-drive, low profile automated tape solution and the first entry automation solution for small- to mid-market tape environments. The TS2900 utilizes the technology of IBM half-high LTO tape drives to help create a high-capacity tape storage solution suited for handling backup and archival data storage for the Windows, Linux and other open system environments. The TS2900 is available with IBM HH LTO 3 or HH LTO 4 tape technology for a reliable, low entry-priced solution.

9.2.2 IBM System Storage TS3100 Tape Library

The IBM System Storage TS3100 Tape Library is well-suited for handling backup, save and restore, and archival data-storage needs for small to medium-size environments. It has a single Ultrium 3 tape drive and 22 tape-cartridge capacity.

9.2.3 IBM System Storage TS3200 Tape Library

The IBM System Storage TS3200 Tape Library is designed for backup, save and restore, and archival data-storage needs for small to medium-size environments. The TS3200 is an external 4U stand-alone or rack-mountable unit that incorporates up to two Ultrium 3 tape drives and 44 tape cartridges, as well as 3 media mail slots and 1 dedicated cleaning cartridge slot.

9.2.4 IBM System Storage TS3400 Tape Library

The IBM System Storage TS3400 Tape Library offers the high capacity and performance advantage of the IBM System Storage TS1130 or TS1120 Tape Drives in a smaller automation footprint for IBM Power Systems, System x, System z and other open systems environments.

9.2.5 IBM System Storage TS3500 Tape Library

The IBM System Storage TS3500 Tape Library combines IBM automation and drive technology to provide a highly scalable, automated tape library for System z and open systems backup and archive in midrange to enterprise environments.

9.2.6 IBM System Storage TS3310 Tape Library

The IBM System Storage TS3310 Tape Library offers simple, rapid expansion as processing needs grow. Its entry-level configuration is a single 5 EIA rack unit high library. Over time, as the need for tape backup expands, you can add an additional 9U expansion module, with space for additional cartridges, tape drives and a redundant power supply.

9.2.7 IBM TotalStorage 3494 Tape Library

The IBM TotalStorage 3494 Tape Library is not available for purchase. The IBM System Storage TS3500 Tape Library is being offered as an adequate replacement in enterprise storage solutions.

9.3 IBM System Storage TS2900 Tape Autoloader Express

The IBM System Storage TS2900 Tape Autoloader (Machine Type 3572) provides compact high capacity, low-cost solutions for simple unattended data backup. The library has a compact 1U form factor with easy access to tape cartridges by a removable magazine. The IBM System Storage TS2900 Tape Autoloader is an external stand-alone or rack-mountable unit that incorporates an IBM Ultrium 3 or Ultrium 4 Half-High Tape Drive. It is equipped with a Serial Attached SCSI (SAS) host adapter attachment that has a data transfer rate of up to 3 Gbps. See Figure 9-3.

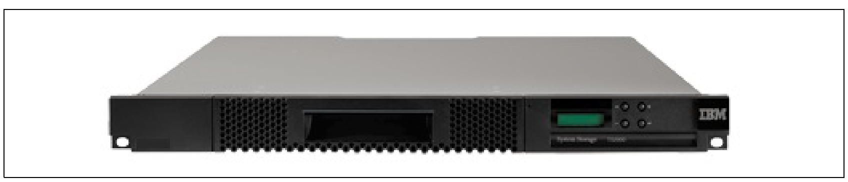


Figure 9-3 IBM System Storage TS2900 Tape Autoloader Express

The IBM System Storage TS2900 Tape Autoloader has a removable cartridge magazine providing nine data cartridge slots, including a configurable two slot I/O station. IBM System Storage TS2900 Tape Autoloader is an entry point for IBM Linear Tape-Open (LTO) tape automation. This autoloader uses the IBM patented high density (HD) slot technology.

The cartridges supported in the IBM System Storage TS2900 Tape Autoloader include these:

- IBM LTO Tape Cartridge Ultrium 4 (800 GB native physical capacity)
- IBM LTO Tape Cartridge Ultrium 3 (400 GB native physical capacity)
- IBM LTO Tape Cartridge Ultrium 2 (200 GB native physical capacity)
- WORM cartridges

Notice that cartridge support is dependent on the tape drive that is installed in the IBM System Storage TS2900 Tape Autoloader. Only the cartridge types supported by the LTO3 or LTO4 drive that is installed are supported in the TS2900.

The library media capacity can be further increased by using hardware compression (2:1 compression factor). The library supports the movement of any media generation in any slot or drive. It is set in the host application to limit any operations that might result in unsupported media issues.

The TS2900 has a 3 Gbps single-port SFF-8088 SAS connector. This is the same connector for all of the other IBM tape products that support the SAS interface. The drive is integrated into the library. There is no drive field-replaceable unit (FRU) or client-replaceable unit (CRU), because the entire library is a CRU.

Designed for tape automation, The TS2900 supports 3 Gbps attachment to IBM Power Systems, IBM System x, Intel and other open systems server platforms. To determine the latest supported servers, see the website:

http://www.ibm.com/systems/storage/tape/

Requirements: The TS2900 Tape Autoloader uses a single SCSI ID and dual LUNs to control the tape drive (LUN 0) and library accessor (LUN 1). The library requires a Host Bus Adapter (HBA) that supports LUN scanning. If it is not enabled, your host system will not scan beyond LUN 0 and will fail to detect the library. It will only see the tape drive. See the IBM System Storage Interoperation Center (SSIC) to determine the supported adapters:

http://www.ibm.com/systems/support/storage/config/ssic

The IBM Ultrium 4 LTO Tape Drive with a Fibre Channel or a SAS interface is encryption-capable. The IBM LTO4 Tape Drive supports Application-Managed Encryption (AME), System-Managed Encryption (SME), and Library-Managed Encryption (LME). However, SME and LME require an additional license key that can be purchased using Feature Code 5901. Remember that the IBM Ultrium 3 LTO Tape drive does not support encryption at all.

9.3.1 TS2900 features

These are the features of the IBM System Storage TS2900 Tape Autoloader Express Model:

- IBM Half-high LTO 4 supports the encryption of data for increased security with archived data
- Supports HH LTO 3 or HH LTO4 tape technology from IBM with 3 Gbps SAS interface
- A single I/O station to help support continuous library operation
- Removable magazine to facilitate the offsite relocation of media and archival data
- Features IBM half-high LTO technology designed for reliable performance and low power consumption
- HH LTO 3 tape drives can read and write to LTO 2 Media and read LTO 1 media; HH LTO 4 tape drives can read and write to LTO 3 media and read LTO 2 media
- Supports LTO3 and LTO4 WORM media
- Bar code reader allows the synchronous or random access to the media cartridges
- Adheres to LTO specifications
- User-friendly Web User Interface helps to manage TS2900 remotely

9.3.2 TS2900 specifications

Table 9-1 summarizes the capabilities of the IBM System Storage TS2900 Tape Library.

Table 9-1 IBM System Storage TS2900 Tape Autoloader Express

Model	**IBM System Storage TS2900 Tape Autoloader Express**
Drive options	Ultrium 3 Half high: 3 Gbps SAS Ultrium 4 Half high: 3 Gbps SAS
Optional Feature codes	N/A
Tape drive type	IBM LTO Ultrium 3 Half-Height and Full Height IBM LTO Ultrium 4 Half-Height and Full Height
Number of drives	1
Number of tape cartridges	9
Number of mail slots	1
Physical capacity	LTO 3: Up to 3.6 TB (7.2 TB with 2:1 compression) LTO 4: Up to 7.2 TB (14.4 TB with 2:1 compression)
Data transfer rate	LTO3: Up to 60 MBps LTO4: Up to 120 MBps
Attachment and systems support	The TS2900 supports 3 Gbps attachment to IBM Power Systems, IBM System x, Intel and other open systems server platforms.

For more information about the IBM System Storage TS2900 Tape Autoloader Express, see the *IBM System Storage Tape Library Guide for Open Systems*, SG24-5946.

For specific details, setup, and operations help, see the website:

http://www.ibm.com/support/docview.wss?uid=ssg1S7002729

9.4 IBM System Storage TS3100 Tape Library Express Model

The IBM System Storage TS3100 Tape Library provides compact, high-capacity, low-cost solutions for simple, unattended data backup. With the use of one LTO Full Height tape drive or up to two LTO Half-Height tape drives and 24 tape cartridge capacity, the IBM TS3100 is designed to take advantage of LTO technology to cost-effectively handle growing storage requirements. The TS3100 Tape Library is configured with two removable cartridge magazines, one on the left side (12 data cartridge slots) and one on the right (12 data cartridge slots). Additionally, the left magazine includes a single I/O station slot to help support continuous library operation while importing and exporting media.

Figure 9-4 IBM System Storage TS3100 Tape Library

The IBM System Storage TS3100 Tape Library Express Model comes as driveless product adaptable to the customers' business and backup solution needs. Customers have an option to purchase one of the following configurations:

- Single Ultrium 5 Full Height tape drive - 6 Gbps SAS or 8 Gbps FC interface
- Up to two Ultrium 5 Half Height tape drives - 6 Gbps SAS or 8 Gbps FC interface
- Single Ultrium 4 Full Height tape drive - 3 Gbps SAS, 4 Gbps FC, or LVD SCSI port
- Up to two Ultrium 4 Half Height tape drives - 3 Gbps SAS or 4 Gbps FC interface
- Up to two Ultrium 3 Half Height tape drives - 3 Gbps SAS interface

Although the IBM Ultrium 4 tape drives are still available for purchase with the Ultra160 SCSI interface, we do not advise using them, because the technology benefits of IBM Ultrium 4 performance parameters are not optimally utilized. IBM Ultrium 3 tape drives are available only in the Half-Height model.

We also strongly suggest to avoid a combination of two Ultrium Half Height tapes drives of different generation because this might cause unlikely complications during their configuration on host machines and in the backup applications. Definitely, refrain from mixing the Ultrium media generations within the same IBM TS3100 Tape Library.

9.4.1 TS3100 features

These are the features for the IBM System Storage TS3100 Tape Library Express Model:

- IBM LTO Ultrium 5, Ultrium 4, or Ultrium 3 in either full or half height dispositions
- Support for 8 Gbps Fibre Channel, 6 Gbps LVD Serial SCSI (SAS) attachment
- Ultrium data rates and capacities:
  - Ultrium 5 native data rate of up to 140 MBps
  - Ultrium 4 native data rate of up to 120 MBps
  - Ultrium 3 native data rate of up to 60 MBps
  - Ultrium 5 native data capacity up to 36 TB (72 TB with 2:1 compression)
  - Ultrium 4 native data capacity up to 19.2 TB (38.4 TB with 2:1 compression)
  - Ultrium 3 native data capacity up to 9.6 TB (19.2 TB with 2:1 compression)
- 2U form factor with 24 data-cartridge slots split by 12 into left and right magazines
- A single input/output station (I/O) slot on the left cartridge magazine providing import/export facilities for cartridges, without interrupting library operation
- Sequential or random access mode with a standard bar-code reader
- Operator front control panel contains power button, front panel LEDs, control keys, and the operator control panel display
- Remote library management through a user-friendly web interface

9.4.2 TS3100 specifications

Table 9-2 summarizes the capabilities of the IBM System Storage TS3100 Tape Library.

Table 9-2 IBM System Storage TS3100 Tape Library Express specifications

Model	**TS3100 Tape Library Express**
Drive options	Ultrium 5 Full Height: 6 Gbps SAS (46X2683); 8 Gbps FC (46X2682) Ultrium 5 Half-Height: 6 Gbps SAS (46X2685); 8 Gbps FC (46X2684) Ultrium 4 Full Height: 3 Gbps SAS (95P5006); 4 Gbps FC (95P5004) Ultrium 4 Half-Height: 3 Gbps SAS (45E2243) Ultrium 3 Half-Height: 3 Gbps SAS (95P5000)

Optional feature codes	Transparent LTO Encryption 45E3081 Rack mount 23R6998 Right-side magazine set 23R6999 Left-side magazine 45E2237 Ultrium Tape Cartridges Ultrium 4 media: 95P4278 Ultrium Cleaning Cartridge 23R7008
Tape drive type	IBM LTO Ultrium 5 Half-Height and Full Height IBM LTO Ultrium 4 Half-Height and Full Height IBM LTO Ultrium 3 Half-Height
Number of drives	1 Full Height or 2 Half-Height
Number of tape cartridges	24
Number of I/O slots	1
Physical capacity	Up to 3 TB per cartridge compressed; 1.5 TB native with LTO5 Up to 1.6 TB per cartridge compressed; 800 GB native with LTO4 Up to 800 GB per cartridge compressed; 400 GB native with LTO3 Up to 72 TB per tape library compressed; 36 TB native (LTO5) Up to 38.4 TB per tape library compressed; 19.6 TB native (LTO4) Up to 19.2 TB per tape library compressed; 9.6 TB native (LTO3)
Data transfer rate	Up to 140 MBps native with LTO Ultrium 5 Up to 120 MBps native with LTO Ultrium 4 Up to 60 MBps native with LTO Ultrium 3
Attachment and systems support	8 Gbps Fibre Channel and 6 Gbps SAS interfaces, attaching to IBM Power Systems, IBM System x, HP-UX, Sun Solaris, UNIX, Linux and Windows servers and non-IBM servers, workstations and personal computers that support the interface specifications.

For the most up to date and detailed operating system and attachment requirements, see:

http://www.ibm.com/systems/support/storage/config/ssic

For more information about the IBM System Storage TS3100 Tape Library, see the *IBM System Storage Tape Library Guide for Open Systems*, SG24-5946, at the website:

For more technical information, see the *IBM System Storage TS3100 Tape Library and TS3200 Tape Library Setup, Operator and Service Guide*, GA32-0545-07, at the website:

http://www.ibm.com/support/docview.wss?uid=ssg1S7003237

9.5 IBM System Storage TS3200 Tape Library

Just like the IBM System Storage TS3100 Tape Library, the IBM System Storage TS3200 Tape Library is a dual or single drive tape library, offering high capacity and performance technology for the midrange environments. The TS3200 Tape Library is an external 4U stand-alone or rack-mountable unit that incorporates up to two Full Height Linear Tape-Open (LTO) IBM TotalStorage Ultrium 5, Ultrium 4, or tape drives or up to four Half-Height tape drives of the Ultrium 5, Ultrium 4, and Ultrium 3 generation.

The IBM System Storage TS3200 Tape Library Express Model is an excellent tape storage solution for organizations with existing digital linear tape or requiring high-performance automated tape backup. The TS3200 is also designed for organizations that have limited physical space in their IT environments.

Operating in a rack environment allows organizations to take the advantage of placing the TS3200 in a standard 19-inch rack, which provides up to 144 TB of compressed tape storage in just a 4U space. Remote management and a barcode reader are standard components of the library, and it can run in sequential or random access mode. Optional available features are rack mount kit, additional power supply, and Control and Data Path Failover.

The TS3200 has IBM patented Multi-Path Architecture for sharing the library robotics. This allows a library with at least two drives to be partitioned into two logical libraries, for sharing between servers and/or applications.

Figure 9-5 shows the IBM System Storage TS3200 Tape Library.

Figure 9-5 IBM System Storage TS3200 Tape Library

The IBM System Storage TS3200 Tape Library (model 4UL) comes as a driveless product adaptable to the customers' business and backup solution needs. The following configurations are available for purchase:

- Up to two Ultrium 5 Full Height tape drive - 6 Gbps SAS or 8 Gbps FC interface
- Up to four Ultrium 5 Half Height tape drives - 6 Gbps SAS or 8 Gbps FC interface
- Up to two Ultrium 4 Full Height tape drive - 3 Gbps SAS, 4 Gbps FC, or LVD SCSI port
- Up to four Ultrium 4 Half Height tape drives - 3 Gbps SAS or 4 Gbps FC interface
- Up to four Ultrium 3 Half Height tape drives - 3 Gbps SAS interface

9.5.1 TS3200 features

These are the main features of the IBM System Storage TS3200 Tape Library:

- Designed to support the new IBM Linear Tape-Open (LTO) Ultrium 5 Half-High (HH) Tape Drive, to help to increase the capacity and performance with 8 Gbps Fibre Channel interface or 6 Gb Serial Attached SCSI (SAS) attachments
- 4U form factor with 48 cartridge slots, four removable magazines, including a three-slot I/O station
- Sequential or random access mode with a standard barcode reader
- Front panel, which integrates the power button, front panel LEDs, control keys, and the operator control panel display, for direct library management
- Remote library management through a web interface
- Transparent data encryption using IBM Ultrium 4 and Ultrium 5 tape drives
- Control Path and Data Path Failover as a licensed feature
- Tape library partitioning to address application needs

9.5.2 TS3200 specifications

Table 9-3 shows the specifications of the TS3200.

Table 9-3 IBM System Storage TS3200 Tape Library specifications

Model	**Type 3573 Models L4U, L3H, F3H**
Drive options	Ultrium 5 Full Height: 6 Gbps SAS (46X2683); 8 Gbps FC (46X2682) Ultrium 5 Half-Height: 6 Gbps SAS (46X2685); 8 Gbps FC (46X2684) Ultrium 4 Full Height: 3 Gbps SAS (95P5006); 4 Gbps FC (95P5004) Ultrium 4 Half-Height: 3 Gbps SAS (45E2243) Ultrium 3 Half-Height: 3 Gbps SAS (95P5000)
Optional feature codes	Path Failover 45E9503 Transparent LTO Encryption 45E3081 Rack mount 23R6998 Right-side magazine set 23R6999 Left-side magazine, upper 45E2225 Left-side magazine, lower 45E2231 Ultrium Cleaning Cartridge 23R7008 Additional Power Supply23R7263
Tape drive type	IBM LTO Ultrium 5 Full Height and Half-Height IBM LTO Ultrium 4 Full Height and Half-Height IBM LTO Ultrium 3 Half-Height
Number of drives	1-4
Number of tape cartridges	48
Number of I/O slots	3
Physical capacity	Up to 3 TB per cartridge compressed; 1.5 TB native with LTO5 Up to 1.6 TB per cartridge compressed; 800 GB native with LTO4 Up to 800 GB per cartridge compressed; 400 GB native with LTO3 Up to 144 TB per tape library compressed; 72 TB native (LTO5) Up to 76.8 TB per tape library compressed; 38.4 TB native (LTO4) Up to 38.4 TB per tape library compressed; 19.2 TB native (LTO3)
Data transfer rate	Up to 140 MBps native with LTO Ultrium 5 Up to 120 MBps native with LTO Ultrium 4 Up to 60 MBps native with LTO Ultrium 3
Attachment and systems support	8 Gbps Fibre Channel and 6 Gbps SAS interfaces, attaching to IBM Power Systems, IBM System x, HP-UX, Sun Solaris, UNIX, Linux and Windows servers and non-IBM servers, workstations, and personal computers that support the interface specifications.

For the most up to date and detailed operating system and attachment requirements, see this website:

http://www.ibm.com/systems/support/storage/config/ssic

For more information about the IBM System Storage TS3200 Tape Library, see the *IBM System Storage Tape Library Guide for Open Systems*, SG24-5946.

For more technical information, see the IBM System Storage TS3100 Tape Library and TS3200 Tape Library Setup, Operator and Service Guide, GA32-0545-07, at the website:

http://www.ibm.com/support/docview.wss?uid=ssg1S7003237

9.6 IBM System Storage TS3400 Tape Library

The IBM System Storage TS3400 Tape Library offers the high capacity and performance advantage of the IBM System Storage TS1130 or TS1120 Tape Drives in a smaller automation footprint for IBM Power Systems, System x, System z, and other open systems environments (see Figure 9-6).

The TS3400 tape library is an external 5U stand-alone or rack-mountable unit supporting one or two TS1130 tape drives or one to two TS1120 tape drives.

The IBM System Storage TS1130 Tape Drive has a native capacity of 1000 GB (1.0 TB) when using the IBM 3592 Extended Data Cartridge (JB), or 640 GB when using the IBM 3592 Enterprise Cartridge (JA). The IBM TS1130 Tape Drive has a dual-ported switched fabric 4 Gbps Fibre Channel attachment and a data transfer rate of up to 160 MBps per drive.

The IBM System Storage TS1120 Tape Drive has a native capacity of 700 GB when using the IBM Extended Data Cartridge (JB), or 500 GB when using the IBM Data Cartridge (JA). The IBM System Storage TS1120 Tape Drive has a native rate of up to 104 MB/s. The IBM System Storage TS1120 Tape Drive has a dual-ported switched fabric 4 Gbps Fibre Channel attachment. The tape drives must be ordered separately with the final order.

The IBM System Storage TS3400 Tape Library supports the IBM TS1120 and the TS1130 built-in encryption capabilities. The supported encryption methods are Application-Managed Encryption (AME), System-Managed Encryption (SME), and Library-Managed Encryption (LME).

The TS3400 tape library has two removable cartridge magazines, providing 18 data cartridge slots. Up to three slots can be used for I/O slots, and up to two slots can be used as cleaning cartridge slots. The TS3400 tape library provides a media capacity of up to 18 cartridges, allowing for up to 18TB of storage (54 TB with 3:1 compression) when using 1 TB extended capacity cartridges.

Remote management by a web browser allows you to communicate directly with the library and perform a wide range of end user, operator and administrator tasks without being at the operator panel. To take further advantage of your investment, you can partition the library into two logical partitions to share the library between various applications. To support continued processing, the TS3400 tape library is equipped with control path and datapath failover.

Figure 9-6 IBM System Storage TS3400 Tape Library

9.6.1 TS3400 features

These are the features for the IBM System Storage TS3400 Tape Library:

- Support for TS1130 or TS1120 tape drives in a small form factor
- Support for 1 to 2 TS1130 or TS1120 tape drives
- Native data rate of up to 160 MB per drive
- Capacity for growth up to 18 TB in a 5U form factor
- Media capacity of up to 18 TB (54 TB with 3:1 compression)
- Control path and data path automatic failover:
  - Enhances the autonomic capabilities of the library
  - Designed to improve the reliability of your backup processes
- Support for IBM tape drive encryption:
  - Helps secure sensitive at-rest data
  - Built-in encryption designed to prevent performance drain on host systems

For latest information about the TS3400, see this website:

http://www.ibm.com/systems/storage/tape/ts3400/index.html

You can download the latest *IBM System Storage TS3400 Tape Library Planning and Operator Guide* at the following website:

http://www.ibm.com/support/docview.wss?uid=ssg1S7001767

9.6.2 TS3400 specifications

Table 9-4 summarizes the capabilities of the IBM System Storage TS3400 Tape Library.

Table 9-4 IBM System Storage TS3400 Tape Library Specifications

Model	IBM System Storage TS3400 Tape Library
Tape Drive	TS1130 or TS1120 tape drives
Number of Drives	Up to 2, no intermix of TS1130 and TS1120
Number of Tape Cartridges	18
Number of Input/Output slots	3
Number of Logical Libraries	2
Capacity	Up to 18 TB native capacity (54 TB with 3:1 compression)
Data Transfer Rate	Up to 320 MBps
Media Type	IBM 3592 JA/JB/JJ and JW/JR/JX Write Once Read Many (WORM) cartridge
Platform/Operating System Supported	IBM System i i5/OS, IBM i System p AIX and Linux System x See open systems support System z IBM z/OS, IBM VSE and Linux Power Systems AIX, IBM i, Linux

9.7 IBM System Storage TS3310 Tape Library

Designed around a 5U high modular base library unit, the TS3310 is tailored to scale vertically with expansion for LTO tape cartridges, drives, and redundant power supplies. The base library module, model L5B, is the entry point for the product family. It contains all of the necessary robotics and intelligence to manage the 5U high library system, which houses up to 41 cartridges (35 storage slots and 6 Input/Output slots) and up to two LTO Ultrium 5, Ultrium 4, or Ultrium generation 3 tape drives.

Each expansion unit E9U contains 92 physical LTO cartridge storage cells and space for up to four additional tape drives; we strongly advise the same Ultrium generation as in the base module, unless the tape library is partitioned and each logical library follows different business requirements, thus a different generation of IBM Ultrium tape drives. Additionally, the E9U has space for up to two (one redundant) power supply modules. (At least one power supply module must be installed if a drive is present in the E9U.)

Furthermore, each expansion unit E9U has built-in 12 I/O station slots, which can be either disabled (then become as common storage slots) or enabled. For example, base module L5B and one expansion unit E9U offers 3 different configurations of I/O station - 6 slots (enabled only L5B), 12 I/O slots (enabled only E9U), or 18 I/O slots (enabled both L5B and E9U). The overall storage capacity of TS3310 can vary, depending on configuration of I/O stations in each module. The required configuration can be done remote using user-friendly Web User Interface. In addition to the local authentication it offers the possibility to use LDAP authentication services to address security requirements for automated user account controls (for example, Quarterly Employee Verification - QEV and Continuous Business Need - CBN).

Figure 9-7 shows the IBM TS3310 base L5B unit with one expansion module. On the right side of each module, you can see the I/O station door (6 slots in base L5U, 12 slots in E9U).

Figure 9-7 IBM System Storage TS3310 Tape Library - Base and Expansion

For organizations unsure of their short or long term tape capacity needs, the TS3310 Tape Library's Capacity on Demand (COD) capability allows the system to scale as needs grow. In the initial shipped configuration, an E9U has half of its storage cells enabled. As your business grows, the purchase of a capacity on demand key allows you to enable the second half of the model E9U storage cells.

The TS3310 supports either the standard or WORM LTO data cartridge and continued support for encryption of data with LTO 4 and LTO 5 tape drives. IBM Tivoli Key Lifecycle Manager V1 (TKLM) is required for encryption key management with Ultrium 5 drives. A key path diagnostic function is also available to assist administrators with the setup, configuration, or troubleshooting of encryption enabled libraries.

This library supports LTO Ultrium 5 native switched fabric Fibre Channel attachment and LTO Ultrium 4 Tape Drives with either Serial Attached SCSI (SAS) or native switched fabric Fibre Channel attachment for connection to a wide spectrum of open system servers. It also supports LTO Ultrium 3 Tape Drives with either LVD Ultra160 SCSI or native switched fabric Fibre Channel attachment.

9.7.1 TS3310 features

These are the features for the IBM System Storage TS3310 Tape Library:

- TS3310 is a modular, scalable library, 123 TB up to 1.2 PB (2:1 compression) (35 to 409 LTO storage slots):
  - From 2 to 18 hot-swappable Full Height tape drives Ultrium 3 - Ultrium 5
  - Vertical expansion over 400 LTO cartridges saves space in data centers
  - Supports Logical Partitioning using Multipath Architecture
  - Optional features; Capacity on demand, Rack Mounting, Control and Data Path Failover, Redundant power, Data Encryption based on Ultrium technology
- TS3310 Base library module supports, 28 TB native capacity (35 slots), up to two drives, 6 slot cartridge I/O station, 2 logical libraries, robotics and control logic, barcode reader and remote management capability are standard, native SMI-S support, and license key to support initial E9U expansion. See the expansion path in Figure 9-8.

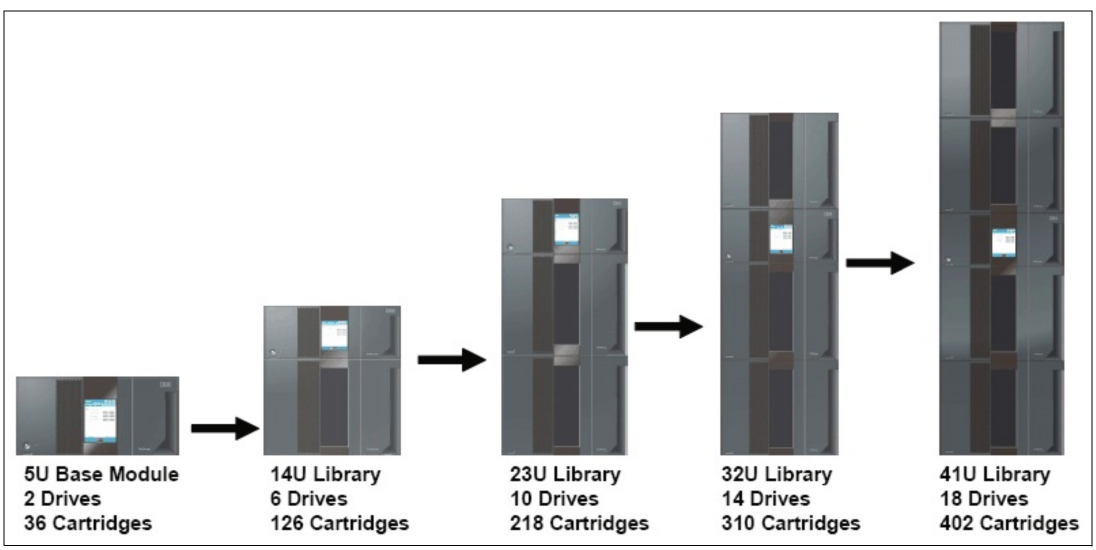


Figure 9-8 TS3310 upgrade path

- Host machines can be attached using the following supported interfaced:
  - Ultrium 5 tape drives - 8 Gbps FC dual port
  - Ultrium 4 tape drives - 4 Gbps FC port, 3 Gbps SAS port
  - Ultrium 3 tape drives - 4 Gbps FC port, Ultra160 LVD SCSI port

For the latest features, functions, and specifications regarding the TS3310, see the website:

http://www.ibm.com/systems/storage/tape/ts3310/index.html

For more technical information, library setup, and configuration guidance, see the website:

http://www.ibm.com/support/docview.wss?uid=ssg1S7003238

See the following online application for supported systems and platforms:

http://www.ibm.com/systems/support/storage/config/ssic

Additional details can be found in the *IBM System Storage Tape Library Guide for Open Systems*, SG24-5946.

9.7.2 TS3310 specifications

The specifications for the IBM System Storage TS3310 Tape Library are listed in Table 9-5.

Table 9-5 IBM System Storage TS3310 Tape Library Specifications

Type and Model	**3576 Model L5B**	**3576 Model L5B and 4 E9U Models**
Configuration	Base library	Base library and 4 expansion units
LTO storage slots (max)	35	401
LTO Input/Output slots (min/max)	6	54
Maximum tape drives	2	18
Total Physical Capacity 2:1 compression	123 TB	1.2 PB
Capacity on Demand increments	n/a	46 cartridges per license key
Maximum logical libraries	2	18
Hot-swap components	Power supplies, tape drives	
Systems management	Data Encryption, SMI-S enabled	
Operating systems/servers supported	OS/400, V5R2, V5R3, or later AIX 5L™ V5.1, V5.2, V5.3, V6.1 or later Sun Solaris 8 and 9 Microsoft Windows 2003 all editions Microsoft Windows 2008 all editions HP-UX 11.0, HP-UX 11.11 and HP-UX 11.231 Linux distributions: Red Hat Enterprise Linux Version 4 SUSE Linux Enterprise Server 9	

9.8 IBM System Storage TS3500 Tape Library

The IBM System Storage TS3500 Tape Library is a highly scalable, automated tape library for mainframe and open systems backup and archive from midrange to enterprise environments. It was formerly known as the IBM TotalStorage Tape Library 3584.

The TS3500 Tape Library supports System z using the IBM 3953 Tape System (3953 tape system) or the IBM Virtualization Engine TS7740,which enable System z hosts to access the TS3500 Tape Library cartridge inventory and allow connection to TS1130, TS1120 and IBM TotalStorage 3592 Model J1A tape drives.

The TS3500 Tape Library can support up to four 3953 tape systems, and up to eight IBM Virtualization Engine TS7740 subsystems per physical library.

The TS3500 Tape Library's entry base frame provides a more flexible upgrade path for users who want to expand their tape storage at any time of need. Capacity on Demand (CoD) configurations for TS3500 Tape Library L-frame models include the "entry-level" configuration, an "intermediate" configuration, and a "full capacity" configuration. IBM High Density S-frame models also allow two CoD expansions.

The TS3500 Model HA1 allows two robotic accessories to operate simultaneously in two to 16 frame configurations. Figure 9-9 shows the minimum and maximum 16 frame TS3500 configuration.

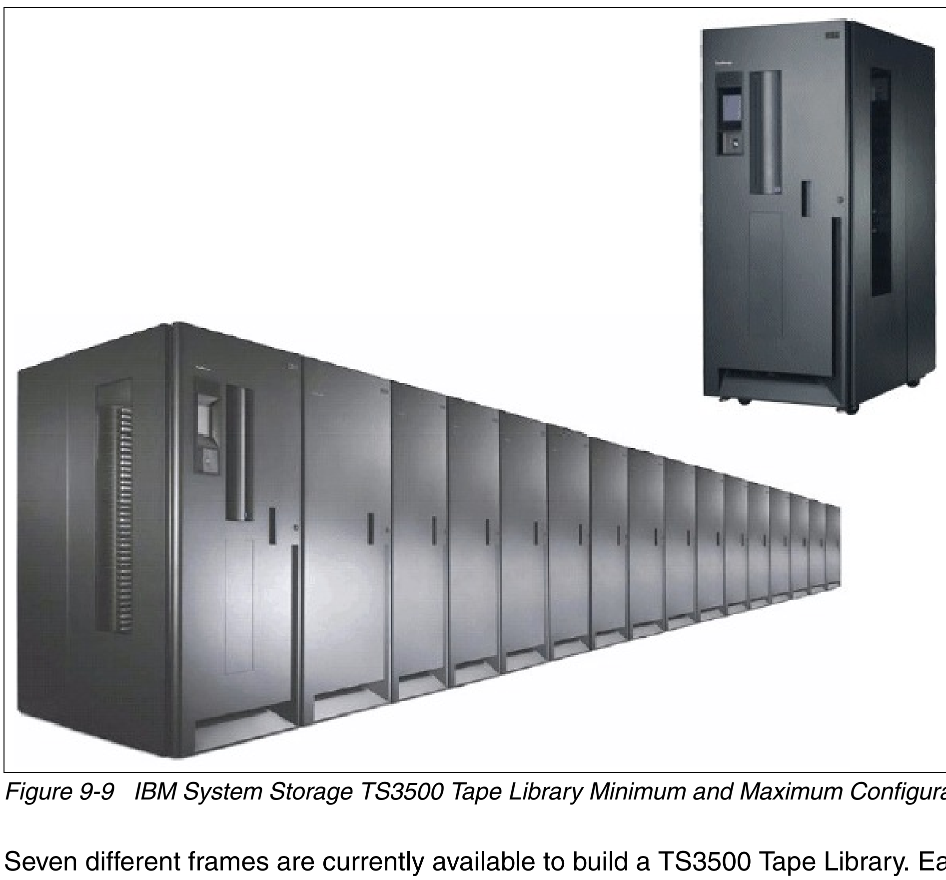


Figure 9-9 IBM System Storage TS3500 Tape Library Minimum and Maximum Configuration

Seven different frames are currently available to build a TS3500 Tape Library. Each frame is identified by a three character model number (L23, L53, D23, D53, S24, S54, or HA1), which describes the nature of the frame.

Libraries are built of modules as follows:

- Every library requires a base frame (model L*xx*) to which optional expansion frames (model D*xx* or model S*xx*) can be added. Only one base frame is permitted in each library configuration.
- Base and Expansion frames support either of the following possibilities:
  - LTO1, 2, 3, and 4 Tape Drives (model *x*53 frames)
  - IBM System Storage 3592 Models E Tape Drives and 3592 Tape Drive Model J1A (model *x*23 frames)
- An optional second accessor is made available through the addition of the model HA1 frames in conjunction with Service Bay frame.

Model L*xx* and Dxx frames can be intermixed with each other and installed frames with the provision that there is only one base frame L*xx* in each tape library. S24 can be attached to the tape library that has 3592 drives installed and S54 can extend tape library with LTO tape drives only. The withdrawn frames L22 and D22 (referring to the former IBM TotalStorage 3584 Tape library) can be upgraded to the respective *x*23 frames and L52 and L53 frames can be upgraded to the respective *x*53 frames of TS3500.

The IBM System Storage TS3500 Tape Library offers a wide scale of capacities and storage solutions based on the concrete frame configuration. Here are the highlights:

- Number of tape cartridges:
  - 3592: L23 - up to 260; D23 - up to 400; S24 - up to 1000; (total > 15000)
  - LTO*x*: L53 - up to 287; D53 - up to 440; S54 - up to 1320; (total > 20000)
- Storage capacity:
  - 3592: up to 15 PB native data (45 PB using 3:1 compression)
  - LTO5: up to 30 PB native data (60 PB using 2:1 compression)
- Functional parameters:
  - Maximum 16 library frames including one base frame L*x*3
  - Maximum 192 in the library (12 per L*x*3 or D*x*3 frame)
  - Maximum 224 I/O slots in maximally 4 I/O station doors (minimum 16 I/O slots)

9.8.1 Advanced Library Management System

The Advanced Library Management System (ALMS) is an available feature that supports dynamic storage management, allowing the user to dynamically create and change logical libraries and configure any drive into any logical library. ALMS is required when attaching to mainframe environments and also when integrating high-density frames into a library configuration. Based on capacity requirements, ALMS can be implemented as an “entry,” “intermediate” or “full” Capacity on Demand level in the TS3500 Tape Library.

ALMS virtualizes the locations of cartridges in the TS3500. Logical libraries can then consist of unique drives and ranges of volume serial numbers instead of fixed locations.

ALMS is an extension of IBM patented Multi-Path Architecture. With ALMS, the TS3500 is the industry’s first standards-based tape library to virtualize the locations of cartridges (called SCSI element addresses) while maintaining native SAN attachment for the tape drives. ALMS enables logical libraries to consist of unique drives and ranges of volume serial (VOLSER) numbers, instead of fixed locations.

When you enable ALMS with its license key, you can assign tape drives to any logical library by using the Tape Library Specialist web interface. Logical libraries can also be added, deleted, or easily changed without disruption. Storage capacity can be changed without impact to host applications.

ALMS offers dynamic management of cartridges, cartridge storage slots, tape drives, and logical libraries. It enables the TS3500 to achieve unprecedented levels of integration for functionality through dynamic partitioning, storage slot pooling, and flexible drive assignment. ALMS eliminates downtime when you add Capacity on Demand (CoD) storage, add or remove logical libraries, or change logical library storage allocation. ALMS also reduces downtime when you add expansion frames, add or remove tape drives, or change logical drive allocation.

9.8.2 IBM high density frames

The IBM System Storage TS3500 storage only frame includes the Model S24 Frame and the Model S54 Frame. The TS3500 Tape Library Model S24 and S54 frames are high density storage only expansion frames compatible with existing TS3500 Tape Libraries and frames. For details about the Advanced Library Management System (ALMS), see 9.8.1, “Advanced Library Management System”).

The TS3500 Tape Library Model S24 expansion frame is designed for 3592 data cartridges. You can add up to 15 Model S24 expansion frames to the TS3500 Model L22 or L23 base frame to increase 3592 cartridge storage. Each Model S24 frame supports up to 1000 IBM 3592 cartridge slots.

The TS3500 Tape Library Model S54 expansion frame is designed for LTO data cartridges. You can add up to 15 Model S54 expansion frames to the TS3500 Tape Library Model L32, L52, or L53 base frame to increase LTO cartridge storage. Each Model S54 frame supports up to 1320 LTO cartridge slots.

To understand the IBM patented technology behind the high density frames, study this concept in 9.1.1, “IBM High Density function” on page 314.

9.8.3 Virtual I/O slots

The IBM TS3500 Tape Library has I/O stations and I/O slots that enable you to import and export up to 32 cartridges at any given time. The I/O slots are also known as import/export elements (IEEs). Virtual I/O (VIO) slots increase the quantity of available I/O slots by allowing storage slots to appear to the host as I/O slots. Storage slots that appear to the host as I/O slots are called virtual import/export elements (VIEEs). The goal of virtual I/O slots is to reduce the dependencies between the system administrator and library operator so that each person performs their import and export tasks without needing the other person to perform any actions. With virtual I/O slots, the library automatically moves cartridges from the I/O stations to physical storage slots and from physical storage slots to the I/O stations.

With virtual I/O slots, you can configure up to 255 VIEEs per logical library. Each logical library will have a unique VIEE address space that is not accessible by other logical libraries. New logical libraries will, by default, be assigned the maximum number of virtual I/O slots, while logical libraries that were defined (before ALMS is enabled) initially have the number of physical I/O slots in the library.

For more information covering ALMS and Virtual I/O slots, see *IBM System Storage TS3500 Tape Library Introduction and Planning Guide IBM 3584 Tape Library* at:

http://www.ibm.com/support/docview.wss?uid=ssg1S7001738

9.8.4 TS3500 features

These are the main features of the IBM System Storage TS3500 Tape Library:

- TS7700 Virtualization Engine:
  - Allows quick access to active data on "virtual volumes" on disk and reduces overall solution cost storing inactive data on "volumes" on tap
  - Optimize data read and write operations on tapes
  - Supports tape automation in a System z environment
- 3593 tape system:
  - Supports tape automation in a System z environment
  - Also supports the TS7700 Virtualization Engine
- Dual accessor option:
  - Increases the performance of mount process and overall system availability
  - Two accessors can operate simultaneously in multiple frame configurations
- Flexible upgrade path:
  - Start with an entry base frame and expand at the time of need
  - Three levels of Capacity on Demand configurations available
- Remote, web browser-based management, can access key management functions
- Redundant power supplies and AC feeds
- Control path and Data path automatic failover for supported systems
- Library partitioning and encryption features
- Support for:
  - A heterogeneous environment
  - TS1130/TS1120 and TS1040 tape drive encryption
- Helps to secure sensitive at-rest data

9.8.5 TS3500 specifications

The specifications for IBM System Storage TS3500 Tape Library are listed in Table 9-6.

Table 9-6 IBM System Storage TS3500 Tape Library specifications

Model	IBM System Storage TS3500 Tape Library
Frame definition	L23 – base frame for TS1130, TS1120 or 3592, D23 – drive capable expansion frame for TS1130, TS1120 or 3592, S24 – storage only expansion frame for 3592 cartridges L53 – base frame for LTO, D53 – drive capable expansion frame for LTO, S54 – storage only expansion frame for LTO cartridges HA1 – High Availability service bay frame for use with the dual accessor feature
Tape drive types	TS1130, TS1120 or 3592 tape drives or IBM LTO Ultrium 5, 4, 3 Tape Drives (LTO1 and 2 supported, but withdrawn from market)
Number of frames	One base frame, up to 15 expansion frames The TS3500 Model HA1 installation provides one of the two additional frames required as service bays in a dual accessor library
Number of drives	Up to 12 per frame (up to 192 per library)

Model	IBM System Storage TS3500 Tape Library
Number of tape cartridges	L23 – up to 260; D23 – up to 400; S24 – up to 1,000; Total supported: 15,000 L53 – up to 287; D53 – up to 440; S54 – up to 1,320; Total supported: 20,000
Number of logical libraries	Maximum of 192 (up to number of drives installed)
Number of 3953 Systems	Maximum of four per TS3500 subsystem
Number of TS7700 Virtualization Engine	Maximum of eight per TS3500 subsystem
Capacity	IBM Ultrium 4 Cartridges: up to 16 PB (32 PB with 2:1 compression) 3592 extended capacity cartridges: up to 15 PB (45 PB with 3:1 compression)
Media type	L23/D23/S24: IBM 3592 JA/JJ/JB and JW/JR/JX Write Once Read Many (WORM) cartridges L53/D53/S54: IBM LTO Ultrium 5, 4, 3, 2, 1 Cartridges
Attachment and systems support	The TS3500 Tape Library can attach to IBM Power Systems, System p, System i, and System x servers and non-IBM servers, workstations Attach to System z can be made by the IBM 3953 Tape System (3953 tape system) or the IBM Virtualization Engine TS7740
Operating systems support	Device driver support is available for IBM AIX; IBM OS/400; IBM i; Windows 2000; Windows Server 2003; Linux; Sun Solaris; and HP-UX

To become more familiar with the IBM System Storage TS3500 Tape Library, you can download the *IBM System Storage TS3500 Tape Library Introduction and Planning Guide IBM 3584 Tape Library* from the following website:

http://www.ibm.com/support/docview.wss?uid=ssg1S7001738

For the latest specifications, features and functions, see the website:

http://www.ibm.com/systems/storage/tape/ts3500/index.html

9.9 IBM TotalStorage 3953 Tape System for System z

The IBM System Storage TS3500 Tape Library supports the attachment of IBM System z host systems to IBM System Storage TS1130 (IBM 3592-E06/EU6), IBM System Storage TS1120 (IBM 3592-E05), and IBM TotalStorage 3592 Model J1A installed inside the TS3500.

9.9.1 Attachment methods

The System z hosts attach using either Enterprise System Connection (ESCON) or Fiber Connection (FICON) to one of the following products:

- IBM System Storage TS1120 Model C06 Tape Controller
- IBM TotalStorage 3592 Tape Controller Model J70 mounted in a base frame
- IBM System Storage TS7700 Virtualization Engine (FICON only)

The IBM TS3500 Tape Library is managed on behalf of the System z hosts by an external Library Manager, the IBM 3953 Model L05. This Library Manager, the System z control units, and various switches are housed in a special frame type, the IBM 3953 Model F05 Frame, which is located physically outside the library enclosure. These two components, the Library Manager Model L05 and the 3953-F05 Frame in which it resides, make up the IBM 3953 Tape System.

Beside the existing TS3500 attachment support for the Open Systems Fibre Channel environments for Linear Tape-Open (LTO) and 3592 drives, the TS3500 together with the IBM 3953 Tape System provides the additional attachment functionality for System z ESCON and FICON environments. Both platforms can be used in an isolated manner, or they can be consolidated into one shared library (Figure 9-10).

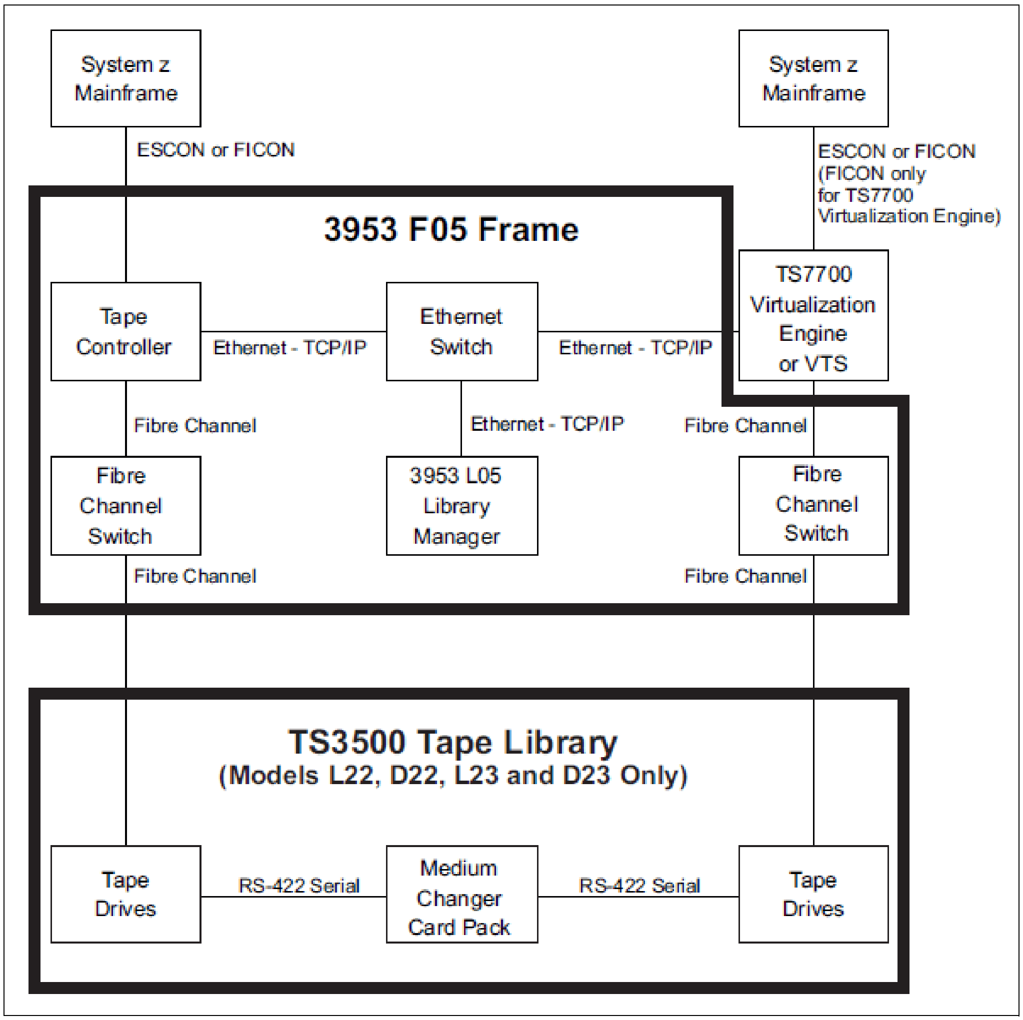


Figure 9-10 TS3500 and 3953 Library Manager Basic Diagram

As shown in Figure 9-10, the System z components are accommodated in their own logical library within the TS3500, using the multi-path capability of the library. The hosts connect to the TS3500 Tape Library only through the TS1120 Model C06 Controller, the TS7700 Virtualization Engine, or through the IBM VTS Model B10 or B20. The supported connection types are ESCON or FICON except for the TS7700 Virtualization Engine, which supports only FICON connections.

One IBM 3953 Model L05 Library Manager (or a pair of separate Library Managers), which manages the TS3500 logical library on behalf of the System z host, is provided. The IBM 3953-L05 is similar in function to the Library Manager in the IBM 3494 Tape Library.

The controllers, TS7700 Virtualization Engines, and VTSs in the subsystem communicate with the IBM 3953 Model L05 Library Manager or the pair of Library Managers, which control the library on behalf of the System z hosts. The Library Managers send simple SCSI commands to the TS3500 library robotics using the controller, TS7700 Virtualization Engine, or VTS path to the logical unit number 1 (LUN 1) address of the drives.

The communication between the IBM 3953 Library Manager and the tape controllers is established over an internal LAN.

For additional information, see the *IBM 3953 Tape System Introduction and Planning Guide* at the website:

http://www.ibm.com/support/docview.wss?uid=ssg1S7001862

9.9.2 3953 Tape System features

These are the features for the IBM TotalStorage 3953 Tape System for System z:

- Builds on recent tape library enhancements:
  - Dual robotics and non-disruptive frame addition
  - Advanced Library Managements System
  - TS1120 and 3592 J1A tape drive support
- Supports VTS B10 / B20 and TS1120 controller; attached to TS1120 and 3592 J1A tape drives
- Supports System z operating systems; Linux is supported natively
- Supports open systems:
  - Coexists with open systems in their own logical library
  - Securely isolated from System z environment
- 3953 L05 Library Manager:
  - Functionally equivalent to 3494 Library Manager
  - Employs identical microcode and server
- The 3953 L05 is mounted in the first 3953 F05 frame:
  - Requires dual internal LAN features
  - Requires TotalStorage Master Console (TSMC)
- Optional 3953 L05 provides redundancy:
  - Mounted in first 3953 F05 frame
  - Facilitates microcode updates
- Issues TS3500 mount requests:
  - Accepts PLF commands from VTS or TS1120 controller
  - Issues SCSI media manager mount request

10

IBM Tape Virtualization products

In this chapter, we discuss tape virtualization, data deduplication, and associated IBM Tape Virtualization products and solutions:

- IBM System Storage ProtecTIER products:
  - IBM System Storage TS7610 ProtecTIER Deduplication Appliance Express
  - IBM System Storage TS7650 ProtecTIER Deduplication Appliance
  - IBM System Storage TS7650G ProtectTIER Deduplication Gateway
  - IBM System Storage TS7680 ProtectTIER Deduplication Gateway for System z
- IBM Virtualization Engine TS7700:
  - IBM Virtualization Engine Model TS7740
  - IBM Virtualization Engine Model TS7720
- DFSMSrmm, formerly known as Enterprise Removable Media Manager (eRMM)

New product: The IBM TotalStorage 3494 Virtual Tape Server has been replaced by the IBM System Storage TS7700 Virtualization product.

10.1 Introduction to tape virtualization

In order to maintain continuous business operations, address regulatory requirements, and archive business records, you need an infrastructure that enables you to manage your data from online application storage to offline, permanent archive media. Tape is a key part of both the backup and archive life cycle. Tape provides the lowest total cost of ownership alternative for securely storing long-term archives for record keeping and disaster recovery. As data centers and data stores grow, manual tape operations can become more complex. This growth can lead to increased backup and restore times and higher management overhead and costs. A solution to this is virtual tape.

A virtual tape library provides high performance backup and restore by using disk arrays and virtualization software. A virtual tape library is a unique blend of several storage tiers. The life cycle of data from its creation at the server level migrates by backup software to a virtual tape library. There is no better place for the data to be, because the virtual tape library is a combination of high performance SAN-attached disk and high performance servers emulating a tape storage device. At this level, you have many options for the data. For example, the data can remain on the virtual tape library indefinitely, as long as there is enough space, or it can be migrated to tape for off-site storage, archive, or both.

Any business with a need for high performance backup and restore might need virtualization solutions. Instant access backups and restores are capabilities that only the disk storage tier can provide. All backup software products were designed to back data up to tape drives and libraries, and virtual tape library emulates tape. You can go directly to a virtual tape library and have your backups completed quickly. The great benefit you get from tape virtualization is the large number of virtual tape drives available to backup applications with minimal cost compared to the same number of physical tape drives installed in the tape library.

Virtual tape libraries fill a void in the backup infrastructure for data that needs to be restored at a certain moment. Many restore requests often happen within six weeks of the data being backed up. Backup software can be configured to back up data to a virtual tape library and then create a virtual tape-to-tape copy for off-site deployment. It is no longer necessary to call the tapes back from an off-site location, unless data is required from years past.

One of the biggest challenges with backup planning today is that the amount of data being backed up is growing, but the time allotted for a backup (the backup window) is shrinking or remaining static. Applications need to be up and operational nearly 24 hours a day. To manage the need for increased data capacity and data protection, customers must find ways to shrink their backup windows and recover as quickly as possible.

Each IBM tape virtualization product is the combination of IBM hardware and software designed to provide backup/recovery operations with the performance benefits of Fibre Channel, iSCSI, or Serial Attached SCSI (SAS). IBM tape virtualization products are able to emulate all currently known tape libraries and tape drives including IBM System Storage TS3100, TS3200, TS3400, TS3310, TS3500, and tape drives either Ultrium LTO or 3592 models. The latest model TS7700 and its software release R1.6 introduce the support for Logical WORM cartridges (LWORM).

Because many applications are not able to fill the high capacity media of today’s tape technology, you can end up with a large number of underutilized cartridges, wasting a lot of space on your physical media and requiring an excessive number of cartridge slots in your tape automation system. Tape virtualization reduces the space required by volumes and fully utilizes the capacity of current tape technology. Tape virtualization enables you to exploit the full potential of modern tape drive and tape media technology without making any changes to your applications.

Here is a short summary of the main benefits that you can expect from tape virtualization:

- Brings efficiency to the tape operation environment.
- Reduces batch window.
- Provides high availability and disaster recovery configurations
- Provides fast access to data through caching on disk.
- Provides utilization of current tape drive, tape media, and tape automation technology.
- Provides the capability of filling high capacity media to 100%.
- Provides a large number of tape drives or concurrent use.
- Provides data consolidation, protection, and sharing.
- Requires no additional software.
- Reduces total cost of ownership (TCO)

In traditional backup environments, as shown in Figure 10-1, the client data is backed up in two ways:

- LAN clients write their backup data by the backup server to tape.
- LAN-free clients utilize the SAN for direct backup to the tape devices.

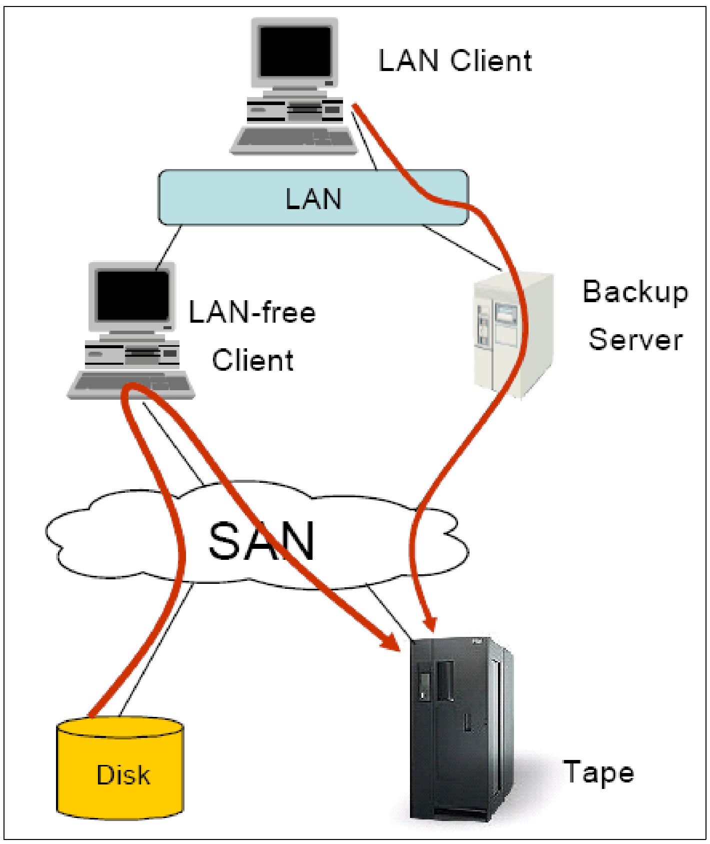


Figure 10-1 Traditional backup

The following problems are encountered with these traditional backups:

- LAN backups cannot benefit from fast tape drives, because the network transfer rate is the limiting factor; data cannot be delivered fast enough to keep the tape drives streaming.
- LAN-free clients require dedicated tape drives for every backup session. So, many tape drives are needed during the backup window.

A solution for these problems is to use disk to disk (D2D) or disk to disk to tape (D2D2T) backups.

LAN backups can be done by using a disk buffer, as shown in Figure 10-2. The client writes the backup data by LAN first to a disk buffer on the backup server. From there it can be recalled quite rapidly if needed. After the backup on disk is completed, the backup server can migrate the data from the disk buffer to a physical tape with no impact on the client.

Furthermore, the disk buffer works as a cache. The most recently backed up data resides in the fast disk buffer until its overwritten by newer data.

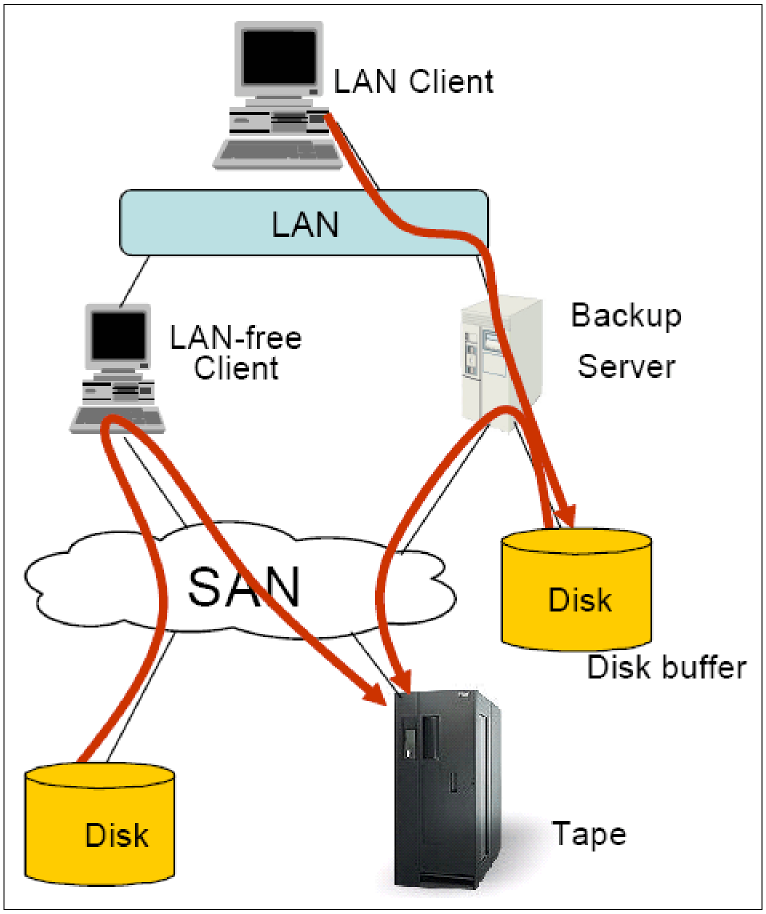


Figure 10-2 Backup to disk buffer

This is a good solution if the backup software supports it. IBM Tivoli Storage Manager supports a hierarchy of storage pools, and can automatically migrate from disk to tape, but other backup applications might not have this capability.

An alternative solution to optimizing backup is to introduce a virtualization and emulation layer. This layer appears to both the backup server and the LAN-free clients as a tape drive; however internally, the backup data is stored as *logical volumes* on disk space.

The combination of hardware (servers, cache controllers, and cache modules), and software (tape drive and robotic emulation) is called a *Virtual Tape Library (VTL)* as seen in Figure 10-3.

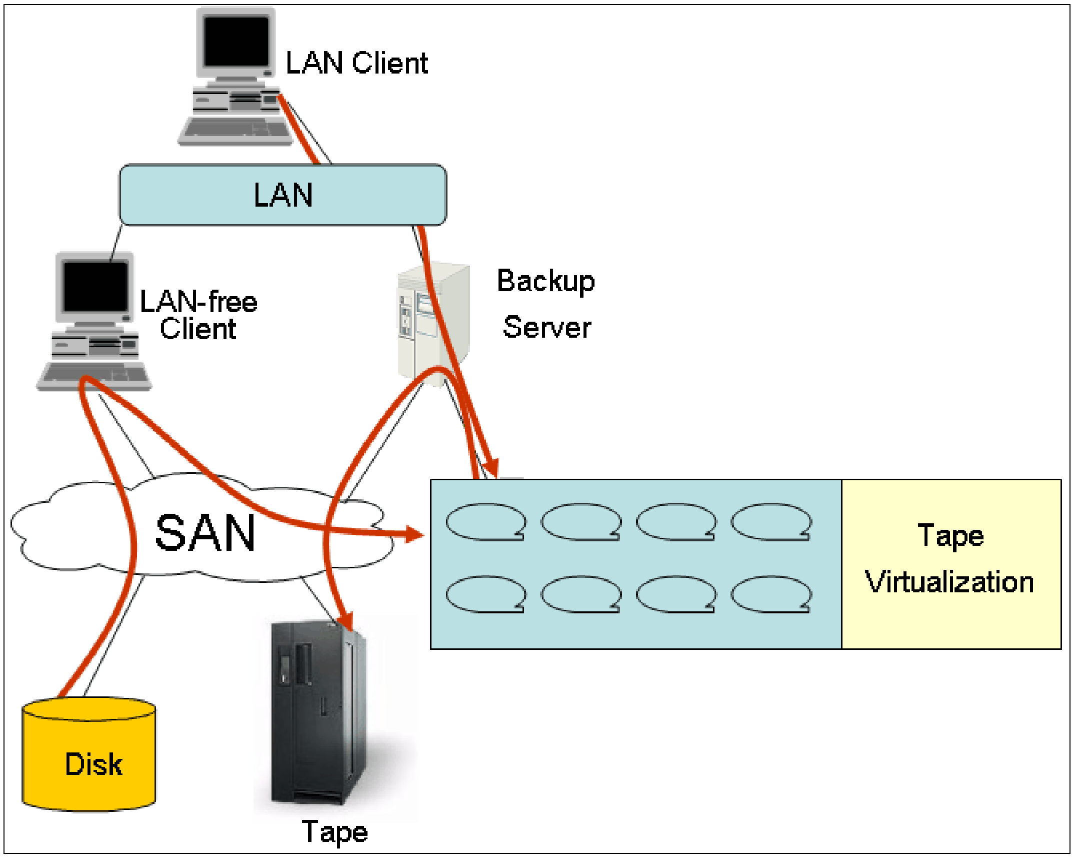


Figure 10-3 Tape virtualization diagram

10.2 Concept of data deduplication

Data deduplication is a technology used to reduce the amount of space required to store data on disk. This is achieved by storing a single copy of data that is backed up repetitively. Data deduplication can provide greater data reduction than previous technologies, such as Lempel-Ziv (LZ) compression and differencing, which is used for differential backups.

The principle of data deduplication is shown in Figure 10-4.

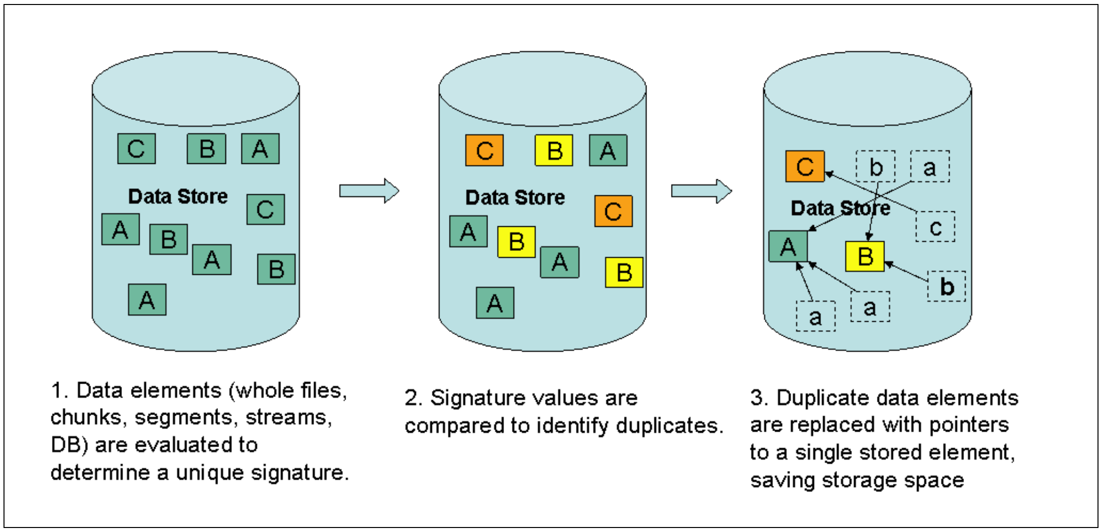


Figure 10-4 The basic concept of data deduplication

With data deduplication, data is read by the data deduplication product while it looks for duplicate data. Different data deduplication products use different methods of breaking up the data into elements, but each product uses some technique to create a signature or identifier for each data element. As shown in item 1 in Figure 10-4, the data store contains the three unique data elements A, B, and C with a distinct signature. Whether using real-time or post processing deduplication, data element signature values are compared to identify duplicate data. In item 2, all the duplicate data items are identified (shown by color coding here). After the duplicate data is identified, one copy of each element is retained, pointers are created for the duplicate items, and the duplicate items are not stored.

The effectiveness of data deduplication is dependent upon many variables including the data rate of data change, the number of backups, and the data retention period. For example, if you back up the exact same incompressible data once a week for six months, you save the first copy and do not save the next 24, which provides a 25 to 1 data deduplication ratio. If you back up an incompressible file on week one, back up the exact same file again on week two and never back it up again, you have a 2 to 1 deduplication ratio. A more likely scenario is that some portion of your data changes from backup to backup so that your data deduplication ratio will change over time.

Data deduplication can reduce your storage requirements but the benefit you derive is determined by your data and your backup policies. Workloads with a high database content generally have the highest deduplication ratios; however, product functions like Tivoli Storage Manager Progressive Incremental, Oracle RMAN, or Light Speed, can reduce the deduplication ratio. Compressed, encrypted, or otherwise scrambled workloads typically do not benefit from deduplication. Good candidates for deduplication are typically text files, log files, uncompressed and non-encrypted database files, email files (PST, DBX, Domino®), Snapshots (Filer Snaps, BCVs,VMWare images).

10.2.1 Types of data deduplication and HyperFactor

Many vendors offer products that perform deduplication. Various methods are used for de-duplicating data. Here are three methods that are frequently used:

- *Hash based deduplication* uses a hashing algorithm to identify chunks of data. Commonly used process is Secure Hash Algorithm 1 (SHA-1) or Message-Digest Algorithm 5 (MDA-5). The details of each technique are out of scope of this publication.
- *Content aware deduplication* methods are aware of the structure of common patterns of data used by applications. It assumes the best candidate to de-duplicate against is an object with the same properties, such as a file name. When a file match is found, a bit by bit comparison is performed to determine if data has changed and saves the changed data.
- *HyperFactor®* is a patented technology that is used in IBM System Storage ProtecTIER Enterprise Edition V2.1 and higher software. HyperFactor takes a different approach and, therefore, reduces the phenomenon of missed factoring opportunities, rather than to compare the new data to the similar data to identify and store only the byte-level changes. With this approach, HyperFactor is able to surpass the reduction ratios attainable by any other data reduction method. HyperFactor can reduce any duplicate data, regardless of its location or how recently it was stored. HyperFactor data deduplication uses a 4 GB Memory Resident Index to track similarities for up to 1 petabyte (PB) of physical disk in a single repository.

HyperFactor technology

HyperFactor technology, as seen in Figure 10-5, uses a pattern algorithm that can reduce the amount of space required for storage in the backup environment by up to a factor of 25, based on evidence from existing implementations. The capacity expansion that results from data deduplication is often expressed as a ratio, essentially the ratio of nominal data to the physical storage used.

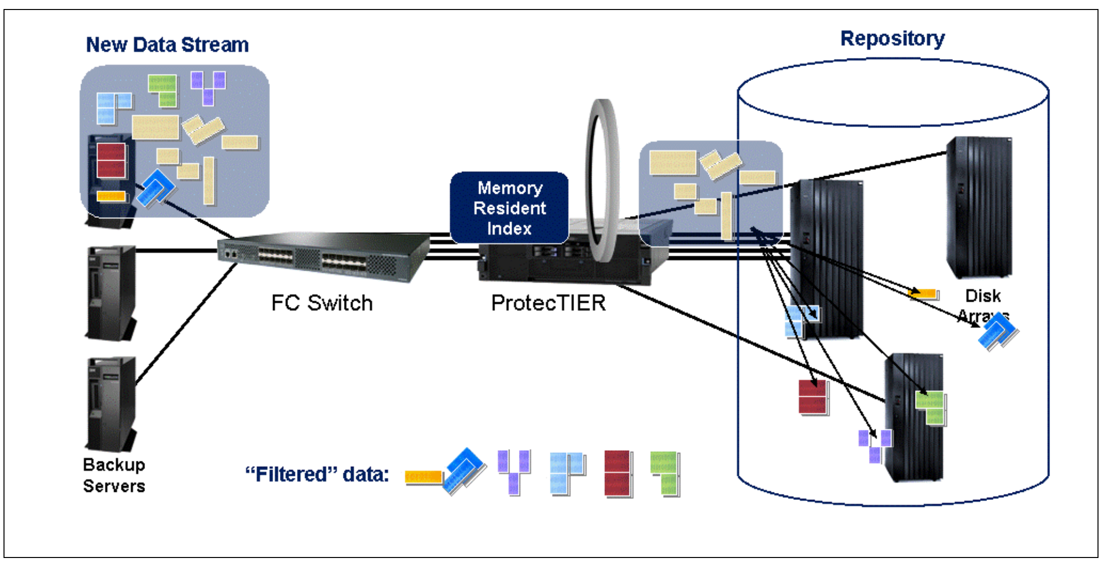


Figure 10-5 IBM HyperFactor technology

Data deduplication processing

Data deduplication can either be performed while the data is being backed up to the storage media (real-time or inline) or after the data has been written to the storage media (post-processing). Each method certainly brings positive and negative aspects, those must be evaluated by the engineer or technical specialist responsible for the concrete solution architecture and deployment. IBM decided to use inline deduplication processing as it offers larger target storage space without any need of temporary disk cache pool for post processed deduplication data.

Bit comparison techniques such as the one used by ProtecTIER were designed to provide 100% data integrity by avoiding the risk of hash collisions.

Deduplication: All available IBM ProtecTIER deduplication products use inline (real-time) deduplication processing.

10.2.2 ProtecTIER Native Replication

ProtecTIER Native Replication is a logical feature that enables customers to replicate and/or “move” any or all of their virtual tape cartridges from their main site to a remote DR location and vice versa. The TS7650 appliance and gateway models employ a IP based replication design. Data is replicated between sites from one two-node cluster to another. Tape archiving capabilities outside of production environment are also provided with this feature.

The user will be able to create policies at the cartridge level to replicate a single or a range of barcodes in a specified timeframe and with a set priority. After being replicated (or moved) to the DR site, users can choose to clone these cartridges to real physical tape from within their backup application and outside of their main production stream. In case of a disaster, the TS7650 or TS7650G located at the DR site can become the production site (failover) until the main site comes back on-line. At that point the user can replicate or move the newly created tapes back to the main production site (failback). ProtecTier and Native Replication enables more frequent testing of Disaster Recovery plans.

Figure 10-6 shows the concept of ProtecTIER Native Replication using IBM ProtecTIER Gateway as a Hub at the central/disaster site and four Spokes at branch offices/remote sites. As mentioned in the figure, each Hub supports up to 12 spokes depending on concrete model and deduplication solution.

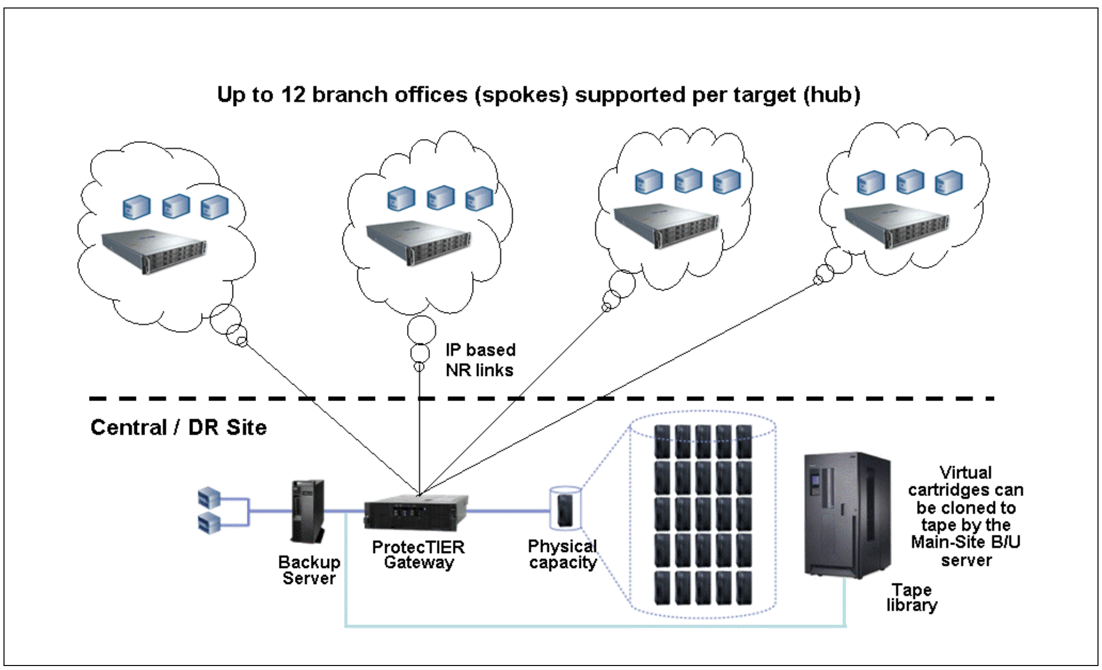


Figure 10-6 Native Replication using IBM ProtecTIER solution

Because ProtecTIER deduplicates data before storing it, only the changes of the data are transferred to the DR site over the replication link. This translates into substantial savings in the bandwidth needed for the replication link. Data transfer is started based on several trigger points such as policy based transfer windows, or movement of the virtual tape to a VTL export slot. (ProtecTIER's VTL emulates import and export slots, as well as opening or closing of the library door to insert or eject a cartridge). Data verification/validation is done at the DR site to ensure integrity of the transferred data prior to make the virtual cartridge/tape available. ProtectTier only replicates a partial set of cartridges. ProtecTIER Native Replication is built on top of the PT two node cluster product and is cluster compliant. Replication can run in parallel to backup and restore activity.

ProtecTIER Native Replication eliminates the risks associated with human intervention and physical tape transportation. Replication occurs automatically (by policy) and simultaneously as data is deduplicated and backed up.

10.3 TS7610 ProtecTIER Deduplication Appliance Express

Available in two configuration options, the TS7610 ProtecTIER Deduplication Appliance Express (type 3959-SM1) is an integrated server and storage hardware platform that ships with the ProtecTIER deduplication software preinstalled and has a preconfigured repository and virtual tape library (VTL) interface. The TS7610 ProtecTIER Deduplication Appliance Express provides capacity, price/performance, and reliability/availability/scalability features for your business demands.

The IBM TS7610 ProtecTIER Deduplication Appliance Express is available as a 2U standard 19-inch rack-mountable enclosure (3U with additional rail kit). It features one quad-core 2.33 GHz Intel XEON processor and twelve 1 TB SATA Drives; those are RAID 6 protected. Two configurations are supported, with 4.0 TiB (4.4 TB) or 5.4 TiB (5.9 TB) useable physical capacity. With the HyperFactor 25:1 it is capable to store up to 135 TiB (150 TB) of de-duplicated data from backup server (see Figure 10-7 for details and typical scenario). Both configurations support sustained write performance of more than 80 MB/s, which usually exceeds the backup data bandwidth in small and midrange business solutions.

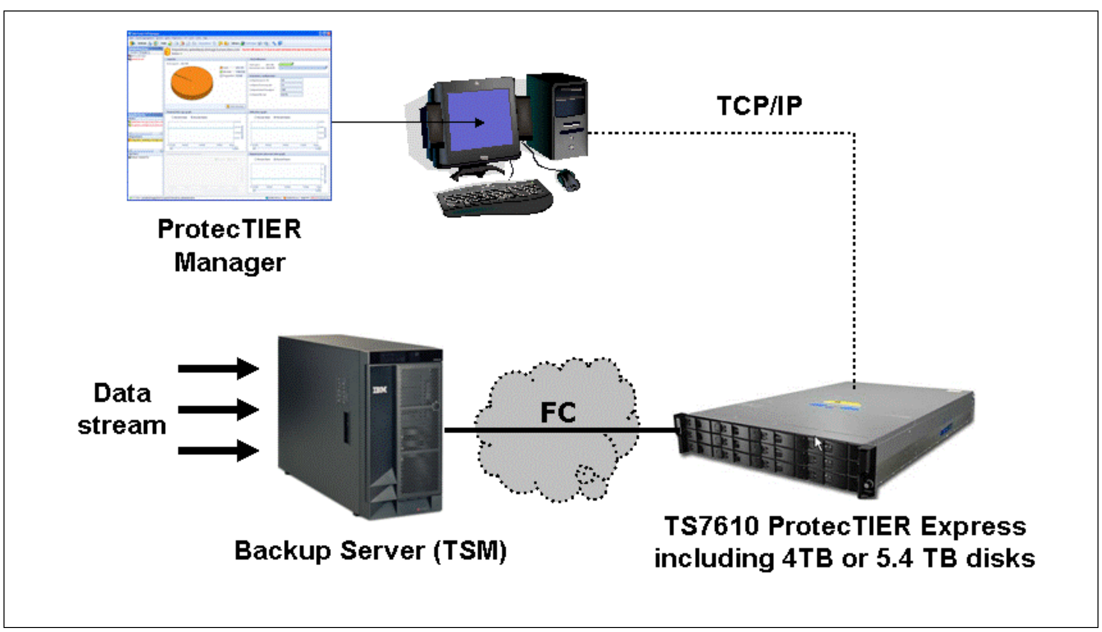


Figure 10-7 Conceptual model of TS7610 ProtecTIER Express implementation

10.3.1 TS7610 solution

IBM System Storage TS7610 ProtecTIER Express is an ideal solution for these customers:

- Those experiencing significant data-growth in small and midrange storage solutions
- Those wanting to make backup/recovery improvements without making radical changes
- Those with weekly full backups 3 TB or less
- Those with daily incremental backups 1 TB or less

10.3.2 TS7610 features

IBM TS7610 ProtecTIER Appliance Express provides the following features:

- Capacity to store up to 150 TB (135 TiB) or more backup data on single 5.4 TiB appliance
- Up to 80 MB/s or more inline deduplication performance
- Emulation of up to four virtual libraries, 64 drives, 8,000 cartridges, and 1022 I/O slots
- Emulation of TS3500 Tape Library and Ultrium LTO3 tape cartridges only
- Functions of IBM System Storage ProtecTIER Entry Edition V2.1 software
- Replication capabilities across the sites with all IBM ProtecTIER devices
- Backup or recovery of 1 TB of data in less than four hour
- Support of SNMP traps and email messaging
- Factory pre-configured with 1 virtual TS3500, 16 LTO3 drives balanced across both FC ports, 400 (4 TiB model) or 540 (5.4 TiB model) cartridges of 200GB, 16 virtual I/O slots
- Easy deployment and manageability
- Field upgradeable from 4.0 to 5.4 TiB configuration
- User-friendly graphical user interface; easy to use
- Plug-and-play solution easy to install
- Stand-alone configuration only

For additional information, see the *IBM System Storage TS7610 ProtecTIER Deduplication Appliance Express User's and Maintenance Guide* at the following website:

http://www.ibm.com/support/docview.wss?uid=ssg1S7003273

Interactive documentation is available online for service and support personnel at this site:

http://publib.boulder.ibm.com/infocenter/ts7610/serv/index.jsp

Comprehensive information for customers and end users can be found at this website:

http://publib.boulder.ibm.com/infocenter/ts7610/cust/index.jsp

10.4 TS7650 ProtecTIER Deduplication Appliance

The IBM System Storage TS7650 ProtecTIER Deduplication Appliance (machine type 3958-AP1 in Figure 10-8) is a preconfigured solution of IBM storage, IBM server, and the IBM revolutionary ProtecTIER data deduplication software designed to improve backup and recovery operations. This is not just a bundle of components, but a truly integrated solution that makes it easy to harness the power of deduplication without making radical changes to the existing environment. The solution is available in four configurations designed to meet the disk-based data protection needs of a wide variety of organizations, from midsized IT environments to enterprise data centers.

The TS7650 Appliance compresses and stores backup data on the attached IBM System Storage DS4700 disk storage unit. To facilitate backup applications that are designed for use with tape storage, the TS7650 Appliance emulates a traditional tape library unit. The TS7650 Appliance is available in a stand-alone configuration, or in a clustered configuration which facilitates increased throughput and higher availability.

The replication function allows ProtecTIER deployment to be distributed across sites. Each site has a single or clustered ProtecTIER environment. Each environment has at least one ProtecTIER server. That server, which is a part of the replication grid, has two dedicated replication ports, Eth3 and Eth4, which are used for replication. Replication ports are connected to the customer's WAN and are configured on two different subnets by default.

ProtecTIER's native replication technology enables virtual tape cartridges to be replicated to a remote location for enhanced disaster recovery and business continuity. By eliminating the need to physically transport actual tape cartridges, systems, storage, and data can be recovered more quickly and reliably in the event of a disaster or major system outage. It also lowers the total cost of ownership of backup and recovery by eliminating the costs associated with moving and storing physical tape cartridges.

Figure 10-8 ProtecTIER Deduplication Appliance

The IBM System Storage TS7650 ProtecTIER Deduplication Appliance offers these benefits:

- Significant reduction of backup window
- Restoration time reduction
- Data sharing and resource virtualization optimization
- Operational efficiency
- Emulation of TS3500 Tape Library with LTO2 and LTO3 virtual tape drives
- Simplified configuration and deployment

10.4.1 TS7650 features

The IBM System Storage TS7650 ProtecTIER Deduplication Appliance offers many features that can create savings in physical storage, processing, and network bandwidth:

- Emulation of up to 12 virtual libraries, 256 virtual drives, and 128,000 virtual cartridges
- IBM ProtecTIER with patented HyperFactor data deduplication technology
- ProtecTIER Native Replication technology
- IBM System x server for enterprise-level performance
- IBM Storage Controller with highly reliable boot FC disk drives
- Up to 500 MBps or more inline data deduplication performance

10.4.2 TS7650 configuration options

The IBM System Storage TS7650 ProtecTIER Deduplication Appliance is available in the following four configurations:

- TS7650 ProtecTIER Deduplication Appliance:
  - 7 TB configuration with performance up to 100 MBps or more inline:
    - Value based configuration that delivers inline data deduplication and scalability that is ideal for medium sized businesses or regional data centers
    - Inline data deduplication with a physical capacity of 7 TB and usable capacity of 175 TB (based on deduplication ratio of 25:1)
  - 18 TB configuration with performance up to 250 MBps or more inline:
    - A flexible solution that delivers inline deduplication and scalability that is ideal for IT organizations that are experiencing rapid data growth and struggling to meet a shrinking backup window
    - Inline data deduplication with a physical capacity of 18 TB and usable capacity of 450 TB (based on deduplication ratio of 25:1)
    - Flexible and scalable growth to 36 TB
  - 36 TB Configuration with performance up to 500 MBps or more inline:
    - A single-node configuration that delivers inline data deduplication and large capacity for enterprise-class IT organization that needs high performance to meet significant backup and recovery workloads
    - Inline data deduplication with a physical capacity of 36 TB and usable capacity of 900 TB
    - Up to nine times faster than the competition delivers
  - 36 TB Dual-node Cluster Configuration with performance up to 500 MBps or more:
    - A dual-node high-availability cluster configuration that delivers inline data deduplication performance and large usable capacity for the most demanding high-volume backup and recovery environments
    - Inline data deduplication with a physical capacity of 36 TB and usable capacity of 900 TB

For additional information about IBM System Storage ProtecTIER products, see *IBM System Storage TS7650 and TS7650G with ProtecTIER*, SG24-7652.

For the latest features and support, see the website:

http://www-03.ibm.com/systems/storage/tape/index.html

Online documentation including web-based training sessions is available at this website:

http://publib.boulder.ibm.com/infocenter/ts7650/serv/index.jsp

The IBM Customer Information Center provides complete and comprehensive information about the IBM System Storage TS7650 Deduplication Appliance to the customers and IT managers under the following link:

http://publib.boulder.ibm.com/infocenter/ts7650/cust/index.jsp

10.5 TS7650G ProtecTIER Deduplication Gateway

The IBM System Storage TS7650G ProtecTIER Deduplication Gateway (Figure 10-9) is designed to meet the disk-based data protection needs of the enterprise datacenter while enabling significant infrastructure cost reductions. The solution offers industry leading inline deduplication performance and scalability up to 1 petabyte (PB) of physical storage capacity per system that can provide up to 25 PB of storage capacity. Combined with IBM storage, the ProtecTIER Gateway solution provides a powerful disk-based repository to improve the retention and availability of backup and archive data.

Figure 10-9 TS7650G ProtecTIER Gateway

10.5.1 TS7650G overview

The TS7650G is available in stand-alone and clustered configurations. For a stand-alone configuration, one IBM machine type and model 3958-DD4 server is required. For a clustered configuration, two 3958-DD4 or 3958-DD3 (or any combination) servers are required, along with a Cluster Connection Kit, which includes two required Ethernet switches and one remote network power switch.

Existing withdrawn stand-alone 3958-DD1 servers can be upgraded to a clustered configuration by clustering a 3958-DD1 server and a 3958-DD3 or 3958-DD4 server. In all cases, the clustered servers must be installed in the same physical frame.

Support: IBM does not support more than one clustered pair of TS7650 Gateway servers in a single frame.

To facilitate backup applications that are designed for use with tape storage, the TS7650G emulates a traditional tape library unit IBM System Storage TS3500 with the support of Ultrium LTO2 and LTO3 tape drives.

The disk storage array attaches to the TS7650G through Fibre Channel connections and holds the repository of factored backup data. The amount of cache available depends on your disk subsystem and configuration. The TS7650G supports the following IBM disk subsystems:

- DS8000 series: All models
- DS5000 series: DS5100 and DS5300
- DS4000 series: DS4200, DS4300, DS4700, and DS4800 (all withdrawn from market)
- DS3000 series: DS3400
- IBM XIV 2810
- IBM SAN Volume Controller (SVC) version 4.3.1 and higher

The replication function allows IBM ProtecTIER deployment to be distributed across sites. Network bandwidth remains the most expensive component in most distributed IT environments. IBM ProtecTIER's patented deduplication technology dramatically reduces the amount of bandwidth required by only transmitting new, unique data to the remote location. This feature radically reduces the costs associated with the electronically transmitting data and extends the benefits of replication to a larger portion of applications and data. See Figure 10-10 for a typical IBM TS7650G ProtecTIER native replication scenario.

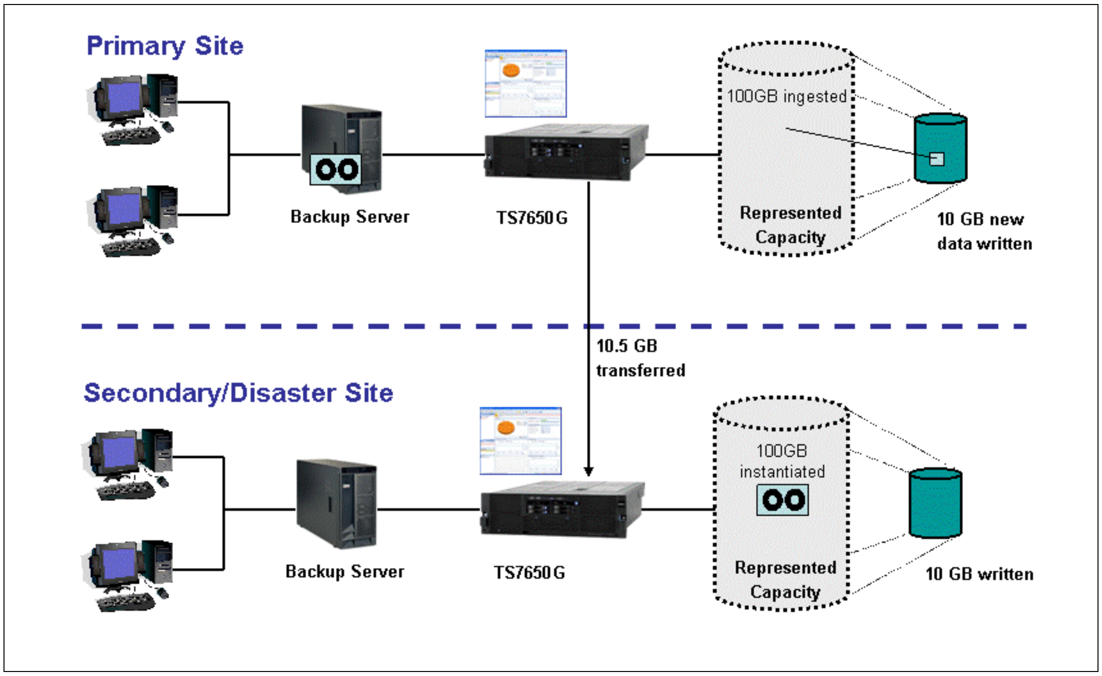


Figure 10-10 ProtecTIER Native Replication using TS7650G Gateways

ProtecTIER Native Replication enables customers to improve their Disaster Recovery capabilities in the following ways:

- Accelerated recovery time: With ProtecTIER, all data is stored on high speed disk, making recovery fast and efficient, enabling systems to be brought online at a fraction of the time of a tape-based recovery environment.
- Expanded DR coverage: IBM ProtecTIER enables more production applications and associated data to be protected with replication, something previously only reserved for Tier 1 applications and mission critical data.
- Automated Operations: Native Replication is a tightly integrated feature of ProtecTIER that enables IT organizations to automate the process of getting backup data to an offsite location quickly and reliably, avoiding the hassles and security risks associated with the transport of physical tapes.

The IBM TS7650G delivers a unique data protection solution that provides these benefits:

- Accelerates backups to meet ever-shrinking backup windows
- Enhances ability to rapidly restore mission-critical data
- Increases reliability of backup operations
- Enables proactive verification of backup data integrity
- Increases onsite recovery capacity to retain using smaller amount of storage
- Does not require changes in existing backup processes, procedures and policies
- Extends disaster recovery capabilities
- Significantly lowers Total Cost of Ownership (TCO)

10.5.2 TS7650G features

The IBM TS7650G ProtecTIER Deduplication Gateway offers the following benefits:

- Virtual tape emulation of up to 16 virtual tape libraries per single node or two node cluster configuration and up to 512 per two node cluster or 256 virtual tape drives per TS7650G
- Inline data deduplication powered by HyperFactor technology
- Multicore virtualization and deduplication engine
- Clustering support for higher performance
- Fibre Channel ports for host and server connectivity
- Performance: up to 1000 MB/s or more sustained inline deduplication (clustered nodes)
- Emulation of the IBM TS3500 Tape Library with IBM Ultrium 2 or Ultrium 3 tape drives
- Scales to 1 PB of physical storage and over 25 PB of user data
- Data integrity non-hashed-based verification avoids any data loss due to hash collision
- Cloning of virtual cartridges to physical tapes at remote sites
- Easy to use GUI management web-based console
- Support of SNMP traps and email messaging

Online documentation including web-based training sessions is available at:

http://publib.boulder.ibm.com/infocenter/ts7650/serv/index.jsp

The IBM Customer Information Center makes accessible the comprehensive information about the IBM System Storage TS7650G Deduplication Gateway to customers and end users at the following website:

http://publib.boulder.ibm.com/infocenter/ts7650/cust/index.jsp

10.6 IBM TS7680 ProtecTIER Gateway for System z

The IBM System Storage TS7680 ProtecTIER Deduplication Gateway for System z (machine type and model 3958-DE2) combines a virtual tape library solution, with the IBM unique and patented HyperFactor deduplication technology and integrated native replication technology to provide users an optimal disk-based target for Systems z applications that traditionally use tape.

10.6.1 TS7680 overview

As the previous models TS7650 and TS7650G, the IBM System Storage TS7680 ProtecTIER is designed to simplify and improve the performance and reliability of tape processing operations while reducing infrastructure costs, the TS7680 offers high-performance inline deduplication, highly available two node clustering and scalability to store up to 25 petabytes (PB) of tape data on high-speed disk capacity per system.

The 3958-DE2 (TS7680) uses the ProtecTIER Virtual Tape, or VT, service to emulate a standard tape library. In this way, the host perceives that the data is being stored on tape cartridges while the data is actually stored as virtual volumes in the disk repository. The disk repository uses disk drive modules (DDMs) as storage media and the ProtecTIER server simulates the function and operation of IBM 3592 J1A tape drives. These simulated tape drives are called virtual tape drives, and to an attached host they appear identical to physical tape drives.

Data written or read through a virtual tape drive resides in a virtual volume on the DDMs in the repository. To a host application, a virtual volume shows the same characteristics as a physical tape volume. The size of virtual volumes is dependent upon the size of data received from the host. Virtual volumes are only as large as necessary to hold the host data.

Important: Customers must *not* use the ProtecTIER Manager to delete a virtual cartridge unless they are instructed to do so by an IBM service representative. Doing this can cause database inconsistencies between the System z host and the TS7680. In addition, deleting cartridges from the ProtecTIER Manager takes the library offline to the host and might require an extended outage while a complete inventory audit is performed.

The TS7680 provides a connection to System z hosts to transfer your data to and from your repository through Fibre Channel connections. The TS7680 combines two Enterprise controllers and two ProtecTIER servers to provide a high-availability Enterprise deduplication solution with drive and library virtualization. While the Enterprise controllers provide the connectivity to your System z hosts and control the operation of the system, the ProtecTIER servers provide connectivity to the disk repository and control the identification and the tagging of duplicate data.

The IBM System Storage TS7680 ProtecTIER Gateway is available in one configuration. When using ProtecTIER Native Replication for disaster recovery, the same hardware configuration is required at both sites (see Figure 10-11 a for typical scenario):

- 2x ProtecTIER server
- 2x Enterprise Controller (lower and upper in the same rack)
- 1x IBM TS3000 System Console (TSSC) and TSSC Ethernet Switch
- 1x Communication module (Keyboard, Video, Mouse - KVM)

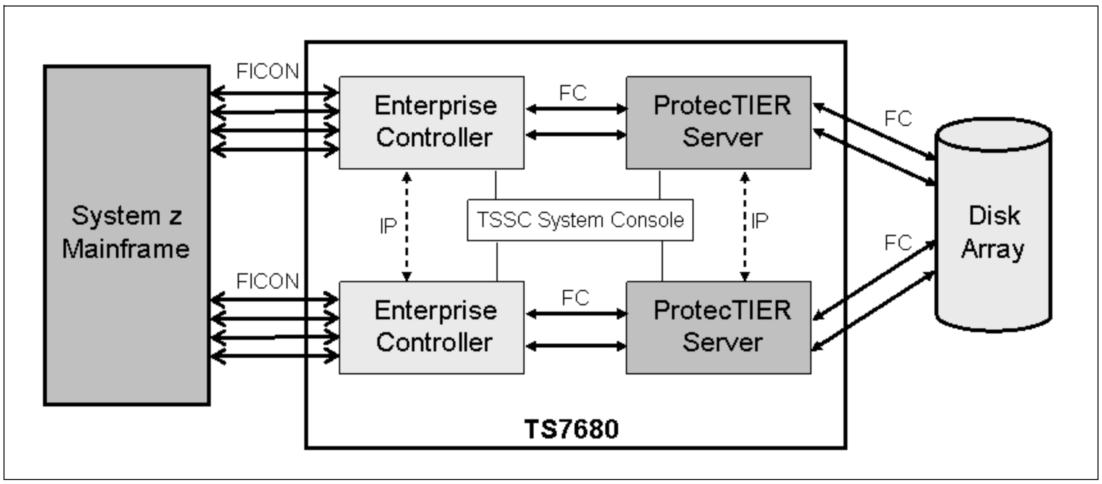


Figure 10-11 Implementation of TS7680 ProtecTIER Gateway

A two-node system uses two servers in an active-active cluster and enables a sophisticated system with the following benefits:

- High availability: The clustered configuration provides hardware redundancy so that in the event of a node failure, the workload can be distributed to the functioning node, keeping the system available
- Increased performance: Provided that there are sufficient disk resources, the two servers can share the host workload for increased total performance

Each node connects through front-end Fibre Channel ports to the backup server, and through back-end Fibre Channel ports to the disk repository. The Enterprise controllers enable the nodes to connect to each other and to the ProtecTIER Manager workstation.

10.6.2 TS7680 features

The 3958-DE2 (TS7680) provides the following capabilities:

- Compatible with wide area of IBM disk subsystems (DS4000, DS5000, DS8000, XIV)
- Up to one million virtual tape volumes
- 128 virtual drive images per Enterprise controller
- Up to 1 PB of raw storage scalability per ProtecTIER server
- Integrated library manager functionality
- Clustering for higher performance and availability
- DFSMS (SMSTAPE) functionality
- Support for z/OS V1R10 and later with program temporary fixes (PTFs)
- Support for z/VM 5.4 and later with PTFs
- Support for replication functions and disaster recovery (DR) management
- FICON attachment (up to 4 ports per Enterprise controller)
- Scratch processing delete function
- Inline data deduplication performance

Extended information for service support and IT personnel can be found at this website:

http://publib.boulder.ibm.com/infocenter/ts7680/serv/index.jsp

For customer related and general information, including all technical details, see this website:

http://publib.boulder.ibm.com/infocenter/ts7680/cust/index.jsp

10.7 IBM Virtualization Engine TS7700

The IBM Virtualization Engine TS7700, a member of the IBM TS7000 virtualization family, provides tape virtualization for the System z environment. As the follow-on product to the highly successful IBM TotalStorage Virtual Tape Server, the TS7700 Virtualization Engine is designed to provide improved performance and capacity to help lower the total cost of ownership for tape processing. It introduces a new modular, scalable, high-performing architecture for mainframe tape virtualization.

The TS7700 Virtualization Engine integrates the advanced performance, capacity, and data integrity design of the 3592 Tape Drives, the IBM industry-leading tape technology, with high-performance disk and a new advanced System p server to form a storage hierarchy managed by robust storage management firmware with extensive self-management capability. It includes functions such as advanced policy management to control physical volume pooling, cache management, dual copy, dual copy across a grid network, and copy mode control. The TS7700 offers a new standards-based management interface and enhanced statistical reporting, compared to the VTS.

IBM offers two models of the TS7700 (Figure 10-12) Virtualization Engine:

- The TS7740 Virtualization Engine supports attachment to and exploits the performance and capacity of the IBM System Storage TS1130 and TS1120 Tape Drives or the IBM TotalStorage 3592 Model J1A Tape Drive installed in an IBM System Storage TS3500 Tape Library or IBM TotalStorage 3494 Tape Library. Support for these tape drives can help to reduce the number of cartridges and the size of the library by allowing the storage of up to 3 TB on a single 3592 JB cartridge, assuming 3:1 compression.

- The TS7720 Virtualization Engine provides high capacity for workloads that are cache friendly due to their rapid recall requirements. The TS7720 Virtualization Engine features 2 TB SATA disk drives with RAID 6 to allow customers to scale their solution to meet the needs of growing workloads without affecting application availability.

Figure 10-12 IBM Virtualization Engine TS7700

As mentioned before, TS7740 attaches TS3500 Tape Library with 3592 family of tape drives opposed to TS7720 which uses disk cache to store the data of attached host system.

10.7.1 TS7700 Virtualization Engine highlights

Here are the main features of the TS7700 Virtualization Engine of Release R1.6:

- System z FICON Attachment (up to 16 channels)
- TS7740 with up to 115.2 TB cache
- TS7720 disk-only with up to 1776 TB cache (using 2 TB SATA disks)
- Support for 2, 3, or 4 cluster GRID
- GRID support with mixed TS7720 and TS7740
- Copy Export for stand-alone cluster
- 3592 drives including native TS1120/TS1130 support (up to 64)
- TS3500 library attachment
- 3494 libraries (with 3592) (RPQ required with R1.6 or higher)
- Up to 1024 Virtual Drive addresses
- Logical WORM support
- Out-of-Band Encryption support
- Broadband Call Home (ECC)
- System Storage Productivity Center (SSPC) user authentication and audit logging
- Code installation improvement

These capabilities are designed to improve performance and capacity to help lower the total cost of ownership for tape processing and avoid the potential impact of human errors. A TS7700 can help improve the efficiency of mainframe tape operations by efficiently using disk storage, tape capacity, and tape speed, and by providing a large number of tape addresses.

The Virtualization Engine TS7700 utilizes outboard policy management functions to manage cache and volume pools, to control selective dual copy, dual copy across a grid network, copy mode control, encryption, and Copy Export. It also includes a new standards-based management interface and enhanced statistical reporting.

The IBM Virtualization Engine TS7700 is designed to provide tape virtualization for IBM System z servers, and can help you meet the major needs in your environment, such as reliability and window reduction of the backup/restore process, services downtime caused for physical tape drives and library outages, impacts to the operational staff that manage daily backup/restore processing, and infrastructure simplification through reduction of the number of physical tape libraries, drives, and media.

10.7.2 Characteristics of components comprising the TS7700

Here we summarize the characteristics of these virtualization engines:

- The Virtualization Engine TS7700 Server provides host connections for up to four FICON channels for attachment to IBM System z servers with the appropriate levels of System z software.
- In a TS3500 Tape Library, the TS7740 supports from four to 64 IBM 3592 tape drives.
- In a 3494 Tape Library, the TS7740 supports from four to 16 IBM 3592 tape drives.
- The TS7720 does not attach to any tape library or drives A TS7700 with Grid Enablement features can be interconnected with one or two other TS7700s (the same model of TS7700) to provide peer-to-peer copy capability between Virtualization Engines for tape using IP network connections.
- Each TS7700 supports up to a maximum of 1024 3490E virtual tape drives.
- A TS7700 Single or Multi Cluster Grid supports up to 1,000,000 logical volumes, each logical volume having a maximum capacity of 1.2 GB to 12 GB (assuming 3:1 compression and using the 400 MB to 4000 MB volume sizes).
- Supported systems include IBM z/OS v1.9, z/VM v5.3, z/VSE™ V4.1, and z/TPF 4.1

For additional information about IBM System Storage TS7700 models, see *IBM Virtualization Engine TS7700 with R1.6*, SG24-7712.

10.7.3 IBM Virtualization Engine TS7740

The IBM TS7740 is designed to help customers reduce costs by potentially using fewer tape drives and therefore reducing tape cartridge handling, reducing floor space requirements, and improving tape library slot utilization, by using disk storage and the performance and capacity of TS1130 tape drives.

Highlights of the TS7740 virtualization Engine are as follows:

- Can be attached to supported IBM System z servers
- Maximum of 1024 virtual drives and 1,000,000 virtual volumes
- Web-based management tools
- Advanced policy management
- IBM TS3000 System Console
- Up to 115.2 TB native tape volume cache (4 Cluster GRID)
- Can attach up to 64 TS1100 or 3592 tape drives
- Up to 16 4 Gbps FICON channel

10.7.4 IBM Virtualization Engine TS7720

IBM TS7720, which addresses the need for a very high volume tape cache capacity for applications that can benefit from having all their data cache resident, uses 2 TB SATA disk drives to provide high capacity cache with rapid recall of data.

Highlights of the TS7720 Virtualization Engine are as follows:

- Can be attached to supported IBM System z servers
- Maximum of 1024 virtual drives and 1,000,000 virtual volumes
- Web-based management tools
- Advanced policy management
- IBM TS3000 System Console
- Up to 1776 TB native tape volume cache using 2TB SATA drives
- Up to 16 4 Gbps FICON channels

10.8 IBM Data Facility Storage Management Subsystem

IBM Data Facility Storage Management Subsystem (DFSMS) is a software suite that automatically manages data from creation to expiration. DFSMS provides allocation control for availability and performance, backup/recovery and disaster recovery services, space management, tape management, and reporting and simulation for performance and configuration tuning. It offers the following benefits:

- Integrated, comprehensive data management solution
- Delivers managed, predictable service to meet Service Level Agreements for Storage
- Up to 50% increased effective storage capacity with reduced overall storage cost

10.8.1 IBM Data Facility Storage Management Subsystem Removable Media Manager for z/OS environments

The IBM Data Facility Storage Management Subsystem Removable Media Manager (DFSMSrmm) is the functional component of DFSMS for managing all removable media resources, including automatic, manual, and virtual tape libraries (such as the IBM TS7700 series), for the z/OS environment.

The following key functions are provided by DFSMSrmm:

- Tape Data Set Recording: DFSMSrmm automatically tracks and records metadata for data written to all types of tape volumes.
- Inventory Management: DFSMSrmm automatically records metadata for tape volumes used on the system, and allows you to define any tape volume, enabling your complete tape inventory be monitored and managed. DFSMSrmm supports tape volumes which are used anywhere in your enterprise, including z/VM, and those managed by the IBM Integrated Removable Media Manager for the enterprise on System z. You can easily partition your tape inventory and tape libraries and use DFSMSrmm to control which system can use the volumes.
- Life Cycle Management: DFSMSrmm provides policies to enable tape data sets and tape volumes to be managed throughout their life. You define your tape data service levels, tape technology retention criteria and DFSMSrmm automatically manages the life cycle.
- Scratch Pool Management: DFSMSrmm supports either a global scratch pool or you can define one or more specific scratch pools for non-system managed tape volumes. DFSMSrmm manages the selection of the pool, and the return of volumes back to the scratch pool after the tape data expires.

10.8.2 DFSMSrmm highlights

Here we list highlights for DFSMSrmm:

- DFSMSrmm is an integral part of DFSMS and is shipped as part of DFSMS with the z/OS operating system. DFSMSrmm cooperates with and exploits many various system components that are required for the complete security, management, and well being of your tape library.
- DFSMSrmm volume retention and movement policies, can optionally be specified interactively with ISPF panels. This allows authorized application owners to alter existing values without contacting the tape librarian.
- DFSMSrmm includes the report generator which is an ISPF based tool for easily building and customizing many various storage management reports. Sample report types and reports enable reporting based on DCOLLECT data, DFSMShsm functional statistics, and DFSMSrmm created data.
- In addition to the regular release updates, the DFSMSrmm enhancements provide many improvements; which recently include support for IBM's Integrated Removable Media Manager for the Enterprise (IRMM) on System z, support for D/T3592 Model E06 and larger tape volumes, support for TS7700 Release 1.6 and copy export, and migration health checks for V1R10 and V1R11.
- DFSMSrmm is a full function removable media management system for your enterprise. DFSMSrmm supports tape volumes which are used anywhere in your enterprise, including z/VM, and those managed by the IBM Integrated Removable Media Manager for the enterprise on System z.
- DFSMSrmm is functionally compatible with existing tape management systems and runs in parallel during conversion. The easy to use conversion tools and related documentation and Redbooks publications enable the easy migration of your existing tape environment to management by DFSMSrmm. The special expiration date formats of 99nnn and 98nnn are supported by DFSMSrmm.

For DFSMSrmm enhancements, past and present, see the website:

http://www-01.ibm.com/support/docview.wss?rs=0&q1=T1010391&uid=isg3T1010391&loc=en_US&cs=utf-8&cc=us&lang=en

To learn more about DFSMS, see the *DFSMS V1.10 and EAV Technical Guide*, SG24-7617.

10.9 More information

For more information about the IBM tape virtualization products and service offerings, see this website:

http://www-03.ibm.com/systems/storage/tape/index.html

Also see the following publications:

- *IBM Virtualization Engine TS7700 Release 1.4a: Tape Virtualization for System z Servers*, SG24-7312
- *IBM Virtualization Engine TS7700 with R1.6*, SG24-7712
- *The IBM Virtualization Engine TS7510: Getting Started with i5/OS and Backup Recovery and Media Services*, SG24-7510
- *IBM System Storage TS7650 and TS7650G with ProtecTIER*, SG24-7652
- *TS7680 Deduplication ProtecTIER Gateway for System z*, SG24-7796

11

Complementary storage products

In this chapter, we discuss entry-level tape products that are complementary to the LTO series of drives and libraries discussed earlier. The entry-level tape products cover a wide range of formats to suit varied business needs. We also consider drive enclosures for table/shelf and rack mounting.

Low cost and high reliability are key in making the right decision to purchase products listed in this chapter. These devices usually do not replace typical central backup solutions such as Tivoli Storage Manager (TSM). Their intention is to offer cost-effective tools for fast recovery of basic operating systems and business critical data without any need to have available a complete backup/recovery environment. Thus these products are very suitable for operating system image backups, application configuration backups, data migration to different environments, and so on.

IBM offers a wide range of external tape drives and external enclosure technology to help support business continuance in the workplace, such as the following models:

- IBM DDS Generation 5 USB Tape Drive
- IBM DDS Generation 6 USB Tape Drive
- IBM TotalStorage 7206 Model 336 External DAT72 (DDS Gen 5) Tape Drive
- IBM TotalStorage 7207 External Tape Drive for AS/400® and System p
- IBM System Storage 7214 Storage Device Enclosure
- IBM System Storage 7216 Storage Device Enclosure
- Half High Tape Drive External Enclosure
- 1U Tape Drive External Enclosure

Availability: The IBM System Storage 7212 Storage Device Enclosure Express model has been withdrawn from market. The IBM System Storage 7216 Storage Device Enclosure is being offered instead.

11.1 IBM DDS Generation 5 USB Tape Drive

The IBM DDS Generation 5 USB tape drive (as seen in Figure 11-1) is the entry point into the IBM DDS tape drive family and offers dependable capacity and performance for value-conscious small and medium or distributed large enterprise businesses. DDS/DAT technology has the proven reliability and low cost of ownership to effectively meet the demanding backup, archival, and regulatory compliance requirements of your System x environment.

Figure 11-1 IBM DDS Generation 5 USB Tape Drive

IBM DDS Generation 5 technology delivers a capacity of up to 72 GB on a single data cartridge and a transfer rate of up to 22 GB/hr (assuming a 2:1 compression ratio) at an entry price point. Its USB 2.0 interface supports internal plug and play capability with the latest System x systems, as well as external attachment in one of the IBM external tape drive enclosures. DDS Generation 5 technology is also backward read and write compatible with DDS-3 and DDS-4/DAT 40 media to ensure an easy migration or upgrade path for existing DDS/DAT users.

11.1.1 IBM DDS Generation 5 USB Tape Drive highlights

Here we list highlights of the IBM DDS Generation 5 USB Tape Drive:

- USB interface allowing for direct internal connections with select System x servers
- Eliminates potential RAID conflicts and extra controllers
- 5.25-inch half-high form factor
- Drive can be converted to 3.5 inch form factor either in the factory (CTO) or in the field using the appropriate enablement kit
- Internal USB interface for simplified plug-and-play installation
- Optional DDS Tape Enablement kits allow for internal installation in select IBM System x rack-optimized servers
- Flexible external USB configuration offerings when used with desktop or 1U rack-mount enclosures
- Support for leading operating systems and popular backup software
- Up to 36 GB native capacity, and up to 72 GB in compressed mode
- Up to 3 MBps native back-up rate, and up to 6 MBps in compressed mode
- USB 2.0 interface
- Read/write compatibility with DDS-4, and DDS-3 cartridges
- Available internal or external USB port

- Available 5.25-inch half-high bay for internal installations
- Supported external tape enclosure for external attachment:
  - IBM 1U Rackmount Tape Enclosure
  - IBM Half High Tabletop Tape Enclosure

11.1.2 Additional information

For more information about the IBM DDS Generation 5 USB Tape Drive, see the website:

http://www.redbooks.ibm.com/abstracts/tips0755.html?Open

11.2 IBM DDS Generation 6 USB Tape Drive

The IBM DDS Generation 6 Internal USB Tape Drive provides optimum capacity, performance, and a low total cost of ownership for small and medium business environments or enterprise workgroups that require the highest capacity and performance DDS (DAT) drive available. The drive supports DDS Generation 6 cartridges, which have a native capacity of 80 GB (160 GB compressed) as well as a transfer rate of up to 6.9 MBps native and up to 13.8 MBps compressed as seen in Figure 11-2.

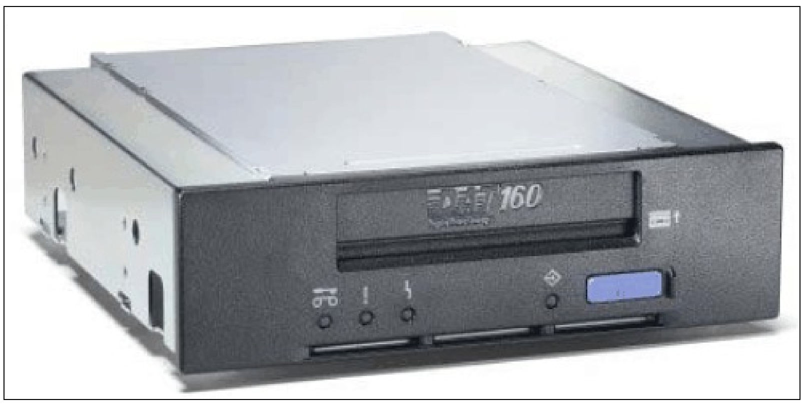


Figure 11-2 IBM DDS Generation 6 USB Tape Drive

The IBM DDS Generation 6 USB Tape Drive maintains the competitive total cost of ownership of Digital Data Storage. Its USB interface supports plug and play capability with the latest System x systems, and can be installed internally in supported servers or supported externally in tape drive enclosures. This option is a higher performance and capacity alternative to the IBM DDS Generation 5 drive.

11.2.1 IBM DDS Generation 6 USB Tape Drive highlights

The main features of the IBM DDS Generation 6 USB Tape Drive include these:

- Highest capacity and performance in the DDS portfolio
- Up to 80 GB native capacity, and up to 160 GB in compressed mode
- 6.9 MBps native back-up rate and up to 13.8 MBps in compressed mode
- USB 2.0 interface
- Read/write compatibility with DDS Gen-5 and DDS-4 cartridges
- Internal USB interface for simplified plug-and-play installation

- 5.25 inch half-high form factor; drive can be converted to 3.5 inch form factor either in the factory (CTO) or in the field using the appropriate enablement kit
- Optional DDS Tape Enablement Kit allows for internal installation in select IBM System x rack-optimized servers
- Flexible external USB configuration offerings when used with desktop, 1U rack-mount, or 4U rack-mount enclosures
- The IBM DDS Generation 6 Media 5 Pack has a limited lifetime warranty

11.2.2 Additional information

For more information about the IBM DDS Generation 6 USB Tape Drive, see the website:

http://www.redbooks.ibm.com/abstracts/tips0725.html?Open

11.3 IBM TotalStorage 7206 External Tape Drive

Availability: IBM 7206 models 220 and 336 have been withdrawn from market by IBM, nevertheless we decided to keep the following information in the chapter because this is a basic model of DAT external tape drive (DDS-5). You can obtain the product as-available from IBM Business Partners.

The IBM 7206 External DAT72 (DDS Gen 5) Tape Drive (as seen in Figure 11-3) is intended to be a cost-effective tape drive featuring the popular DAT72 (DDS) tape technology. It is designed to offer improved data quality and performance and increased capacity compared to the IBM 7206 Model 220. The 7206 Model 336 supports a migration path to greater tape storage capacity at a price point similar to IBM 7206-220 DDS4 tape drives.

The IBM 7206 Model 336 External DDS Gen 5 (DAT72) Tape Drive can attached to System p servers by an Ultra2, Ultra3, or Ultra320 SCSI LVD interface.

The 7206 Model 336 tape drive can achieve a media capacity up to 72 GB with 2:1 data compression, nearly twice the capacity of the previous IBM 7206-220 DDS4 tape drive. The 7206 Model 336 offers a sustained data transfer rate of up to 6 MB per second (with 2:1 compression).

Figure 11-3 IBM TotalStorage 7206 Model 336 External DDS Gen 5 Tape Drive

11.3.1 IBM 7206 Model 336 highlights

Here we list the key elements of the IBM TotalStorage 7206 Model 336 External DDS Gen 5 Tape Drive:

- Designed for improved data rate compared to IBM 7206 Model 220
- Designed for read and write compatibility with previous generation 4mm tape media
- Read and write compatible with two previous generations of DDS tape technology
- Capacity of up to 72 GB per media cartridge
- Data transfer rate up to 6 MBps (with compression)
- Compatible with most IBM System i and IBM System p server models
- Limited lifetime warranty on IBM DAT72 (DDS Gen 5) media

11.3.2 Additional information

For more information, see the website:

http://www.ibm.com/systems/storage/tape/7206/336/index.html

11.4 IBM TotalStorage 7207 External Tape Drive

The IBM TotalStorage 7207 External Tape Drive (as shown in Figure 11-4), offers an affordable backup, archival storage, and data interchange for your iSeries/AS400 and pSeries/RS6000 systems. The 7207 is the modification of previously discussed IBM TotalStorage 7206 Tape Drive, with the different supported platforms.

The 7207 Model 330 SLR60 External Tape drive provides up to 37.5 GB of capacity and a data rate of 4 MBps. Media sizes of 30 GB and 37.5 GB are available. Assuming a compression of 2:1, typical of this tape drive, the tape drive reaches capacities of 60 GB and 75 GB respectively and a transfer rate of 8 MBps.

Figure 11-4 IBM TotalStorage 7207 External Tape Drive

11.4.1 IBM TotalStorage 7207 External Tape Drive highlights

Here we list highlights of the IBM TotalStorage 7207 External Tape Drive:

- SCSI (LVD/SE) attachment to eServer iSeries/AS400 and pSeries/RS6000 systems
- The 7207 model 330 provides Read/Write compatibility with SLR100, MLR3 and MLR1 (QIC) tape formats and read compatible with SLR5 and DC9250 media
- Sustained Data Rate of 4 MBps (8 MBps with compression) for the 7207 model 330
- Capacities of up to 37.5 GB (75 GB when compressed) for the model 330, 4 GB (8 GB with compression) for the 122
- Capacity per cartridge (two options):
  - Up to 30 GB native: Up to 60 GB compressed (Part Number: 14P4209)
  - Up to 5 GB native: Up to 10 GB compressed (Part Number: 35L0661)

11.4.2 Additional information

For more information about the IBM System Storage 7207 External Tape Drive, see the website:

http://www.ibm.com/systems/storage/tape/7207/index.html

11.5 IBM External Tape Enclosures

Server designs are increasingly focused on higher performance in the most compact and affordable packaging possible. At the same time, these designs must provide the save and restore compatibility of storage options offered on systems with larger footprints. IBM External Tape Enclosures provide a space saving in your rack frames and low cost alternative to mounting storage devices internally in your servers.

11.5.1 IBM System Storage 7214 Storage Device Enclosure

The IBM System Storage 7214 Storage Device Enclosure (as seen in Figure 11-5), features the IBM Ultrium LTO4 or DAT160/320 technology options in tape drives and DVD optical drives. The 7214 Storage Enclosure is a low-profile design that is an excellent choice for mounting in your System p 19" rack.

Figure 11-5 IBM System Storage 7214 Storage Device Enclosure

Despite the decreasing availability of server bays for storage devices, it is still important to consolidate storage devices in a single, convenient location to minimize space and cabling impacts. The IBM System Storage 7214 Tape and DVD Enclosure Express is designed to mount in one EIA unit of a standard IBM Power Systems 19-inch rack, and can be configured with one or two tape or DVD drives. The 7214 Express enclosure attaches to SAS-based models of the IBM Power Systems through external serial attached SAS adapters. The 7214 Express also attaches to certain open system adapters.

The SAS electronic interface on the 7214 Express is designed to provide faster transfer rates, greater convenience and a reduction in space required for system-to-device cabling.

IBM System Storage 7214 Storage Device Enclosure highlights

Here we list highlights of the IBM System Storage 7214 Storage Device Enclosure:

- 1U slim profile designed for 19-inch rack system environments
- Features IBM Half-High LTO4 technology designed for reliable performance in small-medium open system environments
- Supports DAT72, DAT160, DVD-RAM and DVD-ROM drives
- IBM Half-high LTO 4 supports the encryption of data for increased security with archived data
- Supports 3 GBps IBM SAS interfaces

- Dual-drive enclosure, side-by-side
- Offers choices of HH LTO4 and DAT160 tape and DVD storage technologies
- Control card sensor designed to track drive function and notify user of maintenance requirements
- Adheres to LTO specifications
- Support of Ultrium WORM media
- DAT160 tape drives are read-write compatible with DAT72 and DDS4 media
- Typical compression
  - 2:1 for tape drives
  - 3:1 for DVD optical drives

Drive options in the 7214 Storage Enclosure

The list of the tape drive options within the 7214 Storage Enclosure includes these:

- DAT160 80GB 4 mm format tape drive:

  Storage capacity of up to 160 GB with a data transfer rate of up to 13.8 MB per second (assumes 2:1 compression).
- DAT320 160GB 4mm format tape drive:

  Storage capacity of up to 320 GB with a data transfer rate of up to 27.6 MBps
- Half-high LTO Ultrium 4 tape drive:

  Storage capacity of up to 1.6 TB with a data transfer rate of up to 240 MB per second (assumes 2:1 compression)
- DVD-RAM drive:

  Native capacity of up to 9.4 GB with a data transfer rate of 2.77 MB per second

Additional information

For additional information about the IBM 7214 Storage Enclosure, see the website:

http://www.ibm.com/systems/storage/tape/7214/index.html

11.5.2 IBM System Storage 7216 Multimedia Enclosure

The 7216 Model 1U2 Multimedia Storage Enclosure is designed to mount in one EIA unit (1U) of a standard System p 19” rack. An IBM 7216 has two drive bays that can contain up to two tape drives, DVD-RAM sleds, and/or Removable Disk Docking Station (RDX). The DVD-RAM sled can be configured with one or two DVD-RAM Serial Attached SCSI (SAS) drives.

For the connection of the 7216 enclosure to IBM POWER7™ Systems, the SAS drive features require the PCI-X DDR Dual-x4 SAS Adapter (available as a feature code). Up to two 7216 enclosures can be attached to this adapter. USB drive features can attach to the standard USB ports on the system or to the 4-port USB Adapter, which needs to be ordered separately. IBM Service offerings include onsite service as well as a lower cost Customer Replaceable Unit (CRU) option for customer to service the unit themselves during 7216 idle time.

The IBM System Storage 7216 Multi-Media Enclosure is an excellent choice for environments where the following conditions exist:

- The availability of internal server bays for storage devices is limited or no bays are available (depending on server model).

- It is important to consolidate storage devices in a single, convenient location to minimize space and cabling impacts.
- There is a need for the versatility of tape, DVD-RAM, and removable disk drives with either SAS and USB interface electronics.
- 19-inch rack space is limited.


Figure 11-6 Two bays of IBM System Storage 7216 Multimedia Enclosure

The two bays (left and right) of the 7216 shown in the Figure 11-6 can accommodate the following concrete tape or DVD drives for IBM POWER7 server models:

- DAT320 160 GB SAS Tape Drive - up to two drives
- DAT320 160 GB USB Tape Drive - up to two drives
- Half-high Ultrium LTO5 1.5 TB SAS Tape Drive - up to two drives
- DVD-RAM SAS Optical Drive - up to four drives
- RDX Removable USB Disk Drives - up to two drives

The IBM System Storage 7216 Multimedia Enclosure is designated as customer setup. The specific 7216 configuration ordered will arrive fully assembled, with drive firmware installed.

IBM System Storage 7216 Multimedia Enclosure highlights

The product just described provides customers with the following features:

- A low-profile design that can be configured with up to four storage devices and mounted in 1U space in a19-inch rack
- Offers the DAT320 4 mm format and Half-height Ultrium 5 tape drives, DVD-RAM or RDX Removable disk drives. DAT320 available with either SAS or USB electronic bus
- Connects to high performance IBM POWER7 System
- Provides performance and capacity enhancements of DAT320 and LTO5 tape drives, and additional versatility of RDX removable disk drives
- Data encryption available on tape drives
- Onsite IBM support or Customer Replaceable Unit (CRU)

Additional information

For more details and additional information about IBM System Storage 7216 Multimedia Enclosure, visit the online repository under the following link:

http://www.ibm.com/systems/storage/tape/7216/index.html

11.5.3 Half High Tape Drive External Enclosure

The Half-High SCSI Tape Enclosure (as seen in Figure 11-7), provides a space saving and low cost alternative to mounting a drive internally in your server. In stealth black, this table or shelf unit becomes an ideal solution when you are looking for one of our wide array of Half-Height System x Tape drives.

Figure 11-7 HH Tape Drive External Enclosure

Half High Tape Drive External Enclosure highlights

Here we list the drive options of the IBM Tape Drive Enclosure unit:

- Single Half-Height Bays
- Either Table Top or Shelf Form Factor
- Drive dependent Interface of either Single SCSI Enclosure Adaptor Kit (42C3910) or SAS Enclosure Adaptor Kit (40K2599) required
- SAS Enclosure Adaptor Kit (40K2599) supports both SAS and SATA Based Drive

Additional information

For more information about the HH Tape Drive External Enclosure, see the website:

http://www.ibm.com/systems/storage/tape/halfhightapedrive/index.html

Availability: The IBM Full High Tape Drive External Enclosure has been withdrawn from the market as of January 2, 2009.

11.5.4 1U Tape Drive External Enclosure

The IBM 1U rack-mount external tape enclosure (as seen in Figure 11-8), provides a cost-effective solution for adding up to two half-height tape drives externally to your IBM rack-optimized system x server environments.

Figure 11-8 1U Tape Drive External Enclosure

1U Tape Drive External Enclosure highlights

The main features of the IBM 1U Tape Drive External Enclosure include these:

- Two Half-Height Bays
- 1U Rack-Mount Form Factor
- Interface of either Single SCSI Enclosure Adaptor Kit (42C3910) or SAS Enclosure Adaptor Kit (40K2599) required (up to 2 maximum)
- SAS Enclosure Adaptor Kit (40K2599) supports both SAS and SATA Based Drives

Additional information

For additional information about the 1U Tape Drive External Enclosure, see the website:

http://www.ibm.com/systems/storage/tape/1utapedrive/index.html

> **Availability:** The IBM 4U Tape Drive External Enclosure has been withdrawn from the market as of July 3, 2008.

Part 3

Storage Networking

In Part 3 we introduce important technologies and protocols that can be used to interconnect storage devices. These include SAN, NAS, and iSCSI. Then we provide information about the recently introduced IBM Ethernet switches and routers.

12

Introduction to storage networking

Variations for storage networking seem to be materializing faster than they can be implemented. Storage networking offers significant capabilities and flexibility for accessing stored data that was not previously available.

Storage area networks (SANs) have become extremely important for today's data storage technologies. Previously, for client server systems, data was stored directly on internal devices or directly attached to the server. Eventually Network Attached Storage (NAS) took the storage devices away from the server and connected them directly to the network.

However, SANs have taken the principle one step further by allowing storage devices to exist on their own separate network and communicate directly with each other over very fast media. Today, storage networking allows users to gain access to their storage devices through server systems that are connected to both the LAN and the SAN. Understanding the technology basics is essential to making the best choices.

In this chapter, we introduce various storage networking options that you can choose to build the infrastructure for accessing your stored data. We mainly cover the fundamentals of SAN and various SAN expansion technologies.

12.1 Overview

Why are there so many forms of storage networking? One reason is that new technologies emerge and evolve but do not replace the investment in previous technologies overnight. And no single storage networking approach solves all problems, or optimizes all variables. There are trade-offs in cost, ease-of-management, performance, distance, and maturity, to name but a few. For the foreseeable future, multiple storage networking alternatives will coexist, often within the same organization.

The three popular models for attaching storage for the network are Storage Area Network (SAN), Network Attached Storage (NAS), and iSCSI. These methods help to remove direct attachments between storage and server, giving more flexibility in storage access.

The SAN can be viewed as an extension to the storage bus concept that enables storage devices and servers to be interconnected using similar elements as in LAN: routers, hubs, switches, directors and gateways. Storage resides on this dedicated network, providing an any-to-any connection for processors and storage on that network. The data traffic is based on a block level I/O (requests access devices directly). The most common media is Fibre Channel. Fibre Channel Protocol (FCP) is the I/O protocol for open systems, and Fibre Connectivity (FICON) replaces it for mainframe environments. Ethernet-based SANs have a new protocols emerging. Today, there are several popular protocols used to build or extend a SAN besides FCP like Internet SCSI (iSCSI), Fibre Channel over IP (FCIP), Internet Fibre Channel Protocol (iFCP), and now there are new emerging protocols, Fibre Channel over Ethernet (FCoE), and Fibre Channel over Convergence Enhanced Ethernet (FCoCEE).

The NAS device is attached to a TCP/IP-based network (LAN or WAN), and accessed using CIFS, NFS or specialized I/O protocols for file access and file sharing. The data traffic is based on a file level I/O. It receives an NFS or CIFS request over a network and has an internal processor which translates that request to the block-I/O commands to access the appropriate device only visible to the NAS product itself.

12.2 Storage Area Network

A Storage Area Network (SAN) is a dedicated network for storage devices and the processors that access those devices. Figure 12-1 shows a picture of a SAN. SANs today are usually built using Fibre Channel technology, but the concept of a SAN is independent of the underlying type of network. I/O requests to disk storage on a SAN are called “block I/Os” because, just as for direct-attached disk, the read and write I/O commands identify a specific device (disk drive or tape drive) and, in the case of disks, specific block (sector) locations on the disk.

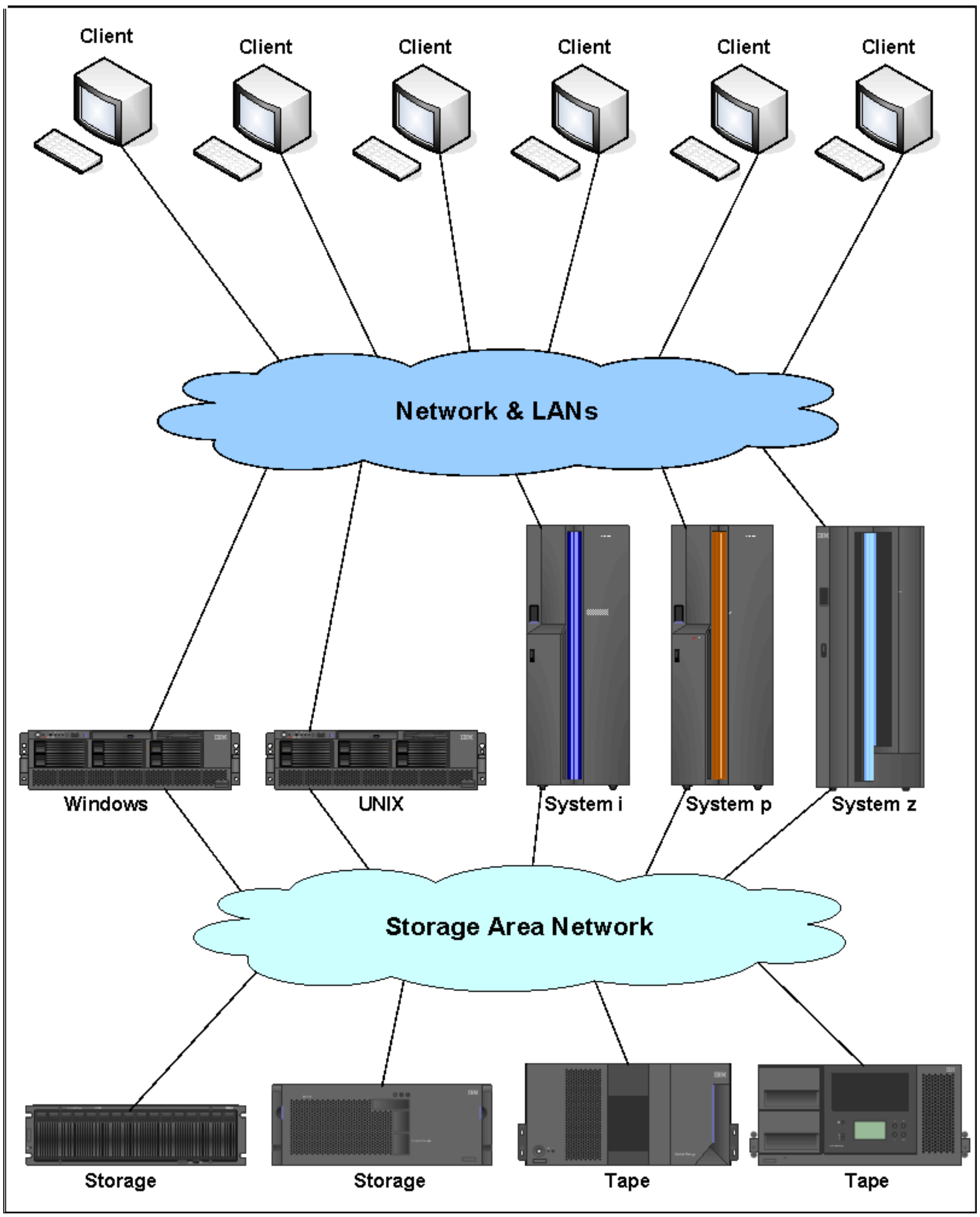


Figure 12-1 A picture of a SAN

The major potential benefits of a SAN can be categorized as follows:

- Improvement to application availability:

  Storage is independent of applications and accessible through multiple data paths for better reliability, availability and serviceability.

- Higher application performance:

  Storage processing is off-loaded from servers and moved onto a separate network, for example, LAN-free and server-free backups.

- Centralized and consolidated storage:

  Simpler management, scalability, flexibility, and availability are provided.

- Data transfer and vaulting to remote sites:

  Remote copy of data is enabled for disaster protection and against malicious attacks.

- Simplified centralized management:

  Single image of storage media simplifies management.

In this section, we explain important concepts involved in SAN.

12.2.1 Fibre Channel

Fibre Channel is well established in the open systems environment as the underlying architecture of the SAN. Fibre Channel is a technology standard that allows data to be transferred from one network node to another at very high speed. The interconnections between nodes are not necessarily based on *fiber* optics, but can also be based on copper cables. Fibre Channel is ideal for moving large volumes of data across long distances quickly and reliably. In current implementations, Fibre Channel standard speed is generally available from 2 Gbps up to 10 Gbps, however most older 2 Gbps equipment is being replaced by faster equipment.

This standard is backed by a consortium of leading vendors and has been accredited by the American National Standards Institute (ANSI).

Fibre Channel is structured with independent layers, as are other networking protocols. There are five layers, where 0 is the lowest layer. The physical layers are 0 to 2. These layers carry the physical attributes of the network and transport the data created by the higher level protocols, such as SCSI, TCP/IP, or FICON.

As shown in Figure 12-2, the top two layers (the session and transport layers) can be used by these protocols to move data segments. These segments are then rolled into a packet, which in turn are rolled into a frame. The originator creates the frame and sends it to the destination, which unravels the frame back to a segment.

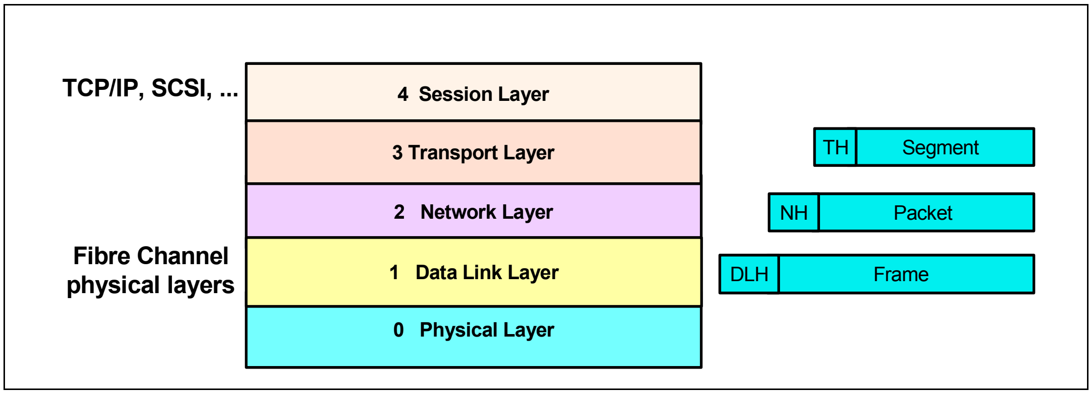


Figure 12-2 Fibre Channel protocol layers

12.2.2 A converged network

The prevalence of FC storage in the world's data centers cannot be ignored when introducing a new technology. The current FC SAN investment must be protected, which is not negotiable. But, this still does not answer the question, "Why converge?" Well, the appeal of the convergence is that the existing FC infrastructure can be maintained, the management model is the same as the existing FC, fewer components will be required, and therefore, there is less power and cooling necessary, giving potential energy savings.

So before we fully answer our question, let us step back and look at a very simple example of the interfaces and networks that exist today. As we touched upon briefly, data centers and applications can all utilize different interfaces or adapters. For example:

- Ethernet (Ethernet network interface card (NIC))
- Fibre Channel (Fibre Channel host bus adapter (HBA))

Figure 12-3 shows a traditional server setup of today.

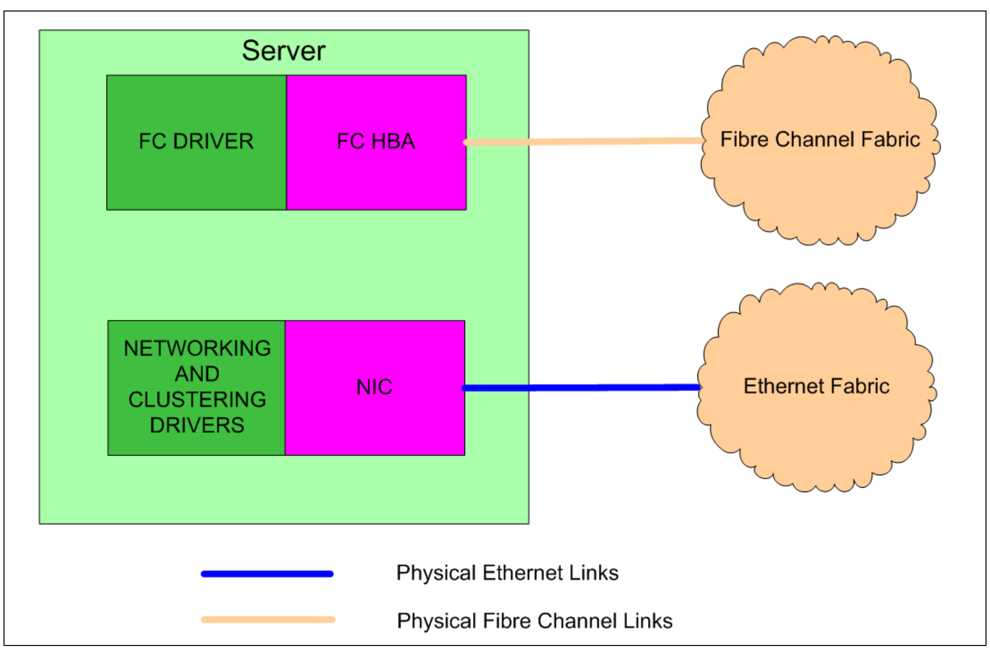


Figure 12-3 Traditional server of today

Using these examples, it is easy to see that we are presented with different networks. And each of these networks has its own adapters, fabrics, cables, tools, switches, management, and skills needed to maintain it. If somehow, all these of these components were combined, or converged, the potential for reducing cables, adapters, switches, and the skills required is obvious. Replacing multiple networks with one network is becoming closer to reality.

At a minimum, a converged network requires an adapter at the server that is capable of carrying FC and networking storage, and at the fabric/network level, FCoE capability will be required, which is sometimes referred to as the "*access layer*."

Using our "traditional server of today" diagram, now in Figure 12-4 we show how a converged network adapter in a server, connected to the Enhanced Ethernet, has the potential to reduce the components required.

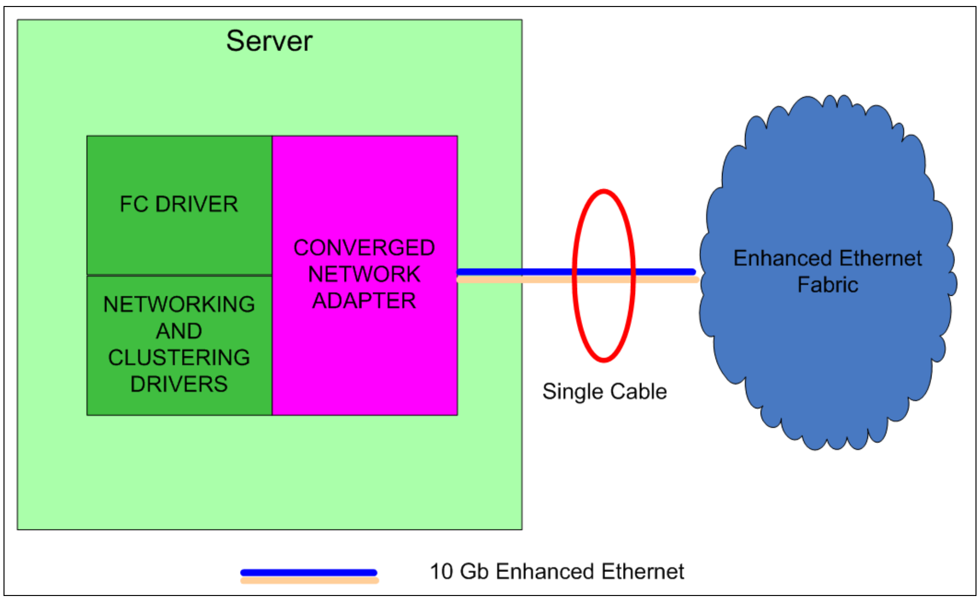


Figure 12-4 Converged Network Adapter

At the server level, we are already starting to see Converged Network Adapters (CNAs). Using a Fibre Channel driver, the CNA functionally represents a traditional Fibre Channel HBA to the server's operating system. Using NIC or clustering drivers, the CNA functionally represents a traditional networking or clustering device to the server's operating system. The Fibre Channel traffic is encapsulated into FCoE frames (as we describe in the topics that follow) and these FCoE frames are converged with networking or clustering traffic.

Within the fabric, we are beginning to see FCoE-capable switches that can pass Fibre Channel traffic to the attached SANs and Ethernet traffic to the attached Ethernet network. These switches need to be able to support the Enhanced Ethernet, and we discuss those demands in the topics that follow.

12.2.3 SAN topologies

Fibre Channel based networks support three types of topologies:

- Point-to-point:

  This is the simplest topology of the FC SAN, which allows the host and storage to connect directly.

- Loop (arbitrated):

  Arbitrated loop, also known as FC-AL, is a Fibre Channel topology in which devices are connected in a one-way loop fashion in a ring topology.
- Switched:

  Switched fabric is a computer network topology where many storage devices connect with each other by switches.

These can be implemented separately or interconnected to form a *fabric*. The fabric can also be extended to cover even greater distances. Currently, the distance limitation for synchronous data transfers is about 100 km and virtually unlimited for asynchronous data transfers (see 12.3, "IP storage networking technologies" on page 385).

Synchronous data transfers require an acknowledgement that the data arrived at the receiving end before the data is discarded at the transmitting end, whereas asynchronous data transfers do not require acknowledgement before the data is discarded.

Point-to-point topology

The point-to-point topology is the easiest Fibre Channel configuration to implement, and it is also the easiest to administer. This simple link can be used to provide a high-speed interconnection between two nodes as shown in Figure 12-5. A node is any device with one or more Fibre Channel ports.

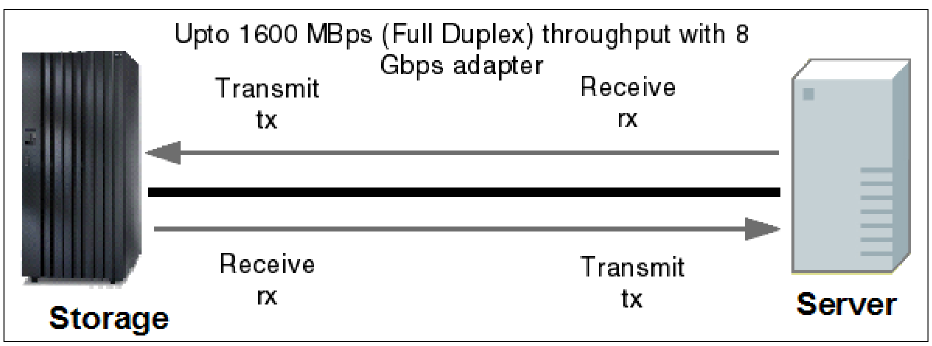


Figure 12-5 Fibre Channel point-to-point topology

Because connectivity is limited to two nodes, the exploitation of point-to-point in tape environments is limited; however the distance between nodes can be up to 10 km, which enables a tape library to be located at another site.

When greater connectivity and performance are required, each device can be connected to a fabric without incurring any additional expense beyond the cost of the fabric itself.

Loop (arbitrated) topology

The Fibre Channel arbitrated loop offers relatively high bandwidth and connectivity at a low cost. For a node to transfer data, it must first arbitrate to win control of the loop. When the node has control, it is now free to establish a virtual point-to-point connection with another node on the loop. After this point-to-point (virtual) connection is established, the two nodes consume all of the loop's bandwidth until the data transfer operation is complete. After the transfer is complete, any node on the loop can now arbitrate to win control of the loop.

A Fibre Channel arbitrated loop includes the following characteristics:

- Support of up to 126 devices is possible on a single loop.
- Devices can be hot-swapped with the implementation of hubs and bypass ports.
- A loop is self-discovering; it finds out who is on the loop and tells everyone else.
- Logic in the port allows a failed node to be isolated from the loop without interfering with other data transfers.
- Virtual point-to-point communications are possible.
- A loop can be interconnected to other loops, essentially forming its own fabric.
- A loop can be connected to a suitable Fibre Channel switch to create fan-out, or the ability to increase the size of the fabric even more. Note that not all switches support direct attachment of loops.

FC hub devices support FC loop connections while offering several of the benefits of switches. Figure 12-6 shows an FC loop using a hub. Be aware that FC hub technology is no longer marketed and is now rare in production environments.

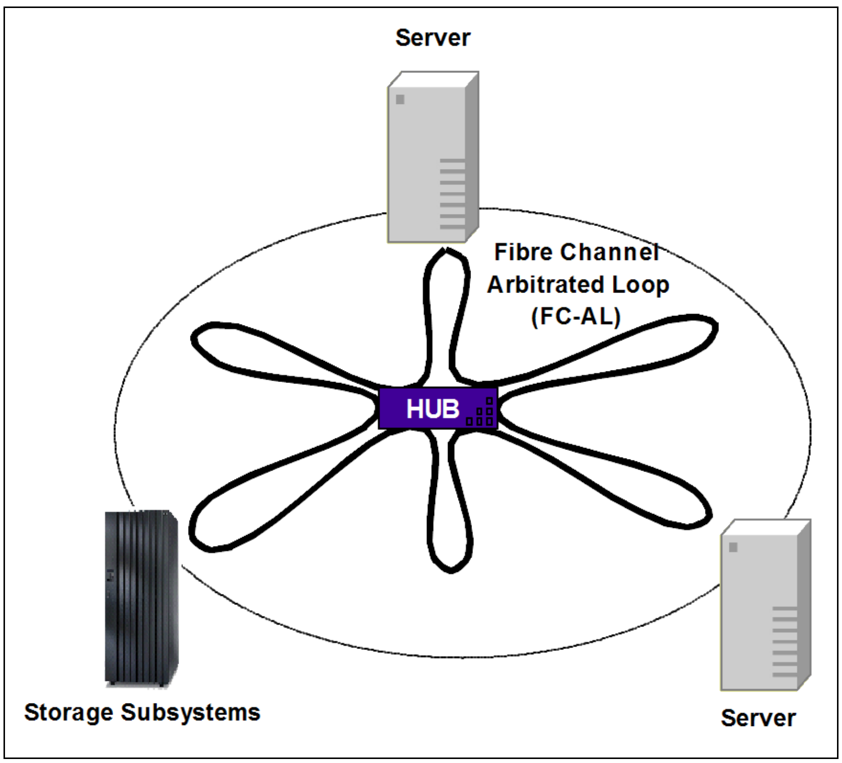


Figure 12-6 Fibre Channel loop topology

Switched topology

Fibre Channel switches function in a manner similar to traditional network switches to provide increased bandwidth, scalable performance, an increased number of devices, and, in certain cases, increased redundancy. Fibre Channel switches vary in the number of ports and media types they support.

> **Topology:** This topology is the most widely used in current SAN implementations.

Multiple switches can be connected to form a switch fabric capable of supporting a large number of host servers and storage subsystems, as shown in Figure 12-7. When switches are connected, each switch's configuration information has to be copied (*cascaded*) into all the other participating switches.

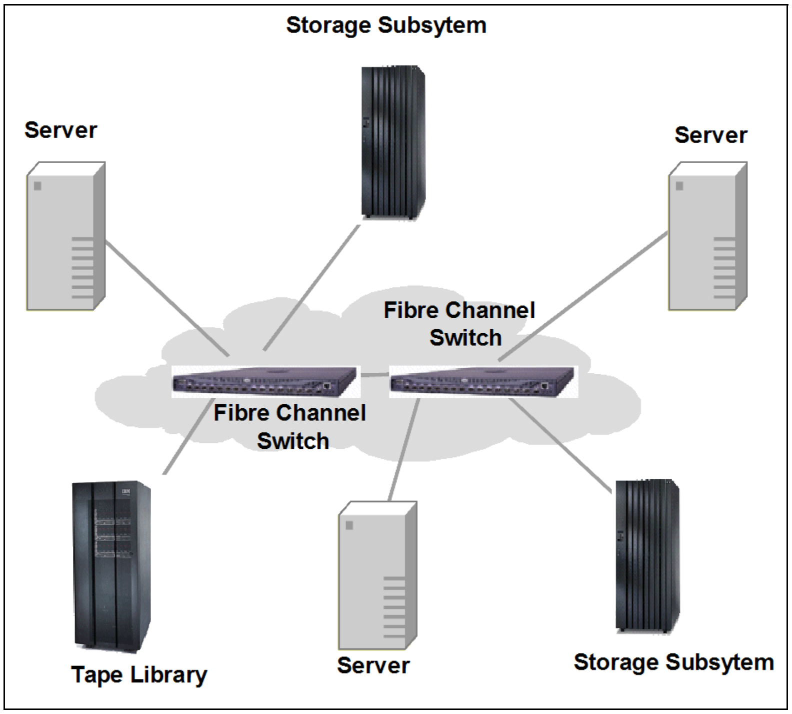


Figure 12-7 Fibre Channel switched topology

Switched fabrics provide the richest function for the tape environment, providing distance for remote tape vaulting and disaster tolerance, multi-server connectivity for tape library sharing, and multiple paths for redundancy. Switches can be connected together (Figure 12-7) to provide extra paths and larger networks.

Single switched fabric

A switched point-to-point fabric without redundancy can support a large number of servers. A configuration can be set up to allow every server to have access to every switch, and every controller to be connected to at least two switches. This allows any server to get to any controller or device, and it allows for continuous operation (although with degraded performance) in the event that a switch fails.

An example of a non-redundant fabric is shown in Example 12-8.

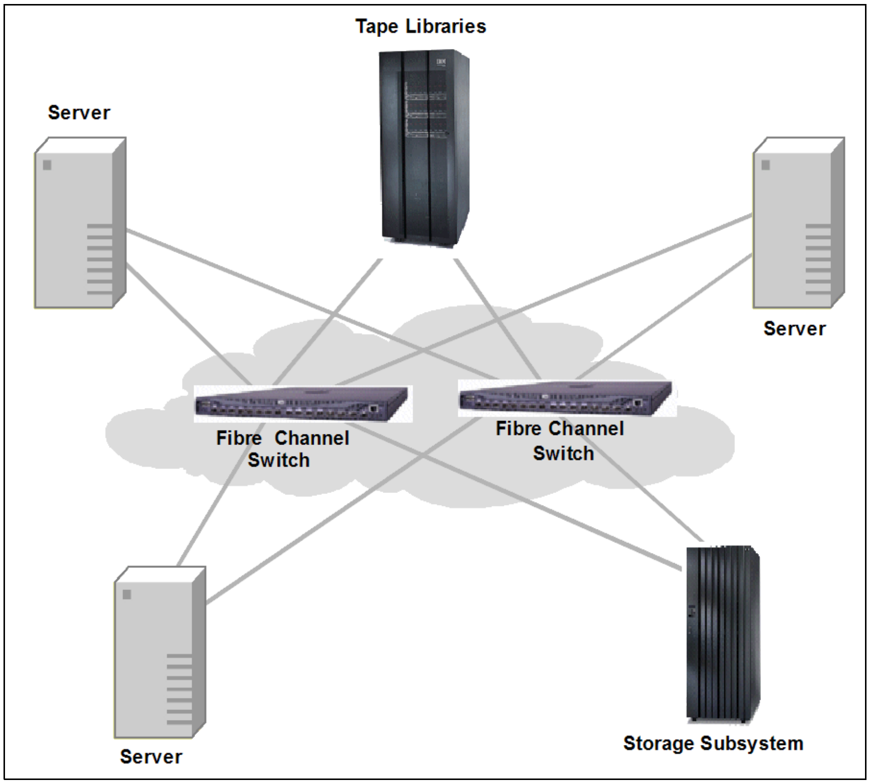


Figure 12-8 Fibre Channel single switched topology

Switched fabric with redundancy

A switched fabric with redundancy provides interconnections between switches, so that the collection of switches looks like one large, any-to-any switch. Fabric management becomes more complex than with basic switched point-to-point configurations and there are often limits imposed by product vendors on the number of switch-to-switch hops permitted when negotiating the fabric. Inter-switch links can fail and must be identified (many switch vendors do not yet support any reporting on inter-switch links).

Traffic can be routed in many ways. For technical, security, or other reasons, various levels of zoning or other mechanisms can be used to restrict the any-to-any access. Performance monitoring and configuration changes or upgrades needed to keep the network performing adequately are more complex.

Tip: Zoning splits the SAN into subnetworks. The servers within a zone have any-to-any connectivity, but anything outside the zone is not visible to them. Virtual SANs (VSANs) are used by Cisco, where the SAN is partitioned at the hardware level, into logical sections, for the purpose of isolating traffic, security, and error containment.

The primary advantage of a switched redundant fabric is that it looks like a very large logical switch, where a single connection provides access to any other port on the total set of switches, as shown in Figure 12-9.

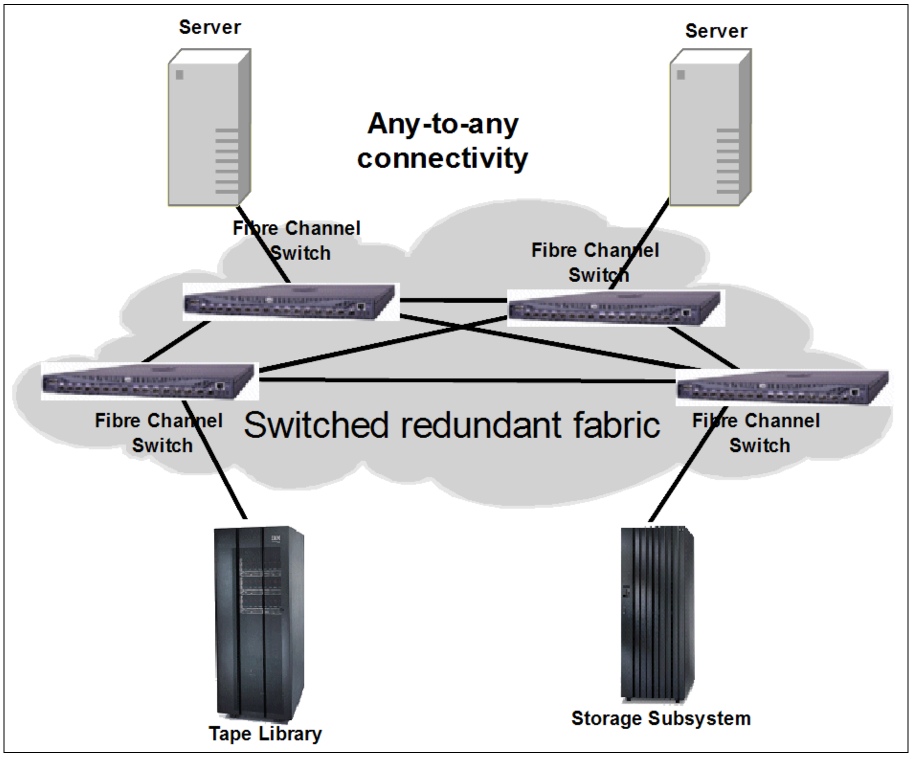


Figure 12-9 Fibre Channel switched topology (redundant switches)

12.2.4 Physical components of SAN infrastructure

Here we take a brief look at components that are commonly encountered in the FC SAN implementations.

Cables and connectors

FC connectors come mainly in two types as LC and SC connectors. Figure 12-10 shows FC connectors and cables. LC connectors are now the standard.

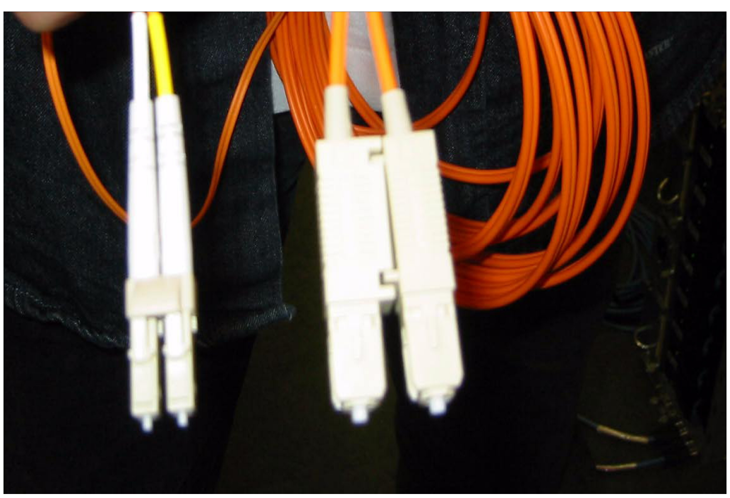


Figure 12-10 LC and SC connectors

Transceivers

Transceivers are plugged on switches or directors on each port and used to convert the internal communication transport to gigabit transport. For 1 Gbps, the transceivers are called Gigabit Interface Converters (GBICs) and for 2 Gbps, 4 Gbps, 8 Gbps and 10 Gbps, the transceivers are called SFPs (Small Form Factor Pluggable Media (SFPs). Figure 12-11 shows SFPs and a GBIC.

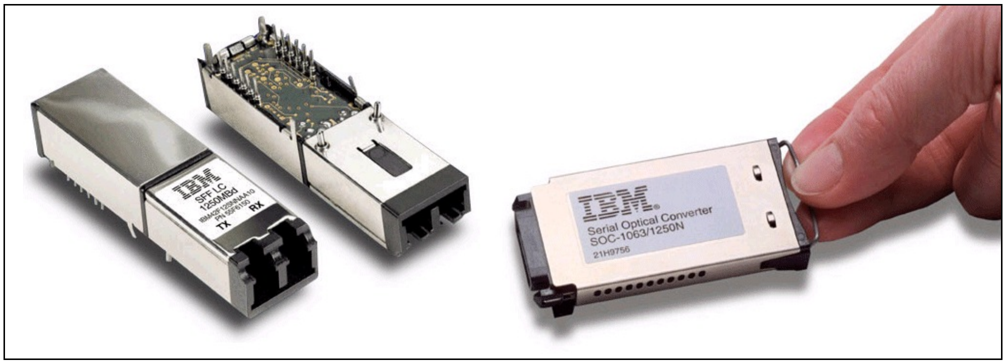


Figure 12-11 SFP (Small Form Factor Pluggable Media) and GBIC (Gigabit Interface Converter)

Fibre Channel Host Bus Adapters

The Host Bus Adapter (HBA) connects to the bus of the host or storage system. It can connect to the cable leading to the SAN. The function of the HBA is to convert the parallel electrical signals from the bus into a serial signal to pass to the SAN. Figure 12-12 shows an HBA.

Figure 12-12 Host Bus Adapter with single Fibre Channel port

HBAs with dual Fibre Channel ports are also available. Figure 12-13 shows a dual port HBA.

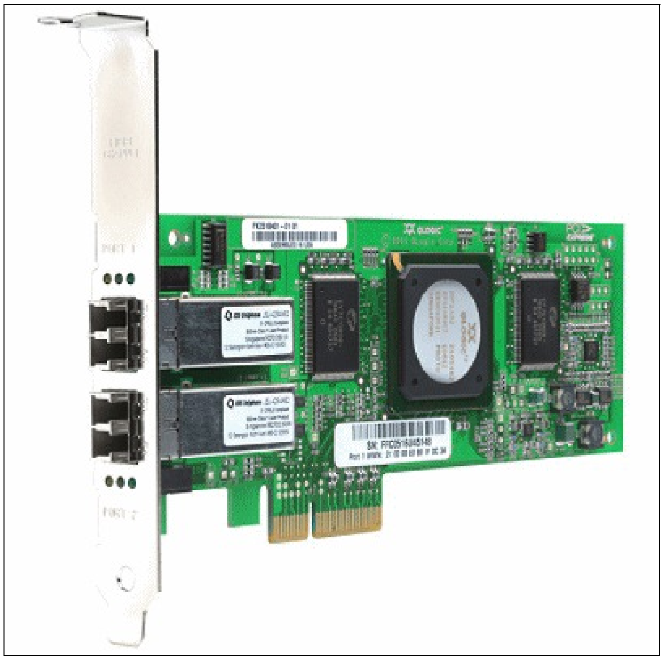


Figure 12-13 Dual port HBA

iSCSI HBAs

For iSCSI based SAN solutions, iSCSI HBAs are available. iSCSI uses TCP/IP and allows two hosts to exchange iSCSI commands using an IP network. Single and dual port iSCSI HBAs are available in the market. Figure 12-14 shows an iSCSI adapter with dual ports.

Figure 12-14 Dual port iSCSI HBA

FCoE adapters

Fibre Channel over Ethernet is one of the new technologies in the market that you can use to make the SAN infrastructure available on Ethernet while retaining your existing Fibre Channel SAN. Figure 12-15 shows an FCoE adapter.

Figure 12-15 FCoE adapter with dual port

SAN switches

SAN switches help your servers, tape drives, libraries, and your SAN storage box to connect in switched fabric. This provides connectivity and easy access to the data stored on your SAN storage devices such as DS5000. SAN switches provide faster speeds up to 10 Gbps with new products in market. Figure 12-16 shows a SAN40B-4 model switch. For more details about the current SAN switch offering by IBM, see Chapter 13, "Storage Area Network products" on page 397.

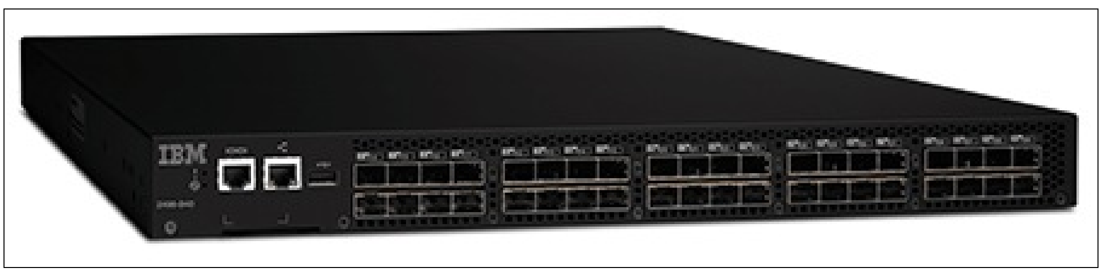


Figure 12-16 IBM System Storage SAN40B-4

12.2.5 Naming and addressing

Because there are various kinds of Fibre Channel ports and addresses, it is important to understand a few important concepts involved in naming and addressing:

- A node is a communicating device.
- A node can contain one or more ports called N_Ports. Each N_port has a unique 8-byte port name or World-Wide-Name.
- During communication, each N_Port is assigned a 24-bit port address called an N_Port ID that is used for frame routing.
- A Fibre Channel fabric switch port is called an F_Port. It is for attachment to N_Ports.
- A standard Fibre Channel mechanism enables switches to network with each other.

12.2.6 Types of ports

Here we describe various types of ports:

- E_Port: A port used to connect a Multiprotocol Router to an edge fabric. An EX_Port follows standard E_Port protocols and supports FC-NAT but does not allow fabric merging across EX_Ports.
- FL_Port: A fabric loop port to which a loop attaches; it is the access to the fabric for NL_Ports on a loop.
- FX_Port: A fabric port that can operate as either an F_Port or an FL_Port.
- G_Port: A generic port that supports either E_Port or F_Port functionality.
- L_Ports: A node port (NL_Port) or fabric port (FL_Port) that has arbitrated loop capabilities
- L_Port: A loop port supporting the Arbitrated Loop protocol. It appears as the part of the output of a switchShow command.
- NL_Port: A node loop port, supporting the Arbitrated Loop protocol.
- NPIV: Refers to N_Port ID Virtualization. It allows a single FC_Port to appear as multiple, distinct ports providing separate port identification and security zoning with the fabric for each operating system image as if each one had its own physical port.
- Nx_Port: A node port that can operate as either an N_Port or NL_Port.

Reference: For more information about naming and addressing, see the Redbooks publication, *Introduction to Storage Area Networks*, SG24-5470.

12.2.7 FICON

FICON (Fibre Connectivity) is a high speed input/output interface for mainframe computer connections to storage devices. A FICON channel is a high bandwidth connection between processor and storage device within a relatively close proximity.

FICON channels increase I/O capacity through the combination of a new architecture and faster physical link rates to make them more efficient than ESCON (Enterprise System Connection), IBM previous fiber optic channel standard.

FICON is based on FCP, and runs on an FCP infrastructure - including all the cabling, switched, and directors.

Reference: For more information about FICON, see the Redbooks publication, *FICON Native Implementation and Reference Guide*, SG24-6266.

12.3 IP storage networking technologies

iSCSI, FCIP, and iFCP are SAN extension technologies ideal for connecting smaller departmental and less I/O intensive servers into a SAN.

SAN deployment and its resulting benefits have primarily been focused on mission-critical islands of application servers within individual data centers. The difficulty and cost associated with migrating the large number of data center midrange servers to Fibre Channel have made it impractical for IT managers to extend the benefits of SAN to midrange applications. A basic diagram of these technologies is shown in Figure 12-17.

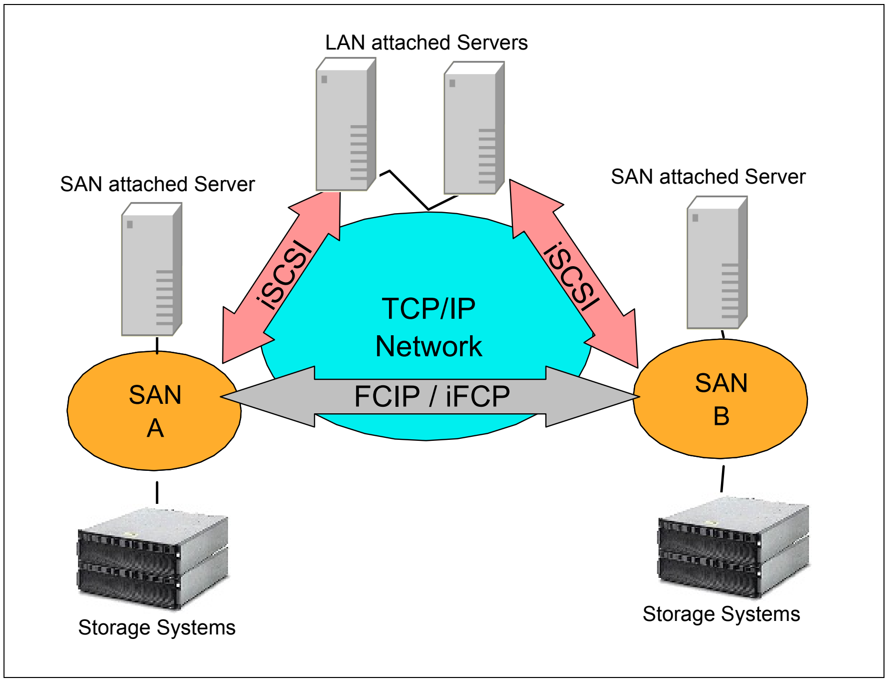


Figure 12-17 IP storage networking technology

12.3.1 iSCSI

iSCSI allows storage to be accessed over a TCP/IP network as though it was locally attached. The server pushes SCSI commands out through the Ethernet NIC. As the SCSI commands exit out through the server, they are encapsulated within IP packet and are forwarded across the LAN to a LAN/SAN gateway interface. These iSCSI packets are then translated onto the Fibre Channel SAN through the TCP/IP transport and conversion protocol.

iSCSI is an ideal point to multipoint solution for connecting dispersed SAN islands. Using iSCSI, midrange servers can gain access to consolidated storage while retaining their existing IP infrastructure, allowing a cost-effective extension of SAN benefits to midrange applications residing on servers within the data center and on departmental servers located throughout the enterprise.

SCSI uses TCP/IP for reliable data transmission over potentially unreliable networks. The iSCSI layer interfaces to the operating system's standard SCSI set. The iSCSI layer includes encapsulated SCSI commands, data and status reporting capability. When, for example, the operating system or application requires a data write operation, the SCSI CDB (Command Descriptor Block) must be encapsulated for transport over a serial gigabit link and delivered to the target. See Figure 12-18.

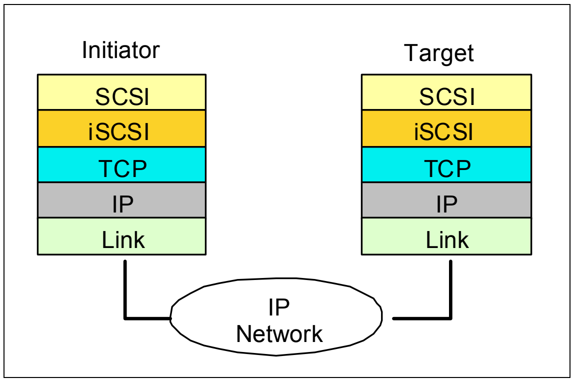


Figure 12-18 iSCSI protocol layering model

The iSCSI protocol monitors the block data transfer and validates completion of the I/O operation. This occurs over one or more TCP connections between initiator and target. In practical applications, an initiator can have multiple target resources over an IP network, and consequently multiple concurrent TCP connections active.

12.3.2 FCIP

Fibre Channel over IP (FCIP) uses a tunneling protocol to transport Fibre Channel frames over an existing IP infrastructure, and therefore is better suited for point-to-point solutions (Figure 12-19). Using FCIP, customers can utilize their current wide-area networking infrastructure for connecting remote SAN islands over long distances.

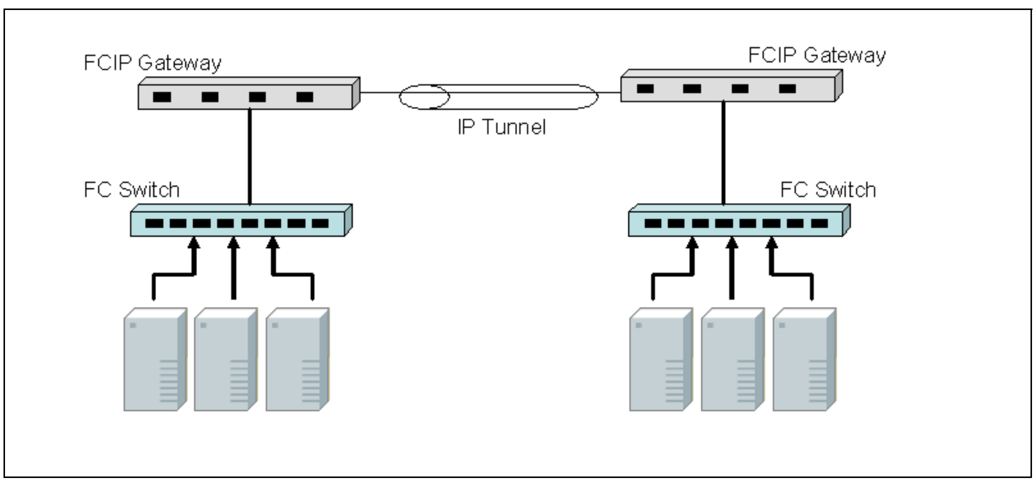


Figure 12-19 FCIP with IP tunneling

Fibre Channel over IP is an ideal combination of technologies to address the dual requirements of storage networking and networking over distance. Fibre Channel is a mature technology optimized for storage data movement within the campus and data center. It represents a major investment in software compatibility, interoperability, and proven applications for campus-based storage networking. Likewise, IP is a mature technology optimized for data movement across WAN distances. It represents a major investment in software compatibility, equipment interoperability, and proven applications for WAN-based data networking.

Today's Fibre Channel-over-IP solutions encapsulate Fibre Channel and transport it over a TCP socket (Figure 12-20). As in all IP networks, performance can vary based on the types of switches and routers, the number of hops the packets must traverse, and the level of congestion in the network. Today, storage transport performance over IP networks-especially over public networks- is limited due to the variable latency of service provider networks.

As IP and Ethernet equipment continues to evolve, higher levels of Quality of Service (QoS), Cost of Service (CoS), provisioning, and circuit emulation must provide the latency guarantees required by synchronous storage applications. In controlled environments, these technologies might even improve the performance of IP networks. Regardless, Fibre Channel over IP is currently a very cost-effective technology for asynchronous applications such as remote data backup.

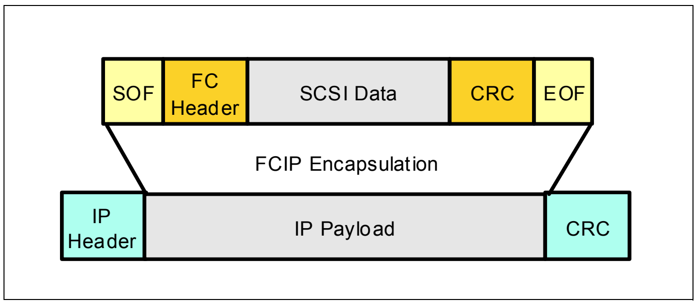


Figure 12-20 FCIP Encapsulation model

12.3.3 iFCP

Internet Fibre Channel Protocol (iFCP) is an emerging standard and TCP/IP-based method for interconnecting Fibre Channel SANs and SAN devices and IP networks. iFCP technology provides multipoint access to Fibre Channel devices. iFCP capitalizes on Internet protocol network services while utilizing the performance and interoperability capabilities of the Fibre Channel network. With iFCP, existing SCSI and Fibre Channel networks can be interconnected into the existing Internet Protocol environment. iFCP can be used in conjunction with Fibre Channel switching and routing protocols, or it can completely replace them.

iFCP is designed for customers who might have a wide range of Fibre Channel devices (that is, Host Bus Adapters, Subsystems, Hubs, Switches, and so on) and want the flexibility to interconnect these devices with IP network. iFCP can interconnect Fibre Channel SANs with IP, as well as allow customers the freedom to use TCP/IP networks in place of Fibre Channel networks for the SAN itself. Through the implementation of iFCP as a gateway-to-gateway protocol, these customers can maintain the benefit of their Fibre Channel devices while utilizing a highly scalable, manageable, and flexible enterprise IP network as the transport medium of choice.

iFCP enables Fibre Channel device-to-device communication over an IP network, providing more flexibility compared to only enabling SAN-to-SAN communication. For example, iFCP has a TCP connection per N_Port to N_Port couple, and such a connection can be set to have its own Quality of Service (QoS) identity (Figure 12-21).

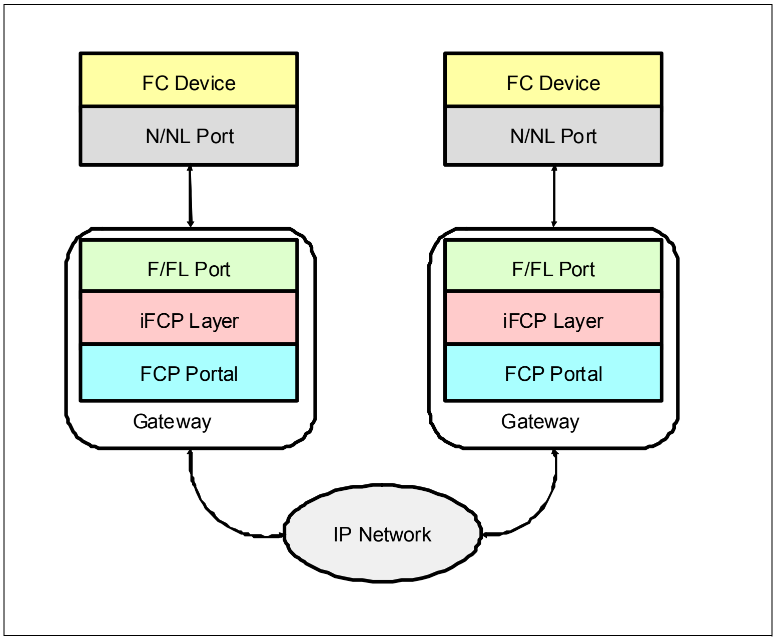


Figure 12-21 iFCP Gateway architecture

A drawback of the FCIP protocol, which makes iFCP more attractive, is that FCIP is a protocol that uses tunneling to encapsulate Fibre Channel data packets for forwarding over the TCP/IP network. This means that FCIP only works within a Fibre Channel infrastructure, whereas, iFCP can handle both iSCSI and FCIP traffic. Applications developed for Fibre Channel SAN environments are supported over iFCP.

Benefits of Internet Fibre Channel Protocol (iFCP) for storage networks are that scalability, distance, and connectivity issues are virtually eliminated. Existing Ethernet protocol structure allows for rapid deployment of applications and solutions that already make use of the TCP/IP protocol layers. With one less routing protocol to support, network complexity and management is also potentially reduced. More importantly, the lower cost of Gigabit Ethernet switches as opposed to Fibre Channel switches enables for a lower total cost of ownership (TCO) of the enterprise SAN.

12.3.4 Comparison of iSCSI, FCIP, iFCP

Here we provide a short comparison to show the differences between iSCSI, FCIP, and iFCP. In Figure 12-22, you can see the unique structure of the protocol stacks as well as the various key attributes listed in Table 12-1.

iSCSI:

- A transport protocol for SCSI that operates on top of TCP
- A new mechanism for encapsulating SCSI commands on an IP network
- A protocol for a new generation of storage end-nodes that natively use TCP/IP

FCIP:

- FCIP is a tunneling protocol for connecting geographically distributed Fibre Channel SANs transparently over LANs, MANs, or WANs
- Relies upon TCP for congestion control and management and upon both TCP and FC for data error and data loss recovery
- Uses TCP/IP as the transport while retaining Fibre Channel services intact

iFCP:

- A gateway-to-gateway protocol for the implementation of a Fibre Channel fabric in which TCP/IP switching and routing elements supplement or replace Fibre Channel fabric components
- The protocol enables the attachment of existing Fibre Channel storage devices or Fibre Channel SANs to an IP network

The following benefits are common to all IP storage protocols:

- Built on SCSI and Ethernet technologies
- Provides more affordable SAN infrastructure
- Increases operating distance
- Improves availability of storage systems

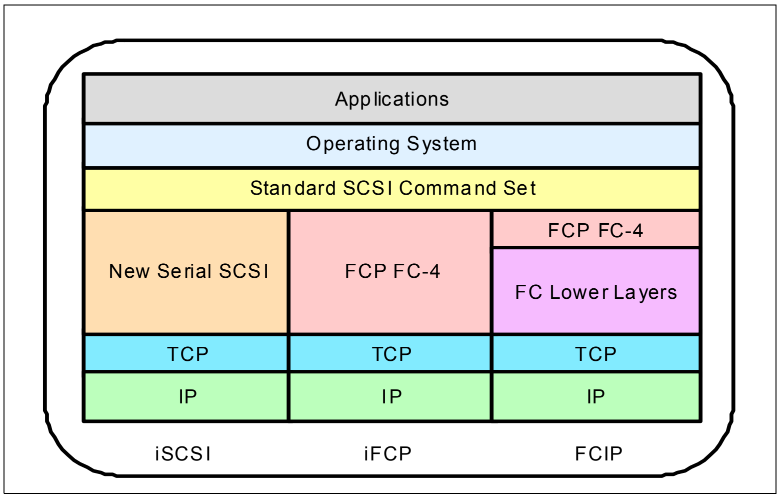


Figure 12-22 iSCSI, FCIP, and iFCP protocol stacks

Table 12-1 summarizes the key attributes of iSCSI, FCIP, and iFCP protocols.

Table 12-1 Key attributes iSCSI, FCIP, iFCP

Protocol Attributes	iFCP	iSCSI	FCIP
Implementation	native IP transport	native IP transport	encapsulation, tunneling
SCSI encapsulation	FCP	new iSCSI layer	FCP
Prioritization based on port identification	yes	yes	no
End device interface	FC/FCP	IP/iSCSI	FC/FCP
End device routing	RIP, OSPF, BGP	RIP, OSPF, BGP	FSPF
Fibre Channel device support	yes	no	yes

12.3.5 FCoE

FCoE is an enhancement that expands FC into the Ethernet by combining two leading-edge technologies (FC and the Ethernet). As its name suggests, it is the transport, or mapping, of encapsulated FC frames over the Ethernet. Very simply, the Ethernet provides the physical interface, and FC provides the transport protocol, giving us an FC frame delivered in an Ethernet frame. Figure 12-23 shows an encapsulated FC frame within the Ethernet frame.

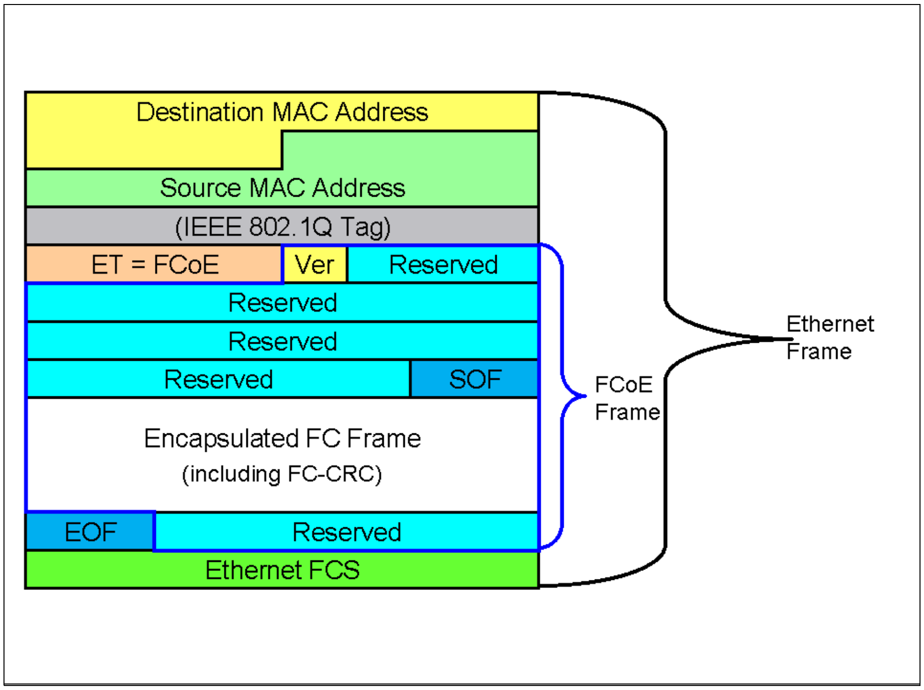


Figure 12-23 Encapsulated FC frame

Within the Ethernet frame, there is a Destination Media Access Control (MAC) Address and a Source MAC Address (as well as an IEEE 802.1Q Tag), but these components are not part of the encapsulation portion of the FCoE frame. Of particular note is that the FC frame that is encapsulated contains the original 24 byte header and the payload. The reason that the original FC header is passed is to enable seamless processing of the frame without the requirement for a separate gateway.

FCoE is the standard that is driving convergence and the emergence of FC over the Ethernet. However, in and of itself (FC over Ethernet), FCoE will not be enough to allow for fabric convergence. Without question, it is a move in the correct direction but without any enhancements. Ethernet itself does not meet the requirements for data center convergence. FCoCEE (pronounced eff-see-oh-see) is Fibre Channel over Convergence Enhanced Ethernet, which is enabled by FCoE. At the same time as providing cost reduction benefits, FCoE and FCoCEE will maintain all the services to which the Fibre Channel SAN is accustomed.

It is the transport, or mapping, of encapsulated FC frames over the Ethernet. Very simply, the Ethernet provides the physical interface, and FC provides the transport protocol, giving us an FC frame delivered in an Ethernet frame.

Mixing FCoE and existing FC and Ethernet networks is easy and expected; the most probable implementation is “from the edge” … adding FCoE with new equipment while keeping existing Ethernet and FC hardware/cabling in place until it makes sense to replace with FCoE.

Here we list highlights of FCoE:

- FCoE uses Converged Network Adapters (CNA)
- CNA run either Ethernet NIC traffic AND/OR Fibre Channel traffic
- Enhanced Ethernet protocol supports FC traffic
- Enhancements adds loss-less data transmission and additional management functions
- FCoE also called FCoCEE – Fibre Channel over Converged Enhanced Ethernet
- Physically CNA use 10Gb Ethernet ports
- Each port can run all NIC, all FC, or mixed NIC/FC traffic

Reference: For more information about FCoE, see the Redpaper™ publication, *An Introduction to Fibre Channel over Ethernet, and Fibre Channel over Convergence Enhanced Ethernet*, REDP-4493.

12.4 Network Attached Storage

Network Attached Storage (NAS) is a device that resides on a network that can be shared with non-storage traffic. Today, the network is usually an Ethernet LAN, but can be any network that supports the IP-based protocols that NAS uses.

Figure 12-24 shows a diagram of an NAS appliance. In contrast to “block I/O” used by SANs, NAS I/O requests are called “file I/Os”. File I/O is a higher-level type of request that, in essence, specifies the file to be accessed, an offset into the file (as though the file was a set of contiguous bytes), and a number of bytes to read or write beginning at that offset. File I/O requests are mainly of the type CIFS, NFS or specialized I/O protocols for file access and file sharing. Unlike block I/O, there is no awareness of a disk volume or disk sectors in a file I/O request. Inside the NAS product, an operating system tracks where files are located on disk, and issues a block I/O request to the disks to fulfill the file I/O read and write requests it receives.

In contrast to SAN devices that can usually also be direct-attached (for example, by point-to-point Fibre Channel) as well as network-attached by SAN hubs and switches, an NAS device is generally only an NAS device and attaches only to processors over a LAN or WAN.

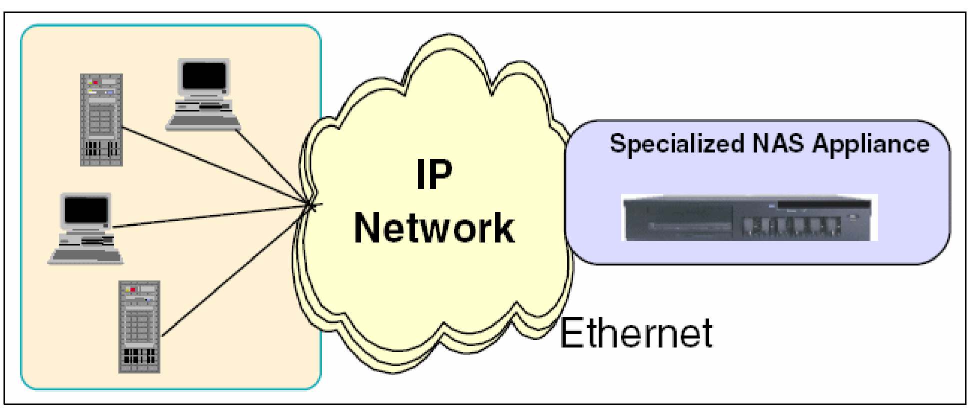


Figure 12-24 A picture of NAS appliance

12.4.1 NAS benefits

Network attached storage (NAS) products provide a wide-range of network attachment capabilities to a broad range of host and client systems.

The major potential benefits of an NAS device can be categorized as follows:

- Ease-of-installation:

  NAS is generally easier to install and manage than a SAN. An NAS appliance can usually be installed on an existing LAN/WAN network. NAS manufacturers often cite “up and running” times of 30 minutes or less. NAS can be accessed by any operating system. Hosts can potentially start to access NAS storage quickly, without needing disk volume definitions or special device drivers. In contrast, SANs take more planning, including design of a Fibre Channel network and selection/installation of SAN management software.

- Resource pooling:

  NAS allows capacity within the appliance to be pooled. That is, the NAS device is configured as one or more file systems, each residing on a specified set of disk volumes. All users accessing the same file system are assigned space within it on demand. That is certainly more efficient than buying each user their own disk volumes (DAS), which often results in certain users having too much capacity and others too little. So NAS pooling can minimize the need to manually reassign capacity among users. However, NAS pooling resides within an NAS appliance, and there is little if any sharing of resources across multiple appliances. This raises costs and management complexity as the number of NAS nodes increases. In contrast, an advantage of a SAN is that all devices on a SAN can be pooled, multiple disk and tape systems. So, eventually as total capacity grows, a SAN might be easier to manage and more cost-effective.

- File sharing:

  NAS provides file sharing using the NFS and CIFS protocol.

12.4.2 NAS gateways

An NAS gateway provides the function of a conventional NAS appliance but without integrated disk storage. The disk storage is attached externally to the gateway, possibly sold separately, and can also be a stand-alone offering for direct or SAN attachment. The gateway accepts a file I/O request (for example, using the NFS or CIFS protocols) and translates that to a SCSI block-I/O request to access the external attached disk storage. In the simplest term NAS gateway is a NAS system in which the storage is not captively attached, but is externally attached.

The gateway approach to file sharing offers the benefits of a conventional NAS appliance, with additional potential advantages:

- Increased disk capacity scalability (compared to the capacity limits of an integrated NAS appliance).
- Ability to offer file sharing and block-I/O on the same disk system. Disk capacity in the SAN can be shared (reassigned) among gateway and non-gateway use. So a gateway can be viewed as an NAS/SAN hybrid, increasing flexibility and potentially lowering costs.

For more information about NAS, see Chapter 5, “IBM System Storage N series” on page 211.

12.5 Wavelength Division Multiplexing

Wavelength Division Multiplexing (WDM) or Multiplexing by itself is not a storage networking protocol. Because it is used also to create storage networking infrastructure, we briefly explain the technology here.

Wavelength Division Multiplexing is deployed as part of the physical layer. It is therefore independent of protocol, simply passing signal information in the format it is received. WDM allows the simultaneous transmission of a number of data streams over the same physical fiber, each using a unique optical wavelength.

WDM receives incoming optical signals from many sources (Fibre Channel, IP, ESCON, FICON) which it converts to electrical signals, it then assigns them a specific wavelength (or lambdas) of light and retransmits them on that wavelength. This method relies on the large number of wavelengths available within the light spectrum. You can think about WDM as though each channel is a particular color of light; several channels then make up a rainbow (Figure 12-25). In summary, WDM enables many signals to be concentrated into a single fibre, all being sent at various wavelengths.

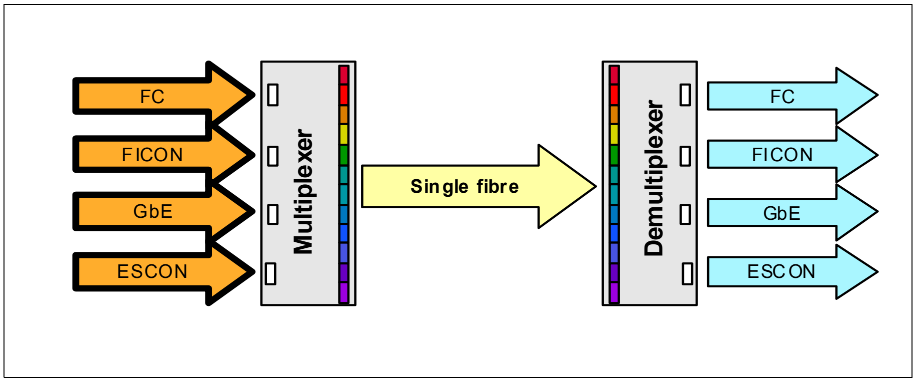


Figure 12-25 Wave Division Multiplexer concept

Each wavelength can carry a signal at any bit rate less than an upper limit defined by the electronics, typically up to several gigabits per second. Due to the nature of these boxes, they are often considered transparent to protocol and bit rate.

Today, WDM of itself, is rarely seen. Coarse Wave Division Multiplexing (CWDM), which combines up to 16 wavelengths onto a single fiber, and Dense Wave Division Multiplexing (DWDM) which combines up to 64 wavelengths onto a single fiber are the standard.

12.6 Selecting the best alternative

Which storage networking alternative is best for a given organization might be obvious based on organizational objectives, current storage infrastructure, and what the alternatives provide. Or, it might be a totally open question. Storage technology has clearly become more varied and sophisticated, and accordingly decisions have become more complex than ever. Choice means flexibility, and that is good, but which choice to make is not always clear.

- If a group of individual users with PCs needs to share disk storage capacity and perhaps also share files in that storage, then a NAS might be easiest to install and manage.
- If application servers need to share disk storage, and are each accessing independent (block I/O) databases, an FC based SAN might be appropriate.
- For a small number of servers where no SAN exists, iSCSI might be less expensive and less complex.
- For a larger number of servers and greater distances, FCOE can be used over existing Ethernet infrastructures. However, this can add increased complexity.
- If required, FCIP or iFCP provide a cost-effective way to achieve business protection, enabling such solutions as remote tape archiving.

12.7 More information

For a better understanding of Fibre Channel, SAN technology, FICON, and NAS technology, see these Redbooks publications:

- *Introduction to Storage Area Networks*, SG24-5470
- *Designing an IBM Storage Area Network*, SG24-5758
- *IBM SAN Survival Guide*, SG24-6143
- *FICON Implementation Guide*, SG24-6497
- *FICON (FCV Mode) Planning Guide*, SG24-5445
- *Introduction to IBM S/390 FICON*, SG24-5176
- *IBM S/390 FICON Implementation Guide*, SG24-5169
- *The IBM TotalStorage NAS Integration Guide*, SG24-6505
- *An Introduction to Fibre Channel over Ethernet, and Fibre Channel over Convergence Enhanced Ethernet*, REDP-4493

13

Storage Area Network products

Companies are searching for more efficient ways to manage ever-expanding volumes of data and to make that data accessible throughout the enterprise, which is propelling the move of storage into the network. The Storage Area Network (SAN) infrastructure offers simplified storage management, scalability, flexibility, availability, and improved data access, movement, and backup.

SAN switches interconnect multiple host servers with storage servers and devices to create a SAN. The SAN switches can be used either as stand-alone devices to build a simple SAN fabric, or they can be interconnected with other switches to build a larger SAN fabric.

In this chapter, we present the IBM System Storage SAN product portfolio, which includes Fibre Channel switches and directors with Fibre Channel and FICON ports.

We describe the following entry, midrange, and enterprise level switch products:

- IBM System Storage SAN b-type switches and director
- Cisco switches and directors

> **Usage:** These products can be used with disk storage systems, which are explained in the chapters for Disk Systems. Additionally, these products can be used with tape drives and libraries, as discussed in Part 2, “Tape Systems” on page 279.

For the latest SAN products and information, see the website:

http://www.ibm.com/servers/storage/san/

13.1 SAN switches and connectivity products

IBM System Storage SAN switch offerings provide integrated small and medium business (SMB) and enterprise solutions with multiprotocol local, campus, metropolitan, and global storage networking. IBM provides the choice of Brocade (b-type), and Cisco switches and directors.

IBM System Storage SAN switch products provide a broad range of storage networking options designed with a common architecture and integrated enterprise SAN management capabilities, and supported by the broadest range of IBM open server and storage devices. The interconnection of IBM and compatible switches can support the creation of scalable, dual redundant core-to-edge SAN fabrics that can support high performance, scalability, and fault tolerance required by e-business applications and enterprise storage management applications.

IBM System Storage SAN switch offerings can be positioned into four broad product groups: entry, midrange, enterprise, and multiprotocol routers. Suitable products for every SAN project can be found among these.

13.1.1 Common characteristics

With all IBM System Storage SAN products, you get the following capabilities:

- Industry standard performance with 1, 2, 4, 8, 10 Gigabit per second (Gbps) throughput
- Broadest range of IBM open server and storage support including fabric, loop, and private loop attachments
- Intelligent Fabric Services Architecture providing switch interoperability
- Enterprise-level scalability with fault-tolerant core-to-edge SAN fabrics containing thousands of devices
- Open fabric management allowing support for the widest range of solutions, from very small workgroup SANs up to very large enterprise SAN fabrics with thousands of devices
- Flexible management options including Tivoli Ready certification for centralized management of very large enterprise SAN fabrics
- Manageable by IBM Tivoli Productivity Center for Fabric
- Common enterprise SAN fabric which simplifies deployment, management and network growth
- Common firmware which enables introduction of new switch technologies while protecting prior switch investments
- Flexible Fibre Channel connectivity provides connectivity to a host of IBM and non-IBM servers and storage products
- Pay-as-you-grow scalability provides scalable network growth in a modular, cost-effective, and non-disruptive manner

13.1.2 Other switch features

Here we cover other features available in selected IBM System Storage SAN switch products.

Advanced Web Tools

Advanced Web Tools is an intuitive graphical user interface (GUI) that allows network managers to monitor and manage SAN fabrics consisting of switches using a Java-capable web browser from standard desktop workstations.

Advanced Performance Monitoring

Advanced Performance Monitoring enables SAN administrators to monitor transmit and receive traffic from the source device all the way to the destination device. This end-to-end visibility into the fabric enables SAN administrators to identify bottlenecks and optimize fabric configuration resources.

Advanced Security

Advanced Security (AS) significantly reduces the security holes left by traditional SAN implementations and greatly improves the ability to minimize SAN-specific vulnerabilities by providing a comprehensive, policy based security system for IBM SAN Switch fabrics.

Advanced Zoning

Advanced Zoning segments a fabric into virtual private SANs. It provides data exchange between devices in the same zone and prohibits exchange to any device not in the same zone. Advanced zoning of 1, 2, and 4 Gbps switches separately enlarges the range of hardware enforcement and so provides the switch with more security access control functions as before, preventing an unauthorized devices from accessing the fabric.

Common IBM SAN Switch capabilities

IBM System Storage SAN Switches include universal ports that can determine the port type when connected to a fabric port (F_port), fabric loop port (FL_port) or expansion port (E_port).

Enterprise Fabric Connectivity Manager

Enterprise Fabric Connectivity Manager (EFCM) software is designed to support interconnection of multiple IBM System Storage SAN m-type switches and directors for the creation of enterprise-to-edge SANs.

Extended Fabric

The Extended Fabric feature provides extensions within the internal switch buffers. This maintains performance with distances greater than 10 km, and up to 120 km, by maximizing buffering between the selected switch interconnect links. With the Extended Fabric feature, the ISLs are configured with up to 60 buffer credits and optimize buffers for up to 120 km on 1 Gbps fiber optic link, and up to 60 km on 2 Gbps fiber optic link.

Fabric Manager

Fabric Manager provides a Java-based application that can simplify management of a multiple switch fabric. It administers, configures, and maintains fabric switches and SANs with host-based software.

Fabric Watch

Fabric Watch enables switches to continuously monitor the health of the fabrics, watching for potential faults based on defined thresholds for fabric elements and events, so making it easy to quickly identify and escalate potential problems.

FlexPort scalability

FlexPort technology is designed to support scalable switch upgrades in four-port increments without fabric disruption.

ISL Trunking

The ISL Trunking feature allows up to four ISLs between the same pair of switches to be grouped and to act as a single, high speed "pipe" or trunk with a capacity of up to 8 Gbps. It is possible to have up to eight ISLs can be combined into a single logical ISL with a total bandwidth of 68 Gbps that can support any number of devices. ISL Trunking is designed to significantly reduce traffic congestion in storage networks.

Remote Switch

The Remote Switch feature enables two fabric switches to be connected over an asynchronous transfer mode (ATM) connection. This requires a compatible Fibre Channel to ATM gateway, and can have a distance of up to 10 km between each switch and the respective ATM gateway.

More information

- For the interoperability matrix, see the website:

  http://www.ibm.com/servers/storage/support/san/index.html

  Select the product from list, then click *Plan and Upgrade* under the desired switch product.
- For technical support information, see the website:

  http://www.ibm.com/servers/storage/support/san/index.html
- SAN-related Redbooks publications include these:
  - *Introduction to Storage Area Networks*, SG24-5470
  - *IBM/Cisco Multiprotocol Routing: An Introduction and Implementation*, SG24-7543
  - *Implementing an IBM/Cisco SAN*, SG24-7545
  - *IBM SAN Survival Guide*, SG24-6143
  - *SAN Storage Performance Management Using TotalStorage Productivity Center*, SG24-7364
  - *Implementing an IBM/Brocade SAN with 8 Gbps Directors and Switches*, SG24-6116

13.2 Entry SAN switches

The IBM System Storage SAN switch entry-level products are designed specifically to address the needs of small to medium-size SAN environments. They can be used to create a wide range of high-performance SAN solutions, from simple single-switch configurations to larger multi-switch configurations that support fabric connectivity and advanced business continuity capabilities.

Infrastructure simplification solutions for IBM System x, IBM System i, and IBM System p include storage consolidation and high-availability server clustering with IBM System Storage disk storage arrays. Business continuity solutions include data protection with IBM System Storage tape libraries and devices and IBM Tivoli Storage Manager data protection software. IBM entry fabric switches provide up to 8 Gbps, 24 ports for fully non-blocking performance, and advanced intelligence features.

Entry-level products include these:

- IBM System Storage SAN24B-4 Express
- Cisco MDS 9124 Express for System Storage

In this section, we introduce IBM System Storage Switch solutions ideal for entry-level applications.

13.2.1 IBM System Storage SAN24B-4 switch

The SAN24B-4 is a high performance scalable switch that provides a 24 port fabric with a “Ports on Demand” feature, so you can scale your network as you grow. You can get the switch with an 8 port license and then can upgrade it conveniently up to 24 ports by just enabling the license. With auto-sensing link speeds at 1, 2, 4, and 8 Gbps and a flexible design to configure this switch as a fabric switch or an Access Gateway, it is suitable for small to midsized businesses.

A single SAN24B-4 Express switch can serve as the cornerstone of a Storage Area Network for those who want to obtain the benefits of storage consolidation and are just beginning to implement Fibre Channel storage systems. Such an entry-level configuration can consist of one or two Fibre Channel links to a disk storage array or to an LTO tape drive. An entry-level eight-port storage consolidation solution can support up to seven servers with a single path to either disk or tape. The “Ports on Demand” feature is designed to enable a base switch to grow to 16 or 24 ports to support more servers and more storage devices without taking the switch offline. Figure 13-1 shows the SAN24B-4 fabric switch.

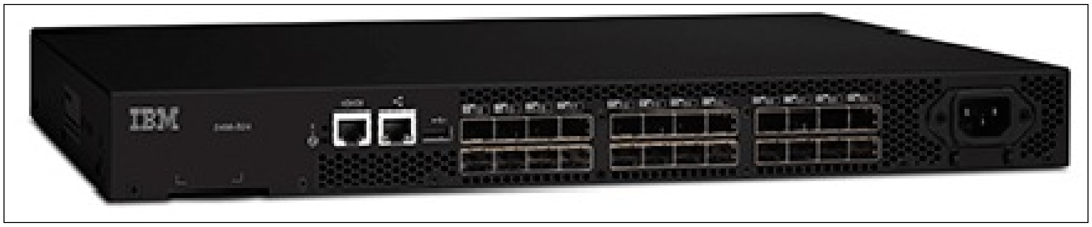


Figure 13-1 IBM System Storage SAN24B-4 Express

The SAN24B-4 fabric switch requires Fabric OS v6.1.0 or later. The switch offers easy to use Web Tools, 8 Gb FC, Long Distance support, Advanced Zoning, Full-Fabric support, Fiber Watch, Advanced Performance Monitoring, Enhanced Group Management, and ISL Trunking. The base switch also offers eight default ports and Ports on Demand (POD) licenses are available in eight-port increments. With flexible architecture based on GoldenEye2 ASIC, the switch supports F, FL,E, and M Ports at 8 Gbps. The switch also has USB port support for firmware download, configuration upload and download, and supportsave. The SAN24B-4 has a 1U form factor and is a single FRU with no field replaceable parts. The switch has one power supply and three integrated fans.

Support: Access Gateway mode is supported only in 24-port configurations, and *only* 2 GB Brocade branded USB drives are supported on the USB port. The 4 Gbps and 8 Gbps link speeds are supported only with Brocade branded SFPs.

Highlights

Here we list highlights of the IBM System Storage SAN24B-4 Express (Figure 13-1):

- Foundation for new infrastructure simplification and business continuity solutions for servers running Microsoft Windows, UNIX, Linux, and IBM AIX and OS/400 operating systems
- “Ports on Demand” scalability from 8 to 16 to 24 ports
- Provides new levels of performance with 8 Gbps Fibre Channel (FC) technology

More information

- For additional product details, see the website:

http://www.ibm.com/systems/storage/san/b-type/san24b-4/express

13.2.2 Cisco MDS 9124 Express for IBM System Storage

Cisco MDS 9124 SAN switch provides 24 auto-sensing Fibre Channel ports capable of speeds of 4, 2, and 1 Gbps in a compact 1RU form-factor chassis and is designed to meet the performance and scalability requirements of the most demanding environments.

The base MDS 9124 comes with eight ports activated, two redundant hot swappable power supplies, and eight shortwave SFPs. Enhanced flexibility of MDS 9124 is provided by the 9124 8-port activation license. Using this functionality, customers can start with a base configuration of 8 ports and upgrade to 16 and 24 ports. Figure 13-2 shows the MDS 9124 Multilayer Fabric Switch.

Higher availability solutions can be created using multiple Cisco MDS 9124 switches. Such implementations can be well-suited to server clustering environments. Such a configuration can support from six to 22 servers, each with dual Fibre Channel adapters cross-connected to redundant 9124 switches, which are cross-connected to a dual-controller storage system.

While the focus of the Cisco MDS 9124 is as the foundation of medium-sized SMB SANs, it can also be configured to participate as a component of a tiered enterprise SAN with other members of the Cisco MDS 9000 for IBM System Storage family. Cisco MDS 9000 SAN-OS firmware provides enterprise-class capabilities such as virtual SANs (VSANs), Port Channels, quality of service (QoS) and security for deployment in core-edge enterprise SAN solutions. These capabilities help provide investment protection as SAN requirements evolve and grow over time (Figure 13-2).

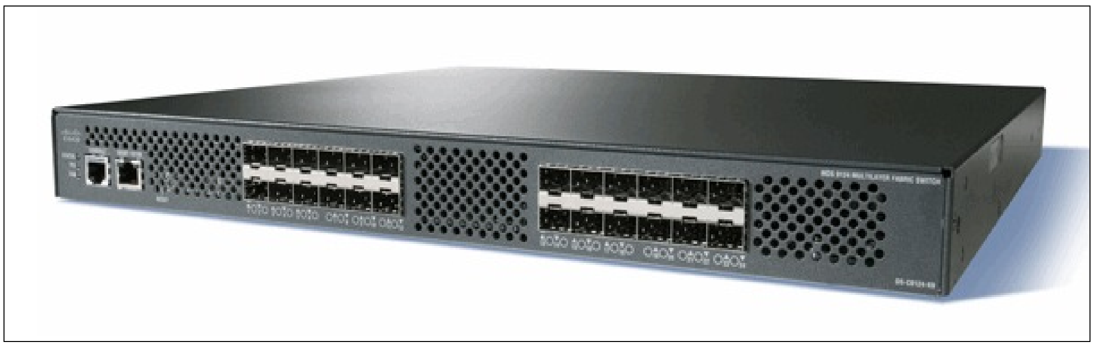


Figure 13-2 Cisco MDS 9124 Express

Highlights

Here we list highlights of the Cisco MDS 9124 Express (Figure 13-2):

- Foundation for new infrastructure simplification and business continuity solutions for servers running Microsoft Windows, UNIX, Linux, NetWare and IBM OS/400 operating systems
- Designed for high availability with hot-swappable, dual power supplies and non-disruptive firmware upgrades
- Cisco MDS 9000 family compatibility supports scalability and consistent service as the SAN grows
- Enterprise Package and Fabric Manager Server Package provide added intelligence and value

> **Support:** The MDS 9124 Multilayer switch supports N-Port identifier virtualization (NPV) to reduce the number of Fibre Channel domain IDs in SANs.

More information

For additional product details, see the website:

http://www.ibm.com/systems/storage/san/ctype/9124

13.3 Midrange SAN switches

IBM System Storage midrange SAN solutions provide additional capability, features, and benefits beyond the simple entry solutions. The IBM System Storage midrange SAN switches provide 1, 2, 4 and 8 Gbps port-to-port non-blocking throughput with auto-sensing capability for connecting to older 1 Gbps host servers, storage, and switches. They come in 40 to 80 ports with “Ports on Demand” scalability models.

IBM System Storage SAN switches can be used to create dedicated, reliable, and high performance networks for storage products like disk subsystems, tape drives, and tape drive libraries. In addition, all of these models are fully interoperable with the previous IBM System Storage SAN Switches, and can be added to existing fabrics, enabling transition from existing Fibre Channel storage networks to the faster technology.

Midrange SAN switches include these:

- IBM System Storage SAN40B-4
- IBM System Storage SAN80B-4
- IBM System Storage SAN32B-E4
- Cisco MDS 9134 for IBM System Storage
- Cisco MDS 9148 for IBM System Storage

In this section, we introduce IBM System Storage Switch solutions ideal for midrange applications.

13.3.1 IBM System Storage SAN40B-4

The IBM System Storage SAN40B-4 SAN fabric switch provides 24, 32, or 40 active ports and is designed for high performance with 8 Gbps link speeds and backward compatibility to support links running at 4, 2, and 1 Gbps link speeds. High availability features make it suitable for use as a core switch in midrange environments or as an edge-switch in enterprise environments where a wide range of SAN infrastructure simplification and business continuity configurations are possible. IBM POWER Systems, System x, System z, and many non-IBM disk and tape devices are supported in many common operating system environments. Optional features provide specialized distance extension, dynamic routing between separate or heterogeneous fabrics, link trunking, FICON, performance monitoring, and advanced security capabilities.

The SAN40B-4 fabric switch requires Fabric OS v6.1.0 or later. The base model of the switch has 24 ports enabled, and the POD licenses are available in 8 port increments. Integrated Routing is a licensed feature that is supported on every port of the switch and requires a POD license for all 40 ports. The ports on the switch are grouped in 8-port groups matching the trunk group, and with ISL Trunking speeds of up to 64 Gbps can be achieved per trunk.

Dynamic Path selection can be used for optimizing the performance and load balancing, and the switch can be managed using Web Tools. The built-in USB port can be used for firmware download, configuration upload and download, and supportsave, and the switch supports non-disruptive firmware downloads.New features in Fabric OS v6.2.0 make the switch Virtual Fabric capable. A single physical chassis can be subdivided into two or more logical switches creating a logical fabric with other switches.

Integrated Routing is a licensed feature that is supported on every port of the switch and requires the POD license for all 40 Ports. Two hot-swappable, redundant 125W power supply and fan assemblies are included with the switch and these are field replaceable units (FRU). Each FRU has an ON/OFF switch AC plug and a power supply/fan status LED, and the switch has a 1U form factor.

Highlights

Here we list highlights of the IBM System Storage SAN40B-4 (Figure 13-3):

- High port density design with up to 40 ports in an efficient, space saving 1U height
- Simple-to-use midrange and enterprise SAN fabric switch for IBM POWER Systems, System x, System z and other server environments
- New levels of performance with 8 Gbps Fibre Channel (FC) technology
- Non-disruptive capacity activation from 24 to 32 to 40 ports with “Ports on Demand” scalability
- High availability with redundant, hot-swappable fans and power supplies and non-disruptive software upgrades

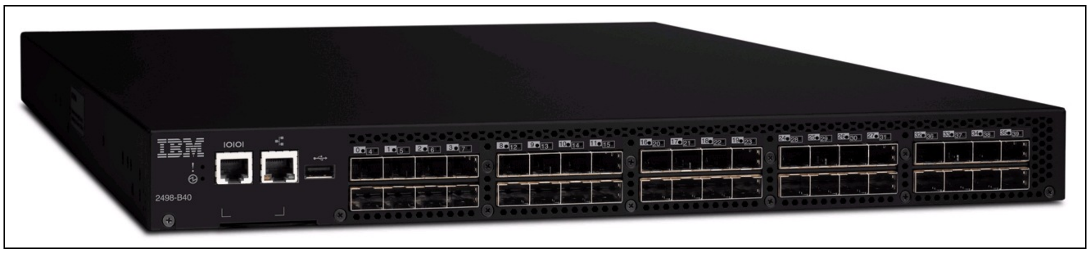


Figure 13-3 IBM System Storage SAN40B-4

More information

For additional product details, see the website:

http://www.ibm.com/systems/storage/san/b-type/san40b-4

13.3.2 IBM System Storage SAN80B-4

The IBM System Storage SAN80B-4 SAN fabric switch provides 48, 64, or 80 active ports and is designed for high performance with 8 Gbps link speeds and backward compatibility to support links running at 4, 2, and 1 Gbps link speeds. High availability features make it suitable for use as a core switch in midrange environments or as an edge-switch in enterprise environments where a wide range of SAN infrastructure simplification and business continuity configurations are possible. IBM Power Systems, System x, System z and many non-IBM disk and tape devices are supported in many common operating system (OS) environments. Optional features provide specialized distance extension, dynamic routing between separate or heterogeneous fabrics, link trunking, Fibre Connection (FICON), performance monitoring and advanced security capabilities.

The SAN80B-4 fabric switch requires Fabric OS v6.1.0 or later. Port hardware is based on the GoldenEye2 ASIC. Each ASIC can support 32 ports at 1, 2, 4, and 8 Gbps link speeds. The base model of the switch comes with 48 ports enabled, and the POD licenses are available in 16-port increments. New features in Fabric OS v6.2.0 make the switch Virtual Fabric capable. A single physical chassis can be subdivided into two or more logical switches creating a logical fabric with other switches. Integrated Routing is a licensed feature that is supported on every port of the switch and requires the POD license for all 80 Ports. The ports on the switch are grouped in 8-port groups matching the trunk group, and with ISL Trunking speeds of up to 64 Gbps can be achieved per trunk. Dynamic Path selection can be used for optimizing the performance and load balancing, and the switch can be managed using Web Tools.

Important: The USB port supports only a 2 GB Brocade branded USB drive. The 4 Gbps and 8 Gbps link speeds are supported only with Brocade branded SFPs.

In IBM/Brocade 8 Gbps Directors and Switches, the built-in USB port can be used for firmware download, configuration upload and download, and supportsave, and the switch supports non-disruptive firmware downloads. The switch has two hot-swappable, redundant 300W power supplies and three hot-swappable fan assemblies. Both the power supplies and the fan assemblies are field replaceable units, and they have a status LED on them.

Highlights

Here we list highlights of the IBM System Storage SAN80B-4 (Figure 13-4):

- High port density design with up to 80 ports in an efficient, compact 2U height helps save rack space
- Robust midrange and enterprise SAN fabric switch for IBM POWER Systems, System x, System z and other server environments
- Provides new levels of performance with 8 Gbps Fibre Channel (FC) technology
- Ports-on-Demand scalability supports non-disruptive capacity activation from 48 to 64 to 80 ports
- Designed to support high availability with redundant, hot-swappable fans and power supplies and non-disruptive software upgrades

Figure 13-4 IBM System Storage SAN80B-4

More information

For additional product details, see the website:

http://www.ibm.com/systems/storage/san/b-type/san80b-4

13.3.3 IBM System Storage SAN32B-E4

The IBM System Storage SAN32B-E4 Encryption Switch is a high-performance stand-alone device designed for protecting data-at-rest in mission-critical environments. In addition to helping IT organizations achieve compliance with regulatory mandates and meeting industry standards for data confidentiality, the SAN32B-E4 Encryption Switch also protects them against potential litigation and liability following a reported breach.

Data is one of the most highly valued resources in a competitive business environment. Protecting that data, controlling access to it, and verifying its authenticity while maintaining its availability are priorities in our security-conscious world. Increasing regulatory requirements are also helping to drive the need for the adequate security of data. Encryption is a powerful and widely used technology that helps protect data from loss and inadvertent or deliberate compromise.

Security: Frame Redirection technology enables easy, non-intrusive deployment of fabric-based security services. Industry-standard AES-256 encryption algorithms are used for both disk and tape in a centralized security platform for SAN environments.

In the context of data center fabric security, IBM provides advanced encryption services for Storage Area Networks (SANs) with the IBM System Storage SAN32B-E4 Encryption Switch. The switch is a high-speed, highly reliable hardware device that delivers fabric-based encryption services to protect data assets either selectively or on a comprehensive basis. The 8 Gbps SAN32B-E4 Fibre Channel Encryption Switch scales non-disruptively, providing from 48 up to 96 Gbps of encryption processing power to meet the needs of the most demanding environments with flexible, on-demand performance. It also provides compression services at speeds up to 48 Gbps for tape storage systems. Moreover, it is tightly integrated with one of the industry-leading, enterprise-class key management systems, the IBM Tivoli Key Lifecycle Manager (TKLM), which can scale to support key lifecycle services across distributed environments.

Highlights

Here we list highlights of the IBM System Storage SAN32B-E4 Encryption Switch (Figure 13-5):

- Enforce data confidentiality and privacy requirements using high-performance, scalable fabric-based encryption
- Centralize administration of data-at-rest encryption services to ensure data protection on both disk and tape
- Reduce operational costs and simplify management through the IBM Tivoli Key Lifecycle Manager solution
- Meet regulatory mandates for securing data while maintaining application performance with on-demand encryption and compression processing power
- Industry-standard AES-256 encryption algorithms for both disk and tape in a centralized security platform for SAN environments
- High-performance encryption processing at up to 96 Gbps to support heterogeneous enterprise data centers
- Plug-in encryption services available to all host servers, including virtual machines, attached to data center fabrics
- Frame Redirection technology to enable easy, non-intrusive deployment of fabric-based security services

Figure 13-5 IBM System Storage SAN32B-E4

More information

For additional product details, see the website:

http://www-03.ibm.com/systems/storage/san/b-type/san32b-e4/index.html

13.3.4 Cisco MDS 9134 for IBM System Storage

A wide range of IBM System Storage medium-size and enterprise storage area network (SAN) IT simplification and business continuity solutions can be created with the Cisco MDS 9134 for IBM System Storage stackable fabric switch. Infrastructure simplification solutions for the IBM System i, System p, System x and System z families of servers include storage consolidation and high-availability server clustering with IBM System Storage disk storage arrays. Business continuity solutions include data protection with IBM System Storage tape libraries and devices and IBM Tivoli Storage Manager data protection software; and disaster protection with IBM System Storage disk metro and global mirroring disaster recovery solutions.

The Cisco MDS 9134 for IBM System Storage is designed to address the needs of medium-sized businesses and large enterprises with a wide range of Storage Area Network (SAN) capabilities. It can be used as part of a high performance simple SAN with single-switch or stacked switch configurations for business-class customers in support of IT simplification and business continuity solutions. It can also be used as an edge switch for device aggregation with 10 Gbps core director configurations for large enterprise customers.

Fabric connectivity capabilities can be the basis for IT simplification solutions for IBM System i, System p, System x and System z servers and storage consolidation and high-availability server clustering with IBM System Storage disk storage arrays. Business continuity capabilities can help businesses protect valuable data with IBM System Storage tape libraries and IBM Tivoli Storage Manager data protection software. Advanced connectivity capabilities can help businesses protect against major disasters with IBM System Storage disk metro and global mirroring disaster recovery solutions.

Highlights

Here we list highlights of the Cisco MDS 9134 for IBM System Storage (Figure 13-6):

- Simple-to-use 4 and 10 Gigabit per second performance for simplification and business continuity solutions with Windows, UNIX, Linux, NetWare, IBM OS/400 and IBM z/OS servers
- Cost-effective “green” switch requires up to 50 percent less power per port
- Stackable design provides pay-as-you-grow scalability and flexibility with On-Demand port activation features
- Designed to support high availability with redundant, hot swappable power supplies and fans and non-disruptive firmware upgrades
- Includes Virtual SAN (VSAN) capability for SAN consolidation into virtual SAN islands on a single physical fabric
- Enterprise, Mainframe, and Fabric Manager Server Packages provide added intelligence and value

> **Support:** The MDS 9134 Multilayer Switch supports N-Port identifier virtualization (NPV) to reduce the number of Fibre Channel domain IDs in SANs.

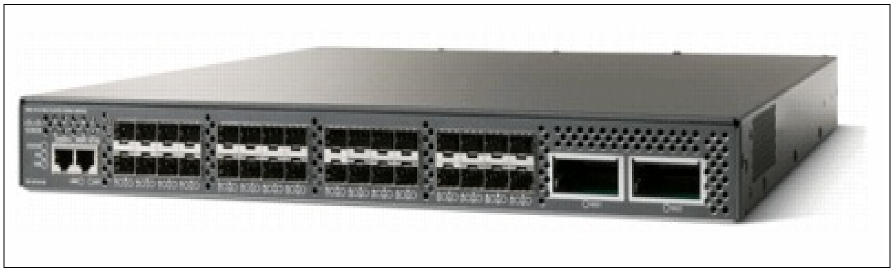


Figure 13-6 Cisco MDS 9134 for IBM System Storage

More information

For additional product details, see the website:

http://www.ibm.com/systems/storage/san/ctype/9134

13.4 Cisco MDS 9148 for IBM System Storage

The Cisco MDS 9148 for IBM System Storage Multilayer Fabric Switch (2417-C48) is designed to provide an affordable, highly capable and scalable storage networking solution for small, midrange and large enterprise customers. The switch provides line rate 8-Gbps ports with high-performance, high-density, and enterprise-class availability. The switch is designed to offer outstanding value by providing flexibility, high availability, security, and ease of use at an affordable price in a compact one-rack-unit (1RU) form factor. With the ability to expand from 16 to 48 ports in eight-port increments, the Cisco MDS 9148 can be used as the foundation for small, stand-alone SANs, as a top-of-rack switch, or as an edge switch in larger core-edge SAN infrastructures.

The Cisco MDS 9148 Multilayer Fabric Switch is designed to support quick configuration with zero-touch plug-and-play features and task wizards that allow it to be deployed quickly and easily in networks of any size. Powered by Cisco MDS 9000 NX-OS Software, it includes advanced storage networking features and functions and is compatible with Cisco MDS 9000 Series Multilayer Directors and Switches, providing transparent, end-to-end service delivery in core-edge deployments.

> **Firmware upgrades:** Non-disruptive firmware upgrades help to significantly reduce software installation time and enable fast software upgrades, which helps avoid disruption to existing fabric when installing updates and reduces administrative overhead.

Fabric connectivity capabilities can be the basis for infrastructure simplification solutions for IBM System i, System p and System x servers and storage consolidation and high-availability server clustering with IBM System Storage disk storage arrays. Business continuity capabilities can help businesses protect valuable data with IBM System Storage tape subsystems and IBM Tivoli Storage Manager data protection software.

Highlights

Here we list highlights of the Cisco MDS 9148 for System Storage (Figure 13-7):

- Extraordinary price/performance with 8 Gbps line rate ports in a compact 1RU platform
- Scales from 16 ports to 48 ports in eight-port increments
- Redundant power supplies and fans and other availability features that help minimize downtime and improve business resiliency

- Built-in management, operational and configuration tools, and plug-and-play features that support quick deployment and easy end-to-end SAN management
- All-in-one licensing with no hidden charges

Figure 13-7 Cisco MDS 9148 for IBM System Storage

Rack space: High-density design that scales from 16 to 48 ports in a 1RU height can help save rack space.

More information

For additional product details, see the website:

http://www-03.ibm.com/systems/storage/san/ctype/9148/index.html

13.5 Enterprise SAN switches

The IBM System Storage SAN switches and directors are well suited to address enterprise SAN customer requirements for infrastructure simplification and improved Business Continuity.

The SAN Director is designed to be interoperable with other members of the IBM System Storage switch family. You can configure a wide range of highly scalable solutions that address demands for integrated, heterogeneous mainframe and open server enterprise SANs.

Enterprise products include these:

- IBM System Storage SAN768B
- SAN 768B and SAN 384B plug-in Encryption Blade
- IBM TotalStorage SAN384B
- IBM TotalStorage SAN256B
- Cisco MDS 9513 for IBM System Storage
- Cisco MDS 9506 for IBM System Storage
- Cisco MDS 9509 for IBM System Storage

In this section, we introduce IBM System Storage Switch solutions ideal for enterprise applications. Advanced security with comprehensive, policy-based security capabilities can improve availability and simplify operation.

13.5.1 IBM TotalStorage SAN256B

The IBM TotalStorage SAN256B is designed to provide outstanding performance, enhanced scalability and a design ready for high-performance 4 Gbps, 8 Gbps, and 10 Gbps capable hardware and expanded capability features. The SAN256B is well suited to address enterprise SAN customer requirements for infrastructure simplification and improved business continuity.

SAN256B: Effective December 18, 2010, IBM TotalStorage SAN256B had been withdrawn from marketing. See the following link for more details:

http://www-01.ibm.com/common/ssi/ShowDoc.jsp?docURL=/common/ssi/rep_ca/7/897/ENUS910-187/index.html&breadCrum=DET001PT022&url=buttonpressed=DET002PT005&specific_index=DET001PEF502&DET015PGL002=DET001PEF011&submit.x=7&submit.y=8&lang=en_US

The SAN256B director interoperates with other members of the IBM TotalStorage SAN b-type and m-type families. It can be configured with a wide range of highly scalable solutions that address demands for integrated IBM System z and open system server enterprise SANs.

Here is a summary of the hardware features of the IBM TotalStorage SAN256B:

- 8, 4, 2, and 1 Gbps server and device interfaces with auto-sensing capability
- Brocade Fabric OS is common across all members of the IBM TotalStorage SAN b-type family
- Supports advanced Inter-Switch Link (ISL) Trunking, Load Balancing and Advanced Zoning
- Web Tools, Fabric Watch, Hot Code Activation and Performance Monitor
- Optional Adaptive Networking Services, Extended Fabric Activation, Remote Switch Activation, FICON Accelerator, FICON with CUP Activation, Advanced Security Activation, FCIP Activation
- Available blades include these:
  - 8 or 4 Gbps 16-port, 32-port and 48-port switch blades
  - 16-port FC/2-port IP routing blades
  - 8-port FC plus 8-port iSCSI blade
  - 6-port 10 Gbps FC ISL blade
- 8 Gbps and 4 Gbps shortwave and longwave Small Form-factor Pluggable (SFP) optical transceivers
- Available 10 Gbps XFPs support high-performance ISLs and distance extension requirements
- Copper GbE SFPs are available for connection to Ethernet fabrics
- Full Fabric Operation and Universal Port (E, F and FL port) operation
- Many non-disruptive software upgrades and hot-swappable switch blades, power supplies and fans
- Fabric Shortest Path First (FSPF) designed to reroute around failed links
- Chassis includes two control processor blades plus space for one to eight port blades, dual power supplies and fans in a 14U rack height and can be installed in IBM TotalStorage SAN Cabinet C36.

Highlights

Here we list highlights of the IBM TotalStorage SAN256B (Figure 13-8):

- High availability with built-in redundancy designed to avoid single points of failure
- Highly scalable director with 16, 32 or 48 Fibre Channel (FC) ports per port switch blade and from 16 to 384 ports in a single domain
- Multiprotocol router blade with sixteen FC ports and two Internet Protocol (IP) ports for SAN routing and distance extension over IP

- iSCSI blade enables servers to access storage over IP (Ethernet)
- 10 Gbps Fibre Channel blade provides extended distance ISL connectivity between directors over dark fibre or DWDM
- Fibre Channel switch blades support either 4, 2, and 1 Gbps link speeds or 8, 4 and 2 Gbps link speeds
- Sixteen and thirty-two port switch blades support IBM FICON
- Interoperable with other IBM TotalStorage SAN b-type and m-type switches and directors
- Offers advanced security with comprehensive policy-based security capabilities
- Offers advanced fabric services such as end-to-end performance monitoring and fabric-wide health monitoring

Figure 13-8 IBM TotalStorage SAN256B

More information

For additional product details, see the website:

http://www.ibm.com/systems/storage/san/b-type/san256b

13.5.2 IBM System Storage SAN384B

The IBM System Storage SAN384B fabric backbone is designed to be the premier platform for consolidation of your data center connectivity, providing high-performance and highly available data networking. Providing new levels of performance with industry-leading 8 Gbps Fibre Channel (FC) technology, it is also one of the first members of the IBM System Storage b-type SAN family designed to exploit Brocade's new Data Center Fabric architecture.

The SAN384B interoperates with other members of the IBM System Storage b-type SAN family as well as other fabrics:

- It can be configured with a wide range of connectivity options, including 10, 8, 4, 2, and 1 gigabit per second (Gbps) Fibre Channel, up to 4 Gbps Fibre Connectivity (FICON), and Fibre Channel over Internet Protocol (FCIP) over 1 gigabit per second Ethernet (GbE).
- It is also designed to enable support for emerging high-performance and high-function network protocols, including Fibre Channel over Converged Enhanced Ethernet (FCoCEE).
- The SAN384B is designed to serve as the basis for transforming existing networks into a unified, high-performance data center fabric, connecting applications with their data and virtual servers with virtual storage.

As a member of the IBM System Storage family of b-type SAN products, the SAN384B is designed to participate in fabrics containing other b-type SAN devices manufactured by Brocade. This versatile hardware can serve as a new top tier (or backbone) in a complex fabric and provide connections to other b-type SAN directors, switches, and routers.

Here is a summary of the hardware features of the IBM System Storage SAN384B:

- Chassis includes two control processor blades and two core module blades plus space for up to four port blades, dual power supplies, and two fan modules in an 8U rack height (plus 1U exhaust shelf).
- Available blades include these:
  - 8 Gbps 16-port, 32-port and 48-port switch blades
  - 24-port FCoCEE blade
  - 6-port 10 Gbps Inter Switch Link (ISL) blades
  - FC routing blade with sixteen 4 Gbps FC ports and two Gigabit Ethernet (GbE) ports
  - 8 Gbps Extension blade containing twelve 8, 4, 2, and 1 Gbps FC ports, ten Ethernet ports supporting 1 GbE and up to two optional 10 GbE ports
- Available optical transceivers include these:
  - 10 Gbps, 8 Gbps and 4 Gbps shortwave small-form-factor pluggable (SFPs)
  - 10 Gbps and 8 Gbps 10 km and 4 Gbps 4 km and 10 km longwave SFPs
  - 8 Gbps 25 km and 4 Gbps 30 km extended distance longwave SFPs
- Full Fabric and Universal Port operation (E_Port, F_Port and FL_Port)
- Can be installed in IBM TotalStorage SAN Cabinet (2109-C36)

Highlights

Here we list highlights of the IBM System Storage SAN384B (Figure 13-9):

- Drive new levels of performance with 8 Gbps Fibre Channel (FC) technology in a compact design
- Reduce total cost of ownership (TCO) through consolidation of network resources
- Protect existing infrastructure investment while positioning for future technologies Manage your infrastructure with greater flexibility and scalability

- Unify management framework for consolidated and virtualized resources
- Improve energy efficiency by combining higher band-width with reduced power consumption


Figure 13-9 IBM System Storage SAN384B

More information

For additional product details, see this website:

http://www.ibm.com/systems/storage/san/b-type/san384b

13.5.3 IBM System Storage SAN768B

The IBM System Storage SAN768B fabric backbone is designed to be the premier platform for consolidation of your data center connectivity, providing high-performance and highly available data networking. Providing new levels of performance with industry-leading 8 Gbps Fibre Channel (FC) technology, it is also the first member of the IBM System Storage b-type family designed to exploit Brocade's new Data Center Fabric architecture.

The SAN768B interoperates with other members of the IBM System Storage b-type and m-type families as well as other fabrics.

- It can be configured with a wide range of connectivity options, including 10, 8, 4, 2, and 1 gigabits per second (Gbps) Fibre Channel, up to 4 Gbps Fibre Connections (FICON), and Fibre Channel over Internet Protocol (FCIP) over 1 gigabit per second Ethernet (GbE).
- It is also designed to enable support for emerging high-performance and high-function network protocols, including Fibre Channel over Converged Enhanced Ethernet (FCoCEE).
- The SAN768B is designed to serve as the basis for transforming existing networks into a unified, high-performance data center fabric, connecting applications with their data and virtual servers with virtual storage.

As a member of the IBM System Storage family of b-type products, the SAN768B is designed to participate in fabrics containing other b-type and m-type devices manufactured by Brocade. This versatile hardware can serve as a new top tier (or backbone) in a complex fabric and provide connections to other b-type and m-type directors, switches and routers

Here is a summary of the hardware features of the IBM System Storage SAN768B:

- Chassis includes two control processor blades and two core module blades plus space for up to eight port blades, dual power supplies with an option for two additional power supplies, and three fan modules in a 14U rack height
- Available Blades include these:
  - 8 Gbps 16-port, 32-port, and 48-port switch blades
  - 24-port FCoCEE blade
  - 10 Gbps Inter Switch Link (ISL) blades
  - FC routing blade with sixteen 4 Gbps FC ports and two Gigabit Ethernet (GbE) IP ports
  - 8 Gbps Extension blade containing twelve 8, 4, 2, and 1 Gbps FC ports, ten Ethernet ports supporting 1 GbE and up to two optional 10 GbE ports
- Available optical transceivers include these:
  - 10 Gbps, 8 Gbps, and 4 Gbps shortwave small-form-factor pluggable (SFPs)
  - 10 Gbps and 8 Gbps 10 Km and 4 Gbps 4 Km and 10 Km longwave SFPs
  - 10 Gbps XFPs, and GbE optical SFPs for IP connectivity
- Full Fabric and Universal Port operation (E_Port, F_Port and FL_Port)
- Can be installed in IBM TotalStorage SAN Cabinet (2109-C36)

Highlights

Here we list highlights of the IBM System Storage SAN768B (Figure 13-10):

- Drive new levels of performance with 8 Gbps Fibre Channel (FC) technology
- Reduce total cost of ownership (TCO) through consolidation of network resources
- Protect existing infrastructure investment while positioning for future technologies
- Manage your infrastructure with greater flexibility and scalability
- Unify management framework for consolidated and virtualized resources
- Improve energy efficiency by combining higher band-width with reduced power consumption

Figure 13-10 IBM System Storage SAN768B

SAN 768B and SAN 384B plug-in Encryption Blade

The IBM System Storage SAN768B and IBM System Storage SAN384B fabric backbones are highly robust network switching platforms designed for evolving enterprise data centers. Each machine combines breakthrough performance, scalability and energy efficiency with long-term investment protection. Supporting open systems and System z environments, they address data growth and server virtualization challenges; enable server, SAN and data center consolidation; minimize disruption and risk; and reduce infrastructure and administrative costs.

Built for large enterprise networks, the SAN768B has eight vertical blade slots to provide up to 512 8-Gbps Fibre Channel ports. The SAN384B is ideal for midsize core or edge deployments, providing four horizontal blade slots and up to 256 8-Gbps Fibre Channel ports. The flexible blade architecture also supports FCoE, fabric-based encryption for data-at-rest and SAN extension advanced functionality for high-performance server I/O consolidation, data protection and disaster recovery solutions.

Encryption: SAN 768B and SAN 384B plug-in Encryption Blade provides an 8 Gbps 16-port Encryption Blade that supports up to 96 Gbps of disk encryption and 48 Gbps of tape encryption with compression.

The SAN768B and SAN384B are extremely efficient at reducing power consumption, cooling and the carbon footprint in data centers. While providing exceptional performance and scale, these networking backbones use less than one watt per Gbps—significantly more efficient than alternate offerings.

The SAN768B and SAN384B build on years of innovation, using the core technology of systems designed to perform at greater than 99.999 percent uptime in the world's most demanding data centers. With its intelligent sixth-generation application-specific integrated circuits (ASICs) and advanced hardware and software capabilities, the SAN768B and SAN384B provide a reliable foundation for fully connected multiprotocol SAN fabrics capable of supporting thousands of servers, storage and networking devices.

As members of the IBM System Storage family of b-type SAN products, the SAN768B and the SAN384B are designed to participate in fabrics containing other b-type and m-type devices manufactured by Brocade. This versatile hardware can serve as the backbone in a complex fabric and provide connections to other b-type and m-type directors, switches and routers.

Fabric optimization services

The IBM System Storage SAN768B and IBM System Storage SAN384B can be expandable platforms for intelligent, policy-driven services that can help manage and protect your enterprise data in virtualized environments. The SAN768B and SAN384B backbones utilize Brocade Fabric OS (FOS), which provides several characteristic features, including Bottleneck Detection, Top Talkers (part of Advanced Performance Monitoring), and Adaptive Networking, a suite of tools that includes Ingress Rate Limiting, Traffic Isolation and quality of service (QoS). Managed through IBM System Storage Data Center Fabric Manager (DCFM) or the command line interface (CLI), these advanced capabilities help optimize fabric behavior and application performance.

QoS and traffic management applications help ensure that application workloads meet service levels if congestion occurs anywhere in the data path. Resource recovery applications can detect stranded resources or inefficiently used resources, and reclaim or reallocate them to optimize data flow according to these rules:

- Bottleneck Detection identifies and alerts administrators to ISL or device congestion and device latency conditions in the fabric, conditions that can cause latency and I/O time outs if left undetected and unresolved, particularly in highly virtualized server environments.
- Top Talkers measures the top bandwidth-consuming traffic (including by individual virtual machine) in real time over a physical device connection or throughout a network switch.
- Ingress Rate Limiting restricts data flow from less-critical hosts at preset bandwidths.
- Traffic Isolation dedicates paths in the fabric to specific data flows, enabling predictability and avoiding network congestion.
- QoS expedites critical traffic in the event of congestion while keeping all traffic flowing.

Virtual Fabrics

The IBM System Storage SAN768B and the IBM System Storage SAN384B support the ANSI standard-based implementation of Virtual Fabrics (VF). Virtual Fabrics adds the capability for physical switches to be partitioned into independently managed logical switches, each with its own data, control, and management paths. Logical switches can be used to allocate fabric resources on a per-port basis rather than on a per-switch basis. Additionally, logical switches can simplify resource allocation by customer, department, application or storage tier, and consolidate resources across multiple fabrics.

Each logical switch belongs to one logical fabric. A logical fabric can include both logical and physical switches. Physical switches joining a logical fabric are not required to support the Virtual Fabric feature, making it compatible with existing fabrics. All fabric services, such as Zoning, QoS and Access Control List (ACL) policies are managed separately in each logical fabric. Virtual Fabrics enable improved ISL bandwidth utilization, per-port resource allocation and flexible management partitioning, which can result in reduced power and cooling costs, more ports for connectivity to end devices, and a simplified management scheme.

Highlights

Here we list highlights of Virtual Fabrics:

- Drive new levels of performance with 8 Gbps and 10 Gbps Fibre Channel (FC) supporting a range of protocol and encryption options
- Secure and protect data against threats and disasters with plug-in blades for data encryption and SAN extension
- Manage your infrastructure with greater flexibility and scalability
- Unify management framework for consolidated and virtualized resources
- Reduce total cost of ownership (TCO) through consolidation of network resources
- Protect existing infrastructure investment while positioning for future technologies
- Improve energy efficiency by combining higher bandwidth with reduced power consumption

More information

For additional product details, see the following website:

http://www.ibm.com/systems/storage/san/b-type/san768b

13.5.4 Cisco MDS 9506 for IBM System Storage

The Cisco MDS 9506 for IBM System Storage supports 1, 2, 4, 8, and 10 Gbps Fibre Channel switch connectivity and intelligent network services to help improve the security, performance, and manageability required to consolidate geographically dispersed storage devices into a large enterprise SAN.

The Cisco MDS 9506 for IBM System Storage utilizes two Supervisor-2 Modules designed for high availability and performance. The Supervisor-2 Module combines an intelligent control module and a high-performance crossbar switch fabric in a single unit. It uses Fabric Shortest Path First (FSPF) multipath routing, which provides intelligence to load balance across a maximum of 16 equal-cost paths and to dynamically reroute traffic if a switch fails.

Each Supervisor-2 Module provides the necessary crossbar bandwidth to deliver full system performance in the Cisco MDS 9506 director with up to four Fibre Channel switching modules. It is designed to eliminate the impact on system performance of the loss or removal of a single crossbar module.

Highlights

Here we list highlights of the Cisco MDS 9506 for IBM System Storage (Figure 13-11):

- Provides Fibre Channel throughput of up to 4 Gbps per port and up to 64 Gbps with each PortChannel Inter-Switch Link connection
- Offers scalability from 12 to 192 Fibre Channel ports
- Offers 10 Gbps ISL ports for inter-Data Center links over metro optical networks
- Offers Gigabit Ethernet IP, GbE ports for iSCSI or FCIP connectivity over global networks
- High-availability design with support for non-disruptive firmware upgrades
- Includes Virtual SAN (VSAN) capability for SAN consolidation into virtual SAN islands on a single physical fabric
- Enterprise, SAN Extension over IP, Mainframe and Storage Services Enabler and Fabric Manager Server Packages provide added intelligence and value

Figure 13-11 Cisco MDS 9506 for IBM System Storage

More information

For additional product details, see this website:

http://www.ibm.com/systems/storage/san/ctype/9506

13.5.5 Cisco MDS 9509 for IBM System Storage

The Cisco MDS 9509 for IBM System Storage provides 1, 2, 4, 8, and 10 Gbps Fibre Channel switch connectivity and intelligent network services to help improve the security, performance and manageability required to consolidate geographically dispersed storage devices into a large enterprise SAN.

The Cisco MDS 9509 for IBM System Storage utilizes two Supervisor-2 Modules to support high availability and performance. The Supervisor-2 Module combines an intelligent control module and a high-performance crossbar switch fabric in a single unit. It uses Fabric Shortest Path First (FSPF) multipath routing, which supports load balancing across a maximum of 16 equal-cost paths that dynamically reroute traffic if a switch fails.

Highlights

Here we list highlights of the Cisco MDS 9509 for IBM System Storage (Figure 13-12):

- Provides Fibre Channel throughput of up to 8 gigabits per second (Gbps) per port and up to 64 Gbps with each PortChannel Inter-Switch Link connection
- Offers scalability from 12 to 336 1, 2, 4 and 8 Gbps Fibre Channel ports
- Offers 10-Gbps ISL ports for inter-data center links over metro optical networks
- Offers Gigabit Ethernet IP (GbE) ports for iSCSI or FCIP connectivity over global networks

- High-availability design with support for non-disruptive firmware upgrades
- Includes Virtual SAN (VSAN) capability for SAN consolidation into virtual SAN islands on a single physical fabric
- Enterprise, SAN Extension over IP, Mainframe and Storage Services Enabler and Fabric Manager Server packages provide added function and value

Figure 13-12 Cisco MDS 9509 for IBM System Storage

More information

For additional product details, see this website:

http://www.ibm.com/servers/storage/san/ctype/9509

13.5.6 Cisco MDS 9513 for IBM System Storage

The Cisco MDS 9513 for IBM System Storage supports 1, 2, 4, 8, and 10 Gbps Fibre Channel switch connectivity and intelligent network services to help improve the security, performance, and manageability required to consolidate dispersed SAN islands into a large-enterprise SAN.

The Cisco MDS 9513 for IBM System Storage utilizes two Supervisor-2 modules to support high availability. The Supervisor-2 Module provides industry-leading scalability, intelligent SAN services, non-disruptive software upgrades, stateful process restart, and failover and redundant operation. Dual crossbar switching fabric modules provide a total internal switching bandwidth of 2.4 terabytes per second (Tbps) for interconnection of up to 11 Fibre Channel switching modules.

Fibre Channel switching modules improve performance, flexibility and density. The Cisco MDS 9513 for IBM System Storage requires a minimum of one Fibre Channel switching module and allows a maximum of 11. These modules are available in 12-, 24- or 48-port 4 and 8 Gbps configurations, enabling the Cisco MDS 9513 to support 12 to 528 Fibre Channel ports per chassis. Optionally, a 4-port 10-Gbps Fibre Channel module is available for high-performance Inter-Switch Link (ISL) connections over metro optical networks.

Highlights

Here we list highlights of the Cisco MDS 9513 for IBM System Storage (Figure 13-13):

- Provides Fibre Channel throughput of up to 8 gigabits per second (Gbps) per port and up to 64 Gbps with each PortChannel Inter-Switch Link connection
- Offers scalability from 12 to 528 1, 2, 4 and 8 Gbps Fibre Channel ports
- Offers 10-Gbps ISL ports for inter-data center links over metro optical networks
- Offers Gigabit Ethernet (GbE) IP ports for iSCSI or FCIP connectivity over global networks
- Features high-availability design with support for non-disruptive firmware upgrades
- Includes Virtual SAN (VSAN) capability for SAN consolidation into virtual SAN “islands” on a single physical fabric
- Provides added function and value through Enterprise, SAN Extension over IP, Mainframe, Storage Services Enabler and Fabric Manager Server packages

Figure 13-13 Cisco MDS 9513 for IBM System Storage

More information

For additional product details, see this website:

http://www.ibm.com/systems/storage/san/ctype/9513

13.6 Multiprotocol routers

Since the introduction of Storage Area Networks (SANs), customers have built multiple SAN networks (or islands) for various applications, often with fabric switch components from various manufacturers. Certain islands were built by various departments within a company, while other islands resulted from mergers, acquisitions, or reorganizations. Dissimilar SAN equipment with various capabilities or a desire to isolate important applications has constrained opportunities for enhanced infrastructure simplification and vital business continuity solutions.

The IBM System Storage multiprotocol router provides Fibre Channel FC-FC Routing Service, which allows the interconnection of multiple SAN islands without requiring that the separate fabrics be merged into a single large SAN. This capability can help create a tiered or extended enterprise SAN infrastructure without having to redesign or reconfigure the entire environment.

Figure 13-14 shows a conceptual view of SAN multiprotocol routing, where SANs from various vendors can be connected.

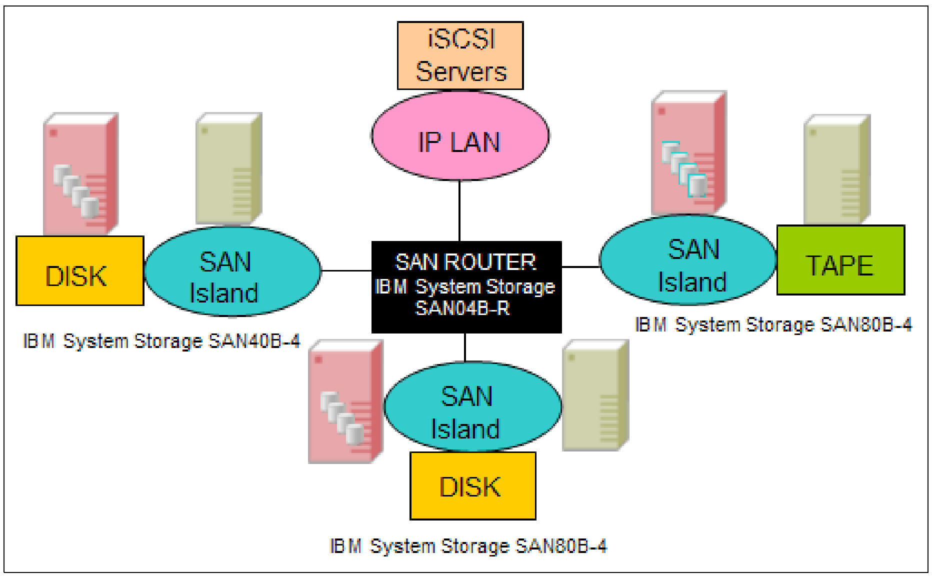


Figure 13-14 SAN multiprotocol routing

Enterprise products include these:

- IBM System Storage SAN04B-R multiprotocol router
- IBM System Storage SAN06B-R multiprotocol router
- Cisco MDS 9222i for IBM System Storage

In this section, we introduce IBM System Storage SAN Multiprotocol Router solutions ideal for enterprises with a business need to route SAN traffic between various SAN islands.

13.6.1 IBM System Storage SAN04B-R multiprotocol router

> **SAN04B-R:** Effective November 27, 2010, IBM System Storage SAN04B-R has been withdrawn from marketing. See the following link for more information:
>
> http://www-01.ibm.com/common/ssi/ShowDoc.jsp?docURL=/common/ssi/rep_ca/7/897/ENUS910-167/index.html&breadCrum=DET001PT022&url=buttonpressed=DET002PT005&specific_index=DET001PEF502&DET015PGL002=DET001PEF011&submit.x=7&submit.y=8&lang=en_US

A wide range of IBM System Storage midrange and enterprise Storage Area Network (SAN) infrastructure simplification and business continuity solutions can be created with the IBM System Storage SAN04B-R multiprotocol router. Infrastructure simplification solutions for the IBM Power Systems and System x families include disaster tolerance over metropolitan and global IP networks with IBM System Storage disk arrays, tape libraries, and IBM Tivoli Storage Manager data protection software. Separate SAN islands can also be consolidated using Fibre Channel routing. Support for System z servers is provided by the optional High-Performance Extension and FICON CUP Activation features.

Local site infrastructure simplification solutions can be extended to one or more remote sites for enhanced data protection and disaster tolerance. The IBM System Storage SAN04B-R multiprotocol router provides Fibre Channel over IP and FCIP Tunneling Service for distance extension, which can enable cost-effective and manageable metro and global business continuity solutions. This extended distance connectivity can help create consolidated remote tape vaulting data protection plus metro mirror and global mirror disk-based, disaster-tolerant solutions.

Since the introduction of Storage Area Networks, customers have built multiple SAN networks (or islands) for various applications, often with fabric switch components from various manufacturers. Certain islands were built by various departments within a company, while other islands resulted from mergers, acquisitions or reorganizations. Dissimilar SAN equipment with various capabilities or a desire to isolate important applications has constrained opportunities for enhanced infrastructure simplification and vital business continuity solutions.

The IBM System Storage SAN04B-R multiprotocol router can provide Fibre Channel FC-FC Routing Service, which allows the interconnection of multiple SAN islands without requiring that the separate fabrics be merged into a single large SAN. This capability can help create a tiered or extended enterprise SAN infrastructure without having to redesign or reconfigure the entire environment.

Highlights

Here we list highlights of the IBM System Storage SAN04B-R multiprotocol router (Figure 13-15):

- Designed for high performance with 4 Gigabit per second (Gbps) Fibre Channel (FC) ports and hardware-assisted traffic processing for line-rate performance across Ethernet Internet Protocol (IP) ports
- Utilizes existing Internet, IP-based Metropolitan Area Network (MAN) or Wide Area Network (WAN) infrastructures for metro and global SAN extension for business continuity solutions
- Enables consolidation of Storage Area Network (SAN) islands for infrastructure simplification without compromising security
- Hardware-based compression, large window sizes, and selective acknowledgement of IP packets designed to optimize performance of SAN extension over IP networks

- Eight virtual FCIP tunnels per IP port are enabled by the High-Performance Extension feature to help maximize scalability and utilization of MAN/WAN resources
- Integrated IBM System Storage SAN b-type (Brocade) switch management helps simplify installation and administration and helps provide fabric investment protection
- FICON Accelerator uses special emulation techniques to reduce or eliminate degradation for selected applications such as IBM z/OS Global Mirror (XRC) and tape pipelining

Figure 13-15 shows the IBM System Storage SAN04B-R multiprotocol router.

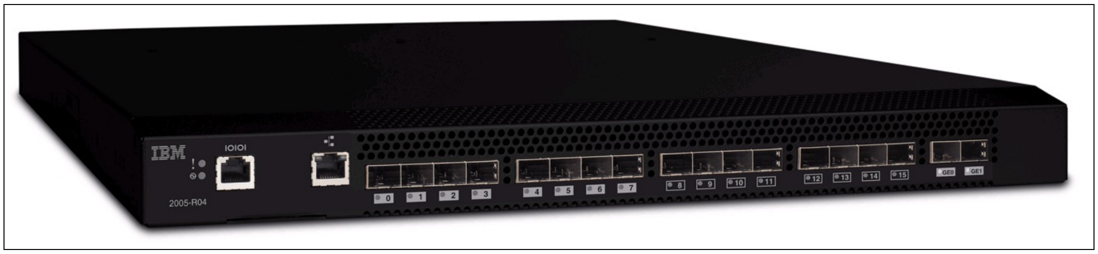


Figure 13-15 IBM System Storage SAN04B-R multiprotocol router

IBM System Storage SAN04B-R provides Fibre Channel FC-FC Routing Service, which allows the interconnection of multiple SAN islands without requiring that the separate fabrics be merged into a single large SAN. As shown in Figure 13-16, this capability can help create a tiered or extended enterprise SAN infrastructure without having to redesign or reconfigure the entire environment.

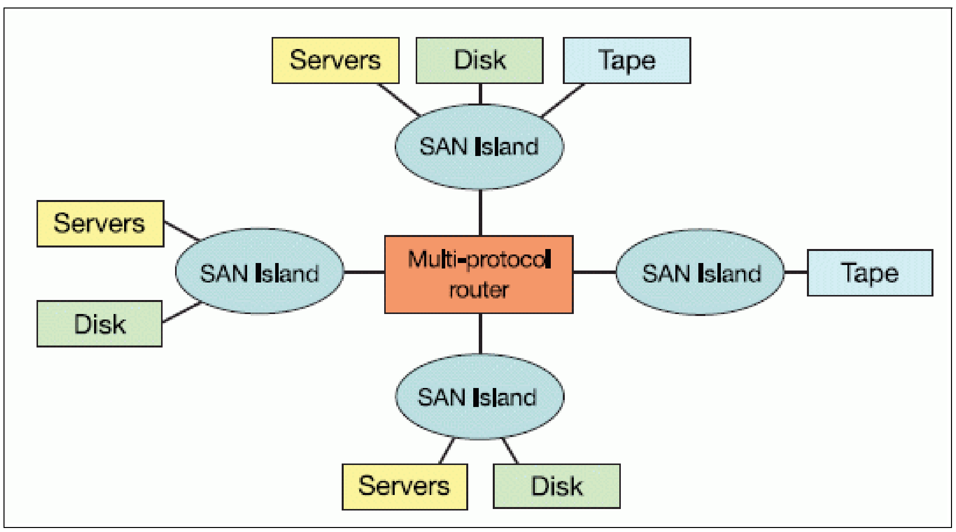


Figure 13-16 Inter-SAN routing

FC-FC Routing Service

The FC-FC Routing Service feature is designed to allow devices located on separate SAN fabrics to communicate without merging the fabrics into a single large SAN environment. This routed network consists of multiple individual SAN fabrics that form one storage network connectivity model, known as a MetaSAN.

FCIP Tunneling Service

The FCIP Tunneling Service feature is designed to allow organizations to extend Fibre Channel SANs over longer distances, using IP-based MAN/WAN infrastructure. This service can be integrated with the FC-FC Routing Service.

iSCSI Gateway Service

The iSCSI Gateway Service is designed to allow the integration of low-cost Ethernet-connected servers into a Fibre Channel SAN by using iSCSI protocol, enabling IP-based servers to utilize Fibre Channel SAN resources. It enhances asset utilization and can help enable new applications such as centralized backup. This level of integration reduces the expense of connecting low-cost servers directly into centrally managed SAN storage.

More information

For additional product details, see the website:

http://www.ibm.com/systems/storage/san/b-type/san04b-r

13.6.2 IBM System Storage SAN06B-R multiprotocol router

In addition to the features of the SAN04B-R router, the SAN06B-R supports 8, 4, 2 Gbps, or 4, 2, 1 Gbps FC link speeds.

Highlights

Here we list highlights of the IBM System Storage SAN06B-R multiprotocol router (Figure 13-17):

- Designed for high performance with 8 Gigabit per second (Gbps) Fibre Channel (FC) ports and hardware-assisted traffic processing for line-rate performance across 1 GbE Ethernet Internet Protocol (IP) ports
- Utilizes existing Internet, IP-based Metropolitan Area Network (MAN) or Wide Area Network (WAN) infrastructures for metro and global SAN extension for business continuity solutions
- Hardware-based compression, large window sizes and selective acknowledgement of IP packets designed to optimize performance of SAN extension over IP networks
- Up to eight virtual FCIP tunnels are available to help maximize scalability and utilization of MAN/WAN resources
- Enables consolidation of Storage Area Network (SAN) islands for infrastructure simplification without compromising security
- Integrated IBM System Storage SAN b-type (Brocade) switch management helps simplify installation and administration and helps provide fabric investment protection

Figure 13-17 shows the IBM System Storage SAN06B-R multiprotocol router.

Figure 13-17 IBM System Storage SAN06B-R multiprotocol router

More information

For additional product details, see this website:

http://www.ibm.com/systems/storage/san/b-type/san06b-r

13.6.3 Cisco MDS 9222i for IBM System Storage

The Cisco MDS 9222i for IBM System Storage is designed to address the needs of medium-sized businesses and large enterprises with a wide range of Storage Area Network (SAN) capabilities. It can be used as a cost-effective high performance SAN extension over IP router switch for midrange SMB customers in support of IT simplification and business continuity solutions. It can also provide remote site device aggregation and SAN extension connectivity to large customer data center directors.

A wide range of IBM System Storage midrange and enterprise Storage Area Network (SAN) IT simplification and business continuity solutions can be created with the Cisco MDS 9222i for IBM System Storage multiservice modular switch. IT simplification solutions for IBM Power Systems, System i, System p, System x and System z servers include storage consolidation and high-availability server clustering with IBM System Storage disk storage arrays. Business continuity capabilities can help businesses protect valuable data with IBM System Storage tape libraries and IBM Tivoli Storage Manager data protection software. Advanced connectivity capabilities can help business protect against major disasters with IBM System Storage disk metro and global mirroring disaster recovery solutions.

Highlights

Here we list highlights of the Cisco MDS 9222i for IBM System Storage (Figure 13-18):

- Multiservice design for high performance business continuity solutions with Windows, UNIX, Linux, NetWare, IBM OS/400 and IBM z/OS servers
- Cost-effective "green" switch design requires up to 27 percent less power per port
- Modular design provides scalability and configuration flexibility
- Excellent availability with redundant, hot swappable components and non-disruptive firmware upgrades
- Includes Virtual SAN (VSAN) capability for SAN consolidation into virtual SAN islands on a single physical fabric
- Enterprise, Mainframe and Fabric Manager Server Packages provide added intelligence and value

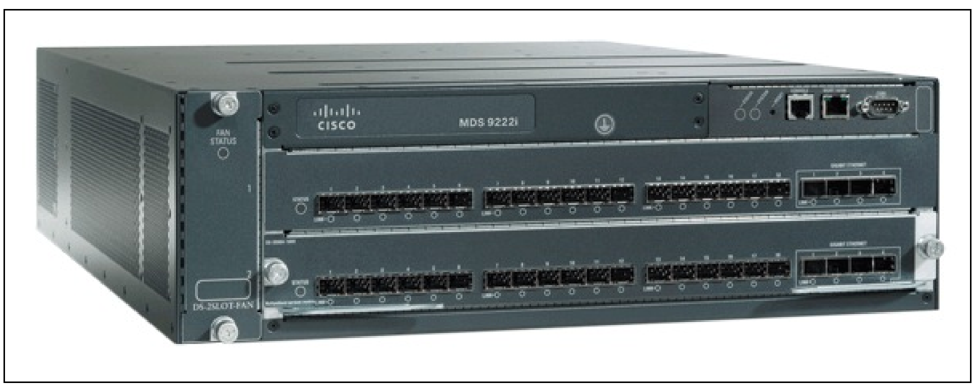


Figure 13-18 Cisco MDS 9222i for IBM System Storage

More information

For additional product details, see this website:

http://www.ibm.com/systems/storage/san/ctype/9222

13.7 SAN management

The IBM System Storage Data Center Fabric Manager allows you to configure and manage multiple IBM System Storage b-type and mixed b-type and m-type network fabrics from a single interface.

13.7.1 Features

IBM System Storage Data Center Fabric Manager (DCFM) is a comprehensive network management application that enables end-to-end management of data center fabrics. DCFM manages and secures the flow of data across multiple fabrics—empowering IT organizations to achieve their SLA, security and compliance goals while containing operational expenses. It provides exceptional scalability and performance that helps maximize data availability. In addition, DCFM features easy-to-use administrative tools that streamline and automate repetitive tasks so organizations can achieve new levels of productivity and efficiency.

The Data Center Fabric Manager is a key component of the IBM New Enterprise Data Center architecture and supports and complements Brocade's Data Center Fabric architecture. DCFM is designed for unified management of data center fabrics—from ports on storage devices all the way to the Host Bus Adapters in physical or virtualized servers. It can be used to configure IBM System Storage SAN768B and Brocade DCX backbone directors along with other SAN products manufactured by Brocade.

13.7.2 Highlights

Here we list highlights of the IBM System Storage Data Center Fabric Manager:

- Centralizes management of IBM System Storage SAN b-type (Brocade) and mixed b-type and m-type (McDATA) network fabrics within and across datacenters
- Maximizes productivity and reduces expenses by automating tasks and providing easy-to-use wizard-driven operations
- Delivers real-time and historical performance monitoring to enable proactive problem diagnosis, maximize resource utilization and facilitate capacity planning
- Supports server virtualization, including setting Quality of Service (QoS) levels for applications running on virtual machines
- Helps administrators meet Service Level Agreements (SLAs) by innovative event notification, monitoring, troubleshooting and diagnosis capabilities.

The IBM System Storage Data Center Fabric Manager also performs these tasks:

- Proactively monitors critical fabric health information (at various levels of detail)
- Configures QoS priorities for applications running on both physical and virtual servers to optimize performance for high-priority applications
- Collects and displays performance statistics in both real-time and historical views for proactive problem determination
- Enables organizations to capture, back up, and compare switch configuration profiles through advanced cloning
- Performs automatic data collection and triggers Call Home notification for easier fault isolation, diagnostics and remote service
- Provides proactive alerts with real-time logging, diagnostic and fault isolation capabilities to resolve issues before they impact SLAs

- Streamlines firmware download, switch configuration, backup and restore, and the collection of diagnostic data across groups of switches
- Enables organization to edit zone information and preview the impact of proposed changes without affecting the production fabric
- Provides a configurable fabric snapshot/compare capability to track changes to fabric objects and membership
- Generates reports for status changes, port usage, zoning activation, and more—either on-demand, automatically on a scheduled basis, or in response to a fabric event
- Configures and manages FICON and cascading FICON environments while providing powerful analysis and diagnostic features
- Configures, monitors and optimizes Fibre Channel over IP (FCIP) tunnels across WAN links
- Provides comprehensive support for Fibre Channel Routing, including configuration, zoning, virtualization, analysis and trouble shooting tools

13.8 SAN solutions

IBM System Storage SAN solutions integrate IBM and other vendor server, storage, SAN switches and software components into solution templates which have been extensively tested to provide high availability, scalability, security, and simplicity of management. IBM SAN solutions are offered with worldwide IBM service and end-to-end solution support. These solutions templates might be customized by IBM Business Partners or IBM Global Services to address individual customer requirements.

IBM System Storage Infrastructure Simplification solutions and Business Continuity solutions are offered for Small and Medium Business (SMB) customers who require simplicity and affordability and for large enterprise customers who demand highest availability, scalability, security and management intelligence.

- Infrastructure simplification solutions consist of storage consolidation with shared disk storage and storage pooling with IBM SAN Volume Controller software.
- Business Continuity solutions consist of data protection with shared local or remote tape library technology and disk storage with point-in-time copy technology and automated backup and recovery software; and disaster tolerance with disk storage mirroring technologies and SAN fabric extension technologies which can provide metro and global distance solutions.

The following examples show solution possibilities using IBM System Storage SAN switches.

For additional IBM SAN solution information, see this website:

http://www.ibm.com/servers/storage/solutions/san/

13.8.1 Infrastructure simplification solutions

IBM offers solutions to simplify IT infrastructures, a key first step in freeing the resources you need to begin developing an on demand operational model.

Complexity can prevent even the best organization from acting nimbly to meet ever-changing market and client demands. Complexity inherent in typical IT infrastructures can stall your business goals by making execution on new tasks too difficult or time consuming.

IBM solutions for infrastructure simplification are designed to help you improve efficiency, lower total cost of ownership, and reduce time-consuming and costly errors. These solutions can help you lower the cost of storing and managing data. IBM System Storage solutions for infrastructure simplification are designed to improve the effectiveness of your storage infrastructure and reduce long-term costs, while reducing the time and effort spent on managing data.

An *entry-level infrastructure simplification solution* consists of up to 22 servers attached to one 24-port IBM System Storage SAN24B-4 Express switch with an IBM System Storage disk array.

An example *infrastructure simplification with high-availability server solution* is shown in Figure 13-19. The topology is created with redundant switches, and each server, with dual Fibre Channel adapters is cross-connected by the separate switches to the IBM System Storage DS5000 disk array.

An easy way to migrate your SAN from *entry-level* to *midrange* products is to shut down one 24-port SAN24B-4 fabric switch and replace it with one 40 port SAN40B-4 fabric switch.

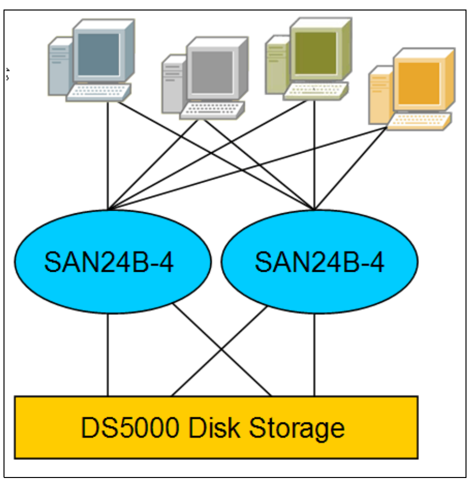


Figure 13-19 Infrastructure simplification with high-availability server solution

An expanded solution provides a higher data transfer rate by using 8 Gbps throughout; servers with an 8 Gbps HBA card, for example: IBM BladeCenter, the IBM System Storage SAN fabric switches with 1, 2, 4, and 8 Gbps auto-sensing capabilities, and the IBM System Storage DS5000 Express with 8 Gbps host connection function, as shown in Figure 13-20.

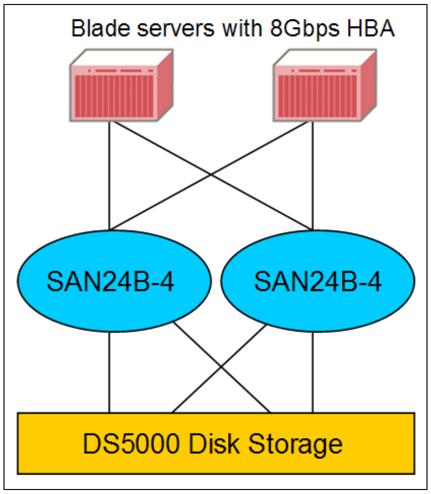


Figure 13-20 Infrastructure simplification with 8Gbps solution

Local site infrastructure simplification solutions can be extended to one or many remote sites for enhanced data protection and disaster tolerance. The IBM System Storage multiprotocol routers provide Fibre Channel over IP and FCIP Tunneling Service for distance extension that can enable cost-effective and manageable metro and global business continuity solutions. This extended distance connectivity can help create consolidated remote tape vaulting data protection plus metro mirror and global mirror disk-based disaster tolerant solutions.

13.8.2 Business continuity solutions

Today's customers, employees, suppliers, and business partners expect to be able to tap into your information any time of day, from any location. At the same time, your business must be increasingly sensitive to issues of customer privacy, data security and regulatory requirements.

To keep your operations running, and your business competitive, you need a comprehensive strategy that addresses three primary aspects of business continuity: high availability, disaster recovery, and continuous operations.

The IBM System Storage SAN Family solutions can help you protect critical business assets, and align recovery costs based on patented business impact and information value. A typical IBM System Storage SAN switch *Business Continuity solutions* example of a backup site solution is shown in Figure 13-21.

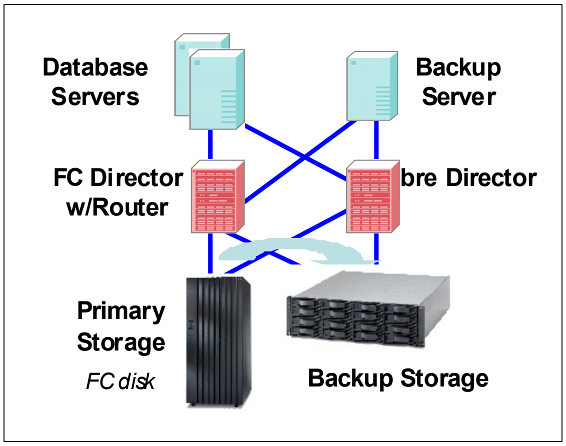


Figure 13-21 Typical backup site solution

When considering total cost of ownership, there are two choices: FCIP or FC direct route by DWDM or CWDM. See Figure 13-22 for FC over IP and Figure 13-23 for FC route through DWDM or CWDM.

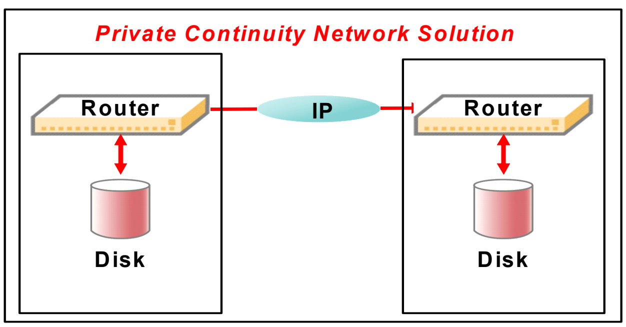


Figure 13-22 FC over IP

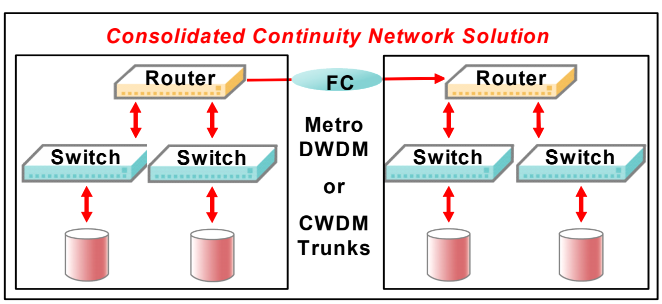


Figure 13-23 FC over DWDM or CWDM

Another IBM System Storage SAN switches *Business Continuity solutions* example is remote tape backup with the IBM SAN Multiprotocol router: As Figure 13-24 shows, an enterprise with a remote backup site can build a tape backup solution over distance with an IBM Multiprotocol router. An offsite Tivoli Storage Manager, by SAN routing, can pull data from a production disk storage array then copy it to the tape drives. This allows a minimal number of tape drives to be used and also utilizes electronic production of offsite media.

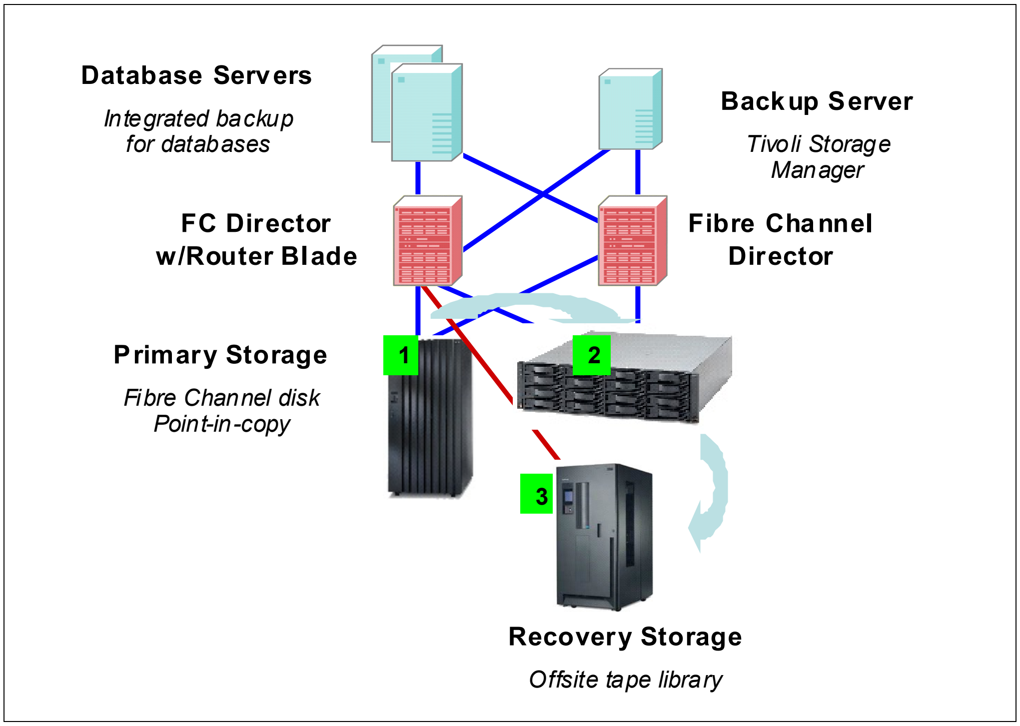


Figure 13-24 Remote tape backup solution

13.9 More information

For more information about all the SAN related topics and the products discussed in this chapter, see the following Redbooks publications:

- *Introduction to Storage Area Networks*, SG24-5470
- *IBM/Cisco Multiprotocol Routing: An Introduction and Implementation*, SG24-7543
- *Implementing an IBM/Cisco SAN*, SG24-7545
- *IBM SAN Survival Guide*, SG24-6143
- *SAN Storage Performance Management Using TotalStorage Productivity Center*, SG24-7364
- *Implementing an IBM/Brocade SAN with 8 Gbps Directors and Switches*, SG24-6116

More details can be found at the following website:

- http://www-03.ibm.com/systems/storage/san/b-type/dcfm/index.html

14

Data Center Networking

As you consolidate and virtualize your IT environment, capitalizing on the latest networking technologies and approaches can help you save money, improve service, and reduce the risk of security breaches. IBM Networking Strategy and Optimization Services, a network infrastructure optimization for consolidation and virtualization, provides services to plan and justify a networking infrastructure that supports and fully contributes to a dynamic, flexible IT environment.

Expanded network technology choices with the new IBM Ethernet switches and routers provide an integrated end-to-end resiliency and security framework. The big product range from IBM makes data center networking a cost efficient solution. The product range includes:

- IBM b-type Ethernet switches and routers
- IBM j-type Ethernet switches, routers, and appliances
- IBM c-type Ethernet switches and routers

In this chapter, we discuss data center networking products and features.

For more information about network technologies, network management, and networking services, see the website:

http://www.ibm.com/systems/networking

14.1 IBM b-type Ethernet products

IBM Networking b-type Ethernet routers and switches provide all the functionality required to build an efficient dynamic infrastructure and transform physical and digital assets into more relevant services. The b-type family was engineered to provide performance, better manage risk, improve service, and reduce cost from the end user to the server connectivity:

- IBM y-series Ethernet Switches are designed to support next-generation campus convergence of video, voice, and data by providing a single-cable solution for devices such as Voice over IP (VoIP) phones, video surveillance cameras, and wireless access points.
- IBM x-series Ethernet Switches are designed to meet the most demanding requirements of the data center Top-of-Rack (TOR) server access, cost-efficient aggregation, and high performance computing solutions.
- IBM r-series Ethernet Switches are designed to meet the most demanding requirements of the data center aggregation and distribution, as well as campus backbone and border layer solutions.
- IBM c-series Ethernet Switches are designed to meet the most demanding requirements of data center TOR server access, metro, and border edge layer solutions.
- IBM g-series Ethernet Switches are designed to meet critical cost requirements of enterprise campus stackable and PoE converged access layer solutions
- IBM m-series Ethernet/IP Routers are designed to meet the most demanding requirements of data center core and border, as well as enterprise campus backbone and border layer solutions.
- IBM s-series Ethernet Switches are designed to meet critical cost requirements of data center aggregation and enterprise campus Power over Ethernet (PoE) access and distribution layer solutions.

14.1.1 IBM y-series Ethernet switches

IBM Ethernet Switch y-series (B24Y and B48Y) are designed to provide the performance, scalability, and flexibility required for today's enterprise data center and campus networks. With advanced capabilities, these switches deliver performance and intelligence to the network edge in a flexible 1U form factor that can help to reduce infrastructure and administrative costs. IBM Ethernet Switch y-series switches are designed for wire-speed and non-blocking performance, and can be deployed in stacks of up to eight switches with up to 384 1 GbE ports using IronStack technology.

Overview

IBM b-type y-series Ethernet switches (4002BY2, 4002BY4, 4002CY2) are available in 24-port and 48-port models and designed for wire-speed, nonblocking performance in a compact 1U form factor. Available with Power over Ethernet Plus (PoE+) capabilities, these switches are designed to support next-generation campus convergence of video, voice, and data by providing a single-cable solution for devices such as Voice over IP (VoIP) phones, video surveillance cameras, and wireless access points. Additionally, multiple switches can be stacked and managed into a single logical switch to enable pay-as-you-grow expansion. The high-performance and reliability features also make the switch ideal for data center top-of-rack server and iSCSI storage connectivity.

The 24-port and 48-port models of y-series Ethernet switches are shown in Figure 14-1.

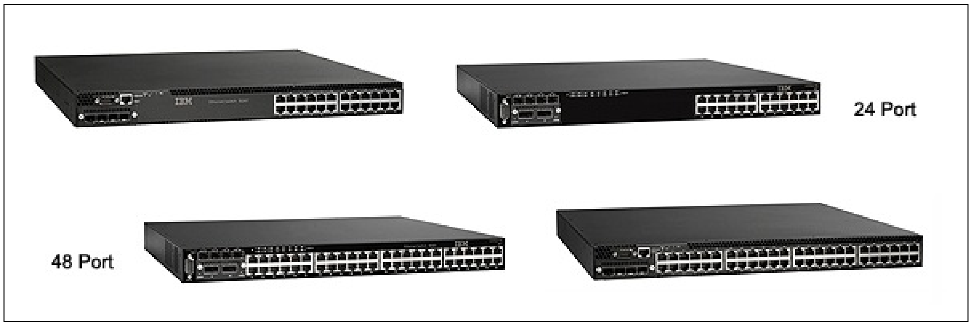


Figure 14-1 IBM y-series Ethernet switches

The y-series Ethernet Switches are available in these model configurations:

- IBM Ethernet Switch B24Y (4002BY2) - 24x 10/100/1000 MbE ports, including 4x 100/1000 MbE combination ports (SFP), 2x 10 GbE module (XFP), 2x 16 Gbps dedicated stacking ports
- IBM Ethernet Switch B48Y (4002BY4) - 48x 10/100/1000 MbE ports, including 4x 100/1000 MbE combination ports (SFP), 2x 10 GbE module (XFP), 2x 16 Gbps dedicated stacking ports
- IBM Ethernet Switch B24Y (4002CY2) - 24x 10/100/1000 MbE ports, 4x 10 GbE module (SFP+).

Key features

Here are the key features of the IBM y-series Ethernet Switches:

- A 1U, high-performance and flexible access switch with 24-port and 48-port models available
- Support next-generation 802.1n access points and pan/tilt video surveillance cameras by providing up to 30 watts of power to end devices through a single cable
- Enable pay-as-you-grow expansion with IronStack technology, allowing up to 8 switches (384 ports) to interoperate as a single logical switch
- Build resilient and loop-free networks with Full Layer 2 Ethernet switching with advanced protocols including Virtual Switch Redundancy Protocol (VSRP) and Metro Ring Protocol (MRP)
- Rich base feature set includes Full Layer 3 IP unicast and multicast routing including support for RIP, OSPF, VRRP-E, IGMP, and PIM
- Support rich media delivery with efficient use of bandwidth using multicast routing, allowing a single stream of video to be delivered to multiple desktops
- Hardware-based sFlow traffic monitoring capabilities, with comprehensive monitoring and security features provide real-time protection from network-based and host-based attacks
- Highly scalable to support large virtualized environments - up to 32k MAC addresses, 64k ARP entries, 16k IP routes
- Open standards management including an industry-standard CLI reduces training costs and increases operational efficiency
- Secure device access using SSHv2, SCP, SNMPv3, TACACS+, and RADIUS
- Automate configuration of end devices such as VoIP phones utilizing LLDP and LLDP-MED

- Comprehensive, policy-driven security enforcement with 802.1x support and a wide variety of Access Control Lists
- High-availability modular design with redundant hot-swappable power supplies

Reference: For additional information, see the following website:

http://www-03.ibm.com/systems/networking/hardware/ethernet/b-type/b48y/

14.1.2 IBM Converged Switch B32

As organizations evolve towards a dynamic infrastructure, they need new ways to reduce the complexity of their environments. To address this challenge, IBM offers a versatile switch that supports both Fibre Channel (FC) and Ethernet LAN data in one fabric using FCoE to help data centers simplify their growing infrastructures.

Overview

The IBM Converged Switch B32 (machine type 3758 model L32 as shown in Figure 14-2) is designed to provide outstanding performance with a reliable platform that helps reduce cabling complexity, equipment acquisition costs, and operational costs associated with space, power consumption and cooling. This multiprotocol top-of-rack switch features excellent space efficiency and low power consumption, leading the way toward a "greener" data center.

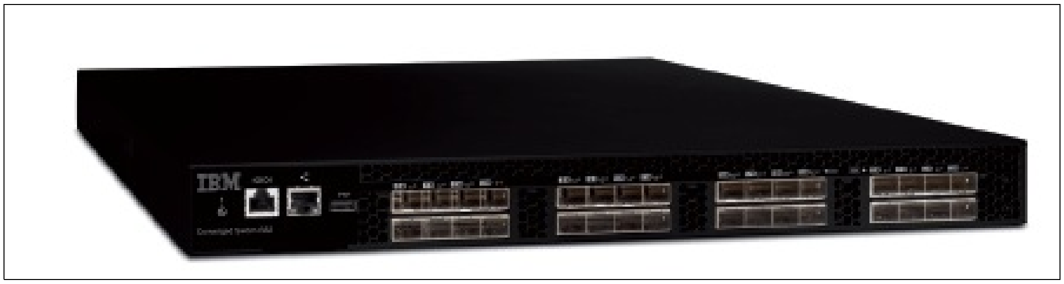


Figure 14-2 IBM Converged Switch B32

Key features

Here are the key features of the IBM Converged Switch B32:

- Designed for outstanding performance with eight Fibre Channel (FC) ports concurrently active at 8 Gbps and twenty-four CEE ports concurrently active at 10 Gbps link speeds
- High density design with 32 ports in a 1 U enclosure
- Exceptional "green" energy efficiency significantly reduces power consumption while generating less heat
- Enterprise-class availability features such as hot-swappable, redundant, and integrated fan and power supply assemblies
- Streamlines management by utilizing IBM System Storage Data Center Fabric Manager (DCFM) and extensions for FCoE and CCE
- CEE ports are capable of transporting both FC storage and Ethernet LAN traffic, eliminating the need for separate server SAN and LAN adapters and cables
- Advanced ASIC technology provides FC port trunking and Ethernet link aggregation
- Common Brocade Fabric OS supports the entire IBM System Storage SAN b-type family helps protect SAN infrastructure investments with backward compatibility

Models: IBM has withdrawn express model 3758-B32 (HVEC/XCC) without replacement. Model 3758-B32 (AAS) is replaced by model 3758-L32.

For more information about specification, model number, product number, and type, see the website:

http://www.ibm.com/systems/networking/hardware/ethernet/b-type/b32

14.1.3 IBM x-series Ethernet switches

In this section we describe the IBM Ethernet Switch B24X and its features.

Overview

The IBM Ethernet Switch B24X (Figure 14-3) is a compact, high-performance, highly-available, and high-density 10 Gigabit Ethernet (GbE) solution designed for mission critical data centers, large enterprises, and High-Performance Computing (HPC) requirements. With an ultra-low latency, cut-through, non-blocking architecture, full wire-speed throughput, this switch provides a cost-effective solution for server or compute-node connectivity.

Figure 14-3 IBM Ethernet Switch B24X

Key features

Here are the key features of the IBM Ethernet Switch B24X:

- 24x ports of dual-speed 10/1 GbE SFP+ ports plus 4x 10/100/1000 MbE RJ45 ports
- Capable of line speed, full-duplex throughput on all ports: 488 Gbps total switch capacity and ultra-low latency (1.5 micro-seconds)
- 1 + 1 redundant, hot-swappable and load-sharing 300 W AC Power Supplies for high availability
- Hot-swappable, resilient triple-fan assembly with automatic speed control for efficient front-to-back cooling: 2+1 redundant fans in assembly
- Variety of SFP+ transceivers available including 1 GbE and 10 GbE Short Reach and Long Reach and available low-power consuming (1.0 watts) SFP+ optics up to 300 meters
- Supports low-cost, low-latency (0.25 micro-seconds), low-energy-consuming (0.1) direct attached SFP+ copper (Twinax) cabling up to 5 meters
- A 1U, high-density top-of-rack data center switch for 10 GbE server access and aggregation with 24x 10 GbE/1 GbE dual-speed (SFP+) ports plus 4x 10/100/1000 MbE (RJ45) ports
- Flexibility to mix 10 GbE and 1 GbE servers, protecting investments and streamlining migration to 10 GbE-capable server farms

Models: IBM has withdrawn Ethernet Switch B24X (model 4002-X2A) from market. Partial replacement is available as IBM Ethernet Switch B24X Bundle (code 0563-012).

For more information about specification, model number, product number, and type, see the website:

http://www.ibm.com/systems/networking/hardware/ethernet/b-type/x-series

14.1.4 IBM r-series Ethernet Switches

The IBM r-series Ethernet Switches (Figure 14-4) are a modular switch series designed to provide improved service with industry leading levels of performance; reduced cost with a high density and energy efficient design; and a commonly used management interface that can utilize existing staff training and experience to help manage risk when integrating new technology.

Doing this allows network designers to standardize on a single product family for end-of-row, aggregation, and backbone switching, and is ideal for data center and enterprise deployment. In addition, the switches, with their high-density and compact design, are an ideal solution for High-Performance Computing (HPC) environments and Internet Exchanges and Internet Service Providers (IXPs and ISPs) where non-blocking, high-density Ethernet switches are needed.

Figure 14-4 IBM r Series Ethernet Switches

Models

IBM r-series Ethernet Switches (Figure 14-4) are available in four chassis models and allow network designers to standardize on a single product family for end-of-row, aggregation, and backbone switching. In addition to their data center and enterprise role, the switches, with their high-density and compact design, are an ideal solution for High-Performance Computing (HPC) environments and Internet Exchanges and Internet Service Providers (IXPs and ISPs) where non-blocking, high-density Ethernet switches are needed.

The r-series Ethernet Switches are available in the following model configurations:

- IBM Ethernet/IP Router B04R (4003-R04) - 4-slot switching router, 400 Gbps data capacity, and up to 64 10GbE and 128 1GbE ports per system
- IBM Ethernet/IP Router B08R (4003-R08) - 8-slot switching router, 800 Gbps data capacity, and up to 128 10GbE and 384 1GbE ports per system
- IBM Ethernet/IP Router B16R (4003-R16) - 16-slot switching router, 1.6 Tbps data capacity, and up to 256 10GbE and 768 1GbE ports per system

Key features

Here are the key features of the IBM r-series Ethernet Switches:

- 4, 8, and 16-slot high-capacity modular switches for end-of-row, aggregation, and core switching in data centers, large enterprises, HPC, IXP, and ISP networks
- Powerful suite of unicast and multicast IPv4 and IPv6 protocol support
- Interchangeable half-height line modules reduce sparing costs, TCO, and provide cost-effective modular growth
- Highly-dense chassis design supports up to 256 10 GbE or 768 wire-speed 1 GbE ports in a single 16-slot chassis
- Highly-available design features redundant and hot-pluggable hardware, hitless Layer 2 software upgrades, and graceful BGP and OSPF restart
- Advanced non-blocking Close fabric features adaptive self-routing with graceful system degradation in the event of two or more module failures
- End to End QoS supported with hardware based honoring and marking and congestion management
- Scalable hardware-based IP routing to 512,000 IPv4 routes per line module.
- Highly available chassis design supports hot-swappable 1:1 management module redundancy, N+1 switch fabric module redundancy, M+N power module redundancy, and N+1 fan redundancy
- Interface modules include 16-port 10 GbE (SFP+), 2-port and 4-port 10 GbE (XFP), 24-port 1 GbE (RJ45 and SFP), and 48-port 1 GbE (MRJ21) modules

> **Reference:** For more information about specification, model number, product number, and type, see the website:
>
> `http://www.ibm.com/systems/networking/hardware/ethernet/b-type/r-series`

14.1.5 IBM c-series Ethernet Switches

IBM c-series Ethernet Switches (Figure 14-5) are powerful enablers of advanced converged enterprise backbones. Featuring state-of-the-art Quality of Service and wire-speed unicast/multicast routing, they enable the efficient rollout of converged backbones, providing reliable transport of Voice over IP (VoIP), video services, and mission critical data. The platform's low latency, high-touch processing and deep buffering makes it an ideal fit for Data Center top-of-the-rack server access switch.

Overview

Whether deployed from a central or remote location, availability of space often determines the feasibility of deploying new equipment and services within any environment. To meet these challenges, IBM c-series Ethernet Switches are purpose-built to offer flexible, resilient, secure and advanced services in a compact form factor.

IBM c-series Ethernet Switches are compact 1 RU, multi-service edge/aggregation switches with a powerful set of capabilities that combine performance with rich functionality at the network edge. These switches offer network planners a broad set of high-performance IPv4 Full Layer 2 and Base Layer 3 functionality with flexible software upgrade options in the same device.

Figure 14-5 IBM C Series Ethernet Switches

The c-series Ethernet Switches are available in these model configurations:

- IBM Ethernet Switch B24C (4002AC2) - 24 x 10/100/1000 MbE RJ-45 ports including 4 x 100/1000 MbE SFP combination ports with optional 2-port 10 GbE XFP upgrade slot
- IBM Ethernet Switch B24C (4002BC2) - 24x 100/1000 MbE SFP ports including 4 x 10/100/1000 MbE RJ-45 combination ports with optional 2-port 10 GbE XFP upgrade slot
- IBM Ethernet Switch B48C (4002-C4A; 4002AC4) - 48 x 10/100/1000 Mbps Ethernet RJ45 ports including 4 x 100/1000 MbE combination SFP ports
- IBM Ethernet Switch B48C (4002-C4B;4002BC4) - 48 x 100/1000 Mbps Ethernet hybrid fiber SFP ports
- IBM Ethernet Switch B50C (4002-C5A;4002AC5) - 48 x 10/100/1000 Mbps Ethernet RJ45 ports and 2 x 10 Gbps Ethernet XFP uplink ports
- IBM Ethernet Switch B50C (4002-C5B; 4002BC5) - 48 x 100/1000 Mbps Ethernet hybrid fiber SFP ports and 2 x 10 Gbps Ethernet XFP uplink ports

Key features

Here are the key features of the IBM c-series Ethernet Switches:

- Flexible model configurations include 24x ports of 1 GbE or 48x ports of 1 GbE with SFP and RJ-45 options and 2x 10 GbE XFP uplinks available
- The systems offers wire-speed, non-blocking performance in all configurations
- Hot-swappable, resilient, six-fan, fan tray with sensors to automatically regulate speed
- Comprehensive hardware-based security and policies including hardware-based Layer 3 and Layer 2 ACLs (both inbound and outbound) with logging
- 64 MB of deep buffering for each 24-port 1 GbE group or 2-port 10 GbE group (64 MB to 192 MB total) excels at handling transient bursts in traffic.
- Advanced Carrier-Grade Ethernet services include platform capable of MPLS (VPLS, VLL), Multi-VRF, MPLS VPNs, along with Provider Bridges, Provider Backbone Bridges
- Comprehensive IPv4 unicast and multicast routing support based on the rich feature set of Brocade Multi-Service IronWare

- Full Layer 2 switching capabilities facilitate network resiliency include STP/RSTP/MSTP, PVST/PVST+ compatibility, Metro Ring Protocol (MRP), IEEE 802.3ad Link Aggregation (LACP), Virtual Switch Redundancy Protocol (VSRP), and jumbo frames.

> **Reference:** For more information about specification, model number, product number, and type, see the website:
>
> `http://www.ibm.com/systems/networking/hardware/ethernet/b-type/c-series`

14.1.6 IBM g-series Ethernet Switches

IBM g-series Ethernet access switches (Figure 14-6) provide enterprise organizations with a flexible and feature-rich solution for building a secure and converged network edge. The switches support 48 x 1 GbE RJ45 ports including 4x 1 GbE SFP combination ports. The B48G is upgradeable with two 10 GbE uplink ports to consolidate connections into the enterprise aggregation point, campus LANs, or metro area networks. The B50G comes with 2x 10 GbE CX4 stacking ports, providing the flexibility of a “pay-as-you-grow” architecture (Figure 14-6).

Figure 14-6 IBM g series Ethernet Switch

Both models enable a converged solution for vital network applications such as VoIP, wireless access, WebTV, video surveillance, building management systems, triple play (voice + video + data) services and remote video kiosks in a cost-effective, high-performance compact design.

Configurations

The g-series Ethernet Switches are available in these model configurations:

- IBM Ethernet Switch B48G (4002-G4A;4002-AG4): 48-port 10/100/1000 with 4-port combo ports that support 10/100/1000 or 100/1000 SFP connections and one redundant, removable power supply; field upgradeable to include a 2-port 10GbE module for either XFP or CX4 connectivity and another redundant removable power supply; PoE upgradeable
- IBM Ethernet Switch B50G (4002-G5A;4002-AG5): The same connectivity, availability and PoE features as B48G plus advanced IronStack stacking technology over 2 x 10 GbE CX4 ports.

Key features

Here are the key features of the g-series Ethernet Switches:

- Compact 48-port 10/100/1000 Mbps access switch models; field upgradeable with Power over Ethernet (PoE), 10 Gigabit Ethernet, and IronStack stacking for scalable and secure network access
- Hot-swappable, load-sharing AC and DC power supply options

- Industry leading IEEE 802.3af PoE Class 3 port capacity in a compact form factor delivers a scalable and cost-effective solution for unified communications at the network edge
- Advanced IronWare Layer 2 Ethernet switching with robust suite of security capabilities including ACLs, MAC filters, TCP SYN and ICMP denial of service (DoS) protection, Spanning Tree BPDU Guard, Root Guard, unicast, broadcast and multicast rate limiting, 802.1X authentication, and enhanced lawful intercept features
- Base Layer 3 capabilities enable routed topologies to the network edge; supported features include: RIP v1/v2 route announcement, static routes, virtual and routed interfaces, DHCP relay, and VRRP (Virtual Router Redundancy Protocol)
- Open and standards-based network access control features multi-host 802.1x access control, multi-device MAC authentication, and policy controlled MAC-based VLANs
- Low packet latency and advanced Quality of Service (QoS) with eight hardware-based priority queues and combined strict priority and weighted round robin scheduling ensure dependable and high-quality network convergence
- Embedded hardware-based sFlow packet sampling enables network wide traffic monitoring for traffic accounting, intrusion detection, 802.1x identity monitoring, link utilization, and fault isolation
- IronShield 360 intrusion protection delivers dynamic, real-time protection from network and host-based attacks
- Brocade’s IronStack stacking technology provides cost-effective expansion at network edge with operational simplicity of a single switch
- IronStack supports up to eight B50G units in a logical chassis scaling to 384 PoE ports, and it features automatic failover in event of link fault or active controller failure and hot insertion and cross-unit trunking for increased resilience

Reference: For more information about specification, model number, product number, and type, see the website:

`http://www.ibm.com/systems/networking/hardware/ethernet/b-type/g-series`

14.1.7 IBM m-series Ethernet/IP Routers

High performance multi-service IP/MPLS routers (Figure 14-7) help virtualize data center core routing and are available in four high density chassis. Featuring state-of-the-art QoS and wire-speed unicast/multicast routing for IPv4, IPv6, and MPLS services, they enable the efficient rollout of converged backbones, providing reliable transport of Voice over IP (VoIP), video services, and mission-critical data.

Figure 14-7 IBM m Series Ethernet/IP Routers

Overview

IBM m-series Ethernet/IP Routers are designed to enable reliable converged infrastructures and support mission-critical applications. The m-series features an advanced N+1 redundant switch fabric architecture designed for very high availability, even in the case of a switch fabric card failure. The redundant fabric architecture is complemented by comprehensive hardware redundancy for the management modules, power supplies, and cooling system.

With their superior 1 GbE and 10 GbE port densities, m-series switching routers are well suited for large-scale high performance cluster computing. By combining superior data capacity with ultra-low latency, m-series switching routers can accelerate application performance in high performance computing clusters, thereby increasing processing power and productivity.

The m-series Ethernet routers are available in the following model configurations:

- IBM Ethernet/IP Router B04M (4003-M04) - 4-slot switching router, 400 Gbps data capacity, and up to 16 10GbE and 128 1GbE ports per system
- IBM Ethernet/IP Router B08M (4003-M08) - 8-slot switching router, 800 Gbps data capacity, and up to 32 10GbE and 384 1GbE ports per system
- IBM Ethernet/IP Router B16M (4003-M16) - 16-slot switching router, 1.6 Tbps data capacity, and up to 64 10GbE and 768 1GbE ports per system
- IBM Ethernet/IP Router B32M (4003-M32) - 32-slot switching router, 3.2 Tbps data capacity, and up to 128 10GbE and 1,536 1GbE ports per system.

Key features

Here are the key features of the IBM m-series Ethernet/IP Routers:

- 4, 8, 16, and 32-slot high-capacity modular routers ideal for a wide range of advanced applications in the high-security data center core, Internet edge/aggregation routing, large-enterprise backbone, high-performance computing (HPC), and Metropolitan Area Networks (MAN)
- Wire-speed IPv4, IPv6, and MPLS routing featuring full Forwarding Information Base (FIB) programming in hardware
- High-performance, wire-speed, non-oversubscribed port density featuring up to 128 10 GbE, 1,536 1 GbE, 256 OC-12/48, or 64 OC-192 ports in a single 32-slot chassis
- Fully distributed, non-blocking architecture with up to 3.2 Tbps data capacity (~2 billion pps) per system
- Exceptional 320 Gbps cross-module link aggregation supports up to 32 10 GbE or OC-192 links enabling high-bandwidth inter-switch trunking in the backbone.
- Scalable hardware-based IP routing to 512,000 IPv4 and 112,000 IPv6 routes in hardware, 2 million IPv4 BGP routes and up to 256 BGP peers H
- Highly available chassis design supports hot-swappable 1:1 management module redundancy, N+1 switch fabric module redundancy, M+N power module redundancy, and N+1 fan redundancy.
- Interface modules include 4-, 2-port 10 GbE (XFP), 48-port 1 GbE (MRJ21), 20-port 1 GbE (RJ-45 and SFP), 2-port OC-192 PoS/SDH (XFP), and 8-, 4-, 2-port OC-12/48 PoS/SDH (SFP) modules.

> **Reference:** For more information about specification, model number, product number, and type, see the website:
>
> http://www.ibm.com/systems/networking/hardware/ethernet/b-type/m-series

14.1.8 IBM s-series Ethernet Switch

IBM s-series Ethernet Switches are designed to extend control from the network edge to the backbone. The switches provide intelligent network services, including superior Quality of Service (QoS), predictable performance, advanced security, comprehensive management and integrated resiliency.

Overview

A common operating system and shared interface and power supply modules between the Ethernet Switch B08S and B16S help reduce the cost of ownership by minimizing operational expenses and improving return on investment (ROI). A highly dense, resilient, and flexible architecture allows scaling up to 384 10/100/1000 Mbps Class 3 (15.4 watts) PoE capable ports or 36 ports of high-speed 10 GbE.

IBM s-series Ethernet Switches (Figure 14-8) have an extensive feature set, making them well suited for real-time collaborative applications, IP telephony, IP video, e-learning and wireless LANs to raise an organization’s productivity. With wire-speed performance and ultra low latency, these systems are ideal for converged network applications such as VoIP and video conferencing. Providing one of the industry’s most scalable and resilient PoE designs, the 1 GbE PoE capable ports support the IEEE 802.1AB LLDP and ANSI TIA1057 LLDP-MED standards, enabling organizations to build advanced multi-vendor networks.

LLDP enables discovery of accurate physical network topologies, including those that have multiple VLANs where all subnets might not be known. LLDP-MED advertises media and IP telephony specific messages, providing exceptional interoperability, IP telephony troubleshooting, and automatic deployment of policies, advanced PoE power negotiation, and location/emergency call service. These features make converged network services easier to install, manage, and upgrade, significantly reducing operational costs.

Figure 14-8 IBM s Series Ethernet Switches

The s-series Ethernet Switches are available in the following model configurations:

- IBM Ethernet Switch B08S (4003-S08): Switch with redundant management and switch fabric modules for enhanced system resilience; 464 Gbps data switching capacity, PoE over tri-speed 10/100/1000 Mbps interfaces
- IBM Ethernet Switch B16S (4003-S16): Switch with redundant management and switch fabric modules for enlaced system resilience; 848 Gbps data switching capacity, up to 384 Class 3 PoE ports with N+1 power redundancy making it the most powerful PoE solution in the industry, PoE over tri-speed 10/100/1000 Mbps interfaces

Key features

Here are the key features of the IBM s Series Ethernet Switch:

- Advanced chassis-based convergence solution provides a scalable, secure, low-latency and fault-tolerant infrastructure for cost-effective deployment of Voice over IP (VoIP), wireless, and high-capacity data services throughout the enterprise
- 8- and 16-slot systems for maximum deployment versatility. Highly available 1+1 management, fabric, and N+1 power redundant architecture enables resilient and fault-tolerant network infrastructures
- The B16S can scale to 384 IEEE 802.3af Class 3 PoE 10/100/1000 Mbps ports, each capable of delivering 15.4 watts to provide customers with a convergence-ready infrastructure that will scale to support future growth
- Robust PoE auto-detection with IEEE 802.1AB LLDP and LLDP-MED enables support for PoE and non-PoE devices along with auto-configuration of VoIP endpoints, simplifying device deployment
- Resilient Advanced Layer 2 protocol support including Protected Link Groups, IEEE 802.3ad Link Aggregation (LACP), UDLD, Virtual Switch Redundancy Protocol (VSRP), Metro Ring Protocol (MRP), and STP/RSTP/MSTP to build a highly tolerant network infrastructure

- Advanced Layer 2 unicast and multicast support including IGMP and PIM snooping to improve bandwidth utilization, with flexibility to upgrade to Full Layer 3 and IGMPv1/v2/v3, IGMP Proxy, and PIM-SM/-SSM/-DM multicast routing optimizes network traffic
- Flexible options to upgrade the software to Full IPv4 Layer 3, including support for IP routing protocols such as RIPv1/v2, OSPFv2, BGP-4, and support for multicast routing, and Full IPv4+IPv6 Layer 3, adding support for RIPng, OSPFv3, 6-to-4 static tunnels, and IPv6 ACLs
- Future-proof with available IPv6 management and interface modules that can integrate today with existing IPv4 switches within and across the network.

> **Reference:** For more information about specification, model number, product number, and type, see the website:
>
> http://www.ibm.com/systems/networking/hardware/ethernet/b-type/s-series

14.2 IBM j-type Ethernet products

IBM j-type Ethernet switches, routers, and appliances are designed to deliver the performance, scalability and high availability required for today's high-density data center and cloud computing environments.

The IBM j-type family includes following products:

- IBM Ethernet Switch J08E/J16E
- IBM Ethernet Switch J48E
- IBM Ethernet Router J02M/J06M/J011M
- IBM Ethernet Appliance J34S/J36S
- IBM Ethernet Appliance J56S/J58S

All IBM j-type Ethernet products use Junos Software, an advanced network operating system that powers some of the world's largest and most complex networks.

Junos Software is the field-proven operating system powering IBM j-type products within the data center. It enables the consolidation of switching and routing onto a common operating system, with feature consistency and interoperability across the entire data center network. Manageability and flexibility of the data center are enhanced to address business needs as they arise and improve data center operations. A common set of tools allows administrators to monitor, administer, and troubleshoot the network, allowing data center operations teams to function more efficiently with less training while providing higher availability for users. Unlike any other networking infrastructure OS on the market, Junos provides one operating system, enhanced through a single release train, and developed upon a common modular architecture, thus giving enterprises a “1-1-1” advantage:

- One Operating System
- One Software Release
- One Modular Software Architecture

Figure 14-9 shows that Junos Software runs on the entire IBM j-type infrastructure.

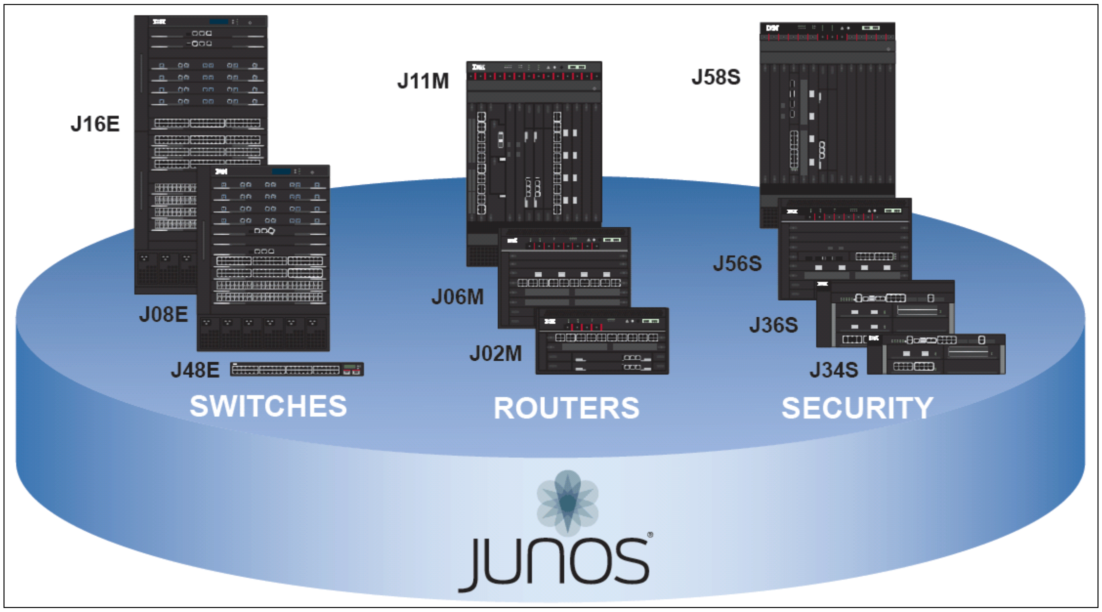


Figure 14-9 Junos Software runs on all IBM j-type systems

IBM provides high-performance network devices that create a responsive and trusted environment for accelerating the deployment of services and applications over a single network. Junos Software is the foundation of these high-performance networks.

In this section we present an overview of the switches, routers and security appliances represented in Figure 14-9. For detailed information about those products and on Junos Operating System, see the following publications:

- *IBM j-type Data Center Networking Introduction*, SG24-7820
- *IBM j-type Ethernet Switches and Routers Implementation*, SG24-7882
- *IBM j-type Ethernet Appliance Implementation*, SG24-7883

The following website also contains information about j-type networking products:

http://www.ibm.com/systems/networking/hardware/j-type

14.2.1 IBM Ethernet Switch J08E and IBM Ethernet Switch J16E

The IBM Ethernet Switch J08E (Figure 14-10) and IBM Ethernet Switch J16E are designed to deliver the performance, scalability, and high availability required for today's high-density data center and cloud computing environments. Supporting a variety of GbE and 10 GbE line cards and featuring a built-in migration path to 100 GbE deployments, the J08E and J16E provide the highly scalable solution required by today's high-performance data centers and are positioned to support even more demanding network environments in the future.

The high-density, high-performance J08E and J16E are also used for aggregating access switches deployed in data center top-of-rack or end-of-row applications, as well as for supporting Gigabit Ethernet server access in data center end-of-row deployments. The J08E delivers up to 960 million packets per second (Mpps) of high-density, wire-speed 10 GbE performance, while the J16E delivers approximately 1.9 billion packets per second (Bpps) of 10 GbE performance. Both systems are designed to provide sufficient capacity to support the most demanding data center networks.

Figure 14-10 IBM j-type J08E and J16E Ethernet Switches

The IBM Ethernet Switch J08E and the IBM Ethernet Switch J16E are high-density, high-performance, and highly available modular switches intended for the most demanding datacenter core environments.

The IBM Ethernet Switch J08E and IBM Ethernet Switch J16E are designed to deliver the performance, scalability and high availability required to support high-density datacenter, cloud computing and enterprise campus environments. The high-density, high-performance J08E and J16E are also used for aggregating access switches deployed in a datacenter top-of-rack or end-of-row applications, as well as for supporting Gigabit Ethernet server access in datacenter end-of-row deployments. The J08E delivers up to 960 million packets per second (Mpps) of high-density, wire-speed 10GbE performance, while the J16E delivers approximately 1.9 billion packets per second (Bpps) of 10GbE performance. Both systems are designed to provide sufficient capacity to support the most demanding datacenter networks.

To maximize investments, the J08E and J16E utilize common wire-speed line cards and power supplies, ensuring consistent performance across the entire product family. Both switches also run the same Juniper Networks Junos Software operating system, which helps to reduce capital and operational expenses across the datacenter infrastructure.

Key features

Here are the key features of the IBM Ethernet Switch J08E and IBM Ethernet Switch J16E:

- High-performance 8-slot (J08E) and 16-slot (J16E) switches support data center as well as campus LAN core and aggregation layer deployments
- Scalable switch fabric delivers up to 320 Gbps per slot
- 48-port 10/100/1000BASE-T and 100BASE-FX/1000BASE-X line cards support up to 384 (J08E) or 768 (J16E) GbE ports per chassis
- Eight-port 10GBASE-X line cards with SFP+ interfaces deliver up to 64 (J08E) or 128 (J16E) 10 GbE ports per chassis
- Carrier-class architecture includes redundant internal Routing Engines, switch fabrics, power and cooling, ensuring uninterrupted forwarding and maximum availability

- All IBM j-type switches and routers run the modular, fault-tolerant Juniper Networks JUNOS Software operating system.
- Fourteen (J08E) rack-unit (RU) and 21 (J16E) RU chassis Eight (J08E) and sixteen (J16E) dedicated I/O slots
- 6.2 (J08E) and 12.4 (J16E) Tbps backplane capacity
- 320 Gbps (full duplex) per slot fabric capacity
- Full 10 GbE line-rate forwarding (even under failure conditions)
- Dedicated data, control and management planes
- LCD panel for system monitoring Energy efficient: 200,000 packets per second per watt

Fully configured, a single J08E can support up to 384 GbE or 64 10 GbE ports at wire speed for all packet sizes. The J16E can support twice that number: 768 GbE or 128 10 GbE wire-speed ports for all packet sizes. Up to three 14 rack-unit (RU) J08Es or two 21 RU J16Es can fit in a standard 42RU wiring rack, enabling up to 1,536 line-rate GbE or 256 line-rate 10 GbE ports in a single rack, delivering one of the highest port densities in the industry.

J08E description

The IBM Ethernet Switch J08E, which features a passive backplane design that supports a capacity of up to 6.2 terabits per second (Tbps), is a high-performance, high-density platform that reduces cost and complexity while improving overall scalability and providing carrier-class reliability in the datacenter.

The J08E base configuration includes a side-mounted hot-swappable fan tray with variable-speed fans, one Switch Fabric and Routing Engine (SRE) module, one dedicated Switch Fabric module, and two 2000 watt internal power supplies. An optional second SRE module for hot-standby resiliency and up to six power supplies can provide component redundancy.

The J08E SRE module performs two functions: It incorporates switch fabric, control plane and management plane functionality on a single module, and it includes an integrated Routing Engine featuring a 1.2GHz processor with 2 gigabytes of DRAM and 2 gigabytes of Flash storage. The Routing Engine on the SRE module includes a central CPU that performs all system control functions and maintains the hardware forwarding table and routing protocol states for the switch.

J16E description

The IBM Ethernet Switch J16E, which delivers a backplane capacity of up to 12.4 Tbps, is designed for core datacenter deployments as well as demanding cloud computing and Internet exchange environments.

The base J16E configuration includes two side-mounted hot-swappable fan trays with variable-speed fans, one Routing Engine module, eight dedicated Switch Fabric modules, and two 3,000 watt power supplies. Redundant configurations include an optional second Routing Engine module to provide hot-standby resiliency and up to six power supplies.

The J16E Routing Engine module supports control and management plane functionality with an integrated routing engine featuring a 1.2GHz processor with 2 gigabytes of DRAM and 2 gigabytes-bytes of Flash storage. As on the J08E,the J16E's routing engine includes a CPU that performs all system control functions and maintains the hardware forwarding table and routing protocol states for the switch.

The switch fabric for the J16E is spread across eight rear-accessible Switch Fabric modules. All eight Switch Fabric modules are always active, enabling the switch to support line-rate Layer 2 and Layer 3 switching on all ports for packets of any size.

Line cards

The J08E and J16E can accommodate various combinations of the following Ethernet line card options:

- Exx 48 Port 1GbE RJ-45 Line Card, that offers the following features:
  - 48 RJ-45 10/100/1000BASE-T interfaces
  - Line-rate for any packet size or type (64-9216 bytes)
  - 48 Gbps, 71 million packets per second
  - 10 to 25 µs port-to-port latency depending on packet size
  - Eight queues, 42MB buffer per port
- Exx 48 Port 100FX/1000B-X Line Card, that offers the following features:
  - 48 SFP 100/1000BASE-X interfaces
  - Line-rate for any packet size or type (64-9216 bytes)
  - 48 Gbps, 71 million packets per second
  - 10 to 25 µs port-to-port latency depending on packet size
  - Eight queues, 42MB buffer per port
- Exx 8 Port 10GbE Line Card, that offers the following features:
  - Eight SFP+ 10GbE interfaces
  - Line-rate for any packet size or type (64-9216 bytes)
  - 80 Gbps, 119 million packets per second
  - 8 to 15 µs port-to-port latency depending on packet size
  - Eight queues, 512MB buffer per port

Reference: For more information about specification, model number, product number, and type, see the website:

http://www.ibm.com/systems/networking/hardware/j-type/j08e

14.2.2 IBM Ethernet Switch J48E

The IBM Ethernet Switch J48E (Figure 14-11) is a high-performance, scalable Ethernet switch for datacenter top-of-rack and end-of-row deployments. It delivers high availability, high performance, and a single point of management in a compact, power-efficient one rack-unit (1RU) form factor system.

Overview

The IBM Ethernet Switch J48E is designed to combine the high availability and carrier-class reliability of modular systems with the economics and flexibility of stackable platforms, thereby providing a high-performance, scalable solution for datacenter top-of-rack and end-of-row applications.Offering a full suite of Layer 2 and Layer 3 switching capabilities as part of the base software, the IBM Ethernet Switch J48E can also satisfy a variety of high-performance branch and campus deployments.

A single 48-port switch can be deployed initially; then as requirements grow, integrated "Virtual Chassis" technology allows up to 10 switches to be interconnected over a 128 gigabit-per-second (Gbps) back-plane and be managed as a single device. This capability delivers a scalable, pay-as-you-grow solution for supporting escalating customer requirements. Optional Gigabit Ethernet (GbE) and 10-Gigabit Ethernet (10 GbE) uplink modules enable high-speed connectivity to aggregation or core-layer switches.

The IBM Ethernet Switch J48E includes features designed for high availability, such as redundant, hot-swappable internal power supplies and field-replaceable, multi-blower fan trays to maximize uptime. In addition, the switch offers Class 3 Power over Ethernet (PoE), delivering 15.4 watts on the first eight ports to support net-worked devices such as top-of-rack security cameras and wireless LAN (WLAN) access points for low-density converged networks.

Figure 14-11 IBM j-type J48E Ethernet Switch

Key features

Here are the key features of the IBM Ethernet Switch J48E:

- Full Layer 2 and Layer 3 Ethernet switching Virtual Chassis technology enables up to 10 switches to be interconnected as a single logical device supporting up to 480 ports in data center top-of-rack or end-of-row applications
- Interconnected switches in a Virtual Chassis configuration share a single control plane and operating system, and automatically assign master (active) and backup (hot-standby) Routing Engines
- Integrated application-specific integrated circuit (ASIC)-based Packet Forwarding Engine and integrated Routing Engine (RE) deliver switching and routing functionality at wire rates
- Front-panel LCD display offers flexible interface for performing device bring-up and configuration rollbacks, reporting switch alarm and LED status, or restoring the switch to its default settings
- Eight ports of IEEE 802.3af-compatible Class 3 Power over Ethernet (PoE)
- Single rack unit-height device (1RU) 48 10/100/1000BASE-T front-panel ports
- Optional GbE or 10 GbE front-panel uplink modules for connecting to other switches or upstream devices
- Scalable to 480 server access ports with up to 20 10 GbE uplinks to the core
- Back-panel Virtual Chassis ports interconnect up to 10 switches over 128 Gbps backplane
- Redundant, internal hot-swappable power supplies
- Hot-swappable fan tray with redundant blowers
- Dual Routing Engines with graceful Routing Engine switchover (GRES)
- Single management interface.

Reference: For more information about specification, model number, product number, and type, see: `http://www.ibm.com/systems/networking/hardware/j-type/j48e`

14.2.3 IBM Ethernet Router J02M/J06M/J11M

IBM j-type m-series Ethernet Routers with powerful switching and security capabilities are designed to deliver the reliability and flexibility needed, to accelerate new business innovations. These routers offer innovations with Advanced Routing features, a single Junos Software operating system across all members of the j-type family, and high performance Application-Specific Integrated Circuits (ASICs).

Optimized for Ethernet, these routers can be used to bring high performance, scalability, and availability to datacenter Aggregation & Core deployments, as well as WAN Edges.

IBM Ethernet Routers J02M, J06M and J11M (Figure 14-12) deliver high-port density as well as performance of up to 960 Gbps throughput, scalability, and reliability in a space-efficient package. The routers offer fully redundant hardware that includes a redundant Switch Control Board (SCB) and Routing Engines (REs) plus fan trays and power supplies designed to increase system availability.

All three j-type m-series routers are designed to address high performance networking requirements that benefit from Advanced Routing features such as network virtualization with MPLS, QoS, logical interface scalability, High Availability (HA), and low-latency Multicast.

Figure 14-12 IBM j-type J02M/J06M/J11M Ethernet Routers

Key features

Here are the key features of the IBM Ethernet Router J02M/J06M/J11M:

- High performance Ethernet L2/L2VPN/L3/L3VPN router, designed to deliver advanced routing features, including network virtualization with MPLS, low-latency Multicast, and Quality of Service, without compromising performance
- Redundant hardware and high availability features designed to ensure that the network is always up and running, with the following components:
  - Redundant hardware: cooling, power supplies, Routing Engines, and Switch Control Boards
  - Modular operating system
  - Separate data and control planes
  - Graceful restart
  - Non-stop routing
  - MPLS FRR
  - VPLS multi-homing
- Excellent performance to ensure that services and customers stay connected:
  - Powered by custom-designed application-specific integrated circuits (ASICs)
  - Enhanced QoS capabilities
  - Additional packet processing flexibility
  - Scaling enhancements including route lookup, next hop, IFL scaling, and interface accounting
  - Additional control storage capacity to provide headroom for future JUNOS Software operating system features
  - Enhanced multicast
- Operational efficiencies and simplicity delivered through JUNOS Software operating system
- Each chassis scales in size with choices of 2, 6 or 11 slots that can be populated with line cards for access or network interfaces
- Flexible port densities and WAN interfaces (Dense Port-Count Line Cards)
- Simultaneous support for Layer 2 and Layer 3 Ethernet services
- Can be deployed in two-tier collapsed architectures, which can yield operational savings through reduced power, cooling and space requirements.
- 2, 6 and 11-slot systems with full duplex throughput per slot provide versatile port densities and WAN interfaces
- Each chassis scales in size and can be populated with line cards for access or network interfaces
- Ideal fit for high-density deployments including the data center, campus and WAN gateways
- Flexible Architecture with IPv6,I PV4,industry leading IP/MPLS and VPLS
- Powered by the I-chip ASIC, the Ethernet Router family includes features such as enhanced QoS capabilities and scaling enhancements and advanced packet processing performance. Each slot provides line-rate 40 1-Gbps packet forwarding.

Virtualization in IBM j-type m-series Ethernet routers

There are numerous benefits for implementing virtualization in the data center. Virtualization is used to improve asset utilization, scalability, privacy, resiliency, and more. IBM j-type m-series Ethernet routers provide a myriad of virtualization features and technologies, as shown in Figure 14-13.

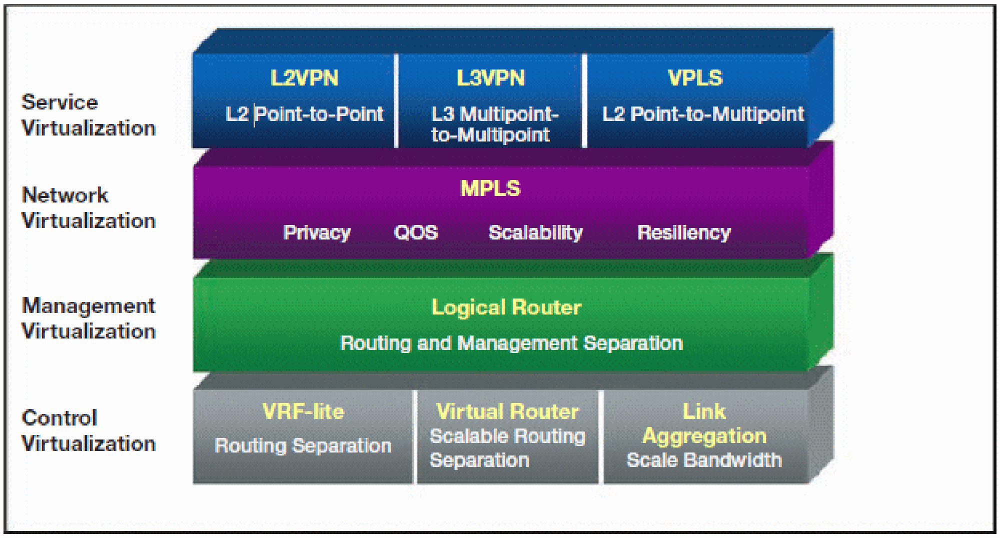


Figure 14-13 IBM j-type m-series Datacenter Virtualization Features and Usage

To address enterprise datacenter requirements for network, management, control, or service virtualization. These features can be used individually or in combination to complement one another. It is not sufficient that there is a myriad of features, but it is also equally important that these features are implemented consistently in one operating system, across the IBM j-type routing platforms, on top of advanced ASICs, enabling a collapsed two-tier data center architecture.

Reference: For more information about specification, model number, product number, and type, see the website:

http://www.ibm.com/systems/networking/hardware/j-type/m-series

14.2.4 IBM Ethernet Appliance J34S/J36S

The IBM Ethernet Appliance J34S and J36S systems are high-performance, scalable security systems for your datacenter's network infrastructure.

The IBM Ethernet Appliance J34S and J36S are based on an innovative Dynamic Services Architecture, that resets the bar in price and performance for enterprise environments. Each multi-services appliance can support near-linear scalability with each additional Services Processing Card (SPC), enabling the J36S to support up to 30Gbps of firewall throughput, 2.25million concurrent sessions and 175,000 new VPN connections per second. The appliances offer denial of service (DoS), Network Address Translation (NAT), Virtual Private Network (VPN) support and quality of Service (QoS). The SPCs are designed to support a wide range of services, enabling future support of new capabilities without the need for service-specific hardware. Using SPCs on all services ensures that there are no idle resources based on specific services in operation—maximizing hard-ware utilization.

Market-leading flexibility and price/performance of the IBM Ethernet Appliance J34S and J36S come from the modular architecture. The IBM J34S and IBM J36S are next-generation multi services appliances delivering leading scalability and service integration in a midsize form factor. These appliances are suited for medium to large enterprise networks:

- Campus and Enterprise server farms and data centers
- Aggregation of departmental or segmented security devices
- Securing managed services and core networking infrastructure

The IBM J34S and IBM J36S appliances can be equipped with a flexible number of I/O cards (IOCs), network processing cards (NPCs) and service processing cards (SPCs). This allows the system to be configured to support the ideal balance of performance and port density so you can tailor each deployment of the IBM Ethernet Appliance J34S and the IBM Ethernet Appliance J36S to specific network requirements. With this flexibility, the J36S can be configured to support more than 100 Gbps interfaces with choices of Gigabit Ethernet or 10-Gigabit Ethernet ports; firewall performance from 10 to 30 Gbps; and services processing to match specific business needs.

The switch fabric employed in the IBM J34S and the IBM J36S Ethernet Appliances enables the scalability of SPCs, NPCs and IOCs. Supporting up to 320 Gbps of data transfer, the fabric enables maximum processing and I/O capability available in any particular configuration. This level of scalability and flexibility enables uninterrupted expansion and growth of the network infrastructure, without the security solution being a barrier. The flexibility of the IBM Ethernet Appliance J34S and IBM Ethernet Appliance J36S extends beyond the innovation and proven benefit of the dynamic services architecture. Enabling the installation of SPCs on both the front and the back of the J34S and J36S, the mid-plane design enables market leading flexibility and scalability. By doubling the number of SPCs supported in half the rack space needed, the J34S and J36S offer not only the underlying architectural innovation but also innovative physical design.

The feature integration on the IBM Ethernet Appliance J34S and IBM Ethernet Appliance J36S is enabled by the Junos operating system. The J34S and J36S are equipped with a robust list of features that include firewall, Internet Protocol Security (IPsec) VPN, Denial of Service (DoS), Network Address Translation (NAT), and quality of service (QoS). In addition, incorporating the various features under a single OS greatly optimizes the flow of traffic through the multi services appliance. With Junos OS, the IBM Ethernet Appliance J34S and IBM Ethernet Appliance J36S enjoy the benefit of a single source OS, single release train, and one architecture that is also available across IBM j-type e-series switches and IBM j-type m-series routers.

J34S overview

The IBM Ethernet Appliance J34S can support up to 2.25 million concurrent sessions, 20 Gbps firewall or 6 Gbps of IPsec VPN, along with up to 175,000 new connections per second. The J34S is ideally suited for securing and segmenting enterprise data center network infrastructures as well as aggregation of various security solutions. The capability to support unique security policies per zones and its ability to scale with the growth of the network make the J34S an ideal deployment for small-to-midsized server farms or hosting sites.

Figure 14-14 shows the IBM Ethernet Appliance J34S.

Figure 14-14 IBM j-type J34S Ethernet Appliance

J36S overview

The IBM Ethernet Appliance J36S is a market leading security solution supporting up to 2.25 million concurrent sessions, a 30 Gbps firewall and a 10 Gbps of IPsec VPN along with up to 175,000 new connections per second. Equipped with the full range of security features, the J36S is ideally suited for securing medium-to-large enterprise datacenters, hosted or co-located data centers, or securing next-generation enterprise services/applications. It can also be deployed to secure cloud provider infrastructures where multi-tenancy is required. Scalability and flexibility of the J36S multi services appliance make it ideal for consolidating legacy security appliances in densely populated data centers, growing data centers, and cloud computing environments. Figure 14-15 shows the IBM Ethernet Appliance J36S.

Figure 14-15 IBM j-type J36S Ethernet Appliance

Line cards

IBM Ethernet Appliance J34S and IBM Ethernet Appliance J36S support a variety of line cards.

Service Processing Cards (SPCs)

IBM Ethernet Appliance J34S and IBM Ethernet Appliance J36S Service Processing Cards (SPCs) act as the “brains” of the systems and are designed to process all available services on the appliance. By eliminating the need for dedicated hardware for specific services or capabilities, there are no instances in which any piece of hardware is taxed to the limit while other hardware sits idle. All of the processing capabilities of the SPCs are used to support any and all services and capabilities of the appliance. The same SPCs are supported on both the IBM Ethernet J34S and IBM Ethernet Appliance J36S.

> **Requirements:** A minimum of one NPC and one SPC is required for proper system functionality.

I/O Cards (IOCs)

In addition to supporting an ideal mix of built-in copper, small form-factor pluggable transceiver (SFP), and high availability (HA) ports, the IBM Ethernet Appliance J34S and IBM Ethernet Appliance J36S allows the greatest I/O port density of any comparable offering in the same class. The J34S and J36S can be equipped with one or several IOCs, each supporting either 16 x 1 copper, or fiber, Gigabit Ethernet, or 2 x 10 Gigabit XFP Ethernet.

With the flexibility to provide multiple IOCs, the J34S and J36S can be equipped to support an ideal balance between interfaces and processing capabilities.

Network Processing Cards (NPCs)

To ensure maximum processing performance and flexibility, the IBM Ethernet Appliance J34S and IBM Ethernet Appliance J36S utilize NPCs to distribute in bound and out bound traffic to the appropriate SPCs and IOCs, apply QoS, and enforce DoS or Distributed Denial of Service (DDoS) protections. The J36S can be configured to support one to three NPCs, while the J34S can be configured to support one or two NPCs. Providing additional NPCs to the appliance allows organizations to tailor the solution to fit their specific performance requirements.

Common architectural components

The IBM Ethernet Appliance J34S and IBM Ethernet Appliance J36S share many architectural elements and characteristics with the IBM J5xS series security offerings. The J34S and J36S can accommodate 2.25 million concurrent sessions and 175,000 new session connections per second with a maximum of 40,000 security policies and no restriction of users supported. Both the IBM Ethernet Appliance J34S and IBM Ethernet Appliance J36S run the Junos Software operating system, enabling customers to quickly and cost effectively “turn on” new capabilities as dedicated or multiple services tightly integrated into the operating system. The J34S and J36S also position customers for long-term growth through the Junos Software’s capacity to easily accommodate new capabilities. In addition, the same Service Processing Cards, I/O Cards, and Network Processing Cards can be used for the IBM Ethernet Appliance J34S and IBM Ethernet Appliance J36S. The J34S and J36S also come with fixed I/O ports (8 10/100/1000 + 4 SFPs).

Common features

Here we list the common features of the products just described:

- Multi services security platform delivers the performance and flexibility to protect high-speed network environments.
- Scalable performance provides a simple and cost-effective solution to utilize new services with appropriate processing.
- System and network resiliency provides data center-class hardware design and proven OS for reliable network deployments.
- High availability interfaces to help achieve resiliency necessary to meet the critical demands of enterprise data centers.
- Interface flexibility offers variable I/O configuration and independent I/O scalability to meet the needs of any particular network requirements.
- Network segmentation features provide security zones, VLANs, and virtual routers to tailor unique security policies to isolate guests and regional servers or databases.
- Runs on the modular, fault-tolerant Junos Software operating system.
- Robust routing engine provides physical and logical separation to data and control planes, enabling the consolidation of routing and security devices.
- Comprehensive threat management features on Junos software, including multi-gigabit firewall, IPsec VPN, DoS, and other services offers integration to protect enterprise networks.

For detailed information about IBM Ethernet appliances, such as firewall performance and capabilities, network connectivity, processing scalability, IPsec VPN, NAT, traffic management, and user authentication information, see *IBM j-type Ethernet Appliance Implementation*, SG24-7883, and the following website:

`http://www.ibm.com/systems/networking/hardware/j-type/j3xs`

14.2.5 IBM Ethernet Appliance J56S/J58S

The IBM Ethernet Appliance J56S and J58S systems offer high-performance and scalability, ensuring uninterrupted expansion and growth of the network infrastructure while satisfying data center security requirements.

Based on the Dynamic Services Architecture, the IBM Ethernet Appliance J56S and J58S provide market leading scalability. Each multi services appliance can support almost linear scalability, with each additional services processing card (SPC) enabling a fully equipped J58S to support:

- Up to 120 Gbps firewall throughput
- Up to 10 million concurrent sessions
- 350,000 new VPN connections per second
- A range of features including denial of service (DoS) protection, Network Address

Translation (NAT), Virtual Private Network (VPN) support and quality of Service (QoS) The SPCs are designed to support a wide range of services enabling future support of new capabilities without the need for service specific hardware. Using SPCs on all services ensures that there are no idle resources based on specific services being used — maximizing the utilization of equipped hardware. The IBM J56S and IBM J58S are next generation multi services appliances delivering leading scalability and service integration in a midsized form factor. These appliances are suited for medium-to-large enterprise networks including:

- Cloud and hosting provider data centers
- Managed service providers
- Secure core data center infrastructure
- Large enterprise data centers
- Aggregate of departmental or segmented security infrastructure

The scalability and flexibility of the IBM Ethernet Appliance J56S and IBM Ethernet Appliance J58S are supported by equally robust interfaces. The J56S and J58S employ a modular approach to interfaces where the appliance can be equipped with a flexible number of I/O cards (IOCs). With the IOCs sharing the same interface slot as the SPCs, the appliance can be configured to support the ideal balance of processing and I/O. Hence, each deployment of the J56S and J58S can be tailored to specific network requirements. With this flexibility, the J58S can be configured to support more than 400 gigabit ports, with choices of Gigabit Ethernet or 10-Gigabit Ethernet.

The switch fabric employed in the IBM J56S and IBM J58S Ethernet Appliances enables the scalability of SPCs and IOCs. Supporting up to 960 Gbps of data transfer, the fabric enables maximum processing and I/O capability available in any particular configuration. This level of scalability and flexibility enables uninterrupted expansion and growth of the network infrastructure, without the security solution being a barrier.

The feature integration on the IBM Ethernet Appliance J56S and IBM Ethernet Appliance J58S is enabled by Junos software. By combining the routing heritage of Junos and the security heritage of Screen OS, the J56S and J58S is equipped with a robust list of features that include firewall, denial of service (DoS), Network Address Translation (NAT), and quality of service (QoS). In addition to the benefit of individual features, incorporating the various features under one OS greatly optimizes the flow of traffic through the services appliance. Network traffic will no longer need to be routed across multiple paths, cards or even disparate operating systems within a single appliance.

The IBM Ethernet Appliance J56S and IBM Ethernet Appliance J58S running Junos also offer data center reliability and resiliency. The J56S and J58S enjoy the benefit of a single source OS, single release train, and one architecture that is also available across IBM j -type e-series switches and IBM j-type m-series routers.

J58S overview

The IBM Ethernet Appliance J58S is the market leading security solution, supporting up to 120 Gbps firewall, 30Gbps IPsec VPN, 10 million concurrent sessions and 350,000 new VPN connections per second. Equipped with the full range of security features, the J58S is ideally suited for securing large enterprise data centers and hosted or co-located data center, as well as cloud provider infrastructures. The massive scalability and flexibility of the services appliance make it ideal for densely consolidated data centers. The service density makes it ideal for cloud computing environments. Figure 14-16 shows the IBM Ethernet Appliance J58S.

Figure 14-16 IBM j-type J58S Ethernet Appliance

J56S overview

The IBM Ethernet Appliance J56S uses the same SPCs and IOCs as the J58S and can support up to 60 Gbps firewall or a 15 Gbps IPsec VPN, offering up to 9 million concurrent sessions with 350,000 new sessions per second. The J56S is ideally suited for securing enterprise data centers as well as aggregation of various security solutions. The capability to support unique security policies per zones and scale with the growth of the network infrastructure makes the IBM Ethernet Appliance J56S an ideal deployment. Figure 14-17 shows the IBM Ethernet Appliance J56S.

Figure 14-17 IBM j-type J56S Ethernet Appliance

Line cards

IBM Ethernet Appliance J56S and IBM Ethernet Appliance J58S support a variety of line cards.

Service Processing Cards (SPCs)

As the “brain” behind the IBM J5xS security series, the SPCs are designed to process all available services on the appliance. Without the need for dedicated hardware for specific services or capabilities, there are no instances in which a piece of hardware is taxed to the limit while other hardware is sitting idle. All of the processing capabilities of the SPCs are designed to process all configured services on the appliance. The same SPCs are supported on both IBM Ethernet Appliance J56S and IBM Ethernet Appliance J58S.

I/O Cards (IOCs)

To provide the most flexible solution, IBM Ethernet Appliance J56S and IBM Ethernet Appliance J58S employ the same modular architecture for SPCs and IOCs. The J56S and J58S can be equipped with one or several IOCs, with each IOC supporting 40 gigabit interfaces (4 x 10-Gigabit Ethernet or 40 x 1Gigabit Ethernet). With the flexibility to install an IOC or an SPC on a given slot, the J56S and J58S can be equipped to support an ideal balance between interfaces and processing capabilities.

Common architectural components

The IBM Ethernet Appliance J56S and IBM Ethernet Appliance J58S share many architectural elements and characteristics of the IBM J3xS series. Based on the Dynamic Services Architecture, the J56S and J58S provide unrivaled scalability. Each appliance can support almost linear scalability, with each additional services processing card (SPC) enabling a fully equipped J58S to support up to120 Gbps firewall throughput. The SPCs are designed to support a wide range of services enabling future support of new capabilities without the need for service specific hardware. Using SPCs on all services ensures that there are no idle resources based on specific services being used — maximizing the utilization of equipped hardware.

Both the IBM Ethernet Appliance J56S and IBM Ethernet Appliance J58S run the Junos software operating system, enabling customers to quickly and cost effectively "turn on" new capabilities as dedicated or multiple services tightly integrated into the operating system. The J56S and J58S also position customers for long-term growth through the Junos software's capacity to easily accommodate new capabilities. All major IBM Ethernet Appliance J56S and IBM Ethernet Appliance J58S components are hot-swappable and all central functions are available in redundant configurations designed to provide high operational availability by allowing continuous system operation during maintenance or repairs.

Key features

Here are the key features of the IBM Ethernet Appliance J56S and J58S:

- Multi services security platform delivers the performance and flexibility to protect high-speed network environments
- Scalable performance provides a simple and cost-effective solution to utilize new services with appropriate processing
- System and network resiliency provides data center-class hardware design and proven OS for reliable network deployments
- High availability interfaces to help achieve resiliency necessary to meet the critical demands of enterprise data centers
- Interface flexibility offers variable I/O configuration and independent I/O scalability to meet the needs of any particular network requirements
- Network segmentation features provide security zones, VLANs, and virtual routers to tailor unique security policies to isolate guests and regional servers or databases
- Runs on the modular, fault-tolerant Junos software operating system
- Robust routing engine provides physical and logical separation to data and control planes, enabling the consolidation of routing and security devices
- Comprehensive threat management features on Junos software—including multi-gigabit firewall, IPsec VPN, DoS, and other services—offer integration to protect enterprise networks

For detailed information about IBM Ethernet appliances, such as firewall performance and capabilities, network connectivity, processing scalability, IPsec VPN, NAT, traffic management, and user authentication information, see *IBM j-type Ethernet Appliance Implementation*, SG24-7883. Also check the following website:

http://www.ibm.com/systems/networking/hardware/j-type/j5xs

14.3 IBM c-type Ethernet products

In this section we discuss the IBM c-type networking systems, represented by the Cisco Nexus products family, in regard to reducing the complexity of an organization's environment.

14.3.1 Cisco Nexus 4000

The Cisco Nexus 4001I Switch Module is the latest Ethernet switching option for the IBM BladeCenter. This offering allows BladeCenter integration with virtually any open standards based local area network (LAN).

Overview

This next-generation 10 Gb switch from Cisco is part of the Nexus family and offers 20 ports of 10 Gb (14 internal and 6 external) bandwidth. This switch can seamlessly integrate with your 1 Gb or 10 Gb network. Because this switch is based on the Nexus architecture, you can manage it using the same set of tools and management software used for Nexus 5000 and 7000.

The innovative architecture of the Cisco Nexus 4001I (Figure 14-18) simplifies data center transformation by enabling a high-performance, standards-based I/O convergence by combining LAN and SAN traffic on a single wire. The Cisco Nexus 10Gb Switch module is designed to support both 10 Gb Ethernet and Fibre Channel over Ethernet (FCoE).

Figure 14-18 Cisco Nexus 4001I for IBM Blade Centers

IBM also offers a FCoE license key for this switch that will enable this switch to work in FCoE mode. When connected to a Converged Adapter on the server, this switch can route CEE packets to an upstream FCoE switch which can then route the packets to the LAN and SAN.

Key features

Here are the key features of the Cisco Nexus 4001I for IBM Blade Centers:

- 10 Gb Ethernet ports with 14 internal, midplane ports for server connectivity and 6 external, SFP+ enabled ports for fabric connectivity
- Line rate performance and HSSM form factor
- Port configuration - 20x 10Gb ports:
  - 6x 10 Gb SFP+ external uplinks; ports can be configured as 10 Gb SFP+ or 1 Gb SFP
  - 10/100/1000 Gb external uplink management port
  - 14 x 10 Gb internal server links; server links can be configured as 10 Gb or 1 Gb
  - 2x internal MM ports
  - RJ45 console port

The Cisco Nexus 10 Gb Switch module is designed to support both 10 Gb Ethernet and Fibre Channel over Ethernet. This software key when applied to this switch enables this switch to work in FCoE mode. When connected to a Converged Adapter on the server, this switch can route CEE packets to a upstream FCoE switch which can then the route the packets to the LAN or SAN.

14.3.2 Cisco Nexus 5000

Cisco Nexus 5000 switches for IBM System Storage is designed for data center environments with technology that supports consistent low-latency Ethernet solutions, with front-to-back cooling, and with network ports in the rear, bringing switching into close proximity with servers and making cable runs short and simple. The switch family is designed to be highly serviceable, with optional redundant, hot-pluggable power supplies and fan modules. It uses data center-class Cisco NX-OS to support high reliability and ease of management.

The switch family, using cut-through architecture, supports line-rate 10 Gigabit Ethernet on all ports while maintaining consistent low latency independent of packet size and services enabled. The product family supports IEEE Data Center Bridging and Converged Enhanced Ethernet (CEE) capabilities that can help increase the reliability, efficiency, and scalability of Ethernet networks. These features allow the switch to support multiple traffic classes over a Ethernet fabric, thus enabling consolidation of LAN, SAN, and cluster environments. Its ability to connect Fibre Channel over Ethernet (FCoE) to native Fibre Channel protects existing storage system investments while dramatically simplifying in-rack cabling.

In addition to supporting standard 10 Gigabit Ethernet network interface cards (NICs) on servers, the Cisco Nexus 5000 switches integrate with multifunction adapters called converged network adapters (CNAs) that combine the functions of Ethernet NICs and Fibre Channel host bus adapters (HBAs), making the transition to a single, unified network fabric consistent with existing practices, management software, and operating system drivers. The switch family is compatible with integrated transceivers and Twinax cabling solutions to help deliver cost-effective connectivity for 10 Gigabit Ethernet to the servers at the rack level, reducing or eliminating the need for expensive optical transceivers.

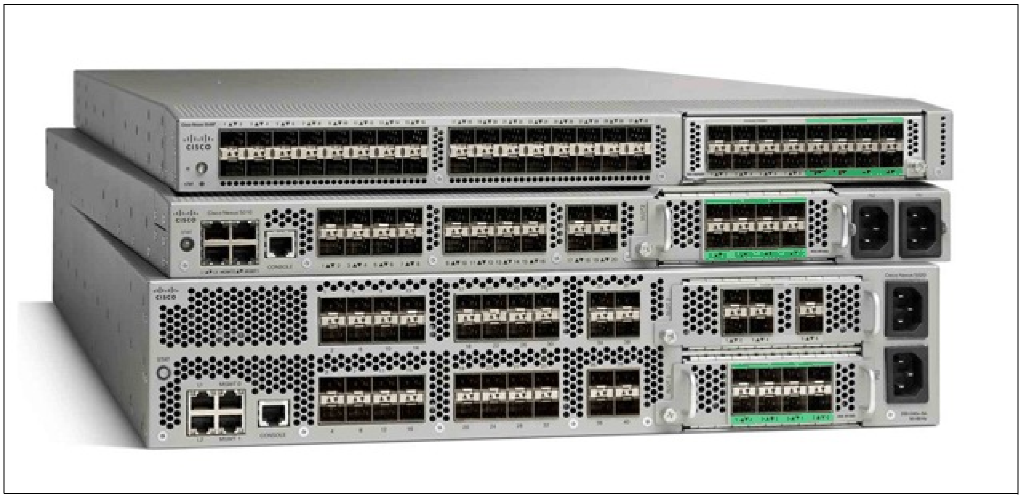


Figure 14-19 Cisco Nexus 5000 product family

The Cisco Nexus 5000 (Figure 14-19) for IBM System Storage switches are a family of line-rate, low-latency, lossless 10 Gigabit Ethernet, Converged Enhanced Ethernet (CEE), and Fibre Channel over Ethernet (FCoE) switches for data center applications.

Cisco Nexus 5010/5020

The Cisco Nexus 5010 28-port switch (3722-S51) for IBM System Storage and Cisco Nexus 5020 56-port switch (3722-S52) for IBM System Storage FCoE switches help reduce costs through data center infrastructure simplification. The unified fabric over 10 Gigabit Ethernet (GbE) for server LAN and SAN traffic enables consolidation of server adapters, cables and top-of-rack (TOR) switches by up to 50 percent.

Both models support 8 Gbps Fibre Channel expansion modules with short wave and long wave transceivers.

Key features

Here are the key features of the Cisco Nexus 5010/5020:

- Ports and power connections are at the rear, closer to server ports, helping keep cable lengths as short and efficient as possible
- IEEE Data Center Bridging features for lossless transmission, priority flow control and enhanced transmission selection
- Standards-based FCoE protocol preserves existing Fibre Channel network management models and tools, helping protect investments in software and staff training
- Unified Fabric designed to consolidate all data center I/O onto Layer 2 Ethernet and reduce capital and operating costs by reducing the number of server adapters, cables, and upstream switches needed
- Server I/O consolidation reduces energy consumption by eliminating the need for separate Fibre Channel adapters, cables, and switches
- Consistent management is provided through consistency of both Cisco NX-OS Software and Cisco MDS 9000 SAN-OS Software management models and tools
- Multiprotocol switches with 10 Gbps Fibre Channel over Ethernet (FCoE), 10 Gbps Converged Enhanced Ethernet, traditional 1, 10 Gbps Ethernet ports and optional 1, 2 and 4 Gbps Fibre Channel (FC) ports
- Cisco Nexus 5010 for IBM System Storage provides eight 1, 10 GbE and twelve 10 GbE fixed ports with one expansion module slot
- Cisco Nexus 5020 for IBM System Storage provides sixteen 1, 10 GbE and twenty-four 10 GbE fixed ports with two expansion module slots
- Expansion modules include eight 1, 2, 4, 8 Gbps FC ports; four 10 GbE and four 1, 2, 4, 8 Gbps FC ports; six 10 GbE ports
- 10 GbE ports are capable of transporting both storage and LAN traffic, eliminating the need for separate server SAN and LAN adapters and cables
- Dual speed 1, 10 GbE ports help provide a smooth transition to 10 Gigabit Ethernet

Reference: For more information about specification, model number, product number, and type, see the website:

`http://www.ibm.com/systems/networking/hardware/ethernet/c-type/nexus`

14.4 More information

For more information about all the products discussed in this chapter, see the following documentation.

- *IBM j-type Data Center Networking Introduction*, SG24-7820
- *IBM j-type Ethernet Switches and Routers Implementation*, SG24-7882
- *IBM j-type Ethernet Appliance Implementation*, SG24-7883
- *IBM b-type Data Center Networking: Product Introduction and Initial Setup*, SG24-7785
- *IBM b-type Data Center Networking: Design and Best Practices Introduction*, SG24-7786

Part 4

IBM System Storage software

In Part 4, we discuss the IBM System Storage software products, which are designed with the goal of helping customers drive down the cost and complexity of storage management while providing greater flexibility to address rapidly changing storage needs.

15

IBM System Storage Virtualization

Storage virtualization reduces the complexity and costs of managing storage networks.

In this chapter, we describe what storage virtualization is, and the need for it in today's environment. We look at the IBM approach to both in-band and out-of-band storage virtualization. The fundamental differences between the two architectures are described and examples are given of IBM products in these categories. We then explain virtualization in relation to storage networking and discuss benefits of implementing an IBM System Storage virtualization solution.

15.1 What is storage virtualization?

Storage virtualization products have become widespread in the IT industry today. They can exist in one or more layers in a storage network and can be described as *the abstraction of the physical location of the data from the logical representation of it*.

Storage virtualization is a general approach to decoupling logical resources from their physical elements, so that those resources can be allocated faster, more cost-effectively, and more dynamically. It is also the pooling of physical storage resources, from one or more storage devices, which are then presented and managed through an abstraction layer in order to present a unified view of a "virtual" storage resource or pool on what appears to be a single device to users and attached hosts.

The abstraction can be made on several levels of the components of storage networks and is not limited to the disk subsystem. The virtualization layer provides the same kind of services to the layer above (as the hidden layer below it provides). Storage virtualization software separates the representation of storage to the operating system (and its users) from the actual physical components.

> **History:** Storage virtualization existed, and was taken for granted in the mainframe computing environment, for many years.

Today, information has become the lifeline for business sustainability and competitive advantage. It shapes every idea and every decision. But as the world becomes more instrumented, interconnected, and intelligent, the ability to manage and deliver trusted information as a strategic asset becomes a critical enabler to making organizations smarter and increasingly more competitive.

15.1.1 Inefficiencies in sharing storage

SAN is making it easier for customers to spread their IT systems out geographically, but even in networks, various types of servers that use various operating systems do not automatically get the full benefit of sharing storage. Instead, the storage is partitioned to each particular type of server, this creates complex management and inefficient use of storage. When storage is added, upgraded, moved or, removed applications can often be disrupted. At the same time, the reduced cost of storage and the technology of storage networks, with ever faster data transfer rates, have enabled customers to use increasingly sophisticated applications. This has caused even greater complexity and difficulty of management as the amount of storage required grows at unprecedented rates.

The following problems arise with the increasing complexity of storage environments:

- Too many storage platforms and server operating systems.
- Multiple management consoles
- IT staff skill levels
- Availability requirements
- Poor utilization levels in traditional environments
  - Typically 30%-50% for disk in a non-virtualized environment[1]
  - Typically 20%-40% for tape in a non-virtualized environment[1]

[1] taken from an SNIA virtualization education document written in 2008.

At the business level, clients are faced with three major storage challenges:

- Managing storage growth: Storage needs continue to grow at a rate that is normally higher than what had been planned for each year. As an example, storage subsystems might be purchased to last for 3 to 5 years; however, organizations are finding that they are filling to capacity much earlier than that.

  In order to accommodate this growth, administrators are either extending their current storage subsystems in chunks, or buying various types of storage subsystems to match their storage needs and budget.

- Increasing complexity: As storage needs grow, this need might be filled by multiple disk subsystems, which might not even be from the same vendor.

  Together with the variety of server platforms and operating systems in a customer's environment, customers might have SANs with multiple and diverse storage subsystems and host platforms, as shown in Figure 15-1.

  Combining this situation with the shortage of skilled storage administrators, the cost and risk of storage increases as the environment becomes more complex.

- Maintaining availability: With the increased range of storage options available, the storage growth rate, and no similar increase in storage budget, businesses have to manage more storage with no staff or minimal additional staff.

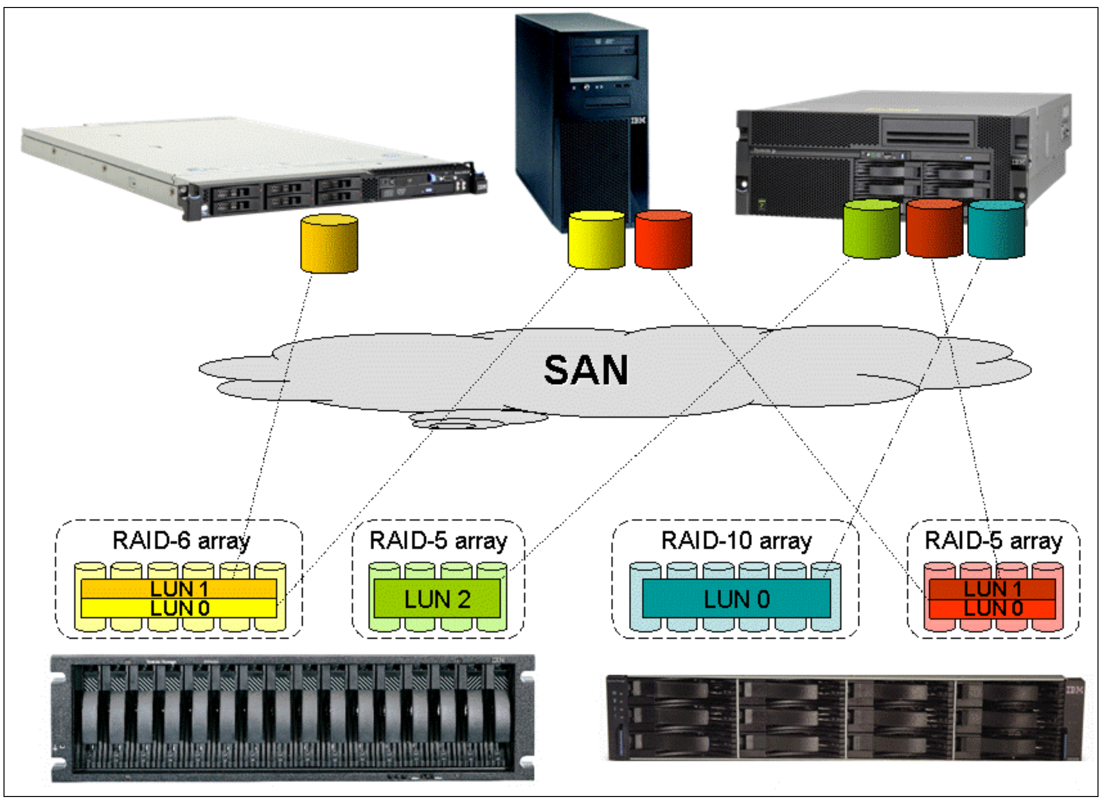


Figure 15-1 Traditional SAN environment

With the complexity highlighted before, and with requirements for higher business system availability, the potential for errors increases as each new storage subsystem is added to the infrastructure. Making changes to the storage infrastructure to accommodate storage growth runs the risk of outages that might not be acceptable to the enterprise.

15.1.2 Benefits of implementing storage virtualization in your SAN

Storage needs are increasing at an ever faster rate, and the challenge of managing disparate storage systems is growing. The case for using storage virtualization to reduce or even eliminate the problems listed becomes stronger as the problems themselves increase:

- Reduced storage management complexity
- Significantly reduced downtime, both planned and unplanned.
- Enhanced productivity through improved data availability
- Consolidation to a single pool of storage
- Heterogeneous storage is presented as homogenous storage
- Better choice of storage, switch, and SAN technologies
- Removal of “Tie-in” to a specific vendor or platform
- Improved storage resource utilization
- A single, cost-effective set of advanced copy services
- Simplification and standardization of the IT infrastructure
- Ease transition to an on demand IT infrastructure

These benefits lead to lower TCO and better flexibility to react to business changes.

The IBM storage virtualization brings storage devices together in a *virtual pool* to make all storage appear as follows:

- One “logical” device to centrally manage and to allocate capacity as needed
- One solution to help achieve the most effective use of key storage resources on demand

Virtualization solutions can be implemented in the storage network, in the server, or in the storage device itself. The IBM storage virtualization solutions are in-band SAN-based, which helps allow for a more open virtualization implementation. Locating virtualization in the SAN, and therefore in the path of input/output (I/O) activity, helps to provide a solid basis for policy-based management. The focus of IBM on open standards means that its virtualization solution supports freedom of choice in storage-device vendor selection.

Figure 15-2 shows a diagram of a virtualized environment.

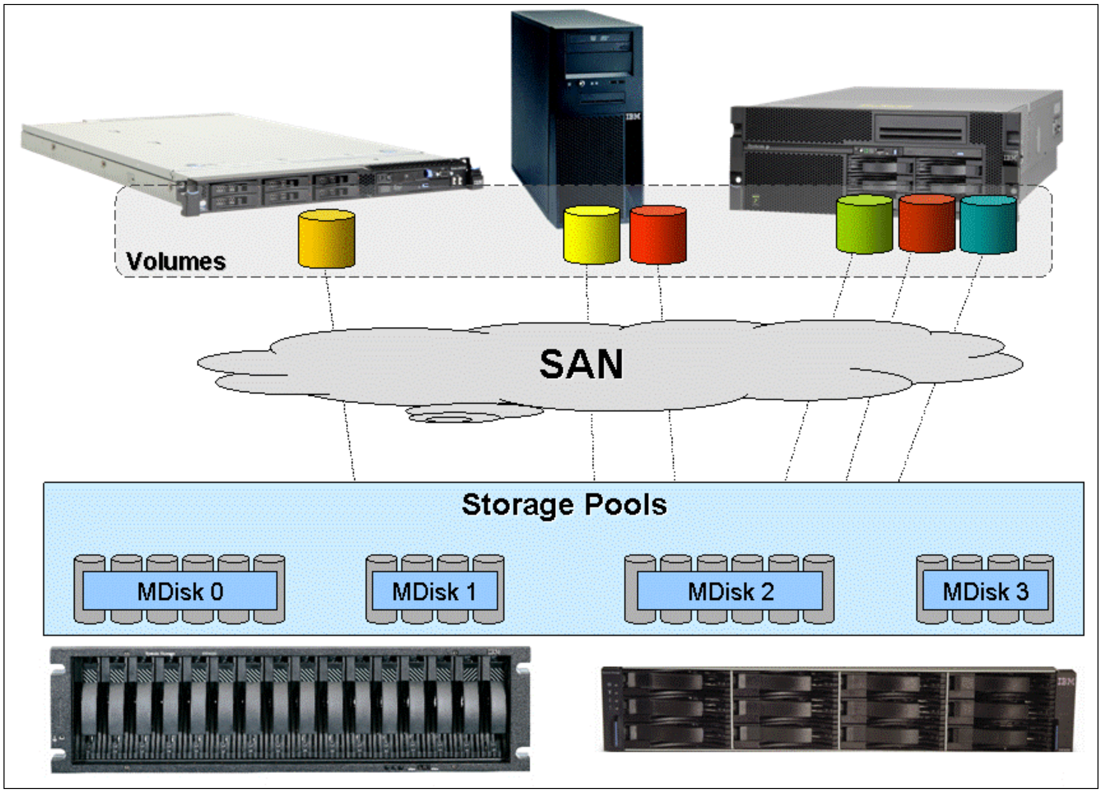


Figure 15-2 Virtualized SAN environment

15.2 Levels of storage virtualization

Virtualization can be achieved at various levels in a storage network (Figure 15-3).

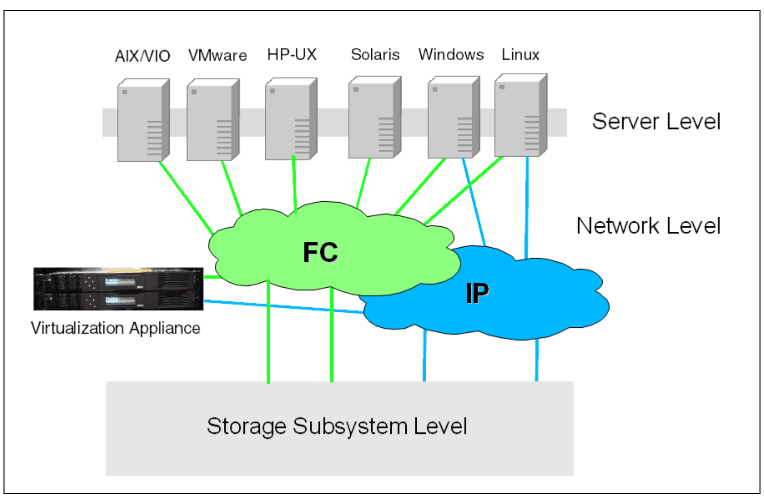


Figure 15-3 Levels of application of storage virtualization

15.2.1 Server level virtualization

Abstraction at the server level is achieved with logical volume management on the server operating systems. At first sight, increasing the level of abstraction on the server seems well suited for environments without storage networks, but this can be important in storage networks too.

15.2.2 Network level virtualization

At the network level, virtualization can enable the independence of storage pools from heterogeneous servers. The network (either FC SAN fabric or IP) is configured to allow the virtualization appliances to see the storage subsystems, and for the servers to see the virtualization appliances. Servers are not able to directly see, or operate on, the storage subsystems.

15.2.3 Storage subsystem level virtualization

Intelligent disk storage systems provide virtualization already by consolidating multiple physical storage devices into larger logical drive groups. They then add disk failure protection and subdivide these large, protected, groups into smaller virtual drives. These RAID storage controllers are commonplace and available for almost all requirements. Storage virtualization takes this to the next level by enabling the presentation, and management, of disparate storage systems by one virtualization appliance.

15.3 Server, network, or storage subsystem virtualization

As we stated, virtualization can be implemented at any of these levels. The IBM strategy is to move the storage device management intelligence out of the server, reducing the dependency of having to implement specialized software, like Logical Volume Managers (LVM), at the server level.

15.3.1 Implementing virtualization at a fabric or network level

By implementing virtualization at a fabric or network level, storage control is moved into the network layer, which gives the virtualization opportunity to all, and at the same time reduces complexity by providing a single view of storage. The storage network can be used to utilize all kinds of services across multiple storage devices, including virtualization.

15.3.2 Fabric level virtualization models

In-band and out-of-band are two implementations of virtualization at the fabric level. Models can be drawn for these methods of storage virtualization, as illustrated in Figure 15-4. These models are not mutually exclusive. In many environments a combination of both might be desired.

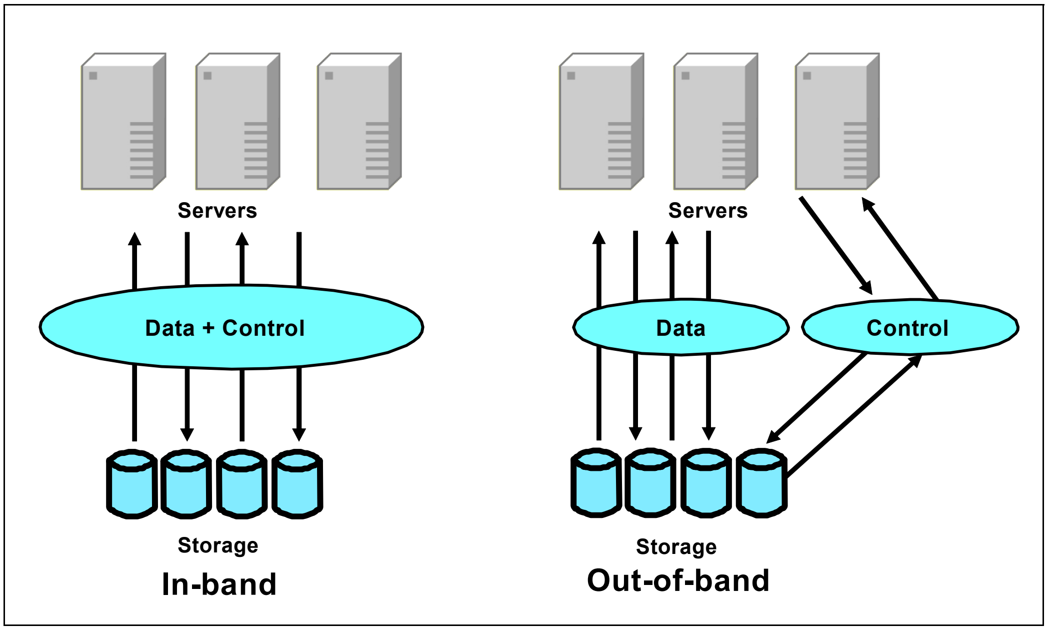


Figure 15-4 In-band and out-of-band virtualization models

In-band or block aggregation

When we implement an in-band virtual storage network, both data and control flow over the same path. Levels of abstraction exist in the data path, and storage can be pooled under the control of a domain manager. In general, in-band solutions are perceived to be simpler to implement, especially because they do not require special software to be installed in servers (other than conventional multipathing software). In-band solutions can also provide caching and advanced functions within the storage network. This can help to improve the performance of existing disk systems and can extend their useful life, and reduce the cost of new storage capacity by enabling the use of lower function, lower cost disk systems, without the loss of performance.

Other advantages include these:

- Ability to off load function from the host
- Providing storage management for the SAN
- Performing performance optimizations in the data path
- Supporting host systems not in a cluster
- Supporting multiple heterogeneous hosts
- Releasing the customer from a particular vendor's storage
- Integrating with storage to create a better management picture
- Offering excellent scalability

The IBM System Storage SAN Volume Controller and the IBM Storwize V7000 are in-band virtualization appliance solutions that maps virtualized volumes visible to hosts and applications to physical volumes on storage devices.

Out-of-band or file aggregation

In an out-of-band implementation, the data flow is separated from the control flow. This is achieved by separating the data and metadata (data about the data) into separate places. Out-of-band virtualization involves moving all mapping and locking tables to a separate server (the metadata controller) that contains the metadata of the files.

In an out-of-band solution the clients request authorization to data from the metadata controller, which grants it, handles locking, and so on. After they are authorized, clients access the data directly without any metadata controller intervention. After a client has obtained access to a file, all I/O will go directly over the SAN to the storage devices. For many operations, the metadata controller does not even intervene.

Separating the flow of control and data in this manner allows the I/O to use the full bandwidth that a SAN provides, while control can go over a separate network or routes in the SAN that are isolated for this purpose.

Other advantages include these:

- Releasing the customer from a particular vendor's storage
- Providing storage management for the SAN
- Offering excellent scalability
- Off loading host processing
- Supporting storage management from multiple vendors
- Integrating well with storage management software
- Supporting multiple heterogeneous hosts
- Relatively low overhead in the data path

IBM GPFS is an example of an out of band virtualization system.

15.4 IBM System Storage approach to virtualization

The IBM approach to helping you with your storage needs is to address the entire problem. From a TCO perspective, the initial purchase price is becoming an increasingly small part of the equation, in the order of 10%. As the cost per megabyte of disk drives continues to decrease, the focus is shifting away from hardware toward software value add functions, storage management software, and services. This is not to downplay the importance of a highly reliable, high performance hardware solution such as the IBM System Storage DS5000 or DS8000. Software, however, is emerging as the differentiating factor and offers a highly competitive advantage. The advantage is due to the fact that advanced functionality provided by software and storage management software play a vital role in administering distributed IT assets, maintaining high availability, and minimizing downtime.

IBM has identified three major product areas where significant improvements can be achieved. The SNIA Storage Model describes these areas as *Block Aggregation*, *File Aggregation*, and *Management and Productivity*, as depicted in Figure 15-5.

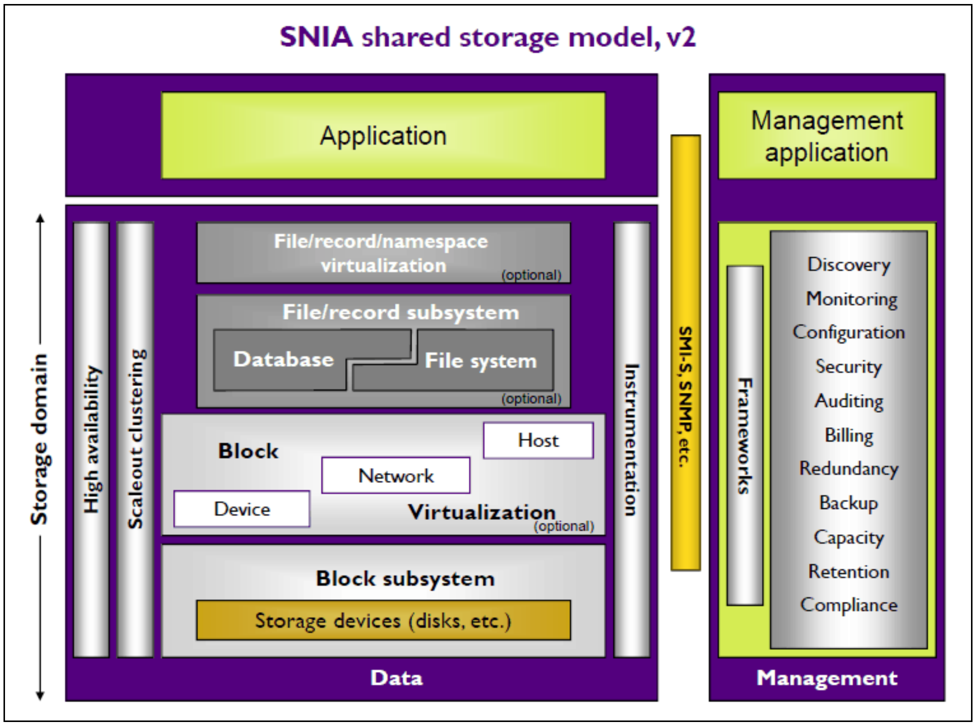


Figure 15-5 SNIA storage model v2

For more information about the SNIA Shared Storage Model, see the website:

http://www.snia.org/education/storage_networking_primer/shared_storage_model/

15.4.1 IBM block aggregation characteristics

Block aggregation in the SNIA model provides what is also referred to in the industry as block virtualization. Block level virtualization provides servers with a logical view of physical storage. The SNIA Block Aggregation Model, as seen in Figure 15-5, specifies that block aggregation can be performed within hosts (servers), in the storage network (storage routers, storage controllers) or in storage devices (intelligent disk arrays). The IBM System Storage SAN Volume Controller and the IBM Storwize V7000 are block aggregation solutions within the storage network.

15.4.2 IBM file aggregation characteristics

For file/record aggregation in the SNIA model, hosts get file metadata from file system or Network Attached Storage (NAS) controllers, then access the data directly. File aggregation can be used in conjunction with or independent from block aggregation.

15.5 IBM System Storage Virtualization family

IBM Storage virtualization products exist in all areas of the storage product portfolio. They are designed to help simplify storage infrastructure, optimize storage utilization, and enable business to adapt quickly and dynamically to variable environments.

IBM System Storage Virtualization family of products can help you with the following tasks:

- Simplify deployment and administration while increasing utilization of physical storage assets.
- Improve business application availability.
- Manage all of your storage assets with a single, comprehensive, management tool set.

15.5.1 IBM SAN Volume Controller

The IBM SAN Volume Controller (SVC) is the world's leading storage virtualization system, which is designed to combine storage capacity from multiple disk systems into a reservoir of capacity that can be better managed as a business resource and not as separate storage islands. The abstraction of the physical location of the data from the logical representation of it, which the application on a server sees, allows better utilization, flexibility, efficiency, and performance.

For more information, see Chapter 16, "IBM System Storage SAN Volume Controller" on page 495 for a brief overview of what SVC is and what business benefits it can deliver.

15.5.2 IBM Storwize V7000

The IBM Storwize V7000 is the new powerful and easy-to-use innovative midrange disk system from IBM. It brings sophisticated enterprise-class storage function in a easy-to-use way for midsized businesses. The system features internal disks itself and is able to virtualize external attached multi-vendor storage systems, just like the IBM SVC does.

IBM Storwize V7000 provides unmatched performance, availability, advanced functions, and highly scalable capacity never seen before in midrange disk systems. Storwize V7000 is a powerful midrange disk system that has been designed to be easy to use and enable rapid deployment without additional resources. Storwize V7000 offers IBM storage virtualization, SSD optimization and thin provisioning technologies built in to improve storage utilization and to enable the system to be reconfigured to meet changing needs quickly and easily.

For more information about the IBM Storwize V7000, see Chapter 17, "IBM Storwize V7000" on page 521.

15.5.3 IBM XIV Storage System

The IBM XIV Storage System is a high-end open disk storage system. An integral part of the IBM broad spectrum of system storage and SAN offerings, the XIV system is based on a grid of standard, off-the-shelf hardware components connected in any-to-any topology by means of massively paralleled, non-blocking Gigabit Ethernet. Its innovative architecture is designed to deliver the highest levels of reliability, performance, scalability and functionality at low overall cost, while providing unprecedented ease of management. Software virtualization features of the XIV system include snapshotting, thin provisioning, space reclamation, and remote mirroring.

For more information about the XIV, see 4.4, "IBM XIV Storage System" on page 177.

15.5.4 IBM System Storage DS8000 Series

The IBM System Storage DS8000 is a high-performance disk storage subsystem for business-critical enterprise workloads. Virtualization features includes thin provisioning, Easy Tier, flexible system logical partitions (LPARs) and Metro/Global Mirror Incremental Resync.

For more information about the DS8000, see 4.3, "DS8000 series" on page 117.

15.5.5 IBM Scale Out Network Attached Storage (SONAS)

IBM SONAS is a highly desired choice for large organizations seeking to better manage their growing demand for file-based storage. IBM SONAS is designed to consolidate files that is scattered in multiple storage locations and allows them to be efficiently shared and managed.

IBM SONAS is highly scalable, helps conserve floor space, and can help to reduce your capital expenditure and enhance your operational efficiency. Its advanced architecture virtualizes and consolidates your file space into a single, enterprise-wide file system, which can translate into reduced total cost of ownership.

For more information about the IBM SONAS, see Chapter 6, “IBM Scale Out Network Attached Storage” on page 245.

15.5.6 IBM Virtualization Engine

The IBM Virtualization Engine (TS7500 and TS7700 Virtualization Engines) are a family of mainframe virtual-tape solutions that are designed to optimize tape processing. With one solution, the implementation of a fully integrated tiered storage hierarchy of disk and tape utilizes the benefits of both technologies to help enhance performance and provide the capacity needed for today’s tape processing requirements. Deploying this innovative subsystem can help reduce batch processing time, total cost of ownership and management overhead.

For more information about the IBM Virtualization Engine, see 10.7, “IBM Virtualization Engine TS7700” on page 353.

15.5.7 IBM System Storage TS7680 ProtecTIER Deduplication Gateway: System z

The IBM System Storage TS7680 ProtecTIER Deduplication Gateway for System z combines a virtual tape library solution, with the IBM unique and patented HyperFactor deduplication technology and integrated native replication technology to provide users an optimal disk-based target for Systems z applications that traditionally use tape.

Designed to simplify and improve the performance and reliability of tape processing operations while reducing infrastructure costs, the TS7680 offers high-performance inline deduplication, highly available two node clustering and scalability to store up to 25 petabytes (PB) of tape data on high-speed disk capacity per system.

For more information about the IBM System Storage 10.6, “IBM TS7680 ProtecTIER Gateway for System z” on page 351.

15.5.8 IBM System Storage TS7650 ProtecTIER Appliance

The IBM System Storage TS7650 ProtecTIER Deduplication Appliance is a preconfigured solution of IBM storage, IBM server, and the IBM revolutionary ProtecTIER data deduplication software designed to improve backup and recovery operations. This is not just a bundle of components, but a truly integrated solution that makes it easy to harness the power of deduplication without making radical changes to the existing environment.

For more information about the TS7650, see 10.4, “TS7650 ProtecTIER Deduplication Appliance” on page 346.

15.5.9 IBM System Storage TS7650G ProtecTIER Deduplication Gateway

The IBM System Storage TS7650G ProtecTIER Deduplication Gateway is designed to meet the disk-based data protection needs of the enterprise data center while enabling significant infrastructure cost reductions. The solution offers industry leading inline deduplication performance and scalability up to 1 petabyte (PB) of physical storage capacity per system that can provide up to 25 PB of storage capacity*. Combined with IBM storage, the ProtecTIER Gateway solution provides a powerful disk-based repository to improve the retention and availability of backup and archive data.

For more information about the TS7650, see 10.5, "TS7650G ProtecTIER Deduplication Gateway" on page 349.

15.5.10 IBM Tivoli Storage Productivity Center

The IBM Tivoli Storage Productivity Center suite of storage infrastructure management tools can help customers reduce the complexity of managing their storage environments by centralizing, simplifying and automating storage tasks associated with storage systems, storage networks, replication services and capacity management. A brief summary of these products is in Table 15-1.

Table 15-1 Tivoli Storage Productivity Center product features

Component	Use
IBM Tivoli Storage Productivity Center for Data	Manage the capacity utilization of storage systems, file systems and databases and to automate file-system capacity provisioning
IBM Tivoli Storage Productivity Center for Disk	Perform device configuration and management of multiple devices from a single user interface, tune and proactively manage the performance of storage devices on the Storage Area Network (SAN)
IBM Tivoli Storage Productivity Center for Replication	Control and monitor copy services operations (like FlashCopy, Metro Mirror and Global Mirror capabilities) and use data replication for data protection and disaster recovery

For more information about the IBM Tivoli Storage Productivity Center products, see Chapter 19, "IBM Tivoli Storage Productivity Center" on page 603.

15.5.11 IBM System Storage N series

Wide ranging suites of virtualization functions and options are available within the N series product line. For more information, see Chapter 5, "IBM System Storage N series" on page 211.

Virtualization features and functions in the N series product line are listed in Table 15-2.

Table 15-2 N series virtualization features

Feature	Use
Snapshot	Almost instantaneous point in time, read only copies of data. Almost zero overhead during creation and space efficient copy using little extra space in most cases.

Feature	Use
Virtual File Manager (VFM)	Provide out of band data management functionality for server and storage consolidation, migration, remote office data management and disaster recovery features; functionality accomplished through automated policy-based data management utilizing a global namespace
MultiStore	Quickly and easily create separate, private logical partitions in filer network and storage resources.
SnapMirror	Mirror data to one or more network filers. Constant updates to the mirrored data keep it current and available for disaster recovery
SnapMover	A fast and simple solution for migrating data among IBM System Storage N series systems while avoiding impact on data availability and disruption to users.
FlexClone	Ability to generate nearly instantaneous real time replicas of data sets and storage volumes.

15.5.12 IBM General Parallel File System

The IBM General Parallel File System (GPFS) is more than just a file system; it is a file management infrastructure. It provides unmatched performance and reliability with scalable access to critical file data. GPFS distinguishes itself from other cluster file systems by providing concurrent high-speed file access to applications executing on multiple nodes of an AIX cluster, a Linux cluster, or a heterogeneous cluster of AIX and Linux nodes.

These virtualization products are part of an IBM commitment to the open standards adopted by the Storage Networking Industry Association (SNIA). They implement standard Common Information Model (CIM) based APIs to allow management applications from IBM, and other vendors to administer and monitor their activities.

For more information about IBM GPFS, see Chapter 21, “IBM GPFS and SoFS” on page 679.

15.6 IBM SAN Volume Controller and Storwize V7000 features

IBM SAN Volume Controller and Storwize V7000 share most of their code and, therefore, their features. In this session we explain IBM SAN Volume Controller and Storwize V7000 common features.

15.6.1 Storage virtualization

As discussed in 15.1, “What is storage virtualization?” on page 468, storage virtualization has a lot of benefits. Both IBM SAN Volume Controller and Storwize V7000 are capable of virtualizing external multi-vendor storage systems.

The virtualization layers and its hierarchy have their own nomenclature. The external virtualized storage systems have their own Logical Units (LUNs). These LUNs are seen as Managed Disks (MDisks). An MDisk refers to the unit of storage that IBM SVC or Storwize V7000 virtualizes. It can be an external virtualized LUN or, regarding Storwize V7000, the internal SAS and SSD drives.

The MDisks are then allocated into one or more storage pools. A storage pool is a collection of MDisks that are grouped together in order to provide capacity for volumes. All MDisks in the pool are split into extents with the same size. When a volume is created from a storage pool the volume is allocated based on the number of extents required to satisfy the capacity requirements for the volume. After volumes are allocated out of a storage pool, they are mapped to a host system.

For more information about specific characteristics, see Chapter 16, “IBM System Storage SAN Volume Controller” on page 495 and Chapter 17, “IBM Storwize V7000” on page 521.

15.6.2 Thin provisioning

Volumes can be configured to be either *fully allocated* or *thin-provisioned*. Thin-provisioned volumes will behave as fully allocated ones to application reads and writes. When a thin-provisioned volume is created, the user specifies two capacities, the real allocated capacity of the volume and its virtual capacity.

The real capacity determines the quantity of MDisk extents that will be allocated for the volume. The virtual capacity is the capacity of the volume reported to the storage system (SAN Volume Controller or Storwize V7000) components, such as FlashCopy and Remote Copy as well as to the host servers. The real capacity is used to store both the user data and the metadata for the thin-provisioned volume. The real capacity can be specified as an absolute value or a percentage of the virtual capacity.

The thin provisioning feature can be used on its own to create over-allocated volumes, or it can be used in conjunction with FlashCopy. thin-provisioned volumes can also be used in conjunction with the mirrored volume feature.

Thin-provisioned volumes can also help simplify server administration. Instead of assigning a volume with some capacity to an application and increasing that capacity as the needs of the application change, you can configure a volume with a large virtual capacity for the application, and then increase or shrink the real capacity as the application needs change, without disrupting the application or server.

A thin-provisioned volume can be configured to autoexpand. The autoexpand feature prevents a thin-provisioned volume from using up its capacity and going offline. As a thin-provisioned volume uses capacity, the autoexpand feature maintains a fixed amount of unused real capacity, called the contingency capacity. For thin-provisioned volumes that are not configured with the autoexpand feature, the contingency capacity can get used up, causing the volume to go offline.

The contingency capacity is initially set to the real capacity that is assigned when the volume is created. If the user modifies the real capacity, the contingency capacity is reset to be the difference between the used capacity and real capacity.

Autoexpand will not cause the real capacity to grow much beyond the virtual capacity. The real capacity can be manually expanded to more than the maximum that is required by the current virtual capacity, and the contingency capacity will be recalculated.

When you configure a thin-provisioned volume, you can use the warning level attribute to generate a warning event when the used real capacity exceeds a specified amount or percentage of the total real capacity. You can also use the warning event to trigger other actions, such as taking low-priority applications offline or migrating data into other storage pools.

For example, if a warning of 80% has been specified, the warning will be logged when 20% of the free capacity remains. A thin-provisioned volume can be converted to a fully allocated volume using volume mirroring (and vice versa).

15.6.3 Volume mirroring

The volume mirroring feature provides a simple RAID 1 function which allows a volume to remain accessible even when an MDisk on which it depends has become inaccessible. This is achieved using two copies of the volume. This provides a single volume image to the attached host systems, while maintaining pointers to two copies of data in separate storage pools. A copy is not a separate object and cannot be manipulated.

The feature does provide a "point in time" copy functionality achieved by "splitting" a copy from the volume.

Figure 15-6 gives an overview of how volume mirroring works.

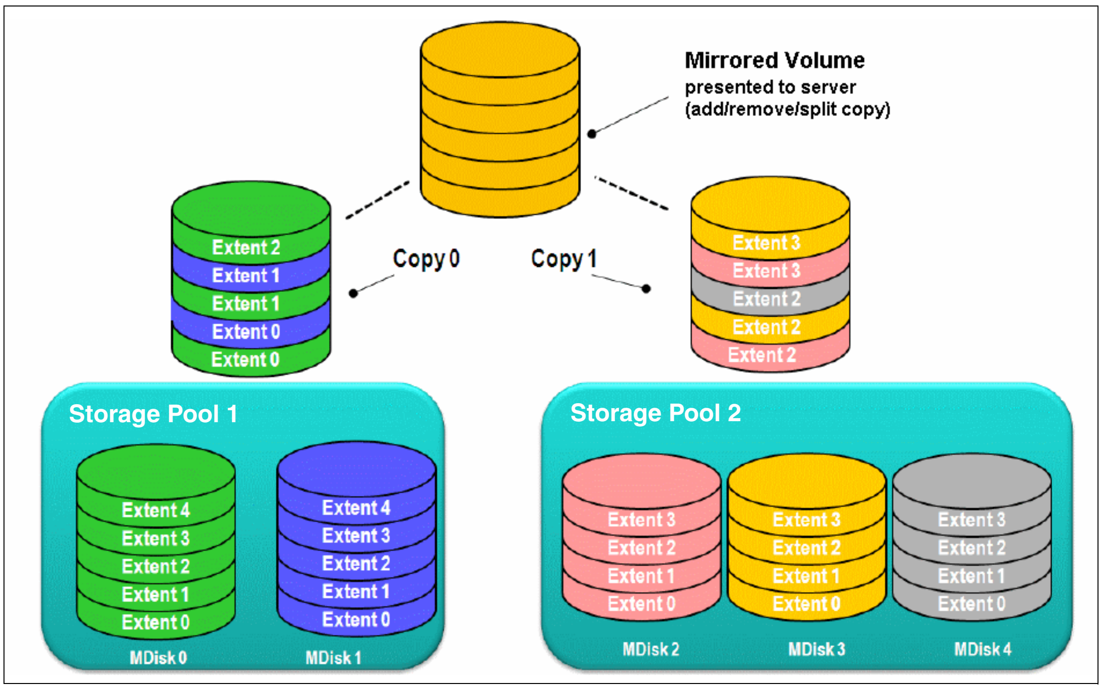


Figure 15-6 Volume mirroring

Space reclamation

Thin-provisioned volumes and volume mirroring enable customers to reclaim unused allocated disk space when converting a fully allocated volume to a thin-provisioned one using volume mirroring. To migrate from a fully allocated to thin-provisioned volume, you simply need to add the target thin-provisioned copy, wait for synchronization to complete, then remove the source fully-allocated copy.

The procedure for migrating from fully allocated “thick” volumes to thin-provisioned volumes can be seen in Figure 15-7.

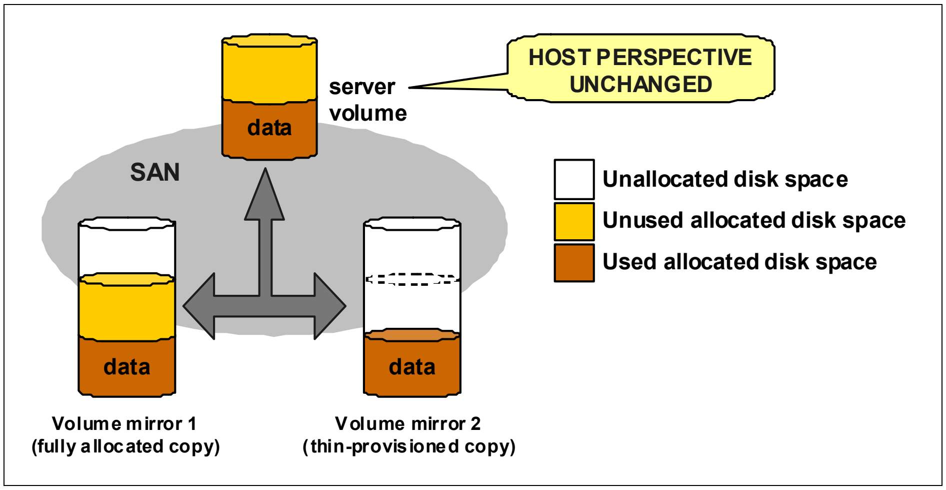


Figure 15-7 Thick to thin volume migration

Data migration

Storage virtualization and Volume Mirroring features used together provide data migration functionality that can be used for the following purposes:

- Move volumes non-disruptively onto a newly installed storage system
- Move volumes off of an older storage system ahead of decommissioning
- Move volumes to rebalance a changed workload

15.6.4 Easy Tier

Usually when a storage system is implemented, only a portion of the configurable physical capacity is deployed. When the storage system runs out of the installed capacity and additional capacity is requested, a hardware upgrade is implemented to add new physical resources to the storage system. This new physical capacity can hardly be configured to keep an even spread of the overall storage resources. Typically, the new capacity is allocated to fulfill only new storage requests. The existing storage allocations will not benefit from the new physical resources. Similarly, the new storage requests will not benefit from the existing resources; only new resources will be used.

In a complex production environment, it is not always possible to optimize storage allocation for performance. The unpredictable rate of storage growth and the fluctuations in throughput (IOPS) requirements often lead to inadequate performance. Furthermore, the tendency to use ever larger volumes to simplify storage management works against the granularity of storage allocation, and a cost efficient storage tiering becomes difficult to achieve. This is particularly true with the introduction of high performing, but expensive, technologies such as Solid State Drives (SSD).

With the availability of SSD in storage systems, the question arises on how to utilize SSDs effectively and efficiently. Considering the superior performance of SSD compared to HDD, it is definitely an advantage to replace all HDDs with SSDs on the disk subsystem. However, given the much higher cost of SSDs, this is generally not a viable solution from an economical point of view. A balance between cost and performance is required.

Easy Tier overview

The workload or I/O characteristics of any installation is unique, even though there are general or similar patterns. Many installations generally do more random I/Os during the day when online transactions are the main activity. After the main online period finishes, the batch period starts, during which time the I/Os become more sequential in nature. For example, with typical financial institutions, the Market Open period is a critical time because of the flood of transactions that come in during a relatively short period of time. Month-end, quarter-end and year-end periods are generally times when I/O transactions might double or even more, compared to normal days.

A very active volume (LUN) during the online period might become a close to idle volume during the batch period. A very busy volume during the online period on one day might not have much activity on the following day.

These variabilities make it next to impossible to manually track the changes in the I/O characteristics of each and every volume, let alone to manage the location or placement of those volumes based on their level of activity. Even within a volume there are hot spots, meaning that the I/Os are not evenly distributed across all extents within the volume. In other words, certain extents are hotter (more active) compared to other extents within the same volume.

As you can infer from the foregoing facts, manually micro managing placement of data at the extent level is definitely an impossible task. Even if that was possible to manage, there is no function available to allow manual placement of data by extent. This apparently impossible micro management is exactly what Easy Tier does.

Hot data and cold data

Note that there are two types of data regarding the use of SSD disks:

- *Hot data* refers to data that can have a significant performance improvement if it were migrated from HDD to SSD.
- *Cold data* refers to data that might have very little or no benefit if it were migrated to SSD (and this can include data that is not accessed at all).

Considering storage hierarchy in a virtualized environment, when we refer to data here, we actually mean extent as Easy Tier performs its operations at the extent level.

Moving the data across the storage system resources (that is, physical disks) is always an expensive task in terms of labor and service availability. Nonetheless, data relocation is often required to adapt to physical configuration changes and new performance requirements. This is particularly true when various disk technologies are implemented on the same hardware.

Business users know which applications are their important, business critical applications, and based on that indication, the storage administrator can determine which are the relevant volumes used by those applications. After the volumes have been identified and their sizes are known, the storage administrator can determine how many SSD ranks will be needed to accommodate all those volumes. Placing all those volumes on SSD can definitely provide a significant performance improvement to the application.

The drawback here is that probably a significant number of SSD ranks might be required, which makes the cost prohibitive, as discussed before. In addition, not all volumes are hot, which means that we might be, inefficiently, placing cold volumes on SSD. Furthermore, even on a volume that is considered hot, most probably not all extents on that volume are hot. This can mean that we are not using the available storage on SSD as effectively as we might have preferred.

Easy Tier concept

A performance monitoring embedded function collects performance metrics, at the extent level, for every extent in every volumes. The *Easy Tier* function can analyze the data collected by the monitor and produce a "heat map". The heat map reflects the degree of hotness or temperature of each extent.

Easy Tier then makes data relocation within SSD+HDD storage pools to achieve the optimum performance, by moving hottest extents to SSD, and cooler extents to HDD. This is done automatically, dynamically and transparently to hosts, that is, without disruption to applications.

This significantly improves the overall storage cost performance and simplifies the performance tuning and management.

Firmware feature: Easy Tier is an embedded firmware feature. No additional software or servers are necessary to implement it and benefit from its features.

Consider the example depicted in Figure 15-8; cooler extents are migrated to standard HDD MDisks and hotter extents are migrated to SDD MDisks. The MDisks have their own RAID level and type of disk. In this example we considered RAID 1 for the SDD MDisk and RAID 5 for the HDD MDisk. Note that both SDD MDisk and HDD MDisk are in the same storage pool, that is, a hybrid storage pool. This condition is necessary to make the Easy Tier feature work.

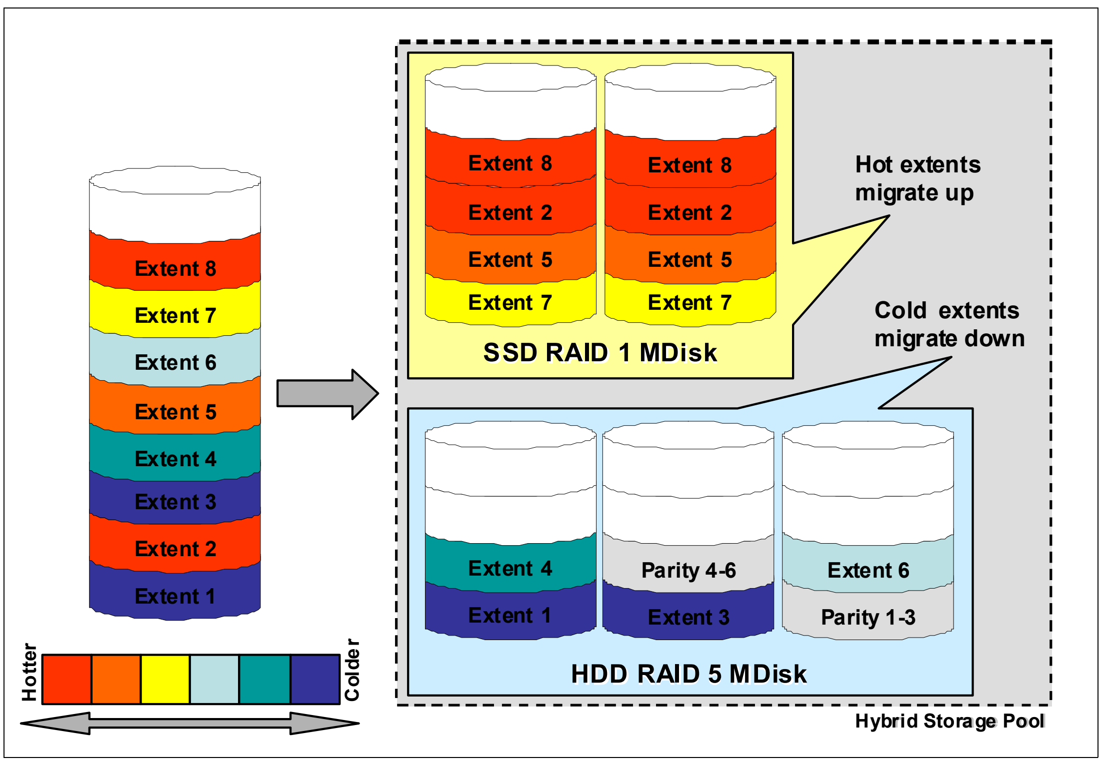


Figure 15-8 The Easy Tier concept

15.6.5 FlashCopy

The FlashCopy function provides the capability to perform a point-in-time (PiT) copy of one or more volumes or groups of volumes (consistency groups). This technique is used to make a consistent copy of a data set that is being constantly updated. The FlashCopy source is frozen for the necessary time to make the PiT copy (typically some seconds). It will be able to accept I/O when the PiT copy bitmap is set up and the FlashCopy function is ready to intercept read/write requests in the IO path. If new data is written to the source or target volume, the existing data on the source is copied to the target volume before the new data is written to the source or target volume. The bitmap is updated to mark that the grain of the source volume has been copied so that later write operations to the same grain do not recopy the data.

To create an instant copy of a volume, you must first create a mapping between the source volume (the disk that is copied) and the target volume (the disk that receives the copy). The source and target volumes must be of equal size.

Although the “real” background copy operation takes time, the resulting data at the target appears as though the copy were made instantaneously. These FlashCopy targets can be used for application data backup, thus reducing backup windows to near zero time from an application perspective. The FlashCopy service also provides the facility to make multiple copies of the same source volume or make copies at various times while preserving the earlier copies (restore points). This is called Multi-target FlashCopy.

With the thin provisioning and volume mirroring functions, it becomes possible to use FlashCopy and thin-provisioned volumes to perform space reclamation within the managed disk space.

FlashCopy can be used to help recover from situations where data has been lost because of application or user error. Here is an example. You are performing routine maintenance and a critical database is accidentally deleted. Typically, after the data is deleted, it is gone permanently. To avoid this problem, you can use FlashCopy to take a snapshot of your data at regular intervals and then use that copy to recover it. Before you begin any maintenance, ensure that your latest backup FlashCopy is complete. Then, after a data loss is discovered, create a new mapping from the FlashCopy target volume to the damaged source volume and start that mapping. Your application will be able to use the recovered source volume while its data is being copied in the background, without any need for you to reconfigure the hosts. After the copy is complete, your data will be recovered to what it was when the most recent backup FlashCopy was started.

Here is another example of how FlashCopy can provide business benefits. FlashCopy can be ideal when you want to create a nightly backup of an application database. Without FlashCopy, the data might have been copied directly to tape, which can take up to 8 hours. During that time, you cannot change data without corrupting the backup tape. And if your company data must be available 24 hours a day, having 8 hours of downtime is unacceptable. Using FlashCopy as part of the backup process can help reduce the time needed for the backup. When FlashCopy is started, your application stops for just a moment, and then immediately resumes. At your leisure you can run the tape backup, using the FlashCopy target volume as the source for the backup. Having minimal downtime while using FlashCopy helps ensure the high availability of your application. While this backup is occurring you can change your data on the source volume without compromising the consistency of the data being copied to tape.

Using FlashCopy for backup can also help you optimize your use of thin provisioning, which occurs when the virtual storage of a volume exceeds its real storage. For example, you can use FlashCopy to map a fully allocated source volume to a thin-provisioned target volume.

The thin-provisioned target volume serves as a consistent snapshot copy that you can use to back up your data to tape. And because this type of target volume uses less real storage than the source volume, it can help you reduce costs in power, cooling, and space.

Full/Incremental FlashCopy

A mapping created with the "incremental" flag copies only the data that has been changed on the source or the target since the previous copy completed. This incremental FlashCopy can substantially reduce the time that is required to recreate an independent image.

The intention of the incremental FlashCopy function is to re-flash an existing FlashCopy relation at a later point in time. In addition, only changes since the last flash must be copied to the target volumes, but not the whole data (Figure 15-9).

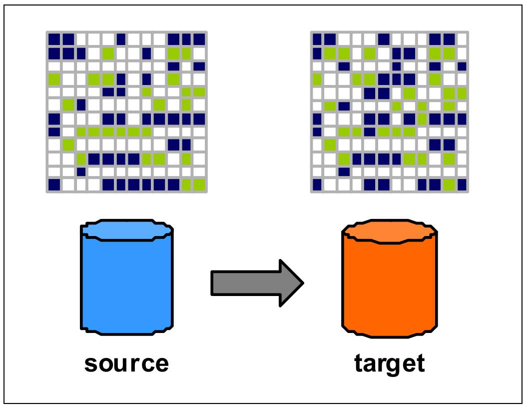


Figure 15-9 Incremental FlashCopy tracks changes in a differences map

For the incremental copy operations, FlashCopy must be capable to identify the differences since last flash operation. For this purpose, two additional bitmaps are introduced, one for the source volume and one for the target volume, as shown in Figure 15-9 on page 486. These bitmaps are referenced as the Change Recording bitmaps. While the out-of-sync bitmap is responsible for the copy process, including blocks which has been copied due to a host change while the copy process has not finished, the change recording bitmaps is journalizing the changes of the relation from the last flash from both volumes independently.

An incremental FlashCopy can also be established as a no-copy relation. In this case just new bitmaps are created, but no copy process will be started. The differences since the last flash recorded in the change recording bitmaps will never be used, because a copy process will not take place. The incremental FlashCopy as a no-copy has in fact the same effect as another no-copy FlashCopy. The advantage of using it is that the relation must not be removed in order to create a new FlashCopy.

If a full copy FlashCopy relation with change recording has to be reversed (see "Reverse FlashCopy", next), in order to restore data to the FlashCopy source volumes, the data which has to be copied in this case, can also be copied incrementally from the target to the source volume. The pair relation has now been turned around, where the source volume has become the target volume and the target volume has become the source volume. When the background copy has been finished, the relation can be used for subsequent incremental FlashCopy operations in this direction, if required.

Multi-target FlashCopy

Multi target volumes are supported from a single source volume to create mappings for different points in time from the source volume. Each copy is managed by a unique mapping and in general, each mapping acts independently and is not affected by other mappings sharing the same source volume. This allows simultaneous multiple actions against the same dataset (using different copies) and facilitates maintenance of multiple versions of the same dataset. This capability can help enhance business continuity solutions implementing the FlashCopy function.

Mappings: Each of the mappings from a single source can be started and stopped independently. If multiple mappings from the same source are active (in the copying or stopping states), a dependency exists between these mappings.

Example 1

Mapping A depends on mapping B if the following statements are true:

- Mapping A and mapping B both have the same source volume.
- Mapping A and mapping B are both in the copying or stopping state.
- Mapping B was started more recently than mapping A.

  If both mappings were in the same consistency group and therefore started at the same time, the order of dependency is decided internally when the consistency group is started.
- Mapping A does not have a complete copy of the source because the copying progress for the mapping is less than 100%.
- A mapping does not exist from the same source started more recently than A and later than B which has a complete copy of the source because the copying progress of the mapping is less than 100%.

Example 2

Target volume A depends on target volume B if the mapping that volume A belongs to depends on the mapping that target volume B belongs to. The target volume of the most recently started mapping from the source volume depends on the source volume until there is a complete copy of the source (progress is 100%).

Cascaded FlashCopy

An extension of FlashCopy technology is cascaded FlashCopy, which allows a target volume in one mapping to be the source volume in another mapping, as shown in Figure 15-10. The linking of mappings in this way is known as a cascade, and there is a limit on the number of mappings allowed in one cascade. This function is used to create copies of copies and supports full, incremental or nocopy operations.

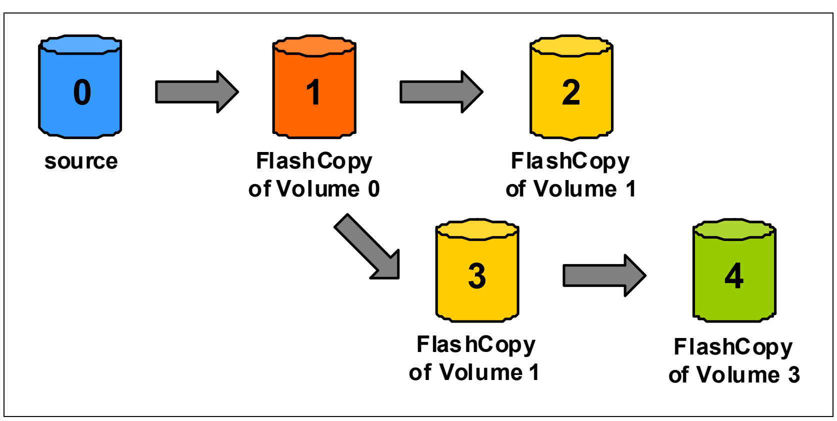


Figure 15-10 Cascading FlashCopy volumes

Reverse FlashCopy

The direction of a FlashCopy relationship can be reversed, where the volume that was previously defined as the target becomes the source for the volume that was previously defined as the source (and is now the target). The data that has changed is copied to the volume previously defined as the source.

You can reverse a FlashCopy relationship if you want to restore a source volume (Volume A) to a point in time before you performed the FlashCopy operation. In effect, you are reversing the FlashCopy operation so that it appears as though no FlashCopy operation ever happened. Keep in mind that the background copy process of a FlashCopy operation must complete before you can reverse volume A as the source and volume B as the target.

There might be certain circumstances when you might want to reverse an original FlashCopy relationship. For example, suppose you create a FlashCopy relationship between source volume A and target volume B. Data loss occurs on source volume A. To keep applications running, you can reverse the FlashCopy relationship so that volume B is copied to volume A.

Reverse FlashCopy enables FlashCopy targets to become restore points for the source without breaking the FlashCopy relationship and without having to wait for the original copy operation to complete.

Mappings: Up to 256 mappings (thus multiple rollback points) can exist in a cascade for both SAN Volume Controller and Storwize V7000. The same limit applies to multi-target FlashCopy: it is possible to copy up to 256 target volumes from a single source volume. Each relationship between a source and target volume is managed by a unique mapping such that a single volume can be the source volume in up to 256 mappings.

A key advantage of Multi-target FlashCopy and Reverse FlashCopy functions is that the reverse does not destroy the original target; thus anything using the target, such as a tape backup process, will not be disrupted; multiple separate recovery points can be tested.

An optional copy of the source volume can be made before starting the reverse copy operation in order to diagnose problems.

Figure 15-11 provides an example of Reverse FlashCopy.

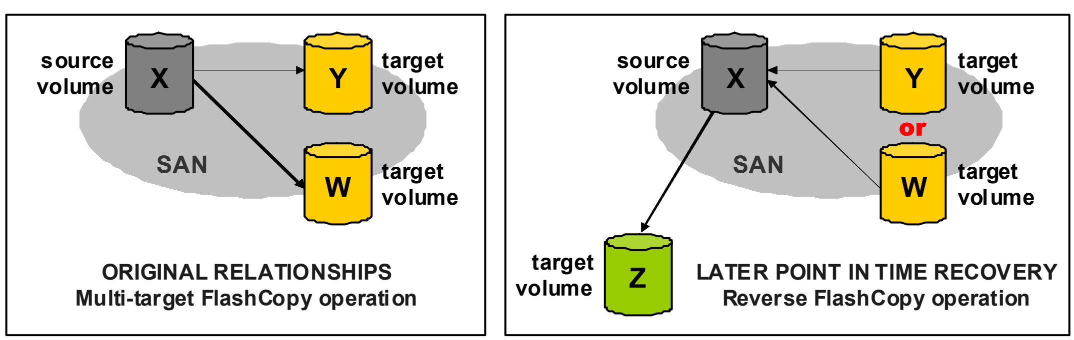


Figure 15-11 Reverse FlashCopy example

The disaster recovery procedure considering a restore from a disk in the provided example can be described as follows:

1. (Optionally) Create a new target volume (Volume Z) and FlashCopy the production volume (Volume X) onto the new target for later problem analysis.
2. Create a new FlashCopy map with the backup to be restored (Volume Y) or (Volume W) as the source volume and Volume X as the target volume if this does not already exist.

3. Start the FlashCopy map (Volume Y → Volume X) with the "-restore" option to copy the backup data onto the production disk.

The production disk will be instantly available with the backup data.

FlashCopy nocopy with thin provisioning

This provides a combination of using thin-provisioned volumes and FlashCopy together to help reduce disk space requirements when making copies. There are two variations of this option:

- Thin-provisioned source and target with background copy

  This copies only the allocated space
- Thin-provisioned target with no background copy

  This copies only the space used for changes between the source and target and is generally referred to as "snapshots".

It can be used with multi-target, cascaded and incremental FlashCopy.

FlashCopy consistency groups

Consistency groups address the problem when applications have related data that spans multiple volumes. In this situation, FlashCopy operations must be performed in a way that preserves data integrity across the multiple volumes. One requirement for preserving the integrity of data being written is to ensure that dependent writes are run in the intended sequence of the application.

When you copy data from one volume to another, the data might not include all that you need to enable you to use the copy. Many applications have data that spans multiple volumes and requires that data integrity is preserved across them. For example, the logs for a particular database usually reside on a different volume than the one that contains the data.

The consistency group is specified when the mapping is created. A consistency group is a container for mappings. You can add many mappings to a consistency group. You can also change the consistency group later. When you use a consistency group, you prepare and start that group instead of the individual mappings. This ensures that a consistent copy is made of all the source volumes. Mappings to control at an individual level are known as stand-alone mappings.

Consistency groups aggregate FlashCopy mappings, not the volumes themselves. Therefore, a source volume with multiple FlashCopy mappings can be in different consistency groups. If a volume is the source volume for several FlashCopy mappings that are in the same consistency group, multiple identical copies of the source volume are created when the consistency group is started.

15.6.6 Metro Mirror and Global Mirror Copy Services

The Metro Mirror and Global Mirror copy services features enable you to set up a relationship between two volumes, so that updates that are made by an application to one volume are mirrored on the other volume.

Although the application only writes to a single volume, the system maintains two copies of the data. If the copies are separated by a significant distance, the Metro Mirror and Global Mirror copies can be used as a backup for disaster recovery. A prerequisite for Metro Mirror and Global Mirror operations is that the SAN fabric to which they are attached provides adequate bandwidth.

For both Metro Mirror and Global Mirror copy types, one volume is designated as the primary and the other volume is designated as the secondary. Host applications write data to the primary volume, and updates to the primary volume are copied to the secondary volume. Normally, host applications do not perform I/O operations to the secondary volume.

Metro Mirror

The Metro Mirror (MM) feature provides a synchronous-copy process. When a host writes to the primary volume, it does not receive confirmation of I/O completion until the write operation has completed for the copy on both the primary volume and the secondary volume, usually in cache, as seen in Figure 15-12. This ensures that the secondary volume is always up-to-date with the primary volume in the event that a failover operation must be performed. However, the host is limited to the latency and bandwidth limitations of the communication link to the secondary volume. Metro Mirror operates over “metropolitan” distances, supporting replication at distances up to 300 Km. As with any synchronous remote replication function, the performance impact on host applications is related to the distance between source and target. Accordingly, application performance requirements might limit the usable distance between sites.

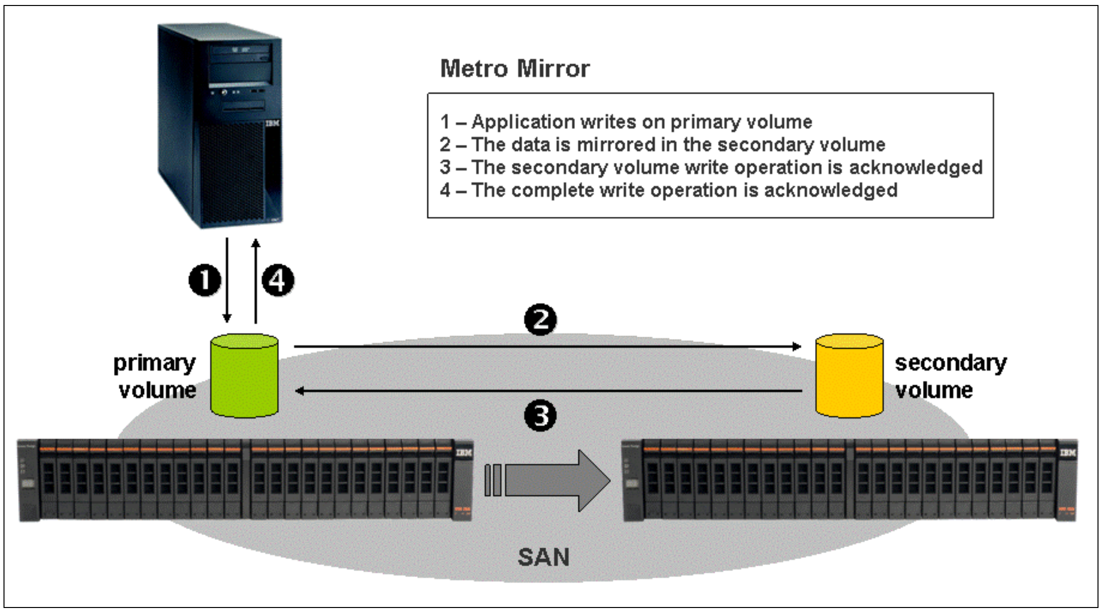


Figure 15-12   Metro Mirror operation

After the initial copy operation from the source location to the target location is complete, the Metro Mirror function is designed to maintain a fully synchronized copy of the source data at the target site at all times. Therefore, Disaster Recovery is the primary application for Metro Mirror. Because an exact copy of your business data can be maintained at a remote location, you can use your remote location as a recovery site in the event of a local disaster.

Global Mirror

The Global Mirror (GM) feature provides an asynchronous-copy process. When a host writes to the primary volume, confirmation of I/O completion is received before the write operation has completed for the copy on the secondary volume, as shown in Figure 15-13 on page 491. That means that the secondary volume is not an exact match of the primary volume at every point in time.

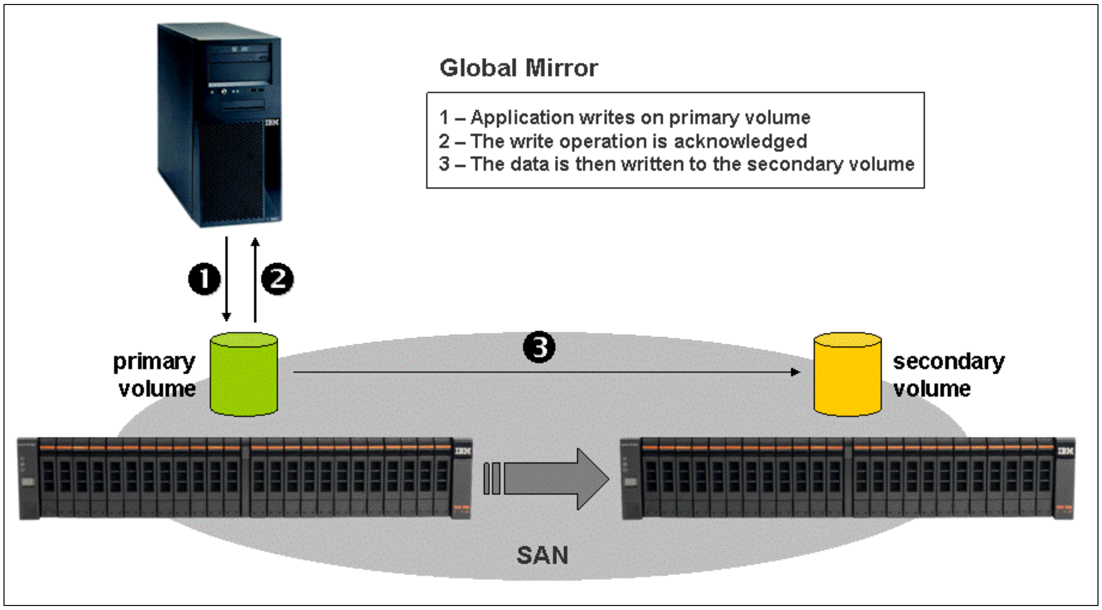


Figure 15-13 Global Mirror operation

This feature is comparable to a continuous backup process in which the last few updates are always missing. When you use Global Mirror for disaster recovery, you must consider how you want to handle these missing updates. If a failover operation is performed, the application must recover and apply any updates that were not committed to the secondary volume. If I/O operations on the primary volume are paused for a small length of time, the secondary volume can become an exact match of the primary volume.

Global Mirror supports much longer distances than those supported by Metro Mirror.

Usage

Metro Mirror and Global Mirror are delivered as a single feature, which gives great flexibility to customers to use one or both functions as necessary. The Storwize V7000 MM and GM functions operate between Storwize V7000 systems at each site. The SVC MM and GM functions operate between SVC clusters at each site.

Unlike conventional Metro Mirror and Global Mirror functions, with virtualized storage, the source and target volumes can be in the same or separate disk systems, which can come from any supported storage, from any supported vendor.

Restrictions: Usage of Remote Mirror target volumes as Remote Mirror source volumes (cascaded remote mirroring) is not allowed. A FlashCopy target volume cannot be used as Remote Mirror source volume as well.

Building up a partnership between up to four IBM Storwize V7000 systems is allowed. Regarding SVC, multiple cluster mirroring enables Metro Mirror and Global Mirror relationships to exist between a maximum of four SVC clusters. Each cluster can maintain up to three partnerships, and each partnership can be with a single remote cluster. The following examples show possible partnerships that can be established among up to four Storwize V7000 or among up to four SAN Volume Controller clusters. Intermixing Storwize V7000 systems and SVC clusters is **not** supported.

Figure 15-14 shows two Storwize V7000 systems or SVC clusters with no partnerships.

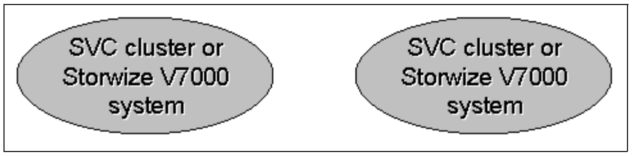


Figure 15-14 Two Storwize V7000 systems or SVC clusters with no partnerships

Figure 15-15 shows two Storwize V7000 systems or SVC clusters with one partnership.

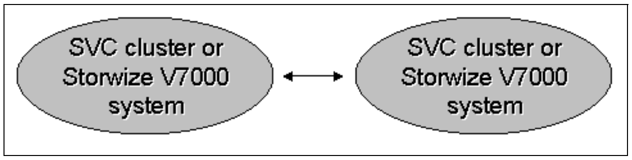


Figure 15-15 Two Storwize V7000 systems or SVC clusters with one partnership

Figure 15-16 shows four Storwize V7000 systems or SVC clusters in a partnership. The one in the center might be a disaster recovery site.

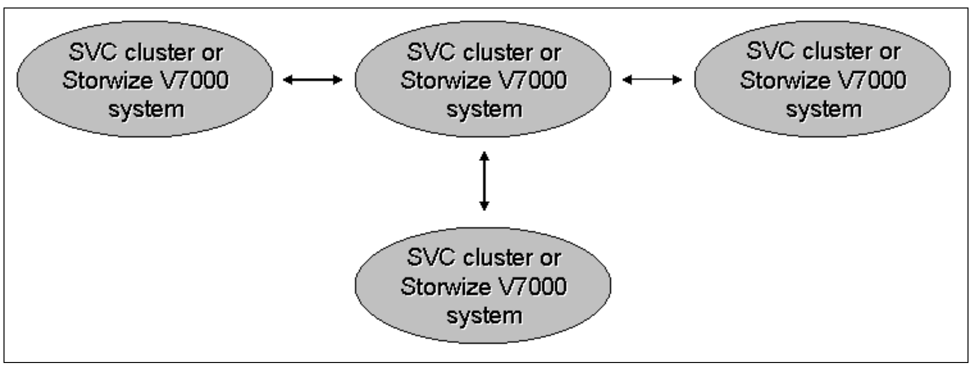


Figure 15-16 Four Storwize V7000 systems or SVC clusters in a partnership

Figure 15-17 shows three Storwize V7000 systems or SVC clusters in a migration situation. The Data Center on the right is migrating to the one down. The DataCenter on the left is host production, and the other ones are disaster recovery.

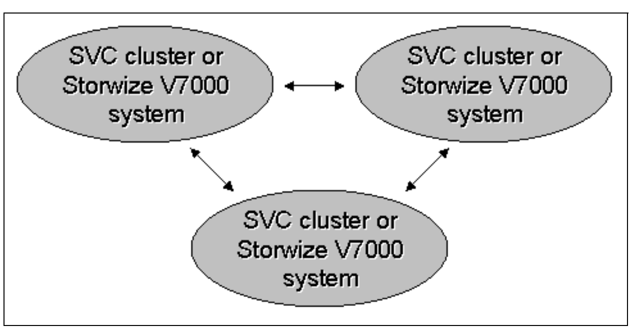


Figure 15-17 Three Storwize V7000 systems or SVC clusters in a migration situation

Figure 15-18 shows a fully connected mesh configuration. Every Storwize V7000 system or SVC cluster has a partnership to each of the three other Storwize V7000 systems or SVC clusters.

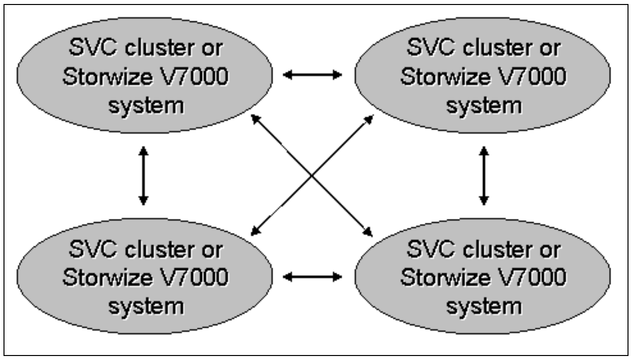


Figure 15-18 Fully connected mesh configuration

Figure 15-19 shows four Storwize V7000 systems or SVC clusters in three partnerships

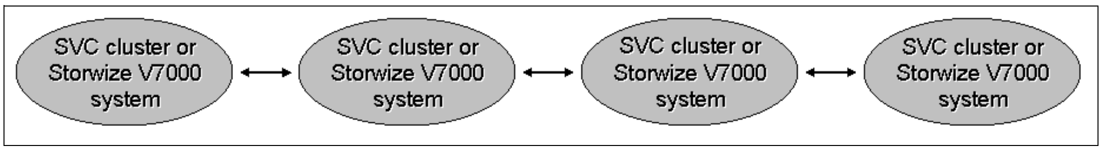


Figure 15-19 Four Storwize V7000 systems or SVC clusters in three partnerships

Interoperation: At the time of writing, it is not possible to interoperate MM and GM between SVC clusters and Storwize V7000 systems.

For the provided examples, both Metro Mirror and Global Mirror are supported within the same overall configuration (for example, site #1 to site #2 as Metro Mirror, and site #3 to site #1 as Global Mirror).

Remote Mirror link requirements

The link requirements are valid for Metro Mirror and Global mirror. Basically, there are two link requirements:

- Round trip latency:

  Total round trip latency must be <80ms, and in each direction <40ms
- Bandwidth:

  The required bandwidth is based on the following considerations:
  - Peak write load for all mirrored volumes
  - Additional background copy rate (best practice is 10% to 20% of maximum peak load) for initial synchronization and re synchronization
  - Remote Mirror internal communication with approximately 2.6 Mbps

For more information about Remote Mirroring, see *Implementing the IBM System Storage SAN Volume Controller V5.1*, SG24-6423 and *SAN Volume Controller V4.3.0 Advanced Copy Services*, SG24-7574.

Metro Mirror and Global Mirror consistency groups

You can group Metro Mirror or Global Mirror relationships into a consistency group so that they can be updated at the same time. A command that is issued to the consistency group is simultaneously applied to all of the relationships in the group.

Metro Mirror or Global Mirror relationships can be based on “loose” or “tight” associations. A more significant use arises when the relationships contain volumes with a tight association. A simple example of a tight association is the spread of data for an application across more than one volume. A more complex example is when multiple applications run on different host systems. Each application has data on different volumes, and these applications exchange data with each other. In both examples, specific rules exist as to how the relationships can be updated. This ensures that the set of secondary volumes contain usable data. The key property is that these relationships are consistent.

Metro Mirror or Global Mirror relationships can only belong to one consistency group; however, they do not have to belong to a consistency group. Relationships that are not part of a consistency group are called stand-alone relationships. A consistency group can contain zero or more relationships. All relationships in a consistency group must have matching primary and secondary clusters, which are sometimes referred to as master and auxiliary clusters. All relationships in a consistency group must also have the same copy direction and state.

Metro Mirror and Global Mirror relationships cannot belong to the same consistency group. A copy type is automatically assigned to a consistency group when the first relationship is added to the consistency group. After the consistency group is assigned a copy type, only relationships of that copy type can be added to the consistency group. Each cluster can have a maximum of six different types of consistency groups.

15.7 More information

For more information about the IBM System Storage Virtualization family, see this website:

http://www.ibm.com/systems/storage/virtualization

For more information about SAN virtualization, see *Virtualization in a SAN*, REDP-3633,

For more information about the SNIA Shared Storage Model, see this website:

http://www.snia.org/education/storage_networking_primer/shared_storage_model/

For an Introduction to Virtualization tutorial from SNIA, see this website:

http://www.snia.org/images/tutorial_docs/VirtualStnds/Peglar_Virtualization_I.pdf

16

IBM System Storage SAN Volume Controller

The IBM System Storage SAN Volume Controller (SAN Volume Controller) is an IBM storage virtualization solution that helps increase the utilization of existing capacity and centralize the management of multiple controllers in an open-system SAN environment.

The SAN Volume Controller supports attachment to IBM and non-IBM storage systems. It enables storage administrators to reallocate and scale storage capacity and make changes to underlying storage systems without disrupting applications.

In this chapter, we provide an overview of the SAN Volume Controller (SVC) and discuss some of its features and capabilities.

16.1 IBM System Storage SAN Volume Controller: Overview

The IBM System Storage SAN Volume Controller (SVC), machine type 2145, provides the ability to simplify the storage infrastructure, utilize storage resources more efficiently, improve personnel productivity and increase application availability. The SAN Volume Controller pools storage volumes from IBM and non-IBM disk arrays into a single reservoir of capacity which can be managed from a central point. The SAN Volume Controller allows data to be migrated between disk arrays without disrupting the applications and moves copy services into the network where the same suite of copy services tools can be applied across the entire storage configuration irrespective of storage vendor restrictions that normally apply for the individual disk controllers in use.

16.1.1 Introduction

Storage area networks (SAN) enable companies to share homogeneous storage resources across the enterprise. But for many companies, information resources are spread over a variety of locations and storage environments, often with products from various vendors. To achieve higher utilization of resources, companies need to be able to share their storage resources from all of their environments, regardless of vendor. While storage needs rise rapidly, and companies operate on lean budgets and staffing, the best solution is one that utilizes the investments already made and that provides growth when needed. The IBM System Storage SAN Volume Controller offers a solution that can help strengthen existing SANs by increasing storage capacity, efficiency, uptime, administrator productivity and functionality.

16.1.2 Design intent

The IBM System Storage SAN Volume Controller is designed to handle the following tasks:

- Combine storage capacity from multiple vendors into a single repository of capacity with a central management point
- Help increase storage utilization by providing host applications with more flexible access to capacity
- Help improve productivity of storage administrators by enabling management of combined storage volumes from a single interface
- Support improved application availability by insulating host applications from changes to the physical storage infrastructure
- Enable a tiered storage environment, in which the cost of storage can be better matched to the value of data
- Support advanced copy services, from higher-cost to lower-cost devices and across subsystems from multiple vendors

The SAN Volume Controller combines hardware and software into a comprehensive, modular appliance. Using IBM System x server technology in highly reliable clustered pairs, the SAN Volume Controller has no single points of failure. SAN Volume Controller software is a highly available cluster optimized for performance and ease of use.

Storage utilization

The SAN Volume Controller is designed to help increase the amount of storage capacity that is available to host applications. By pooling the capacity from multiple disk arrays within the SAN, it helps enable host applications to access capacity beyond their island of SAN storage. SNIA estimates are that open systems disk utilization in a non-virtualized environment is only between 30%-50% currently.

Scalability

A base configuration SAN Volume Controller consists of a single I/O group. An I/O group is a pair of high performance, redundant Intel processor-based servers (referred to as *nodes* or *storage engines*). Highly available I/O groups are the basic configuration of a cluster. Adding another I/O group can help increase cluster performance and bandwidth.

The SAN Volume Controller can scale *out to* support up to four I/O groups, and it can scale *up* to support 1024 host servers. For every cluster, the SVC supports up to 8192 *volumes*. SAN Volume Controller Version 6.1 supports up to 256 virtualized disk systems, and supports volumes up to 256 TB in size. This configuration flexibility means that SAN Volume Controller configurations can start small with an attractive price to suit smaller environments or pilot projects and then can grow with your business to manage very large storage environments.

Management

The SAN Volume Controller is managed at the cluster level, providing a single point of control over all the managed storage. The SAN Volume Controller provides a comprehensive, easy-to-use graphical interface for central management. This simple interface incorporates the Storage Management Initiative Specification (SMI-S) API, and further demonstrates the IBM commitment to open standards. With this single interface, administrators can perform configuration, management and service tasks over storage volumes from all the attached storage controllers. The GUI allows administrators to map disk storage volumes to virtual pooled volumes to help better use existing storage. The GUI offers a single point access, available anywhere on the network, with a web browser.

SAN Volume Controller Version 6.1 introduces a completely new graphic user interface modeled on the IBM XIV Storage System, which has been very well received by customers. The new user interface is designed to be much easier to use and includes many built-in IBM guidelines to help simplify storage provisioning and enable new users to get started quickly with a rapid learning curve. At the same, the new interface preserves access to all the functional richness that experienced users have come to expect from SVC.

SAN Volume Controller uses the IBM System Storage Productivity Center (SSPC), an advanced management console that can provide a view of both IBM and non-IBM storage environments. While the new design provides many advantages over the former SVC Console, enhancements include greater flexibility of views, increased number of characters allowed for naming objects, display of the command lines being executed, and improved user customization within the GUI.

Customers using Tivoli Storage Productivity Center and IBM Systems Director can take advantage of integration points with the new SVC Console. As with managing the SVC under Tivoli Storage Productivity Center, IBM Systems Director will be enabled to perform most common day to day activities for SVC without ever needing to leave the IBM Systems Director user interface. SVC Console users on SVC V5.1 and prior releases will need to migrate from their present user interface to the new user interface when upgrading to SVC V6.1. See the *Implementing the IBM System Storage SAN Volume Controller V6.1*, SG24-7933 further instructions.

Linking infrastructure performance to business goals

By pooling storage into a single reservoir, the SAN Volume Controller helps insulate host applications from physical changes to the storage pool, in order to minimize disruption. The SVC simplifies the storage infrastructure by including a dynamic data-migration function, which migrates storage from one device to another, without taking it offline. Using this function, administrators can reallocate and scale storage capacity without disrupting applications, increasing application availability.

With the SVC, your business can build an infrastructure from existing assets that is simpler to manage, easier to provision, and can be changed without impacting application availability. Businesses can use their assets more efficiently and actually measure the improvements. They can allocate and provision storage to applications from a single view and know the effect on their overall capacity situation instantaneously. They can also quantify improvements in their application availability to enable better quality of service goals. These benefits help businesses manage their costs and capabilities more closely, linking the performance of their infrastructure to their individual business goals.

Tiered storage

In most IT environments, inactive data makes up the bulk of stored data. The SAN Volume Controller helps administrators control storage growth more effectively by moving low-activity or inactive data into a hierarchy of lower-cost storage. Administrators can free disk space on higher-value storage for more-important, active data. This is achieved by creating various groups of storage, corresponding to underlying storage with various characteristics, for example, speed and reliability. With the SAN Volume Controller, you can better match the cost of the storage used to the value of data placed on it.

Copy services

With many conventional SAN disk arrays, copy services can be performed within the array, or between identical arrays. The SAN Volume Controller enables administrators to apply a single set of advanced copy services, such as the IBM FlashCopy and, Metro Mirror, and Global Mirror service across multiple storage subsystems from various vendors.

Technology for an on demand environment

Businesses are facing growing, critical application data supported by complex heterogeneous storage environments, while their staffs are overburdened. The SAN Volume Controller is one of many offerings in our System Storage portfolio that are essential for an on demand storage environment. These offerings can help you simplify your IT infrastructure, manage information throughout its lifecycle and maintain business continuity.

16.2 New features in SAN Volume Controller 6.1

SVC 6.1 features new functional enhancements, with functionality improvements and increased maximum configuration limits. These are the most recent technical changes:

- Easy Tier function
- Updated license settings
- Enhanced automatic upgrade functions
- New external storage systems supported
- Enhanced iSCSI host attachment support
- New command-line interface commands
- SVC for XIV

For detailed information about the new enhancements, see the “What’s New session in SVC” Information Center:

http://publib.boulder.ibm.com/infocenter/svc/ic/index.jsp

16.2.1 Terminology changes

To coincide with new and existing IBM products and functions, several common terms have changed and are incorporated in the SAN Volume Controller. Table 16-1 shows the current and previous usage of the changed common terms.

Table 16-1 SVC terminology changes

SVC new term	SVC previous term	Description
volume	*virtual disk (VDisk)*	A discrete unit of storage on disk, tape, or other data recording medium that supports some form of identifier and parameter list, such as a volume label or input/output control.
thin provisioning (or thin-provisioned)	*space-efficient*	The ability to define a storage unit (full system, storage pool, volume) with a logical capacity size that is larger than the physical capacity assigned to that storage unit.
storage pool	*managed disk (MDisk) group*	A collection of storage capacity that provides the capacity requirements for a volume.
host mapping	*VDisk-to-host mapping*	The process of controlling which hosts have access to specific volumes within a cluster.
event	*error*	An occurrence of significance to a task or system. Events can include completion or failure of an operation, a user action, or the change in state of a process.

16.2.2 Easy Tier

SVC Version 6.1 adds the Easy Tier capability, identical in function to the version on IBM DS8000 or IBM Storwize V7000. Here we discuss SSD support in SVC and its use on Easy Tier function. For more information about the Easy Tier, see 15.6.4, “Easy Tier” on page 482.

SSD support in the SAN Volume Controller

The optional solid state drives (SSDs) available in the 2145-CF8 nodes provide high-speed managed disk (MDisk) capability for SAN Volume Controller. They are available in the 2145-CF8 nodes only. SDDs can be pre-installed in the new nodes or installed on a per disk basis at a later point in time without interrupting service, as a field hardware upgrade.

The performance improvements made in CPU cache/memory access times have been far greater than the physical disk performance improvements made during the same period of time. The disks are limited by the rotational speed and mechanical positioning technology used. As a result there is now a huge difference between time to access data resident in cache or memory (typically in the region of 10 - 50 nanoseconds for L2 cache and DRAM) and data on even the fastest disks (5 -10 ms).

SSD technology or Storage Class Memory (SCM) can help in overcoming the problem that has grown over the last few decades, and is known as the *Memory/Storage Bottleneck*. The diagram in Figure 16-1 shows a graphical representation of the scale of this problem and how SCM can help.

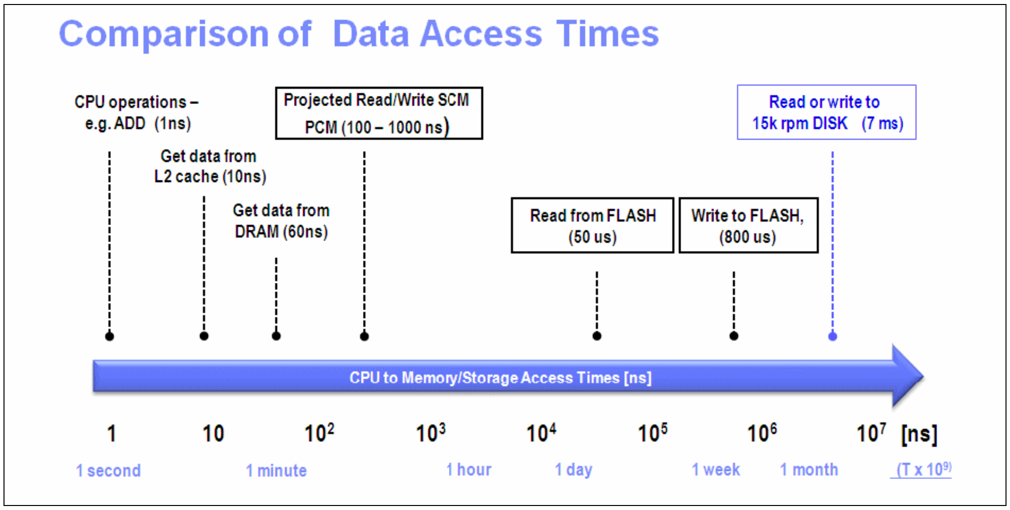


Figure 16-1 The Memory/Storage bottleneck

SVC SSD configuration rules

There are some rules that must be followed to use SSD disks.

SSD configuration rules for nodes, I/O groups, and clusters

You must follow the SAN Volume Controller SSD configuration rules for nodes, I/O groups, and clusters:

- Nodes that contain SSDs can coexist in a single SAN Volume Controller cluster with any other supported nodes.
- Do not combine nodes that contain SSDs and nodes that do not contain SSDs in a single I/O group. However, while upgrading an earlier SAN Volume Controller node to a SAN Volume Controller 2145-CF8 node, you can temporarily combine the two node types in a single I/O group.
- Nodes in the same I/O group must share the same number of SSDs.
- Quorum functionality is not supported on SSDs within SAN Volume Controller nodes.

SSD configuration rules for MDisks and storage pools

You must follow the SAN Volume Controller SSD configuration rules for MDisks and MDisk groups:

- Each SSD is recognized by the cluster as a single MDisk.
- For each node that contains SSDs, create a single MDisk group that includes only the SSDs that are installed in that node.

SSD configuration rules for volumes

You must follow the SAN Volume Controller SSD configuration rules for volumes that use storage from SSDs within SAN Volume Controller nodes. In the following rules, SAN Volume Controller SSD storage is a storage pool that uses SSDs within a SAN Volume Controller node.

Rules: SSD storages within SAN-attached storage systems, such as the IBM DS8000, are not subject to these configuration rules.

These are the configuration rules for volumes:

- Volumes that use SAN Volume Controller SSD storage must be created in the I/O group that the SSDs physically reside in.
- Volumes that use SAN Volume Controller SSD storage must be mirrored to another managed disk group to provide fault tolerance. The following mirroring configurations are supported:
  - To maximize performance, create the two volume copies in the two storage pools that correspond to the SAN Volume Controller SSD storage in two nodes in the same I/O group.
  - To maximize utilization of SSD capacity, place the primary volume copy on SAN Volume Controller SSD storage, and the secondary copy on Tier 1 storage such as an IBM DS8000.
- To balance the read workload, evenly split the primary and secondary volume copies on each node that contains SSDs.
- The preferred node for the volume must be the node that contains the SSDs that are used by the primary volume copy.
- If you shut down a node that contains unmirrored volume that use SAN Volume Controller SSD storage, you will lose access to any volume that are associated with SSD storage in that node.
- I/O requests to SSDs in other nodes are automatically forwarded, but this produces additional delays. The SSD configuration rules are designed to direct all host I/O operations to the node that contains the relevant SSDs.

SVC SSD performance

The scale out performance provided by the unique SVC SSD implementation will deliver ultra-high throughput and fast response time for hard-to-tune workloads, up to 800,000 read IOPS. Also, SSD is fully integrated within the SAN Volume Controller architecture. Replication, data movement, and management are the same for the SSD backed MDisk or volume storage as for any other managed storage in the SAN Volume Controller.

SVC SSD features

Here we highlight a few of the SSD features available:

- Up to four SSDs can be installed on each SAN Volume Controller 2145-CF8 node.
- Each SSD provides up to 140 GB of capacity.
- SSDs are hot-pluggable and hot-swappable.
- There can be up to 560 GB usable SSD capacity per node, 2.4 TB (mirrored) per cluster.
- SVC Version 6.1 further improves efficiency when using SSDs by supporting RAID protection for internal solid-state drives in addition to mirroring.

Easy Tier feature

Easy Tier is a function that responds to the presence of solid-state drives (SSDs) in a storage pool that also contains hard disk drives (HDDs). The system automatically and non disruptively moves frequently accessed data from HDD MDisks to SSD MDisks, thus placing such data in a faster tier of storage.

Easy Tier eliminates manual intervention when assigning highly active data on volumes to faster responding storage. In this dynamically tiered environment, data movement is seamless to the host application regardless of the storage tier in which the data resides. Manual controls exist so that you can change the default behavior, for example, such as turning off Easy Tier on storage pools that have both types of MDisks.

SAN Volume Controller supports these tiers:

- Generic SSD tier:

  The SSD tier exists when SSDs are in the storage pool. The SSDs provide greater performance than hard disk drives (HDDs).

- Generic HDD tier:

  The HDD tier exists when HDDs are in the storage pool.

  All MDisks belong to one tier or the other, which includes MDisks that are not yet part of a storage pool.

An overview of the Easy Tier feature is shown in Figure 16-2.

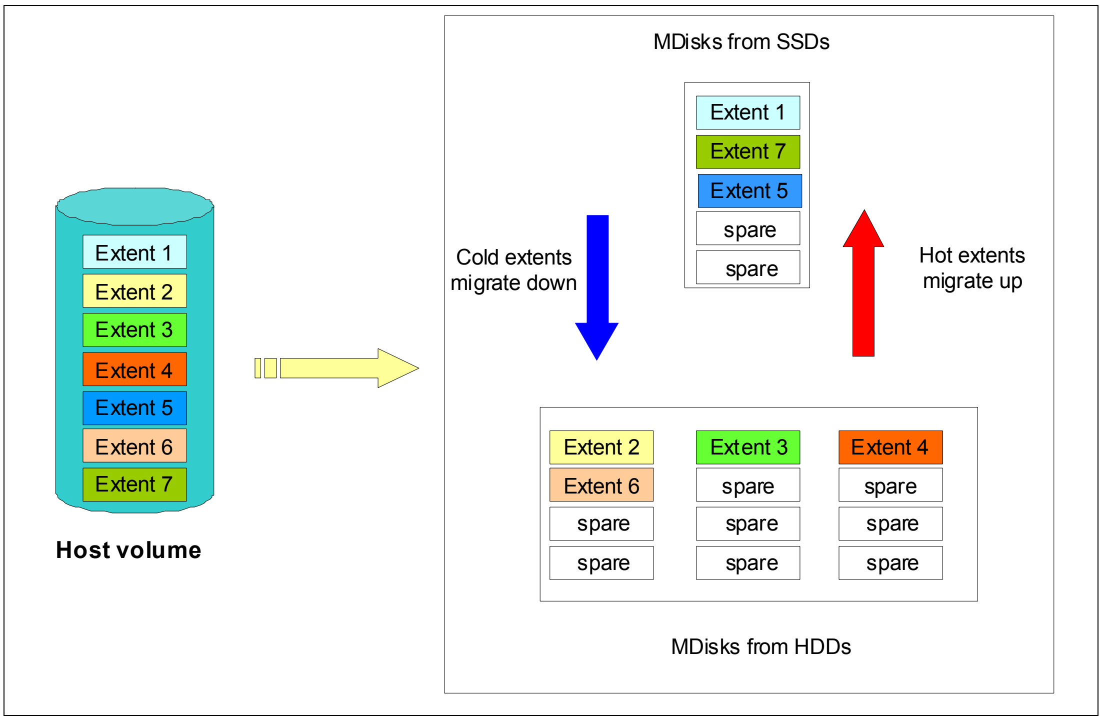


Figure 16-2 Easy Tier overview

Note that the Easy Tier function works in an extent level. For more information, see 15.6.4, "Easy Tier" on page 482.

16.2.3 SVC for XIV (5639-SX1)

The new PID 5639-SX1, IBM SAN Volume Controller for XIV Software V6, is priced by the number of storage devices (also referred to as modules or enclosures). For example, a six-module XIV system behind SVC requires a quantity six storage devices of the appropriate feature code under 5639-SX1. There are unique feature codes for the two different drive size offerings from XIV (1 TB and 2 TB). There are no unique feature codes for FlashCopy and Metro/Global Mirror under 5639-SX1. Use of FlashCopy and Metro/Global Mirror is covered for the capacity of the storage devices licensed under 5639-SX1.

Customers can determine how many enclosures of 5639-SX1 to order by the size of the XIV system configuration. For example, a 12-module XIV configuration has 61 TB usable capacity (after factoring in disk space used by mirroring for redundancy, spares, and metadata) for 1 TB drives and 125 TB usable capacity for 2 TB. For more information about the usable capacity, see the product fact sheet for XIV available from this website:

http://www.ibm.com/systems/storage/disk/xiv/

A customer managing heterogeneous storage with XIV systems can calculate the remaining storage to virtualize under a 5639-VC6 license, by subtracting the usable capacity of the XIV configuration. Customers will use a similar methodology to enter what capacity they are entitled to by adding up the usable capacity of the XIV systems managed under the 5639-SX1 license with the remaining capacity under the 5639-VC6 license. In every other way, other than those points described herein, the 5639-SX1 license is like the 5639-VC6 license (same code prerequisites, same hardware limitations, and so on) which is described in the license information. There is no conversion of 5639-VC6 licenses to 5639-SX1. For existing SAN Volume Controller customers, changes to licensing must be addressed with an IBM sales representative.

16.3 SAN Volume Controller architecture

The IBM System Storage SAN Volume Controller is based on the COMmodity PArts Storage System *(Compass)* architecture developed at the IBM Almaden Research Center. The overall goal of the Compass architecture is to create storage subsystem software applications which minimize the changes required when new storage hardware is deployed. The approach is to minimize the dependency on unique hardware, and to allow exploitation of, or migration to, new SAN interfaces simply by plugging in new commodity adapters. Compass solutions can scale and expand over time, because they can be ported to just about any platform and remain current with the latest processor and chipset technologies on each. The SAN Volume Controller compass architecture implementation uses Linux as a convenient development platform to deploy this function. This has, and will continue to, enhance the ability of IBM to deploy robust function in a timely way.

The SAN Volume Controller is a modular solution that consists of a management console (SSPC) for management, up to eight cluster nodes, and external UPS, one for each node, for write cache data protection.

A SAN Volume Controller node is a single processing unit within a SAN Volume Controller cluster. For redundancy, nodes are deployed in pairs to make up a cluster. A cluster can have one to four pairs of nodes. Each pair of nodes is known as an I/O group. Each node can be in only one I/O group. A maximum of four I/O groups each containing two nodes is supported. At any one time, a single node in the cluster manages configuration activity. This configuration node manages a cache of the configuration information that describes the cluster configuration and provides a focal point for configuration commands. If the configuration node fails, another node in the cluster takes over its responsibilities. Each of the engines in the cluster is populated with up to 24GB of high-speed memory, which serves as the cluster cache. A management card installed in each server monitors various parameters used by the cluster to determine the optimum and continuous data path.

In simple terms, a cluster is a collection of servers that, together, provide a set of resources to a client. The key point is that the attached hosts (clients) using the SAN Volume Controller to access storage have no knowledge of the underlying physical hardware of the cluster. This means that the host client is isolated and thus protected from changes to the physical storage hardware. This brings a number of benefits. Perhaps the most important of these benefits is high availability. Resources on clustered servers act as highly available versions of unclustered resources. If a node (an individual computer) in the cluster is unavailable, or too busy to respond to a request for a resource, the request is transparently passed to another node capable of processing it. Clients are, therefore, unaware of the exact locations of the resources they are using, as can be seen in the diagram in Figure 16-3.

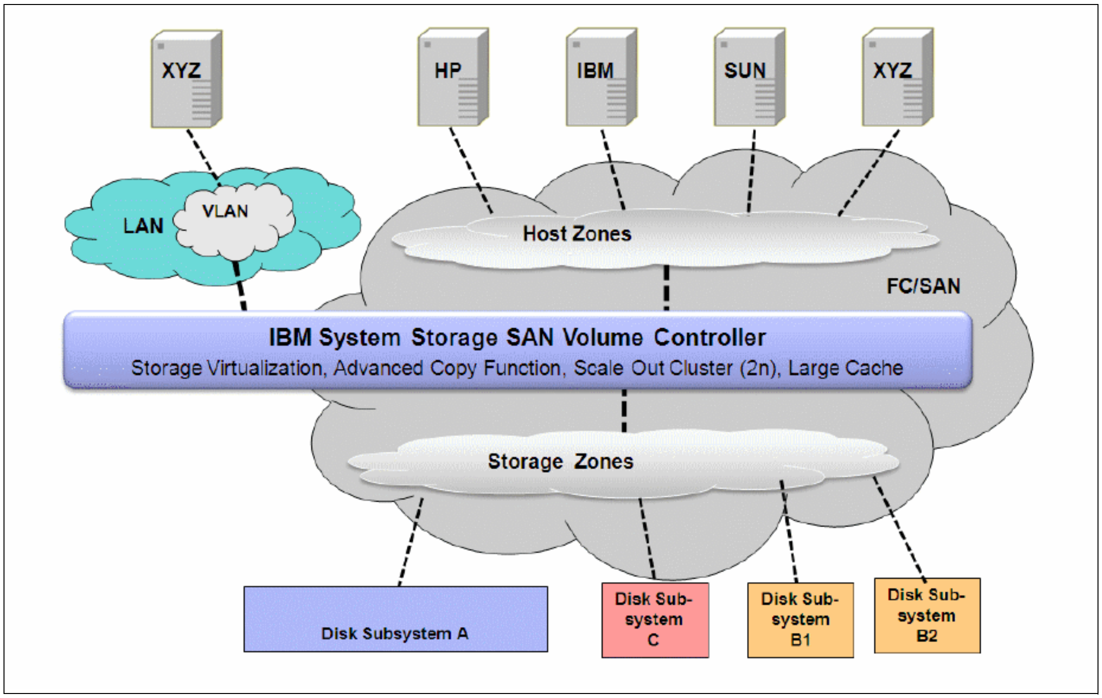


Figure 16-3 SAN Volume Controller Architecture overview

During normal cluster operation, the nodes keep in touch with each other. If a node is idle for a while (a few seconds) then a heartbeat signal is sent to assure connectivity with the cluster. If a node fails for any reason, the workload intended for it will be taken over by another node until the failed node has been restarted and re-admitted to the cluster (which happens automatically). If the microcode on a node becomes corrupted, resulting in a failure, the workload is transferred to another node. The code on the failed node is repaired, and the node is re-admitted to the cluster (again, all automatically).

Clustering: Although the SAN Volume Controller code is based on a Linux kernel, the clustering feature is not based on Linux clustering code. The clustering failover and failback feature is part of the SAN Volume Controller application software itself.

SAN Volume Controller nodes within the cluster are grouped into pairs (called I/O groups), with a single pair being responsible for serving I/O on a given volume (a volume is the SAN Volume Controller device that appears to a host system as a SAN attached disk). One node within the I/O Group represents the preferred path for I/O to a given volume; the other node represents the non-preferred path. This preference will alternate between nodes as each volume is created within an I/O Group to balance the workload evenly between the two nodes.

Each I/O group contains up to 4 of mirrored cache (on SAN Volume Controller model CF8 nodes). Each node also includes a Host Bus Adapter (HBA) providing four 8 Gbps FC SAN connections, and two 1 Gbps Ethernet connections for iSCSI and management interface connectivity.

The HBA allows the SAN Volume Controller to connect and operate at up to 8 Gbps SAN speed.

- 8Gbps for CF8 and 8A4 nodes.
- 4 Gbps (Standard for 8G4 and 8F4 and option for 8F2)
- 2 Gbps (standard for model 4F2 and 8F2)

Beyond automatic configuration and cluster administration, data from attached storage clients is also transmitted reliably. When data is written by the host, the preferred node within the I/O Group stores a write in both its own write cache and the write cache of its partner (non-preferred) node before sending an "I/O complete" status back to the host application. To ensure that data is written if a node fails, the surviving node empties its write cache and proceeds in write-through mode until the cluster is returned to a fully operational state.

As yet another data protection feature, the SAN Volume Controller is supplied with UPS. In addition to voltage regulation to protect valuable electronic components within the SAN Volume Controller configuration, in the event of a main power outage, the UPS provides enough power to destage data to the SAN Volume Controller internal disk and shut down the nodes within the SAN Volume Controller cluster gracefully. This is a feature found in most high-end disk subsystems.

Important: The SAN Volume Controller UPS is essentially an NVram destage backup battery. This UPS does not provide "normal" UPS facilities to allow the SAN Volume Controller to continue operation in the event of external power failure. Ensure that an external UPS is provided if this functionality is required.

16.3.1 SVC Hardware

The IBM 2145 System Storage SAN Volume Controller Storage Engine Model CF8, based on the IBM System x3550 M2, has an Intel Core Xeon 5500 Series quad-core processor, two power supply units (PSUs), 24 GB of cache, and four 8 Gbps Fibre Channel host bus adapter (HBA) ports for attachment to the SAN, two 1 Gbps Ethernet ports, plus support to SSD drives. This model auto-negotiates the fabric speed on a per-port basis and is not restricted to run at the same speed as other node pairs in the cluster.

Availability: The SVC model 8A4 has been withdrawn on November 2010.

16.3.2 SVC features

The IBM SAN Volume Controller makes possible several enhancements in business solutions, as discussed in 16.7, "SAN Volume Controller solutions" on page 516. To achieve that, SVC offers the features discussed next.

Thin provisioning

Traditional fully allocated volumes allocate real physical disk capacity for an entire volume even if never used. Thin provisioning provides the ability to allocate real physical disk capacity only when data is actually written to the logical volume. A thin-provisioned volume can have a logical capacity size that is larger than the physical capacity assigned to it.

A thin-provisioned volume can be configured to autoexpand, which causes SVC to automatically expand the real capacity of a thin-provisioned volume as its real capacity is used.

A thin-provisioned volume can be converted to a fully allocated volume using volume mirroring (and vice versa).

For more information, see 15.6.2, "Thin provisioning" on page 480.

Volume mirroring

Volume mirroring enables a volume to have two physical copies, each one of them in separate storage pool. Depending on how the storage pools are allocated, copies can be on completely separate disk storage systems that are being virtualized. If one copy fails, SVC will provide continuous data access by redirecting I/O to the remaining copy. When the failed copy becomes available automatic resynchronization occurs.

For more information, see 15.6.3, “Volume mirroring” on page 481.

FlashCopy

This function provides volume level point-in-time copy function for any storage being virtualized by SVC. This is designed to create copies for backup, parallel processing, test and development and have the copies available almost immediately.

IBM SVC offers the following FlashCopy functions:

Full/Incremental Copy

This function copies only the changes from either the source or target data since the last FlashCopy operation and is designed to enable completion of point-in-time online backups much more quickly than using traditional FlashCopy.

Multi-target FlashCopy

IBM SVC supports copying up to 256 target volumes from a single source volume. Each copy is managed by a unique mapping and in general, each mapping acts independently and is not affected by other mappings sharing the same source volume.

Cascaded FlashCopy

This function is used to create copies of copies and supports full, incremental or nocopy operations.

Reverse FlashCopy

This function allows for data from an earlier point-in-time copy to be restored with minimal disruption to the host.

FlashCopy Nocopy with Thin Provisioning

This function provides a combination of using thin-provisioned volumes and FlashCopy together to help reduce disk space requirements when making copies. There are two variations of this option:

- Thin-provisioned source and target with background copy:

  This copies only the allocated space.

- Thin-provisioned target with no background copy:

  This copies only the space used for changes between the source and target and is generally referred to as “snapshots”.

It can be used with multi-target, cascaded and incremental FlashCopy.

For more information about FlashCopy, see 15.6.5, “FlashCopy” on page 485.

FlashCopy consistency groups

Consistency groups address the issue where application data resides across multiple volumes. By placing the FlashCopy relationships into a consistency group, commands can be issued against all of the volumes residing in the group. This enables a consistent point-in-time copy of all of the data even though it might reside on a separate physical volume.

FlashCopy mappings can be members of a consistency group, or they can be operated in a stand-alone manner, not as part of a consistency group. FlashCopy commands can be issued to a FlashCopy consistency group, which affects all FlashCopy mappings in the consistency group, or to a single FlashCopy mapping if it is not part of a defined FlashCopy consistency group.

For more information, see “FlashCopy consistency groups” on page 489.

Metro Mirror and Global Mirror

Metro Mirror provides synchronous remote mirroring function up to approximately 300 Km between sites. As the host write operation only completes after the data is cached at both locations, performance requirements can limit the practical distance. Metro Mirror provides fully synchronized copies at both sites with zero data loss after the initial copy is completed.

Global Mirror provides long distance asynchronous remote mirroring function for up to approximately 8,000 Km between sites. With Global Mirror the host write operation is completed with a local write and the changed data is sent to the remote site later. This is designed to maintain a consistent recoverable copy of data at the remote site which lags behind the local site.

Metro Mirror and Global Mirror can operate between multiple SVC clusters. For more information, see 15.6.6, “Metro Mirror and Global Mirror Copy Services” on page 489.

Remote Mirror consistency groups

A consistency group is a logical entity that groups copy relationships. By grouping the relationships, you can ensure that these relationships are managed in unison and the data within the group is in a Consistent state. consistency groups have the same limitations as standard volumes.

For more information, see 15.6.6, “Metro Mirror and Global Mirror Copy Services” on page 489.

16.4 SAN Volume Controller virtualization

The SAN Volume Controller provides block aggregation and volume management for disk storage within the SAN. Essentially this means that the SVC manages a number of back-end storage controllers and maps the physical storage within those controllers to logical disk images that can be seen by application servers and workstations in the SAN. The SAN is zoned in such a way that the application servers cannot see the back-end storage, preventing any possible conflicts caused by the SVC and the application servers both trying to manage the same back-end storage devices or LUNs.

The SVC I/O Groups are connected to the SAN so that all back-end storage and all application servers are visible to all of the I/O Groups. The SVC I/O Groups see the storage presented to the SAN by the back-end controllers as a number of disks, known as Managed Disks or MDisks. Because the SVC does not attempt to provide recovery from physical disk failures within the back-end controllers MDisks are usually, but not necessarily, part of a RAID array. The application servers, on the other hand, do not see the MDisks at all.

The zoning layout is shown in Figure 16-4. Host zones connect the hosts to the I/O Groups, and the disk zone connects the I/O Groups to the storage controllers. Typically there are several host zones, because hosts can be grouped together in “host groups” to better manage access.

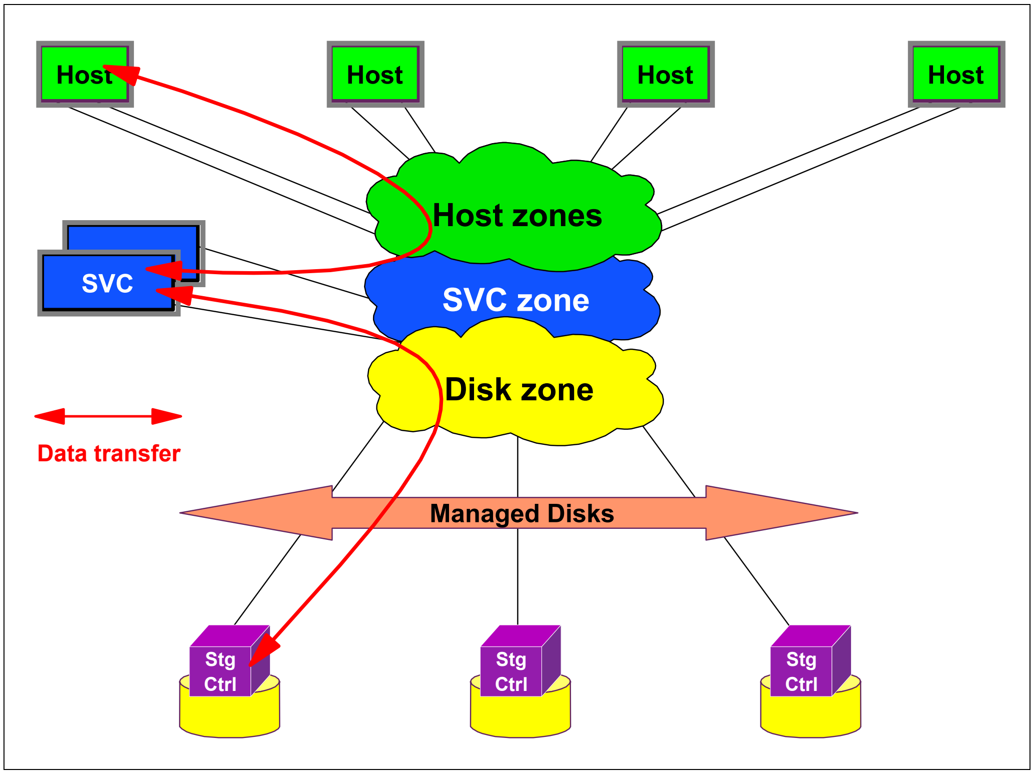


Figure 16-4 How to zone for correct SAN Volume Controller disk access

The MDisks are collected into groups, known as storage pools. The MDisks that are used in the creation of a particular volume must all come from the same storage pool. Each MDisk is divided up into a number of extents (default minimum size 16 MB, maximum size of 8 GB), which are numbered sequentially from the start to the end of each MDisk. The maximum 8 GB extent size is a SVC version 6.1 improvement. Conceptually, this can be represented as shown in Figure 16-5.

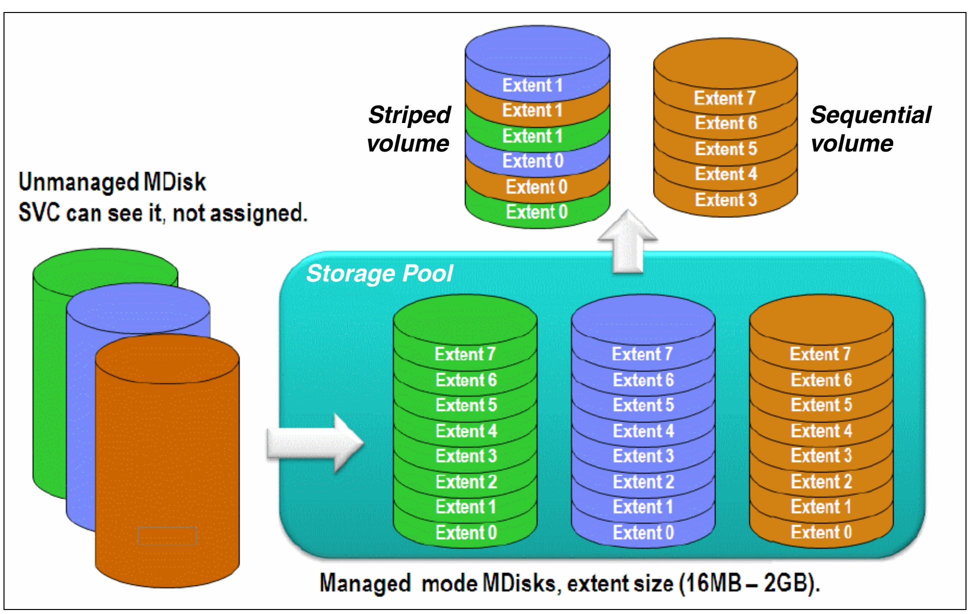


Figure 16-5 Extents being used to create a volume

The virtualization function in the SAN Volume Controller maps the volumes seen by the application servers on to the MDisks provided by the back-end controllers. I/O traffic for a particular volume is, at any one time, handled exclusively by the nodes in a single I/O Group. Therefore, although a cluster can have many nodes within it, the nodes handle I/O in independent pairs. This means that the I/O capability of the SVC scales well (almost linearly), because additional throughput can be obtained by simply adding additional I/O Groups.

Each SVC node presents a volume to the SAN through multiple paths, usually four. In normal operation, two nodes are used to provide redundant paths to the same storage, meaning that depending on zoning, a single host HBA will see up to eight paths to each LUN presented by the SVC. See Figure 16-6. Because most operating systems are not able to resolve multiple paths back to a single physical device, IBM provides a multipathing device driver at no additional cost.

The multipathing driver provided by IBM is the IBM Subsystem Device Driver (SDD). Note that the SDD code supports both the SVC and the disk systems such as the ESS, DS6000, and DS8000. Provided the latest version is used, a host can connect concurrently to both an SVC and a “native” DS6000 or Ds8000 environment. Other multipath softwares are also supported, like MPIO for Windows and AIX, MPxIO for Solaris, native NetWare, VMware, OpenVMS, Tru64, and SGI Irix. For more information about the supported multipath software, see the IBM SVC Datasheet, available at the following website

http://www.ibm.com/systems/storage/software/virtualization/svc/index.html

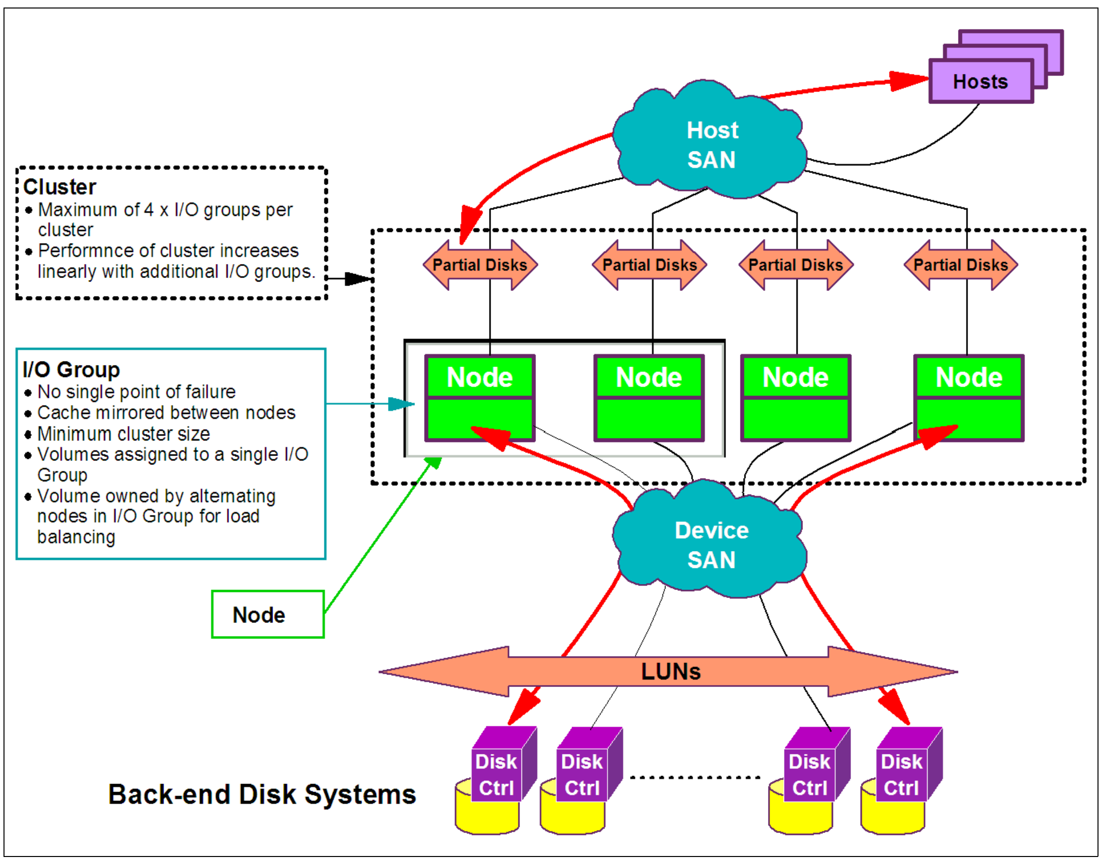


Figure 16-6 SAN Volume Controller logical view

Considerations:

- Nodes auto-negotiate the fabric speed on a per-port basis and are not restricted to run at the same speed as other node pairs in the cluster.
- To provide high availability, the SAN Volume Controller nodes must be configured in redundant SAN fabrics.
- The Fibre Channel switches need to be zoned to permit the hosts to see the SVC nodes and the SVC nodes to see the storage Controllers. The SVC nodes within a cluster must be able to see each other and the master console. In addition, if there are two SVC clusters with Metro Mirror (formerly referred to as PPRC) services between them, zoning must be set so that all the nodes in both clusters see all the other nodes in both clusters.
- As well as a Fibre Channel connection or connections, each device has an Ethernet connection for configuration and error reporting, though only one of the nodes, the configuration node, binds an IP address to its Ethernet connection.

16.5 SAN Volume Controller iSCSI host attachment

SVC supports attachment to servers using iSCSI protocols over IP networks, which can help reduce costs and simplify server configuration. iSCSI attachment avoids the cost of Fibre Channel host bus adapters (HBAs) in servers and reduces the need for Fibre Channel switch ports. This capability can be particularly attractive for IBM BladeCenter server configurations.

All SVC functionality available to FC attached hosts is also available to any iSCSI attached hosts with the exception of host boot support. This new functionality is available at no extra cost to all SVC customers, the iSCSI attachment feature is part of the SVC base software since version 5.1.

SVC uses the node built-in Ethernet ports for iSCSI traffic. All node types which can run SVC v5.1.0 or later can use the iSCSI feature (that is all nodes apart from model 4F2).

SVC supports the CHAP authentication methods for iSCSI, IP addresses can fail over to the partner node in the IO group if a node fails. This reduces the need for multipathing support in the iSCSI host.

Support for iSCSI features one additional ipv4 and one additional ipv6 address for each Ethernet port on every node. These IP addresses are independent of the cluster configuration IP addresses.

16.5.1 Sample configurations

The following diagrams indicate a sample of the available configurations for iSCSI and management interface connections. We only show ipV4 addresses for clarity, but ipV6 addresses can also be assigned in addition to, or instead of, ipV4 addresses:

- Figure 16-7 indicates the simplest configuration with all interfaces on the same subnet.
- Figure 16-8 shows a three subnet configuration with redundant iSCSI connections and a single management subnet.
- Figure 16-9 shows a fully redundant configuration.

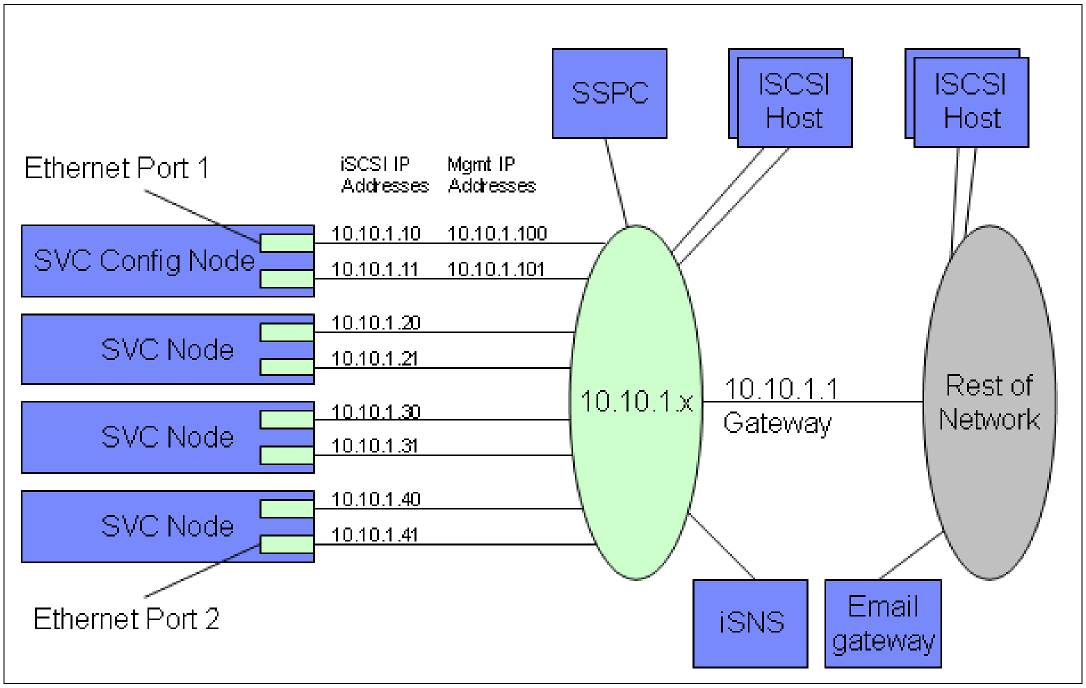


Figure 16-7 Simple single subnet config

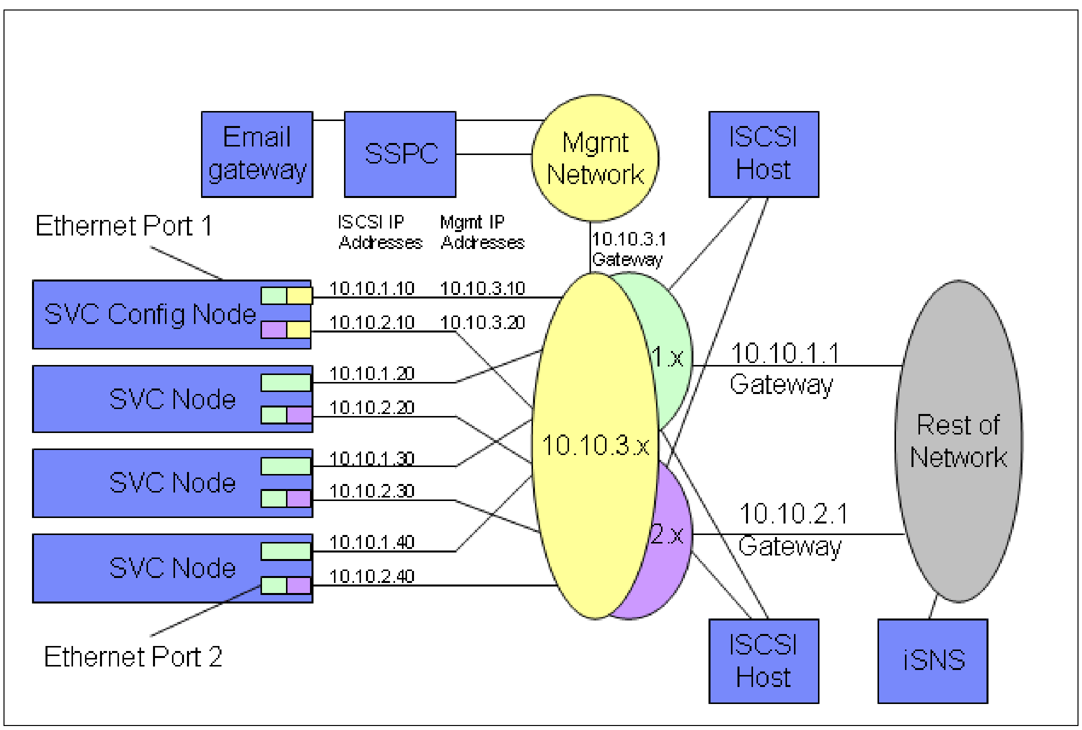


Figure 16-8 Redundant iSCSI subnets

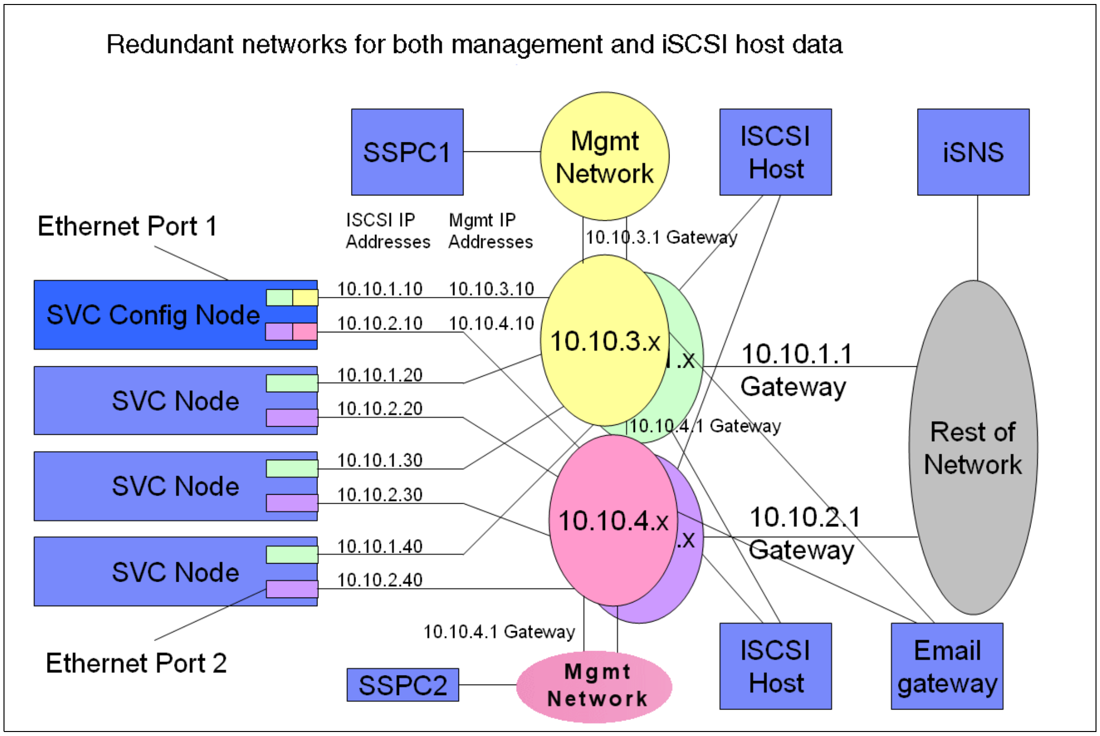


Figure 16-9 Fully redundant iSCSI and management subnets

16.5.2 Supported iSCSI host attachments

The following list details the available iSCSI host attach options:

- RHEL SP 5.3, RHEL 4 update 6 (32 and 64-bit)
- SLES10 SP2 (32 and 64-bit)
- Windows 2003 SP1, SP2
- Windows 2008 SP1, SP2
- AIX 5.3, 6.1
- Sun Solaris 10
- HP-UX 11i V3
- VMware vSphere ESX 4.0

16.6 SAN Volume Controller software licensing

SVC software 5639-VC6 is licensed on a per-terabyte (with cumulative tiers) site-wide capacity basis. Users can only install this program on IBM System Storage SAN Volume Controller 2145-CF8, 2145-8G4, 2145-8A4, 2145-8F4, and 2145-8F2 Storage Engines, or subsequent IBM replacements of these.

Customers are licensed to use this program only to manage storage capacity within a single site, and only for the amount of storage capacity within that site for which they have received proper authorization from IBM. Customers must obtain a separate license for any additional sites within which they want to use SAN Volume Controller Software V6 (5639-VC6) and obtain separate capacity authorizations for each such site. The 5639-VC6 site license subsumes and supersedes all individual 5639-VC1, 5639-VC2, 5639-VCT, 5639-VC3, 5639-VC4, and 5639-VC5 licenses previously in effect at that site.

A customer's right to use the IBM FlashCopy for SAN Volume Controller and Metro/Global Mirror for SAN Volume Controller features of this program is also limited to the amount of authorizations obtained from IBM. The authorizations for FlashCopy and for Metro/Global Mirror cannot exceed the total capacity authorization for the amount of managed storage on all clusters within the site.

Use of FlashCopy features requires license authorizations for only the FlashCopy sources, not the targets. Use of Metro/Global Mirror features requires license authorizations for both the Metro/Global Mirror source and target capacities in use. Use of the Metro/Global Mirror feature between clusters located in different sites requires separate authorization for each site.

In the following topics, we show a detailed version of software licensing, with examples.

There are three parameters to consider when licensing the SAN Volume Controller software:

- The amount of storage managed by the SAN Volume Controller cluster:

  The total amount of storage that is managed by the SAN Volume Controller cluster might be greater than the amount of storage that is virtualized by the cluster. Usage is charged based on the amount of managed disk and not the amount of storage virtualized by a cluster, as shown in Figure 16-10.

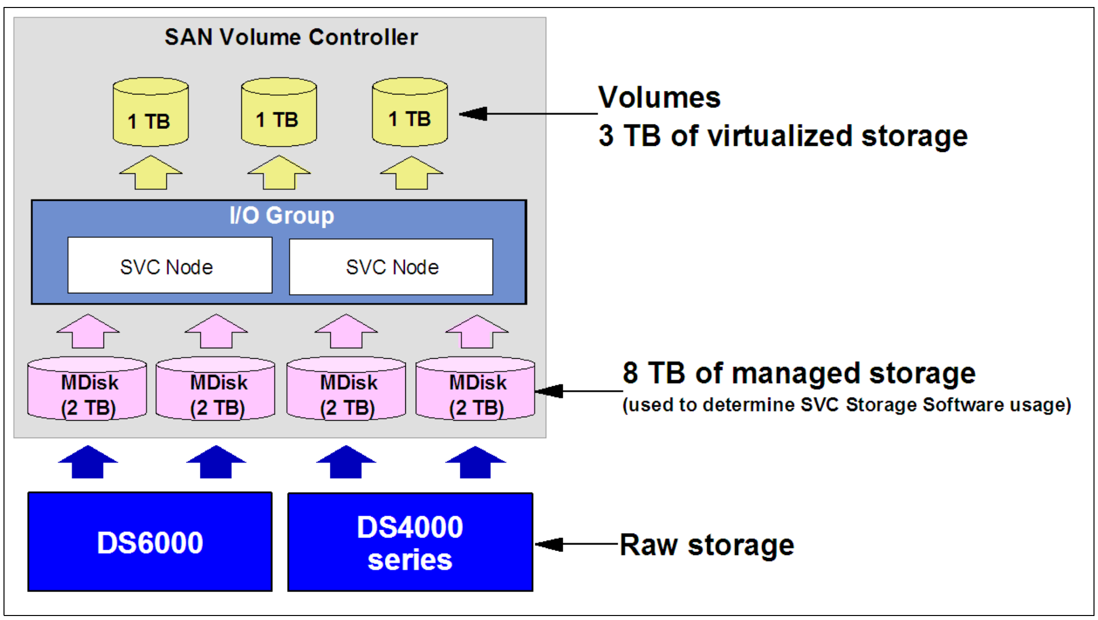


Figure 16-10 SAN Volume Controller managed storage-based licensing

- The amount of storage participating in FlashCopy:

  The amount of virtualized storage that you want to participate in simultaneous active FlashCopy relationships is priced based on the amount of source storage using FlashCopy in a cluster. You might want to manage 8 TB of storage, but FlashCopy only 1 TB of storage. In this case, you need a 1 TB FlashCopy license even though there is 1 TB of source and 1 TB of target FlashCopy volumes. See Figure 16-11.

  A single mapping from a source volume of 1 TB to a target of 1 TB consumes 1 TB of license quota, further multiple target mappings from the same source consume no extra license quota. A mapping from a 1 TB target of an existing mapping to another 1 TB target (a cascaded mapping) consumes a further 1 TB of license quota because the target data from the first mapping becomes source data for the cascaded mapping.

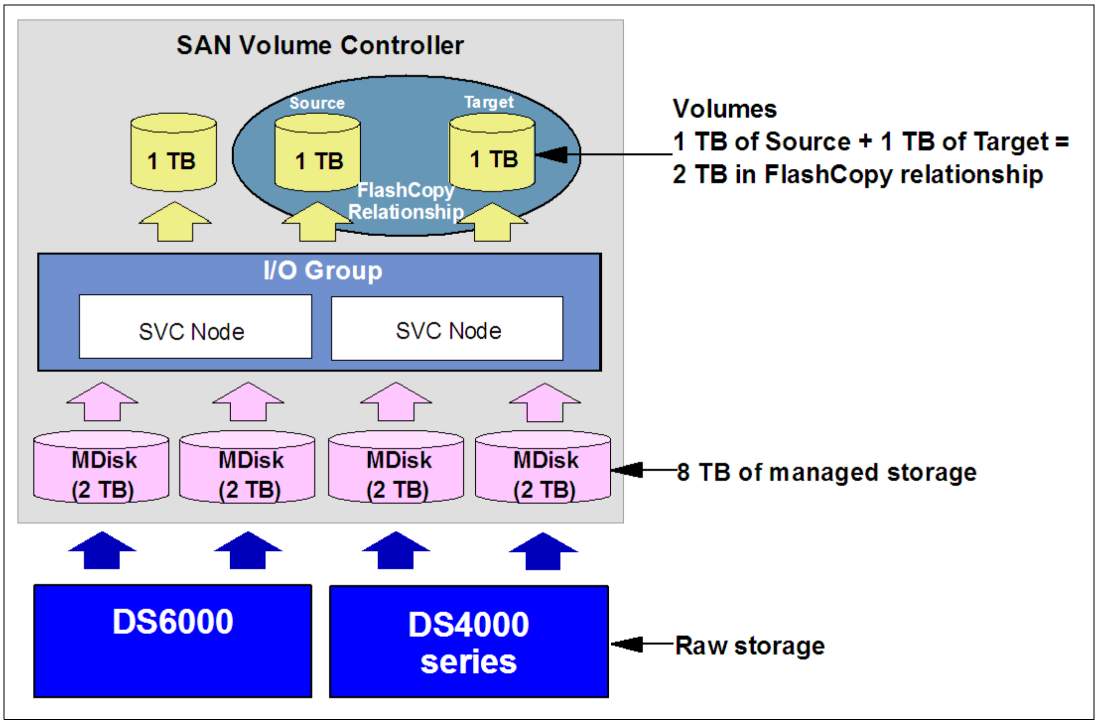


Figure 16-11 FlashCopy license illustration

- The amount of virtualized storage in Metro or Global Mirror relationships:

  You might be managing 8 TB of storage and cascading FlashCopies of 1 TB of data (2 TB FlashCopy license required) and Metro Mirror copying 1 TB. In this case, both clusters that are taking part in the Metro Mirror relationship require a 1 TB Metro Mirror license. Both primary and secondary volume sizes must be licensed even if it is an intracluster Metro Mirror, where both volumes are in the same cluster. See Figure 16-12.

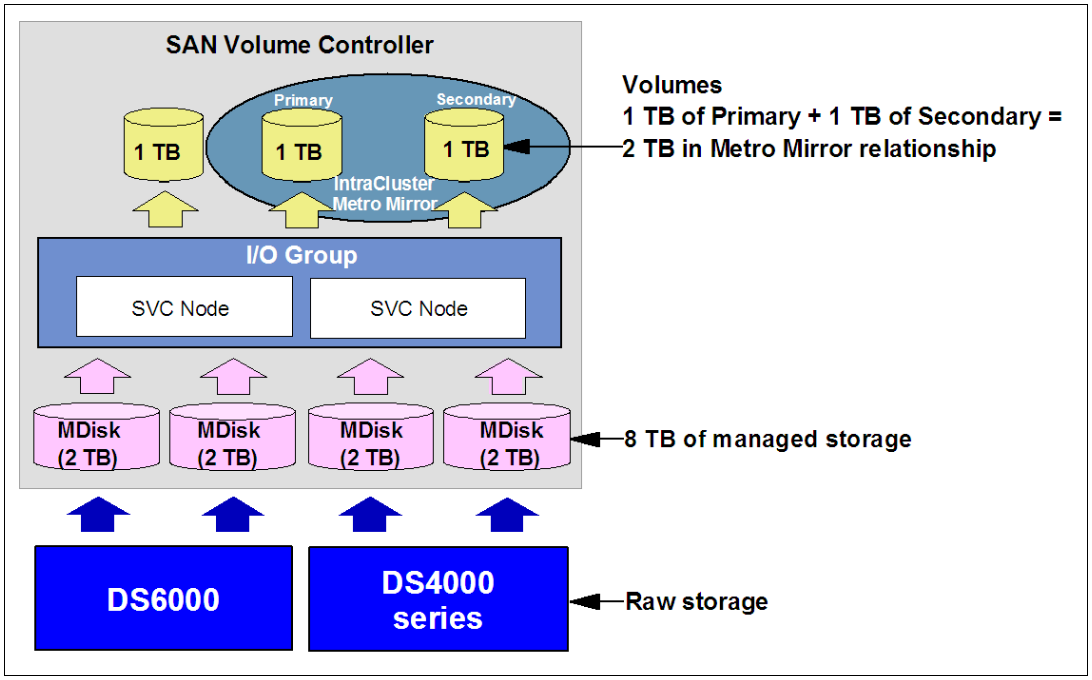


Figure 16-12 Metro Mirror and Global Mirror license illustration

As another example including Global Mirror, consider at site A: 10 TB of virtualization, 2 TB source for Metro Mirror, 2 TB target for Metro Mirror, and 2 TB source for Global Mirror; at Site B: Base virtualization of 4 TB, and 2 TB of target for Global Mirror (source is at Site A). This requires a Site A order for 10 TB base virtualization with 6 TB Metro/Global Mirror and a Site B order for 4 TB base virtualization and 2 TB of Metro/Global Mirror.

It is possible to increase any one of these three licenses independently of the other. That is, you can increase the total amount of managed storage without increasing the other licenses if the amounts of storage being copied remains unchanged. Similarly it is possible to change the copy licenses independently of each other.

16.7 SAN Volume Controller solutions

The SAN Volume Controller's unique features give it real advantages when used for storage tasks such as replication, data migration and storage capacity allocation.

16.7.1 Business continuity

Replicating data in a heterogeneous SAN environment from a high performance storage type at a central site to a lower cost set of storage at a remote site is always a performance concern. There are limits to the array based replication ability to have consistency groups across unlike devices. Also host level replication consumes precious server resources. SAN Volume Controller with its Metro Mirror and Global Mirror functions eliminates this problem making it significantly simpler to deploy for disaster recovery.

The Metro Mirror and Global Mirror functions operate between SVC systems at different locations to help create copies of data for use in the event of a catastrophic event at a data center. Metro Mirror is designed to maintain a fully synchronized copy at “metropolitan” distances (up to 300 Km) whereas Global Mirror is designed to operate asynchronously and so helps maintain a copy at much greater distances (up to 8,000 Km).

Both functions are designed to support VMware vCenter Site Recovery Manager to help speed disaster recovery. The SVC Multiple Cluster Mirror function is designed to enable an SVC cluster to have remote copy relationships with more than one other cluster. For example, this function helps support a single consolidated disaster recovery location supporting up to three production locations, which can help reduce overall costs for implementing a business continuance strategy.

Both Metro Mirror and Global Mirror on SVC are supported by IBM TotalStorage Productivity Center for Replication.

16.7.2 Infrastructure simplification

The SAN Volume Controller helps simplify the storage infrastructure by data migration and storage capacity utilization features.

Data migration

Data migration is the process of moving data from one storage volume to another. This might be required because you want to move less valuable data to cheaper storage, or perhaps a new faster storage system has been purchased, and you want to move critical data onto it. In non-virtualized environments, this is a disruptive, time-consuming operation, requiring application downtime. Certain storage systems do not support a direct remote copy function - which forces host-based volume drain, back up to tapes or restore from tapes during the migration. In addition data is unavailable during the migration process.

Figure 16-13 shows a typical migration process without the SAN Volume Controller:

- Step 1: Take the storage offline.
- Step 2: Migrate data from old storage array to new storage array.
- Step 3: After migration, re-establish connections to host and bring the new storage system online.
- Step 4: Return or dispose of old array.

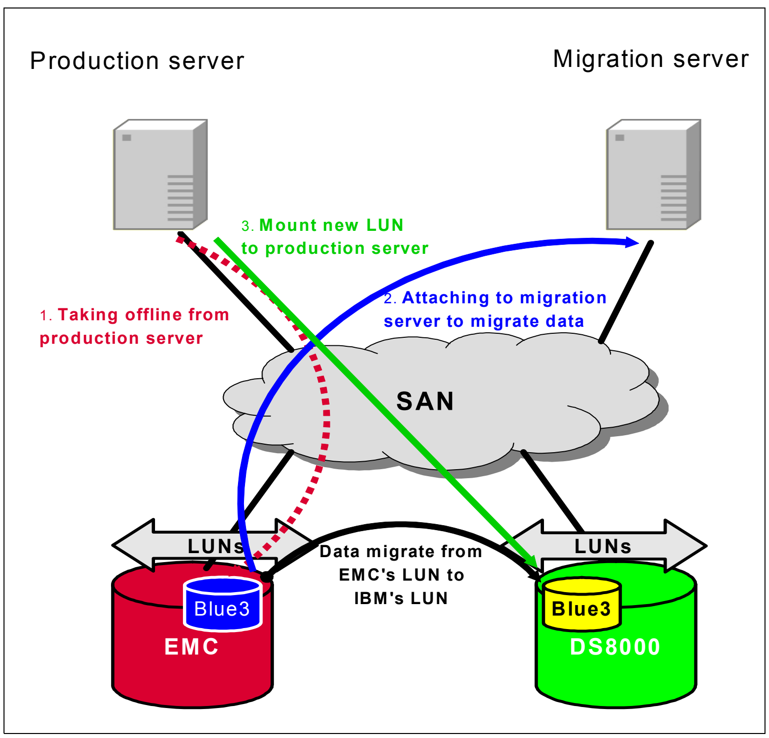


Figure 16-13 Data migration using SAN

Figure 16-14 shows how you can migrate from a non-virtualized environment, to a SAN Volume Controller virtual environment:

1. The existing storage, applications and hosts are identified.
2. Next the SVC is installed, and the original volume to be migrated is mapped as a “hypothetical” or unmanaged SAN volume on the SVC. The application server now sees the virtual volume with all the existing data mapped to it. Operations can proceed as before.
3. Finally, if for example, more space is required for that data, you can non-disruptively move the data from the original volume to a new virtual volume. This will allow dynamic expansion of the volume and frees up the space used by the original application disk.

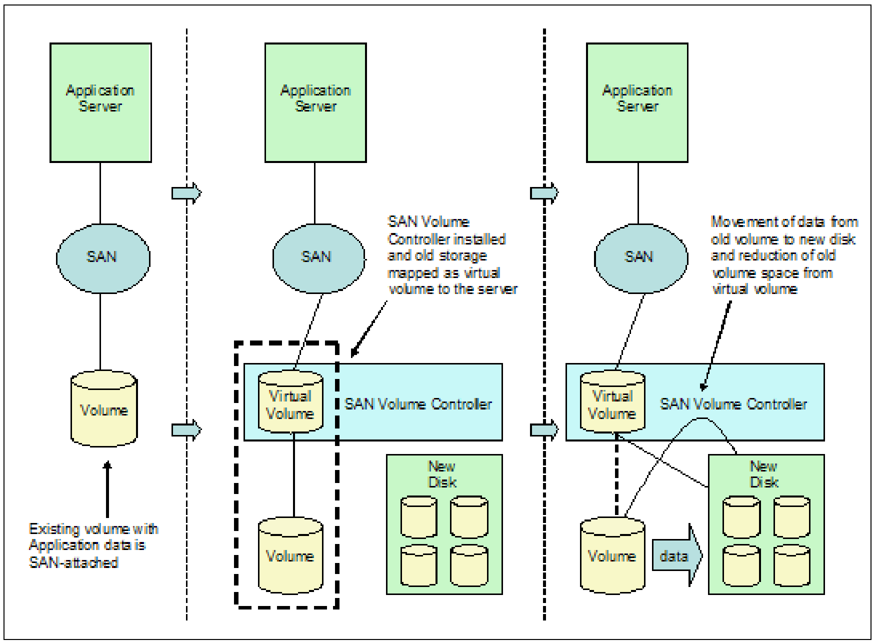


Figure 16-14 Data migration using SAN Volume Controller

To migrate existing SAN Volume Controller data to other storage, you simply tell SVC to remap the data on the virtual disk from one MDisk (managed disk) to another, online, without disrupting the application. The SVC manages all the physical infrastructure, and the attached hosts have no awareness of this, because the volume mapping and structure remains unchanged.

Storage capacity utilization

Although traditional SAN heterogeneous environments share the physical network, but it offers very limited sharing capacity resulting in poor utilization of storage assets. It has procurement limitations due to the various purchasing requirements for each storage array island. Configuration changes are very complex as well as consolidating storage across data centers. It is hard to identify where storage pools capacity imbalances to move blocks around to improve and balance utilization.

The SAN Volume Controller enables hosts to use volumes which consist of managed disks from any device within the storage pools. Unused storage capacity can be easily reallocated to help improve capacity utilization. The procurement of extra storage (in an environment using the SAN Volume Controller) can be deferred until the total SAN capacity approaches utilization trigger points. Storage capacity balancing done at the virtualization layer transparently to servers and applications.

16.8 SAN Volume Controller compatibility

The SAN Volume Controller supports a wide range of host operating systems, server platforms, FC SAN switches, and storage controllers. An Interoperability Matrix for each SVC version is available at the following website:

http://www.ibm.com/systems/storage/software/virtualization/svc/interop.html

16.9 SAN Volume Controller commonly used terms

Here is a short glossary of the most commonly used SAN Volume Controller terms (in alphabetic order).

Boss node A single node acts as the boss node for overall management of the cluster. If the boss node fails, another node in the cluster will take over the responsibilities.

Configuration node At any one time, a single node in the cluster is used to manage configuration activity. This configuration node manages a cache of the configuration information that describes the cluster configuration and provides a focal point for configuration commands. Similarly, at any one time, a single node acts as the boss node for overall management of the cluster.

Extent An extent is a fixed size unit of data that is used to manage the mapping of data between MDisks and volumes.

Front-end and back-end SVC takes managed disks and represents these to application servers (hosts). The managed disks are looked after by the “back-end” application of the SAN Volume Controller. The virtual disks presented to hosts are looked after by the “front-end” application in the SVC.

Grain A grain is the unit of data represented by a single bit in a FlashCopy bitmap, 256 K in SVC.

I/O group An input/output (I/O) group contains two SVC nodes defined by the configuration process. Each SVC node is associated with exactly one I/O group. The nodes in the I/O group provide access to the volumes in the I/O group.

LU and LUN Strictly speaking, there is a difference between a logical unit (LU) and a logical unit number (LUN). A LUN is a unique identifier used on a SCSI bus that enables it to differentiate between up to eight separate devices (each of which is a logical unit). In practice, the two terms are used interchangeably. In this book, when we talk about a LUN, we mean the unit of storage that is defined in a storage subsystem such as an IBM System Storage DS5000, DS6000 and DS8000 Storage Server or storage servers from other vendors.

Managed disk Managed disk (MDisk) is a SCSI disk presented by a RAID controller and managed by the SAN Volume Controller. The MDisk must not be configured to be visible to host systems on the SAN.

Managed disk group The storage pool is a collection of MDisks that jointly contain all the data for a specified set of volumes.

Master console The master console is the platform which runs the software used to manage the SVC.

Node — Node is the name given to the individual servers in an SVC cluster that run the SVC software.

SAN Volume Controller — The SAN Volume Controller (SVC) is a SAN appliance designed for attachment to a variety of host computer systems, which carries out block level virtualization of disk storage.

Volumes — Volumes (previously referred as Virtual Disks or VDisks) are SVC devices that appears to host systems attached to the SAN as a SCSI disk. Each volume is associated with exactly one I/O group.

16.10 More information

For more information, see the following Redbooks publications:

- *Implementing the IBM System Storage SAN Volume Controller V5.1*, SG24-6423
- *Implementing the IBM System Storage SAN Volume Controller V6.1*, SG24-7933

Also see the following websites:

- For the latest SAN Volume Controller product information:

  http://www.ibm.com/servers/storage/software/virtualization/svc/
- SAN Volume Controller 6.1 Recommended Software Levels:

  http://www.ibm.com/support/docview.wss?rs=591&uid=ssg1S1003698
- SAN Volume Controller Information Center

  http://publib.boulder.ibm.com/infocenter/svc/ic/index.jsp
- SAN Volume Controller Support

  http://www.ibm.com/servers/storage/support/software/sanvc/
- SAN Volume Controller 6.1.0 Configuration Limits and Restrictions

  http://www.ibm.com/support/docview.wss?rs=591&uid=ssg1S1003704
- SAN Volume Controller Interoperability and Restrictions Information

  http://www.ibm.com/systems/storage/software/virtualization/svc/interop.html

17

IBM Storwize V7000

IBM has more than thirty years experience in virtualization technologies, with thousands of virtualization systems installed worldwide. Server virtualization started in enterprise systems, and in the past few years it became part of the small and medium businesses (SMB). Now is the time for Storage Virtualization to reach SMB customers as well.

In this chapter, we describe how the new IBM Storwize V7000 uses virtualization to reduce complexity and provide unmatched performance, availability, advanced functions, and highly scalable capacity never seen before in midrange disk systems. We explain hardware architecture, topology, and its features, and then explore the benefits of the Storwize V7000 solution.

17.1 IBM Storwize V7000: Overview

The IBM Storwize V7000 solution provides a modular storage system that includes the capability to consolidate external virtualized SAN-attached storage and its own internal storage and present it as a centralized pool of storage. The IBM Storwize V7000 solution is built upon the IBM SAN Volume Controller (SVC) technology base and offers enterprise capabilities from the IBM DS8000 family technology.

Simplified management is one of the key features from IBM Storwize V7000. It provides a web user interface with a number of preset configuration options and automated wizards to assist in resolving any events that might occur. As the web Graphical User Interface (GUI) runs on the IBM Storwize V7000 system, there is no need for a separate console.

IBM Storwize V7000 provides an active-active, clustered, scalable, and reliable storage solution, as well as an external virtualization device.

There are two models of the Storwize V7000 control enclosures and two expansion enclosures. All the models have internal disks slots, supporting 3.5 inch or 2.5 inch Serial Attached SCSI (SAS) drives only. Table 17-1 shows the model comparison.

Table 17-1 IBM Storwize V7000 models

Specification	Control enclosures		Expansion enclosures	
	2076-112	**2076-124**	**2076-212**	**2076-224**
Supported drives	12 x 3.5”	24 x 2.5”	12 x 3.5”	24 x 2.5”
Cache	16 GB	16 GB	-	-
FC ports	8 x 8 Gbps	8 x 8 Gbps	-	-
iSCSI ports	4 x 1 Gbps	4 x 1 Gbps	-	-
SAS drive ports	4 x 6 Gbps	4 x 6 Gbps	4 x 6 Gbps	4 x 6 Gbps

Figure 17-1 shows the front view of the 2076-112 and 2076-212 enclosures, where the drives are positioned in 4 columns of 3 horizontal mounted drive assemblies.

Figure 17-1 IBM Storwize V7000 front view for 2076-112 and 2076-212 enclosures

Figure 17-2 shows the front view of the 2076-124 and 2076-224 enclosures, where the drives are positioned in 1 row of 24 vertically mounted drive assemblies.

Figure 17-2 IBM Storwize V7000 front view for 2076-124 and 2076-224 enclosures

17.2 IBM Storwize V7000 components

The IBM Storwize V7000 is a modular storage solution composed by control and expansion enclosures. Figure 17-3 shows a system composed of one control enclosure and nine expansion enclosures. It is possible to mix 12 disk slots and 24 disk slots models. Each Storwize V7000 enclosure takes 2EIA units in a standard 19 inch rack.

Each enclosure fits disk drives, two power supplies, and two canisters. The dual power supplies are redundant, hot-swap and include cooling systems. Each power supply contains an IEC C14 socket.

Figure 17-3 Example of a rack mounted Storwize V7000 solution

17.2.1 Control enclosures

Each IBM Storwize V7000 system has one control enclosure, which contains two node canisters, as well as disk drive slots and two power supply units (PSUs), as shown in Figure 17-4. Each canister has 8 GB cache with battery backup for cache destage to include flash memory in case of power failure.

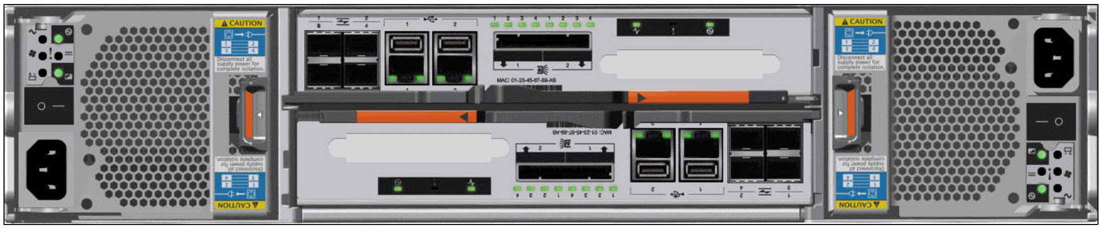


Figure 17-4 Rear view of a Storwize V7000 control enclosure

The two nodes act as a single processing unit and form an I/O group that is attached to the fabric using the Fibre Channel or iSCSI ports. The two nodes provide high availability and fault tolerance because, if one node fails, the surviving node automatically takes over.

Figure 17-5 shows a single canister. Each canister has four Fibre Channel ports, operating at 2, 4, or 8 Gbps, two 10/100/1000 Mbps iSCSI Ethernet ports, two 6 Gbps SAS ports, and two USB 2.0 ports. The Fibre Channel ports are used for fabric connection, and their use is optional. The Ethernet ports are also used for fabric connection as well as management.

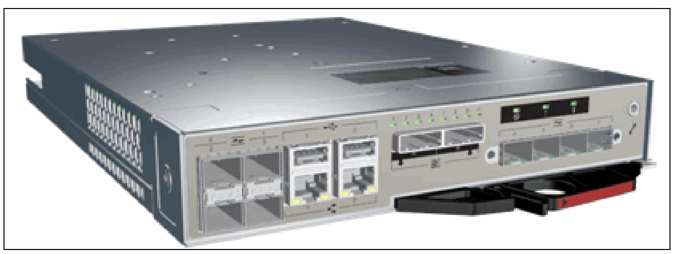


Figure 17-5 A single Storwize V7000 canister

Support: Direct Fibre Channel port to server Host Bus Adapter (HBA) and iSCSI port to server Ethernet adapter are not supported. The use of Fibre Channel and Ethernet switches is mandatory in order to connect servers to the corresponding ports.

The USB ports are used for initial configuration. The SAS ports are used for expansion connection only.

17.2.2 Expansion enclosures

The Storwize V7000 systems can operate with internal disks only. As a scalable system, it is possible to add expansion enclosures. Each expansion enclosure contains two expansion canisters, disk drive slots, and power supplies, as shown in Figure 17-6. The expansion enclosure power supplies are similar to the control enclosure power supplies but do not contain a battery.

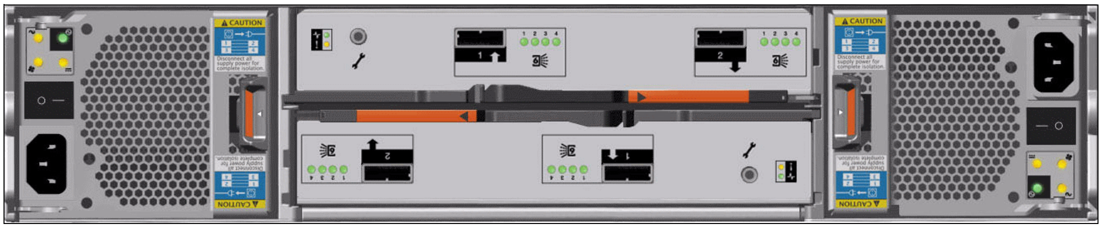


Figure 17-6 Rear view of a Storwize V7000 expansion enclosure

Each expansion canister, as shown in Figure 17-7, provides two SAS ports that are used to connect to the control enclosure and other expansion enclosures in a dual, redundant way.

Figure 17-7 A single Storwize V7000 expansion canister

This redundant connection is done as shown in Figure 17-8. There are two ways to connect to each expansion enclosure, SAS Chain 1 and SAS Chain 2. That way there is no single point of failure (SPOF) in the cabling connections.

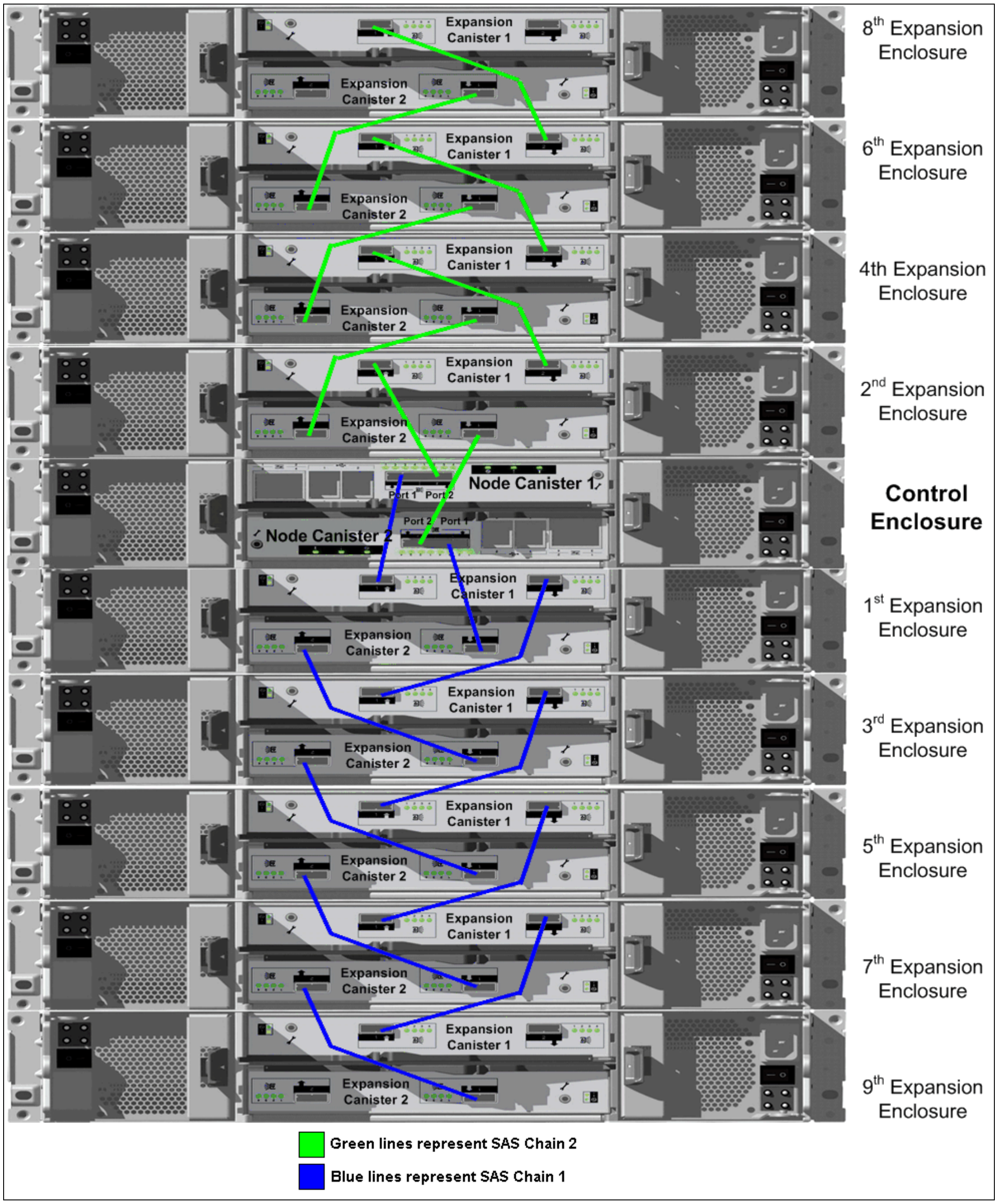


Figure 17-8 Storwize V7000 control enclosure and expansion enclosures cabling diagram

17.2.3 Disk drive modules

The IBM Storwize V7000 disk makes available multi performance tiers, because Storwize V7000 enclosures currently support SSD, SAS 2.0, and Nearline SAS 2.0 disk drives. Each SAS 2.0 drive is dual-ported, and I/O can be issued down both paths simultaneously, just like Fibre Channel drives.

The available disk drives at the time of writing are shown in Table 17-2.

Table 17-2 IBM Storwize V7000 disk drive types

Feature	Drive type	Speed	Size	Form factor
#3504	SSD	-	300 GB	2.5”
#3203	SAS	10.000 RPM	300 GB	2.5”
#3204	SAS	10.000 RPM	450 GB	2.5”
#3206	SAS	10.000 RPM	600 GB	2.5”
#3302	SAS Nearline	7.200 RPM	2 TB	3.5”

Requirement: The SSD disk drives are 2.5” form factor only. To use them, it is necessary to have at least one 2076-124 or 2076-224 enclosure in the installation.

17.3 IBM Storwize V7000 features

IBM Storwize V7000 features enterprise class scalability and connectivity, supporting these:

- RAID 0, 1, 5, 6, 10 arrays
- Maximum of 240 internal drives in up to 9 expansion enclosures
- Maximum of 2,048 host volumes with up to 512 volumes per host
- Maximum capacity of 256 TB per volume
- Maximum of 256 Fibre Channel attached hosts
- Maximum of 64 iSCSI attached hosts
- Maximum of 256 combined (iSCSI and Fibre Channel hosts)
- Maximum of 4096 MDisks
- Maximum of 1 PB capacity per MDisk
- Maximum virtualization capacity of 32 PB

There are also advanced features and licensing as discussed in Table 17-3.

Table 17-3 Storwize V7000 features and licensing information

Feature	Licensing	Required software
Thin provisioning	No charge	-
Volume mirroring		
Data migration		
Easy Tier	Included in Storwize V7000 base license	5639-VM1
FlashCopy		
Full/incremental copy		
Multi-target FlashCopy		
Cascaded FlashCopy		
Reverse FlashCopy		
FlashCopy nocopy with thin provisioning		
Metro Mirror and Global Mirror	License required	5639-RM1
External storage virtualization	License required	5639-EV1

License: All the Storwize V7000 software is licensed based on the number of enclosures.

- Each IBM Storwize V7000 Disk Control Enclosure and each IBM Storwize V7000 Disk Expansion Enclosure uses the IBM Storwize Base Software, 5639-VM1. A quantity of one 5639-VM1 IBM Storwize V7000 Base Software license is required for each enclosure, whether control or expansion enclosure.
- Each IBM Storwize V7000 Disk Control Enclosure has the ability to attach and manage external storage devices on the SAN in the same way as the SAN Volume Controller. To authorize use of this function, the user licenses the IBM Storwize V7000 External Virtualization Software, 5639-EV1. You will need to license the number of storage enclosures attached externally to the IBM Storwize V7000.
- Each IBM Storwize V7000 Disk Control Enclosure has the ability to attach and manage external storage devices on the SAN in the same way as the SAN Volume Controller. To authorize use of this function, the user licenses the IBM Storwize V7000 External Virtualization Software, 5639-EV1. You will need to license the number of storage enclosures attached externally to the IBM Storwize V7000.

The Storwize V7000 advanced features are highlighted next. For more information about any of those features, see Chapter 15, “IBM System Storage Virtualization” on page 467.

17.3.1 Thin provisioning

Traditional fully allocated volumes allocate real physical disk capacity for an entire volume even if never used. Thin provisioning provides the ability to allocate real physical disk capacity only when data is actually written to the logical volume. A thin-provisioned volume can have a logical capacity size that is larger than the physical capacity assigned to it.

A thin-provisioned volume can be configured to autoexpand, which causes IBM Storwize V7000 to automatically expand the real capacity of a thin-provisioned volume as its real capacity is used.

A thin-provisioned volume can be converted to a fully allocated volume using volume mirroring (and vice versa).

For more information, see 15.6.2, “Thin provisioning” on page 480.

17.3.2 Volume mirroring

Volume mirroring enables a volume to have two physical copies, each one of them in a separate storage pool. Depending on how the storage pools are allocated, copies can be on completely separate disk storage systems that are being virtualized. If one copy fails, the IBM Storwize V7000 will provide continuous data access by redirecting I/O to the remaining copy. When the failed copy becomes available, automatic resynchronization occurs.

For more information, see 15.6.3, “Volume mirroring” on page 481.

17.3.3 Data migration

IBM Storwize V7000 provides a data migration wizard that can be used to import external storage systems into the IBM Storwize V7000 system, to any of its MDisks, internal or virtualized external ones.

It also has the same capability as the SVC, which allows it to perform these functions:

- Move volumes non-disruptively onto a newly installed storage system
- Move volumes off of an older storage system ahead of decommissioning
- Move volumes to rebalance a changed workload
- Migrate data from older back-end storage to Storwize V7000 managed storage

The connection to old storage systems to Storwize V7000 is a disruptive operation. However, after this operation is done the migration is a online and transparent process to the servers.

> **Attention:** Migrating from an existing disk controller to IBM Storwize V7000 considers that the original disk controller will be removed from IBM Storwize V7000 control when complete.

17.3.4 Easy Tier

Easy Tier provides a mechanism to seamlessly migrate hot spots to a higher performing storage pool within the IBM Storwize V7000 solution. This can be to internal drives within IBM Storwize V7000 or to external storage systems that are virtualized by IBM Storwize V7000. This process is shown in Figure 17-9.

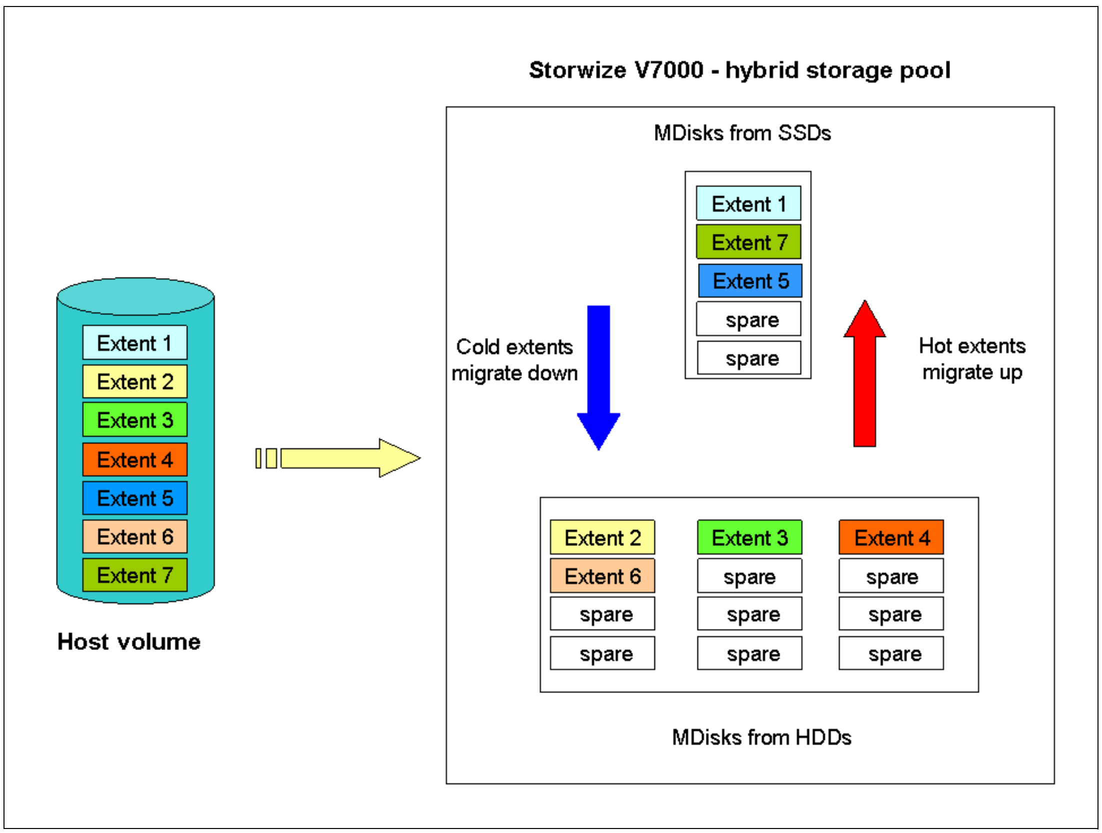


Figure 17-9 Easy Tier overview

Notice that the Easy Tier function works in an extent level.

The best way to benefit from Easy Tier is by using SSD disks, as shown in Figure 17-9. This can be done with as little as two SSD disks.

For more information, see 15.6.4, “Easy Tier” on page 482.

17.3.5 FlashCopy

This function provides volume level point-in-time copy function for any storage being virtualized by IBM Storwize V7000. It is designed to create copies for backup, parallel processing, test. and development. and have the copies available almost immediately.

IBM Storwize V7000 includes the following FlashCopy functions.

Full/Incremental Copy

This function copies only the changes from either the source or target data since the last FlashCopy operation and is designed to enable completion of point-in-time online backups much more quickly than by using traditional FlashCopy.

Multi-Target FlashCopy

IBM Storwize V7000 supports copying up to 256 target volumes from a single source volume. Each copy is managed by a unique mapping and in general, each mapping acts independently and is not affected by other mappings sharing the same source volume.

Cascaded FlashCopy

This function is used to create copies of copies and supports full, incremental, or nocopy operations.

Reverse FlashCopy

This function allows for data from an earlier point-in-time copy to be restored with minimal disruption to the host.

FlashCopy Nocopy with Thin Provisioning

This function provides a combination of using thin-provisioned volumes and FlashCopy together to help reduce disk space requirements when making copies. There are two variations of this option:

- Thin-provisioned source and target with background copy:

  This copies only the allocated space.

- Thin-provisioned target with no background copy:

  This copies only the space used for changes between the source and target and is generally referred to as “snapshots.”

It can be used with multi-target, cascaded, and incremental FlashCopy.

For more information about FlashCopy, see 15.6.5, “FlashCopy” on page 485.

FlashCopy consistency groups

Consistency groups address the issue where application data resides across multiple volumes. By placing the FlashCopy relationships into a consistency group, commands can be issued against all of the volumes residing in the group. Doing this enables a consistent point-in-time copy of all of the data even though it might reside on a separate physical volume.

FlashCopy mappings can be members of a consistency group, or they can be operated in a stand-alone manner, not as part of a consistency group. FlashCopy commands can be issued to a FlashCopy consistency group, which affects all FlashCopy mappings in the consistency group, or to a single FlashCopy mapping if it is not part of a defined FlashCopy consistency group.

For more information, see “FlashCopy consistency groups” on page 489.

17.3.6 Metro Mirror and Global Mirror

Metro Mirror provides synchronous remote mirroring function up to approximately 300 Km between sites. As the host write operation only completes after the data is cached at both locations, performance requirements can limit the practical distance. Metro Mirror provides fully synchronized copies at both sites with zero data loss after the initial copy is completed.

Overview

Global Mirror provides long distance asynchronous remote mirroring function for up to approximately 8,000 Km between sites. With Global Mirror the host write operation is completed with a local write and the changed data is sent to the remote site later. This is designed to maintain a consistent recoverable copy of data at the remote site which lags behind the local site.

Metro Mirror and Global Mirror can operate between multiple IBM Storwize V7000 systems. For details, see 15.6.6, “Metro Mirror and Global Mirror Copy Services” on page 489.

Remote Mirror consistency groups

A consistency group is a logical entity that groups copy relationships. By grouping the relationships, you can ensure that these relationships are managed in unison and the data within the group is in a Consistent state. Consistency groups have the same limitations as standard volumes.

For more information, see “Metro Mirror and Global Mirror consistency groups” on page 494.

17.3.7 External storage virtualization

The IBM Storwize V7000 solution has the ability to virtualize and manage external storage devices on the SAN the same way the SAN Volume Controller does. Storwize V7000 can consolidate multi vendor disk controllers into one or more common pools of storage. This way it is possible, from a single user interface, to provision volumes to hosts and utilize a common set of advanced functions across all the disk under Storwize V7000’s control.

For more information, see 15.6.1, “Storage virtualization” on page 479.

17.4 IBM Storwize V7000 topology

Host access to storage is independent of the physical storage layer because Storwize V7000 virtualizes the external disk systems, as well as its own internal storage, into consolidated storage pools. Therefore there are two ways of seeing the Storwize V7000 topology: a logical one and a physical one.

17.4.1 Logical topology and storage hierarchy

Figure 17-10 shows a logical topology of an example scenario. In this example, a Storwize V7000 has disk drives itself and it is virtualizing two external disk storages, a IBM DS5020 and a IBM DS3400.

Each external virtualized disk storage has its own disks, organized in arrays with a RAID level and then split into logical units (LUNs). They have their own hot spare drives, which are transparent to the Storwize V7000.

The Storwize V7000 receives LUNs from external virtualized disk storages and treats them as Managed Disks (MDisks). A managed disk refers to the unit of storage that IBM Storwize V7000 virtualizes. This can be a logical volume on an external storage array or the internal SAS and SSD drives that are presented to the IBM Storwize V7000.

The MDisks are then allocated into one or more storage pools. A storage pool is a collection of MDisks that are grouped together in order to provide capacity for volumes. All MDisks in the pool are split into extents with the same size. When a volume is created from a storage pool, the volume is allocated based on the number of extents required to satisfy the capacity requirements for the volume. After volumes are allocated out of a storage pool, they are mapped to a host system.

In the example presented here, all the LUNs provided by external virtualized storage systems are organized as MDisks the same way that the Storwize V7000's internal disks are. The MDisks are then organized into storage pools, split into volumes, and mapped to hosts.

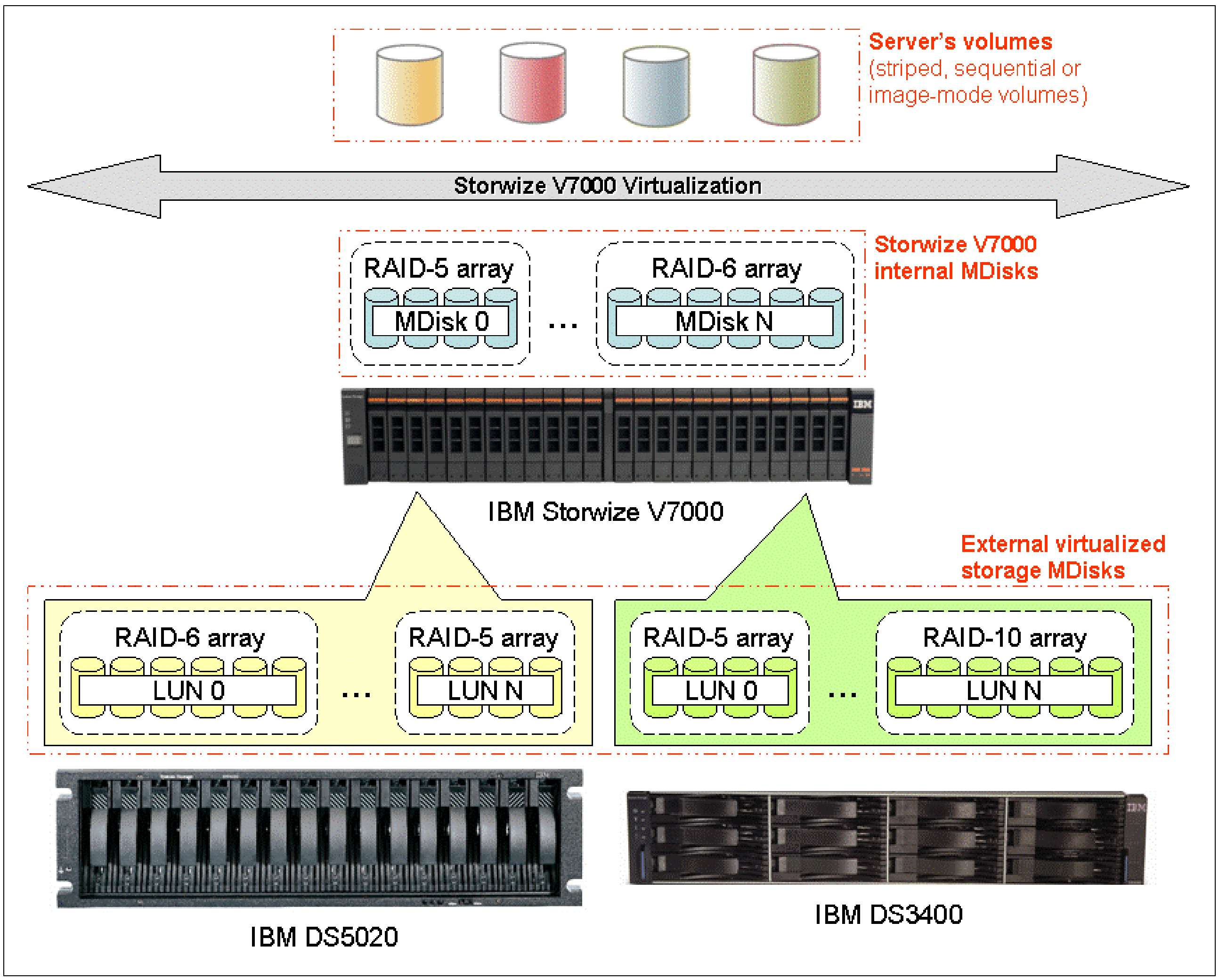


Figure 17-10 Storwize V7000 logical topology

The Storwize V7000 GUI makes storage management simple. In the GUI Overview panel, it is possible to see, in a graphic and straightforward way, how the existing internal disks, external storages, MDisks, storage pools, and volumes are organized. For the example provided, the GUI Overview panel looks like Figure 17-11.

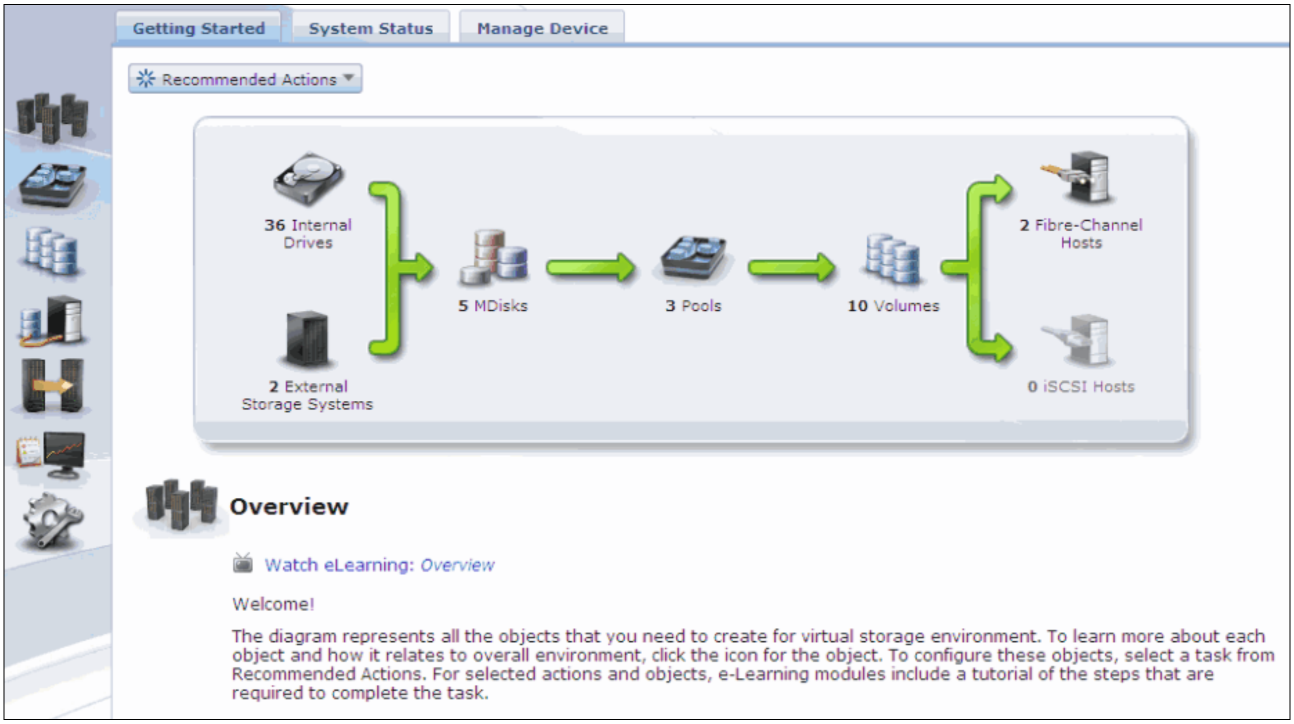


Figure 17-11 Storwize V7000 GUI Overview screen

For information regarding Storwize V7000 planning and implementation, see *Implementing the IBM Storwize V7000*, SG24-7938.

17.4.2 Physical topology

Although the Storwize V7000 is able to virtualize external storage systems, there is no direct connection between virtualized external storages and the Storwize V7000. Every single communication between systems and servers, whether passing through Storwize V7000 or not, is done in a Storage Area Network (SAN) level. Regarding the example presented in 17.4.1, “Logical topology and storage hierarchy” on page 532, the physical topology is as shown in Figure 17-12, considering three servers connected to the SAN.

The correct data path from external virtualized storages LUNs to Storwize V7000 is done using SAN zoning. The same works for server level communication; servers read from and write to Storwize V7000. The servers do not know where the Storwize V7000 is reading from or writing to, because after implementation, this is an automated and transparent virtualized process.

> **Tip:** It is possible to have, in the same SAN, Storwize V7000 virtualized storage systems and non-virtualized storage systems, considering that they are in different SAN zones.

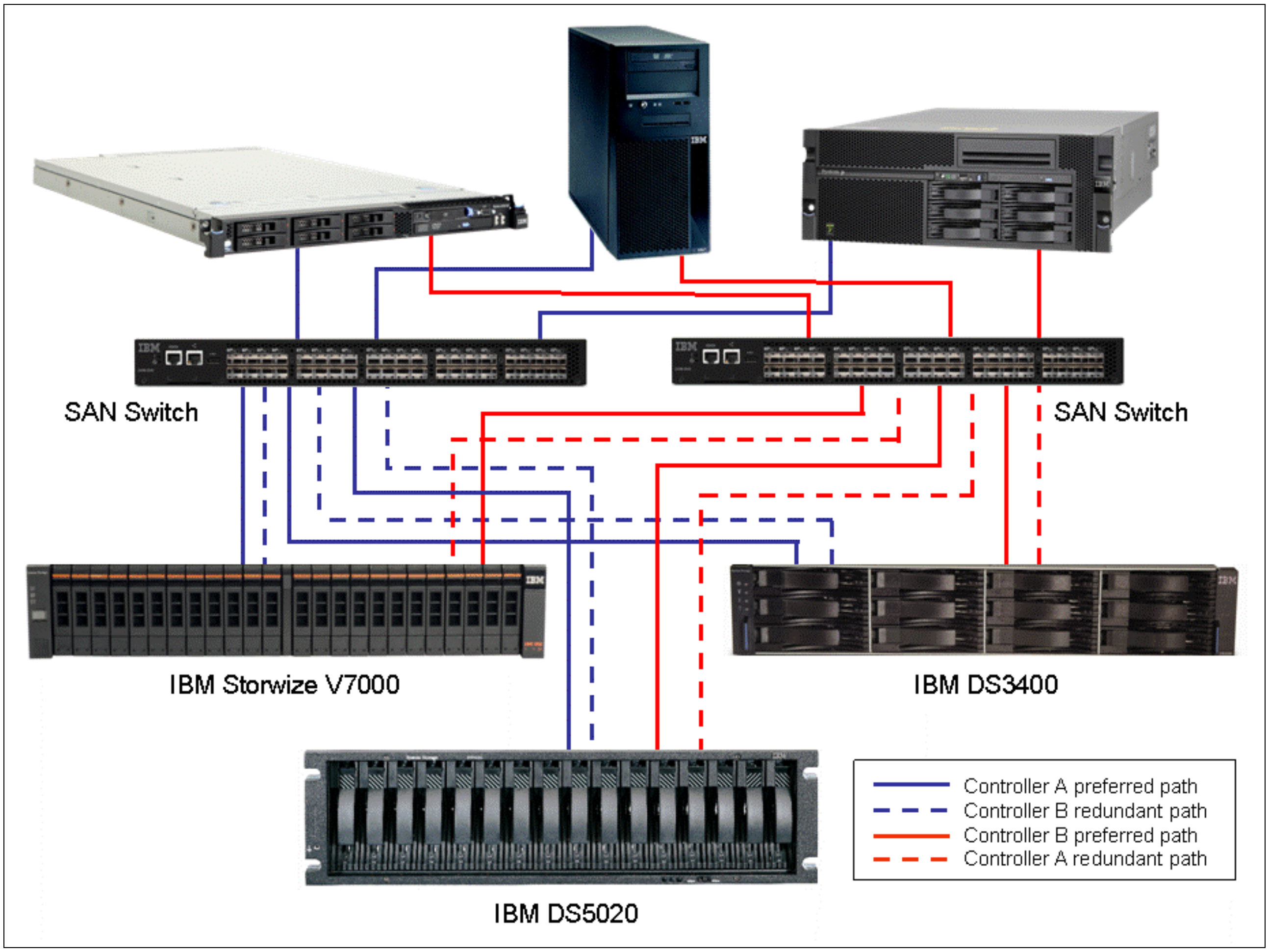


Figure 17-12 Storwize V7000 physical topology

17.5 IBM Storwize V7000 management and support tools

The Graphical User Interface (GUI) is used to configure, manage, and troubleshoot the IBM Storwize V7000 system. It is used primarily to configure RAID arrays and logical drives, assign logical drives to hosts, replace and rebuild failed disk drives, and expand the logical drives.

17.5.1 Overview

The GUI allows for troubleshooting and management tasks, such as checking the status of the storage server components, updating the firmware, and managing the storage server. Finally, it offers advanced functions, such as FlashCopy, Disk Mirroring, and Enhanced Remote Mirroring. A Command Line Interface (CLI) for the IBM Storwize V7000 system is available as well.

Besides the GUI, there are three other ways of managing the IBM Storwize V7000 system:

- Through an existing SVC Master Console
- By the IBM Systems Storage Productivity Center (SSPC)
- Using the SSH protocol Command Live Interface (CLI)

17.5.2 Event notifications

IBM Storwize V7000 can use Simple Network Management Protocol (SNMP) traps, syslog messages, and Call Home email to notify you and the IBM Support Center when significant events are detected. Any combination of these notification methods can be used simultaneously.

Each event that IBM Storwize V7000 detects is assigned a notification type of Error, Warning, or Information. You can configure IBM Storwize V7000 to send each type of notification to specific recipients.

17.6 IBM Storwize V7000 supported environments

The IBM Storwize V7000 supports a comprehensive list of host operating systems and multi-vendor disk storage compatibility. The complete list is available at the following website:

http://www.ibm.com/support/docview.wss?uid=ssg1S1003703

17.7 More information

For more information about the Storwize V7000, see *Implementing the IBM Storwize V7000*, SG24-7938 and the URLs listed here:

- Product site

  http://www.ibm.com/systems/storage/disk/storwize_v7000/index.html

- Information Center

  http://publib.boulder.ibm.com/infocenter/storwize/ic/index.jsp

- Configuration Limits and Restrictions

  http://www.ibm.com/support/docview.wss?uid=ssg1S1003702

- Techdocs Library

  http://www.ibm.com/support/techdocs/atsmastr.nsf/Web/Search

- Product Manuals

  http://www.ibm.com/support/docview.wss?uid=ssg1S7003318

18

IBM Tivoli Storage Manager

IBM Tivoli Storage Manager is the number one product of choice for an efficient and effective enterprise-wide backup/recovery solution. It provides a data protection solution for backup, archiving, disaster recovery planning, space management, database and application protection, bare machine recovery, and record retention. More than 45 operating platforms are supported, using a consistent graphical user interface, and a simple command line interface.

In this chapter, we describe the capabilities that Tivoli Storage Manager provides:

- Centralized administration for data and storage management
- Fully automated data protection
- Efficient management of information growth
- Enhanced data security with innovative access and encryption features
- High-speed automated server recovery
- Data deduplication and a hierarchy of storage to help increase efficiencies and conserve resources
- Full compatibility with hundreds of storage devices, and local area network (LAN), wide area network (WAN), and storage area network (SAN) infrastructures
- Optional specifically designed backup solutions for major groupware, enterprise resource planning (ERP) applications, and database products.
- Transparent licensing reflecting the business needs

Tivoli Storage Manager is the premier storage management solution for mixed platform environments.

18.1 New in IBM Tivoli Storage Manager V6.2

New features and enhancements are available in Tivoli Storage Manager Version 6.2 and subsequent fix packs, for the server, backup-archive clients, and related products. For information about how to use the features, see the documentation listed in 18.10, “More information” on page 600.

These features and enhancements are summarized in short descriptions, so that you can start thinking about the potential benefits to your storage management operations.

18.1.1 Server updates

Many features in the Tivoli Storage Manager Version 6.2 server are new for previous Tivoli Storage Manager users. The most significant change is the new database for the server. Here we describe the most important of them in relation to the previous Version 5.4 and 5.5. Changes in Version 6.2 against Version 6.1 are specifically highlighted.

Tivoli Storage Manager server database server database

Tivoli Storage Manager Version 6.2 provides a new DB2-based server database engine (currently at level DB2 V9.7). Advantages include automatic statistics collection and database reorganization, full-function SQL queries, and elimination of the need for offline audits of the database.

Upgrading either to V6.1 or directly to V6.2 from Version 5.5 requires that data in a current Tivoli Storage Manager server database to be extracted and then inserted into the new database structure. Tivoli Storage Manager provides utilities to perform the process.

Upgrades: Tivoli Storage Manager server database servers running Version 5.4 must be first upgraded to TSM V5.5 prior to the migration to the new, DB2-based TSM servers V6.1. or V6.2.

Tivoli Integrated Portal GUI

The IBM Tivoli Integrated Portal is a graphical user interface (GUI) that is included with Tivoli Storage Manager V6.2. The Tivoli Integrated Portal provides all the functions that were available in the Integrated Solutions Console.

The Administration Center, Tivoli Storage Manager reporting and monitoring feature, and other applications are integrated into this new graphical user interface. The Administration Center can be moved to the Tivoli Integrated Portal if the servers being managed are at Version 5.5 or later. By deploying the Tivoli Integrated Portal early, you can prepare your system for an upgrade to Tivoli Storage Manager V6.2. Servers at versions earlier than 6.2 that are managed using the V6.2 Administration Center cannot use the version V6.2 features.

Administration Center in V6.2

Many features in the Tivoli Storage Manager Administration Center Version 6.2 are new for previous users:

- Updated Integrated Solutions Console:

  Since V6.1, the Administration Center is hosted by the IBM Integrated Solutions Console (ISC) Advanced Edition Version 7.1. After installation of the ISC installation completes, open a web browser and enter the following URL, which will display the logon screen for the Integrated Solutions Console: https://*local_host*:9043/ibm/console. The status screen indicates a successful installation of the Integrated Solutions Console.

- WebSphere® Windows service:

  Since V6.1, the WebSphere Windows service is named TSM Administration Center - TsmAC.

- Identify managing servers:

  The table of servers that is the hub of the enterprise-management work page has a column identifying the managing server, if one exists, for each listed server. By sorting or filtering on the column, you can display the set of servers managed by a given server.

- Hover help for table links:

  The Administration Center typically displays Tivoli Storage Manager objects in a table. In V6.1 and higher, when the cursor hovers over an object image, hover-help text is displayed. The hover help identifies the default action that results when you click the link that is associated with the object.

- Links to information about server messages and Administration Center messages:

  When a problem or issue occurs with the server or Administration Center, you are immediately notified and provided with a brief message about the problem or issue. The message number is also provided. In V6.1, you can obtain detailed information about a message by clicking the link that is associated with the message number. The information is displayed in a new browser window.

- Maintenance script enhancements:

  Tivoli Storage Manager utilizes a maintenance script to perform scheduled maintenance tasks. In V6.2, you can generate a maintenance script in one of two styles: *predefined* and *custom*:

  - A *predefined* maintenance script is one that is generated through a wizard. This script contains standard commands that cannot be altered. A predefined script can only be modified in the wizard.
  - A *custom* maintenance script is created using the Administration Center maintenance script editor. To have more control of your maintenance tasks, you can modify the commands that you specify. You can also use the editor to update your custom maintenance script.

- Client nodes and backup sets enhancements:

  The redesigned Administration Center displays information about backup sets, client nodes, and client-node groups in one portlet. The design includes search functions that you can use to find and display information more quickly. When you select a client node, a summary panel is displayed with the current operation status, server actions, and client-node actions.

- Session and process information available in the health monitor:

  The Administration Center health monitor now includes information about server processes and sessions. The information is also available in the properties notebooks for servers.

- Centralized server-connection management:

  In V6.2, server-connection tasks, such as adding a server connection, changing a password, and creating a server instance, are consolidated in a single location, the *Manage Servers* work item, located in the ISC navigation tree.

- Changes to management-class activation:

  In V6.2, Tivoli Storage Manager no longer activates changes to the existing management classes automatically. You must activate the changes manually. Before the changes take effect, they are validated. Results of the validation are displayed. You or another administrator can review them, and then either confirm or cancel the activation.

Automatic backup-archive client deployment

IBM Tivoli Storage Manager V6.2 can deploy backup-archive client code to workstations that already have the backup-archive client installed.

You can now deploy backup-archive client code to candidate client workstations from the Tivoli Storage Manager V6.2 Administration Center. From the Administration Center, you can coordinate the client updates to each workstation that is at release 5.4 and later to V6.2. You are helped through the process by wizards that configure your workstation and schedule the deployments. The backup-archive client deployment feature is available for supported Windows backup-archive clients only.

Upgrades: We do not advise to push the automatic upgrades of Windows TSM clients on servers where an additional Tivoli Data Protection tool is running to support TSM backups of database systems (DB2, Oracle, SAP, SQL, ERP, Domino, and so on). Those client upgrades must be considered manually because Tivoli Data Protection utilities share the API of backup-archive TSM clients.

Server-side and client-side data deduplication

Data deduplication is a method of eliminating redundant data in sequential-access disk (FILE) primary, copy, and active-data storage pools. One unique instance of the data is retained on storage media, and redundant data is replaced with a pointer to the unique data copy. The goal of deduplication is to reduce the overall amount of time that is required to retrieve data by letting you store more data on disk, rather than on tape.

Data deduplication in Tivoli Storage Manager is a two-phase process. In the first phase, duplicate data is identified. During the second phase, duplicate data is removed by certain server processes, such as reclamation processing of storage-pool volumes. By default, a duplicate-identification process begins automatically after you define a storage pool for deduplication. (If you specify a duplicate-identification process when you update a storage pool, it also starts automatically.) Because duplication identification requires extra disk I/O and CPU resources, Tivoli Storage Manager lets you control when identification begins as well as the number and duration of processes.

You can deduplicate any type of data except encrypted data. You can deduplicate client backup and archive data, Tivoli Data Protection data, and so on. Tivoli Storage Manager can deduplicate whole files as well as files that are members of an aggregate. You can deduplicate data that has already been stored. No additional backup, archive, or migration is required.

In V6.2, you have the option of identifying and removing redundant data during backup and archive processing before data is sent to the server. This method of data deduplication is called *client-side data deduplication*. It is available with V6.2 backup-archive clients and the V6.2 Tivoli Storage Manager application programming interface (API).

Client-side data deduplication provides several advantages to server-side data deduplication. Client-side data deduplication reduces the amount of data sent over the local area network (LAN). In addition, the processing power that is required to identify duplicate data is offloaded from the server to client nodes. The processing that is required to remove duplicate data on the server is eliminated. Space savings occur immediately.

If you used server-side data deduplication, V6.2 client nodes can access existing deduplicated data and storage pools that are already set up for data deduplication. When restoring or retrieving files, the client node queries for and displays files as it normally does. If a user selects a file that exists in a deduplicated storage pool, the server manages the work of reconstructing the file.

You enable client-side data deduplication using a combination of settings on the client node and the server. The primary storage pool that is specified by the copy group of the management class associated with the client data must be a sequential-access disk (FILE) storage pool that is enabled for data deduplication.

Important: You can use the data deduplication feature with Tivoli Storage Manager Extended Edition V6.1. Starting with version TSM 6.2, data deduplication is available also in Basic Edition.

Figure 18-1 shows an overview of the deduplication process.

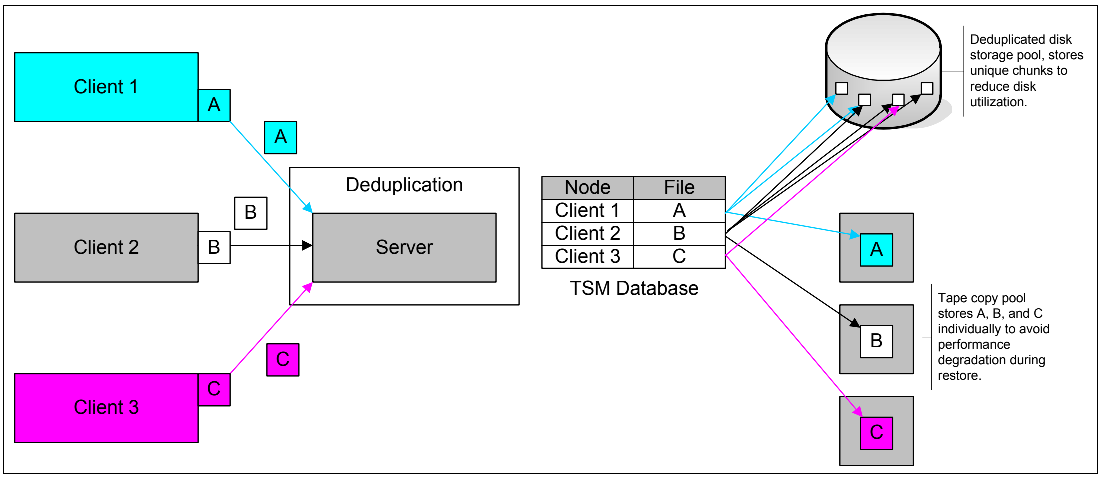


Figure 18-1 Deduplication overview

Parallel write operation during migration

With Tivoli Storage Manager, you can now write data simultaneously to copy storage pools and active-data pools during server data-migration processes.

The simultaneous-write function during migration can reduce the amount of time required to back up storage pools or copy active data. Data that is simultaneously written to copy storage pools or active-data pools during migration is not copied again to the copy storage pools or active-data pools. For example, suppose that you migrate all the data in your primary random-access disk storage pool nightly and then back up your primary storage pools. By using the simultaneous-write function during migration, you can significantly reduce the amount of time required for backup operations.

You can also use the simultaneous-write function during migration if you have many client nodes and the number of mount points that are required to perform the simultaneous-write function during client store operations is unacceptable. If mounting and demounting tapes when writing data simultaneously during client store operations is taking too much time, consider writing data simultaneously during migration.

With Tivoli Storage Manager V6.2, you can specify the simultaneous-write function for a primary storage pool if it is the target for any of the eligible operations (client store sessions, server import processes, and server data-migration processes).

Concurrent read-and-write access to Centera volumes

In previous versions of Tivoli Storage Manager, a client session or server process had to wait for a Centera volume if the volume was in use by another session or process. In V6.2, server read-access and write-access to a Centera volume are available concurrently.

Concurrent access improves restore performance. Two or more clients can read the same volume at the same time. One client can also write to the volume while it is being read. In addition, multiple client sessions and server processes (for example, a client restore operation and an export node operation) can read the same volume concurrently.

The following server processes can share read access to Centera volumes:

- Exporting client node definitions or file data to sequential media or directly to another server for immediate import
- Exporting all or part of server control information and client file data (if specified) from the server to sequential media
- Generating a backup set for a backup-archive client node

The following server processes cannot share read access to Centera volumes:

- Checking for inconsistencies between a storage pool volume and database information
- Deleting a storage pool volume and, optionally, the files stored in the volume

A Centera volume can appear as the current volume for more than one session and as the target of concurrent read and write operations. There are no command changes associated with this feature.

Storage devices

New device support and other changes to storage devices are available in Tivoli Storage Manager Version 6.2:

- ACSLS functionality for Windows systems
- Passthru device driver for HP-UX 11i v2 and v3 on the IA64 architecture
- Support for HP and Quantum DAT160 drives and media
- Support for Sun StorageTek T10000 drives, T10000B drives, and T10000 media including application managed encryption (AME).

In-flight data encryption using SSL

Support for Secure Sockets Layer (SSL) is available on HP-UX, Linux, Solaris, AIX, and Windows platforms.

With SSL industry-standard communications, you can encrypt all traffic between the backup-archive client, the administrative command-line clients, and the IBM Tivoli Storage Manager server. You can use either self-signed or vendor-acquired SSL certificates.

Inventory expiration enhancements

The EXPIRE INVENTORY command is now enhanced with new functionality.

The additional parameters that you can now use are NODE, DOMAIN, TYPE, DURATION, AND RESOURCE. You can use these parameters to target specific client nodes and domains, and also to determine the type of data to be processed. You can use the RESOURCE parameter to specify the number of parallel processes that you want to run within the single EXPIRE INVENTORY process. You can run up to ten threads at one time, but if you are processing one node, only one thread is utilized.

Enabled functions

Functions that were disabled in Tivoli Storage Manager V6.1.0 and V6.1.1 are now enabled since Version 6.1.2

Until Tivoli Storage Manager V6.1.2, a database that contained backup sets or tables of contents (TOCs) cannot be upgraded to V6. These restrictions no longer exist. There is only a warning message issued during the upgrade process, that the TSM server includes TOC-based backups (backupsets, NAS backups).

In addition, the following commands have been enabled since Version 6.1.2:

- BACKUP NAS client command if the TOC parameter specifies PREFERRED or YES
- BACKUP NODE if the TOC parameter specifies PREFERRED or YES
- DEFINE BACKUPSET
- GENERATE BACKUPSET
- GENERATE BACKUPSETTOC.

Tivoli Storage Manager server options

The following options are available:

- Support for SAN discovery functions is now available for the Linux on zSeries® operating system beginning in Tivoli Storage Manager fix pack level 6.1.2.
- A new server option SANDISCOVERYTIMEOUTis available for SAN discovery functions beginning in Tivoli Storage Manager fix pack level 6.1.2.
- With the new CHECKTAPEPOS server option since V6.2.1.0, you can determine the validity and consistency of the position of data blocks on tape.
- The MOVESIZETHRESH server option default value has been increased from 2048 to 4096 and the maximum value from 2048 to 32768.

18.1.2 Tivoli Storage Manager licensing

Tivoli software products are priced using Tivoli *Enhanced Value-Based Pricing*. This licensing and pricing system is based upon the Tivoli Environment-Managed Licensing Model, which uses a managed-environment approach; whereby price is determined by what is managed rather than the number and type of product components installed.

Unlike typical systems management licensing models that require entitlements of specific software components to specific systems, the IBM Tivoli Environment-Managed Licensing Model provides the customer flexibility to deploy its Tivoli software products within its environment in a manner that can address and respond to the customer's evolving architecture. That is, as the architecture of a customer's environment changes, the customer's implementation of Tivoli software can be altered, as needed, without affecting the customer's license requirements (as long as the customer does not exceed its entitlements to the software).

Tivoli products priced by processor value units (PVU) participate in the Passport Advantage® sub-capacity license terms. PVU Sub-capacity licensing lets the customer license an eligible software product for less than the full processor core capacity of a server or group of servers. It provides the licensing granularity needed to utilize various multicore chip and virtualization technologies. Further information about PVU Sub-capacity licensing can be found on the Passport Advantage licensing website:

http://www-01.ibm.com/software/lotus/passportadvantage/licensing.html

The Processor Value Unit (PVU) is a unit of measure by which the Program can be licensed. Proofs of Entitlement for PVUs are based on processor technology (defined within the PVU Table by Processor Vendor, Brand, Type and Model Number at:

http://www.ibm.com/software/lotus/passportadvantage/pvu_licensing_for_customers.ht
ml

IBM continues to define a processor, for the purpose of PVU-based licensing, to be each processor core on a chip. Licensee must obtain entitlements sufficient to cover every activated processor core in the environment that is made available to the Program.

The IBM Tivoli Storage Manager product family is Processor Value Units (PVU) based priced (licensed) software, except the following two products that are licensed per terabyte of managed *Capacity*:

- IBM Tivoli Storage Hierarchical Storage Manager (HSM) for Windows:

  IBM Tivoli Storage HSM for Windows TB Capacity includes primary HSM disk storage pool size combined with the amount of utilized HSM removable media storage pool. Storage pools are configured on the IBM Tivoli Storage Manager server.

- IBM System Storage Archive Manager:

  IBM System Storage Archive Manager Terabyte (TB) Capacity includes primary disk storage pool size combined with the amount of utilized primary removable media storage used by the IBM System Storage Archive Manager server.

Consider the following notes regarding the capacity measurement:

- Capacity does not include these items:
  – Copy storage pools for the space-managed data that reside on any media
  – Disk on the host being space managed
  – Space used on the TSM server for any purpose other than the primary storage of space-managed data
- A virtual tape library (VTL) is considered a removable media device.
- The minimum amount of capacity that can be purchased is 1 TB.
- Partial capacity will be rounded up to the next whole number of TB.
- Additional capacity must be added in increments of 1 TB

Capacity: In terms of capacity licensing, 1 terabyte (TB) of managed storage is equal to 2 to the 40th power bytes = 1,099,511,627,776 bytes.

Additionally, IBM Tivoli Storage Manager includes components that have program-specific license terms. The following components have specific entitlements:

- Tivoli Storage Manager server (known also as TSM Basic Edition)
- Tivoli Storage Manager Extended Edition server
- Tivoli Storage Manager for SAN (storage agent)
- Each NAS device being backed up requires license

Read the following notes carefully to properly determine what type of license entitlement is necessary for your environment:

- IBM Tivoli Storage Manager supports tape libraries (including virtual tape libraries) up to 4 tape drives or 48 slots. A PoE for IBM Tivoli Storage Manager Extended Edition is required to use any of the following support: disaster recovery manager, Network Data Management Protocol (NDMP), support of tape libraries (including virtual tape libraries) with more than four drives or more than 48 slots.
- TSM server V6.2 includes data deduplication feature, while V6.1 requires license entitlement for TSM Extended Edition.
- If the NAS device is backed up using NDMP, entitlement for TSM Extended Edition is required.
- License entitlements for IBM Tivoli Storage Manager and TSM Extended Edition are required for all managed servers including the managing server (library manager server).
- For a Manager server that is sharing a library where an IBM Tivoli Storage Manager acts as the library manager, a license is required for each library client and library manager. An IBM Tivoli Storage Manager for Storage Area Networks license is required for each system that performs LAN-free operations.

- License entitlements for client devices (laptops, desktops, technical workstations) are required for all client devices being managed. Licensing is per client device.

Tip: License upgrade from the IBM Tivoli Storage Manager server (Basic Edition) to Tivoli Storage Manager Extended Edition server is a simple, online process that does not require application downtime.

18.1.3 Reporting and monitoring feature

The Tivoli Storage Manager reporting and monitoring feature, Version 6.2, has a few new changes:

- The Tivoli Storage Manager reporting and monitoring feature, Version 6.2, has been integrated into a new user interface called the Tivoli Integrated Portal. This move affects the reporting and monitoring reports that are run from the Administration Center. The Administration Center moved from the Integrated Solutions Console to the Tivoli Integrated Portal. The Tivoli Integrated Portal provides all the functions that were available in the Integrated Solutions Console, but with a new look-and-feel.
- The Administration Center is installed separately and is not included in the reporting and monitoring installation.

There is a new information roadmap for the Tivoli Storage Manager reporting and monitoring feature on the Tivoli Storage Manager Wiki. This roadmap has detailed information about planning, installing, configuring, customizing, and troubleshooting for either Version 6.1 or Version 6.2 of the Tivoli Storage Manager server. See the following website:

https://www.ibm.com/developerworks/wikis/display/tivolistoragemanager/Reporting+and+monitoring+feature+information+roadmap

18.1.4 Backup-archive client updates

The following features are new for IBM Tivoli Storage Manager in Version 6.2 and 6.1:

- Backup of Windows System State:

  TSM V6.2 introduces the progressive incremental backup of Windows System State to address the explosive growth of System State data, especially in large organizations. This feature enables significant performance improvement for Windows 2008 customers and reduces the amount of objects in TSM server database.
- MacOS X API support:

  The Tivoli Storage Manager API is now supported on MacOS X platforms.
- Improved memory usage for backup of Hierarchical Storage Management (HSM) managed file systems:

  The Tivoli Storage Manager Backup-Archive client can do a full incremental backup of very large HSM managed file systems containing 100,000,000 files or more.
- Space Management for UNIX and Linux system enhancements in V6.2:

  GPFS policy-based file list reconciliation is being added to Tivoli Storage Manager for Space Management. The reconciliation synchronizes the content on the local file system and on the server. The GPFS policy engine generates a file list of all the premigrated and migrated files. The HSM reconcile command processes the file list and updates the content on the server.

- UTF-8 encoding support is added for Tivoli Storage Manager UNIX and Linux clients:

  UTF-8 is added for the language locales that are already supported by the Tivoli Storage Manager Backup-Archive Client.

  The Tivoli Storage Manager Version 6.1 and higher client message catalogs and help files are encoded in UTF-8. If you are installing Tivoli Storage Manager client message catalogs for languages other than English, you must also have the appropriate iconv UTF-8 converters installed on your system. If the appropriate iconv UTF-8 converters are not installed, all Tivoli Storage Manager client messages will be displayed in English.

- Snapdiff option for CIFS and NFS data stored on NetApp® filers:

  When used with the incremental command, the snapdiff option streamlines the incremental process by performing an incremental backup of the files reported as changed by NetApp, instead of scanning the volume looking for files that have changed.

- Full VM backup and restore support:

  The Tivoli Storage Manager **backup vm** command has been enhanced to provide full VM backup capabilities in addition to the file-level backup capabilities previously provided. You can copy full VM virtual disk exports to the backup proxy from snapshots. The entire virtual machine is backed up as a single item, similar to a Tivoli Storage Manager image backup. The exports are broken into 2 GB file chunks that the Tivoli Storage Manager backup-archive client backs up at a file level.

- Support for restoring Active Directory individual objects:

  You can use Active Directory individual object recovery and item-level restore during normal day-to-day operations to recover from accidental corruption or deletion of Active Directory objects by restoring one or more individual Active Directory objects. This feature does not require you to shut down or restart the Active Directory server.

- The Windows Native GUI has been replaced with the Java GUI:

  The Windows GUI is a Java application. The non-Java Windows Native GUI is installed as dsmmfc.exe in the installation directory. However, it has not been updated with the new Tivoli Storage Manager Version 6.1 features.

- Support for **querysummary** option:

  You can use the **querysummary** processing option to extend the **query archive** and **query backup** commands. This support provides a restore preview so that you can determine whether to use the classic or no-query restore method.

- Enhanced help facilities:

  The command-line client help command is enhanced so that you can specify the command, option, or message on which you want help information.

18.1.5 Application program interface (API) updates

Several features in IBM Tivoli Storage Manager Version 6.2 are new for previous Tivoli Storage Manager users.

The following features are new in API for Tivoli Storage Manager in Version 6.2:

- Deduplication:

  Client-side data deduplication is available through the API. Data deduplication reduces storage needs by eliminating redundant data. Client-side data deduplication reduces the amount of data sent over the LAN. The processing required to remove duplicate data on the server is eliminated. Space savings occur immediately. Client-side data deduplication requires a Tivoli Storage Manager Version 6.2 or later server.

- Structure changes:
  - The **objAttr structure** has been enhanced to include a new field that lets the application force no data deduplication on that specific object.
  - The **archDetailCG** structure has been enhanced to include a new field that indicates whether the archive copy group has a deduplication-enabled storage pool destination.
  - The **backupDetailCG** structure has been enhanced to include a new field that indicates whether the backup copy group has a deduplication-enabled storage pool destination.
  - The **qryRespArchiveData** structure has been enhanced to include a new field that indicates whether this object has been deduplicated during archive.
  - The **qryRespBackupData** structure has been enhanced to include a new field that indicates whether this object has been deduplicated during backup.
  - The **ApiSessInfo** structure has been enhanced to include a new field that indicates whether this node is enabled for client-side data deduplication. The possible values are **dedupServerOnly** or **dedupClientorServer**.
  - The **dsmEndSendObjExOut_t** structure has been enhanced to include two new fields. `Objdeduplicated` indicates whether the object was deduplicated by the client during a send operation. `TotalDedupSize` indicates the number of bytes sent to the server after data deduplication.

18.1.6 Space Management for UNIX and Linux client updates

The following features are new for IBM Tivoli Storage Manager since Version 6.1 and enhanced in Version 6.2:

- GPFS 3.2 storage pool support:
  - Tivoli Storage Manager 6.1 or higher allows multiple General Parallel File System (GPFS) storage pools in one file system. Monitoring a file system includes monitoring each storage pool in the file system.
  - The automigration command, **dmsautomig**, permits automatic migration of storage pools and file systems.
- Hierarchical Storage Management (HSM) for AIX and Linux for GPFS does not require RSCT fileset for cluster support:

  A new responsiveness service function is being added that provides:
  - Node response monitoring
  - Node failure detection and initiate failover actions
  - Event notification processing

  This function replaces the requirement of installing the RSCT Group Services. Do not use RSCT fileset for cluster support.
- Partial file recall enhancements for optimal tape access:

  The **dsmrecall** command will recall partial files with the **-OFFset** and **-SIZE** options. With this command, you can specify the portion of a file that is to be recalled.
- GPFS policy-based file list reconciliation is being added to Tivoli Storage Manager for Space Management.

18.1.7 HSM for Windows updates

Several features in the Hierarchical Storage Management (HSM) for Windows client Version 6.1 are new for previous HSM for Windows client users.

The following features are new for the IBM Tivoli Storage Manager HSM for Windows client in Version 6.1:

- Threshold migration:

  Threshold migration provides the capability to automatically maintain a certain amount of free space on protected file systems. No further interaction and manual inspection or monitoring is needed to prevent out-of-space conditions.

- Support for IPv6:

  You can configure a connection with the Tivoli Storage Manager server that uses only IPv4, or a connection that uses either IPv4 or IPv6. In the latter case, the version depends on the network configuration of the file server where HSM for Windows client is installed, and the capabilities of the Tivoli Storage Manager server. The default setting is **`commmethod v6tcpip`**.

- Support for Microsoft Windows Server 2008:

  With the HSM for Windows client, you can use 64-bit versions of Microsoft Windows Server 2008, Standard Edition, and Enterprise Edition.

18.1.8 IBM Tivoli Storage FlashCopy Manager V2.2

IBM Tivoli Storage FlashCopy Manager V2.2 is designed to deliver high levels of data protection for business-critical databases through snapshot backup and restore capabilities that are integrated with the databases.

Tivoli Storage FlashCopy Manager can back up IBM DB2, SAP, Oracle, Microsoft Exchange, and Microsoft SQL databases. IBM DB2 and Oracle databases can be used either with or without SAP environments.

Tivoli Storage FlashCopy Manager uses advanced IBM storage hardware snapshot technology to help create a high performance, low impact application data protection solution. It integrates with IBM System Storage DS8000, IBM SAN Volume Controller, and IBM XIV Storage System products. For Microsoft Windows environments, Tivoli Storage FlashCopy Manager also supports other hardware that is capable of Microsoft Volume Shadow Copy Services (VSS) functions, such as IBM System Storage DS3000, DS4000, and DS5000.

Tivoli Storage FlashCopy Manager can replace the following products:

- IBM Tivoli Storage Manager for Copy Services
- IBM Tivoli Storage Manager for Advanced Copy Services.

These are the new features for Tivoli Storage FlashCopy Manager V2.2:

- Microsoft Exchange Server 2010 is supported.
- Improved Microsoft Exchange Server mailbox history and mailbox restore performance
- Complete implementation of instant restore from space-efficient target volumes for SAN Volume Controller (SVC) 5.1
- Support for IBM DB2 and Oracle databases, with or without SAP environments, is extended to Solaris SPARC and Linux x64 operating system platforms

- Database cloning of IBM DB2, Oracle, and the IBM DB2 or Oracle databases of SAP applications is available to help you perform tasks that are not directly related to backup and recovery procedures such as quality assurance, education, and data mining.

18.1.9 Data Protection for Mail updates

Data Protection for Exchange 6.1 provides the new mailbox restore feature. Data Protection for Exchange provides a single, easy to use, and well-integrated interface to perform the back up and restore of mailbox databases, individual mailbox-level recovery, and item-level recovery for Microsoft Exchange Server 2010.

With the Data Protection for Exchange 6.1 mailbox restore feature, you can also perform individual mailbox recovery and item-level recovery operations in Microsoft Exchange Server 2003 or Microsoft Exchange Server 2007 environments using Data Protection for Exchange backups.

> **Tip:** Mailbox restore tracks and stores mailbox location history, which is used to automate mailbox restore operations. This causes a slight delay before each backup.

Mailbox restore applies to backups that are taken with Data Protection for Exchange:

- For Exchange Server 2003 environments, mailbox restore applies to Data Protection for Exchange Legacy backups only. For Exchange Server 2003, mailbox restore operations cannot be performed using VSS Backups.
- For Exchange Server 2007 environments, mailbox restore applies to any Data Protection for Exchange Legacy backups or VSS Backups.
- Data Protection for Exchange 6.1 (and later) maintains mailbox location history. No mailbox location history is available for backups taken with prior versions. When restoring from these prior version backups, if the mailbox to be restored from has been moved or deleted since the time of the backup, the */mailboxoriglocation* parameter is necessary.

18.1.10 Data Protection for SAP updates

The following new functionality has been added to Version 6.1 of Data Protection for SAP Oracle or DB2 and enhanced in Version 6.2:

- Executable files on Windows platforms (except Java applets) now bear a digital signature.
- Install Anywhere has replaced Install Shield as the installation vehicle.
- As of version 7.1, the SAP BR*Tools components have a facility for invoking snapshot (in SAP terminology, volume) backups and restores. Such requests received by TSM for ERP are redirected to the Tivoli Storage Manager for Advanced Copy Services (TSM for ACS) product (if it is installed). To facilitate the interaction of TSM for ACS with TSM for ERP when the user wants to perform a Tivoli Storage Manager backup of the snapshots produced, certain parameters have been added to the TSM for ERP profile for use by TSM for ACS. For more information, see the TSM for ACS documentation.
- AIX 6.1 is now supported.
- In Data Protection for SAP Oracle or DB2 Version 6.2, backup objects are partitioned into smaller segments to improve the handling of very large objects.

Support for 32–bit platforms has been discontinued.

18.1.11 Storage agent updates

With Tivoli Storage Manager for Storage Area Networks Version 6.1, you can use the file-device-sharing software IBM General Parallel File System. You can also continue to use either Tivoli SANergy® or IBM TotalStorage SAN File System. IBM General Parallel File System is the preferred option for the operating systems on which it is supported.

With Tivoli Storage Manager for Storage Area Networks Version 6.2, the CHECKTAPEPOS option applies only to operations using tape drives. It does not apply to non-tape, sequential-access device classes such as FILE or OPTICAL. If the server information about position does not match the position detected by the drive, an error message is displayed, the transaction is rolled back, and the data is not committed to the database.

18.1.12 Previous products and components prior to V6.2

Here is a summary of products and components that are not available in V6.2 and might be available in earlier versions.

The following products and components were last updated in V6.1:

- IBM Tivoli Storage Manager for Advanced Copy Services
- IBM Tivoli Storage Manager HSM for Windows
- IBM Tivoli Storage Manager for Mail: Data Protection for Microsoft Exchange
- IBM Tivoli Storage Manager for Microsoft SharePoint

The following products and components were last updated in V5.5:

- IBM Tivoli Storage Manager server for z/OS operating systems
- IBM Tivoli Storage Manager for Data Retention for z/OS
- IBM Tivoli Storage Manager backup-archive client for Novell NetWare
- IBM Tivoli Storage Manager for Copy Services
- IBM Tivoli Storage Manager for Mail: Data Protection for Lotus® Domino for UNIX, Linux, and i5/OS
- IBM Tivoli Storage Manager for Databases: Data Protection for Oracle
- IBM Tivoli Storage Manager for Databases: Data Protection for Microsoft SQL Server
- IBM Tivoli Storage Manager for System Backup and Recovery

For information about these products, see the website:

http://publib.boulder.ibm.com/infocenter/tivihelp/v1r1

18.2 IBM Tivoli Storage Manager overview

Businesses face a tidal wave of information and data that seems to increase daily. The ability to successfully manage information and data has become imperative. The IBM Tivoli Storage Manager 6.*x* family of products help businesses successfully gain better control and efficiently manage the information tidal wave with significant enhancements in multiple facets of data protection.

From its inception, Tivoli Storage Manager has been a highly scalable and available data protection solution. Tivoli Storage Manager 6.2 takes data protection scalability to the next level with a new relational database, based on IBM DB2 technology, designed to store many more objects and manage more data. Greater availability is delivered through enhancements such as online, automated database reorganization. In addition, the increased scalability and the ability to utilize the latest in server technology helps deliver increased performance of backup and recovery processes.

Tivoli Storage Manager 6.2 delivers new near real-time monitoring and operational reporting capabilities.

Tivoli Storage Manager 6.2 helps decrease the rate of storage capacity required to contain data growth with a new built-in data deduplication feature that helps eliminate redundant data. This can enable significantly more backup data to be stored on disk.

For enterprise IT departments, the ability to work around the clock anywhere in the world, can translate to increasingly stringent recovery point objectives and recovery time objectives, and drives the need for more effective business continuity, planning, and execution. Tivoli Storage Manager 6.2 helps address these challenges with several new features and enhancements, including:

- Individual mailbox and item level recovery for Microsoft Exchange users
- Up to two times throughput improvement for a single Tivoli Storage Manager server for operations, such as backing up small files from multiple clients
- Enhancements designed to improve performance for IBM System Storage N series and NetApp Network Attached Storage (NAS)
- Disaster recovery preparedness enhanced for VMware, IBM System Storage N series, NetApp NAS environments, and Microsoft Windows Active Directory environments.

18.3 IBM Tivoli Storage Manager architecture

This topic provides general information about IBM Tivoli Storage Manager architecture. For more details, see the *Tivoli Storage Manager - Administrator's Guide*.

IBM Tivoli Storage Manager clients are the workstations, file servers, mobile computers, and other machines that must have their data protected. IBM Tivoli Storage Manager client software is installed on these systems.

The IBM Tivoli Storage Manager architecture is shown in Figure 18-2.

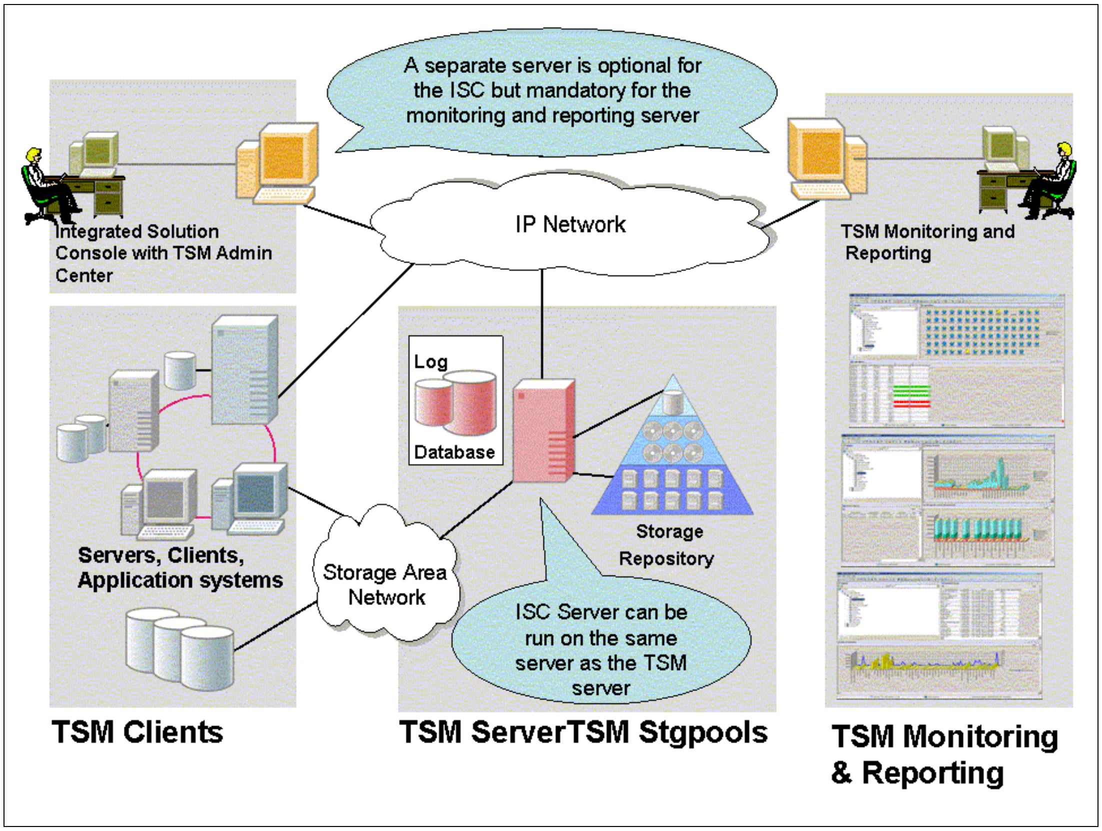


Figure 18-2 IBM Tivoli Storage Manager architecture

Tivoli Storage Manager is based on a DB2 database that tracks what is backed up, where it is stored, how long it will be stored, how many versions of the data are kept, and the number and length of time a copy of the file is kept after it is deleted from the original file system.

The relational database allows Tivoli Storage Manager to perform tasks that are not possible when you use a flat file master catalog to track metadata and enables a two-phase commit, which protects the integrity of the database and allows interrupted backups and restores to be restarted. For example, the relational database can:

- Move data from one type of storage pool to another
- Retroactively update backed-up data when a policy changes
- Track individual files
- Schedule any type of client or administrative process
- Reclaim expired dead space on tapes.

The Tivoli Storage Manager client sends its data to the Tivoli Storage Manager server either by the LAN or by the SAN. Most backups occur through schedules, but clients can perform on demand backups whenever they want. Clients can also perform their own restores. Tivoli Storage Manager has an improved Administration Center that was introduced in Version 5.3 and can now be installed either on the same machine as the Tivoli Storage Manager Server or on a separate machine.

The actual data that the client sends is stored in storage pools. Tivoli Storage Manager is unique in the fact that the storage pools can form a storage hierarchy made up of more than 500 supported devices. This allows for flexibility, longevity, and, most important, fast backups and fast restores.

Most businesses back up their data initially to disk storage. This allows for hundreds of clients to back up at the same time. Then, based on policies, the data migrates in a fashion that expedites restores to tape or optical disk. When the data migrates, all data belonging to one client is moved together to the next pool. By keeping all of that data together, restores are faster because not as much tape positioning is required. This migration process can also accommodate data movement to collocated tapes, which further expedites restores by having data for just one user on them. Collocation can be used to group important functions of your business to ensure rapid recovery in the event of disaster.

The environment can be firewall protected, and Tivoli Storage Manager allows individual configuration of nearly every TCP port that it uses for communication:

- TCP/IP port:

  To enable the Backup/Archive client, command-line Administrative Client, and the scheduler to run outside a firewall, the port specified by the tcpport server option must be opened by the firewall administrator. This port is set on the client and the server using the tcpport option. The setting must be the same on the client and server. The default TCP/IP port is 1500.

- TCP/IP ports for the remote workstation:

  The two TCP/IP ports for the remote workstation client must be opened. Use the WEBPORTS option in the remote workstations option file to specify these ports. If you do not specify the values for the WEBPORTS option, the default zero (0) causes TCP/IP to randomly assign two free port numbers.

18.3.1 IBM Tivoli Storage Manager architectural components

The IBM Tivoli Storage Manager consists of several key components. This topic identifies these components and shows how they are related.

For more information, see the documentation listed in 18.10, “More information” on page 600.

IBM Tivoli Storage Manager Server

The principal architectural component of the IBM Tivoli Storage Manager server is its DB2 database. The IBM Tivoli Storage Manager database was especially designed for the task of managing data and implements zero-touch administration.

All policy information, logging, authentication and security, media management, and object inventory are managed through this database.

Most of the fields are externalized through IBM Tivoli Storage Manager high-level administration commands, SQL SELECT statements, or, for reporting purposes, by using an ODBC driver. Obviously, this database is fully protected with software mirroring, roll-forward capability, and its own management, online backup and restore functions.

For storing the managed data, the IBM Tivoli Storage Manager server manages a storage repository. The storage repository can be implemented in a hierarchy using any combination of supported media or magnetic or optical disk, tape, and robotic storage devices, which are locally connected to the server system or are accessible through a SAN. To take advantage of SAN technology, the IBM Tivoli Storage Manager server has features implemented that dynamically share SAN-connected, automated tape library systems among multiple IBM Tivoli Storage Manager servers, as well as provide (as an option) local area network, or LAN-free and server-free backup.

Figure 18-3 shows a Tivoli Storage Manager server storage example.

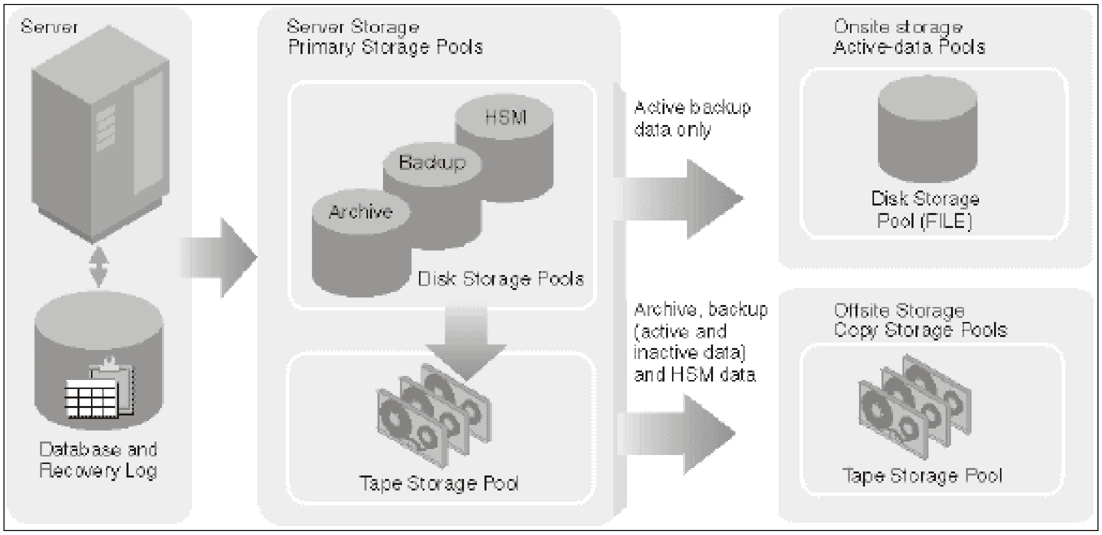


Figure 18-3 Example of server storage

IBM Tivoli Storage Manager Backup/Archive client

Data is sent to the IBM Tivoli Storage Manager server using the IBM Tivoli Storage Manager Backup/Archive client and complementary products. These products work together with the IBM Tivoli Storage Manager Server base product to ensure that any data stored is managed as defined.

The IBM Tivoli Storage Manager Backup/Archive client, included with the server, provides the operational backup and archive functions. The client implements the patented progressive backup methodology, adaptive sub-file backup technology, and unique record retention methods for backup and archive functions.

The Backup/Archive clients are implemented as multi-session clients, which means that they are able to take advantage of the multi-threading capabilities of modern operating systems.

IBM Tivoli Storage Manager for Storage Area Networks

IBM Tivoli Storage Manager for Storage Area Networks allows client systems to write data directly to, or read data directly from, storage devices attached to a SAN. This is called *LAN-free data movement*.

LAN-free data movement makes LAN bandwidth available for other uses and decreases the load on the Tivoli Storage Manager server, allowing it to support a greater number of concurrent client connections.

The key component of Tivoli Storage Manager for Storage Area Networks is the *storage agent*. You install the storage agent on a client system that shares storage resources with the Tivoli Storage Manager server, as shown in Figure 18-4.

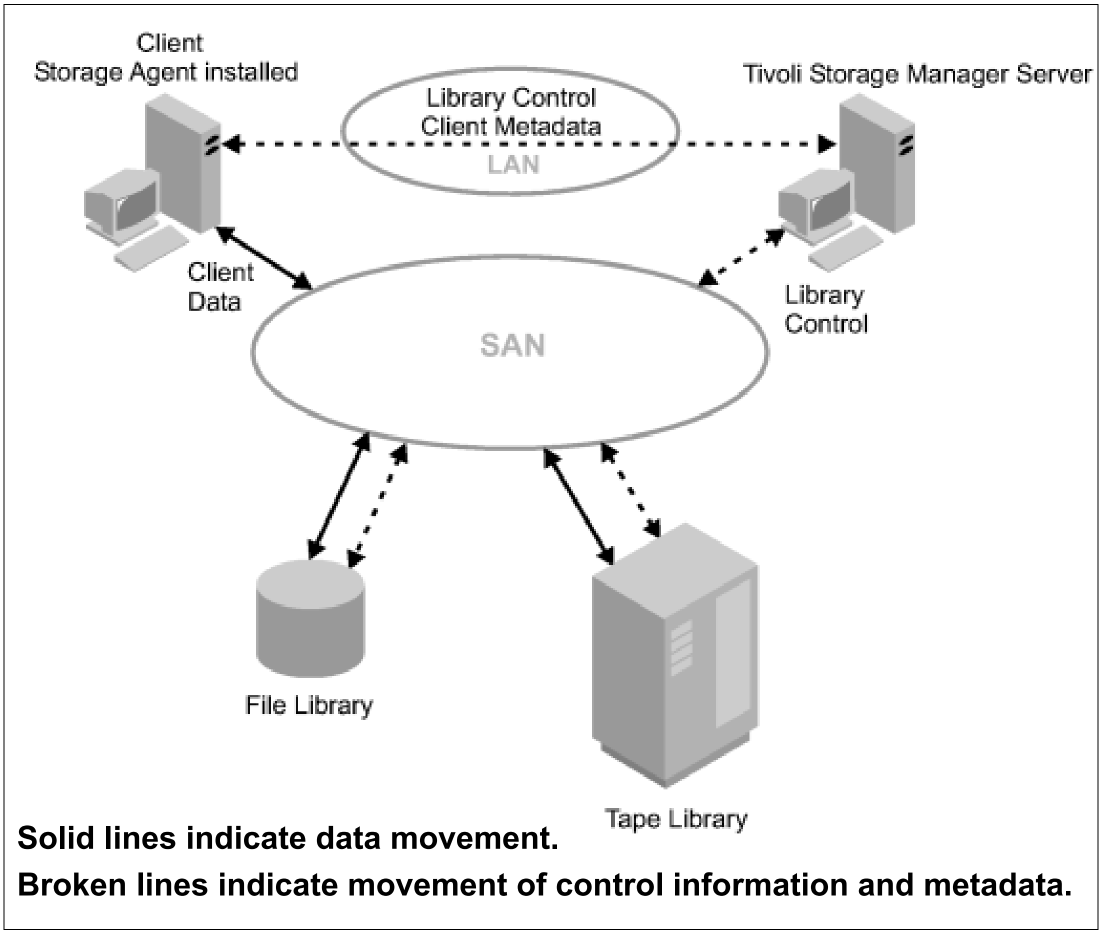


Figure 18-4 SAN data movement

The storage agent can support several clients while installed on only one of the clients. You can also install the storage agent on a client system that does not share storage resources with the Tivoli Storage Manager server, but that is connected to a client system that does share storage resources. The LANFREECOMMMETHOD option allows a client system that shares storage resources to communicate with the storage agent. The LANFREECOMMMETHOD option also allows the storage agent to support several clients while installed on only one of the clients.

Figure 18-5 shows SAN data movement with the LANFREECOMMMETHOD option.

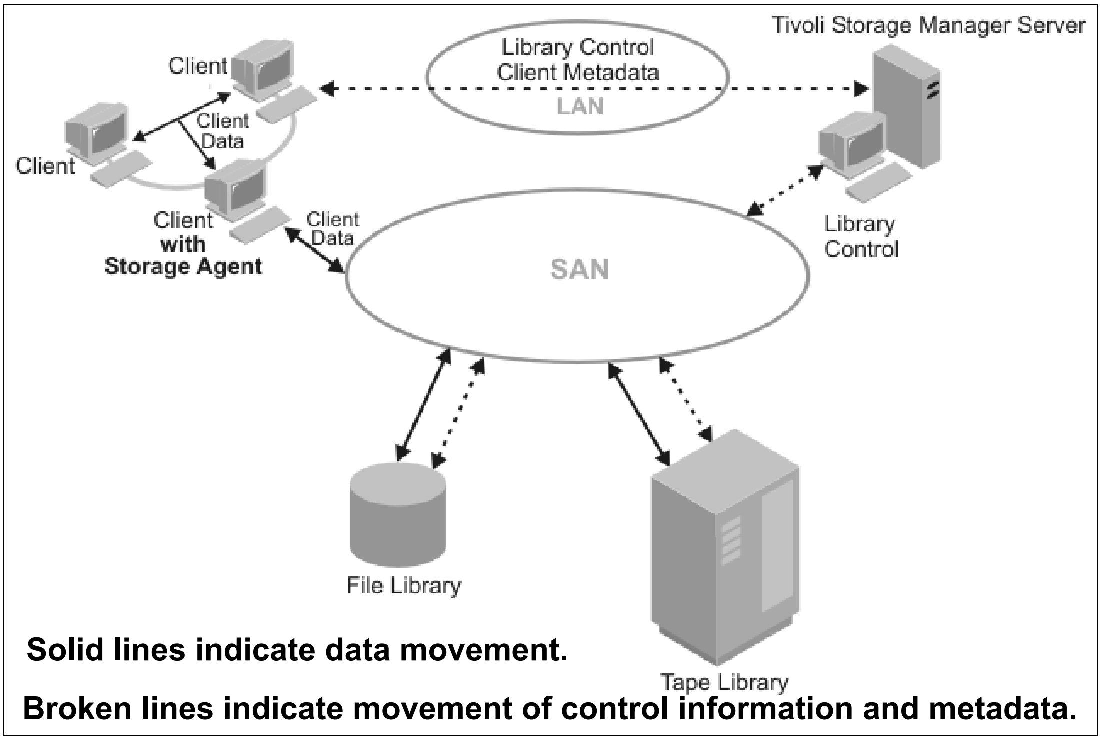


Figure 18-5 SAN data movement with the LANFREECOMMMETHOD option

A Tivoli Storage Manager server, acting as a library manager, controls the storage devices. This server can be the server working in conjunction with the storage agent or another Tivoli Storage Manager server in the enterprise. The Tivoli Storage Manager server keeps track of the metadata that the client has stored. The metadata, such as policy information and file name and size, is passed over the LAN connection between the storage agent and server.

The storage agent communicates with the server to obtain and store database information and to coordinate device and volume access. The server and client coordinate and transfer data access through the SAN. The client uses the storage agent for operations where appropriate. For example, if a SAN path is defined, the client (by means of the storage agent) transfers data on that path. If a failure occurs on the SAN path, failover occurs and the client uses its LAN connection to the Tivoli Storage Manager server and moves the client data over the LAN.

The storage agent can send the data directly to the server using the LAN control paths between the storage agent and the server. An example is a LAN-free storage pool that is updated to read-only after the client connects to the server and obtains its initial policy information. The storage agent, instead of failing the operation, sends the data to the server. If the storage hierarchy is configured so that the Next storage pool destination is available, the server performs the operation.

Tivoli Storage Manager supports SAN-attached device sharing in the following environments:

- Tivoli Storage Manager native library management support consists of an ACSLS, SCSI, or 349X library manager and library clients or just a library manager.
- Shared disk storage using a FILE library and the integration of IBM General Parallel File System, Tivoli SANergy, or IBM TotalStorage SAN File System. IBM General Parallel File System is the preferred option for operating systems on which it is supported.
- External libraries are used.

18.3.2 How client data is stored

Tivoli Storage Manager policies are rules that determine how the client data is stored and managed. The rules include where the data is initially stored, how many backup versions are kept, how long archive copies are kept, and so on.

You can have multiple policies and assign the various policies as needed to specific clients, or even to specific files. Policy assigns a location in server storage where data is initially stored. Server storage is divided into storage pools that are groups of storage volumes.

Server storage can include hard disk, optical, and tape volumes.

Clients use Tivoli Storage Manager to store data for any of the following purposes:

- Backup and restore:

  The backup process copies data from client workstations to server storage to ensure against loss of data that is regularly changed. The server retains versions of a file according to policy, and replaces older versions of the file with newer versions. Policy includes the number of versions and the retention time for versions.

  A client can restore the most recent version of a file, or can restore earlier versions.

- Archive and retrieve:

  The archive process copies data from client workstations to server storage for long-term storage. The process can optionally delete the archived files from the client workstations. The server retains archive copies according to the policy for archive retention time. A client can retrieve an archived copy of a file.

- Instant archive and rapid recovery:

  Instant archive is the creation of a complete set of backed-up files for a client. The set of files is called a *backupset*. A backupset is created on the server from the most recently backed-up files that are already stored in server storage for the client. Policy for the backupset consists of the retention time that you choose when you create the backupset.

  You can copy a backupset onto compatible portable media, which can then be taken directly to the client for rapid recovery without the use of a network and without having to communicate with the Tivoli Storage Manager server.

- Migration and recall:

  Migration, a function of the Tivoli Storage Manager for Space Management program, frees up client storage space by copying files from workstations to server storage. On the client, the Tivoli Storage Manager for Space Management program replaces the original file with a stub file that points to the original in server storage. Files are recalled to the workstations when needed.

  For Windows, this process is also called Hierarchical Storage Management (HSM). After being configured, the process is transparent to the users. Files are migrated and recalled automatically.

  Policy determines when files are considered for automatic migration. On the UNIX or Linux systems that support the Tivoli Storage Manager for Space Management program, policies determine whether files must be backed up to the server before being migrated. Space management is also integrated with backup. If the file to be backed up is already migrated to server storage, the file is backed up from there.

Figure 18-6 shows policy as part of the Tivoli Storage Manager process for storing client data.

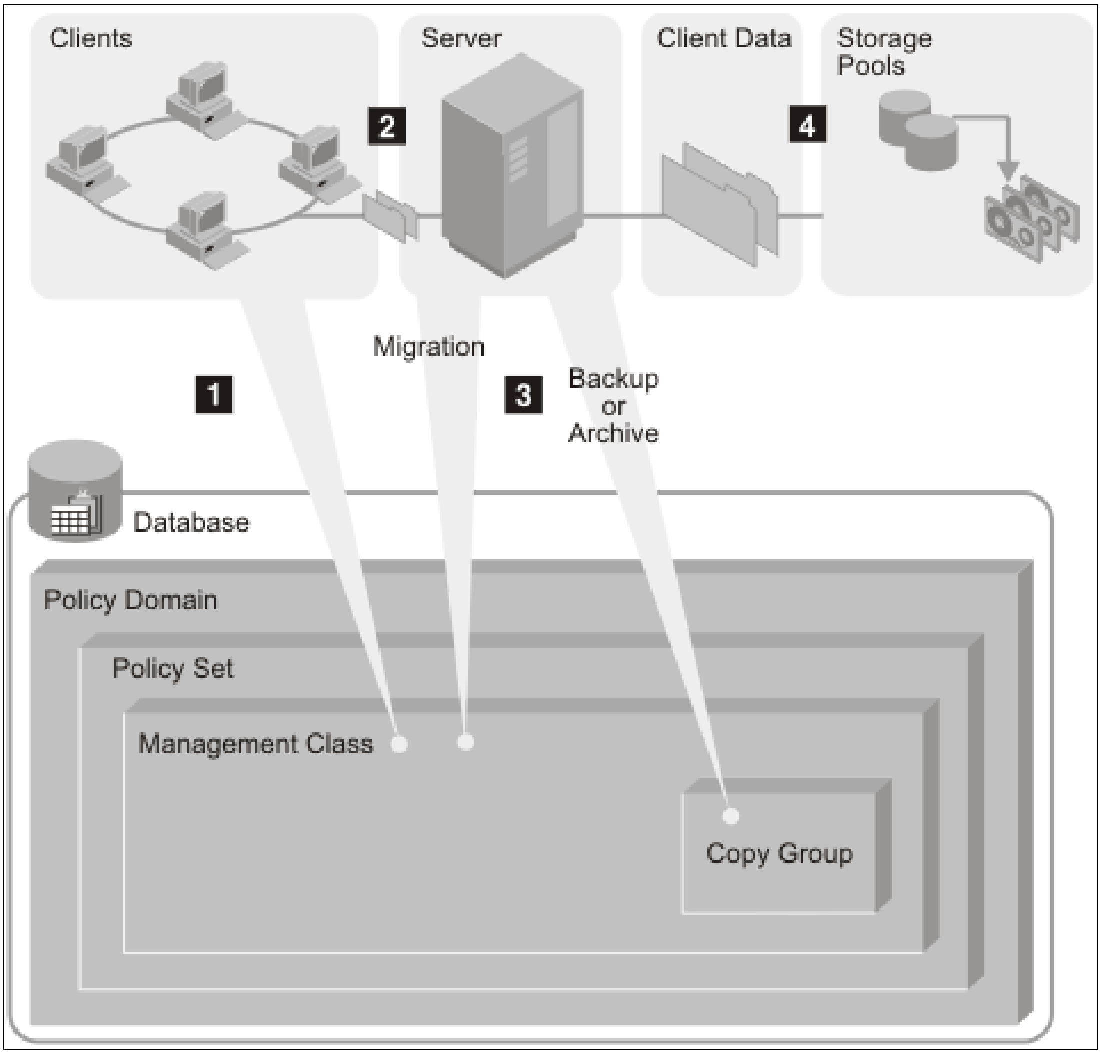


Figure 18-6 How IBM Tivoli Storage Manager Controls Backup, Archive, and Migration Processes

The steps in the process are as follows:

1. A client initiates a backup, archive, or migration operation. The file involved in the operation is bound to a management class. The management class is either the default or one specified for the file in client options (the client's include-exclude list).
2. If the file is a candidate for backup, archive, or migration based on information in the management class, the client sends the file and file information to the server.
3. The server checks the management class that is bound to the file to determine the destination, the name of the Tivoli Storage Manager storage pool where the server initially stores the file. For backed-up and archived files, destinations are assigned in the backup and archive copy groups, which are within management classes. For space-managed files, destinations are assigned in the management class itself.
4. The server stores the file in the storage pool that is identified as the storage destination. The Tivoli Storage Manager server saves information in its database about each file that it backs up, archives, or migrates. If you set up server storage in a hierarchy, Tivoli Storage Manager can later migrate the file to a storage pool other than from the one where the file was initially stored. For example, you might set up server storage so that Tivoli Storage Manager migrates files from a disk storage pool to tape volumes in a tape storage pool.

Files remain in server storage until they expire (retention policies are met) and expiration processing occurs, or until they are deleted from server storage. A file expires because of criteria that are set in policy. For example, the criteria include the number of versions allowed for a file and the number of days that have elapsed since a file was deleted from the client's file system. If data retention protection is activated, an archive object cannot be inadvertently deleted.

18.3.3 How the server manages storage

Through the server, you manage the devices and media used to store client data. The server integrates the management of storage with the policies that you define for managing client data. For more information, see the documentation listed in 18.10, “More information” on page 600.

Device support

With Tivoli Storage Manager, you can use of a variety of devices for server storage. Tivoli Storage Manager can use direct-attached storage devices as well as network-attached storage devices.

See the current list on the IBM Tivoli Storage Manager website:

http://www.ibm.com/support/entry/portal/Overview/Software/Tivoli/Tivoli_Storage_Manager

Tivoli Storage Manager represents physical storage devices and media with the following administrator-defined objects:

- Library:

  A library is one or more drives (and possibly robotic devices) with similar media mounting requirements.

- Drive:

  Each drive represents a drive mechanism in a tape or optical device.

- Data mover:

  A data mover represents a device that accepts requests from Tivoli Storage Manager to transfer data on behalf of the server. Data movers transfer data between storage devices.

- Path:

  A path represents how a source accesses a destination. For example, the source can be a server, and the destination can be a tape drive. A path defines the one-to-one relationship between a source and a destination. Data might flow from the source to the destination, and back.

- Device class:

  Each device is associated with a device class that specifies the device type and how the device manages its media.

- Storage pools and volumes:

  A storage pool is a named collection of volumes that have the same media type. A storage pool is associated with a device class. A storage pool volume is associated with a specific storage pool.

Data migration through the storage hierarchy

You can organize the server's storage pools into one or more hierarchical structures. This storage hierarchy allows flexibility in a number of ways. For example, you can set policy to have clients send their backup data to disks for faster backup operations, then later have the server automatically migrate the data to tape.

Storage pool hierarchies

You can arrange storage pools in a storage hierarchies, which consist of at least one primary storage pool to which a client node backs up, archives, or migrates data. Typically, data is stored initially in a disk storage pool for fast client restores, and then moved to a tape-based storage pool, which is slower to access but which has greater capacity. The location of all data objects is automatically tracked within the server database.

You can set up your devices so that the server automatically moves data from one device to another, or one media type to another. The selection can be based on characteristics such as file size or storage capacity. A typical implementation might have a disk storage pool with a subordinate tape storage pool. When a client backs up a file, the server might initially store the file on disk according to the policy for that file. Later, the server might move the file to tape when the disk becomes full. This action by the server is called *migration*. You can also place a size limit on files that are stored on disk, so that large files are stored initially on tape instead of on disk.

For example, your fastest devices are disks, but you do not have enough space on these devices to store all data that needs to be backed up over the long term. You have tape drives, which are slower to access, but have much greater capacity. You define a hierarchy so that files are initially stored on the fast disk volumes in one storage pool. This provides clients with quick response to backup requests and certain recall requests. As the disk storage pool becomes full, the server migrates, or moves, data to volumes in the tape storage pool.

Another option to consider for your storage pool hierarchy is IBM 3592 tape cartridges and drives, which can be configured for an optimal combination of access time and storage capacity.

Migration of files from disk to sequential storage pool volumes is particularly useful because the server migrates all the files for a group of nodes or a single node together. This gives you partial collocation for clients. Migration of files is especially helpful if you decide not to enable collocation for sequential storage pools.

Keeping client files together using collocation

With collocation enabled, the server attempts to keep files belonging to a group of client nodes, a single client node, or client file space on a minimal number of sequential-access storage volumes. Collocation reduces the number of volume mounts required when users restore, retrieve, or recall a large number of files from the storage pool. Collocation thus reduces the amount of time required for these operations.

You can set collocation for each sequential-access storage pool when you define or update the pool.

Figure 18-7 shows an example of collocation by client node with three clients, each having a separate volume containing that client's data.

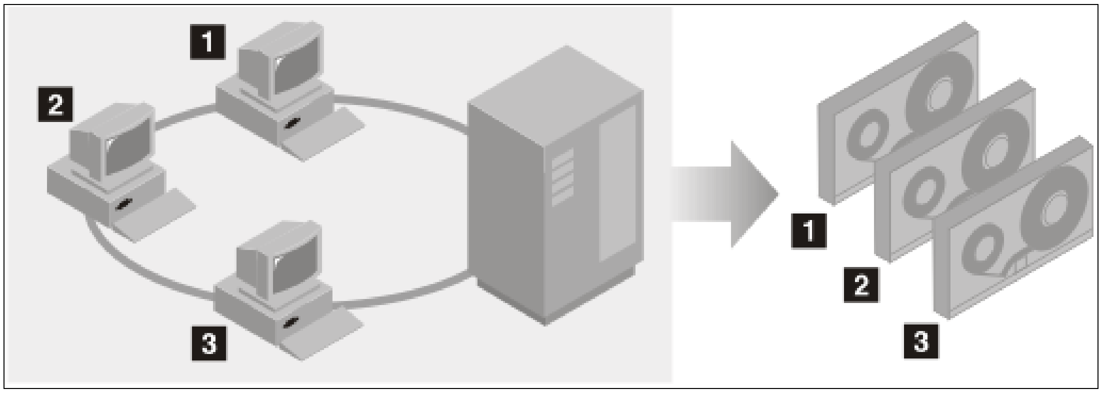


Figure 18-7 Example of collocation enabled (by node)

Figure 18-8 shows an example of collocation by group of client nodes. Three groups have been defined, and the data for each group is stored on separate volumes.

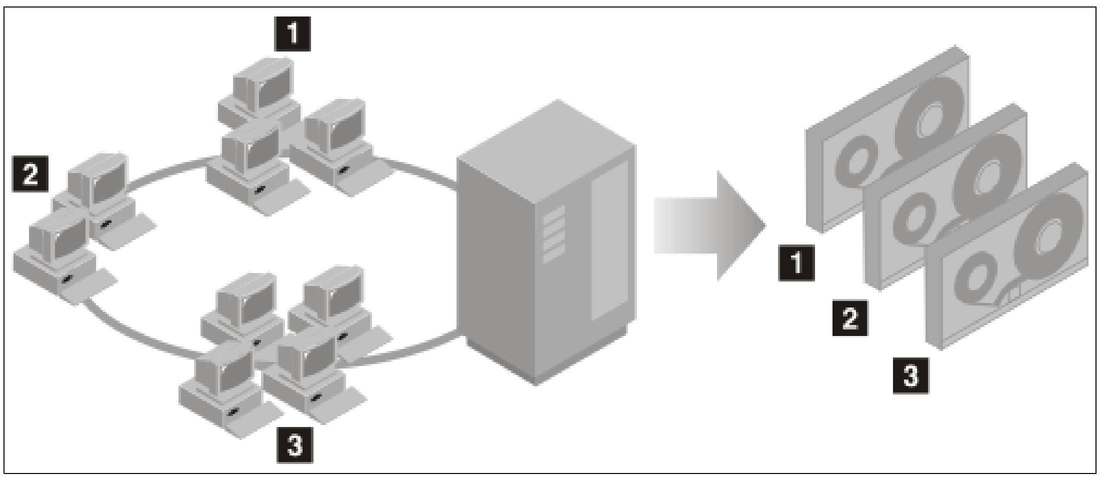


Figure 18-8 Example of collocation enabled (by group)

When collocation is disabled, the server attempts to use all available space on each volume before selecting a new volume. While this process provides better utilization of individual volumes, user files can become scattered across many volumes. Figure 18-9 shows an example of collocation disabled, with three clients sharing space on single volume.

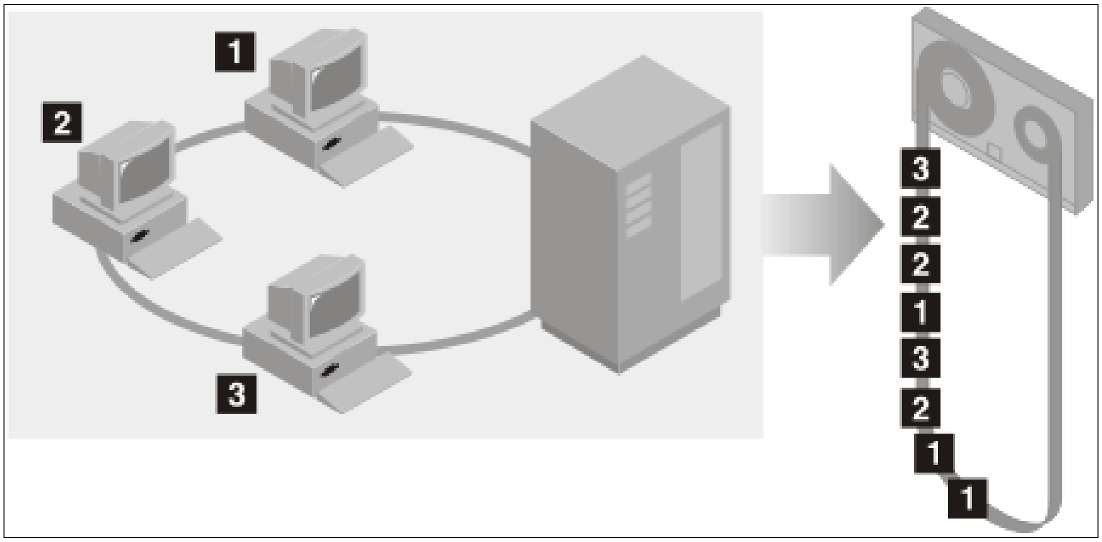


Figure 18-9 Example of collocation disabled

With collocation disabled, more media mount operations might be required to mount volumes when users restore, retrieve, or recall a large number of files.

Collocation by group is the Tivoli Storage Manager system default for primary sequential-access storage pools. The default for copy storage pools and active-data pools is *no collocation*.

Removal of expired data

A policy that you define controls when client data automatically expires from the Tivoli Storage Manager server. The expiration process is how the server implements the policy.

For example, you have a backup policy that specifies that three versions of a file be kept. File A is created on the client, and backed up. Over time, the user changes file A, and three versions of the file are backed up to the server. Then the user changes file A again. When the next incremental backup occurs, a fourth version of file A is stored, and the oldest of the four versions is eligible for expiration.

To remove data that is eligible for expiration, a server expiration process marks data as expired and deletes metadata for the expired data from the database. The space occupied by the expired data is then available for new data.

You control the frequency of the expiration process by using a server option, or you can start the expiration processing by command or scheduled command.

Media reuse by reclamation

As server policies automatically expire data, the media where the data is stored accumulates unused space. The Tivoli Storage Manager server implements a process, called *reclamation*, which allows you to reuse media without traditional tape rotation.

Reclamation is a server process that automatically defragments media by consolidating unexpired data onto other media when the free space on media reaches a defined level. The reclaimed media can then be used again by the server. Reclaiming media allows the automated circulation of media through the storage management process. Use of reclamation can help minimize the number of media that you need to have available.

18.3.4 Tivoli Storage Manager backup and archive concepts

Backup, in Tivoli Storage Manager terms, means creating a copy of a data object to be used for recovery. A Tivoli Storage Manager data object can be a file, a part of a file, a volume image, a directory or a user-defined data object like a database table. The backup version of this data object is stored separately in the Tivoli Storage Manager server storage hierarchy. Tivoli Storage Manager policy tools allow great flexibility for the way data is managed for each client. Backup frequency, retention, and copy policies are easily implemented on the Tivoli Storage Manager client.

In addition to data backup, *archive* copies of data can also be created using Tivoli Storage Manager. Archive creates an additional copy of data and stores it for a specific amount of time, known as the retention period. Tivoli Storage Manager archives are not expired until the retention period is past, even if the original files are deleted from the client system.

Therefore, the difference between *backup* and *archive* is that backup creates and controls multiple backup versions, whereas archive creates an additional file that is retained for a specific period of time.

For details, see the documentation listed in 18.10, “More information” on page 600.

18.3.5 Progressive incremental backups

One of the key differentiators between Tivoli Storage Manager and other data protection products is the *progressive incremental backup methodology*. Tivoli Storage manager only backs up new or changed files. It tracks all of the backups at a file level. It has no concept of a full backup with dependent incrementals or differentials. Because of Tivoli Storage Manager’s powerful relational database, it does not require periodic full backups. Incremental backup by date is also available. This methodology reduces network and storage resource consumption and lowers the overall cost of storage management. Tivoli Storage Manager’s file level progressive backup methodology is far superior to other traditional backup methods such as Full+Incremental or Full+Differential, because progressive incremental backups are never redundant.

For more information, see the documentation listed in 18.10, “More information” on page 600.

18.3.6 Tivoli Storage Manager reporting and monitoring

The IBM Tivoli Storage Manager reporting and monitoring feature uses a combination of reporting and monitoring components to offer you historical reports and real-time monitoring information for the IBM Tivoli Storage Manager servers and clients.

You can view the historical reports to see if there are any issues that need attention, such as uncontrolled growth over time. You can also view workspaces that are being monitored to see the Tivoli Storage Manager server IDs, database size, agent status, client node status, scheduled events, and so on.

The reporting component, sometimes referred to as Tivoli Common Reporting, reports on the retrieved historical data. IBM Tivoli Monitoring acts as a monitoring application that provides workspaces for you to monitor real-time information.

The Tivoli Storage Manager monitoring agent communicates with the Tivoli Storage Manager reporting and monitoring server to retrieve data from its database and return this data to the Tivoli Monitoring server. The Tivoli Storage Manager monitoring agent communicates with the Tivoli Storage Manager reporting and monitoring server to retrieve data from its database and return this data to the Tivoli Monitoring server.

Important: You can view reporting and monitoring information for Solaris and HP-UX systems, but only on a Windows, AIX, or Linux IBM Tivoli Monitoring server.

The monitoring server stores this data in the Tivoli Data Warehouse.

The Tivoli Storage Manager reporting and monitoring feature uses the following components:

- Tivoli Monitoring:

  Consists of a number of components that accumulate and monitor historical data for reporting:

  - IBM Tivoli Enterprise Portal
  - IBM Tivoli Enterprise Management Server
  - Tivoli Data Warehouse.
- IBM DB2:

  Stores historical data that is obtained from Tivoli Storage Manager servers that are monitored using IBM Tivoli Monitoring.
- Tivoli Storage Manager monitoring agent:

  Queries and formats data to be presented to you in the following ways:

  - As workspaces using the Tivoli Enterprise Portal
  - As reports using the Tivoli Data Warehouse and the reporting portion of the Tivoli Storage Manager reporting and monitoring feature

  The agent is installed on the Tivoli Storage Manager server or the Tivoli Monitoring server, and is a multi-instance data collection agent.
- Tivoli Storage Manager reporting and monitoring reporting infrastructure:

  Reports on the Tivoli Storage Manager server activities from data that is collected using the Tivoli Storage Manager monitoring agent. The monitoring feature uses the Tivoli Enterprise Portal to view the current status of the Tivoli Storage Manager server.

Figure 18-10 shows how the data flows between the various components.

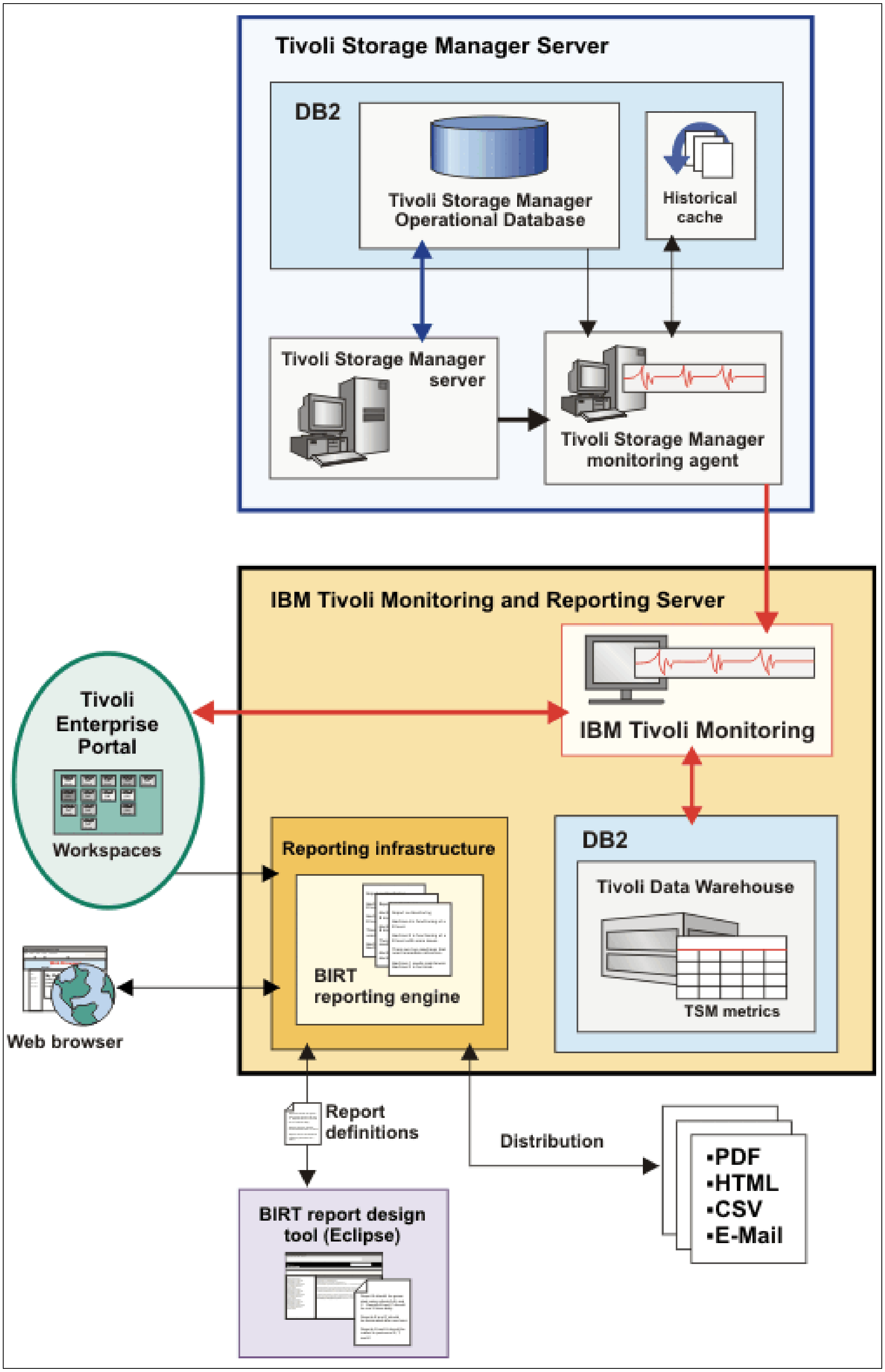


Figure 18-10 Tivoli Storage Manager reporting and monitoring feature infrastructure and data flow

If you are interested in creating your own custom reports, you are required to install the Business Intelligence and Reporting Tools (BIRT) software. The Tivoli Storage Manager reporting and monitoring feature does not have an option to create custom reports using Tivoli Storage Manager.

For more information, see the documentation listed in 18.10, “More information” on page 600.

18.3.7 Tivoli Storage Manager Administration Center

The Tivoli Storage Manager Administration Center is a web-based interface for centrally configuring and managing IBM Tivoli Storage Manager Version server V5.3 and later, including V6.1 and V6.2. This topic provides general information about Tivoli Storage Manager Administration Center.

For details, see the documentation listed in 18.10, “More information” on page 600.

The Administration Center is a task-oriented interface that replaces the previous administrative web interface. The Administration Center provides wizards to help guide you through common configuration tasks. Properties notebooks allow you to modify settings and perform advanced management tasks.

> **Important:** The Tivoli Storage Manager V5.3 server and Administration Center (AC) are out of regular service. To obtain technical support for the V5.3 server and Administration Center, you need an extended-support contract.
>
> To administer a V6.1 and higher server using the Administration Center, the Administration Center must be at least V6.1. It is highly desirable to upgrade AC together with a new release of the Tivoli Storage Manager server and its upgrade.

Key features of the Administration Center

Here we list the key features of the Administration Center:

- You only need to log in once to access multiple Tivoli Storage Manager servers from a single interface.
- You can easily monitor the health of your storage environment. Regular status updates are provided for items such as these:
  - Scheduled events
  - The server database and recovery log in server Versions 5.3, 5.4, and 5.5 (using rules based on best practices)
  - The database manager in server Version 6.1 and Version 6.2
  - Storage devices, including information about off-line drives and paths, and mounted volumes
- You can filter and sort storage objects, such as client nodes and library volumes.
- You can use wizards to more easily perform complex tasks such as these:
  - Creating schedules to perform client node and administrative operations
  - Creating a server maintenance script to perform database and storage pool backup, migration, expiration, and reclamation
  - Configuring storage devices; a comprehensive wizard helps you create a library, add drives, check in media volumes, and create storage pools
  - Configuring a Version 6.1 server on the local or a remote UNIX system

IBM Integrated Solutions Console infrastructure

The Integrated Solutions Console (ISC), is a component framework that allows you to install components provided by multiple IBM applications, and access them from a single web interface. The Administration Center is installed as an Integrated Solutions Console component.

The Administration Center provides several other features that can help you monitor and manage your storage management environment:

- To centrally manage multiple Tivoli Storage Manager servers from a single server
- To monitor Tivoli Storage Manager server status
- To generate usage and security reports for your Tivoli Storage Manager servers.

Attention: The V6.2 Administration Center can only be used with V5.5, V6.1, and V6.2 servers. The Tivoli Storage Manager Version 5.3 server is out of regular service. To obtain technical support for the V5.3 server, you need an extended-support contract.

18.3.8 Tivoli Storage Manager API

The Tivoli Storage Manager application program interface (API) enables an application client to use storage management functions.

The API includes function calls you can use in an application to perform these operations:

- Start or end a session
- Assign management classes to objects before they are stored on a server
- Back up or archive objects to a server
- Restore or retrieve objects from a server
- Query the server for information about stored objects
- Manage file spaces
- Send retention events.

For information about installing the API, see the documentation listed in 18.10, “More information” on page 600.

18.3.9 Tivoli Storage Manager security

Security is a vital aspect for enterprise storage management. Data must be protected, available, and secure. From the moment data is backed up from the client, IBM Tivoli Storage Manager provides a secure storage management environment. Tivoli Storage Manager is the only interface to your backup and archive data.

Before a communication session between the Tivoli Storage Manager client and the Tivoli Storage Manager server begins, an authentication handshaking process occurs with authentication tickets and a mutual suspicion algorithm. The Tivoli Storage Manager security protocol is modeled after the Kerberos network authentication protocol, which is a highly respected method for secure sign-on cryptography. The client uses its password as part of an encryption key, and does not send the password over the network. Each session key is unique, so replaying a session stream will not result in a sign-on to the Tivoli Storage Manager server. This significantly lowers the chance of a Tivoli Storage Manager session being hijacked by an outside user.

To heighten security for Tivoli Storage Manager sessions, data sent to the Tivoli Storage Manager server during backup and archive operations can be encrypted with standard DES 56-bit encryption. For WAN implementations of Tivoli Storage Manager across public networks, data encryption compliments and completes data security for Tivoli Storage Manager.

IBM Tivoli Storage Manager has enhanced support for environments with firewalls in which communication originating from outside the firewall is to be restricted. Clients normally contact the server but with the new firewall support, you can choose to restrict session initiation to the server (sessioninitiation=serveronly). Scheduled backup-archive client operations can be restricted to server-initiated sessions.

For details, see the documentation listed in 18.10, “More information” on page 600.

18.4 IBM Tivoli Storage Manager family of products

This topic provides information about Tivoli Storage Manager family of products. For more information about Tivoli Storage Manager family of products, see the documentation listed in 18.10, “More information” on page 600.

18.4.1 IBM Tivoli Storage Manager Basic or Standard Edition

With the advent of Version 6.2, there is no longer an Express Edition, so there is no longer a Standard Edition. The standard version of IBM Tivoli Storage Manager (Basic Edition) contains a rich set of features and provides the core functions of backup, recovery, and archive management:

- Progressive backup methodology:

  Saves time and storage space by backing up only new files and modified files. The progressive backup feature uses Tivoli Storage Manager’s own relational database to track data wherever it is stored, delivering a direct one-step file restore. Progressive backup eliminates the requirement for traditional full-plus-incremental or full-plus-differential backup and restore procedures, commonly used by other storage management products.

- Tape resource sharing:

  Enables multiple Tivoli Storage Manager servers to use the same tape library and drives, optimizing tape hardware asset utilization.

- Network-free rapid recovery:

  Supports high-speed client data recovery directly from tape or optical devices. Recovery time is minimized by eliminating the use of network and central server resources.

- Dynamic multithreaded transfer:

  Permits multiple clients to simultaneously transfer data to and from the same Tivoli Storage Manager server. Performance is boosted to more than three times the rate of a single-threaded session. The higher speed is achieved by transparently optimizing the number of data transfer sessions, based on available system resources.

- Adaptive differencing technology:

  Changes the way data is backed up from the client. Using adaptive differencing, data is transferred to the server either by byte, block, or file level, based on the size of the file being backed up, and the portion of the file that has changed since the last backup. Adaptive differencing technology supports all connectivity strategies, including LANs, WANs, SANs, internet, and dial-up connections. Adaptive differencing was initially designed with mobile computer users in mind. However, other users with a requirement to minimize data transmitted over the network can also benefit from the technology.

- Enterprise administration:

  Simplifies centralized control across multiple Tivoli Storage Manager implementations without sacrificing network performance. Tivoli Storage Manager 6.1 employs the Integrated Solutions Console (ISC), which provides a task-based GUI interface to Tivoli Storage Manager administrative tasks.

- Clustering:

  Tivoli Storage Manager includes enhanced support for IBM High Availability Cluster Multi-Processing (HACMP™), Microsoft Cluster Server (MSCS), Novell Cluster Services (NCS), and VERITAS Cluster Services (VCS) on Windows.

  Tivoli Storage Manager 6.1 has improved the support for Small Computer System Interface (SCSI) and fibre-attached tape device failover on Windows and UNIX, and support for Storage Agents, Library Managers, and Library Clients as cluster members.

- LAN-free data transfer:

  An optional module for Tivoli Storage Manager effectively exploits SAN environments by moving data transfers from the communication network to a SAN. Communication bandwidth availability is therefore improved, increasing service levels for users and customers.

- Hierarchical Storage Management:

  An optional module for Tivoli Storage Manager automatically and transparently moves unused data files from online disk storage to offline tape storage. In the event that a file is accessed after it has been moved to offline storage, Tivoli Storage Manager transparently recalls the file.

- Data deduplication:

  Data deduplication is a method of eliminating redundant data in sequential-access disk (FILE) primary, copy, and active-data storage pools. One unique instance of the data is retained on storage media, and redundant data is replaced with a pointer to the unique data copy. The goal of deduplication is to reduce the overall amount of time that is required to retrieve data by letting you store more data on disk, rather than on tape. TSM V6.2. offers server-side or client-side data deduplication.

- Library and device support:

  Tivoli Storage Manager supports libraries with up to three tape drives and up to 40 cartridge capacity. Larger libraries can be accommodated, but with only three devices and 40 slots enabled.

  You can find more information about IBM Tivoli Storage Manager at this website:

  `http://www.ibm.com/software/tivoli/products/storage-mgr/`

18.4.2 IBM Tivoli Storage Manager Extended Edition

The IBM Tivoli Storage Manager Extended Edition expands on the features and possibilities of the standard version described in the previous section.

Tivoli Storage Manager Extended Edition adds disaster recovery planning capability for the server, Network Data Management Protocol (NDMP) control for network-attached storage (NAS) filers, and support for larger capacity tape libraries and more tape drives.

You can find more information at this website:

`http://www.ibm.com/software/tivoli/products/storage-mgr-extended/`

Disaster Recovery Manager

The Disaster Recovery Manager (DRM) component of Tivoli Storage Manager Extended Edition provides disaster recovery for the Tivoli Storage Manager server and assists with disaster recovery for clients.

DRM offers various options to configure, control, and automatically generate a disaster recovery plan (DRP) file. The plan contains the information, scripts, and procedures required to automate restoration and help ensure quick recovery of data after a disaster. The scripts contain the commands necessary to rebuild the Tivoli Storage Manager server.

One of the key features of Tivoli Storage Manager and DRM is the ability to track media in all possible states, such as on-site, in transit, or in a vault. The media movement features of DRM assist greatly with the daily tasks of sending disaster recovery media off-site, and receiving expired media on-site for reuse. With these features, the system administrator can quickly locate all available copies of data.

DRM functions help maintain business continuity by taking care of these functions:

- Establishing and helping to automate a thorough server DRP; clients can then subsequently restore their data from the server if required, and can continue their daily backup procedures.
- Ensuring that vital site-specific information is available in the same plan.
- Automating vital recovery steps to return the Tivoli Storage Manager server and backup environment to normal operation.
- Managing and identifying off-site media required for recovery.
- Tracking and reporting destroyed systems in the event of a disaster.
- Storing client configuration information and assigning client recovery priorities

With DRM, you can recover at an alternate site, on a replacement system with another hardware configuration, and with people who are not familiar with the applications. The DRP can be periodically tested to certify the recoverability of the server. The DRP can, and must, be recreated easily every day so that it stays up to date.

During a disaster, these are commonly encountered errors:

- A DRP does not exist
- The DRP was not tested, or if it was, it is now out of date
- The testing team’s skills were not sufficient to perform and evaluate testing
- The disk volume definitions for the recovery site are not known
- The location of recovery tapes is not known
- It is not known which tapes are to be applied first

DRM keeps track of all the vital information required to rebuild the Tivoli Storage Manager environment, such as these:

- The current server configuration information and its location
- The current Tivoli Storage Manager server database volumes (size, location, and number)
- The recovery sequence
- The currency of the DRP
- The server and client machines configurations
- The people to be contacted in the event of a disaster
- The location of the recovery media and the organization or persons responsible
- The point in time (PIT) to which the environment can be restored

During recovery from a disaster, DRM automates the following procedures to restore the Tivoli Storage Manager servers:

- Restore Tivoli Storage Manager server's key option files
- Copy files from alternate locations to production locations
- Initialize the Tivoli Storage Manager database and log volumes
- Match sizes and locations of the Tivoli Storage Manager database and log volumes
- Automatically launch restoration of the Tivoli Storage Manager database
- Track media required and availability
- Register installed Tivoli Storage Manager server features and return the server state to a valid license configuration
- Update Tivoli Storage Manager volume catalog information, including whether volumes have been destroyed during the disaster
- Rebuild Tivoli Storage Manager hierarchical storage configuration
- Restore destroyed volumes from those available where possible
- Recreate customer backup environment

A detailed description, recovery scenario, and recovery plan built with DRM can be found in *Disaster Recovery Strategies with Tivoli Storage Management*, SG24-6844. Also, guidelines and examples of using DRM to store client machine information in the DRM plan file for use during a client disaster recovery are given in the same book.

In summary, DRM will systematically rebuild the Tivoli Storage Manager server environment and ensure that current application data for the entire enterprise is available for recovery. This can all be done automatically from a single scripted command.

NDMP support for Network Attached Storage

For NAS devices, Tivoli Storage Manager Extended Edition uses NDMP to perform high-performance, scalable backups and restores. NDMP-based backups and restores minimize network traffic and transfer data outboard of the Tivoli Storage Manager client and server. NDMP enables a full and differential file system image backup and restore of Network Appliance™ file servers with OS Data ONTAP V7.1 or higher, and EMC Celerra systems. Multiple backup and restore operations can be performed simultaneously. General NDMP support also allows other NAS vendors to certify integration with Tivoli Storage Manager.

The NDMP backup and restore features are fully integrated with Tivoli Storage Manager Extended Edition server and client. No extra software is required on the server, client, or NAS appliance. When doing backups and restores, the NAS device and the Tivoli Storage Manager server and client all have specific roles, as shown in Figure 18-11.

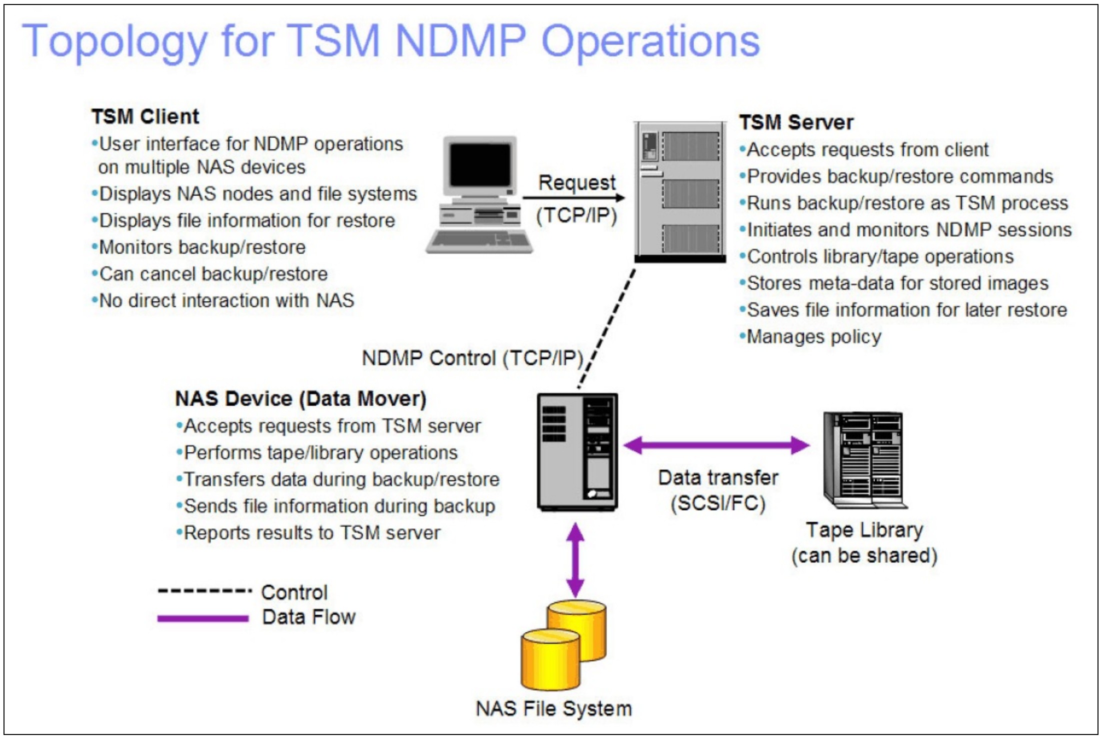


Figure 18-11 Topology for NDMP using IBM Tivoli Storage Manager

Tivoli Storage Manager Extended Edition offers the ability to do file-level and full/differential file system image backups and restore of servers that support the NDMP protocol. You can back up directly to the Tivoli Storage Manager hierarchy and also implement DRM, as it now supports NAS storage. Multiple backup and restore operations can be performed in parallel.

During backup and restore operations, data flows directly between the tape drive and the NAS appliance. NDMP for NAS backup uses either an SCSI-attached tape device local to the NAS appliance, or a SAN-attached SCSI or Automated Cartridge System Library Software (ACSLS) device that can be shared with the Tivoli Storage Manager server. Library robotics can be controlled directly by the Tivoli Storage Manager server or by passing SCSI commands through an NAS file server.

Drives must be supported by both the NAS appliance and the NAS OS. Drives can be dedicated to NDMP operations from a single NAS file server or can be shared. Multiple NAS appliances can share SAN-attached shared tape resources if backups are performed through the same Tivoli Storage Manager server. Drives can be also shared with LAN-free backup/restore operations, provided that the library is controlled directly by the Tivoli Storage Manager server.

Extended library and drive support

Tivoli Storage Manager Extended Edition supports larger tape libraries, thus removing the 48-cartridge limit for library capacity, and allowing more than four tape drives within a single library.

Database and application online protection

This feature protects a wide range of application data through the protection of the underlying databases and application management systems holding that data. This module automates data protection tasks and allows database and application servers to continue running their primary applications while they back up and restore data to and from offline storage.

Data retention

IBM System Storage Archive Manager, previously known as Tivoli Storage Manager for Data Retention, helps manage and simplify the retrieval of the ever-increasing amount of data that organizations must retain for strict records retention regulations. Many regulations demand archiving of records, emails, design documents, and other data for many years, in addition to requiring that the data is not changed or deleted.

Bare Machine Recovery

This feature backs up and automatically restores the operating system structures required to rebuild the operating system, as well as data files. It schedules regular operating system backups so that a recovery brings back the latest information.

18.5 IBM Tivoli Storage Manager complementary products

IBM Tivoli Storage Manager can be integrated with several optional applications that together form a powerful integrated storage management solution:

- IBM Tivoli Storage Manager for Mail
- IBM Tivoli Storage Manager for Databases
- IBM Tivoli Storage Manager for Microsoft SharePoint
- IBM Tivoli Storage Manager for Advanced Copy Services
- IBM Tivoli Storage Manager for Copy Services
- IBM Tivoli Storage Manager for Enterprise Resource Planning
- IBM Tivoli Storage Manager for Space Management
- IBM Tivoli Storage Manager HSM for Windows
- IBM Tivoli Storage Manager for Storage Area Networks
- IBM Tivoli Storage Manager for System Backup and Recovery
- IBM Tivoli Storage Manager FastBack
- IBM Tivoli Storage Manager FastBack for Microsoft Exchange
- IBM Tivoli Storage Manager FastBack for Bare Machine Recovery
- IBM Tivoli Storage Manager FastBack for Workstations
- IBM Tivoli Storage Manager FastBack Center
- IBM Tivoli Continuous Data Protection for Files

Updates: Not all of the products mentioned before have been updated with Tivoli Storage Manager Version 6.1 or Version 6.2. The backward compatibility is guaranteed with the previous Version 5.5.

18.5.1 .IBM Tivoli Storage Manager for Mail

IBM Tivoli Storage Manager for Mail is a software module for IBM Tivoli Storage Manager that automates the data protection of email servers running either Lotus Domino or Microsoft Exchange. This module utilizes the application programming interfaces (APIs) provided by email application vendors to perform online backups without shutting down the email server and improve data-restore performance. As a result, it can help protect the growing amount of new and changing data that must be securely backed up to help maintain mail server application availability 24x7, 365 days a year. The two products available are:

- IBM Tivoli Storage Manager for Mail: Data Protection for Microsoft Exchange Server 6.2
- IBM Tivoli Storage Manager for Mail: Data Protection for Lotus Domino 5.5.

For more information, see *Tivoli Storage Manager for Mail - Data Protection for Microsoft Exchange Server, Installation and User's Guide*, SC23-9796-00.

18.5.2 IBM Tivoli Storage Manager for Databases

IBM Tivoli Storage Manager for Databases is a software module designed to work with IBM Tivoli Storage Manager to protect a wide range of application data through the protection of the underlying database management systems holding that data. IBM Tivoli Storage Manager for Databases exploits the various backup-certified utilities and interfaces provided for Oracle using RMAN functionality and Microsoft SQL Server (with or without VSS.)

This same functionality is included in the IBM DB2 Universal Database™ package and Informix® Dynamic Server, using ONBAR enabling them to work directly with IBM Tivoli Storage Manager without the need to buy any additional modules.

For more information, see the website:

`http://www.ibm.com/software/tivoli/products/storage-mgr-db/`

18.5.3 IBM Tivoli Storage Manager for Microsoft SharePoint

IBM Tivoli Storage Manager 6 for Microsoft SharePoint is a policy-based backup and recovery solution. It allows you to restore of your Microsoft SharePoint business data and content after almost any kind of business interruption.

It provides the following functionality:

- Performs backup and recovery of Microsoft SharePoint Portal 2003 and Microsoft Office SharePoint Server 2007 environments
- Restores portals, top level sites, subsites and individual document libraries, attachments, lists, folders, areas, and sub areas
- Schedules full, incremental, or differential backup at the site-level, subsite-level and item-level
- Preserves all meta-data versions
- Integrates with the Tivoli Storage Manager server so that you can create synchronous or asynchronous copies of SharePoint data for off-site protection
- Includes an easy-to-use browser-based graphical user interface (GUI).

For more information, see the website:

`http://www.ibm.com/software/tivoli/products/storage-mgr-sharepoint/`

18.5.4 IBM Tivoli Storage Manager HSM for Windows

IBM Tivoli Storage Manager for HSM for Windows V6 provides Hierarchical Storage Management functionality to the Windows platform. As with IBM Tivoli Storage Manager for Space Management, HSM for Windows automatically migrates rarely-accessed files to alternative storage, without disrupting the most frequently used files in local Windows file systems. Similarly, migrated files are automatically and transparently recalled to their original location when required by applications or users.

HSM for Windows allows various levels of granularity for migration of files. Files can be migrated individually, and file systems can be partially or fully migrated, based on a comprehensive set of policy options.

IBM Tivoli Storage Manager for Space Management complements both IBM Tivoli Storage Manager and IBM Tivoli Storage Manager Extended Edition.

The following new support is provided in Version 6:

- Support for Microsoft Windows Server 2008 (64 bit)
- Support for Internet Protocol V6 (IPv6)
- Automatic threshold migration that automatically helps maintain a certain amount of free space on protected file systems

For more information, see the website:

http://www.ibm.com/software/tivoli/products/storage-mgr-hsm/

18.5.5 IBM Tivoli Storage Manager for Advanced Copy Services

IBM Tivoli Storage Manager for Advanced Copy Services (formerly known as IBM Tivoli Storage Manager for Hardware) is an optional software module for AIX that integrates with Tivoli Storage Manager Extended Edition. Tivoli Storage Manager for Advanced Copy Services protects mission-critical data that must be available 24x7, and integrates hardware- and software-based snapshot capabilities with Tivoli Storage Manager and its Data Protection components for DB2 UDB, Oracle, and mySAP.

Tivoli Storage Manager for Advanced Copy Services supports a wide range of hardware:

- IBM Enterprise Storage Server (ESS)
- IBM DS6000
- IBM DS8000
- SAN Volume Controller (SVC) and all IBM and non-IBM devices supported by the SVC. For a complete list, see the website:
  http://www.ibm.com/systems/storage/software/virtualization/svc/interop.html

Tivoli Storage Manager for Advanced Copy Services also provides the following functionality:

- IBM FlashCopy support for ESS for Oracle
- FlashCopy support for ESS for DB2
- FlashCopy support for ESS for mySAP on DB2 UDB
- FlashCopy support for ESS for mySAP on Oracle
- Snapshot support for DS8000, DS6000, and SVC for DB2 UDB
- Snapshot support for DS8000, DS6000, and SVC for Oracle
- Snapshot support for DS8000, DS6000, and SVC for mySAP on DB2 UDB
- Snapshot support for DS8000, DS6000, and SVC for mySAP on Oracle
- Multiple snapshot versions managed by Tivoli Storage Manager policy
- Coordinated FlashCopy backup of multi-partition DB2 UDB databases distributed across multiple host systems.

Support of FlashCopy and snapshot functionality allows for “Zero Impact” backups and instant recovery. Data transfer to the Tivoli Storage Manager server is handled from a separate storage server, allowing the primary production data to remain online and undisturbed.

For more information, see *Tivoli Storage Manager for Advanced Copy Services - Data Protection for Snapshot Devices Installation and User’s Guide*, SC33-8331-00.

18.5.6 IBM Tivoli Storage Manager for Copy Services

IBM Tivoli Storage Manager for Copy Services is a new optional module for Windows that integrates with Tivoli Storage Manager or Tivoli Storage Manager Extended Edition. It is designed to utilize Microsoft’s Volume Snapshot Services (VSS) on Windows 2003. Tivoli Storage Manager for Copy Services provides similar functionality to Tivoli Storage Manager for Advanced Copy Services, but supports Windows VSS and Microsoft Exchange Server 2003 only.

Tivoli Storage Manager for Copy Services includes the following features:

- Single command-line interface (CLI) for performing earlier and VSS snapshot backup, restore, and query operations
- Single GUI for performing earlier and VSS snapshot backup, restore, and query operations
- Support for both hardware and software VSS providers that strictly adhere to Microsoft VSS provider requirements
- Support for a clustered Exchange environment.

Full and Copy backup types are supported, with granularity at the Exchange Storage Group level. Backups are managed by Tivoli Storage Manager policies and can be stored on the Tivoli Storage Manager server, local disks or both. Different policies can be assigned for the various storage locations and backup types (Full or Copy). As with Tivoli Storage Manager for Advanced Copy Services, zero impact backups and instant recovery allow the primary production data to remain online and undisturbed. Data movement to Tivoli Storage Manager storage can be off-loaded to a secondary machine through a VSS hardware provider that supports transportable shadow copy volumes.

For more information, see the website:

http://www-01.ibm.com/software/tivoli/products/storage-mgr-copy-services/

18.5.7 IBM Tivoli Storage Manager for SAP Version 6

Previously known as IBM Tivoli Storage Manager for Enterprise Resource Planning, Data Protection for SAP for V6 is a software module that works with IBM Tivoli Storage Manager to better protect infrastructure and application data and improve the availability of SAP R/3 servers.

For more details, see the following publications:

- *Tivoli Storage Manager for Enterprise Resource Planning - Data Protection for SAP, Installation and User's Guide for DB2*, SC33-6341-10
- *Tivoli Storage Manager for Enterprise Resource Planning - Data Protection for SAP, Installation and User's Guide for Oracle*, SC33-6340-10.

18.5.8 IBM Tivoli Storage Manager for Space Management

IBM Tivoli Storage Manager for Space Management provides Hierarchical Storage Management (HSM) to automatically migrate rarely-accessed files to alternative storage, without disrupting the most frequently used files in local storage. Migrated files are automatically and transparently recalled to primary storage when required by applications or users. Administrators and users are freed from manual file system maintenance tasks, and more online disk space is available for more important active data. Tivoli Storage Manager for Space Management can also help defer the requirement to purchase additional disk storage for clients, by making optimal use of available client storage.

Tivoli Storage Manager for Space Management offers increased scalability and performance through parallel migrations, improved candidate search, and optimized synchronization between the IBM Tivoli Storage Manager server and the HSM client.

IBM Tivoli Storage Manager for Space Management complements both IBM Tivoli Storage Manager and IBM Tivoli Storage Manager Extended Edition, and is supported on AIX, HP/UX, Solaris, and Linux.

For more information, see *Tivoli Storage Manager for Space Management for UNIX and Linux - User's Guide*, SC23-9794-00.

18.5.9 IBM Tivoli Storage Manager for Storage Area Networks

IBM Tivoli Storage Manager for Storage Area Networks enables your SAN-connected Tivoli Storage Manager servers and client computers to make maximum use of their direct network connection to storage. This software extension enables both servers and client computers to make the bulk of their backup/restore and archive/retrieve data transfers over the SAN instead of the LAN, either directly to tape or to the Tivoli Storage Manager disk storage pool. This ability greatly reduces the impact of data protection on the LAN while also reducing CPU utilization on both client and server.

Certain SAN configurations allow specific SAN devices to perform data movements directly to and from certain tape devices, further reducing client and server CPU utilization.

Tivoli Storage Manager for Storage Area Networks complements and coexists with the standard library-sharing functionality of both standard version and Extended editions of the Tivoli Storage Manager server.

The core functions of IBM Tivoli Storage Manager for Storage Area Network are:

- LAN-free backup/restore
- SAN-connected tape library.

This Tivoli Storage Manager component is also commonly referred to as a Storage Agent.

For more information, see the following publications:

- *Tivoli Storage Manager for SAN for AIX - Storage Agent User's Guide*, SC23-9797-00
- *Tivoli Storage Manager for SAN for HP-UX - Storage Agent User's Guide*, SC23-9798-00
- *Tivoli Storage Manager for SAN for Linux - Storage Agent User's Guide*, SC23-9799-00
- *Tivoli Storage Manager for SAN for Sun Solaris - Storage Agent User's Guide*, SC23-9800-00
- *Tivoli Storage Manager for SAN for Windows - Storage Agent User's Guide*, SC23-9553-00.

18.5.10 IBM Tivoli Storage Manager for System Backup and Recovery

IBM Tivoli Storage Manager for System Backup and Recovery (SysBack®) provides a flexible backup method for AIX systems to help protect data and provide bare machine recovery capabilities. It offers a comprehensive system backup, restore, and reinstallation tool. SysBack is a simple-to-use and highly effective tool. Any feature might be executed from either the AIX command line or by using the SMIT menu interface.

For Windows platforms, bare machine recovery can be achieved with the Tivoli Storage Manager Backup/Archive client's Automated System Recovery capability.

In addition, Windows, Sun, and Linux bare machine recovery can be done with Cristie Bare Machine Recovery. This integrates directly with Tivoli Storage Manager to provide operating system recovery for these platforms.

Tivoli Storage Manager for FastBack products also provide similar recovery capabilities for the Windows environment only.

For more information, see *Tivoli Storage Manager Backup-Archive Clients - Installation and User's Guide*.

18.5.11 IBM Tivoli Storage Manager FastBack

IBM Tivoli Storage Manager FastBack is recovery software, a specific kind of storage management that ensures that applications and users are back up and running within minutes following any data loss while performing full data recovery in the background:

- Protect and recover data for critical Windows applications
- Reduce the need for traditional backup windows with storage management software that captures data changes at the block level while providing extremely low systems overhead
- Schedule automated data transfers based on flexible, policy-based settings, helping administrators meet data protection and retention requirements on a per-application basis
- Enable data asset recovery from any Windows application, including Microsoft Exchange, Microsoft SQL Server, Oracle, IBM DB2 and SAP
- Make the most effective use of available bandwidth with strategies such as multi-threading, bundling of small files and industry-standard compression
- Operating systems supported: Windows.

For more information about Tivoli Storage Manager FastBack, see the website:

http://www.ibm.com/software/tivoli/products/storage-mgr-fastback/

18.5.12 IBM Tivoli Storage Manager FastBack for Microsoft Exchange

IBM Tivoli Storage Manager FastBack for Microsoft Exchange provides the ability to recover Microsoft Exchange data such as email, attachments, calendar entries, contacts and tasks.

It helps you to accomplish the following tasks:

- Minimize business risk with the ability to recover Microsoft Exchange data objects from virtually any Microsoft Exchange database, even corrupt databases
- Optimize Microsoft Exchange recovery by applying it at a granular level to any individual data object or group of objects, such as individual email messages, contact lists, tasks, or calendar entries
- Increase operational efficiency and user productivity by helping reduce recovery time from hours or days to minutes
- Improve service levels by helping to minimize the downtime associated with data recovery
- Enable recovery of objects that were previously considered unrecoverable, such as deleted email messages, or address books lost due to synchronization errors
- Restore objects directly to an Exchange Server or to send objects to a user-defined destination by SMTP
- Integrate with Active Directory and Exchange Server security to help limit unauthorized access to backup and restore systems.

For more information, see the website:

http://www.ibm.com/software/tivoli/products/storage-mgr-fastback-exchange/

18.5.13 IBM Tivoli Storage Manager FastBack for Bare Machine Recovery

IBM Tivoli Storage Manager FastBack for Bare Machine Recovery provides recovery following a disaster or catastrophic server failure, restoring systems within an hour:

- Enables systems recovery following a disaster or catastrophic server failure
- Provides the flexibility of recovering to comparable hardware, to dissimilar hardware or to a virtual machine using VMware or Microsoft Virtual Server
- Helps protect remote or branch offices with a cost-effective disaster recovery and business resiliency strategy that requires a minimum of standby hardware
- Utilizes IBM Tivoli Storage Manager FastBack to provide near-instant access to applications and data while full recovery takes place in the background
- Facilitates the migration of workloads to new hardware platforms, making it fast and easy to move workloads from old hardware or stand-alone servers to new hardware or blade servers
- Enables organizations to perform bare machine recovery in a local office, in a data center or in a central recovery site
- Operating systems supported: Windows.

For more information, see the website:

http://www.ibm.com/software/tivoli/products/storage-mgr-fastback-bmr/

18.5.14 IBM Tivoli Continuous Data Protection for Files

According to industry surveys, almost 70% of corporate data exists on notebooks (mobile computers) or desktop machines, and less than 8% of it is backed up regularly. For notebook, desktop, and file server machines that contain important, critical, or sensitive data that is constantly being updated, a typical 24-hour backup cycle might not be sufficient to provide adequate data protection. The addition of IBM Tivoli Continuous Data Protection for Files provides a client machine with the capability of being able, transparently in real time, to back up a file to a Tivoli Storage Manager server as soon as the file is saved. Files that are backed up by this method are managed in the same way as other corporate data by the Tivoli Storage Manager server.

Tivoli Continuous Data Protection for Files was developed with notebook (mobile computer) and desktop users in mind, but can be applied to any client with a high rate of change of data on its file systems.

Tivoli Continuous Data Protection for Files provides clients with true point-in-time recoverability. It is supported on AIX, Solaris, Linux, and Windows platforms.

For more information, see the website:

http://www.ibm.com/software/tivoli/products/continuous-data-protection/

18.6 Client backup and restore operations

It is important to understand Tivoli Storage Manager options for client backup and restore operations. It is also important to understand the characteristics of each of these operations because each method might have an effect on backup and restore efficiency, retention periods, portability, CPU utilization, connection time, and network utilization. The standard backup method that Tivoli Storage Manager uses is called progressive incremental backup. It is a unique and efficient method for backup.

For details, see the documentation listed in 18.10, “More information” on page 600.

18.6.1 Traditional LAN and WAN backup topology

In a traditional LAN and WAN environment the Tivoli Storage Manager backup and archive client or application reads data from locally attached disks and sends it over the LAN to the Tivoli Storage Manager backup server. The server receives the data, and then writes it out to its storage pool (tape, disk, or optical media) based on predefined policies and server configuration. Data is read and written by both the Tivoli Storage Manager Client and Tivoli Storage Manager Server machines. In addition, control information is also sent over the LAN to the Tivoli Storage Manager Server.

Traditional LAN and WAN backup flow is shown in Figure 18-12.

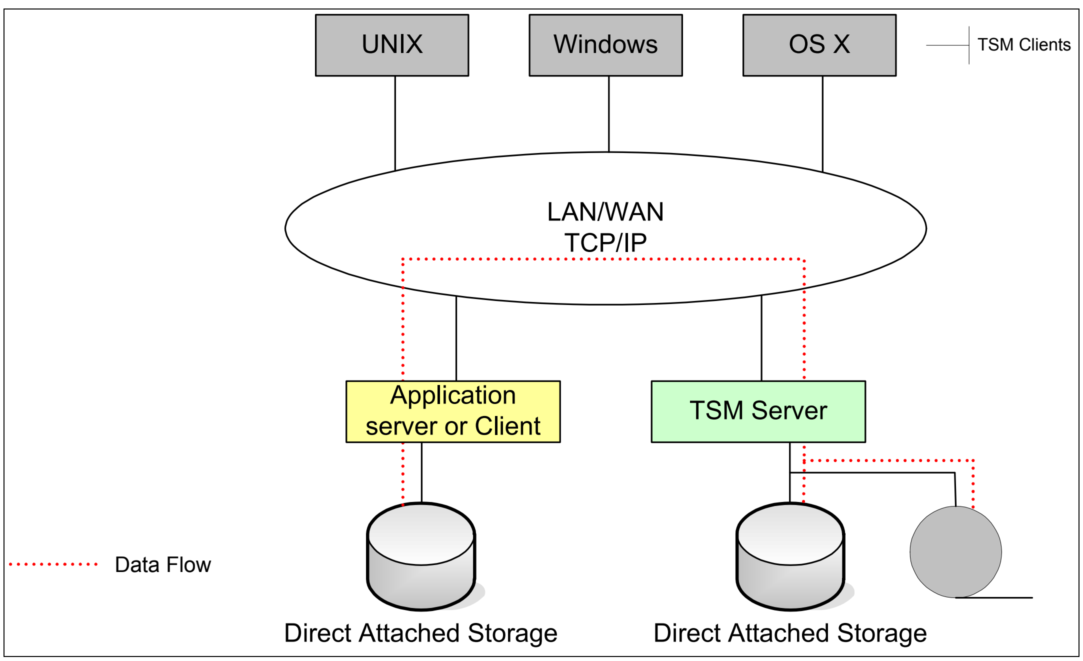


Figure 18-12 Tivoli Storage Manager LAN and WAN backup flow

18.6.2 SAN backup topology: LAN-free

SAN technology provides an alternative path for data movement between the Tivoli Storage Manager client and the server. Shared storage resources (disk, tape) are accessible to both the client and the server through the Storage Area Network. Data movement is off-loaded from the LAN and from the server processor and allows for greater scalability. LAN-free backups decrease the load on the LAN by introducing a Storage Agent.

The Storage Agent can be thought of as a small Tivoli Storage Manager server (without a database or recovery log), which is installed and run on the Tivoli Storage Manager client machine. The Storage Agent handles the communication with the Tivoli Storage Manager server over the LAN but sends the data directly to SAN attached tape devices or disks, relieving the Tivoli Storage Manager server from the actual I/O transfer.

For more information, see the following publications:

- *Tivoli Storage Manager for SAN for AIX - Storage Agent User's Guide*, SC23-9797-00
- *Tivoli Storage Manager for SAN for HP-UX - Storage Agent User's Guide*, SC23-9798-00
- *Tivoli Storage Manager for SAN for Linux - Storage Agent User's Guide*, SC23-9799-00
- *Tivoli Storage Manager for SAN for Sun Solaris - Storage Agent User's Guide*, SC23-9800-00
- *Tivoli Storage Manager for SAN for Windows - Storage Agent User's Guide*, SC23-9553-00.

18.6.3 Split-mirror/point-in-time copy backup using SAN

A split-mirror/point-in-time backup occurs when a copy volume generated by Operating System mirroring or a hardware assisted instant copy function (as found on many of today's high-end storage systems) is backed up to a Tivoli Storage Manager server. Such a backup method virtually eliminates the backup-related performance impact on the production host. This approach is facilitated and automated with the Tivoli Storage Manager for Advanced Copy Services product, which integrates IBM FlashCopy on disk systems with Tivoli Storage Manager and its database protection capabilities for Oracle, SAP, and DB2. This *Copy-Backu*p procedure adds value to storage and backup procedures, because it helps ensure that essential applications can continue to run 24x7 with minimal backup-related impact.

Figure 18-13 shown split-mirror/point-in-time backup flow.

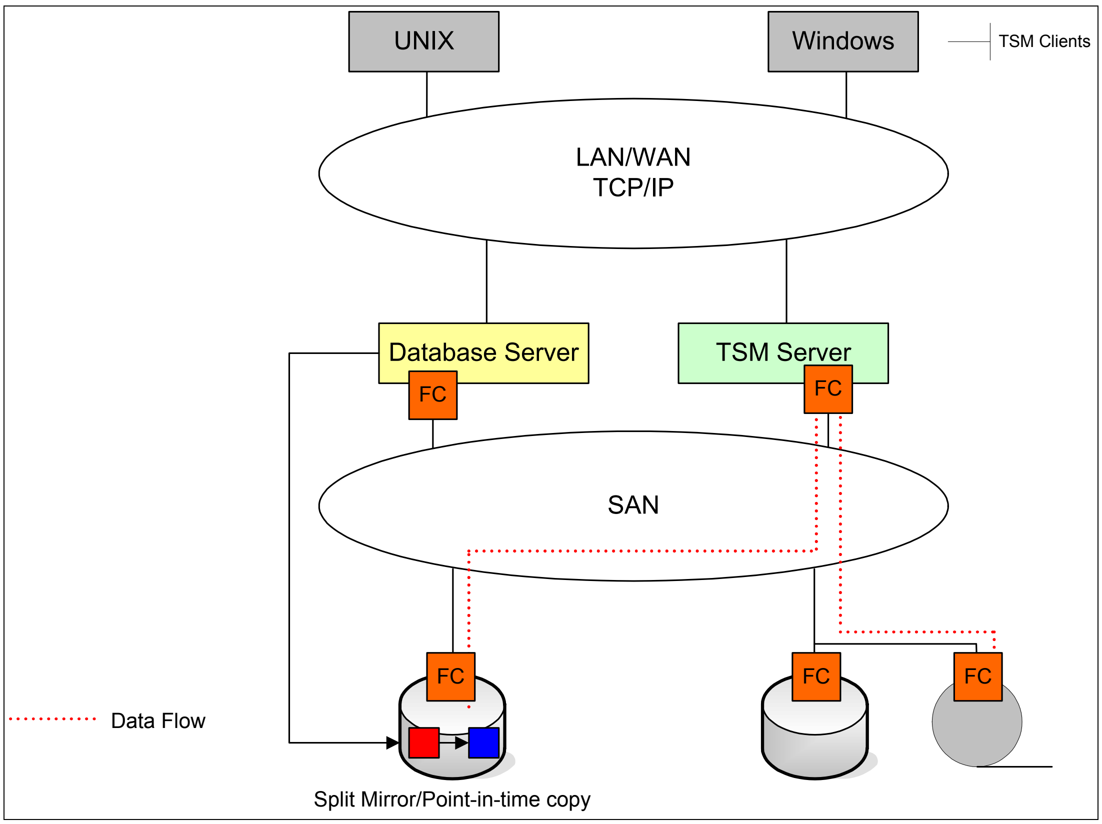


Figure 18-13 Tivoli Storage Manager split-mirror/point-in-time copy backup flow

18.6.4 Network-attached storage backup and restore

Network-attached storage (NAS) file servers are dedicated storage machines whose operating systems are optimized for file-serving functions. NAS file servers typically do not run third-party software. Instead, they interact with programs like Tivoli Storage Manager through industry-standard network protocols, such as network data management protocol (NDMP).

Tivoli Storage Manager provides two basic types of configurations that use NDMP for backing up and managing NAS file servers. In one type of configuration, Tivoli Storage Manager uses NDMP to back up a NAS file server to a library device directly attached to the NAS file server. The NAS file server, which can be distant from the Tivoli Storage Manager server, transfers backup data directly to a drive in a SCSI-attached tape library. Data is stored in special, NDMP-formatted storage pools, which can be backed up to storage media that can be moved offsite for protection in case of an on-site disaster.

See Figure 18-14 for details.

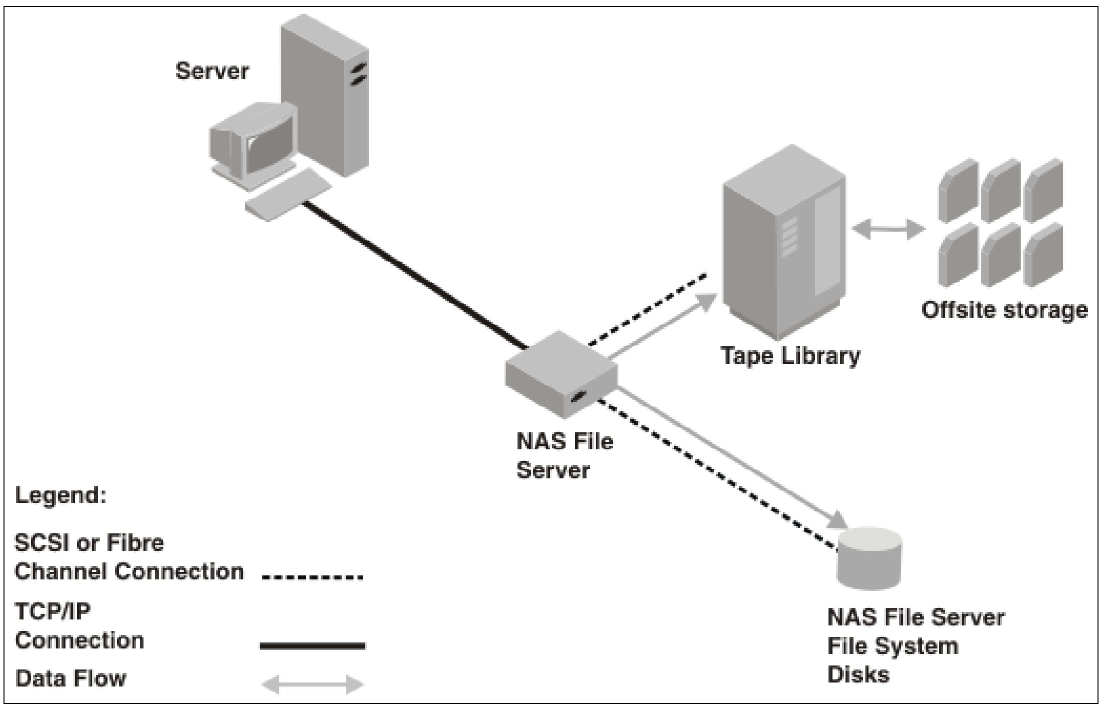


Figure 18-14 Library device directly attached to a NAS file server

In the other type of NDMP-based configuration, Tivoli Storage Manager uses NDMP to back up a NAS file server to a Tivoli Storage Manager storage-pool hierarchy. With this type of configuration, you can store NAS data directly to disk (either random access or sequential access) and then migrate the data to tape. Data can also be backed up to storage media that can then be moved offsite. The advantage of this type of configuration is that it gives you all the back-end data management features associated with a conventional Tivoli Storage Manager storage pool hierarchy, including migration and reclamation.

Figure 18-15 shows the NAS file server to Tivoli Storage Manager storage-pool hierarchy.

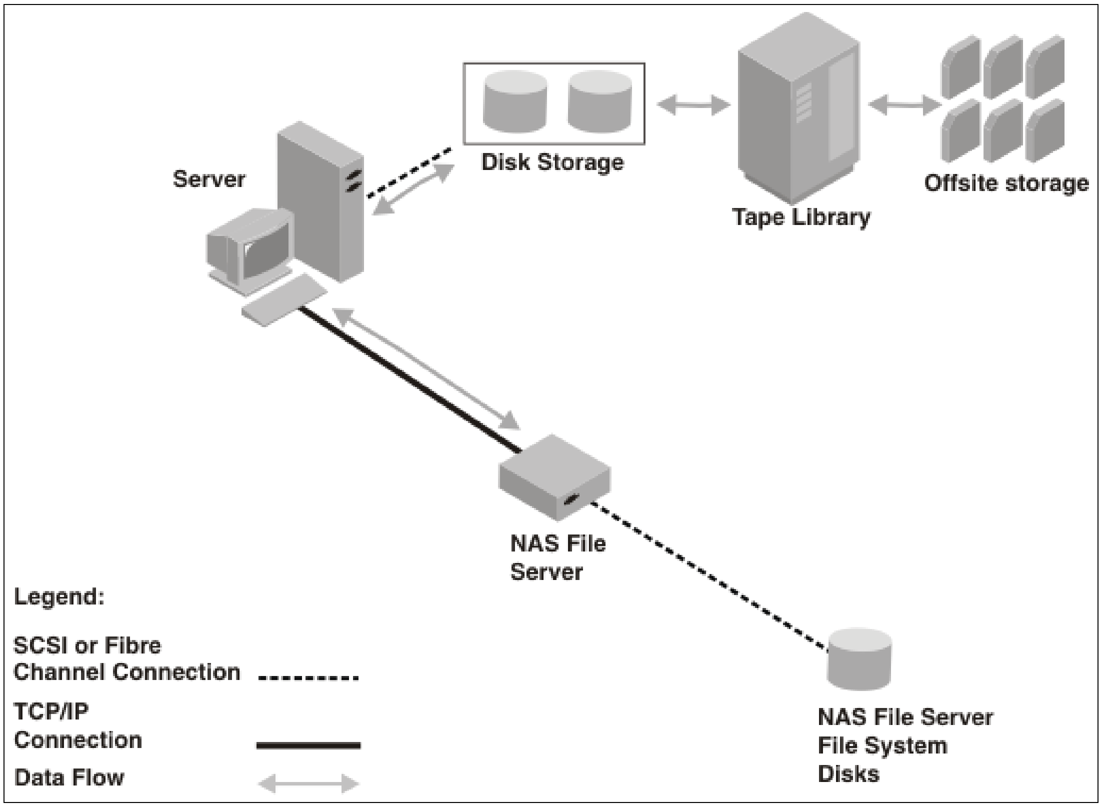


Figure 18-15 NAS file server to Tivoli Storage Manager storage-pool hierarchy

In both types of configurations, Tivoli Storage Manager tracks file-system image backups and has the capability to perform NDMP file-level restores.

For more information, see the documentation listed in 18.10, "More information" on page 600.

18.6.5 Image backup

An image backup is a block-by-block copy, single object backup of a volume (typically a UNIX file system or raw logical volume, or Windows drive) on a Tivoli Storage Manager client. Being able to restore an entire volume as one object can lead to faster recoveries. Image backup is available at the time of writing on AIX, HP, Sun, Linux, and Windows client platforms. Review the specific image backup requirements for each platform in their associated installation guides found at this website:

`http://publib.boulder.ibm.com/infocenter/tsminfo/v6/index.jsp`

With image backup, the Tivoli Storage Manager server does not track individual files in the file system image. File system images are tracked as individual objects and the management class policy are applied to the file system image as a whole.

An image backup provides the following benefits:

- Backs up file systems containing a large number of files faster than a full file system incremental back up
- Improves the speed with which Tivoli Storage Manager restores file systems containing many small files

- Conserves resources on the server during backups because only one entry is required for the image
- Provides a point-in-time picture of your logical volume, which might be useful if your enterprise needs to recall that information
- Restores a corrupt file system or raw logical volume. Data is restored to the same state it was when the last logical volume backup was performed.

To restore an image backup of a volume, the Tivoli Storage Manager client must be able to obtain an exclusive lock on the volume being restored.

> **Important:** Do not use the Tivoli Storage Manager dynamic image backups for file systems, because the file system's design can provide inconsistent data even when there is no write activity. Dynamic image backup might result in a fuzzy image, and is not guaranteed to be valid or complete when restored.

On Windows client platforms, a Logical Volume Storage Agent (LVSA) is used, which can take a snapshot of the volume while it is online. Optionally, only occupied blocks can be copied. If the snapshot option is used (rather than static) then any blocks that change during the backup process are first kept unaltered in an Original Block File. In this way the client can send a consistent image of the volume, as it was at the start of the snapshot process, to the Tivoli Storage Manager server.

> **Attention:** File systems managed by Tivoli Storage Manager for space management are not enabled for image backup.

18.6.6 VMware Consolidated Backup

VMware Consolidated Backup is a VMware backup solution for the ESX 3.0 server and above in a storage area network (SAN) and non-SAN environment.

By offloading the backup away from the virtual machines and the ESX host, you can reduce the load on the production VMware ESX host for backup operations. It also allows backup in a LAN-free environment.

18.7 Tivoli Storage Manager server-to-server communications

With a solution that includes multiple Tivoli Storage Manager servers, you can use server-to-server communications and virtual volumes to enhance management and improve disaster recoverability. Tivoli Storage Manager server-to-server communications provide the capability to do the following tasks:

- Configure and manage multiple servers with enterprise administration
- Distribute a consistent configuration for Tivoli Storage Manager servers through a configuration manager to managed servers. By having consistent configurations, you can simplify the management of a large number of servers and clients
- Perform tasks simultaneously on multiple servers by using command routing, enterprise logon and enterprise console
- Send server and client events to another server for logging
- Monitor events of many servers and clients from a single server
- Store data on another server using virtual volumes.

For details, see the documentation listed in 18.10, “More information” on page 600.

18.7.1 Enterprise configuration

The Tivoli Storage Manager enterprise configuration functions make it easier to consistently set up and manage a network of Tivoli Storage Manager servers. You can set up configurations on one server and distribute the configurations to other servers. You can make changes to configurations and have the changes automatically distributed.

To use enterprise configuration, select the Tivoli Storage Manager server that is to act as the *configuration manager*. You might want to dedicate a new server for this purpose.

Figure 18-16 illustrates a simple configuration.

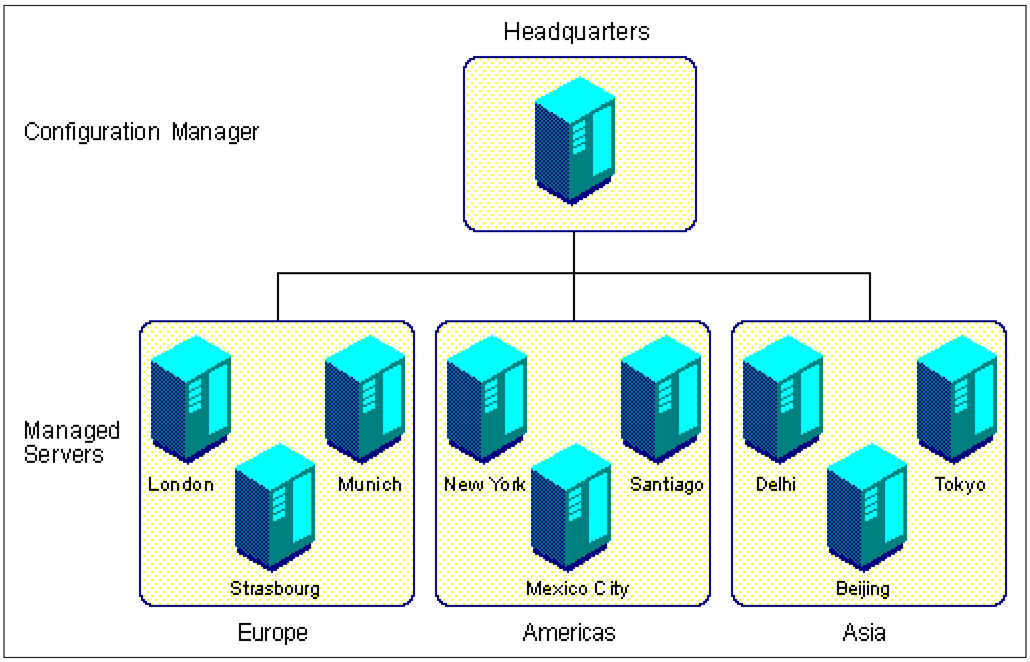


Figure 18-16 A scenario for implementing enterprise configuration

At the configuration manager, you can define the details of the server configurations that you want to distribute, for example:

- Set up backup and archive policies and client option sets
- Designate one or more administrators to have access to the servers, and control their authority levels
- Define the servers that you want the configuration manager to manage or communicate with, and you set up communications among the servers

In one or more *profiles*, point to the definitions of the configuration information that you want to use to manage other servers.

On each server that is to receive the configuration information, identify the server as a *managed server* by defining a *subscription* to one or more profiles owned by the configuration manager. All the definitions associated with the profiles are then copied into the managed server's database. Things defined to the managed server in this way are managed objects that cannot be changed by the managed server. From then on, the managed server gets any changes to the managed objects from the configuration manager by the profiles. Managed servers receive changes to configuration information at time intervals set by the servers, or by command. For details, see Figure 18-17.

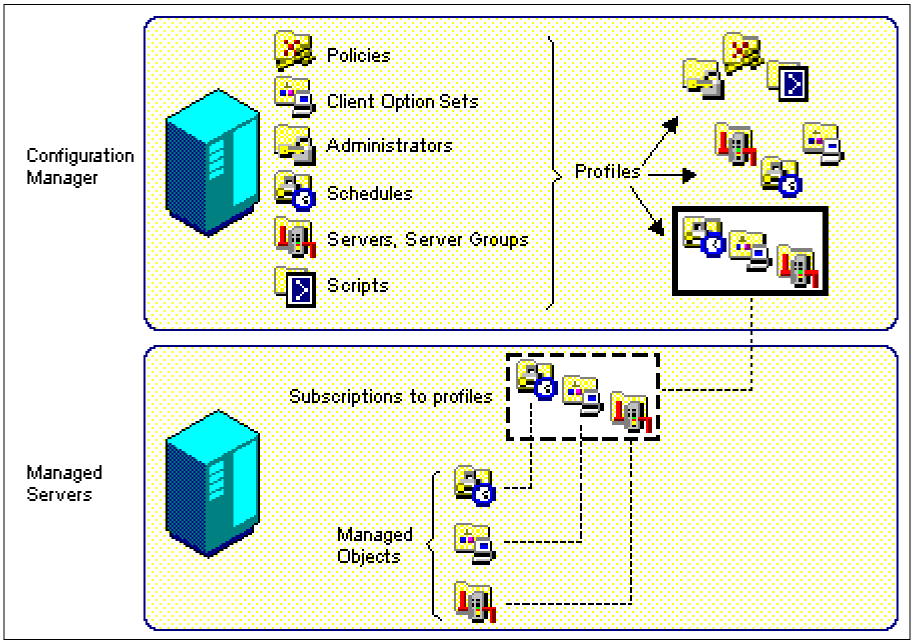


Figure 18-17 Enterprise configuration

For more information about enterprise configuration, see the documentation listed in 18.10, “More information” on page 600.

18.7.2 Using server-to-server virtual volumes for disaster recovery

Server-to-server virtual volumes can be used as a strategy for site disaster protection and disaster recovery.

For site disaster protection, server-to-server virtual volumes (with Tivoli Disaster Recovery Manager) can be used to back up storage pools from one Tivoli Storage Manager server to another and back up the Tivoli Storage Manager database of one server to another. This form of virtual vaulting can occur on a peer-to-peer basis, between any number of servers, and at separate data centers or separate sites. For example, two servers can back up each other in an equal level relationship.

For disaster recovery, server-to-server virtual volumes can be used to store the Disaster Recovery Plan file remotely. In this strategy, the source server creates the Disaster Recovery Manager plan files, then stores the files on a remote target server. You can display information about recovery plan files from the server that created the files (the source server) or from the server on which the files are stored (the target server). You can easily display a list of all recovery plan files that have been saved on a target server.

For details, see the documentation listed in 18.10, “More information” on page 600.

18.8 Tivoli Storage Manager and high availability clustering

High availability clustering can be used to configure either or both a highly available Tivoli Storage Manager server and/or clients. A highly available Tivoli Storage Manager server provides highly available services to its clients without significant disruptions; and a highly available Tivoli Storage Manager client provides highly available backup or restore services to an application and data.

For a highly available Tivoli Storage Manager server, critical resources such as the database and storage pools must be shared between the clustered nodes. A highly available Tivoli Storage Manager client will be able to back up file systems that are commonly available to all nodes in the cluster.

Tivoli Storage Manager supports clustering using supporting software such as IBM PowerHA™, IBM HACMP, Microsoft Cluster Server (MSCS), VERITAS Storage Foundation, and Tivoli System Automation.

This section provides overview information about a few of these environments. For more information, see the documentation listed in 18.10, “More information” on page 600.

18.8.1 IBM High Availability Cluster Multi-Processing

A Tivoli Storage Manager server can use IBM High Availability Cluster Multi-Processing (HACMP) software for high availability. HACMP is an AIX-based clustering solution, which allows automatic system recovery on system failure detection. Using HACMP together with Tivoli Storage Manager ensures server availability. HACMP offers local or campus disaster survivability with real-time automated failover and reintegration within distance limitations. In an HACMP environment, TCP/IP is the communications method used to support the checking of status and availability of the production and failover server, also commonly referred to as the *heartbeat* connection.

> **PowerHA:** The new version of IBM HACMP for AIX Version 6.1 and Version 7.1 with significant processing enhancements is called PowerHA. Tivoli Storage Manager with embedded DB2 database engine behind can benefit from the new PowerHA.

HACMP detects system failures and manages failover to a recovery processor with a minimal end-user downtime. You can set up a 2-way active-passive HACMP clustered configuration so that, if the production Tivoli Storage Manager server fails, the server will be brought up on the standby system in the cluster, as shown in Figure 18-18. Scripts are provided with Tivoli Storage Manager to automate the failover and failback operations. The Tivoli Storage Manager database, recovery log, and storage pools are stored on shared storage, available to both servers in the cluster.

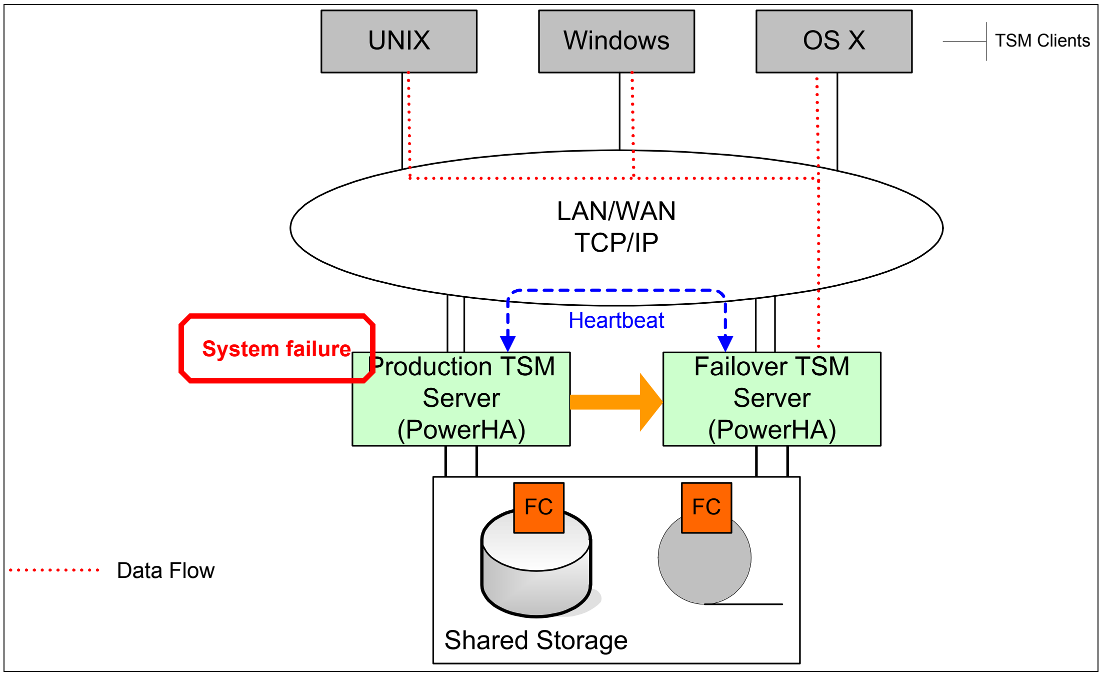


Figure 18-18 PowerHA and Tivoli Storage Manager server high availability configuration

Both failover and fallback act as though a Tivoli Storage Manager server has crashed or halted and was then restarted - the fact that the server is running on other hardware is transparent to the clients. Any transactions that were in-flight at the time are rolled back, and all completed committed transactions are still complete. Tivoli Storage Manager clients see this as a communications failure and try to re-establish the connection. The backup-archive clients can usually restart from the last committed transaction.

Reference: For a detailed discussion of supported environments, prerequisites, install, setup, and testing of a PowerHA and Tivoli Storage Manager server failover environment, see *Tivoli Storage Manager for AIX - Administrator’s Guide*, SC23-9769-00, and *PowerHA for AIX Cookbook*, SG24-7739-00.

18.8.2 Backup-archive client support with HACMP

The Tivoli Storage Manager backup-archive client itself (including the administrator, backup-archive, HSM, and API pieces) can also be clustered using PowerHA to provide highly available backup-restore operations. This configuration allows scheduled Tivoli Storage Manager client operations to continue processing in the event of a system failure on a redundant clustered failover server. See Figure 18-19 for an illustration of how this works.

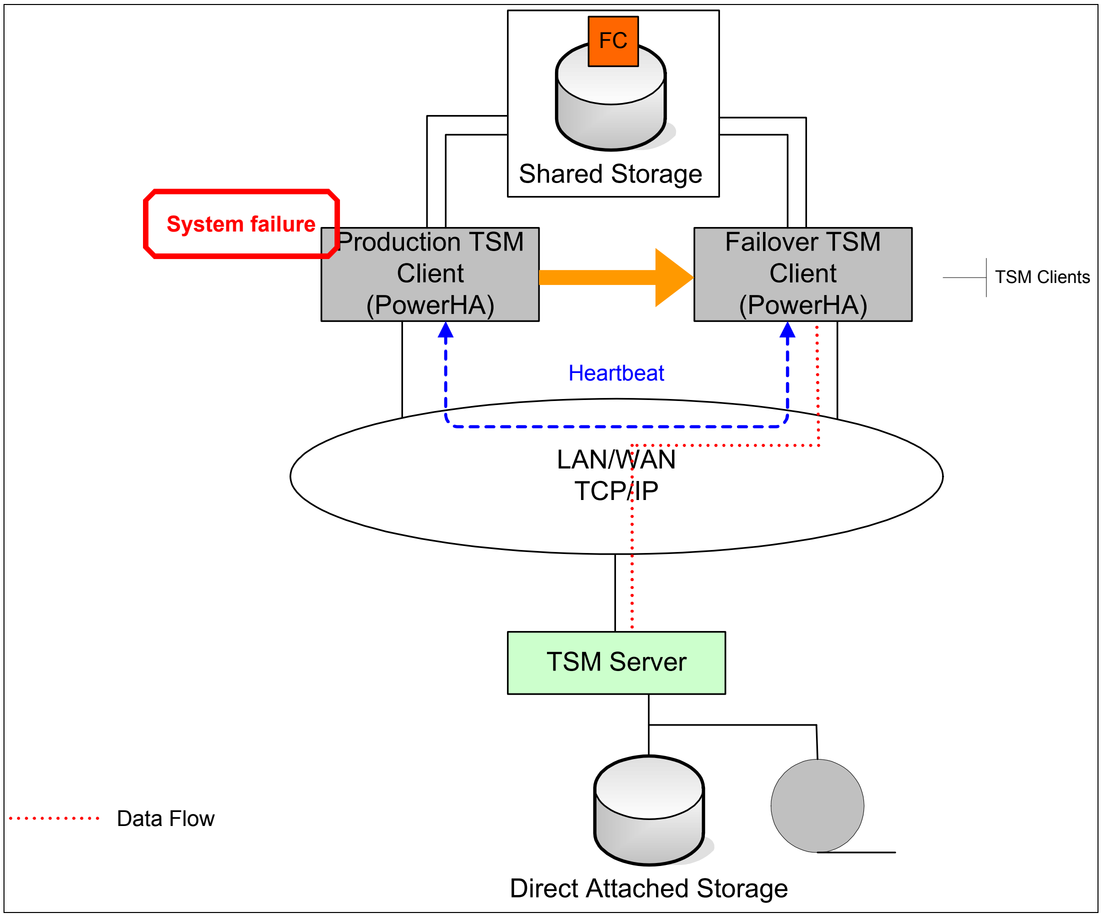


Figure 18-19 PowerHA and Tivoli Storage Manager client high availability configuration

In this configuration, the data to be backed up is stored on shared disk which is available to either of the clustered client nodes.

If a scheduled incremental backup of a clustered volume is running on machine-a and a system failure causes a failover to machine-b, machine-b then reconnects to the server. If the re-connection occurs within the start window for that event, the scheduled command is restarted. This scheduled incremental backup will reexamine files sent to the server before the failover. The backup will then *catch up* to where it terminated before the failover situation.

If a failover occurs during a user initiated (that is, non-scheduled) client session, the Tivoli Storage Manager client starts on the node that is handling the takeover. This allows it to process scheduled events and provide web client access. You can install the Tivoli Storage Manager client locally on each node of an PowerHA environment. You can also install and configure the Tivoli Storage Manager Scheduler service for each cluster node to manage all local disks and each cluster group containing physical disk resources.

PowerHA supports for Hierarchical Storage Management (HSM) clients on AIX provides support for PowerHA failover on AIX so that HSM managed file systems can continue to operate in the case of an PowerHA node failover and fallback.

18.8.3 Tivoli Storage Manager server and Microsoft Cluster Server (MSCS)

Tivoli Storage Manager is a cluster-aware application and can be configured in a MSCS high availability environment. Clustered systems are connected to the same disk subsystem and provide a high-availability solution that minimizes or eliminates many potential sources of downtime. Microsoft Cluster Server (MSCS) is software that helps configure, monitor, and control applications and hardware components that are deployed on a Windows cluster. When you use cluster configurations, you enhance the availability of your servers.

With a Microsoft Cluster Server, you can place Tivoli Storage Manager server cluster resources into a virtual server. A *virtual server* is an MSCS cluster group that looks like a Windows server. The virtual server has a network name, an IP address, one or more physical disks, and a service. A Tivoli Storage Manager server can be one of the virtual services provided by an MSCS virtual server.

The virtual server name is independent of the name of the physical node on which the virtual server runs. The virtual server name and address migrate from node to node with the virtual server. Clients connect to a Tivoli Storage Manager server using the virtual server name, rather than the Windows server name. The virtual server name is implemented as a cluster network name resource and maps to a primary or backup node. The mapping is dependent on where the virtual server currently resides. Any client that uses WINS or directory services to locate servers can automatically track the virtual server as it moves between nodes. Automatically tracking the virtual server does not require client modification or reconfiguration.

As mentioned earlier, each virtual server has its own disk as part of a cluster resource group. Therefore, they cannot share data. Each Tivoli Storage Manager server that has been implemented as a virtual server has its database, recovery log, and set of storage pool volumes on a separate disk owned by that virtual server.

Because the server's location is transparent to client applications, this affords Tivoli Storage Manager the maximum ease of failover and failback, while minimizing the impact on the Tivoli Storage Manager clients.

> **TCP/IP:** MSCS only supports an IP Address as a resource. This means that any Tivoli Storage Manager server running on a cluster must limit its supported communication method to just TCP/IP. Any client *not* using TCP/IP as a communication method will not be able to reach the virtual server if it fails over to the other cluster node.

The following example demonstrates the way the MSCS virtual server concept works.

Assume that a clustered Tivoli Storage Manager server called TSMSERVER1 is running on node A and a clustered Tivoli Storage Manager server called TSMSERVER2 is running on node B. Clients connect to the Tivoli Storage Manager server TSMSERVER1 and the Tivoli Storage Manager server TSMSERVER2 without knowing which node currently hosts their server. The MSCS concept of a *virtual server* ensures that the server's location is transparent to client applications. To the client, it appears that the Tivoli Storage Manager server is running on a virtual server called TSMSERVER1.

Figure 18-20 illustrates the MSCS virtual server concept.

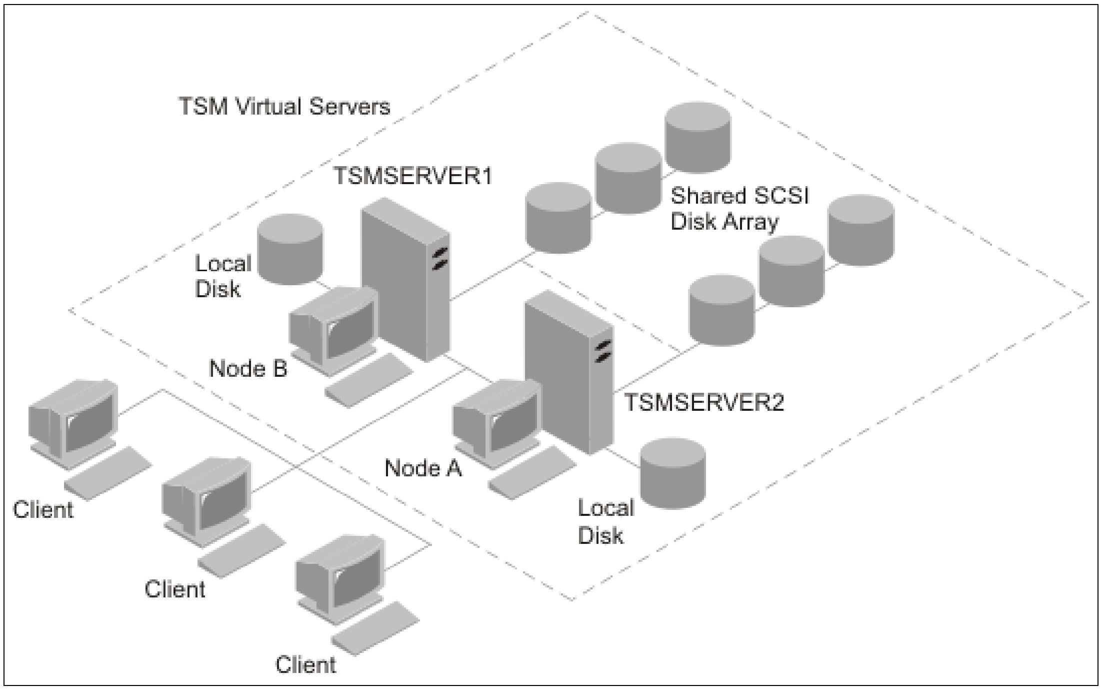


Figure 18-20 Clustering with TSMSERVER1 as node a and TSMSERVER2 as node b

When one of the software or hardware resources fails, failover occurs. Resources (for example, applications, disks, or an IP address) migrate from the failed node to the remaining node. The remaining node takes over the Tivoli Storage Manager server resource group, restarts the Tivoli Storage Manager service, and provides access to administrators and clients.

If node A fails, node B assumes the role of running TSMSERVER1. To a client, it is exactly as if node A were turned off and immediately turned back on again. Clients experience the loss of all connections to TSMSERVER1 and all active transactions are rolled back to the client. Clients must reconnect to TSMSERVER1 after this occurs. The location of TSMSERVER1 is transparent to the client.

Figure 18-21 demonstrates clustering with TSMSERVER2 as node b and assuming the role of TSMSERVER1 as node a.

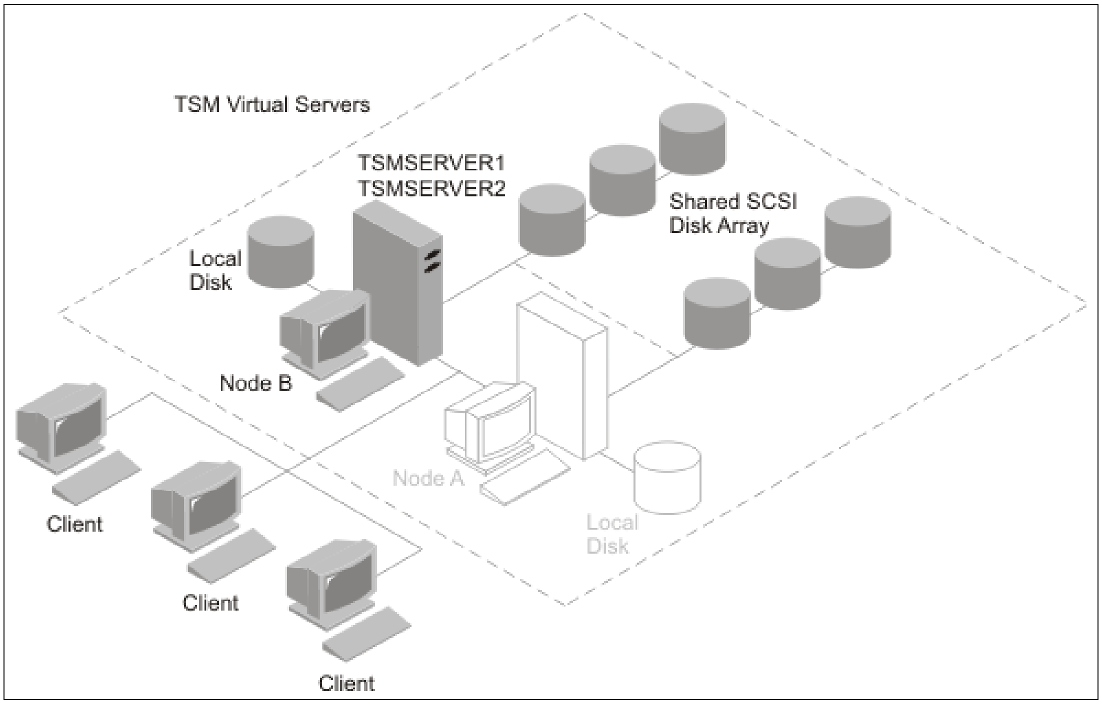


Figure 18-21 Clustering with TSMSERVER2 as node b and assuming the role of TSMSERVER1 as node a

SCSI tape failover

With MSCS and VCS, you cannot use failover for tape devices. However, Tivoli Storage Manager can handle this type of a failover pattern.

Tivoli Storage Manager uses a shared SCSI bus for the tape devices. Each node (two only) involved in the tape failover must contain an additional SCSI adapter card. The tape devices (library and drives) are connected to the shared bus. When failover occurs, the Tivoli Storage Manager server issues a SCSI bus reset during initialization. In a failover situation, the bus reset is expected to clear any SCSI bus reserves held on the tape devices. This allows the Tivoli Storage Manager server to acquire the devices after the failover.

Table 18-1 describes the hardware and software tested for use with Tivoli Storage Manager SCSI tape failover.

Table 18-1 Hardware and software supported for SCSI tape failover

Operating System	Windows Advanced Server or Datacenter Server
SCSI Adapter	Adaptec AHA-2944UW PCI SCSI Controller
SCSI Tape Library	IBM 3590-B11 or IBM 3570-C12

Fibre tape failover

With MSCS and VCS, you cannot use failover for tape and library devices. However, Tivoli Storage Manager can handle the failover of Fibre Channel direct attached tape and library devices on the Windows 2003 or Windows 2008 server without any additional hardware.

Fibre Channel devices have to be directly attached and not connected through a gateway (for example, Passlight 5000) in order for failover to be successful. The following section describes a specific hardware and software configuration for Tivoli Storage Manager Fibre tape failover support. Table 18-2 on page 594 describes the hardware and software tested for use with Tivoli Storage Manager Fibre tape failover.

Table 18-2 Hardware and software supported for fibre tape failover

Operating system	**Windows 2003 or Windows 2008 32-bit server**
Fibre Channel Adapter	QLogic HBA 2340 with Storport driver
Fibre Channel Tape Library and Drives	IBM and other vendor Fibre Channel directly attached tape and library devices

For a detailed discussion on supported environments, prerequisites, install, setup, and testing of a MSCS and Tivoli Storage Manager server failover environment, see *Tivoli Storage Manager for Windows - Administrator's Guide*, SC23-9773-00.

18.8.4 Tivoli Storage Manager backup-archive client support with MSCS

The Tivoli Storage Manager client is supported in an MSCS cluster environment. This configuration allows scheduled Tivoli Storage Manager client operations to continue processing in the event of a system failure on a redundant clustered failover server as shown in Figure 18-22.

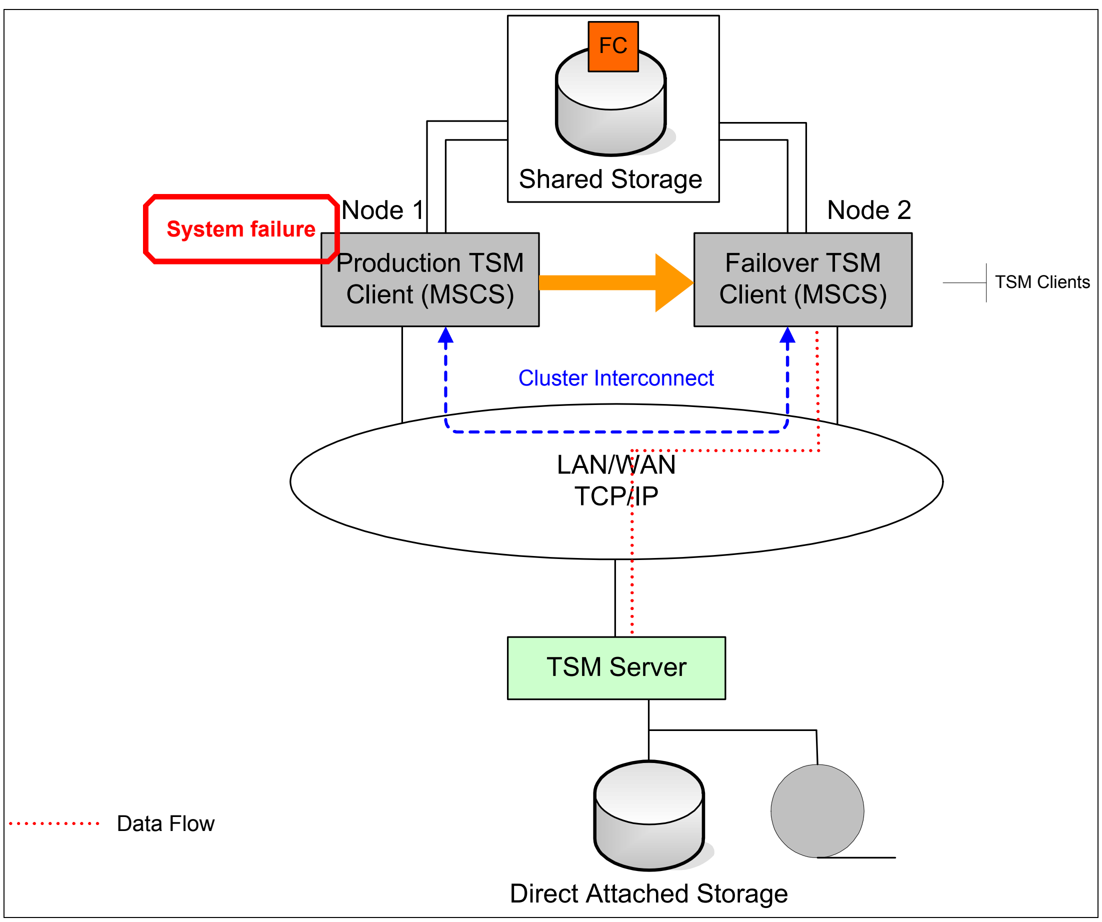


Figure 18-22 MSCS and Tivoli Storage Manager client high availability configuration

In this example, the cluster contains two nodes: Node 1 and Node 2, and two cluster groups containing physical disk resources. In this case, an instance of the Tivoli Storage Manager Backup-Archive Scheduler Service is installed for each node: Node 1 and Node 2. This ensures that proper resources are available to the Backup-Archive client when disks move (or fail) between cluster nodes. The CLUSTERNODE option in the client option file ensures that Tivoli Storage Manager manages backup data logically, regardless of which cluster node backs up a cluster disk resource.

18.9 Tivoli Storage Manager and tape vaulting

Traditionally, disaster recovery plans include daily off-site tape backups that are picked up from the local site and transported by a courier to a secure facility, which is often a tape vaulting service provider. Vaulting of tapes at off-site locations can provide a secure means to protect data in the event of a disaster at the primary site. To recover from a disaster, you must know the location of off-site recovery media. Tivoli Storage Manager DRM helps determine which volumes to move off-site and back on-site and tracks the location of the volumes.

With tape vaulting, you can back up primary storage pools to a copy storage pool and then send the copy storage pool volumes off-site. You can track these copy storage pool volumes by changing their access mode to off-site, and updating the volume history to identify their location. If an off-site volume becomes expired, the server does not immediately return the volume to the scratch pool. The delay prevents the empty volumes from being deleted from the database, making it easier to determine which volumes must be returned to the on-site location. DRM handles all of this automatically.

18.9.1 Electronic tape vaulting

Using Tivoli Storage Manager with electronic tape vaulting provides additional data protection capabilities, with backups made to remote tape drives over communication links. Electronic tape vaulting can enable shorter recovery times and reduced data loss if the server is damaged. An electronic tape vaulting solution combined with Tivoli Storage Manager is fundamental to achieving Tier 3 and above RPO and RTOs, that is, less than 24 hours.

With electronic tape vaulting, the Tivoli Storage Manager server will have an alternate location to store primary and copy storage pools as though they are directly attached. The Tivoli Storage Manager server can first write a copy of disk storage pool data to tape pools at the remote site (Datacenter #2), then the data can be migrated to the tape storage pools at the primary site (Datacenter #1). See Figure 18-23.

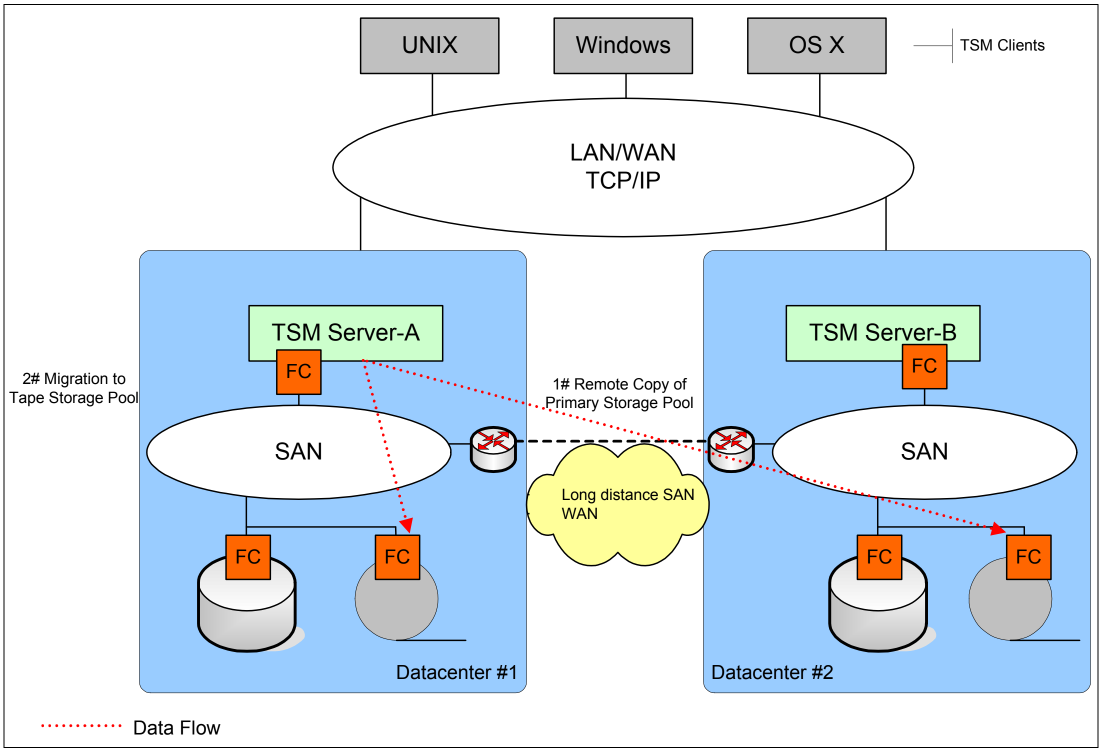


Figure 18-23   Tivoli Storage Manager and electronic tape vaulting

Depending on your configuration (and whether or not remote disk replication is being used in conjunction with electronic tape vaulting) you might choose to backup the Tivoli Storage Manager database and configuration files by this method. This ensures a copy of the data is stored at both sites and that the Tivoli Storage Manager server can rapidly recover at the remote site. If remote disk replication is used for mirroring of the Tivoli Storage Manager database and storage pools, the Tivoli Storage Manager server can be recovered very quickly without any loss of client data. A peer-to-peer configuration can be used to balance the load of Tivoli Storage Manager services in the enterprise and provide data protection and rapid recovery for a failure at either site.

Using electronic tape vaulting with Tivoli Storage Manager offers these advantages:

- Critical data can be frequently and rapidly vaulted to remote off-site locations.
- In the event of a disaster, up-to-date data can be restored at a hotsite, therefore improving recovery time and recovery point objectives.
- It eliminates physical tape handling that can result in damaged tapes, lost tapes, tapes delayed in transit, or data that is sabotaged. Increased reliability.
- It eliminates costs associated with couriers and off-site vaulting vendors.
- Government off-site vaulting regulations are satisfied.
- It lowers the cost of downtime and storage management.
- It increases company control and data security.
- Peer solutions eliminate or reduce costs associated with hot-site service providers.

18.9.2 Remote disk mirroring and tape vaulting solutions

A variety of technologies exist for remote disk mirroring and electronic tape vaulting:

- Long distance SANs
- Dense Wavelength Division Multiplexing (DWDM)
- Fibre extenders
- WAN based channel extension using telco and IP protocols
- Newly emerging NAS and iSCSI gateways.

Table 18-3 summarizes several of these technologies. The use of such technologies also might depend on a particular vendor's replication or vaulting solution. For example, the IBM System Storage DS6000 and DS8000 use PPRC to achieve data replication. Metro Mirror is supported by ESCON links, which can be further extended by DWDM or WAN channel extension.

Table 18-3 Extended electronic vaulting technologies

Electronic vaulting technology	Commonly supported distances between sites	Common product vendors	Relative technology costs
Long Distance SAN (shortwave/longwave Fibre Channel)	up to 30km	Brocade (OEM) McDATA (OEM)	Low
CWDM, DWDM and fibre extenders	up to 300km	Cisco Nortel Ciena Finisar CNT	Medium
WAN, IP Based Routers and Channel Extension	up to 1000's km	CNT Cisco (OEM)	Low to High (depending on solution)

SANs were designed to overcome the distance limitations of other storage channel protocols, such as SCSI. Longwave laser GBICs available on most SAN hubs, switches and directors enable a transmission distance of up to 10 kilometers (11 kilometers when including switch to host connections) when used with 9 micron diameter single-mode optical fibre. Shortwave GBICs use multi-mode fibre and is the ideal choice for shorter distance (less than 500 meters from transmitter to receiver or vice versa).

CWDM or DWDM is a way to open up the conventional optical fibre bandwidth by breaking it up into many channels, each at a particular optical wavelength (a unique color of light). Each wavelength can carry a signal at any bit rate less than an upper limit defined by the electronics, typically up to several gigabits per second. DWDMs are implemented in areas that have dark fibre available through telcos and service providers. The DWDM is deployed as part of the physical layer. It is therefore independent of protocol, simply passing signal information in the format it is received. Examples of the protocols it can support are ATM, Gigabit Ethernet, ESCON, FICON and Fibre Channel.

WAN and IP based channel extenders typically use telecommunication lines for data transfer and therefore enable application and recovery sites to be located longer distances apart. The use of WAN and IP channel extenders provides the separation for disaster recovery purposes and avoids various barriers imposed when customers do not have a "right of way" to lay their fibre cable. WAN and IP channel extenders generally compress the data before sending it over the transport network, however the compression ratio needs to be determined based on the application characteristics and the distance.

Network attached storage (NAS) and iSCSI solutions are beginning to offer low cost IP based storage. Copies of Tivoli Storage Manager storage pools and the Tivoli Storage Manager database can be storage at a remote site using IP based storage to offer a low cost implementation while utilizing existing infrastructure. Configurations can include Tivoli Storage Manager clients attached to iSCSI based data backing up to a Tivoli Storage Manager server or Tivoli Storage Manager servers using iSCSI based storage as storage pools.

For a detailed overview of technologies, products, costs, and best practices with distance solutions, review *Introduction to Storage Area Networks*, SG24-5470-03.

18.9.3 Collocation considerations for off-site vaulting

With collocation, large numbers of files belonging to a client node can be restored, retrieved and recalled more quickly. However, using collocation on copy storage pools requires special consideration. Primary and copy storage pools perform various recovery roles. Normally you use primary storage pools to recover data to clients directly. You use copy storage pools to recover data to the primary storage pools. In a disaster where both clients and the server are lost, the copy storage pool volumes will probably be used directly to recover clients. The types of recovery scenarios that concern you the most will help you to determine whether to use collocation on your copy storage pools.

You might also want to consider that collocation on copy storage pools will result in more partially filled volumes and probably increased off-site reclamation activity. Collocation typically results in a partially filled sequential volume for each client or client file space. This might be acceptable for primary storage pools because these partially filled volumes remain available and can be filled during the next migration process. However, for copy storage pools this might be unacceptable because the storage pool backups are usually made to be taken off-site immediately. If you use collocation for copy storage pools, you will have to decide between these courses of action:

- Taking more partially filled volumes off-site, thereby increasing the reclamation activity when the reclamation threshold is lowered or reached
- Leaving these partially filled volumes on-site until they fill and risk not having an off-site copy of the data on these volumes.

With collocation disabled for a copy storage pool, typically there will be only a few partially filled volumes after storage pool backups to the copy storage pool are complete. Consider carefully before using collocation for copy storage pools. Even if you use collocation for your primary storage pools, you might want to disable collocation for copy storage pools. Or, you might want to restrict collocation on copy storage pools to certain critical clients, as identified by the Business Impact Analysis.

18.9.4 Reclamation considerations for off-site vaulting

Space on a sequential volume becomes reclaimable as files expire or are deleted from the volume. For example, files become obsolete because of aging or limits on the number of versions of a file. In reclamation processing, the Tivoli Storage Manager server rewrites files on the volume being reclaimed to other volumes in the storage pool, making the reclaimed volume available for reuse.

When an off-site volume is reclaimed, the files on the volume are rewritten to another copy storage pool volume that is on-site. The Tivoli Storage Manager server copies valid files contained on the off-site volumes being reclaimed, from the original files in the primary storage pools. In this way, the server can reclaim off-site copy storage pool volumes without having to recall and mount these volumes. Logically, these files are moved back to the on-site location. The new volume must be moved off-site as soon as possible. However, the files have not been physically deleted from the original off-site volume. In the event of a disaster occurring before the newly written copy storage pool volume has been taken off-site, these files can still be recovered from the off-site volume, provided that it has not already been reused and the database backup that you use for recovery references the files on the off-site volume.

The server reclaims an off-site volume which has reached the reclamation threshold as follows:

1. The server determines which files on the volume are still valid.
2. The server obtains these valid files from a primary storage pool, or if necessary, from an on-site volume of a copy storage pool.
3. The server writes the files to one or more volumes in the copy storage pool and updates the database. If a file is an aggregate file with unused space, the unused space is removed during this process.
4. A message is issued indicating that the off-site volume was reclaimed.
5. The newly written volumes are then marked to be sent off-site, and after this has occurred, the reclaimed volume can be returned to an on-site scratch pool.

Volumes with the access value of off-site are eligible for reclamation if the amount of empty space on a volume exceeds the reclamation threshold for the copy storage pool. The default reclamation threshold for copy storage pools is 100%, which means that reclamation is not performed.

If you plan to make daily storage pool backups to a copy storage pool, then mark all new volumes in the copy storage pool as off-site and send them to the off-site storage location. This strategy works well with one consideration; if you are using automatic reclamation (the reclamation threshold is less than 100%). Each day's storage pool backups will create a number of new copy storage pool volumes, the last one being only partially filled. If the percentage of empty space on this partially filled volume is higher than the reclaim percentage, this volume becomes eligible for reclamation as soon as you mark it off-site. The reclamation process causes a new volume to be created with the same files on it. The volume you take off-site is then empty according to the Tivoli Storage Manager database. If you do not recognize what is happening, you can perpetuate this process by marking the new partially filled volume off-site.

If you send copy storage pool volumes off-site, it is best that you control copy storage pool reclamation by using the default value of 100. This turns reclamation off for the copy storage pool. You can start reclamation processing at desired times by changing the reclamation threshold for the storage pool.

Depending on your data expiration patterns, you might not need to do reclamation of off-site volumes each day. You might choose to perform off-site reclamation on a less frequent basis. For example, suppose you send copy storage pool volumes to and from your off-site storage location once a week. You can run reclamation for the copy storage pool weekly, so that as off-site volumes become empty they are sent back for reuse.

When you perform reclamation for off-site volumes, use the following sequence:

1. Back up your primary storage pools to copy storage pools.
2. Turn on reclamation for copy storage pools by lowering the reclamation threshold below 100%.
3. When reclamation processing completes, turn off reclamation for copy storage pools by raising the reclamation threshold to 100%.
4. Mark any newly created copy storage pool volumes as off-site and then move them to the off-site location.

This sequence ensures that the files on the new copy storage pool volumes are sent off-site, and are not inadvertently kept on-site because of reclamation.

Attention: If collocation is enabled and reclamation occurs, the server tries to reclaim the files for each client node or client file space onto a minimal number of volumes.

18.10 More information

- More information about Tivoli Storage Manager can be found on the following website:

  http://www.ibm.com/software/tivoli/products/storage-mgr/

- Product manuals for API and Backup-Archive Clients:
  - *Using the Application Programming Interface*, SC23-9793-00
  - *Tivoli Storage Manager for UNIX and Linux Backup-Archive Clients Version 6.1 - Installation and User's Guide*, SC23-9791-00
  - *Tivoli Storage Manager for Windows Backup-Archive Clients*, SC23-9792-00
- Product manuals for Storage Manager for AIX:
  - *Tivoli Storage Manager for AIX - Administrator's Guide*, SC23-9769-00
  - *Tivoli Storage Manager for AIX - Administrator's Reference*, SC23-9775-00
  - *Tivoli Storage Manager for AIX - Installation Guide*, GC23-9781-00
  - *Tivoli Storage Manager for SAN for AIX - Storage Agent User's Guide*, SC23-9797-00
- Product manuals for Storage Manager for HP-UX:
  - *Tivoli Storage Manager for HP-UX - Administrator's Guide*, SC23-9770-00
  - *Tivoli Storage Manager for HP-UX - Administrator's Reference*, SC23-9776-00
  - *Tivoli Storage Manager for HP-UX - Installation Guide*, GC23-9782-00
  - *Tivoli Storage Manager for SAN for HP-UX - Storage Agent User's Guide*, SC23-9798-00
- Product manuals for Storage Manager for Linux:
  - *Tivoli Storage Manager for Linux - Administrator's Guide*, SC23-9771-00
  - *Tivoli Storage Manager for Linux - Administrator's Reference*, SC23-9777-00
  - *Tivoli Storage Manager for Linux - Installation Guide*, GC23-9783-00
  - *Tivoli Storage Manager for SAN for Linux - Storage Agent User's Guide*, SC23-9799-00
- Product manuals for Storage Manager for Sun Solaris:
  - *Tivoli Storage Manager for Sun Solaris - Administrator's Guide*, SC23-9772-00
  - *Tivoli Storage Manager for Sun Solaris - Administrator's Reference*, SC23-9778-00
  - *Tivoli Storage Manager for Sun Solaris - Installation Guide*, GC23-9784-00
  - *Tivoli Storage Manager for SAN for Sun Solaris - Storage Agent User's Guide*, SC23-9800-00

- Product manuals for Storage Manager for Windows:
  - *Tivoli Storage Manager for Windows - Administrator's Guide*, SC23-9773-00
  - *Tivoli Storage Manager for Windows - Administrator's Reference*, SC23-9779-00
  - *Tivoli Storage Manager for Windows - Installation Guide*, GC23-9785-00
  - *Tivoli Storage Manager for SAN for Windows - Storage Agent User's Guide*, SC23-9553-00
- Product manual for Space Management:

  Tivoli Storage Manager for Space Management for UNIX and Linux - User's Guide, SC23-9794-00
- Product manual for ACS:

  Tivoli Storage Manager for Advanced Copy Services - Data Protection for Snapshot Devices Installation and User's Guide, SC33-8331-00
- Product manuals for SAP:
  - *Tivoli Storage Manager for Enterprise Resource Planning - Data Protection for SAP, Installation and User's Guide for DB2*, SC33-6341-10
  - *Tivoli Storage Manager for Enterprise Resource Planning - Data Protection for SAP, Installation and User's Guide for Oracle*, SC33-6340-10
- Product manual for Mail:

  Tivoli Storage Manager for Mail - Data Protection for Microsoft Exchange Server, Installation and User's Guide, SC23-9796-00

19

IBM Tivoli Storage Productivity Center

IBM Tivoli Storage Productivity Center (TPC) is an integrated suite that includes a single user interface to manage capacity utilization of storage systems, file systems, and databases, and to automate file system capacity provisioning in both physical and virtual environments.

In this chapter, we discuss the IBM Tivoli Storage Productivity Center components that can be ordered as a bundled suite or ordered separately based on specific needs.

These individual components are included:

- IBM Tivoli Storage Productivity Center for Data
- IBM Tivoli Storage Productivity Center for Disk
- IBM Tivoli Storage Productivity Center for Disk Midrange Edition
- IBM Tivoli Storage Productivity Center for Replication for System z

These integrated packages are included:

- IBM Tivoli Storage Productivity Center Basic Edition
- IBM Tivoli Storage Productivity Center Standard Edition
- IBM Tivoli Storage Productivity Center with Advanced Provisioning
- IBM System Storage Productivity Center.

19.1 New with IBM Tivoli Storage Productivity Center V4.2.1

You can use this information to learn about new features and enhancements in IBM Tivoli Storage Productivity Center version 4.2.1. This section highlights the changes since IBM Tivoli Storage Productivity Center 4.1 and IBM TotalStorage Productivity Center 3.3.2.

For more information about each of the features, go to the Tivoli Storage Productivity Center Information Center and search for Planning for the IBM Tivoli Storage Productivity Center family. For information about how to use the features, see the *IBM Tivoli Storage Productivity Center User's Guide*, SC27-2338-01.

Tivoli Storage Productivity Center 4.2.1 adds the following new features, functions, and enhancements.

19.1.1 Name and licensing changes

This section notifies about the changes in naming convention and licensing.

Name change

IBM Tivoli Storage Productivity Center V4.2.1 has been renamed from IBM TotalStorage Productivity Center. All user interfaces, documentation, online help, and messages have also been changed to reflect the name change.

Licensing changes

These are the licensed software packages available for IBM Tivoli Storage Productivity Center:

- IBM Tivoli Storage Productivity Center Basic Edition
- IBM Tivoli Storage Productivity Center for Data
- IBM Tivoli Storage Productivity Center for Disk
- IBM Tivoli Storage Productivity Center for Disk Midrange Edition
- IBM Tivoli Storage Productivity Center Standard Edition.

If you have an IBM TotalStorage Productivity Center for Fabric license only, you can upgrade to IBM Tivoli Storage Productivity Center Standard Edition.

If you have an IBM TotalStorage Productivity Center for Basic Edition license only, you can upgrade to IBM Tivoli Storage Productivity Center Basic Edition, IBM Tivoli Storage Productivity Center for Disk, IBM Tivoli Storage Productivity Center for Disk Midrange Edition, IBM Tivoli Storage Productivity Center for Data, or IBM Tivoli Storage Productivity Center Standard Edition.

If you have an IBM TotalStorage Productivity Center for Data license only, you can upgrade to IBM Tivoli Storage Productivity Center for Data or IBM Tivoli Storage Productivity Center Standard Edition.

If you have an IBM TotalStorage Productivity Center for Disk license only, you can upgrade to IBM Tivoli Storage Productivity Center for Disk, IBM Tivoli Storage Productivity Center for Disk Midrange Edition, IBM Tivoli Storage Productivity Center for Data (Disk plus Data), or IBM Tivoli Storage Productivity Center Standard Edition.

If you have an IBM TotalStorage Productivity Center Standard Edition license, you can upgrade to IBM Tivoli Storage Productivity Center Standard Edition.

IBM Tivoli Storage Productivity Center for Replication integrates with these products.

19.1.2 Integration features

Tivoli Storage Productivity Center (TPC) provides the following integration features.

Integration of TPC and TPC for Replication

Tivoli Storage Productivity Center and IBM Tivoli Storage Productivity Center for Replication, previously separate products, are now integrated. You can start the IBM Tivoli Storage Productivity Center for Replication user interface from within the Tivoli Storage Productivity Center user interface.

The IBM Tivoli Storage Productivity Center and IBM Tivoli Storage Productivity Center for Replication Installation and Configuration Guide, SC27-2337-01 also includes the installation, upgrade, and uninstallation information for IBM Tivoli Storage Productivity Center for Replication.

This integration enables you to perform the following tasks:

- Start the IBM Tivoli Storage Productivity Center for Replication user interface from within the Tivoli Storage Productivity Center user interface
- Use the Tivoli Storage Productivity Center GUI to set up IBM Tivoli Storage Productivity Center for Replication SNMP alerts and IBM Tivoli Enterprise Console® (TEC) events.
- Provide a Tivoli Storage Productivity Center superuser role that has authority over all Tivoli Storage Productivity Center commands. IBM Tivoli Storage Productivity Center for Replication includes a replication administrator role that has authority to all IBM Tivoli Storage Productivity Center for Replication commands. IBM Tivoli Storage Productivity Center for Replication will honor the Tivoli Storage Productivity Center superuser role giving the superuser role authority over all Tivoli Storage Productivity Center and IBM Tivoli Storage Productivity Center for Replication commands.

Integration of TPC and IBM Tivoli Integrated Portal

Tivoli Integrated Portal is a standards-based architecture for web administration. Tivoli Integrated Portal enables developers to build administrative interfaces for IBM and independent software products as individual plug-ins to a common console network. The installation of Tivoli Integrated Portal is required to enable single sign-on for Tivoli Storage Productivity Center.

Single sign-on is an authentication process that enables you to enter one user ID and password to access multiple applications. Single sign-on integrates with the launch in context feature to enable you to move smoothly from one application to a specific location in a second application.

Launch in context feature

The launch in context feature enables you to access external applications from the Tivoli Storage Productivity Center GUI. Element managers are the most prevalent external applications that use the launch in context feature. An element manager is usually the vendor-specific software that is used to administer a particular storage device. The launch in context feature provides starting points in the Tivoli Storage Productivity Center GUI so you can click a button or select a menu item to start an element manager.

When you install TPC, Tivoli Integrated Portal, and Tivoli Storage Productivity Center for Replication, the components are automatically configured to use launch in context. You can access Tivoli Storage Productivity Center and Tivoli Storage Productivity Center for Replication from the Tivoli Integrated Portal GUI and you can access Tivoli Storage Productivity Center for Replication from the Tivoli Storage Productivity Center GUI.

Single sign-on

Single sign-on is an authentication process that enables you to enter one user ID and password to access multiple applications. It enables you to access these features:

- Tivoli Storage Productivity Center and Tivoli Storage Productivity Center for Replication from the Tivoli Integrated Portal GUI
- Tivoli Storage Productivity Center for Replication from the Tivoli Storage Productivity Center GUI
- External applications such as element managers from the Tivoli Storage Productivity Center GUI

The single sign-on feature requires a centralized user and group repository, such as an LDAP-compliant directory, that all participating applications can access.

Tivoli Storage Productivity Center uses Lightweight Third Party Authentication (LTPA) tokens to pass the user information between applications. To use LTPA tokens for single sign-on, each participating application must possess the same set of keys to encode and decode the user information contained in the token. As an additional security feature, the LTPA tokens expire after a determined amount of time. When the tokens expire, you must re-enter your user ID and password information.

If you select operating system authentication, then the use of the single sign-on feature is limited. Operating system authentication does not support single sign-on for element managers, even when the element manager is installed on the same machine as Tivoli Storage Productivity Center.

19.1.3 Storage Resource agents

Tivoli Storage Productivity Center now supports Storage Resource agents on Microsoft Windows, AIX, and Linux. The Storage Resource agent probe is equivalent to the information that is collected by probes using the Data agent.

The Storage Resource agents do not require the Agent Manager and can be deployed to other systems using the Tivoli Storage Productivity Center GUI on the server system.

You can use the following functions:

- Asset reports (including HBA)
- Capacity reports
- Subsystem to host storage correlation including multipathing information
- Topology and Data Path explorer functions.

This support does not include file system scans, NAS discovery or topology, zoning and zone control functions or subsystem device driver configuration. You can still use the Data agent and Fabric agent for this information.

19.1.4 SQL access to Tivoli Storage Productivity Center database

Tivoli Storage Productivity Center will provide a set of DB2 views that represent key information that has been collected by monitoring jobs and stored in the database repository. A view is a way of describing data that exists in one or more tables within the database repository. It does not contain data but, instead, is a stored set of SQL commands that define a subset of rows and columns in the base tables.

You can use the Structured Query Language (SQL) to retrieve the information from the views and create reports using your own tools, such as Business Intelligence and Reporting Tools (BIRT) or Microsoft Excel. Other applications can also use these views to gather and import information that is collected by Tivoli Storage Productivity Center.

These categories of views contain information collected by Tivoli Storage Productivity Center.

Storage entity views

These views include information about the properties of the entity. For example, the name, capacity, freespace, and so forth for a storage subsystem.

Entities defined by Tivoli Storage Productivity Center

These entities include Data agents, Fabric agents, alert log, Tivoli Storage Productivity Center server, computer groups, storage subsystem groups, file system groups, storage resource groups, and so forth.

Aggregated views

These views provide summary information for the database history, data in a database instance, and the Data agent file system.

Reporting views

These views combine several various entities in one view for a report.

Rollup views

These views include rollup report information from the master and subordinate Tivoli Storage Productivity Center servers, Data agents and Fabric agents, host cluster data, computer group, host, database computer groups, fabric SAN assets, switch assets, storage subsystem group, storage subsystems, and Tivoli Storage Productivity Center for Databases.

19.1.5 Performance management improvements

Tivoli Storage Productivity Center release 4.2.1 provides performance management improvements for metrics, thresholds, and alert definitions. For more information, search for **improvements to performance metrics** in following Information Center:

http://www.ibm.com/systems/storage/software/center/index.html

19.1.6 Storage Optimizer

The Storage Optimizer is a tool to help you analyze your storage networks to identify hot spots or bottlenecks, plan for storage growth, improve performance, and help develop storage migration or storage consolidation plans. Using the data in the Tivoli Storage Productivity Center database, the Storage Optimizer enables you to create an analysis report and an optimization report. The analysis report analyzes your data storage environment and proposes changes to improve your environment. Based on the analysis report, the optimization report includes storage migration or storage consolidation guidelines.

This feature requires an IBM Tivoli Storage Productivity Center Standard Edition license.

19.1.7 Advanced Brocade Discovery

The Advanced Brocade Discovery function has been removed from Tivoli Storage Productivity Center. This function uses the Brocade API. If you have a fabric that is managed by the Brocade API and do not have a Brocade SMI-S agent, install and configure the Brocade SMI-S agent to manage the fabric before or after you upgrade Tivoli Storage Productivity Center. You must install and configure the Brocade SMI-S agent to view zoning data or perform zone control through Tivoli Storage Productivity Center. When you upgrade Tivoli Storage Productivity Center, you receive a warning message if you are using the Advanced Brocade API but no Brocade SMI-S agent is configured to manage the fabric.

19.1.8 Discovery Library Adapter

Tivoli Storage Productivity Center provides a Discovery Library Adapter that can be used in a multiple IBM Tivoli product environments to exchange data with other Tivoli products. The data gathered by Tivoli Storage Productivity Center is put in a common data model format and written to a file using the Identification Markup Language. This file can be loaded into IBM Tivoli Change and Configuration Management database (CCMDB) so that other Tivoli products such as IBM Tivoli Application Dependency Discovery Manager or IBM Tivoli Business Service Manager can use that data.

19.1.9 Storage resource groups

Storage resource groups are new objects provided to help storage administrators plan, monitor, and report on the managed environment.

A storage resource group is a set of entities managed by Tivoli Storage Productivity Center. These entities can be servers, switches, storage subsystems, fabrics, storage pools, and storage volumes. Storage resource groups can be a group of heterogeneous objects and can also contain other storage resource groups without any connectivity.

Policies for provisioning (volume creation and selection, workload profiles, zoning and multipathing configuration) can be specified and associated with storage resource groups. These policies are used by the SAN Planner to populate default settings.

Storage resource groups are used primarily for planning functions but is also available with the Tivoli Storage Productivity Center Basic Edition license. With the basic license, you can create and view storage resource groups in the topology. With the Standard Edition license, the planner function is enabled and you can use storage resource groups as input.

Storage resource groups also work with the following profiles.

Workload profiles

Describes the requirements that define the performance characteristics of newly provisioned capacity.

Provisioning profiles

Describes the requirements such as total capacity, number of volumes, Redundant Array of Independent Disks (RAID) level, volume name prefix, multipathing options, zoning options, and so forth.

19.1.10 IBM Support Assistant

Tivoli Storage Productivity Center Standard Edition contains a plug-in for IBM Support Assistant (ISA, version 4.1.1 includes all features of TPC). IBM Support Assistant is an application provided at no charge to help discover solutions, and fix issues with IBM software. For more information about ISA, see the website:

http://www.ibm.com/software/support/isa/

19.1.11 IBM General Parallel File System

Tivoli Storage Productivity Center supports the monitoring of the IBM General Parallel File System (GPFS) 3.2 on AIX. GPFS provides access to critical file data. GPFS also provides concurrent high-speed file access to applications that are running on multiple nodes of an AIX cluster, a Linux cluster, or a heterogeneous cluster of AIX and Linux nodes. In addition to providing file storage capabilities, GPFS provides storage management, information lifecycle tools, centralized administration and allows for shared access to file systems from remote GPFS clusters.

For more information about GPFS, see the *General Parallel File System - Concepts, Planning, and Installation Guide*, GA76-0413-02.

19.1.12 Installation changes

This section highlights the installation changes since IBM TotalStorage Productivity Center 3.3.2.

IBM Tivoli Storage Productivity Center for Replication

IBM Tivoli Storage Productivity Center for Replication is now installed with IBM Tivoli Storage Productivity Center. The *IBM Tivoli Storage Productivity Center and IBM Tivoli Storage Productivity Center for Replication Installation and Configuration Guide* SC27-2337-01 also includes the installation, upgrade, and uninstallation information for IBM Tivoli Storage Productivity Center for Replication.

The specific installation procedure is required when deploying IBM TPC for Replication for System z. The documentation just mentioned covers that topic as well.

IBM DB2 Database for Linux, UNIX, and Windows

Tivoli Storage Productivity Center now supports DB2 9.7. You will be able to migrate your Tivoli Storage Productivity Center databases from DB2 9.1 or DB2 8.2 to DB2 9.5. DB2 9.7 is optional. Tivoli Storage Productivity Center still supports DB2 9.1.

> **Attention:** DB2 installation is an embedded part of the installation process of TPC. Thus, TPC cannot be installed on the system where any independent DB2 application is already running.

Installation of IBM Tivoli Integrated Portal

Tivoli Storage Productivity Center now installs IBM Tivoli Integrated Portal along with Tivoli Storage Productivity Center.

Embedded WebSphere 6.1 and JRE version 6

The Device server is upgraded to run under Embedded WebSphere 6.1 (from Embedded WebSphere 6.0.2). The Data server, GUI, and CLI is upgraded to use JRE version 6. InstallShield uses JRE 1.5 during the installation and uninstallation process when Tivoli Storage Productivity Center is installed using the disk1 image. The image to perform local agent installations uses JRE version 1.4.2.

Silent installation

Tivoli Storage Productivity Center and IBM Tivoli Storage Productivity Center for Replication do not support silent installation except for the Data agents and Fabric agents.

19.1.13 New device and application support

You can use this information to learn about new device and application support in IBM Tivoli Storage Productivity Center version 4.2.1.

IBM System Storage DS8800 R6

This release supports DS8800 R6 with these additional items:

- Storage pool striping
- Dynamic volume expansion
- Internet Protocol Version 6 (IPv6)
- Redundant Array of Independent Disks (RAID 6)
- Variable logically partitioned mode (LPARs)
- Space-efficient FlashCopy
- Data encryption
- Solid-state drives
- 2 TB SATA drives.

IBM Storwize V7000

Productivity Center's (TPC) latest update, v4.2.1 delivers complete support for the new IBM Storwize V7000.

DS5000 series

Support for the following DS5000 features is targeted for a future release of Tivoli Storage Productivity Center. These features are included in the following DS5000 series systems:

- DS5100 and DS5300: Full Disk Encryption, solid-state drives, 2 TB SATA drives
- DS5020: Full Disk Encryption

IBM System Storage SAN Volume Controller 6.1.0

This release supports SAN Volume Controller 6.1.0 (SVC) and higher, with these additional items:

- Embedded CIM agent
- 64-bit logical block address (LBA) for the back end array
- 2 TB virtual disks (VDisks) and managed disks (MDisks).
- SVC with Solid-State Disk (SSD) drives

Microsoft SQL Server 2005 and Microsoft SQL Server 2008 databases

Tivoli Storage Productivity Center can now monitor the Microsoft SQL Server 2005 and Microsoft SQL Server 2008 databases. You must configure Microsoft SQL Server before you can monitor the database. For information about configuration, see the Information Center. Search for **Configuring Microsoft SQL Server 2005 or 2008**.

EMC PowerPath

With Tivoli Storage Productivity Center, you can now use EMC PowerPath storage systems like CLARiiON and Symmetrix. Using these storage systems, you can discover host volume information and display detailed information for the volume for capacity planning purposes. Connection reports can show the connectivity from the host to the storage subsystems. EMC PowerPath version 4.0 or later is supported.

LSI SMI-S Provider

Support for the LSI SMI-S Provider for IBM System Storage DS4000 and IBM System Storage DS5000 storage systems is targeted for a future release of Tivoli Storage Productivity Center. The LSI SMI-S Provider supports the Storage Management Initiative Specification (SMI-S) 1.3 specifications. The LSI SMI-S Provider also provides performance metrics.

Network Appliance (NetApp)

With Tivoli Storage Productivity Center, you can use the Network Appliance SMI-S agent to support block storage devices. The SMI-S agent supports the SMI-S 1.2 array profile.

IBM XIV Storage System

XIV Storage System will have an embedded CIM agent that Tivoli Storage Productivity Center will use to run discovery and probe jobs.

You will be able to start the XIV Storage System GUI from within Tivoli Storage Productivity Center if the GUI is installed on the same system as the Tivoli Storage Productivity Center GUI. The XIV Storage System GUI will be supported on Windows and Linux.

Both the Data agent and Storage Resource agent will support XIV Storage System.

For the IBM XIV Storage System software release 10.2 and later, the XIV Storage System CIM agent must use user authentication credentials that are defined for the XIV Storage System system. XIV Storage System offers the option of using a Lightweight Directory Access Protocol (LDAP) repository for user authentication and authorization. For information about user authentication for XIV Storage System, see the *IBM XIV Storage System User Manual*.

Important: The XIV Storage System information provided in the Tivoli Storage Productivity Center 4.2.1 documentation is only for planning purposes until the supported XIV Storage System software is available. Tivoli Storage Productivity Center support is targeted for a future XIV Storage System software release. A flash will be issued when Tivoli Storage Productivity Center support for XIV Storage System is available.

Multipath subsystem device drivers

Tivoli Storage Productivity Center supports these subsystem device drivers (SDD):

- AIX SDD
- Windows SDD
- Windows SDD DSM
- Linux SDD
- HP SDD
- Solaris SDD
- Novell SDD (reporting only)
- AIX SDD PCM
- Linux DM_Multipath.

IBM System Storage N Series Gateway servers

IBM Tivoli Storage Productivity Center supports IBM System Storage N Series Gateway servers as Other NAS. This support allows you to monitor and report on file systems through the Windows CIFS or UNIX NFS shares that are accessible to the scan or probe jobs for the Data agent. No back-end storage information such as controllers, disks, and logical volumes is collected or reported.

High-Availability Cluster Multi-Processing

This release provides additional support for High-Availability Cluster Multi-Processing (HACMP) version 5.5.

Tivoli Enterprise Portal

A Universal Agent for Tivoli Storage Productivity Center that utilizes a set of Tivoli Storage Productivity Center web services calls to gather information and provide results files that will display enhanced information such as job status and Tivoli Storage Productivity Center status in the IBM Tivoli Integrated Portal.

Terminology

The Tivoli Storage Productivity Center documentation uses the term *storage subsystem* and the Tivoli Storage Productivity Center for Replication documentation uses the term *storage system*. Both terms mean the devices used for storage management.

19.2 Tivoli Storage Productivity Center overview

IBM Tivoli Storage Productivity Center provides a set of policy-driven automated tools for managing storage capacity, availability, events, performance and assets in your enterprise environment, including NetWare, NAS, Tivoli Storage Enterprise Storage Server, and Microsoft Cluster Server technologies, as well as RDBMSs such as Oracle, Sybase SQL Server, Microsoft SQL Server, and DB2 UDB. Tivoli Storage Productivity Center provides storage management from the host and application to the target storage device. It provides disk and tape subsystem configuration and management, performance management, SAN fabric management and configuration, and usage reporting and monitoring.

Tivoli Storage Productivity Center can help you identify, evaluate, control and predict your enterprise storage management assets. Because it is policy-based, it can detect potential problems and automatically make adjustments based on the policies and actions that you define. For example, it can notify you when your system is running out of disk space or warn you of impending storage hardware failure. By alerting you to these and other issues related to your stored data, it enables you to prevent unnecessary system and application downtime.

Tivoli Storage Productivity Center is designed to offer these benefits:

- Simplifies the management of storage infrastructures
- Manages, configures, and provisions SAN-attached storage
- Monitors and tracks performance of SAN-attached devices
- Monitors, manages, and controls (through zones) SAN fabric components
- Manages the capacity utilization and availability of file systems and databases.

Figure 19-1 shows the main window, which is displayed when you log into IBM Tivoli Storage Productivity Center.

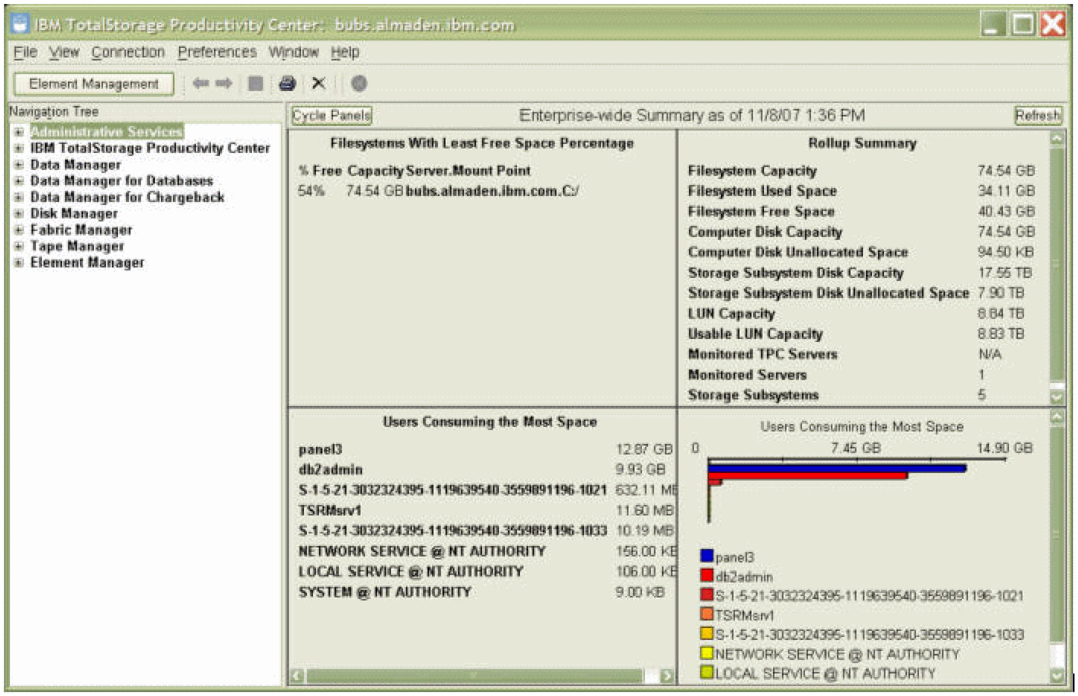


Figure 19-1 IBM Tivoli Storage Productivity Center main window

19.3 Tivoli Storage Productivity Center architecture

The IBM Tivoli Storage Productivity Center (TPC) consists of several key components. This topic identifies these components and shows how they are related.

For more information about the TPC architecture, see the *IBM Tivoli Storage Productivity Center V4.1 Release Guide*, SG24-7725-00.

19.3.1 Tivoli Storage Productivity Center components

Here we discuss the components of the Tivoli Storage Productivity Center.

Data server

This component is the control point for product scheduling functions, configuration, event information, reporting, and GUI support. It coordinates communication with and data collection from agents that scan file systems and databases to gather storage demographics and populate the database with results. Automated actions can be defined to perform file system extension, data deletion, and Tivoli Storage Productivity Center backup or archiving, or event reporting when defined thresholds are encountered. The Data server is the primary contact point for GUI user interface functions. It also includes functions that schedule data collection and discovery for the Device server.

Device server

This component discovers, gathers information from, analyzes performance of, and controls storage subsystems and SAN fabrics. It coordinates communication with and data collection from agents that scan SAN fabrics and storage devices.

Database

A single database instance serves as the repository for all Tivoli Storage Productivity Center components.

Agents

Data agents, Storage Resource agents, and fabric agents gather host, application, and SAN fabric information and send this information to the Data Server or Device server.

GUI

The graphical user interface (GUI) lets you enter or receive information for all Tivoli Storage Productivity Center components.

CLI

The command-line interface (CLI) lets you issue commands for major Tivoli Storage Productivity Center functions.

Tivoli Integrated Portal

The IBM Tivoli Storage Productivity Center installation program includes IBM Tivoli Integrated Portal. Tivoli Integrated Portal is a standards-based architecture for web administration. Tivoli Integrated Portal enables developers to build administrative interfaces for IBM and independent software products as individual plug-ins to a common console network.

The installation of Tivoli Integrated Portal is required to enable single sign-on for Tivoli Storage Productivity Center. Single sign-on is an authentication process that enables you to enter one user ID and password to access multiple applications. Single sign-on integrates with the launch in context feature to enable you to move smoothly from one application to a functionally-related location in a second application.

Availability: The single sign-on feature is not available for the following programs:

- IBM XIV Storage System element manager
- IBM System Storage SAN Volume Controller
- IBM System Storage DS4000 (withdrawn from marketing).

Figure 19-2 shows a diagram of the Tivoli Storage Productivity Center components.

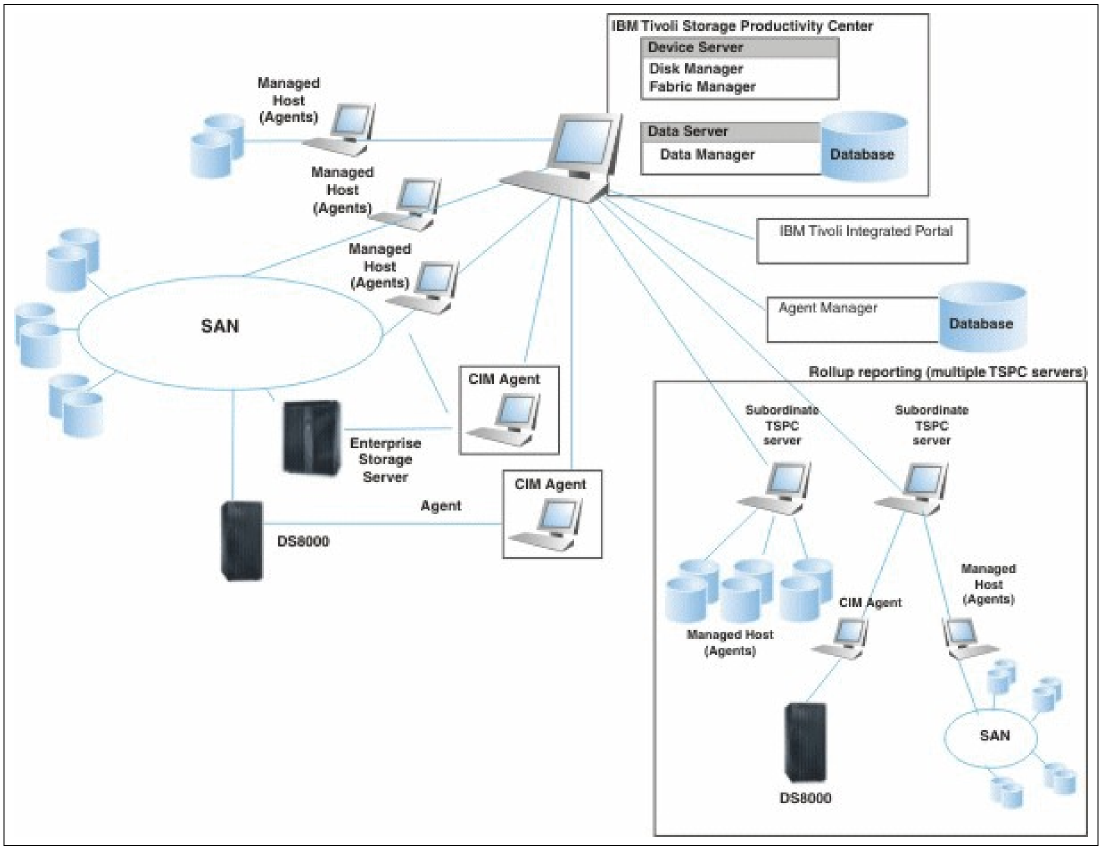


Figure 19-2 Tivoli Storage Productivity Center components

19.3.2 Tivoli Storage Productivity Center structure

In this section we look at the Tivoli Storage Productivity Center structure from the logical and physical view.

Logical structure

The logical structure of Tivoli Storage Productivity Center V4.2.1 has three layers, as shown in Figure 19-3.

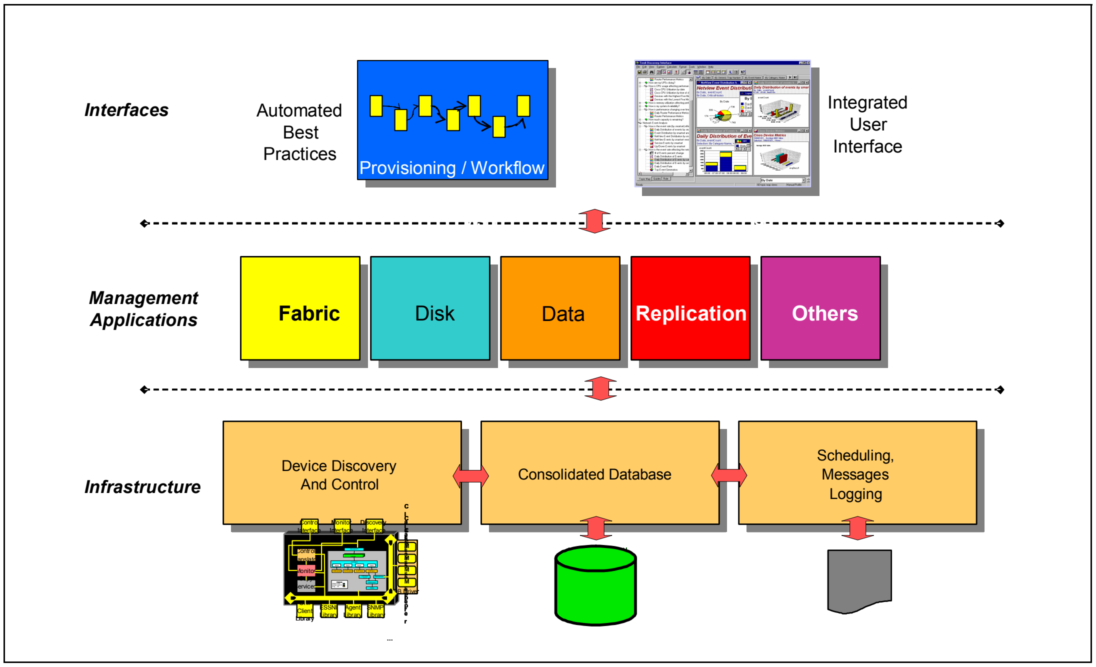


Figure 19-3 IBM TPC v4.2.1 logical structure

The infrastructure layer consists of basic functions such as messaging, scheduling, logging, device discovery, and a consolidated database shared by all components of Tivoli Storage Productivity to ensure consistent operation and performance.

The application layer consists of core Tivoli Storage Productivity Center management functions, that rely on the common base infrastructure to provide various options of storage or data management. These application components are most often associated with the product components that make up the product suite, such as fabric management, disk management, replication management, and data management.

The interface layer presents integration points for the products that make up the suite. The integrated graphical user interface (GUI) brings together product and component functions into a single representation that seamlessly interacts with the components to centralize the tasks for planning, monitoring, configuring, reporting, topology viewing, and problem resolving.

Physical structure

IBM Tivoli Storage Productivity Center is comprised of the following components:

- A data component: Data Manager
- A disk component: Disk Manager
- A fabric component: Fabric Manager
- A tape component: Tape Manager.

Figure 19-4 shows the Tivoli Storage Productivity Center V4.2.1 physical structure.

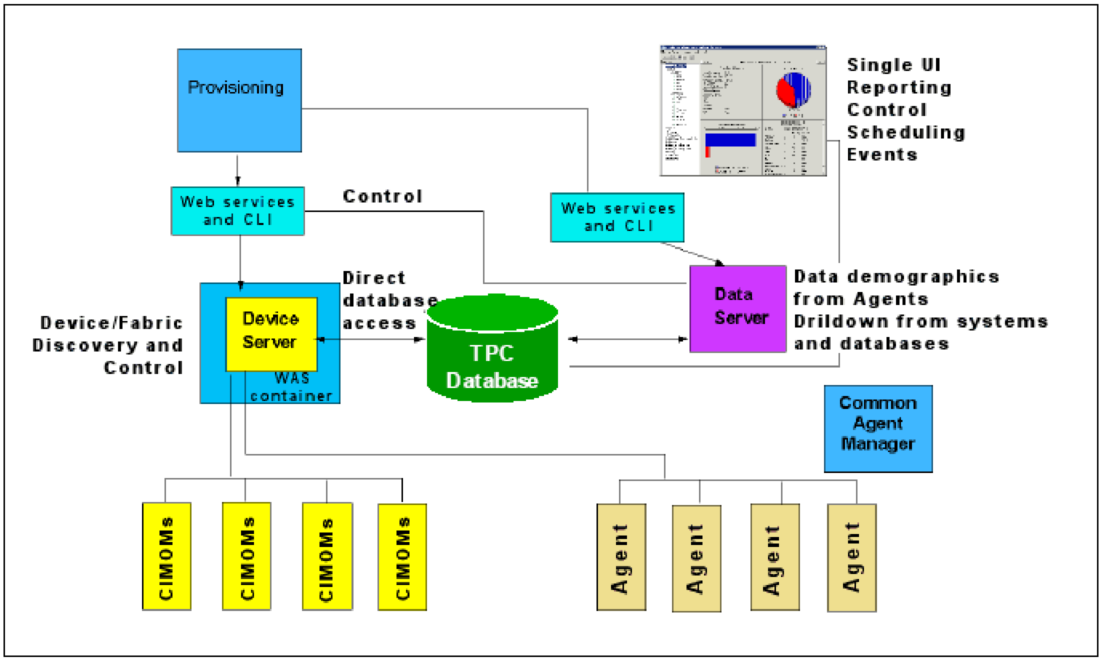


Figure 19-4 TPC V4.2.1 physical structure

The Data server is the control point for product scheduling functions, configuration, event information, reporting, and GUI support. It coordinates communication with agents and data collection from agents that scan file systems and databases to gather storage demographics and populate the database with results. Automated actions can be defined to perform file system extension, data deletion, and backup or archiving or event reporting when defined thresholds are encountered. The data server is the primary contact point for GUI user interface functions. It also includes functions that schedule data collection and discovery for the device server.

The device server component discovers, gathers information from, analyzes performance of, and controls storage subsystems and SAN fabrics. It coordinates communication with agents and data collection from agents that scan SAN fabrics.

The single database instance serves as the repository for all Tivoli Storage Productivity Center components.

The Data agents and Fabric agents gather host, application, and SAN fabric information and send this information to the data server or device server.

The GUI allows you to enter information or receive information for all Tivoli Storage Productivity Center components.

The command-line interface (CLI) allows you to issue commands for major Tivoli Storage Productivity Center functions.

For more details, see 19.5, “IBM Tivoli Storage Productivity Center management applications” on page 620.

19.4 Standards and protocols used in IBM Tivoli Storage Productivity Center

Tivoli Storage Productivity Center was built upon storage industry standards. This section presents an overview the standards used within the various TPC components.

For more information about standards and protocols used in the IBM Tivoli Storage Productivity Center architecture, see the *IBM Tivoli Storage Productivity Center V4.1 Release Guide*, SG24-7725-00.

19.4.1 Common Information Model and Web-Based Enterprise Management

Web-Based Enterprise Management (WBEM) is an initiative of the Distributed Management Task Force (DMTF) with the objective to enable the management of complex IT environments. It defines a set of management and Internet standard technologies to unify the management of complex IT environments.

The three main conceptual elements of the WBEM initiative are as follows:

- Common Information Model (CIM): A formal object-oriented modeling language that is used to describe the management aspects of systems.
- xmlCIM: The syntax used to describe CIM declarations and messages used by the CIM protocol.
- Hypertext Transfer Protocol (HTTP)
- Hypertext Transfer Protocol over Secure Socket Layer (HTTPS)

HTTP and HTTPS are used as a way to enable communication between a management application and a device that both use CIM.

The CIM Agent provides a means by which a device can be managed by common building blocks rather than proprietary software. If a device is CIM-compliant, software that is also CIM-compliant can manage the device. Using CIM, you can perform tasks in a consistent manner across devices and vendors.

The CIM/WBEM architecture defines the following elements:

- Agent code or CIM Agent:

  An open-systems standard that interprets CIM requests and responses as they transfer between the client application and the device. The Agent is normally embedded into a device, which can be hardware or software. When not embedded (which is the case for devices that are not CIM-ready such as the DS4000/DS5000), a device provider (usually provided by the device manufacturer) is required.
- CIM Object Manager (CIMOM):

  The common conceptual framework for data management that receives, validates, and authenticates the CIM requests from the client application (such as TPC for disk). It then directs the requests to the appropriate component or a device provider.
- Client application or CIM Client:

  A storage management program, such as Tivoli Storage Productivity Center, that initiates CIM requests to the CIM Agent for the device. A CIM Client can reside anywhere in the network, because it uses HTTP to talk to CIM Object Managers and Agents.

- Device or CIM Managed Object:

  A Managed Object is a hardware or software component that can be managed by a management application by using CIM.

- Device provider:

  A device-specific handler that serves as a plug-in for the CIMOM. That is, the CIMOM uses the handler to interface with the device.

> **Terms:** The terms *CIM Agent* and *CIMOM* are often used interchangeably. At this time, few devices come with an integrated CIM Agent. Most devices need an external CIMOM for CIM to enable management applications (CIM Clients) to talk to the device.

For more information, see the website:

http://www.dmtf.org/standards/wbem/

19.4.2 Storage Management Initiative - Specification

The Storage Networking Industry Association (SNIA) has fully adopted and enhanced the CIM for Storage Management in its Storage Management Initiative - Specification (SMI-S). SMI-S was launched in mid-2002 to create and develop a universal open interface for managing storage devices, including storage networks.

The idea behind SMI-S is to standardize the management interfaces so that management applications can use these and provide cross-device management. This means that a newly introduced device can be immediately managed as it conforms to the standards. TPC for disk uses that standard.

The API provided by SMI-S makes it easier for management applications to collect data from devices. The specification also provides consistent definitions of the data fields in the API, which in theory will give consistent views and comparisons between devices (vendors are free to interpret the fields as they see fit.) So, it is important to know your devices and understand just what is meant by the performance metrics returned by the device.

TPC uses SMI-S for the following tasks:

- Storage Array discovery and reporting
- Storage Array provisioning
- Storage Array performance monitoring and reporting
- Fabric (switch port) performance monitoring and reporting
- Tape discovery and reporting
- SVC discovery and reporting (IBM only).

> **Reference:** For a list of IBM and non-IBM SMI-S Compliant devices that TPC supports, see the website:
>
> http://www.snia.org/ctp/conformingproviders/

19.4.3 Service Location Protocol

The Service Location Protocol (SLP) is an IETF standard that SLP provides as a scalable framework for the discovery and selection of network services.

SLP enables the discovery and selection of generic services, which can range in function from hardware services such as those for printers or fax machines, to software services such as those for file servers, email servers, web servers, databases, or any other possible services that are accessible through an IP network.

Traditionally, to use a particular service, an end-user or client application needs to supply the host name or network IP address of that service. With SLP, however, the user or client no longer needs to know individual host names or IP addresses (for the most part). Instead, the user or client can search the network for the desired service type and an optional set of qualifying attributes.

The SLP architecture includes three major components:

- Service agent (SA):

  A process working on the behalf of one or more network services to broadcast the services.

- User agent (UA):

  A process working on the behalf of the user to establish contact with a network service. The UA retrieves network service information from the service agents or directory agents.

- Directory agent (DA):

  A process that collects network service broadcasts.

The SA and UA are required components in an SLP environment, where the SLP DA is optional.

The SMI-S specification introduces SLP as the method for the management applications (the CIM clients) to locate managed objects. In SLP, an SA is used to report to UAs that a service that has been registered with the SA is available.

19.5 IBM Tivoli Storage Productivity Center management applications

Tivoli Storage Productivity Center provides four general types of support: data management, disk management, fabric management, and tape management. The following table summarizes the support provided by each function. To obtain each function, you must install the appropriate package.

The Tivoli Storage Productivity Center functions are shown in Table 19-1.

Table 19-1 Tivoli Storage Productivity Center functions

Data management	Disk management	Fabric management	Tape management
Host-centric: ▸ Discovery ▸ Monitoring ▸ File system extension ▸ Enterprise- wide reporting Application-centric: ▸ Monitor DB2, Oracle, SQL Server, Sybase ▸ Discovery ▸ Monitoring ▸ Chargeback	For storage subsystems: ▸ Discovery ▸ Monitoring ▸ Configuration (for example, creating volumes) ▸ Performance management	For fabrics: ▸ Discovery ▸ Monitoring ▸ Configuration (for example, zoning) ▸ Performance management	For tape libraries: ▸ Discovery ▸ Monitoring

Each license determines the functions that are accessible in the user interface.

For more information about IBM Tivoli Storage Productivity Center management applications, see these publications:

- *IBM Tivoli Storage Productivity Center Workflow User's Guide*, SC27-2341-01
- *IBM Tivoli Storage Productivity Center V4.1 Release Guide*, SG24-7725-00.

19.5.1 Data Manager

This topic introduces the Data Manager application and discusses its architecture and key features.

For details, see *IBM Tivoli Storage Productivity Center V4.1 Release Guide*, SG24-7725-00.

Data Manager overview

Data Manager is a comprehensive file and capacity management solution for heterogeneous storage environments. Data Manager includes enterprise-wide reporting and monitoring, policy-based management and automated capacity provisioning for Direct Attached Storage (DAS), network attached storage (NAS), and SAN environments.

Data Manager helps you improve storage utilization, plan for future capacity, and ensure availability by providing storage on demand for file systems. Use Data Manager to perform the following functions:

- Discover and monitor disks, partitions, shared directories, and servers
- Monitor and report on capacity and utilization across platforms to help you to identify trends and prevent problems
- Provides a wide variety of standardized reports about file systems and storage infrastructure to track usage and availability
- Provide file analysis across platforms to help you to identify and reclaim space used by non-essential files
- Provide policy-based management and automated capacity provisioning for file systems when user-defined thresholds are reached.

Using these functions, Data Manager helps you lower storage costs in these ways:

- Improving storage utilization
- Enabling intelligent capacity planning
- Helping you manage more storage with the same staff
- Supporting application availability through computer uptime reporting and application database monitoring.

Information collected by Data Manager helps you understand what is really going on with data on your servers and in your storage environment. View when files are created, accessed, and modified, and by what group or user. This type of information helps system administrators map storage resources to the consumers of the resource. The ability to map storage consumption to storage hardware has become increasingly important as the size of open systems environments has increased.

In addition to understanding the current consumption and usage of data within the enterprise, Data Manager tracks the information over time. Not only does this historical view of storage consumption and utilization show usage trends over time, the system administrator can also see a projected use of storage in the future. System administrators can prepare for the need to purchase additional capacity in a planned proactive manner rather than reacting to out-of-space emergencies.

Use Data Manager policy functions to help you evaluate and control the usage and status of your enterprise storage management assets. Because Data Manager is policy-based, it has autonomic self-healing capabilities that can detect potential problems and automatically make adjustments based on the policies and actions you have established. Use the capability to provision storage based upon storage policies to expand a file system, and to allocate storage to a volume.

For example, Data Manager can notify you when your system is running out of disk space or warn you of impending storage hardware failure. By alerting you to these and other issues related to your stored data, Data Manager enables you to prevent unnecessary system and application downtime.

Data management

Every storage administrator likes to have an unlimited amount of storage. Unfortunately in the real world, this is not possible. The best you can hope for is to manage effectively the storage which is available, and accurately predict what is needed for the future. An important tool to assist this is knowing how much storage is actually needed, and to do that, you need to know what you actually need to store. Data stored electronically essentially can be divided into the categories shown in Figure 19-5.

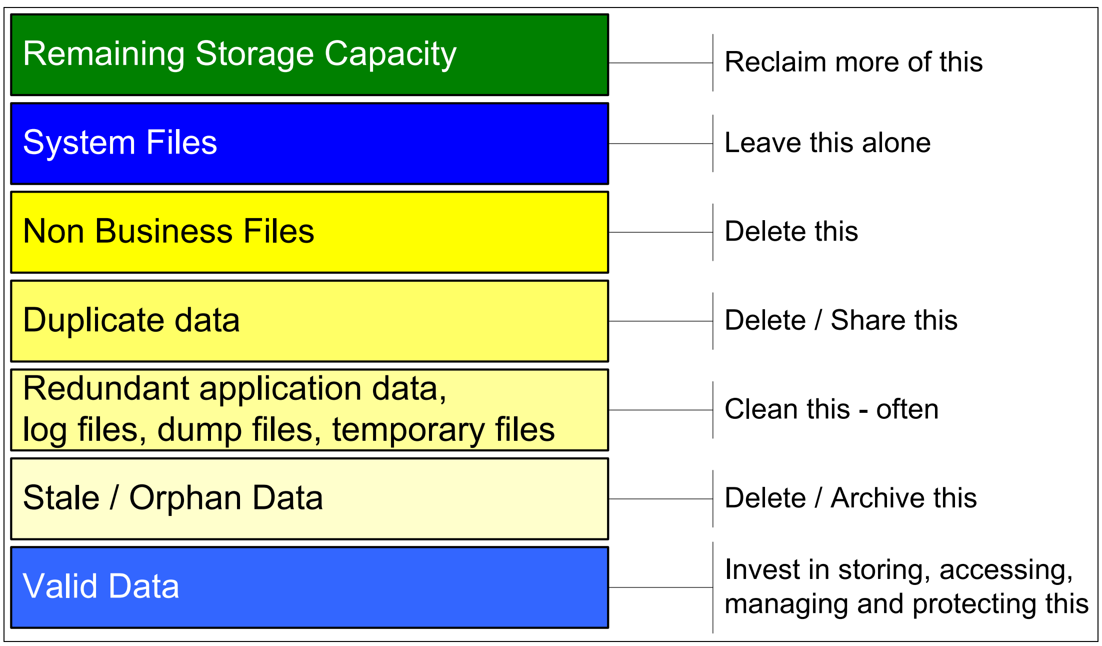


Figure 19-5 Types of data typically found in an enterprise and what do with them

Data Manager helps you identify how much of each type of data that you have, and automate actions to deal with each type.

Data Manager functions

Data Manager provides you with a number of functions that enable you to collect information about and perform tasks against the storage resources within your enterprise. This section provides a brief overview of the main functions that can help you manage and automate capacity utilization of your file systems and databases.

Monitoring

Data Manager uses three methods to discover information about the assets in the storage environment:

- Pings:

  A ping is a standard ICMP (Internet Control Message Protocol) ping which collects information about the availability of the storage assets in your storage environment. By running pings and viewing the results of those pings in Availability and System reports, you can monitor and report on the availability of your storage, both from a network point of view and from a computer uptime perspective. This allows you to see what percentage of the time the storage in your enterprise (or on particular server or group of servers), is off-network due to network problems or perhaps is unavailable due to system downtime.

  You can define any number of pings to check the availability of various storage resources at various times. If an agent does not respond to a ping (or a predefined number of pings), you can set up an alert to take action. The actions can be one, any or all of SNMP Trap, TEC Event, Login Notification, Windows Event Log, UNIX Syslog, running a script, and email.

- Scans:

  Use scans to collect statistics about the usage and trending of storage consumption within your environment. You can view the information collected by scans in Capacity, Usage, Usage Violations, Backup, and System reports, as well as use that information as part of quota analysis.

  Scans are always directed against a Data agent and deliver very detailed information about the file systems, files, and RDBMS objects (instances, databases, devices, table spaces, tables, indexes, data files, containers) of computers. Use the statistics gathered by scans as follows:

  – View information about when storage resources are created, accessed, and modified and by what group or user
  – Map the actual storage resource to the consumers of that resource
  – Generate a historical view of storage consumption to help determine usage trends over time.

  You can define any number of scans to gather information about various storage resources at various times.

- Probes:

  Probes are used to gather information about the assets and system resources of monitored servers, such as processor count and speed, memory size, disk count and size, file systems, and so on. Probes also gather information about the files, instances, logs and objects that makeup the monitored databases. Data collected by probes is used in Asset, Capacity, Storage Subsystems, and System reports.

Alerting

An alert defines an action to be performed if a particular event occurs or condition is found. Alerts in Data Manager can be set on computers, file systems, and directories. Alerts in Data Manager for Databases can be set on instances, database-table spaces, and tables. Alerts can tell you, for instance, if a file system or database is approaching capacity.

An Alert will register in the Alert log, plus you can also define one, any or all of the following actions to be performed in addition:

- Send an SNMP trap
- Send an alert to the Tivoli Enterprise Console (TEC)
- Generate a login notification next time a specified user logs in to TPC for Data

- Write out alert messages to the OS log (Windows Event Log or UNIX Syslog)
- Run a script in response to an alert (you can execute any third-party tools for actions, such as archiving, backup and recovery, or provisioning)
- Send an email or a page indicating the nature of the alert.

Reporting

Reporting in Data Manager is very rich, with over 300 predefined views, and the capability to customize those standard views, save the custom report, and add it to your menu for scheduled or ad hoc reports. You can also create your own individual reports according to particular needs and set them to run as needed, or in batch (regularly). Reports can be produced in table format or a variety of charting (graph) views. You can export reports to a PDF file, an HTML file, a CSV file or a formatted text file for external usage.

Reports are generated against data already in the repository. A common practice is to schedule scans and probes just before running reports.

Reporting can be done at almost any level in the system, from the enterprise down to a specific entity and any level in between.

Data Manager allows you to group information about similar entities (disk, file systems, and so on) from various servers or business units into a Summary Report so that business and technology administrators can manage an enterprise infrastructure. Or, you can summarize information from a specific server. The flexibility and choice of configuration is entirely up to the administrator.

These are major reporting categories for file systems and databases:

- Assets Reporting uses the data collected by probes to build a hardware inventory of the storage assets. You can then navigate through a hierarchical view of the assets by drilling down through computers, controllers, disks, file systems, directories, and exports. For databases, information about instances, databases, tables, and data files is presented for reporting.
- Availability Reporting shows responses to ping jobs, as well as computer uptime.
- Capacity Reporting shows how much storage capacity is installed, how much of the installed capacity is being used and how much is available for future growth. Reporting is done by disk and file system, and for databases, by database.
- Usage Reporting shows the usage and growth of storage consumption, grouped by file system, and computers, individual users, or enterprise-wide.
- Usage Violation Reporting shows violations to the corporate storage usage policies, as defined through Data Manager. Violations are either of Quota (defining how much storage a user or group of users is allowed) or Constraint (defining which file types, owners and file sizes are allowed on a computer or storage entity). You can define what action is to be taken when a violation is detected; for example, SNMPT trap, email, or running a user-written script.
- Backup Reporting identifies the most at risk files in your enterprise that are not backed up properly.

Policy Management

Data Manager can enable you to define and enforce storage policies through user-defined alerts, quotas, and constraints, notifying the user by email, pager, or the event log, or a systems management console for events such as when a quota has been exceeded or a constraint violated.

However, finding a problem is not enough. You need a way to fix problems, or potential problems as they are discovered. Data Manager can provide automated solutions through event management.

Policy Management function provides the following features:

- Setting storage usage quotas:

  Use quotas to set limits on the amount of storage space that a user or group of users can consume. You can use Data Manager and Data Manager for Databases to set quotas at the file system, computer, network, database, table space, and instance levels.

- Storage usage for Network Appliance quotas:

  Use Network Appliance quotas to import quotas from Network Appliance file servers and determine how and when you will be alerted to the hard limits defined in those quotas.

- Setting file constraints:

  Use constraints to define the acceptable and unacceptable file types, file sizes, and file owners for a NAS filer or a set of NAS filers in your environment. You can also use constraints to request an IBM Tivoli Storage Manager archive and backup of the largest violating files identified by a constraint.

- Using file system extensions:

  Use file system extensions to create additional space in the local file systems of managed hosts. You can extend file systems manually, or set up policies to do it automatically.

  File system extension is supported for JFS file systems running on AIX 5.1 and VxFS file systems running on Sun Solaris 2.8. The AIX JFS2 file system is not supported.

  File system extension/LUN provisioning jobs are not supported under Solaris 9.

- LUN provisioning:

  By default, IBM Tivoli Storage Productivity Center will attempt to extend a file system in its local volume group. If there is not enough space in the local volume group and an TotalStorage Enterprise Storage Server subsystem is available, additional LUNs can be provisioned for file system extension. Provisioning consists of creating and formatting a new LUN according to the parameters specified in the file system extension policy, and assigning the new LUN to the managed host. You can enable and configure LUN provisioning using the Provisioning tab in the File System Extension window.

- Scheduling script-based actions:

  Use scheduled actions to run user-defined scripts against selected computers and computer groups.

  You can access the scheduled actions facility using either Data Manager or Data Manager for Chargeback. The actions that you schedule to run are based on user-defined scripts, allowing you to use any third-party tools for actions, such as recovery or provisioning. You can schedule scripts to run:

  - Immediately
  - Once at a specified time and date
  - Repeatedly according to a schedule you specify.

- Archive and backup functions:

  Data Manager provides a method within the alerting function of a constraint by which you can automatically invoke a IBM Tivoli Storage Manager archive or backup to run against the files that violate that constraint.

  Let us say that, as a result of running a report, you find a large number of files that have not been accessed in over two years. Looking at the cumulative sizes of these files, you determine that they are taking up space that is better utilized elsewhere. You can archive and delete these files to reclaim that space. If, at a time in the future, those files are needed, they can be retrieved from the archive. The result of the archive job is more free space without data loss.

Data Manager for Databases

Data Manager for Databases provides a set of policy-driven automated tools for managing storage capacity, availability, events, performance and assets in your relational databases. It can help you identify, evaluate, control and predict the storage needs of Relational Database Management Systems (RDBMSs), which include Oracle, Sybase SQL Server, Microsoft SQL Server, and DB2.

Data Manager for Databases is policy-based and through its autonomic self-healing capabilities it can detect potential problems and automatically make adjustments based on the policies and actions you have established. For example, it can notify you when your database tables are running out of storage space or warn you of a dropped table space. By alerting you to these and other issues related to your stored data, it enables you to prevent unnecessary system and application downtime.

Table 19-2 lists the RDBMS objects whose storage usage is monitored by Data Manager for Databases.

Table 19-2 RDBMS objects

Oracle	SQL Server	Sybase	DB2
Instances	Instances	Instances	Instances
Databases	Databases	Devices	Databases
Table spaces	Data files	Databases	Table spaces
Data files	Tables	Fragments	Containers
Tables	Indexes	Tables	Tables
Indexes	Log Files	Indexes	Indexes
Extents			
Segments			
Redo Log files			
Control Files			
Archive Log Directories			

Data Manager for Databases collects information about RDBMS storage assets and performs tasks against the RDBMS storage assets. Methods for managing and automating capacity utilization of your databases can help you perform these tasks:

- Monitor storage assets associated with enterprise-wide databases and notification of potential problems before they occur
- Make intelligent capacity management decisions based on current and trended historical data
- See how much storage is being consumed by users, groups of users and OS's within the database
- Create policy-based management for databases when user-defined threshold is reached
- View storage utilization management from a database and application perspective.

Data Manager for Chargeback

Data Manager for Chargeback uses the storage usage information gathered by Data Manager and Data Manager for Databases to generate invoices that chargeback for storage usage.

With Data Manager for Chargeback, you can collect usage information about a departmental, group, or user level. You can allocate costs by storage usage by user, disk capacity by computer, table space, or file system/physical device. You can create cost centers by creating user, computer, or table space groups, allowing organization to chargeback individuals or business units for their storage usage. By understanding the costs associated with existing and future storage usage, you can improve the use of that storage and reduce the costs associated with its maintenances and upgrades.

Using Data Manager, you can run monitoring jobs that gather detailed statistics about the usage and trending of the storage consumed by the users and user groups within your organization. Using Data Manager for Databases, you can run monitoring jobs that gather detailed statistics about the usage and trending of the storage consumed within RDBMS Instances by the users and user groups within your organization.

In addition to providing invoicing for storage usage, Data Manager for Chargeback also integrates with the chargeback systems already implemented in your environment. It provides you with a higher level, application-specific CIMS output format which can be imported into CIMS applications. With Data Manager for Chargeback, you can export chargeback data for direct import into CIMS, giving you the ability to integrate your storage usage data with other enterprise chargeback information and processes.

19.5.2 Disk Manager

This topic introduces the Disk Manager application and discusses its architecture and key features.

For details, see *IBM Tivoli Storage Productivity Center V4.1 Release Guide*, SG24-7725-00.

19.5.3 Disk Manager overview

As a component of the IBM Tivoli Storage Productivity Center, Disk Manager helps you manage SANs and heterogeneous storage from a single console.

With Disk Manager, you can manage network storage components based on SMI-S:

- IBM System Storage SAN Volume Controller
- IBM Storwize V7000
- IBM TotalStorage Enterprise Storage Server (TotalStorage Enterprise Storage Server)
- Tivoli Storage Productivity Center disk systems (DS4000, DS5000, DS6000, and DS8000 series)
- IBM XIV Storage System
- Other storage subsystems that support the SMI-S standards.

> **Support:** Certain disk management features are not supported for XIV Storage System. See “Planning for XIV Storage System” in the *IBM Tivoli Storage Productivity Center and IBM Tivoli Storage Productivity Center for Replication Installation and Configuration Guide*.

Disk Manager can provide these capabilities:

- Collect and store performance data and provides alerts
- Provide graphical performance reports
- Help optimize storage allocation
- Provide volume contention analysis.

Through the use of data collection, setting of thresholds and use of performance reports, performance can be monitored for the TotalStorage Enterprise Storage Server, DS4000, DS5000, DS6000, DS8000, SAN Volume Controller, IBM Storwize V7000 and any other storage subsystem that supports the SMI-S block server performance subprofile. The performance function starts with the data collection task, which captures performance statistics for the devices and stores the data in the database.

After data collection is done, you can set thresholds to identify exceptions for certain performance metrics, depending on the type of device. Threshold checking is performed during data collection, and when performance is outside the specified bounds, alerts can be generated.

After performance data has been collected, you can configure Disk Manager to present graphical or text reports on the historical performance behavior of specified devices, or of specific internal components of those devices. The performance reports provide information about past period performance metrics or current performance in graphical form.

Device discovery is done using the Service Location Protocol (SLP), as specified by SMI-S. Configuration of the discovered devices is possible in conjunction with CIM agents associated with those devices, using the standard mechanisms defined in SMI-S. Disk Manager also gathers events, and can launch an element manager specific to each device.

> **Support:** Tivoli Storage Productivity Center supports discovery of and reporting on both FB and CKD volumes (and pools and arrays), but can create only FB volumes. Tivoli Storage Productivity Center does not support the creation of CKD volumes.

Disk Manager functions

Disk Manager provides you with a number of functions that enable you to manage SANs and heterogeneous storage from a single console. This section provides a brief overview of the main functions that management application provides.

- Monitoring:

  Monitoring functions run regularly scheduled or as one-time data collection jobs. These jobs gather detailed statistics about the storage subsystem performance. This data is later used in reports, probes, and so forth.

  The rules of monitoring are as follows:

  - Threshold violations (exceptions) are always logged and saved in the TPC database.
  - The user can view the exceptions that were detected in the TPC alert log, or can generate an exception report. The exception report allows the user to drill-down into the details of individual exceptions.

- Alerting:

  TPC for Disk allows configured alerts such as email, SNMP trap, SMTP, windows Event Log, run a script for all devices managed from TPC. Use the Alerting feature of Disk Manager to set alerts that notify you of storage-related events that occur within your environment. After you have defined the events or conditions for which you want to be alerted, you can let Disk Manager monitor your storage so that you do not have to.

- Reporting:

  Disk Manager can provide performance monitoring, customization of thresholds based on your storage environment, and generation of events if thresholds are exceeded. In addition, Disk Manager can help the IT administrators select LUNs for better performance.

  The reporting data can be displayed in table format, giving the actual values of the various collected metrics, or can be displayed in a graphical format, primarily as line-graphs. Reports can be displayed on recent data, historical data, or on exception conditions. Exception reports allow the user to view a list of any threshold violations in a given time range. They are usually displayed as bar graphs, showing the total number of threshold violations.

  Disk Manager has defined the following performance reports:

  - Storage Subsystem Performance
  - Storage Subsystem Controller Performance
  - Storage Subsystem Controller Cache Performance
  - I/O Group Performance
  - Array Performance
  - Managed Disk Group Performance
  - Port Performance
  - Top 25 Volumes I/O Rate
  - Top 25 Volumes Data Rate
  - Top 25 Volumes Cache Hit
  - Top 25 Volumes Response Time
  - Top 25 Volumes Disk
  - SAN Switch Report
  - Switch Port Error Report
  - Top 25 Switch Ports Ops Rate Report
  - Top 25 Switch Ports Data Rate Report

  However, the user can define their owner reports:

  - The By Controller report (user-defined) has all possible metrics available, and the user can select whatever they want. And they can save their customizations.
  - They can make it act like a system-defined report (it's a “My Report”) if they want.
  - “Customizing” here means: selecting which components are in the report, which columns/metrics to include, what order to show them in. Reports can also be scheduled to run in a “batch” on a schedule and generate, say, HTML files that can be viewed later.

Performance management capabilities

Disk Manager has the following performance management capabilities:

- “By Volume”, “By Array”, “By Port”, “By Subsystem” Reports can be produced.
- By Volume, they are viewing a (textual) report of volume-level performance statistics across multiple volumes.
- A set of default thresholds are in effect for all devices of a particular device type. In addition, thresholds can be user-defined for individual devices, overriding the default thresholds for those individual devices.
- Thresholds can be enabled or disabled, and the upper (stress) and lower (idle) boundaries of the threshold can be set.
- Performance data collection must be active for thresholds to be monitored.

- All thresholds defined by PM are bi-level thresholds, meaning that two unique boundary conditions can be defined, one to indicate a warning condition, and another to indicate a critical condition.
- Each threshold can allow a total of 4 boundary values to be defined, the critical stress, warning stress, warning idle, and critical idle boundaries, if so desired.

Configuring performance thresholds

You can use the Disk Manager to set performance thresholds for each device type. Setting thresholds for certain criteria enables Disk Manager to notify you when a certain threshold has been exceeded, so that you to take action before a critical event occurs.

You can specify what action must be taken when a threshold-exceeded condition occurs. The action might be to log the occurrence or to trigger an event. The threshold settings can vary by individual device.

Managing TagmaStore CIM agents with TPC for Disk

The TagmaStore CIM agents are provided by Hitachi Data Systems for the TagmaStore storage subsystem. The TagmaStore CIM agent collects information from the TagmaStore storage subsystem.

IBM Tivoli Storage Productivity Center now supports the Hitachi Data Systems TagmaStore CIM Agent 5.8. This version of the CIM Agent supports only the Array Profile and not the Storage Virtualizer Profile. However, Tivoli Storage Productivity Center will support the TagmaStore as a Storage Virtualizer. Tivoli Storage Productivity Center will be able to display information for virtual disks and local disks.

Tivoli Storage Productivity Center cannot provide correlation information between the virtual storage used by TagmaStore and the volumes created on the storage due to an existing limitation of the CIM agent 5.8 from Hitachi Data Systems. However, Tivoli Storage Productivity Center reports correctly display the correlation between volumes created on the local storage and the local disks. This limitation has no impact on the topology but it does affect several reports that show the correlation:

- **Data Manager → Reporting → Asset → By Storage Subsystem → HDS_device → Disks → Volumes** (will not show the relation between the disk and Volume or volume in the tree)
- **Disk Manager → Reporting → Storage Subsystem → Volume to Back-end Volume Assignment**
- **Disk Manager → Reporting → Storage Subsystem → Computer Views** (because Tivoli Storage Productivity Center cannot populate the information for volumes created on the virtual disks)

All volumes are created from a storage pool that is allocated from a primordial storage pool and an imported primordial pool. A volume cannot be created over both local and virtual extents.

For volume correlation, the host machine must have the Data agent installed and the TagmaStore device must be in the same SAN fabric. There must also be a zone configured in the active zoneset between the ports of the host machine and the ports of the TagmaStore device. The Fabric agent needs to be configured for the fabric to which the host is connected.

For back-end correlation, the TagmaStore device ports and back-end subsystem ports must be in the same zone and the back-end subsystem has assigned storage volumes to all ports of the TagmaStore device.

19.5.4 Fabric Manager

This topic introduces the Fabric Manager application and discusses its architecture and key features.

For details, see *IBM Tivoli Storage Productivity Center V4.1 Release Guide*, SG24-7725-00.

Fabric Manager overview

Fabric Manager helps you manage the SAN fabric that connects the host systems and applications to the storage devices. It is a comprehensive management solution for multi-vendor SANs and includes automatic resource and topology discovery, monitoring and alerts, and zone control.

Fabric Manager is an enterprise scalable solution architected to ANSI SAN standards, allowing you to choose the products right for your environment. It helps you:

- Simplify the task of SAN management and configuration
- Ensure SAN availability
- Improve SAN return on investment.

Fabric Manager is able to do SAN fabric performance and capacity management reporting and monitoring. Zoning is one of many SAN security options. Zoning is the only configuration supported for this release. Along with subsystem based volume masking, it is almost universally employed to ensure that only systems that are authorized can access selected data. Zoning is provided by the switch at the port level, so that, for example, a host on port X can access the subsystem connected by port Y. When business needs change, often zones must change also.

Zone control is enabled from a centralized location. Existing zones can be discovered and the members that make up the zone can be viewed and modified by adding or deleting them. New zones can be created and existing zones can be deleted. Fabric Manager makes working with zones easy by providing a GUI that discovers SAN devices and makes them available to add or remove from zones as individual devices.

The ability to do switch performance and capacity management reporting and monitoring can help you to determine if more bandwidth is needed. Wide-area and local-area IP networks, and storage area networks (SANs) move data from one place to another. The management of the bandwidth is needed to continually monitor for link utilization and errors. Data needs to be gathered to tune resources, balance workloads, and do capacity planning.

With Fabric Manager, the comprehensive management of multi-vendor SANs can help simplify the IT infrastructure by providing automatic resource and topology discovery, monitoring, and alerts, and zone control. It brings all the sources of information about SAN topology and configuration into a single place, and creates topology mapping of the SANs. This topology offers both host-centric and device-centric views that can be displayed graphically. The SAN topology display tracks all topology and configuration changes through in-band, out-of-band, and SMI-S monitoring. Without this type of centralized topology, information from a number of sources, such as Element Management tools, device logs, and SNMP traps, have to be continually monitored and manually correlated to determine the current SAN configuration and topology.

Fabric Manager provides you with the ability to view events happening in your SAN environment and records state changes. The events are displayed in a color-coded fashion and can be further customized to reflect organizational priorities. It will forward events signaling topology changes or updates to the IBM Tivoli Enterprise Console, another SNMP manager, or both. Source side filtering by the Fabric Manager enables you to control what events get sent to your centralized console. Filtering helps ensure that the administrators get the information they need and are not overwhelmed by extraneous information.

Fabric Manager functions

Fabric Manager provides you with a number of functions that enable you to discover and manage SAN components and devices, and the topology of the storage area network environment. You can monitor storage utilization on the SAN and determine the availability of SAN components.

This section provides a brief overview of the main functions that Fabric Manager provides.

Discovery

The process of finding resources within an enterprise, including detection of network topology, is called *discovery*. Fabric Manager uses the following two methods to discover the network:

- In-band:

  Fabrics are automatically discovered and the Fabric agents can provide information about the fabrics or switches to which the computers are attached. When Fabric agents (in-band agents) are installed on the computers attached to the fabric and these agents are registered with IBM Tivoli Storage Productivity Center, you do not have to perform a specific discovery step for these agents.

  For example, if you have McDATA and QLogic switches and have Fabric agents installed on the computers that are attached to these switches, the switches are automatically discovered when you install the Fabric agents.

  If you have a McDATA switch, ensure that the switch has the Open Systems Management Server (OSMS) feature enabled. OSMS is required for in-band discovery. The host control option needs to be enabled if you want to do zone control and if no CIM Agent for the fabric is present. See your McDATA documentation for information about these features and how to enable them.

  In-band discovery provides this following information:

  – Topology information for switches, connections, nodes, and ports of the devices connected to the fabric, zones, zone sets
  – Host and device information (collected from in-band agents only)
  – Basic information to identify the host and devices in the fabric.

- Out-of-band:

  Monitors the switches, managed hosts, and storage over an IP network by standardized Management Information Base (MIB) files, which typically are loaded only onto the managed switches. Fabric Manager gathers SNMP-collected information from out-of-band agents.

Managing fabrics

A Storage Area Network *zone* is a grouping of multiple ports to form a virtual private storage network. A *zone set* is a collection of zones that belong to a single SAN and can be activated or deactivated as a single entity across all switches in the fabric. A zone set can contain one or more zones, and a zone might be a member of more than one zone set. A zone might contain one or more *zone members* (aliases), and an alias might belong to more than one zone. Ports that are members of a group or zone can communicate with each other, but are isolated from ports in other zones. Devices, however, can belong to more than one zone.

Using zoning, you can automatically or dynamically arrange fabric-connected devices into logical groups, or zones, across the physical fabric. Support for aliases is also provided. An alias is a name assigned to a device so that the name can be meaningful and familiar. Also, an alias can be a group of devices that can be managed together to make the zoning process easier.

To configure zones, you can use Fabric Manager, or the management application for the devices. Advantages to zoning through Fabric Manager are that with Fabric Manager you can perform zoning tasks from a single interface. Fabric Manager supports industry zone management standards, which means that you can work with devices from multiple vendors using consistent, familiar methods.

Topology viewer console lets you view zones in SANs. Fabric Manager lets you create, update, and delete zones and zone sets within a SAN. In addition, you can:

- Assign zones to zone sets
- Activate and deactivate zone sets
- View zone membership
- Add and remove zone members.

Topology views

The Topology Viewer provides an extended graphical topology view; a graphical representation of the physical and logical resources (for example, computers, fabrics, and storage subsystems) that have been discovered in the storage environment. In addition, the Topology Viewer depicts the relationships among resources (for example, the disks comprising a particular storage subsystem). Detailed, tabular information (for example, attributes of a disk) is also provided. With all the information that topology viewer provides, you can easily and more quickly monitor and troubleshoot your storage environment.

The Topology Viewer provides a central location to view a storage environment, quickly monitor and troubleshoot problems, and gain access to additional tasks and function within the TPC user interface without users losing their orientation to the environment.

Monitoring fabrics

With monitoring feature, you can monitor fabrics by following divisions:

- Groups:

  A group represents a user-defined set of related objects against which you want to run monitoring jobs. An object represents a storage resource, such as a computer, fabric, storage subsystem, table space, and so on. For example, if you want to scan all of the SAN switches in your Payroll department, create a Fabric Group named Payroll and populate that group with the individual SAN switch from the Payroll department. Then, whenever you want to collect information about those switches, you can simply select the Fabric Group named Payroll when defining a monitoring job. As switches are added or removed from the Payroll department, you can simply update the Payroll Fabric Group to reflect those changes.

- Switch Performance Monitors:

  You can monitor the performance of selected fabric switches. Fabric Manager can collect performance data for the switches and generate reports from the results of those monitors.

  Report data is collected on data rates, operations rates, switch port errors, and other performance statistics.

Alerting

The alerting feature lets you define alerts for events that occur in your environment. You can define alerts as part of monitoring jobs, or use the alerting nodes under the Fabric Manager component. For example, you can define an alert that will send you an email when a switch goes offline or comes online. You can also define an alert to be triggered if one of your monitoring jobs fails.

There are three type of Fabric Manager alerts:

- Fabric alerts:

  You can use these alerts to monitor fabrics for changes such as these:

  – Fabric Discovered: A fabric is discovered
  – Fabric State Change: A fabric is missing or is rediscovered
  – Fabric Status Change: Offline A fabric goes offline
  – Fabric Status Change: Online A fabric comes online
  – Fabric to Switch Change: A switch to fabric association is discovered, rediscovered, or missing
  – Zone State Change: A zone is missing or is rediscovered
  – Zone Discovered: A zone is discovered
  – Zone Set State Change: A zone set in a fabric was activated, deactivated, or has gone missing
  – Zone Set Discovered: A zone set is discovered
  – Zone to Zone Alias Change: A zone to zone alias association is discovered, missing, or rediscovered
  – Zone to Zone Member Change: A zone to zone member association is discovered, is missing, or is rediscovered
  – Zone Set to Zone Change: A zone set to zone association is discovered, is missing, or is rediscovered
  – New Connection: A new connection is detected
  – Connection State Change: A connection is missing or rediscovered
  – Zone Alias to Member Change: A zone alias to member association is discovered, rediscovered, or is missing

- Switch alerts:

  You can use these alerts to monitor switches for changes in configuration or status such as these:

  – Switch Discovered: A switch is discovered
  – Switch State Change: A switch is missing or is rediscovered
  – Switch Property Changes: A switch port is discovered, is missing, or is rediscovered
  – Switch Status Change Offline: The status of the switch has changed from OK to a lower status. This does not necessarily mean that the switch has gone missing
  – Switch Status Change Online: The status of the switch status of the switch has been upgraded to OK
  – Switch Version Change: The version of a switch changes
  – Switch to Port Change: A switch to switch port association is discovered, is missing, or is rediscovered
  – Switch Blade Change: A switch module is discovered, is missing, or is rediscovered
  – Switch Blade Change Offline: A switch module goes offline
  – Switch Blade Change Online: A switch module comes online
  – Total Port Data Rate Threshold: A total port data rate threshold is reached

- Port Receive Bandwidth Percentage Threshold: The threshold on the average port bandwidth utilization percentage for receive operations. The Port Send Utilization Percentage metric is checked against the threshold boundaries for each collection interval. This threshold uses the following default values: 85,75,-1,-1
- Port Send Bandwidth Percentage Threshold: The threshold on the average port bandwidth utilization percentage for send operations. The Port Send Utilization Percentage metric is checked against the threshold boundaries for each collection interval. This threshold uses the following default values: 85,75,-1,-1
- Link Failure Rate Threshold: A link failure rate threshold is reached
- Error Frame Rate Threshold: An error frame rate threshold is reached
- Total Port Packet Rate Threshold: A total port packet rate threshold is reached.

- Endpoint device alerts:

  You can use these alerts to monitor endpoint devices for following conditions:

  - Endpoint Discovered: An endpoint device is discovered
  - Endpoint State Change: An endpoint device is missing or is rediscovered
  - Endpoint to Node Change: A peripheral entity to node association is missing, newly discovered, or rediscovered
  - Endpoint Version Change: The version for an endpoint device changes.

Reporting

In addition to performance data collection and performance thresholds, TPC allows the user to display the collected data and the recognized threshold exceptions in a user-friendly format. Data can be displayed in table format, giving the actual values of the various collected metrics, or can be displayed in a graphical format, primarily as line-graphs. Reports can be displayed on recent data, historical data, or on exception conditions. They allow the user to pick a device, a device component, to pick a particular metric, and to specify a time range, and the performance data for the given device component and the given metrics will be plotted over the given time range. Exception reports allow the user to view a list of any threshold violations in a given time range. They are usually displayed as bar graphs, showing the total number of threshold violations.

There are predefined reports of Fabric Manager:

- SAN Switch Report
- Switch Port Error Report
- Top 25 Switch Ports Ops Rate Report
- Top 25 Switch Data Rate Report.

19.5.5 Tape Manager

This topic introduces the Tape Manager application and discusses its key features.

For details, see *IBM Tivoli Storage Productivity Center V4.1 Release Guide*, SG24-7725-00.

Tape Manager overview

IBM Tivoli Storage Productivity Center Tape Manager helps you manage your SMI-S compliant tape libraries which are based on SMI-S 1.1 profile for tape libraries.

You must have at least Tape Operator authority to access the functions in the Tape Manager node. To view your authority level, open the Role to Group Mappings window in the **Administrative Services** → **Configuration node** in the navigation tree.

With Tape Manager you can perform these tasks:

- Discover SMI-S compliant tape libraries attached to your SAN fabrics
- View tape library information
- Monitor tape libraries by probing for data and viewing alerts
- Create and view asset and capacity reports using data collected from your tape libraries.

Use the topology viewer to view information about tape libraries.

Tape library support

IBM Tivoli Storage Productivity Center Tape Manager provides support for tape library management. Tape Manager is present and available in the GUI whenever the Device Server is installed. No separate license is required. Using Tape Manager, you can discover tape libraries, group libraries to monitor multiple libraries, view alerts generated by tape libraries, and launch tape library element managers.

Tape Manager supports the following tape libraries:

- TS3500 (formerly IBM 3584)
- TS3310 (model 3576).

Managing tape libraries

Tape Manager provides the capability to manage your tape libraries. For this release, tape library management capabilities are limited to support for the TS3500 Tape Library (full support) and the TS3310 tape library.

The tape library management functions allow you to:

- Discover TS3500 and TS3310 tape libraries attached to your SAN fabrics
- Create groups of tape libraries with similar attributes, making it easier to perform management tasks on multiple tape libraries at one time
- Create and view asset reports using data collected from your tape libraries; these reports can include such information as the library identifier and the status of the library
- Create and view capacity reports using data collected from your tape libraries; these reports can include such information as the number of drives in a library, the number of tape slots, the number of occupied tape slots
- View alerts generated by tape libraries; these alerts include read or write errors, media changer errors, and maintenance requests
- Launch the element manager from several places in the product user interface.

19.6 Performance analysis with Storage Optimizer

This section provides brief description of the Storage Optimizer and how to use it through Tivoli Storage Productivity Center to analyze storage subsystems to identify performance bottlenecks.

For more information about performance analysis with Storage Optimizer, see the *IBM Tivoli Storage Productivity Center V4.1 Release Guide*, SG24-7725-00.

19.6.1 Storage Optimizer overview

Analyzing large amounts of performance data and interpreting the results is a time consuming exercise and requires a certain set of skills. The Storage Optimizer changes all this by automating the task of interpreting the vast amounts of configuration and performance data, which allows even the most junior storage administrator the ability to identify areas for improvement within their storage networks.

The Storage Optimizer uses data in the IBM Tivoli Storage Productivity Center database to analyze your storage subsystems to identify performance bottlenecks, and propose changes to improve performance. This topic lists the supported subsystems and describes the general steps for using Storage Optimizer, as well as a look into how the Storage Optimizer functions.

The Storage Optimizer also helps you develop storage migration or storage consolidation plans, and helps you plan for the growth of your storage infrastructure, based on the various performance behaviors.

Two main aspects to the Storage Optimizer

There are two main aspects to the Storage Optimizer that we discuss in more detail later on in this topic. The first portion of work is called the Analysis, and the second portion is the actual Optimization itself. At a high level, the Analysis is responsible for collecting, aggregating and predicting the utilizations of the storage subsystem infrastructure. The Optimization is responsible for utilizing the results of the Analysis to help put together a plan for potential migrations and consolidations, to improve overall utilization of the infrastructure.

> **Analysis:** The Storage Optimizer does not actually perform any migrations or make any modifications to subsystem configurations. It is the Storage Optimizer's primary purpose to provide you with a performance analysis and optimization report that you can choose to implement at your own discretion.

Who ultimately uses the Storage Optimizer

The Storage Optimizer is used by the following staff members:

- Junior storage who that do not have much experience with interpreting existing performance reports
- Senior storage administrators looking to validate a hunch or what other reports indicate to be the case
- All storage administrators looking for a plan to consolidate/retire storage hardware

  This is useful when looking at retiring obsolete subsystems, or alternatively, when looking at consolidating onto a subset of subsystems to improve their density, thus leaving various subsystems shut down (saving money on maintenance, depreciation, and energy costs) until such a time that their data growth actually catches up to their hardware capacities.
- Anyone with a *Standard Edition* license.

  The Storage Optimizer uses a unique "Heat Map" style of display that makes narrowing in on "Hot Spots" (bottlenecks) much easier than having to analyze huge amounts of raw performance data to identify problem areas.

The two primary use-cases are as follows:

- Migration Scenario: Provides guidelines to neutralize the "hot spots"
- Retirement Scenario: Provides guidelines to retire selected pools (move all volumes away from the selected pools)

Important: To use the Storage Optimizer, you must have an IBM Tivoli Storage Productivity Center Standard Edition license.

19.6.2 How the Storage Optimizer works

The first process of the Storage Optimizer is the *analysis*. The analysis process uses the Disk Magic[1] tool to produce *predicted* utilizations based on actual, measured performance metrics that are collected for that device by Tivoli Storage Productivity Center. These predicted utilizations are provided on a *per storage pool* basis.

What do we mean by “utilizations”? The analysis reports on four unique aspects of the internals of a storage subsystem and how these are specific to a particular pool, and produces a percentage that represents how much of the total capacity of that component is being used by the measured workload and configuration.

The analysis predicts these utilizations:

- HDD (hard disk drive):

  This is the estimated overall “saturation” of the physical disks in a given subsystem. This number is impacted by the RPM speed, capacity and workload being measured. This does not apply to situations where the subsystem is a virtualizer with no internal disk (such as the SAN Volume Controller). This utilization is closely related to the “Disk Utilization” metric in the *By Array* performance reports, but not exactly the same, because this number comes from Disk Magic.

- HA (host adapter):

  Sometimes known as a fibre adapter or fibre card, this is the estimated “saturation” of the ports on the subsystem. This number is impacted by the number of total ports, maximum hardware bandwidth, and workload being measured. You can see raw performance metrics related to this utilization in the *By Port* performance reports.

- DA (device adapter):

  Sometimes known as a Redundant Array of Independent Disks (RAID) controller, this is the estimated “saturation” of the RAID controllers of the subsystem. This number is impacted by the workload being measured and logical configuration of disks to pools.

- SMP (controller):

  This is the estimated “saturation” of the processor complex of the subsystem. This number is impacted by the model of subsystem and the workload being measured.

Tip: If you are analyzing large numbers of subsystems, it is best to schedule a time to run the Storage Optimizer when processor demand is at a minimum.

[1] Disk Magic is an IBM licensed component from a company called IntelliMagic.

Additionally, there are two utilization numbers provided by the Storage Optimizer that are somewhat unique in their computation:

- Utilization:

  This overall “utilization” number is computed as MAX(HDD, HA, DA, SMP), meaning it represents the largest value of the four other components – it does not represent a separate component.

- Space:

  This utilization number is unique in that it is not *predicted*, it is measured. This is provided to give an indication of how full a particular pool has become, in terms of allocated-capacity versus total-capacity.

After the analysis is completed, the optimization capabilities can be used to migrate or consolidate the storage infrastructure. *Migratio*n is the ability to alleviate hot spots by relocating “hot” volumes in the “hot” pools to “colder” pools and subsystems. *Consolidation* is the ability to identify possibilities for reclaiming poorly utilized space.

19.6.3 Important performance metrics

The Storage Optimizer looks at eleven raw metrics to feed into the Disk Magic models:

- Read I/O Rate (normal)
- Read I/O Rate (sequential)
- Read I/O Rate (overall)
- Write I/O Rate (normal)
- Write I/O Rate (sequential)
- Write I/O Rate (overall)
- Read Cache Hits Percentage (overall)
- Write Cache Hits Percentage (overall)
- Cache to Disk Transfer Rate
- Read Transfer Size
- Write Transfer Size.

19.6.4 Supported subsystems or applications

The following IBM storage subsystems or applications are supported, see Table 19-3

Table 19-3 Support Matrix

Support matrix	FC drives	SATA drives	SAS drives	Solid state drives
DS3000	No	No	No	No
DS4000	Yes	No	No	No
DS5000	No	No	No	No
DS6000	Yes	No	No	No
DS8000	Yes	No	No	No
SVC	Yes	No	No	No
Storwize V7000	No	No	No	No
XIV	No	No	No	No

No special firmware or CIMOM level requirements are introduced by this feature and the supported TPC levels will be sufficient.

Support: Non-IBM subsystems are not supported by the Storage Optimizer.

You can analyze the front-end of an SVC that has non-IBM back-end storage, however no guidelines will be offered for these non-IBM back-end subsystems because there are no Disk Magic models for those devices. The analysis will be useful when looking at the "Hot Spots" and determining where the bottlenecks lie on the SVC.

19.7 IBM Tivoli Provisioning Manager

This section provides a brief description of IBM Tivoli Provisioning Manager.

For more information about performance analysis with Storage Optimizer, see the *IBM Tivoli Storage Productivity Center User's Guide*, SC27-2338-01.

19.7.1 Tivoli Provisioning Manager overview

IBM Tivoli Provisioning Manager, built on a Service Oriented Architecture (SOA)[2], enhances usability for executing changes while keeping server and desktop software compliant. Tivoli Provisioning Manager helps organizations with provisioning, configuration and maintenance of servers and virtual servers, operating systems, middleware, applications, storage and network devices acting as routers, switches, firewalls, and load balancers. With this release of the Tivoli Provisioning Manager, users can benefit from significant ease of use enhancements including a new graphical user interface, better reporting and streamlined use scenarios that provide more out of the box value.

Key functional areas of enhancement include these:

- Improved discovery and reporting of datacenter resources
- Operating system imaging and bare metal provisioning
- Software distribution and patch management over a scalable secure infrastructure
- Automated deployment of servers through software templates
- Simplification and automation of datacenter tasks
- Compliance reporting and remediation.

These capabilities allow companies to manage the complete lifecycle of datacenter and distributed resources from initial provisioning to patching and configuration maintenance to resource repurposing or end of life. Through the automation of tasks, IT administrators can manage more resources with fewer people, allowing key skilled people to focus on activities that grow the business rather than serve to maintain it.

IBM Tivoli Provisioning Manager also contains a number of other new features designed to simplify use and improve time-to-value. These features include a graphical user interface with role based views designed to simplify change execution tasks and pre-canned reports that can be easily modified to fit user needs.

[2] SOA is an architectural approach to building applications and enables rapid development and deployment of new services to meet business needs.

Here is a list of IBM Tivoli Provisioning Manager core functions:

- Discovery of resources
- Operating system provisioning
- Software deployment and configuration
- Automating tasks through best practice automation workflows
- Auditing, compliance and remediation
- Common management Infrastructure for datacenter or distributed software management
- Storage provisioning
- Change and configuration management

19.7.2 Tivoli Provisioning Manager workflow

The next two figures show how IBM Tivoli Provisioning Manager makes it easier to provide storage.

Figure 19-6 shows the workflow that is necessary to provide a new disk to a server without using IBM Tivoli Provisioning Manager.

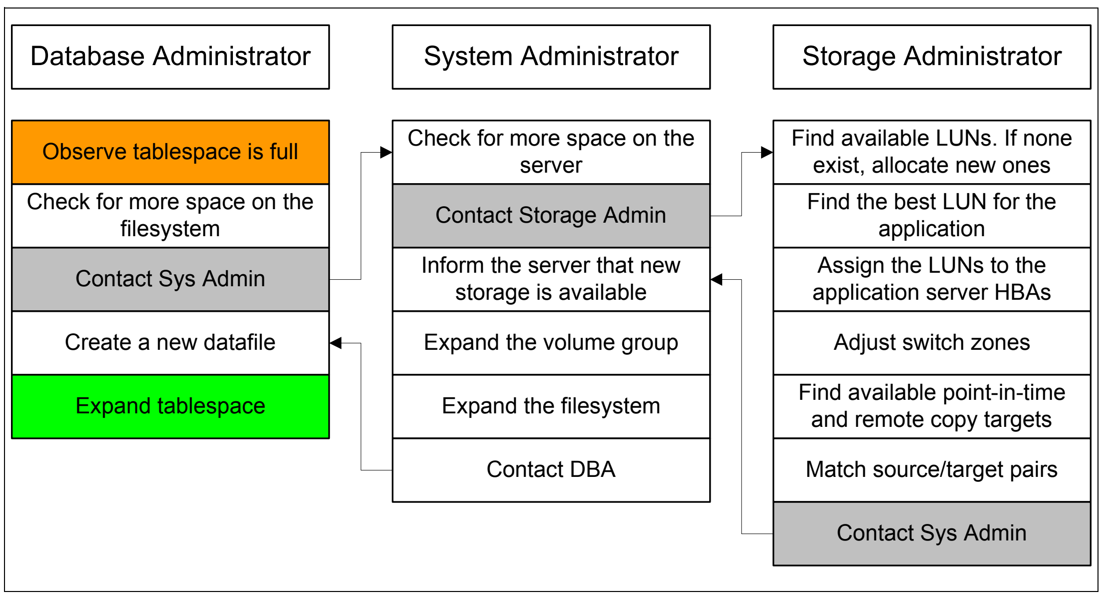


Figure 19-6 Storage provisioning: Manually

Manual Storage provisioning includes the following steps:

1. The database administrator (DBA) will find out there is a need for more space on the file system because a table space is going to be full. The DBA will have to contact the system administrator who will have to contact the storage administrator, if there is no more space available on the server.
2. The storage administrator will have to allocate a new LUN, if none exists, assign the LUN, adjust the zoning, prepare copy targets, and match source and target pairs, because the database requires mirrored data. Finally, the storage administrator will have to contact the system administrator again when the LUN is ready.
3. The system administrator will have to add the new LUN to the server, expand the volume group, and expand the file system. Finally, the system administrator will have to contact the database administrator.
4. The database administrator now can create a new data file and expand the table space.

Figure 19-7 shows the workflow to do the same thing if you have Tivoli Provisioning Manager supporting you in this task. After defining the tasks within Tivoli Provisioning Manager once, the storage administrator just has to initiate the process.

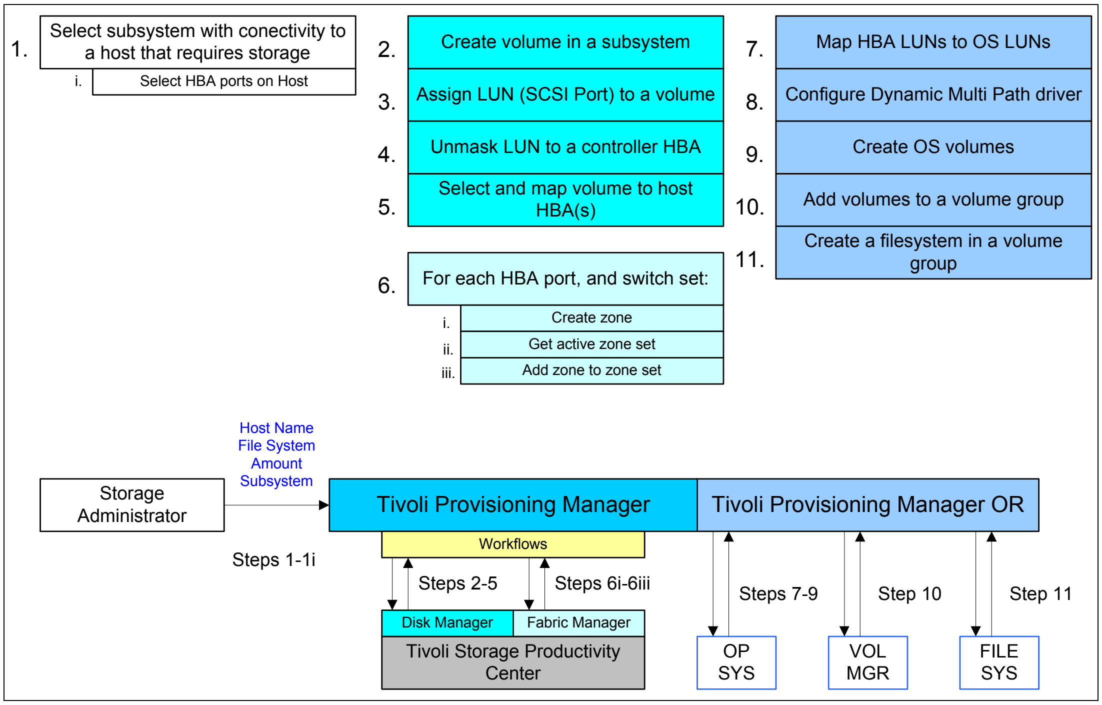


Figure 19-7 Storage provisioning supported by Tivoli Provisioning Manager

19.8 Tivoli Storage Productivity Center components and packages

This topic provides information about the IBM Tivoli Storage Productivity Center components and packages. For more information about TPC individual components and packages, see the *IBM Tivoli Storage Productivity Center V4.1 Release Guide*, SG24-7725 and new TPC V4.2.1 information Center under the following link:

http://publib.boulder.ibm.com/infocenter/tivihelp/v4r1/index.jsp

Use Table 19-4 to compare specific functions and data sources available in each license.

Table 19-4 TPC package comparison

Data source	Functionality	Required TPC license
Hypervisor		
	Probe	Data Edition
Storage Resource Agent		
	Host Probe	Basic Edition
Storage Resource Agent / Fabric Agent		
	Fabric Probe	Basic Edition
	Fabric Provisioning	Basic Edition
	Fabric Health Monitoring	Basic Edition

Data source	Functionality	Required TPC license
Data Agent		
	NetApp/NAS Probe	Data Edition
	Database Probe	Data Edition
	Deep Filesystem Scans	Data Edition
	Batch Reporting	Data Edition
Storage Resource Agent / Data Agent		
	Planning	Standard Edition
	Analytics	Standard Edition
Fibre Channel Switch		
	Probe	Basic Edition
	Provisioning	Basic Edition
	Health Monitoring	Basic Edition
	Performance Monitoring	Standard Edition
	Planning	Standard Edition
	Analytics	Standard Edition
Storage Subsystem		
	Probe	Basic Edition
	Provisioning	Basic Edition
	Health Monitoring	Basic Edition
	Performance Monitoring	Disk Edition
	Planning	Standard Edition
	Analytics	Standard Edition

19.8.1 IBM Tivoli Storage Productivity Center Basic Edition

IBM Tivoli Storage Productivity Center Basic Edition is focused on providing basic device management services for IBM System Storage DS3000, DS4000, DS5000, DS6000, DS8000 products, Storwize V7000, IBM SAN Volume Controller and heterogeneous storage environments. This is a management option available with IBM Tivoli Storage hardware acquisitions. This tool provides storage administrators a simple way to conduct device management for multiple storage arrays and SAN fabric components from a single integrated console that also is the base of operations for the IBM Tivoli Storage Productivity Center suite. Productivity Center Basic Edition also does discovery and asset management of tape libraries, specificallyTS3310 and TS3500 Tape Libraries.

Key features include these:

- Discovery and configuration of supported devices
- Event gathering, error logging, and launch of device element managers
- Provisioning support, including LUN allocation and assignment
- Basic Asset and Capacity Reporting
- Topology viewer: End to End Storage Topology View and Health Console
- Simple upgrade path to IBM Tivoli Storage Productivity Center for Disk, Data or Fabric

IBM Tivoli Storage Productivity Center Basic Edition enables device configuration and management of SAN-attached devices from a single console. Basic Edition simplifies the complexity of managing multiple SAN-attached storage devices. It enables you to manage SANs and heterogeneous storage from a single console.

Basic Edition enables you to manage network storage components based on SMI-S, such as:

- IBM System Storage SAN Volume Controller
- IBM System Storage disk systems (DS3000, DS4000, DS5000, DS6000, and DS8000 series)
- IBM Storwize V7000 storage virtualization system
- Other storage systems that support SMI-S standards.

Device discovery is performed by Service Location Protocol (SLP), as specified by SMI-S. Configuration of the discovered devices is possible in conjunction with CIM agents associated with those devices, using the standard mechanisms defined in SMI-S. Tivoli Storage Productivity Center gathers events and can start an element manager specific to each discovered device.

For SAN fabrics, Tivoli Storage Productivity Center simplifies the management and improves the availability of the SAN environment. You can monitor and report on SAN resources and use a single location for zone control. Tivoli Storage Productivity Center discovers existing zones and zone members and allows you to modify or delete them. In addition, you can create new zones. Support for aliases is also provided.

Tivoli Storage Productivity Center gives you the ability to view events happening in your SAN environment and record state changes. Events related to topology changes or updates can be forwarded to the IBM Tivoli Enterprise Console, to another manager that uses Simple Network Manager Protocol (SNMP), or to both.

For the SAN fabric, Tivoli Storage Productivity Center supports host bus adapters (HBAs), disk systems, tape systems, SAN switches, routers, and gateways.

> **Tip:** IBM Tivoli Storage Productivity Center Basic Edition includes basic disk, fabric, tape, and data management functions, but does not include chargeback, database monitoring, and performance monitoring functions.

19.8.2 IBM Tivoli Storage Productivity Center for Data

TPC for Data is an advanced Storage Resource Management (SRM) tool for storage environments that provides a set of policy-driven automated features for Data for managing storage capacity, availability, events, data assets, and green initiatives including DAS, NAS, and SAN technologies.

Key features include the following capabilities:

- Utilize and optimize existing storage resources and perform storage management with a high level of control
- Improve storage utilization
- Enable intelligent capacity planning
- Manage more storage with the same staff
- Support high application availability
- Detect failed backup and archive tasks
- Provide enterprise-wide reports on capacity by role-based management

- Assist customers in support of data classification, ILM assessments, and ITIL® storage practices.

> **Tip:** IBM Tivoli Storage Productivity Center for Data includes data management, basic tape, disk, and fabric management, database monitoring, and chargeback functions, but does not include performance monitoring functions.

19.8.3 IBM Tivoli Storage Productivity Center for Disk

IBM Tivoli Storage Productivity Center for Disk is designed to enable device configuration and management of SAN-attached devices from a single console. In addition, it also includes performance capabilities to help monitor and manage the performance of the devices' disks. IBM Tivoli Storage Productivity Center for Disk is designed to help simplify the complexity of managing multiple SAN-attached storage devices.

Productivity Manager for Disk is designed to enable the IT administrator to do these tasks:

- Enable proactive performance management by provide an IT administrator with a single, integrated console for the performance management of IBM System Storage devices.
- Monitor performance metrics across multiple storage subsystems from a single console.
- Designed to allow administrators to monitor metrics, such as I/O rates and cache utilization, and support optimization of storage through the identification of the best LUNs across multiple storage subsystems.
- Monitor and analyze performance statistics for storage systems to measure services levels by storing received performance statistics into database tables for later use, and analyze and generate reports on monitored devices for display in central administrative console.
- Receive timely alerts to enable event action based on customer policies by setting performance thresholds for the devices based on performance metrics and the generation of alerts when those thresholds are exceeded.
- Provides a Performance Optimization Engine that can help reduce service times of resource-constrained application by an average of 48% and up to a maximum of 90% using a heat map that provides storage IO utilization reports that can be used to determine hotspots in the environment and generate plans for migration to distribute workload.

Key benefits include these:

- Designed to help you potentially improve storage return on investment by keeping SANs operational reliably and dependably
- Designed to help reduce storage administration costs by simplifying the management of complex SANs
- Designed to offer continuous real-time monitoring and fault identification to improve SAN availability.

> **Tip:** IBM Tivoli Storage Productivity Center for Disk includes basic disk, fabric, tape, and data management functions and storage system performance monitoring, but does not include fabric performance monitoring, chargeback, and database monitoring functions.

19.8.4 IBM Tivoli Storage Productivity Center For Disk Midrange Edition

IBM Tivoli Storage Productivity Center for Disk Midrange Edition offers equivalent functionality to IBM Tivoli Storage Productivity Center for Disk. It is designed to provide storage device configuration, performance monitoring, and management of IBM System Storage DS3000 and DS5000 systems from a single console.

Administrators can monitor and analyze performance statistics for these storage systems down to five minute intervals.The performance data can be viewed in real time in the topology viewer, stored for historical reporting, or used to generate timely alerts by monitoring performance thresholds for various device parameters.

Utilizing a new Storage Management Initiative—Specification (SMI-S) Common Information Model (CIM) agent, Tivoli Storage Productivity Center for Disk Midrange Edition helps gather performance data such as:

- Controller input and output rate (read/write/total)
- Controller data rate (read/write/total)
- Controller cache hits percentage (read/write/overall)
- Port I/O rate (read/write/total)
- Port data rate (read/write/total)

TPC for Disk Midrange Edition is designed to enable the IT administrator to:

- Provide reporting across multiple disk arrays from a single console
- Receive timely alerts that can enable event action based on business policies by monitoring performance thresholds for the devices based on performance metrics and the generation of alerts when those thresholds are exceeded
- Monitor performance metrics such as input and output(I/O) and data rates, and cache utilization across multiple storage subsystems from a single console
- Help administrators measure service level agreements (SLA) by storing received performance statistics into database tables for later use, and helps analyze and generate reports on monitored devices for display in the central administrative console

Key benefits include these:

- Designed to offer proactive performance analysis with comprehensive monitoring and fault identification to help improve SAN availability
- Designed to help customers improve storage return on investment (ROI) by keeping SAN operational reliably and dependably
- Designed to help reduce storage administration costs by simplifying the management of complex SAN infrastructures

19.8.5 IBM Tivoli Storage Productivity Center for Replication

This section provides an overview of the IBM Tivoli Storage Productivity Center (TPC) for Replication, describes the key concepts necessary to use the product and its components, and contains several scenarios that illustrate how to perform specific types of replication.

For more information about the TPC for Replication, see *IBM Tivoli Storage Productivity Center and IBM Tivoli Storage Productivity Center for Replication Installation and Configuration Guide*, SC27-2337-01.

Tivoli Storage Productivity Center TPC for Replication overview

IBM Tivoli Storage Productivity Center For Replication can help simplify and automate the configuration of your replication environment. The basic functions of Tivoli Storage Productivity Center (TPC) for Replication are designed to provide management of the advanced copy services: IBM FlashCopy, Metro Mirror and Global Mirror capabilities for the IBM System Storage DS8000, IBM System Storage DS6000 and the IBM System Storage SAN Volume Controller (SVC).

It is designed to do the following processing:

- Automate the configuration of IBM DS8000, DS6000, and the IBM SAN Volume Controller advanced copy services features
- Monitor the progress of the copy services so you can verify the amount of replication that has been done as well as the amount of time needed to complete the replication
- Manage and coordinate the copy operations to ensure successful completion from your source volumes to your disaster recovery volumes:
  - Flash Copy
  - Metro Mirror
  - Global Mirror
  - Metro Global Mirror.
- Execute automated failover to keep your critical data online and available to your users even if your primary site fails. When the primary site comes back on, the software manages failback to the default configuration as well.

Products: With Tivoli Storage Productivity Center V4.2.1, Tivoli Storage Productivity Center and Tivoli Storage Productivity Center for Replication, previously separate products, are now integrated. You can start the IBM Tivoli Storage Productivity Center for Replication user interface from within the Tivoli Storage Productivity Center user interface.

IBM Tivoli Storage Productivity Center for Replication for System z is still a separate, stand-alone product on z/OS.

The IBM Tivoli Storage Productivity Center (TPC) for Replication V4 includes new capabilities and enhancements:

- Metro Global Mirror with Practice Volumes
- Metro Global Mirror with HyperSwap
- Global Mirror with Practice Volume (Both Directions)
- Global Copy, to minimize application impact when initializing Metro Mirror sessions
- Replicating session progress indicators.

TPC for Replication architecture

The architecture of TPC for Replication is shown in Figure 19-8.

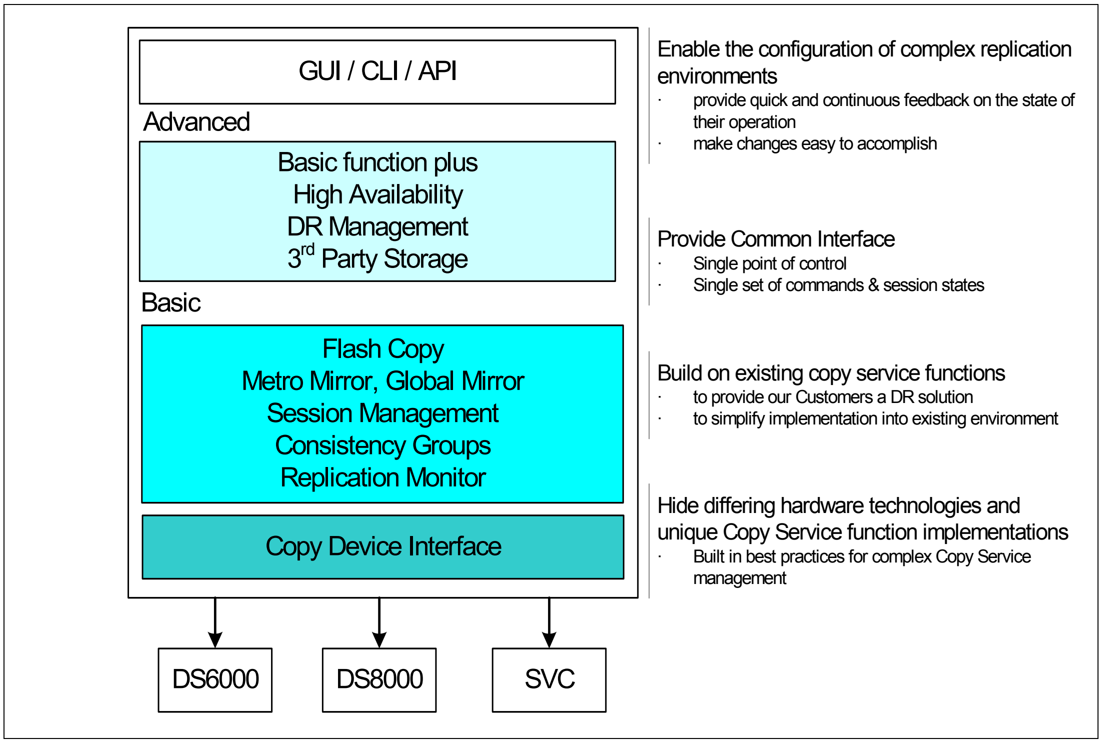


Figure 19-8 TPC for Replication architecture

Consistency management

To maintain integrity of data in any operating system, the sequence in which updates are being written is crucial. If that sequence is changed, data corruption will occur. The correct sequence must be maintained within a volume, across volumes, and across multiple storage systems.

In remote disk mirroring environments, the order of dependant writes across volumes and across multiple storage systems must be maintained at the remote location. During a real disaster (fire, flooding, earthquake), all the components in your environment will almost certainly not fail simultaneously. Failures will more likely be intermittent and gradual, and the disaster time frame will take many seconds or even minutes. This is known as a rolling disaster.

Advanced Copy Services integrated with automation software such as TPC for Replication can protect data from being a mirror of a “dying scenario” - that is, where multiple failures are occurring during a rolling disaster.

TPC for Replication *freezes* affected sessions at a known point instead of mirroring literally hundreds of time-offset failures in a short amount of time, as shown in Figure 19-9.

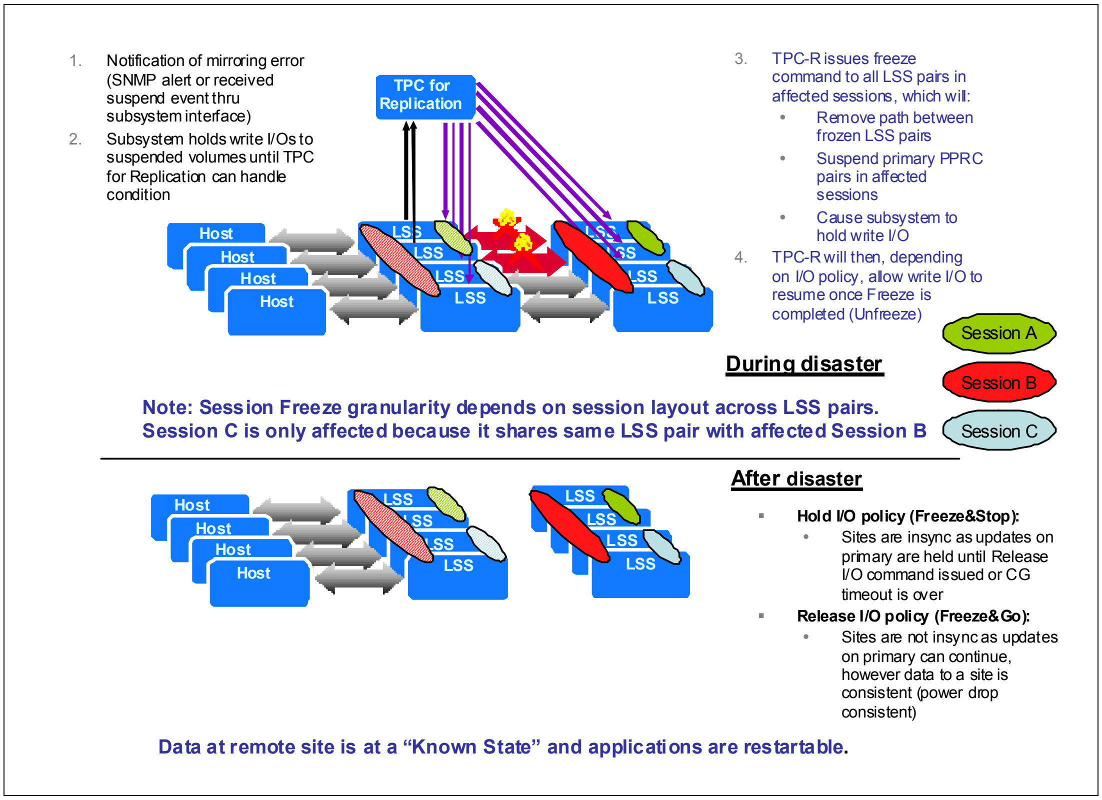


Figure 19-9 TPC for Replication monitoring and freeze capability

The heartbeat functionality on managed LSSes (logical subsystems) is used to avoid losing the alerting and freeze functionality of isolated subsystems (when the TCP/IP connection is broken). See Figure 19-10.

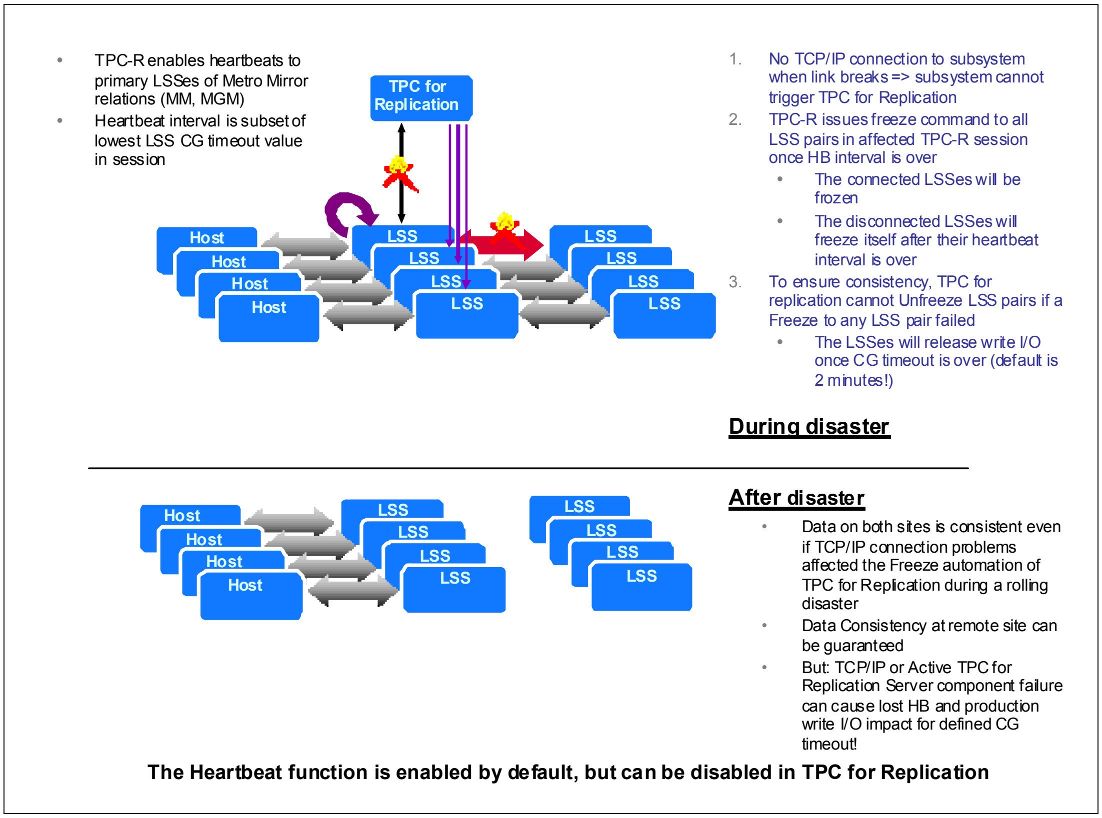


Figure 19-10 TPC for Replication Heartbeat on DS6000/DS8000

Replication management

TPC for Replication uses a simple graphical user interface (GUI) as well as a command line interface (CLI) to configure automation, manage ongoing activities and monitor progress of all key tasks. Different types of storage systems can be managed by a single integrated tool.

The functions are:

- Manage the entire Copy Services environment:
  - Add, modify and remove subsystems
  - Add and remove Paths
  - Add, modify and remove Sessions
  - Add and remove Copy Sets in Sessions
  - Manage Sessions with simple commands depending on Session type and state.
- Monitor the entire Copy Services environment:
  - Health Check screen
  - All sessions overview screen
  - Individual session views with Copy sets overview and details
  - Progress Bars.
- Diagnostics:
  - Error overview
  - Detail view of each error
  - Error messaging and history console.

Session and copy sets

A copy set is a set of volumes that contain copies of the same data, shown in Figure 19-11. All the volumes in a copy set are the same format (count key data (CKD) or fixed block) and size. In a replication session, the number of volumes in a copy set and the role that each volume in the copy set plays are determined by the copy type.

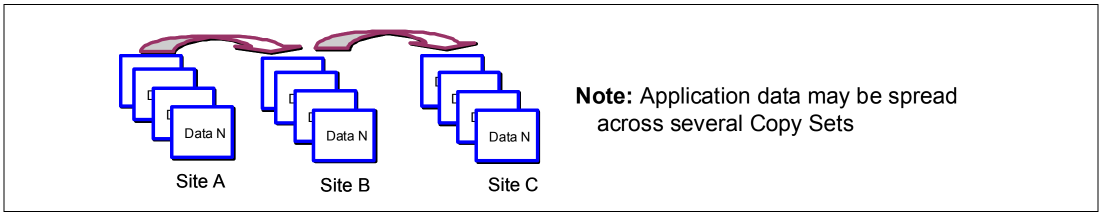


Figure 19-11 TPC for Replication copy set

A session is a container of multiple copy sets making up a consistency group, shown in Figure 19-12.

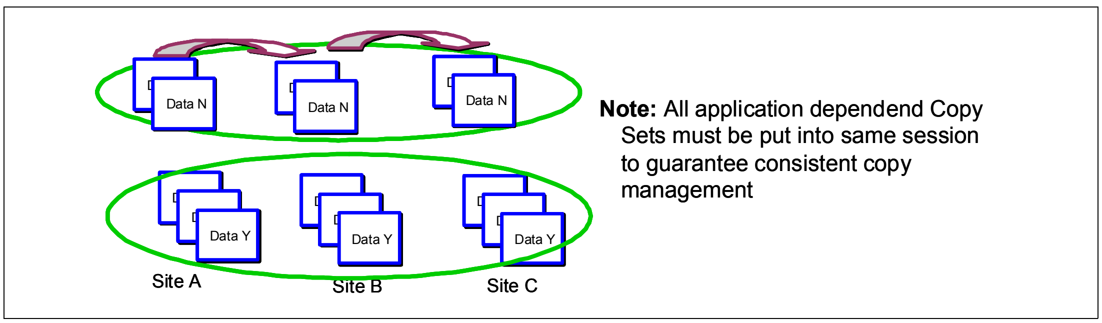


Figure 19-12 TPC for Replication sessions

Three types of sessions can be created, corresponding to the type of the copy service required:

- FlashCopy:

  A FlashCopy is a point-in-time local copy. FlashCopy replication creates the target volume with a copy of the data that represents the data at the time the relationship was established. Both source and target can be referenced and updated independently.

- Metro Mirror:

  A Metro Mirror session is synchronous remote replication. In this context, remote means the source is in one physical subsystem and the target is in a separate physical subsystem. Synchronous means that when a write is issued to change the source, the change is propagated to the target before the write is completely posted. This method of replication maintains identical data in both the source and target (unlike FlashCopy where the copy is static). The advantage of Metro Mirror is that when a disaster occurs, there is no data loss at the recovery site because both writes must complete before signaling completion of a write to the source application.

- Global Mirror:

  A Global Mirror session is continuous asynchronous remote replication. As with Metro Mirror, remote means the source is in one physical subsystem and the target is in a separate subsystem. Asynchronous means that when a write is issued to the source copy, the change is not synchronously propagated and applied to the target. The updates to the target occur after control is given back to the application. Asynchronous replication greatly reduced (and might eliminate) performance impact of the copy on the application and is preferred for copying data at distances of greater that 300 km. However, because the write is not applied synchronously, there is a chance for data loss in the case of a disaster.

After you have decided which method of replication you want to use (copy type), you set up the copy sets. In a replication session, the number of volumes in a copy set and the role that each volume in the copy set plays is determined by the copy type.

The following terms are used in describing sessions:

- Host volume:

  A host volume is a volume that an application, such as a database, reads data from and writes data to. A host volume can be the source for a copy function. A host volume can also be the target of the copy function, in which case you cannot write to the volume directly - it is only written by the copy service.

- Journal volume:

  A journal volume holds a consistent copy of the data until a new consistent copy is formed. The journal volume restores the last consistent point during a recovery.

- Role:

  A volume's role is the function it assumes in the copy set, and is composed of the intended use and, for Global Mirror and Metro Mirror, the volume's site location. Every volume in a copy set is assigned a role. A role can assume the functions of a host volume, journal volume, or target volume.

- Role pair:

  A role pair is the association of two roles in a session. For example, in a Metro Mirror session, the role pair can be the association between volume roles Host 1 and Host 2.

- Target volume:

  A target volume is an intermediate volume that receives data from a source. Depending on the session type, that data might or might not be consistent.

Copy sets as well as sessions can be created by using TPC for Replication wizards.

IBM Tivoli Storage Productivity Center for Replication Two Site Business Continuity (AIX, Linux, Windows, z/OS)

IBM TPC for Replication Two Site Business Continuity helps to obtain continuous availability and disaster recovery solutions by using point-in-time replication, which includes FlashCopy; and continuous replication, which includes Metro Mirror and Global Mirror.

Use IBM Tivoli Storage Productivity Center for Replication Two Site Business Continuity for the following tasks:

- Perform a FlashCopy for DS6000, and DS8000
- Perform a FlashCopy for SAN Volume Controller
- Perform a Global Mirror Single Direction for DS6000, and DS8000
- Perform a Global Mirror Either Direction with Two-Site Practice for DS6000, and DS8000
- Perform a Global Mirror Single Direction for SAN Volume Controller
- Perform a Global Mirror Failover/Failback for DS6000, and DS8000
- Perform a Global Mirror Failover/Failback for SAN Volume Controller
- Perform a Global Mirror Failover/Failback with Practice for DS6000, and DS8000
- Perform a Global Mirror Failover/Failback with Practice for SAN Volume Controller
- Perform a Metro Mirror Single Direction for SAN Volume Controller
- Perform a Metro Mirror Failover/Failback for SAN Volume Controller
- Perform a Metro Mirror Failover/Failback with Practice for SAN Volume Controller
- Perform a Metro Mirror or Global Copy for DS6000, and DS8000
- Perform a Metro Mirror Failover/Failback or Global Copy for DS6000, and DS8000
- Perform a Metro Mirror Failover/Failback with HyperSwap for DS6000, and DS8000
- Practice recovery procedures while maintaining disaster recover capability.

IBM Tivoli Storage Productivity Center for Replication Three Site Business Continuity (AIX, Linux, Windows, z/OS)

IBM TPC for Replication Three Site Business Continuity helps to obtain continuous availability and disaster recovery solutions by using point-in-time replication, which includes FlashCopy, and continuous replication, which includes Metro Mirror, Global Mirror, and Metro Global Mirror to secondary and tertiary sites.

Use IBM Tivoli Storage Productivity Center for Replication Three Site Business Continuity for the following tasks:

- Perform a FlashCopy for DS6000, and DS8000
- Perform a FlashCopy for SAN Volume Controller
- Perform a Global Mirror Single Direction for DS6000, and DS8000
- Perform a Global Mirror Either Direction with Two-Site Practice for DS6000, and DS8000
- Perform a Global Mirror Single Direction for SAN Volume Controller
- Perform a Global Mirror Failover/Failback for DS6000, and DS8000
- Perform a Global Mirror Failover/Failback for SAN Volume Controller
- Perform a Global Mirror Failover/Failback with Practice for DS6000, and DS8000
- Perform a Global Mirror Failover/Failback with Practice for SAN Volume Controller
- Perform a Metro Mirror Single Direction for SAN Volume Controller
- Perform a Metro Mirror Failover/Failback for SAN Volume Controller
- Perform a Metro Mirror Failover/Failback with Practice for SAN Volume Controller
- Perform a Metro Mirror or Global Copy for DS6000, and DS8000
- Perform a Metro Mirror Failover/Failback or Global Copy for DS6000, and DS8000
- Perform a Metro Mirror Failover/Failback with HyperSwap for DS6000, and DS8000
- Perform a Metro Global Mirror for DS8000 (with failover and failback)
- Perform a Metro Global Mirror for DS8000 (with failover and failback)
- Perform a Metro Global Mirror with Practice for DS8000 (with failover and failback)
- Perform a Global Metro Mirror with HyperSwap for DS8000
- Practice recovery procedures while maintaining disaster recover capability.

Important: IBM Tivoli Storage Productivity Center for Replication Three Site Business Continuity requires a BC license key.

IBM Tivoli Storage Productivity Center for Replication for System z

IBM TPC for Replication Basic Edition for System z provides a disaster-recovery capable solution, and helps protect from storage system failures.

Use IBM Tivoli Storage Productivity Center for Replication Basic Edition for System z with Basic HyperSwap for the following tasks:

- Monitoring for events that indicate a storage device has failed
- Determining if the failing storage device is part of a peer-to-peer remote copy (PPRC) pair
- Determining from policy, the action to be taken
- Ensuring that data consistency is not violated
- Swapping the I/O between the primary logical devices in the consistency group with the secondary logical devices in the consistency group (performing a HyperSwap for DS6000, and DS8000)
- Allowing only z/OS attached count key data (CKD) volumes to be added to the HyperSwap session.

IBM Tivoli Storage Productivity Center for Replication Basic Edition for System z provides only the HyperSwap session and not the functionality of the other IBM Tivoli Storage Productivity Center for Replication products.

> **License:** No license is required for IBM Tivoli Storage Productivity Center for Replication Basic Edition for System z. If you want to use IBM Tivoli Storage Productivity Center for Replication or IBM Tivoli Storage Productivity Center for Replication Three Site Business Continuity, a separate license for each of these products is required.
>
> The z/OS HyperSwap license is required for running Basic HyperSwap.

IBM TPC for Replication for System z overview

IBM Tivoli Storage Productivity Center for Replication for System z provides the functions as the IBM Tivoli Storage Productivity Center for Replication open systems products. It runs on System z servers, using a mixture of FICON and TCP/IP communications, to provide replication management of DS8000, and DS6000, regardless of type of data on them (ECKD™ or FBA).

IBM Tivoli Storage Productivity Center for Replication for System z provides:

- Volume protection to exclude any volumes from being used for disaster-protection copy operations
- Command prompting to confirm storage administrator actions before running the copy services commands
- User roles for administrative levels of access
- Site awareness to indicate site locations of the storage volumes and help assure copies are done correctly
- Metro Global Mirror support for the DS8000, providing failover and failback support, fast reestablishment of three-site mirroring, quick resynchronization of mirrored sites using incremental changes only, and data currency at the remote site.

License: If you want to use IBM Tivoli Storage Productivity Center for Replication or IBM Tivoli Storage Productivity Center for Replication Three Site Business Continuity, a separate license for each of these features is required.

19.8.6 IBM Tivoli Storage Productivity Center Standard Edition

IBM Tivoli Storage Productivity Center Standard Edition is one of the industry's most comprehensive storage resource management solutions by combining the consolidated benefits of the following three components as one bundle:

- Tivoli Storage Productivity Center for Data
- Tivoli Storage Productivity Center for Disk
- Tivoli Storage Productivity Center Basic Edition.

In addition to the benefits and features of Data, Disk and Basic Edition, Productivity Center Standard Edition offers additional management, control and performance reporting for the Fibre Channel SAN infrastructure. These features include the following benefits:

- Provide automated device discovery, topology rendering, error detection and fault isolation, SAN error predictor, zone control, real-time monitoring and alerts, and event management for heterogeneous enterprise SAN environments.
- Help simplify the management and improve the availability of the SAN environment
- Provide automatic device discovery and allow multiple SAN views, including physical, logical and zone views.
- View and analyze multiple aspects of the storage environment, including capacity, utilization, assets and availability.
- Detect storage events and generate the appropriate alerts to the administrator.
- Provide a number of SAN availability features, including SAN error protector. An autonomic computing capability, SAN error predictor is designed to help predict SAN network problems before they become severe and impact data and application availability. This functionality incorporates predictive failure analysis into the storage network environment, designed to allow administrators to be proactive in managing SAN availability.
- Provide basic diagnostic capabilities to show which resources are impacted by an availability or performance issue in the SAN. Today, it can monitor performance at the port and switch level, and display this information in the common topology viewer for IBM Tivoli Storage Productivity Center.

Tip: IBM Tivoli Storage Productivity Center Standard Edition contains all the functions for data management, disk management, fabric management, and tape management, plus:

- Analytical functions
- Configuration Analysis
- Configuration History
- SAN Planner

19.8.7 IBM Tivoli Storage Productivity Center with Advanced Provisioning

IBM Tivoli Storage Productivity Center with Advanced Provisioning is an integrated storage capacity provisioning solution designed to simplify and automate complex cross-discipline tasks for provisioning storage capacity in the enterprise environment and is designed to move you from just-in-case provisioning to intelligent, automated on demand provisioning.

The IBM Tivoli Storage Productivity Center with Advanced Provisioning is comprised of:

- IBM Tivoli Provisioning Manager
- IBM Tivoli Storage Productivity Center:
  - IBM Tivoli Storage Productivity Center for Data
  - IBM Tivoli Storage Productivity Center for Disk
  - IBM Tivoli Storage Productivity Center for Replication

Tivoli Storage Productivity Center with Advanced Provisioning is designed to allow you to automate and execute the numerous steps necessary to provision storage in a consistent manner, helping reduce or eliminate human error. Provisioning capabilities are provided by the Tivoli Storage Productivity Center, while Tivoli Provisioning Manager facilitates the automation of the provisioning tasks through the use of storage workflows.

Tivoli Storage Productivity Center with Advanced Provisioning includes workflow building blocks designed to help you easily build and customize your own solution workflows with minimal effort. The simplicity and flexibility of workflows helps enable you to automate at your own pace. Through the use of automated storage capacity provisioning workflows, helps allow you to:

- Provision storage capacity with consistency in a repeatable and auditable manner
- Automate storage capacity provisioning at your own pace with minimal effort
- Enable staff to manage cross discipline IT projects more effectively and efficiently
- Improve responsiveness to the storage needs of applications

19.9 IBM Tivoli Storage Productivity Center licenses

The following product licenses are available for IBM Tivoli Storage Productivity Center: Basic, Data, Disk, Disk Midrange, and Standard. Each license determines the functions that are accessible in the user interface.

For more information about licensing in the TPC, see the *IBM Tivoli Storage Productivity Center V4.1 Release Guide*, SG24-7725-00.

Table 19-5 provides the list of functions that are included with each license to help you determine which one best meets your storage management needs.

Table 19-5 Tivoli Storage Productivity Center packages

Package/License	Function
IBM Tivoli Storage Productivity Center for Data	Includes data management, basic tape, disk, and fabric management, database monitoring, and chargeback functions, but does not include performance monitoring functions.
IBM Tivoli Storage Productivity Center for Disk	Includes basic disk, fabric, tape, and data management functions and storage system performance monitoring, but does not include fabric performance monitoring, chargeback, and database monitoring functions.
IBM Tivoli Storage Productivity Center for Replication (Two Site Business Continuity license and Three Site Business Continuity license)	IBM Tivoli Storage Productivity Center for Replication functions. When you install IBM Tivoli Storage Productivity Center for Replication, no licenses will be installed. You must install the Two Site or Three Site Business Continuity license after you install IBM Tivoli Storage Productivity Center for Replication.
IBM Tivoli Storage Productivity Center Basic Edition	Includes basic disk, fabric, tape, and data management functions, but does not include chargeback, database monitoring, and performance monitoring functions.
IBM Tivoli Storage Productivity Center Standard Edition	Contains all the functions for data management, disk management, fabric management, and tape management, plus: ► Analytical functions ► Data path explorer view (or context-sensitive performance analysis) ► Configuration Analysis ► Configuration History ► SAN Planner

Important: Each marketing package contains the complete Tivoli Storage Productivity Center product, and all functions are installed. However the various licenses that are shipped with each marketing package will limit the functionality available at the graphical user interface level.

Attention: IBM Tivoli Storage Productivity Center for Replication for System z is still a separate, stand-alone product on z/OS.

19.10 IBM System Storage Productivity Center

This topic describes the features and functionalities of IBM System Storage Productivity Center (SSPC).

For more information about SSPC, see *IBM System Storage Productivity Center V1.4: Introduction and Planning Guide*, SC23-8824-06.

19.10.1 New with IBM System Storage Productivity Center Version 1.5

You can use this information to learn about the new features and enhancements that are included in IBM System Storage Productivity Center Version 1.5. SSPC 1.5 adds the following new features, functions, and enhancements.

Name change

IBM TotalStorage Productivity Center has been renamed to Tivoli Storage Productivity Center V4.2.1. All user interfaces, documentation, online help, and messages reflect the new name.

IBM Tivoli Storage Productivity Center

IBM Tivoli Storage Productivity Center Basic Edition 4.2.1 is preinstalled on the IBM System Storage Productivity Center server, with the option to have HBA card pre-installed.

New Model 2805-MC4

System Storage Productivity Center Model 2805-MC4 includes a hard drive that is 10 GB larger than the previous model. System Storage Productivity Center Models 2805-MC2 and 2805-MC3 are no longer available for purchase.

IBM System Storage DS8800 R6 is supported

You can monitor System Storage DS8800 R6 with System Storage Productivity Center. (You can also monitor previous releases.)

IBM Storwize V7000

Customers can manage their Storwize V7000 virtualization product from SSPC V1.5.

IBM System Storage SAN Volume Controller

IBM SAN Volume Controller Console 6.1.0 is preinstalled on the System Storage Productivity Center server. Because this level of the console no longer requires a CIM agent to communicate with the SAN Volume Controller, a CIM agent is not installed with the console. Instead, you can use the CIM agent that is embedded in the SAN Volume Controller hardware. To manage older levels of the SAN Volume Controller, install the corresponding CIM agent on the SSPC server. PuTTY remains installed on the System Storage Productivity Center and available for key generation.

IBM System Storage DS Storage Manager

A new version of the System Storage DS Storage Manager user interface is available for you to optionally install on the System Storage Productivity Center server or on a remote server. The DS Storage Manager 10.60 can manage the IBM DS3000, IBM DS4000, and IBM DS5000. With DS Storage Manager 10.60, when you use Tivoli Storage Productivity Center to add and discover a DS CIM agent you can launch the DS Storage Manager from the topology viewer, the Configuration Utility, or the Disk Manager of the Tivoli Storage Productivity Center.

IBM Java Version 6 is preinstalled

IBM Java is preinstalled and supports DS Storage Manager 10.60. You do not need to download Java from Sun Microsystems.

DS CIM agent management commands

The DS CIM agent management commands (DSCIMCLI) for 5.4.3 are preinstalled on the System Storage Productivity Center system.

Enhancements to Password Tool

The Password Tool that you use to change the DB2 user, WebSphere user, and DB2 service passwords now generates fewer messages and command windows.

19.10.2 System Storage Productivity Center overview

The IBM System Storage Productivity Center (SSPC) is an integrated hardware and software solution that will help you improve and centralize the management of your storage environment through the integration of products. It provides a single point from which to manage your storage systems.

The SSPC combines the power of a customized IBM System x server with preinstalled storage software that represents a significant point of centralized management. SSPC enhances several rudimentary device utilities for easier, more intuitive, context based administration and on the whole lowers resource overhead.

System Storage Productivity Center simplifies storage management in these ways:

- Centralizing the management of storage network resources with IBM storage management software
- Providing greater synergy between storage management software and IBM storage devices
- Reducing the number of servers that are required to manage your software infrastructure
- Providing a simple migration path from basic device management to using storage management applications that provide higher-level functions.

The System Storage Productivity Center is a 1U, rack-mounted hardware appliance that has IBM Tivoli Storage Productivity Center Basic Edition and IBM Tivoli Storage Productivity Center for Replication installed on it.

Figure 19-13 shows an overview of how the SSPC, TPC, TPC for Replication, and the hardware and software for IBM System Storage DS8000, IBM System Storage SAN Volume Controller, IBM System Storage DS3000, IBM System Storage DS4000, and IBM System Storage D5000 all relate with each other.

Product name: The IBM Tivoli Storage Productivity Center was formerly known as the IBM TotalStorage Productivity Center.

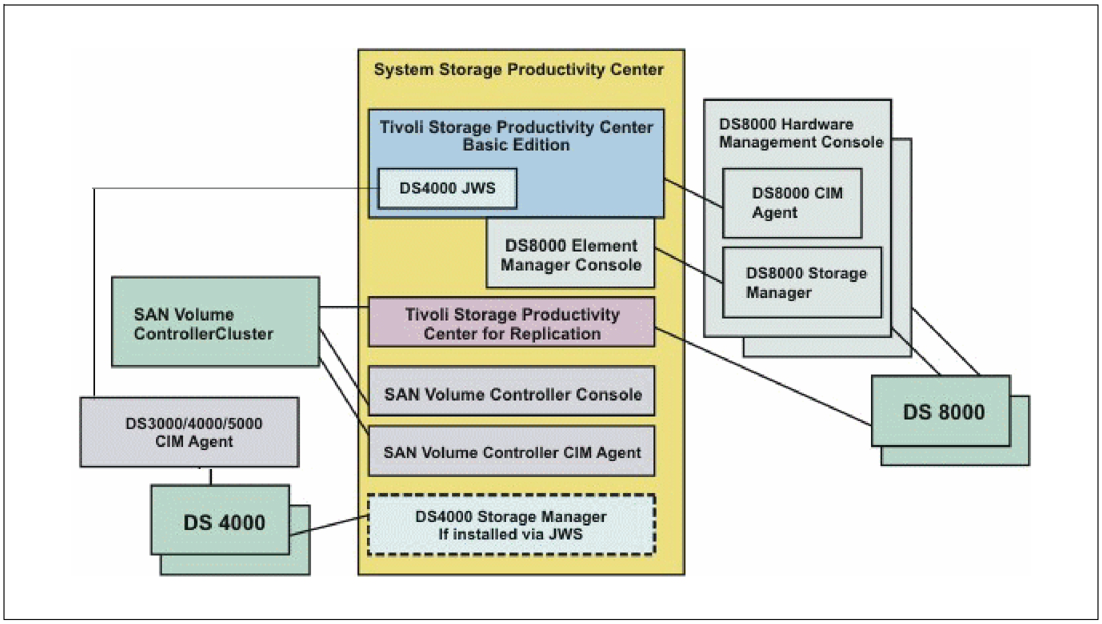


Figure 19-13 Overview of System Storage Productivity Center

The System Storage Productivity Center provides integration of storage management applications by providing support for the following products:

- IBM Tivoli Storage Productivity Center Basic Edition: IBM Tivoli Storage Productivity Center Basic Edition enables device configuration and management of SAN-attached devices from a single console. Basic Edition simplifies the complexity of managing multiple SAN-attached storage devices. It enables you to manage SANs and heterogeneous storage from a single console.
- IBM System Storage DS8000 Storage Manager: The IBM System Storage DS8000 Storage Manager user interface is accessible from the Tivoli Storage Productivity Center user interface. Tivoli Storage Productivity Center provides a DS8000 element manager page, which allows you to add and manage multiple DS8000 element managers from one console. You can use the DS8000 element manager page to:
  - Access the IBM DS8000 Storage Manager interface that is embedded in the DS8000 Hardware Management Console (HMC)
  - Use the DS8000 Storage Manager interface to configure and administer its associated IBM DS8000 storage arrays.
- IBM System Storage SAN Volume Controller: The IBM System Storage SAN Volume Controller Console is installed with System Storage Productivity Center. The SAN Volume Controller Console is a separate icon from the Tivoli Storage Productivity Center user interface icon on your desktop.
- IBM Tivoli Storage Productivity Center for Replication: Beginning with Release 4.1, IBM Tivoli Storage Productivity Center for Replication and Tivoli Storage Productivity Center, previously separate products, are integrated. This means that you can start the IBM Tivoli Storage Productivity Center for Replication user interface from within the Tivoli Storage Productivity Center user interface.
- IBM System Storage DS3000, DS4000, and DS5000 Storage Manager: You can optionally install the DS3000, DS4000, and DS5000 Storage Manager user interface on the System Storage Productivity Center server, or a remote server so that you can manage the storage systems from a single console.

  To use Tivoli Storage Productivity Center to view reports and topology from the DS3000, DS4000, or DS5000, you must first install the Engenio provider (CIM agent) for the storage system (on a separate server; not the System Storage Productivity Center server). For information about the Engenio provider, contact LSI at the website:

  `http://www.lsi.com/storage_home/products_home/external_raid/management_software/smis_provider/index.html`
- DS CIM agent management commands: The DS CIM agent management commands (DSCIMCLI) are installed on the System Storage Productivity Center system. The DSCIMCLI can manage the CIM agents for DS8000, and DS6000.

  For information about the CIM agent management commands, see *DS Open Application Programming Interface Reference* at the website:

  `http://www.ibm.com/servers/storage/support/software/cimdsoapi/`

Figure 19-14 illustrates the steps that the IBM service representative and you must perform to install and configure the IBM System Storage Productivity Center.

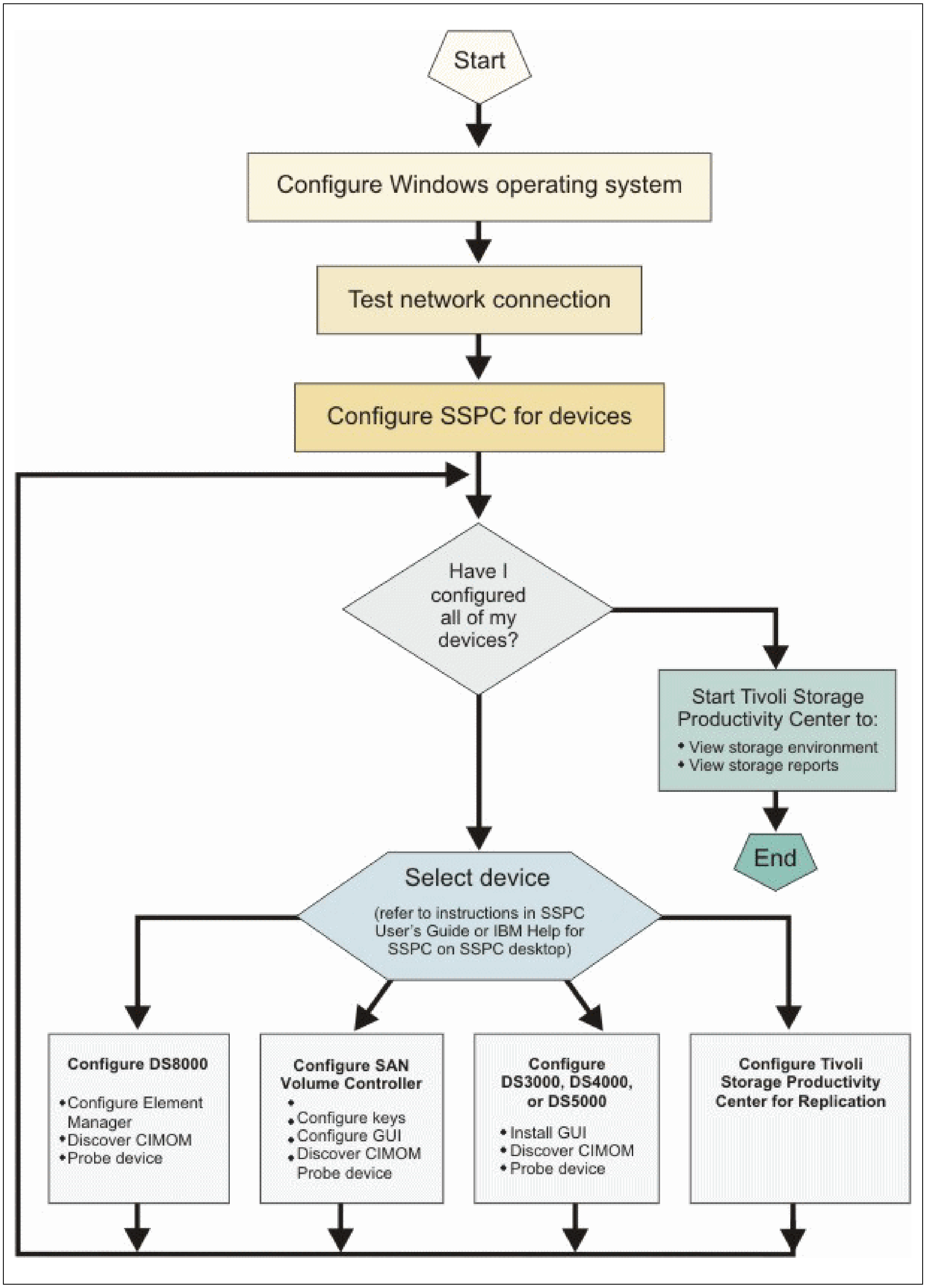


Figure 19-14 Overview of installing and configuring the System Storage Productivity Center

19.10.3 System Storage Productivity Center hardware components

The SSPC consists of an IBM System x server running the Microsoft Windows Server 2008 Enterprise Edition operating system. This topic describes the standard SSPC server configuration.

The SSPC Model 2805-MC4 server is based on the IBM System x3550 M2 Type 7946 server, with IBM Tivoli Storage Productivity Center, DS CIM agent management commands (DSCIMCLI), the SAN Volume Controller Console, and IBM Tivoli Storage Productivity Center for Replication all preinstalled. The System x3550 server is a rack-model server for high-volume network-transaction processing. This quad-core server is suited for networking environments that require microprocessor performance, input/output (I/O) flexibility, and manageability. For detailed information, see the *IBM System x3550 M2 Type 7946 Installation and User's Guide*. This publication is available on the *IBM System Storage Productivity Center Documentation CD*, which comes with the server.

The System Storage Productivity Center Model 2805-MC4 server includes the following characteristics:

- One Intel Xeon quad-core central processing unit, with speed of 2.4 GHz, cache of 8 MB, and power consumption of 80 W
- 8 GB of RAM (eight 1-inch dual inline memory modules of double-data-rate three memory, with a data rate of 1333 MHz)
- Two 146-GB hard disk drives, each with a speed of 15 K
- One Broadcom 6708 Ethernet card
- One CD/DVD bay with read and write-read capability

Optionally, you can add a keyboard, video, and mouse (KVM) unit, or a redundant power supply. The SSPC Model 2805-MC4 server supports six 2.5-inch hot-swap Serial Attached SCSI (SAS) hard disk drives.

SSPC: You can create a server that is equivalent to the SSPC by installing the SSPC software on any supported server. However, the hardware support included with the SSPC is available only if the software is installed on a Model 2805-MC4 server. For more information, see the section about installing SSPC components in the *IBM System Storage Productivity Center User's Guide*.

See this publication for more information about IBM System Storage Productivity Center: *IBM System Storage Productivity Center V1.4: Introduction and Planning Guide*, SC23-8824-06.

19.10.4 System Storage Productivity Center licensing

License entitlement for preinstalled and optional software must be purchased separately from the IBM System Storage Productivity Center server. Ensure that the necessary licenses have been purchased before the IBM service representative arrives to install the System Storage Productivity Center server.

Preinstalled software

The following software is preinstalled on the System Storage Productivity Center server:

- Microsoft Windows Server 2008 Enterprise Edition
- IBM Tivoli Storage Productivity Center 4.2.1 Basic Edition
- IBM Tivoli Storage Productivity Center for Replication 4.2.1
- IBM DB2 Enterprise Server Edition 9.7
- IBM System Storage SAN Volume Controller Console version 6.1.0
- PuTTY

The Basic Edition of Tivoli Storage Productivity Center can be upgraded to the Standard Edition, which includes additional data analysis and performance reporting features. For information about upgrading to these packages, see the topic about upgrading in the IBM System Storage Productivity Center Information Center at:

http://publib.boulder.ibm.com/infocenter/tivihelp/v4r1/index.jsp

Also see the *IBM System Storage Productivity Center User's Guide*.

Licensing details

The IBM Tivoli Storage Productivity Center Basic Edition software is licensed per System Storage Productivity Center server, regardless of the number of processors or amount of data managed. Licensing includes the first year of software support. After the first year, support is provided on a subscription basis.

Tivoli Storage Productivity Center for Replication is installed with local OS authentication. This program is non-licensed. You are required to purchase and install the 2-site or 3-site license to use the functions of Tivoli Storage Productivity Center for Replication.

Licensing for the IBM DB2 Enterprise Server is included in the Tivoli Storage Productivity Center Basic Edition license agreement.

> **Attention:** As a best practice, install antivirus software on the SSPC server but not other software (except for the upgrades to the software listed in this topic). While antivirus applications can offer protection to servers that might be in an unprotected environment, installing other software can cause port conflicts or performance issues. Other precautions that you can take to protect the SSPC server include enabling security updates to the operating system and establishing a backup procedure for the SSPC.

19.10.5 System Storage Productivity Center support matrix

This topic describes IBM System Storage Productivity Center software support for each supported hardware system.

Table 19-6 provides details for a support matrix.

Table 19-6 System Storage Productivity Center supported hardware

Supported hardware (see note)	**Supported software**				
	IBM Tivoli Storage Productivity Center	**IBM Tivoli Storage Productivity Center for Replication**	**IBM System Storage SAN Volume Controller**	**DSCIMCLI**	**IBM DS Storage Manager**
DS3000	X				X
DS4000	X				X
DS5000	X				X
DS6000	X	X		X	
DS8000	X	X		X	
SAN Volume Controller	X	X	X		
TS3310 Tape Library	X				
TS3500 Tape Library	X				

Support: The SSPC might also support other hardware because that hardware is supported by Tivoli Storage Productivity Center. For a complete list of supported devices, go to the following website:

`http://www.ibm.com/software/sysmgmt/products/support/IBMTotalStorageProductivityCenterStandardEdition.html`

Then select: → **Plan** → **[View all Plan documents]**.

19.11 Interoperability

IBM Tivoli Storage Productivity Center supports:

- Storage Systems:
  - EMC
  - Fujitsu
  - Hewlett-Packard
  - Hitachi Data Systems
  - IBM
  - LSI
  - NEC
  - NetApp
  - SGI
  - Sun Microsystems.

- Operating Systems:
  - AIX
  - HP-UX
  - Solaris
  - Red Hat Linux
  - SUSE Linux
  - Microsoft Windows.
- Host Business Adapters:
  - IBM
  - Brocade
  - QLogic
  - Emulex
  - LSI
  - Hewlett-Packard.
- Switches and Directors:
  - Brocade
  - Cisco
  - QLogic
  - McData.

19.12 More information

See these publications for more information about IBM Tivoli Storage Productivity Center:

- *IBM Tivoli Storage Productivity Center V4.1 Release Guide*, SG24-7725
- *IBM Tivoli Storage Productivity Center User's Guide*, SC27-2338-01
- *IBM Tivoli Storage Productivity Center Workflow User's Guide*, SC27-2341-01
- *IBM System Storage Productivity Center V1.4: Introduction and Planning Guide*, SC23-8824-06.

For the latest information about IBM Tivoli Storage Productivity Center, see following link:

http://www.ibm.com/systems/storage/software/center/index.html

The atest documentation is available from the TPC Infocenter at:

http://publib.boulder.ibm.com/infocenter/tivihelp/v4r1/index.jsp

20

IBM Tivoli Key Lifecycle Manager

Organizations have to manage their data effectively to ensure its availability, security, resiliency, and compliance. At the same time, the volume of the data continuously grows year-by-year, often at double-digit rates, which leads to increased threats to the data from within or outside the organization, increasing regulatory requirements from the government or industry sector, as well as more stringent contractual requirements from business partners.

Data is a crucial resource of any organization, and if it is lost, compromised, or stolen, the negative effects on the business continuity can be truly devastating. One of the ways that organizations can resist to the threats to their data, is by using the encryption tools to protect the data against exposure and misuse.

In this chapter, we provide basic information about the IBM Tivoli Key Lifecycle Manager, which is the IBM strategic tool for the encryption key lifecycle management process for disk and tape systems.

20.1 Introduction to data encryption

All physical storage media (such as disk and tape) will at some point in time be removed from the data center. This might be due to maintenance or archiving, being sent to a business partner, being returned to the vendor, or being scrapped at the end-of-life, or it might simply be lost or stolen. As a result, organizations focus on encryption to ensure that the data on such storage media cannot be inadvertently exposed, in particular, with storage being built into the infrastructure rather than as an add-on.

There are many ways to encrypt the data, but they all basically rely on two components: the *encryption algorithm* (which is usually well documented and well known) and the *encryption key*. The encryption algorithm uses the key to encrypt the data, and also uses the same key (or a mathematically related key) to decrypt the data. For each encryption algorithm there is a very large number of possible keys. For example, when the key length is 128 bits there are up to 2 to the 128th power keys (34 x 1036). In general, it is the key that is kept secret, not the algorithm itself.

Figure 20-1 demonstrates the basic principle of the encryption and decryption process, using the same encryption key with the known and agreed implemented encryption algorithm.

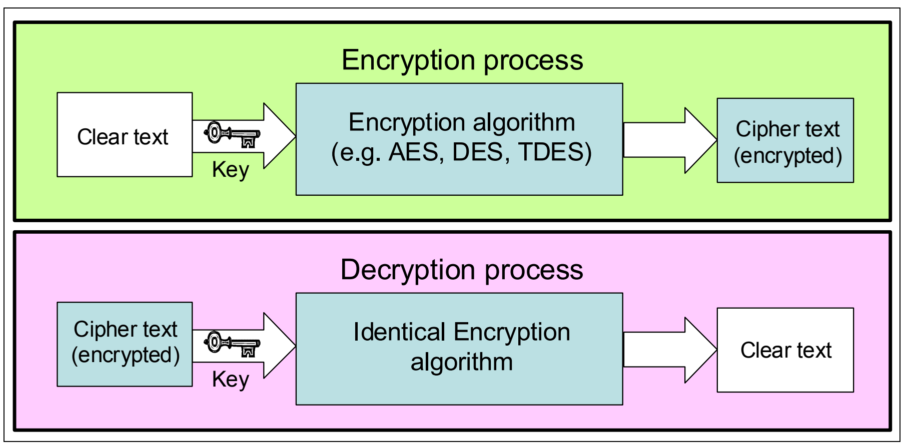


Figure 20-1 Encryption and decryption process overview

The key is a critical resource in the encryption process because without it, the data cannot be encrypted and, more importantly, it cannot be decrypted. The loss of the decryption key means that the data cannot be read and to all intents and purposes it is considered lost (or *cryptographically erased*). The way the keys are controlled can have a critical impact on the management of storage and information systems. However, storage professionals do not need to become security experts in order to deploy encryption. The storage administrator has to be assured that implementing encryption will not adversely affect the performance or availability of the storage subsystems (including backup and recovery, disaster recovery, and business continuity processes, because this data will also be encrypted).

Encryption management is the management of the data to be encrypted and of the encryption keys. Availability of the overall solution is closely tied to the availability of the encryption keys, whereas the performance is more tied to the actual encryption process and whether dedicated encryption hardware is used. The focus for key management is to reduce complexity and cost for encryption.

Tivoli Key Lifecycle Manager (TKLM) is the IBM product that meets the specified criteria for reliable encryption data and encryption keys management in midrange and enterprise tape and disk solutions. TKLM is the strategic and mandatory tool being used to manage encryption process with IBM LTO Ultrium 5 tape drives in specific IBM tape libraries.

20.2 Encryption key lifecycle management

Like most of the IT assets, the encryption keys have a life cycle, starting when they are created and ending when they are destroyed.

Before the data can be encrypted, an encryption key of an appropriate type and length must be generated. This key can be used once or many times; it can be used for just one tape or disk, or for many. In order to decrypt the data later, the storage administrator must know which key was used to encrypt that piece of data, while keeping the key itself secure and confidential to avoid any misuse and potential data exposure. In addition, there might be government or other regulations specifying the use of keys that must be followed as well.

The place where you keep the keys (the keystore) must be highly available (because without the keystore your data is inaccessible) and highly secure and finally any disaster recovery site must hold an up-to-date copy of your keystore, so that you are able to read and create data at your disaster recovery site.

You have to ensure that you do not prematurely delete keys, unless the explicit data destruction is required. In fact, you can only safely delete a key when you are sure that all data that it has been used to encrypt is no longer in use or already all decrypted. Because it is often very difficult to be certain of this, the keys are usually archived rather than destroyed at the end of their lives.

Here is a short summary of the main requirements for the encryption key management during their lifetime:

- *High Availability* of the keystore affects the availability of the data.
- *High Performance* of the keystore is crucial because the first read or write action is in fact operation against the keystore. The keystore performance issues can affect overall data access performance.
- *Scalability* of the keystore is needed; the number of keys and devices is expected to grow.
- *Security* of the keystore ensures that the data cannot be exposed or misused.
- *Reliability* of the key generation and expiration guarantees the consistent encryption and decryption process.
- *Simplicity and transparency* of the whole encryption key management process is needed.
- *Audit readiness* of the key management process implies the customer's confidence in data security.

One approach to encrypt the data is *application level encryption*, where not necessarily all the data is encrypted, but only a subset that represents the confidential or high-value data. This encryption is often performed by an application itself, by middleware located on one of the servers, or by a specialized appliance. Application level encryption allows you to encrypt at the field level, but requires extensive data classification to determine exactly what needs encryption. This approach can often lead to the significant performance overhead, especially if the encryption is done on the application server itself. In addition, the data classification needs to be re-assessed frequently, as applications and data change, to ensure that the right fields are being encrypted.

Disk or tape level encryption reduces the need for data classification, and with the encryption engine as part of the physical disk or tape drive the performance impact of encryption process can be virtually eliminated. This approach also scales well because each additional disk or tape drive comes with it its own encryption engine. It is the stated intention of IBM to provide centralized encryption key life cycle management across a range of deployment scenarios. The IBM strategic tool is called IBM Tivoli Key Lifecycle Manager.

20.3 IBM Tivoli Key Lifecycle Manager

Whereas many of the current solutions of encryption key management add unnecessary complexity and cost by using a number of different elements to secure the data, the IBM Tivoli Key Lifecycle Manager (TKLM) is a software solution that can run on many industry standard platforms including AIX, Linux, Solaris, Windows, z/OS. Key management is removed from the data read/write path and thus has no impact on the performance of the data transfer. The solution architecture is straightforward: when a disk or tape drive requires an encryption key (for read or write operation), it communicates with the IBM Tivoli Key Lifecycle Manager over the network using TCP/IP and requests the required key. TKLM then sends the key to the device over a secure (SSL) session and the data operation can be then processed, with the encryption itself being performed by the dedicated encryption engine within the storage device.

IBM Tivoli Key Lifecycle Manager provides two main functions:

- Key serving
- Key and certificate management

Each of those functions includes the logical components as shown in Figure 20-2.

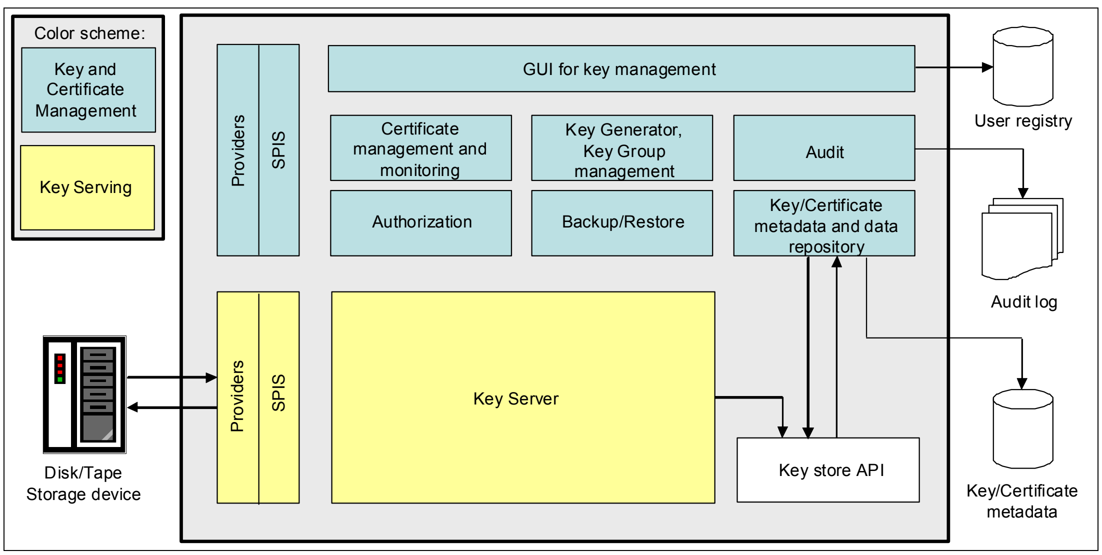


Figure 20-2 Conceptual model of IBM Tivoli Key Lifecycle Manager

The GUI for key management is the primary user interface into the IBM Tivoli Key Lifecycle Manager and provides all the functionality for day-to-day key management. The Audit component creates and sends audit information into an external Audit Log file and the Backup/Restore facility enables backup of the IBM Tivoli Key Lifecycle Manager keystore and associated metadata. The Key/Certificate metadata and data repository function maintains the metadata associated with the keys (such as key identifier, the tape serial number, and so on) and stores it in IBM DB2 database. Keys are generated and key grouping maintained by the Key generator/Key group management component, which also manages key group rotation. Certificate management and monitoring handles certificate management, for example, the creation of certificates or the obtaining of them from third parties, checking the validity of certificates (that they have a valid root certificate and have not expired) and manages their renewal.

IBM Tivoli Key Lifecycle Manager serves the encryption keys to the predefined storage devices only, and the Authorization component validates these devices as eligible.

Tivoli Key Lifecycle Manager is designed to be a shared resource deployed in several locations within an enterprise solution, and it is capable of serving many IBM encrypting devices regardless of where those drives reside. Tivoli Key Lifecycle Manager communicates with the managed storage devices over TCP/IP.

20.3.1 Tape encryption methods

There are three methods of tape encryption management that are supported by the IBM tape data encryption solution. These methods differ in where the encryption policy engine resides, where key management is performed, and how Tivoli Key Lifecycle Manager (TKLM) is connected to the drive. Encryption policies control which volumes need to be encrypted.

> **Encryption:** In case of Virtual Tape Libraries (VTL), the tape encryption methods do not apply. There is always disk storage system behind the tape virtualization solution, even if the application manages those virtual cartridges as standard physical tape. Disk encryption is used instead, if there is such requirement.

System managed encryption

In a System Managed Encryption (SME) implementation, encryption policies reside within the system layer. This method of tape encryption requires an TKLM for key management. SME is fully transparent to the application and library layers. Figure 20-3 shows the principle of the System Managed Encryption.

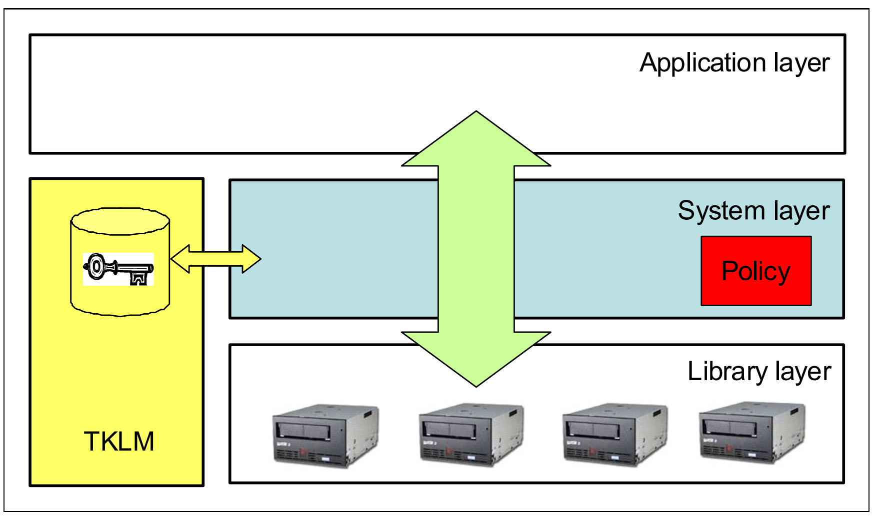


Figure 20-3 System Managed Encryption overview

SME offers the centralized enterprise class key management, which facilitates tape interchange and migration. Another advantage is its support for stand-alone tape drives. Disadvantages are seen in its policy granularity for open systems, the additional responsibilities for the storage administrator, and the dependency of data access on the availability of TKLM and the key path.

Library managed encryption

In a Library Managed Encryption (LME) implementation, encryption policies reside within the tape library. This method of tape encryption requires a TKLM for key management. LME is fully transparent to the application and system layers. Figure 20-4 shows the conceptual model of Library Managed Encryption.

LME offers the broadest range of application and operating system support. Centralized enterprise class key management facilitates tape interchange and migration. If you implement LME on a TS3500 or 3494 tape library, you get policy granularity on a per-volume basis. LME requires an additional responsibilities for the storage administrator as compared to AME. Data access depends on the availability of TKLM and the key path.

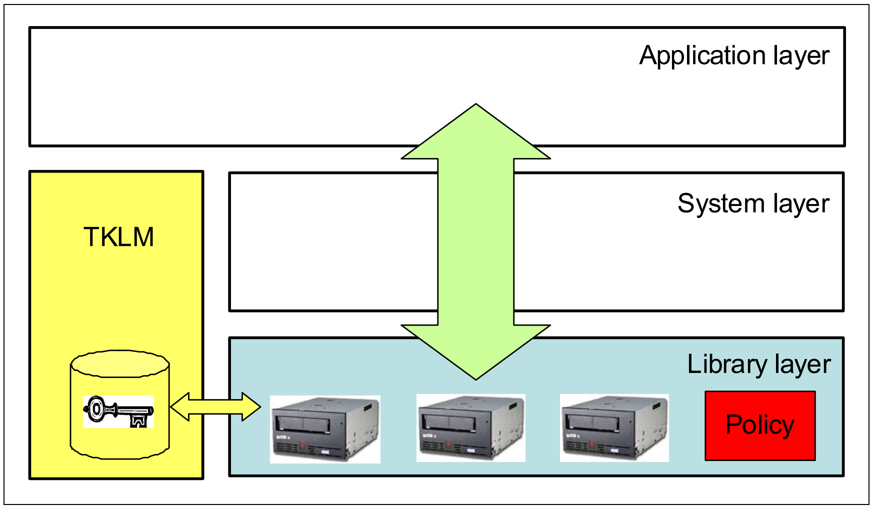


Figure 20-4 The concept of Library Managed Encryption

Key generation and management is handled by TKLM, running on a host with a TCP/IP connection to the library. Policy control and keys pass through the library-to-drive interface, therefore, encryption is transparent to the applications.

For TS3500 and IBM 3494 tape libraries, you can use barcode encryption policies to specify when to use encryption. On an IBM TS3500 Tape Library, you set these policies through the IBM System Storage Tape Library Specialist web interface. On a 3494 tape library, you can use the Enterprise Automated Tape Library Specialist web interface or the Library Manager Console. With barcode encryption policies, policies are based on cartridge volume serial numbers. LME also allows for encryption of all volumes in a library, independent of barcodes.

Encryption: Throughout the variety of open system environments, Library Managed Encryption is the most preferred method for tape encryption.

Application managed encryption

For Application Managed Encryption (AME), the application has to be capable of generating and managing encryption keys and of managing encryption policies. The IBM Tivoli Storage Manager contains these capabilities. Policies specifying when encryption is to be used are defined through the application interface. The policies and keys pass through the data path between the application layer and the encrypting tape drives. Encryption is the result of the interaction between the application and the encryption-enabled tape drive and does not require any changes to the system and library layers. See Figure 20-5 to understand the concept of this type of encryption method.

AME is the easiest encryption method to implement and adds the fewest responsibilities for the storage administrator. Because the data path and the key path are the same, there is no additional risk to data and drive availability. Policy granularity depends on the application.

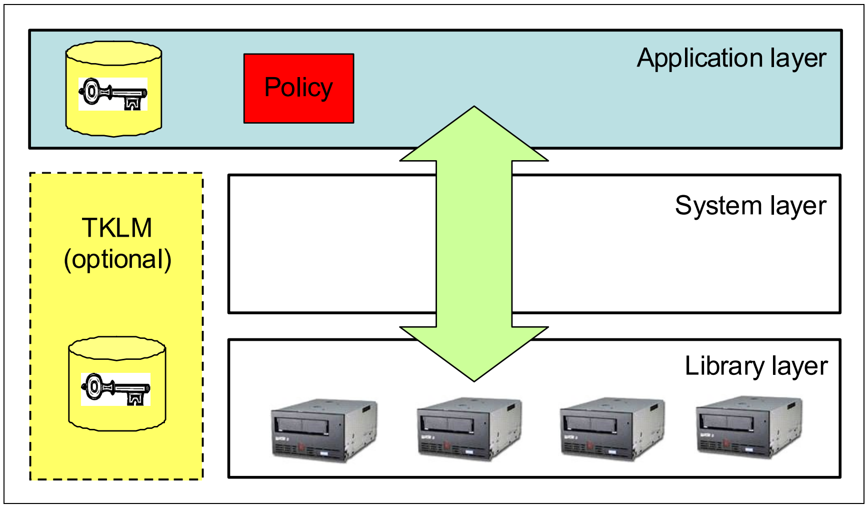


Figure 20-5 Application Managed Encryption

With Tivoli Storage Manager, you control encryption on a storage pool basis. There is no centralized key management with AME, because the application generates, stores, and manages the encryption keys. The lack of centralized key management makes tape interchange and migration more difficult. AME can be the most convenient solution when Tivoli Storage Manager is the only application that utilizes tape encryption.

The IBM Tivoli Storage Manager does not restrict you to using AME. You can also choose SME or LME to encrypt Tivoli Storage Manager data.

Attention: You cannot use Application Managed Encryption with IBM LTO Ultrium 5 tape drives. This tape technology supports the Tivoli Key Lifecycle Manager as an encryption provider only. Customers can use either System or Library Managed Encryption.

20.3.2 Key serving

Tivoli Key Lifecycle Manager enables definition and serving of keys. Tivoli Key Lifecycle Manager also enables definition of keys or groups of keys that can be associated with a device. Different devices require different key types. After you configure devices, Tivoli Key Lifecycle Manager deploys keys to the devices that request them.

Tivoli Key Lifecycle Manager acts as a process awaiting key generation or key retrieval requests sent to it through a TCP/IP communication path between Tivoli Key Lifecycle Manager and the disk subsystem, the tape library, tape controller, tape subsystem, device driver, or tape drive. When a disk or tape drive writes encrypted data, it first requests an encryption key from Tivoli Key Lifecycle Manager. The tasks that Tivoli Key Lifecycle Manager performs upon receipt of the request differ for each device type.

DS8000 family of disk subsystems

Tivoli Key Lifecycle Manager requests an *asymmetric key* from the cryptographic services that is associated with the DS8000. When the DS8000 is enabled for encryption, Tivoli Key Lifecycle Manager then generates a *symmetric data key*, which it wraps with the public key (from the previously mentioned asymmetric key) and sends the wrapped data key to the DS8000 in a structure known as the externally encrypted data key (EEDK). The EEDK is stored on the system area of the disk. Only Tivoli Key Lifecycle Manager can extract the data key from the EEDK, because only Tivoli Key Lifecycle Manager holds the private key. The data key is also encrypted using the DS8000's public key and sent to the DS8000 in a structure known as the session encrypted data key (SEDK). Because the DS8000 holds the corresponding private key, the DS8000 can retrieve the data key from the session encrypted data key. This data key is then used to create an access credential for the disk, and the Tivoli Key Lifecycle Manager server erases its copy o the data key.

The DS8000 Full Disk Encryption (FDE) encrypts all data on disks at all times, even when the disks are set to be non-encrypting. Each disk holds its own symmetric key (not the data key previously mentioned) that it uses to encrypt all data. The act of enabling encryption merely requires that the controller presents access credentials to the disk before the disk will allow access to the encrypted data. If encryption is not enabled, the disk does not require these access credentials, and it will simply read the encrypted data, decrypt it using its own symmetric key, and serve it to the host. In this way, the data key acts as an access credential, not as the major encrypting key.

When the DS8000 is powered off, it erases the data key, so that the only way that it can access the unlocking credentials and, hence, the data on the disk when it is powered up, is by obtaining the data key. The DS8000 sends the externally encrypted data key to the Tivoli Key Lifecycle Manager. Tivoli Key Lifecycle Manager is able to extract the data key, because it holds the corresponding private key, and Tivoli Key Lifecycle Manager sends the data key to the DS8000 in a session encrypted data key. Because the DS8000 holds the private key for the session encrypted data key, it is able to extract the data key and unlock the drives.

TS1120 and TS1130 tape drives

Tivoli Key Lifecycle Manager requests an Advanced Encryption Standard (AES) key from the cryptographic services and serves it to the tape drives in two protected forms:

- The key can be encrypted or wrapped, using Rivest-Shamir-Adleman (RSA) key pairs. TS1100 tape drives write this copy of the key to the cartridge memory and to three additional places on the tape media in the cartridge for redundancy.
- The key can be separately wrapped for secure transfer to the tape drive where it is unwrapped upon arrival, and the key inside is used to encrypt the data being written to tape.

Additionally, the libraries now support Secure Sockets Layer (SSL)-encrypted connections between the Tivoli Key Lifecycle Manager and the library for all communication. However, even when not using SSL for general communication, Tivoli Key Lifecycle Manager always sends the keys to the library using a secured, encrypted session.

When an encrypted tape cartridge is read by a TS1100 Tape Drive, the protected AES key on the tape is sent to Tivoli Key Lifecycle Manager where the wrapped AES key is unwrapped. The AES key is then wrapped with a separate key for secure transfer back to the tape drive, where it is unwrapped and used to decrypt the data that is stored on the tape. Tivoli Key Lifecycle Manager also allows protected AES keys to be rewrapped, or rekeyed, using separate RSA keys from the original keys that were used when the tape was written. Rekeying is useful when an unexpected need arises to export volumes to business partners whose public keys were not included; it eliminates having to rewrite the entire tape and enables a tape cartridge's data key to be re-encrypted with a business partner's public key.

Figure 20-6 shows the whole process of write operation of the initial encrypted data to the empty tape.

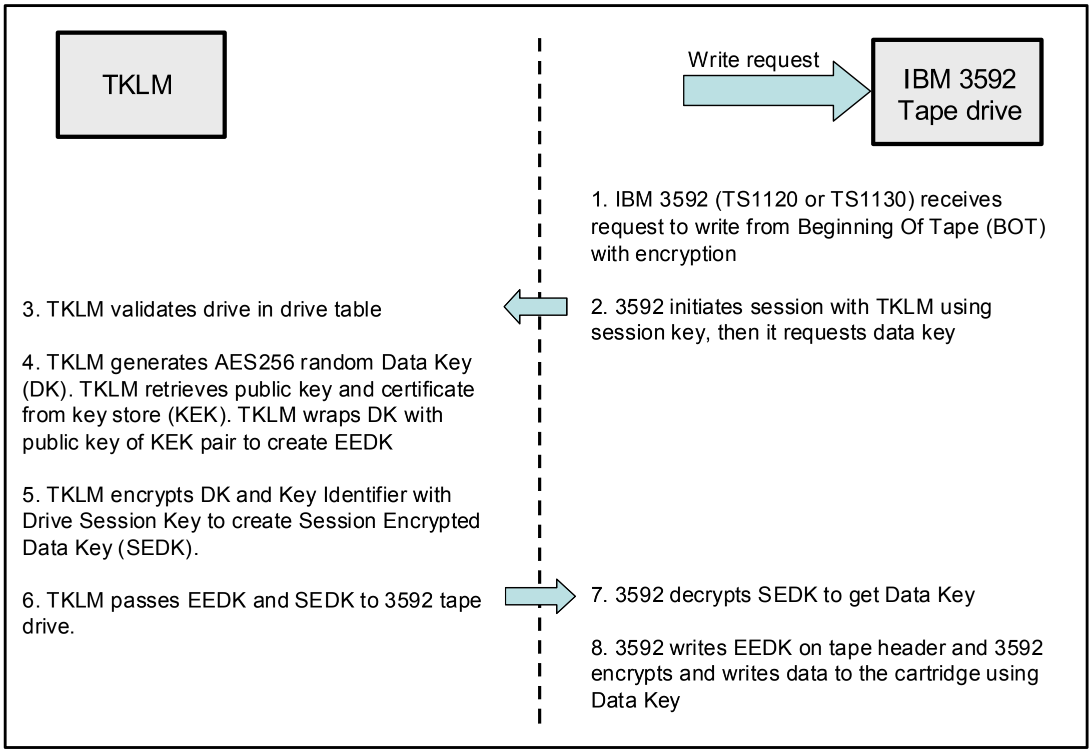


Figure 20-6 Initial write operation of encrypted data on IBM 3592 tape

A similar process between tape drive and Tivoli Key Lifecycle Manager applies when application initiates write operation to the 3592 tape cartridge already occupied by some initial data.

LTO Ultrium 4 and 5 tape drives

Tivoli Key Lifecycle Manager fetches an existing AES key from a keystore and wraps it for secure transfer to the tape drive where it is unwrapped upon arrival and used to encrypt the data being written to tape.

When an encrypted tape is read by an LTO Ultrium 4 Tape Drive, Tivoli Key Lifecycle Manager fetches the required key from the keystore, based on the information in the Key ID on the tape, and serves it, wrapped for secure transfer, to the tape drive.

20.4 Summary of key features and benefits

IBM Tivoli Key Lifecycle Manager (TKLM) helps IT organizations better manage the encryption key lifecycle by enabling them to centralize and strengthen key management processes throughout the enterprise.

While the amount of data continues to grow, the same applies to the demand for data encryption. The encryption keys are an integral and vital part of this strategy and need to be carefully managed, otherwise data loss or data exposure can occur. A reliable key management solution can provide the whole life cycle management in an effective, centralized, and transparent way.

IBM Tivoli Key Lifecycle Manager is a full life cycle encryption key manager that addresses many of the requirements and concerns of storage, security, and data governance teams:

- It reduces encryption management costs related to setup, use, and expiration of keys.
- It enables organizations to comply with data disclosure laws and regulations.
- It helps prevent loss of information due to key manual mismanagement.
- It transparently detects encryption-capable media to assign authorization keys.
- It supports the majority of platforms to utilize the servers' existing access control/high availability/disaster recovery configurations.

IBM Tivoli Key Lifecycle Manager simplifies, centralize, and strengthen encryption key management of organizations in the enterprise disk and tape solutions by enabling the following features:

- Transparently simplifies, centralizes, and automates the encryption key management process in an audit-ready way
- Enhances the data security while dramatically reducing the cost and complexity of managing encryption keys
- Simplifies encryption key management with an easy to use and intuitive user interface for configuration and management
- Utilizes the support for Key Management Interoperability Protocol (released through OASIS) and consolidate key management in a single enterprise key management system hence reducing operational costs and enhancing data security
- Helps minimize the risk of loss or breach of sensitive information
- Helps facilitate compliance management of government or industry regulatory standards
- Enhances security of key management operations with support for role based access control
- Utilizes open standards to help enable flexibility and facilitate vendor interoperability

20.4.1 Compliance with key lifecycle management process

Finally, we take a closer look at how Tivoli Key Lifecycle Manager (TKLM) meets some of the requirements for a key management solution as identified in 20.2, “Encryption key lifecycle management” on page 669.

- High availability:

  Disk drives and tape systems only need to communicate with TKLM once at power up when they obtain the key. Most of the time these devices can operate independently from TKLM. However, multiple TKLMs can be configured (primary and secondaries). If one of these systems becomes unavailable, there are one or more secondary systems available to take over the key serving task. In addition, because the TKLM is network attached to the device, the secondary Tivoli Key Lifecycle Managers can reside in remote location if needed. TKLM provides management tools to enable the primary and secondary systems to be kept synchronized. TKLM offers management tools to allow full backup and restore of all its critical data.

- High performance:

  TKLM is typically deployed on a dedicated server. The connectivity to the target device is usually achieved by fast network, and the data volumes (used to deliver the keys to the storage devices) are relatively small and independent of the amount of data being encrypted, so network overhead is negligible.

- Scalability:

  By far the main potential overhead of any encrypting solution is the actual task of encrypting the data, which is performed by dedicated encryption hardware in each storage device (and not by Tivoli Key Lifecycle Manager). More supported storage devices can be added to this solution in the future, and each one can bring its own encryption engine. This implies scalable solution.

- Security:

  All versions of Tivoli Key Lifecycle Manager support the userid/password protected JCEKS keystore in addition to any platform specific security. In the z/OS environment, three additional keystore types are supported. Selecting the appropriate keystore for your environment is driven by the regulations and requirements that your business must meet.

- Reliability:

  TKLM provides a web-based graphical user interface (GUI) for the creation and management of keys. It provides sufficient level of monitoring when certificates are due for expiration so they can be renewed or replaced in advance. TKLM also validates the devices to which it must provision the keys, efficiently and reliable delivers those keys to the authorized systems, while denying the key serving to all others.

- Simplicity and transparency:

  Tivoli Key Lifecycle Manager runs on a server that is effectively out-of-band to the data path. The applications have no awareness of the data being encrypted. They send the data to the disk, and the disk then handles the communication with Tivoli Key Lifecycle Manager to encrypt the data. The whole encryption process is transparent to the application.

  In addition, the TKLM environment is easy to install and use, with an installation wizard reducing the overall installation and configuration time to less than an hour for the distributed versions of Tivoli Key Lifecycle Manager. TKLM is managed by user-friendly web-based GUI as a part of Tivoli Integration Portal.

- Audit readiness:

  In order to provide the proof of correct and mandated encryption, full audit log is available. An audit record can be created for every type of encryption event and it is stored as a flat file in the filesystem, independently on the running TKLM application.

20.4.2 More information

For more information about the IBM Tivoli Key Lifecycle Manager, and to study typical scenarios of its implementation, see the following documentation:

- IBM Tivoli Key Lifecycle Manager Information Center Version 2, including planning, installation guide, and administration reference:

  http://publib.boulder.ibm.com/infocenter/tivihelp/v2r1/topic/com.ibm.tklm.doc_2.0/welcome.htm
- *IBM System Storage Data Encryption*, SG24-7797
- *IBM System Storage Open Systems Tape Encryption Solutions*, SG24-7907
- *IBM System Storage Tape Encryption Solutions*, SG24-7320
- *IBM System Storage DS8700 Disk Encryption*, REDP-4500
- *IBM Tivoli Key Lifecycle Manager for z/OS*, REDP-4472
- *Tivoli Key Lifecycle Manager for z/OS: Migration Guide for the IBM Encryption Key Manager*, REDP-4646
- *Using IBM Tivoli Key Lifecycle Manager: Business Benefits and Architecture Overview*, REDP-4529

21

IBM GPFS and SoFS

IBM General Parallel File System (GPFS) is a scalable, parallel, clustered file system. In addition to high-speed parallel file access, GPFS provides fault tolerance, including automatic recovery from disk and node failures. IBM General Parallel File System (GPFS) currently powers many of the world's largest scientific supercomputers and commercial applications requiring high-speed access to large volumes of data.

IBM scale out file services (SOFS) is a flexible storage virtualization service that will help alleviate data storage challenges by enabling quick implementation of highly scalable, global, clustered network attached storage systems.

These virtualization products are part of an IBM commitment to the open standards adopted by the Storage Networking Industry Association (SNIA). They implement standard common information model (CIM) based APIs to allow management applications from IBM, and other vendors to administer and monitor their activities.

Storage software solutions are a key element in the IBM overall storage strategy. This strategy addresses several of the most pressing needs currently facing Chief Information Officers (CIO) and IT managers. As part of its strategy, IBM intends to deliver industry-leading technologies that will help dramatically reduce total cost of ownership (TCO) for storage.

In this chapter, we first discuss IBM GPFS and then give you an overview of IBM SoFS.

21.1 IBM General Parallel File System

The IBM General Parallel File System (GPFS) is more than just a file system; it is a file management infrastructure. It provides unmatched performance and reliability with scalable access to critical file data. GPFS distinguishes itself from other cluster file systems by providing concurrent high-speed file access to applications executing on multiple nodes of an AIX cluster, a Linux cluster, or a heterogeneous cluster of AIX and Linux nodes. New with GPFS 3.4, you can add windows client nodes to an AIX, Linux or mixed cluster. In addition to providing file storage capabilities, GPFS provides storage management, information life cycle management tools, centralized administration and allows for shared access to file systems from remote GPFS clusters.

GPFS provides file system services to parallel and serial applications. GPFS allows parallel applications simultaneous access to the same files, or other files, from any node which has the GPFS file system mounted while managing a high level of control over all file system operations.

GPFS is particularly appropriate in an environment where the aggregate peak need for data bandwidth exceeds the capability of a distributed file system server. GPFS allows users shared file access within a single GPFS cluster and across multiple GPFS clusters.

GPFS currently powers many of the world's largest scientific supercomputers and commercial applications requiring high-speed access to large volumes of data such as these:

- Engineering design
- Digital Media
- Business intelligence
- Financial Analytics
- Seismic data processing
- Geographic information systems
- Scalable file serving

GPFS provides online storage management, scalable access, and integrated information lifecycle management tools capable of managing petabytes of data and billions of files. Virtualizing your file storage space and allowing multiple systems and applications to share common pools of storage provides you the flexibility to transparently administer the infrastructure without disrupting applications, improving cost and energy efficiency, while reducing management overhead.

Massive namespace support, seamless capacity and performance scaling, along with proven reliability features and flexible architecture of GPFS helps your company foster innovation by simplifying your environment and streamlining data workflows for increased efficiency.

Solutions that are powered by GPFS include these:

- IBM Scale Out Network Attached Storage
- IBM Smart Business Storage Cloud
- IBM Information Archive
- IBM Smart Analytics Optimizer
- IBM Digital Media Center
- Information Life cycle management
- The IBM TotalStorage Virtual Tape
- ServerSAP BI Accelerator

21.2 GPFS: Overview

A GPFS cluster consists of the following components:

- AIX nodes, Linux nodes, Windows nodes, or a combination thereof

  A node can be one of these possibilities:

  – An individual operating system image on a single computer within a cluster.

  – A system partition that contains an operating system. Certain IBM System p5® and IBM System p machines allow multiple system partitions, each of which is considered to be a node within a GPFS cluster.

- Network shared disks (NSDs) created and maintained by the NSD component of GPFS

  – All disks used by GPFS must first be given a globally-accessible NSD name.

  – The GPFS NSD component provides a method for cluster-wide disk naming and access.

  – On Linux machines running GPFS, you can give an NSD name to these components:

    • Physical disks
    • Logical partitions of a disk
    • Representations of physical disks (such as LUNs)

  – On AIX machines running GPFS, you can give an NSD name to these components:

    • Physical disks
    • Virtual shared disks

- A shared network for GPFS communications allowing a single network view of the configuration. A single network, a LAN or a switch, is used for GPFS communication, including the NSD communication.

GPFS allows users shared access to files in either the cluster where the file system was created or other GPFS clusters. Each site in the network is managed as a separate cluster, while allowing shared file system access. When multiple clusters are configured to access the same GPFS file system, Open Secure Sockets Layer (OpenSSL) is used to authenticate and check authorization for all network connections.

GPFS V3.4 adds enhanced Windows cluster support:

- Windows Server 2008 R2 x64.

- Directly attached disks support higher bandwidth by local I/O: The use of fully SAN-connected Windows clusters can enable much higher bandwidth to Windows systems using GPFS, and SAN connectivity can provide greater flexibility in configuring GPFS clusters.

- Homogeneous Windows clusters: GPFS clusters can now be formed using only Windows nodes; Linux or AIX are no longer required as NSD servers. The Windows nodes can perform most of the required management and administrative operations. Exceptions include these:

  – Certain GPFS commands to apply policy, administer quotas and ACLs
  – The ability to mount DMAPI-enabled file systems
  – Support for Tivoli Storage Manager (TSM) Backup Archive client or the native Windows Backup utility

See the *GPFS Concepts, Planning and Installation Guide* for a full list of limitations:

http://publibz.boulder.ibm.com/epubs/pdf/a7604134.pdf

There are further improvements for performance and scalability:

- Extended attributes for a file can now be stored in the file's i-node:

  This can improve the performance of applications that use extended attributes and reduce the amount of disk space required to store them. This change enables the high-performance GPFS policy engine to refer to extended attributes with the same scale-out performance as the regular file attributes, providing richer semantics to content managers and middleware.

- Provides support for more than 2,147,483,648 files in a file system. For the current maximum tested limit, see the GPFS FAQs at the following website:

  http://publib.boulder.ibm.com/infocenter/clresctr/vxrx/topic/com.ibm.cluster.gpfs.doc/gpfs_faqs/gpfs_faqs.html

- A new diagnostic command: The new **mmdiag** command better enables IBM Service to determine the state of your GPFS cluster.

> **Important:** Nodes running GPFS 3.4 can coexist and interoperate with nodes running GPFS 3.3. GPFS 3.4 is not compatible with GPFS 3.2 or earlier versions. After you install GPFS 3.4 on some of the nodes in the cluster, nodes that are still running GPFS 3.2 or earlier will not be able to join the cluster. Similarly, in a multicluster environment in which clusters are remotely mounting file systems from other clusters, if one of the clusters is migrated to GPFS 3.4, the remaining clusters are expected to be at GPFS 3.3 or later.

21.3 Benefits and highlights of GPFS

GPFS provides a wide range of beneficial features, among which are high levels of scalability and performance, data availability, flexibility, and simplified storage management.

21.3.1 Scalable high-performance shared disk file systems

GPFS is not a network file system like NFS. There is no single-server bottleneck or protocol overhead for data transfer. GPFS takes file management beyond a single system by providing scalable access from multiple systems to a global namespace. This is done by:

- Allowing multiple processes or applications on all nodes in the cluster simultaneous access to the same file using standard file system calls.
- Increasing aggregate bandwidth of your file system by spreading reads and writes across multiple disks.
- Balancing the load evenly across all disks to maximize their combined throughput. One disk is no more active than another.
- Supporting very large file and file system sizes.
- Allowing concurrent reads and writes from multiple nodes.
- Allowing for distributed token (lock) management.
- Independent paths to the same file by the same name from anywhere in the cluster
- Allowing for the specification of various networks for GPFS daemon communication and for GPFS administration command usage within your cluster.

Achieving high throughput to a single, large file requires striping data across multiple disks and multiple disk controllers. Rather than relying on striping in a separate volume manager layer, GPFS implements striping in the file system. Managing its own striping affords GPFS the control it needs to achieve fault tolerance and to balance load across adapters, storage controllers, and disks. Large files in GPFS are divided into equal sized blocks, and consecutive blocks are placed on separate disks in a round-robin fashion.

To exploit disk parallelism when reading a large file from a single-threaded application, whenever it can recognize a pattern, GPFS prefetches data into its buffer pool, issuing I/O requests in parallel to as many disks as necessary to achieve the bandwidth of which the switching fabric is capable. GPFS recognizes sequential, reverse sequential, and various forms of striped access patterns.

GPFS uses a sophisticated token management system to provide data consistency while allowing multiple independent paths to the same file by the same name from anywhere in the cluster

21.3.2 Increased data availability

GPFS provides multiple features that improve the reliability of your file system. This includes automatic features like file system logging and configurable features like intelligently mounting file systems on startup to providing tools for flexible synchronous replication.

GPFS allows you to organize your storage hardware into failure groups. A failure group is defined as a set of disks that share a common point of failure that can cause them all to become simultaneously unavailable. Failure groups are defined by the system administrator, so care needs to be taken when defining disks to ensure proper failure group isolation. When used in conjunction with the replication feature of GPFS, the creation of multiple failure groups provides for increased file availability in case a group of disks fails. Replication in GPFS ensures that there is a copy of each block of replicated data and metadata on disks in different failure groups. In this case, if a set of disks becomes unavailable, GPFS fails over to the replicated copies in another failure group.

During configuration, you assign a replication factor to indicate the total number of copies of data and metadata you wish to store. Currently the maximum replication factor is 2, indicating that two copies of data and metadata must be kept for replicated files. Replication allows you to set different levels of protection for each file or one level for an entire file system. Because replication uses additional disk space and requires extra write time, consider the impact of replication on your application, especially if the replication is occurring over a WAN. To reduce the overhead involved with the replication of data, you can also choose to replicate only metadata as a means of providing additional file system protection.

GPFS is a logging file system and creates separate logs for each node. These logs record the allocation and modification of metadata aiding in fast recovery and the restoration of data consistency in the event of node failure. Even if you do not specify replication when creating a file system, GPFS automatically replicates recovery logs in separate failure groups, if multiple failure groups are available. This replication feature can be used in conjunction with other GPFS capabilities to maintain one replica in a geographically separate location which provides the capability to survive disasters at the other location.

Disks can be added or deleted while the file system is mounted. When the time is right and system demand is low, you can then rebalance the file system across all currently configured disks. In addition, you can also add or delete nodes without having to stop and restart the GPFS daemon on all nodes.

In a SAN configuration where you have also defined NSD servers, if the physical connection to the disk is broken, GPFS dynamically switches disk access to the servers nodes and continues to provide data through NSD server nodes. GPFS falls back to local disk access when it has discovered the path has been repaired.

21.3.3 Simplified storage management

GPFS provides storage management based on the definition and use of these elements:

- Storage pools
- Policies
- Filesets

Storage pools

A storage pool is a collection of disks or RAIDs with similar properties that are managed together as a group. Storage pools provide a method to partition storage on the file system, which assists with improvements in these areas:

- Price-performance, by matching the cost of storage to the value of the data
- Performance, by reducing the contention for premium storage, and reducing the impact of slower devices
- Reliability, by providing for replication based on need and better failure containment

Policies

Files are assigned to a storage pool based on defined policies, providing these capabilities:

- Placing files in a specific storage pool when the files are created
- Migrating files from one storage pool to another
- File deletion based on file characteristics
- Snapshot metadata scans and file list creation

Filesets

Filesets provide a method for partitioning a file system and allow administrative operations at a finer granularity than the entire file system. For example, filesets allow you to do these tasks:

- Define data block and inode quotas at the fileset level
- Apply policy rules to specific filesets

Comprehensive features and benefits of the GPFS file system are highlighted in Table 21-1.

21.3.4 Simplified administration: Features and benefits of GPFS

GPFS offers many of the standard UNIX file system interfaces allowing most applications to execute without modification or recompiling. UNIX file system utilities are also supported by GPFS. That is, users can continue to use the UNIX commands they have always used for ordinary file operations

The only unique commands are those for administering the GPFS file system. GPFS administration commands are similar in name and function to UNIX file system commands, with one important difference: the GPFS commands operate on multiple nodes. A single GPFS command performs a file system function across the entire cluster.

GPFS commands save configuration and file system information in one or more files, collectively known as GPFS cluster configuration data files. The GPFS administration commands are designed to keep these files synchronized between each other and with the GPFS system files on each node in the cluster, thereby providing for accurate configuration data.

Table 21-1 summarizes the key features and benefits provided.

Table 21-1 GPFS features and benefits.

Feature	Benefit
Highly Scalable File System. Supports thousands of nodes and thousands of disks.	GPFS enables the scale out expansion of the file system using a building block approach with commodity components as service demands and data volumes increase.
Data Protection. Both user data and metadata can be replicated (mirrored) in the GPFS installation.	Improves availability by ensuring reliable access to data and metadata.
Parallel File System. Divides individual files into multiple blocks and stores these blocks across multiple disks or disk arrays in parallel.	Higher performance and reliability by eliminating the bottlenecks that typically arise when an entire file resides on a single node.
Storage Pools. User-defined grouping of storage resources.	Storage can be grouped or tiered based on factors such as location, performance and reliability.
External Storage Pools. Policy driven interactions with external applications for near-line data storage.	External pools utilize the high performance policy engine to expand your data storage options. For example, an external pool data can be stored on a tape library.
Policy-Driven Automation	Simplifies data management and allows matching the cost of storage to the value/importance of the data. For example, critical data can be stored on the fastest storage.
Concurrent File Access and Block-Level Locking	Enables multiple users, programs or nodes to access a single file simultaneously – accelerates processing for parallel applications that share data and eliminates the need for multiple copies of data, reducing data storage and management costs.
High Availability	Automatically recovers from events that can normally interrupt data availability. Applications and users can continue without interruption in the event of a node, path or storage system failure.
Clustered NFS. Tools to deploy and manage a clustered NFS file serving solution.	Provides an integrated solution enabling scalable NFS file serving from a cluster of Linux servers.
Large Blocksize Options	Data blocks of 16K, to 4MB can be used to optimize throughput for various applications. Large blocks allow more data to be written or read in a single operation. The wide range of block sizes enables more efficient use of disk bandwidth and available storage space.

21.4 SoFS: Overview

IBM scale out file services (SOFS) is a combination of hardware and software components combined to form a system, or solution, which provides highly scalable and highly available virtualized shared file system access, as shown in Figure 21-1. Virtualizing the file sharing system (NFS, CIFS, and so on) using a single, global, namespace means that an end user sees one device rather than individual servers and storage devices that comprise this virtual NAS device.

At the heart of the SoFS system is the IBM General Parallel File System (GPFS). GPFS is one of the most scalable commercial file systems available, installed in thousands of nodes and storing petabytes of data in discrete installations. Scale out file services enable the virtualization of the NFS service, transparently distributing service requests across multiple servers, which in turn enables the creation of a scale-out NAS farm installation.

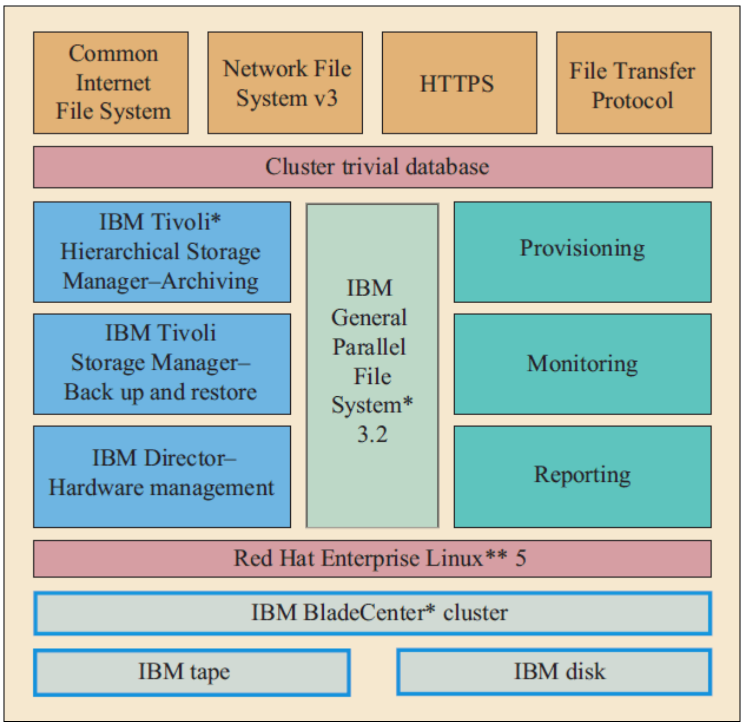


Figure 21-1 SoFS components

The SoFS solution is extremely resilient. It is designed so there is no single point of failure in the system. It also allows for a disaster recovery configuration that uses the global file system. It also supports snapshots and mirroring for high availability and smaller backup windows. The SoFS solution also supports data lifecycle management. Data can be stored in ways relative to the data value and performance requirements. And SoFS also supports LTO-4 tape backup with data encryption. This offers protection for archived data.

21.5 How SoFS works

The SoFS system provides file services by implementing a *scale-out* approach, hence the product name, IBM Scale out File Services. SoFS uses the wide-striping capability of IBM GPFS to spread the blocks of a single file across as many nodes as possible to combine the streaming performance of many midrange back-end storage devices. By doing so, a bandwidth of multiple gigabytes per second is possible because the I/O performance of many disks can be combined instead of storing data only to a small RAID device as filers do today.

By fully exploiting the capabilities of GPFS, the integration of a policy-based lifecycle management interface and the possibility to place files in a directory that spans multiple independent storage classes creates a single file system with multiple storage classes. Each has its own performance, availability, and cost criteria, on a file basis, not on a filer basis, as has been done in the past.

SoFS utilizes and expands the IBM Tivoli Storage Manager and Tivoli Hierarchical Storage Manager products to integrate tape as an additional storage class inside the scale-out NAS. This allows transparent migration of data between disk and tape storage and provides end-to-end lifecycle management of the data.

The physical implementation of SoFS utilizes the IBM Bladecenter for highly efficient and scalable processing with various IBM storage devices. The Bladecenter provides a scalable platform for adding storage controllers into the SoFS pool to achieve the right performance balance. Processing blades share power, cooling, and I/O connectivity within the Bladecenter chassis and achieve very efficient performance versus stand-alone servers.

To provide a single global namespace to the user, SoFS uses virtualization and redirection technologies available within GPFS clusters. Each SoFS cluster node has internal access to all data blocks simultaneously and is able to assume the responsibility for each of the other nodes in a cluster. This provides the means for a transparent, non-disruptive protocol failover for client applications. As none of the existing cluster technologies provides a transparent failover of network-based file systems, SoFS introduces an extremely scalable cluster suite dealing with the specifics of file systems to provide a high degree of semantic correctness while being able to scale to very high bandwidths.

21.6 Why use SoFS

The efficient management of data is an ongoing struggle between access and scalability. Providing access to file-level data (that is, those files associated with individual documents, multimedia content, databases, and other applications) becomes more difficult as the number of users with access, and the amount of data stored, both grow.

21.6.1 Using the scale-up approach

Achieving the scalability needed to respond to the growth of data volume typically results in higher hardware and software costs and greater management challenges. Network-attached storage (NAS) solutions provide simplicity, manageability, and access, but until now, they lacked a single capability that has kept them from playing a role beyond the departmental level: scalability.

If a traditional filer is reaching a scalability or capacity limit, users upgrade to the next higher filer level until they reach the highest available system; this is the *scale-up* approach.

Instead of scaling up in a single high-end enterprise-class server node or building failover clusters to provide high availability for the filers, the SoFS system utilizes software functions to build a global namespace and exposes to the end user *a single virtual cluster node* with very high scalability.

21.6.2 Difference between SoFS and other clustered file systems

Whereas other clustered File systems are just that, SoFS is more of a "storage controller in a grid," meaning that the ownership of data is handled dynamically. In many clustered file system implementations, there is one node that is the default owner of a portion of the data. To maintain this structure requires high volumes of internode communication and in case the owning node goes down, the IP and data must be taken over by another node. While IP takeover is not a big problem, the takeover of data often proves difficult. In SoFS, this problem is completely non-existent, as any node can see any data at any time.

21.7 Components within an SoFS solution

In this section, we discuss the various hardware and software components of the SoFS solution.

21.7.1 SoFS hardware components

The hardware side of a SoFS solution consists of servers, SAN switches, and disk storage. Tape storage for archiving data is an optional part of any SoFS solution.

Storage server

The servers used in a SoFS solution are clusters of BladeCenter HS21 or HS21 XM blades or rack mounted X3650M2 servers. Production servers might be connected by Gigabit or 10 Gigabit Ethernet. Connectivity to the switches and storage units is by Fibre Channel only for the blades, and Fibre Channel or SAS attachment for the rack mounted servers.

As a minimum, three System x servers are required. All servers in a configuration will be the same type. A separate management console can be added, or that function can be located in one of the System x servers. The BladeCenter HS21 or HS21 XM blades can be housed in a BladeCenter H with Gigabit Ethernet or a BladeCenter H with 10 Gigabit Ethernet.

SAN hardware

The SAN switch hardware currently used for SoFS systems can be seen in Table 21-2. The base configuration of these switches activates less than the maximum number of Fibre Channel ports on the switch, but for SoFS configurations, all ports will be activated.

Table 21-2 SoFS SAN switch hardware

Switch model	Description
2005-B16	SAN16B-2, 16-port 4Gbps Fibre Channel Switch
2498-24E	SAN24B-4, 24-port 8Gbps Fibre Channel Switch
2498-40E	SAN40B-4, 40-port 8Gbps Fibre Channel Switch

Storage units

Data is stored on one or more of the IBM storage system units described in Table 21-3.

Table 21-3 SoFS storage units

Storage unit	Description
XIV (2810-A14)	This large solution provides a capacity of 180 TB and uses only 1 TB or 2 TB SATA disk drives. The system has up to 240 GB cache and 24 FC host ports and up to 6 iSCSI ports.
DS8000	SoFS will support the use of DS8100, DS8300, and DS8700 systems, but a special request must be made. Configurations will be customized to the particular solution. This large solution provides up to 512 TB using FATA disks or 307.2 TB using FC disks, up to 32 GB cache, up to 128 FC host ports
IBM SVC	SoFS will support attachment of IBM SVC managed devices, this means any devices not on the supported hardware list can be used for SoFS storage devices if they are supported by SVC.
DCS9900	SoFS will support the use of the DCS9900. This midsize solution provides up to 1.2 PB per system (2.4 TB with 2 TB using SATA disks, SAS 450 GB and 600 GB, RAID-6, 8 FC 8 GB host ports. Through its parallel, non-blocking architecture, the DCS9900 delivers up to 5.9 GBps data streaming bandwidth from/to disk media whether reading or writing data.
DS4800	This midsize solution provides up to 168 TB using SATA disks or 67.2 TB using FC disks, up to 16 GB cache, 8 FC host ports
DS4200	This midsize solution provides up to 84 TB using SATA disks, 2 GB cache, 4 FC host ports.
DS3400	This dual controller model of the DS3400 is the only one supported in SoFS configurations. Any number of DS3400 systems that can fit into the SAN network are supported in SoFS configurations. The preferred LUN configuration with 4 enclosures is RAID 5 in a 3+P arrangement so that each drive is in a separate enclosure. As a result, the system can survive the loss of a complete enclosure without losing a LUN.
DS3200	This entry-level solution provides up 14.4 TB using SAS disks, up to 1 GB cache, and 6 SAS host ports.

Support: Supported hardware device information is supplied by Techline and current as of 1 October 2009. Consult your IBM or business partner sales team for updated information.

21.7.2 SoFS software components

IBM GPFS 3.2 product on servers running Red Hat Enterprise Linux 5 Is the heart of the SoFS system; this provides the SoFS cluster nodes with a single-system view of the file system. See Figure 21-1 on page 686 for an overview of the software components of SoFS system.

Included within SoFS is a CIFS component that is based on the Samba open source project and a newly developed, high speed, cluster-aware version of the TDB metadata store database used by Samba. This Cluster Trivial Database (CTDB) allows Samba to scale well across multiple cluster nodes. A more detailed explanation of this is available in the following paper: IBM Scale out File Services: Reinventing network-attached storage, at this website:

http://www-935.ibm.com/services/us/its/pdf/sofs-am-journal-final-070108.pdf

Other software components included and their function are shown in Table 21-4.

Table 21-4 SoFS software components

Component	SoFS function
IBM Director	Hardware management
IBM Tivoli Storage Manager	Backup and restore
IBM Tivoli Hierarchical Storage manager	Archiving
DS Storage Manager SMclient	Storage device management
SoFS GUI	User interface
SoFS Toolset	Management of SoFS system

21.8 Data protection and disaster recovery

There are a number of choices the operator can make in the area of data protection and disaster recovery. SoFS allows for appropriate choices for each type of data, giving maximum flexibility to enable the right choice for each tier of data.

21.8.1 Data protection

The data protection choices match the choices available on the storage system used in the SoFS solution. These typically include RAID 5, RAID 6, RAID 10, and the unique XIV data protection algorithm.

21.8.2 Simple SoFS single site solution: No disaster recovery

A simple SoFS solution as shown in Figure 21-2 allows users to access data locally using a LAN, and remotely using a WAN. Although the high availability is built into a single system, there is no disaster recovery built into this solution.

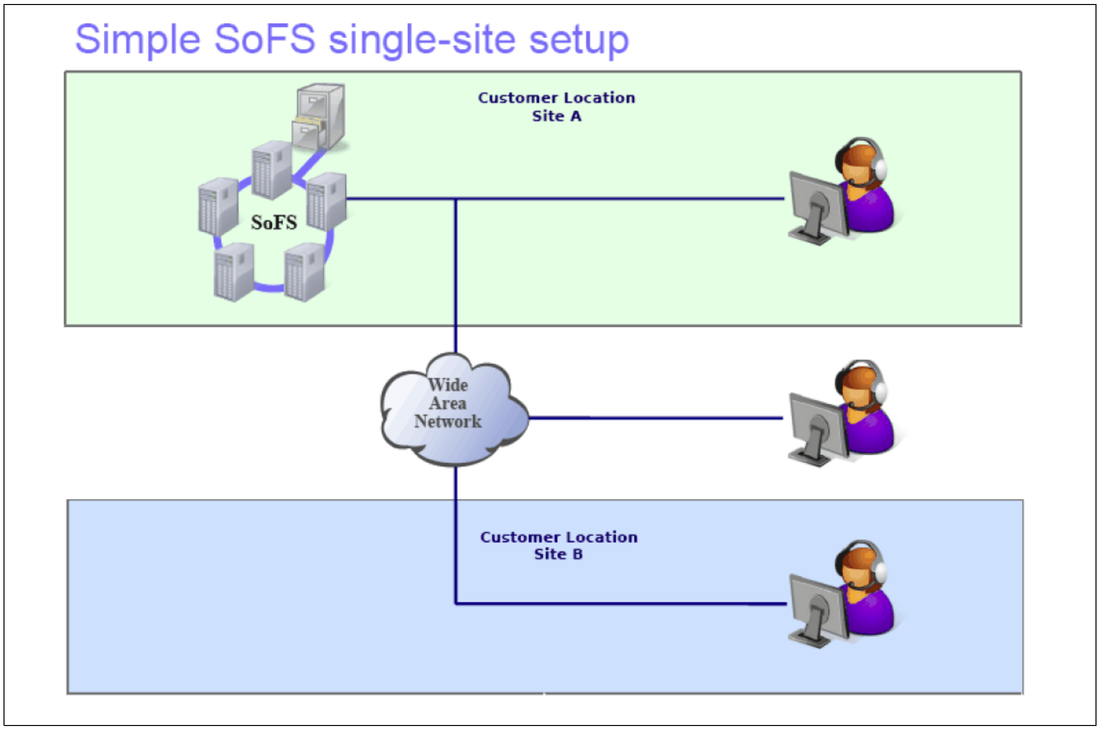


Figure 21-2 Single-site setup

21.8.3 SoFS with synchronous replication on-site

The operator can set up synchronous replication of part or all of the data to other nodes within the same SoFS site as shown in Figure 21-3.

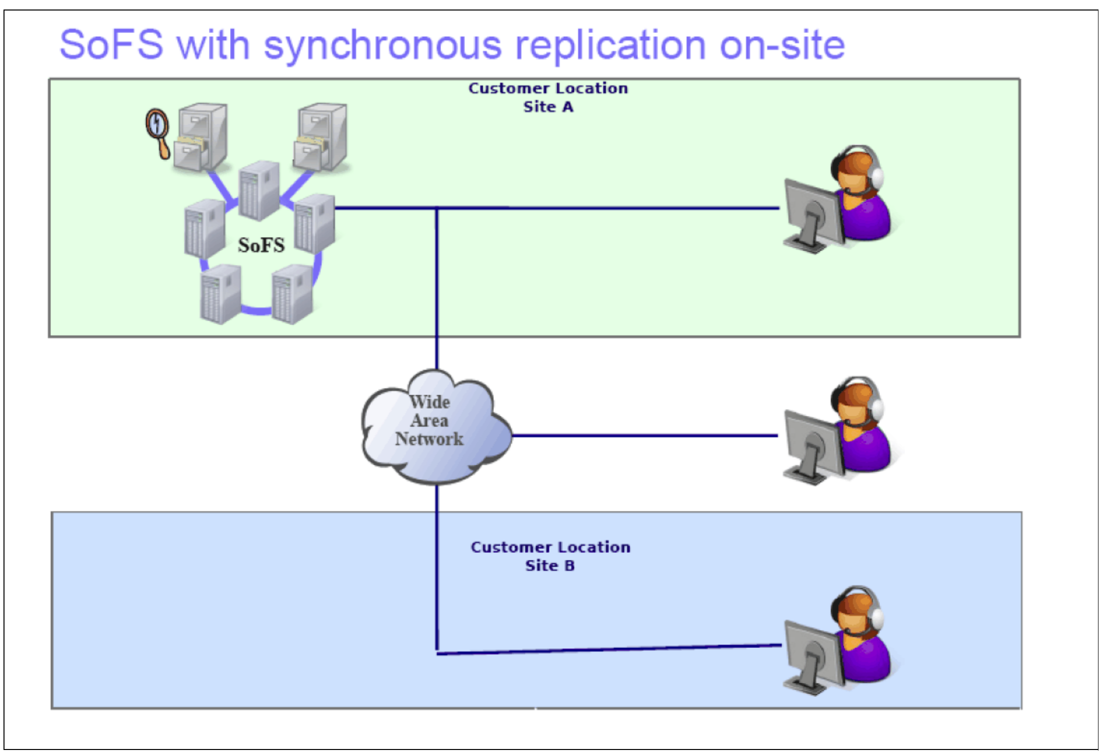


Figure 21-3 Sync replication on a single site

21.8.4 SoFS with cross site replication

The operator can set up replication of data between SoFS clusters on various sites as shown in Figure 21-4. The replication can be synchronous if the distance can be traversed by Fibre Channel cables. It is asynchronous if the distance is longer.

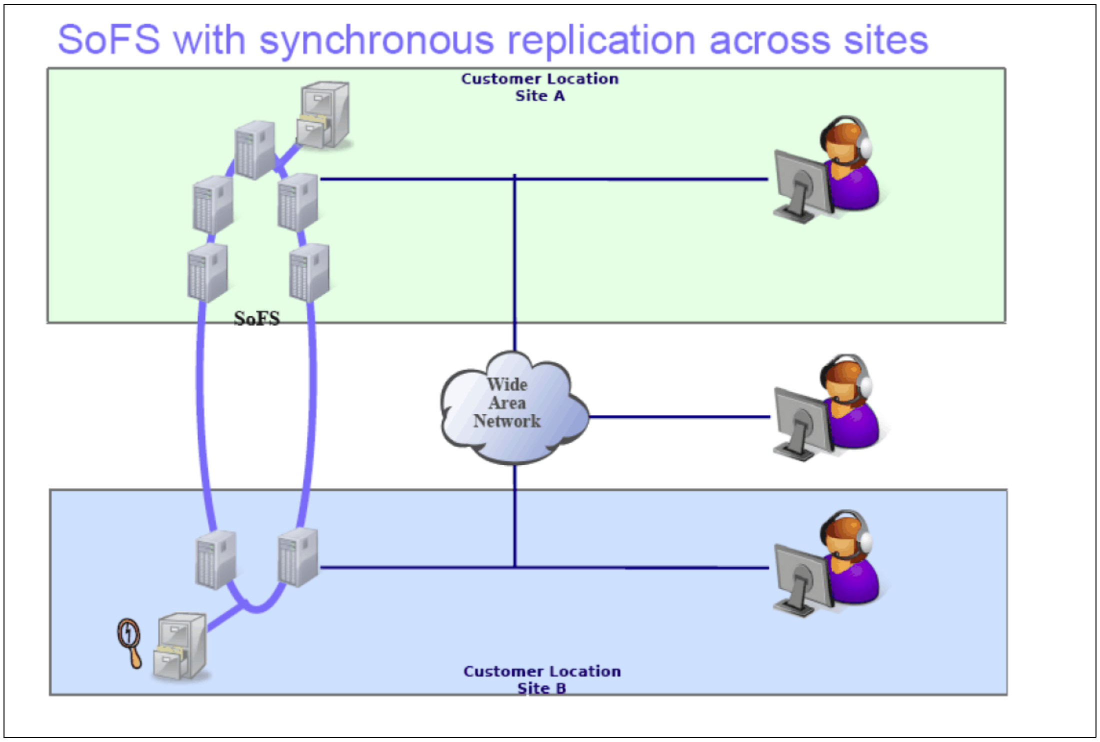


Figure 21-4 Cross site replication

21.8.5 SoFS with a cross cluster mount

Two SoFS sites can be connected and each file system mounted on the other to provide a solution that works as one large SoFS that covers two sites as shown in Figure 21-5. Within that complex, mirrors of data can be set up on various sites within the single SoFS solution. The cross cluster mount requires a TCP/IP connection between the clusters. This IP connection can be used for data and metadata traffic. As an option, there is also the ability to send data traffic over a Fibre Channel (SAN) connection between the clusters.

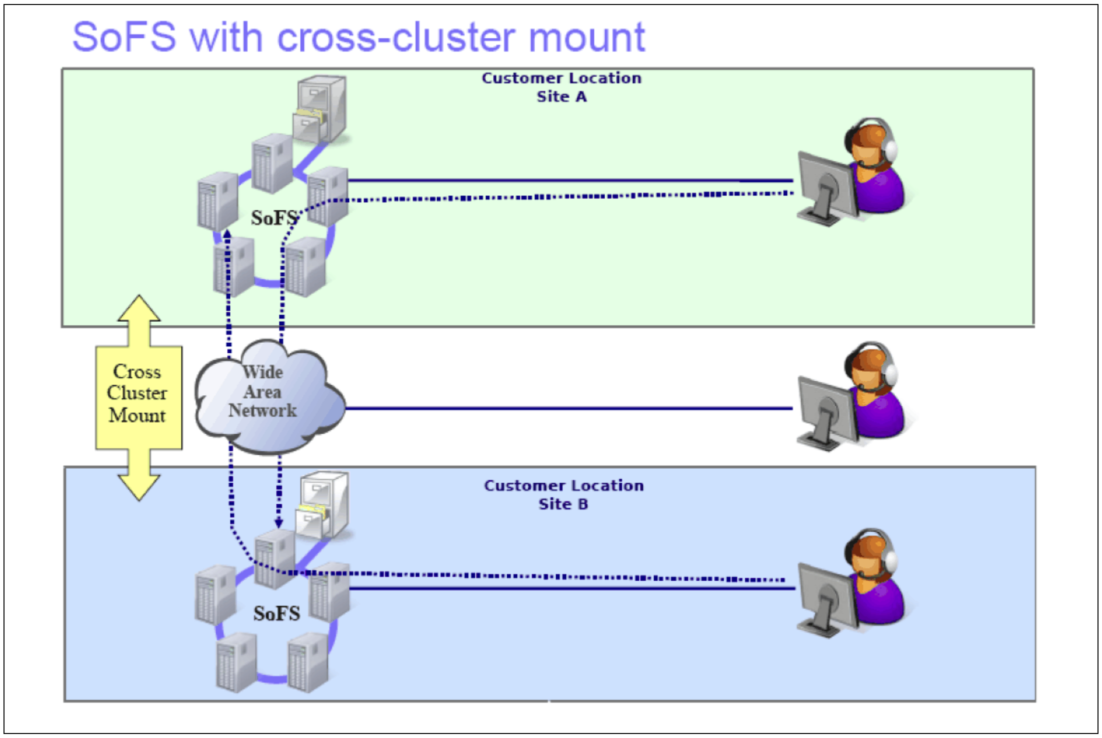


Figure 21-5 Cross cluster mounts

21.8.6 Snapshot technology

A snapshot of an entire GPFS file system might be created to preserve the file system's contents at a single point in time. A snapshot contains a copy of only the file system data that has been changed since it was created, using a copy on write technique. Snapshots of a file system are read-only; changes might only be made to the active (that is, normal, non-snapshot) files and directories.

The snapshot function allows a backup or mirror program to run concurrently with user updates and still obtain a consistent copy of the file system as of the time that the snapshot was created. Snapshots also provide an online backup capability that allows easy recovery from common problems such as accidental deletion of a file, and comparison with older versions of a file. Because snapshots are not copies of the entire file system, they must not be used as protection against media failures.

21.9 More information

Further information about SoFS can be found here:

http://www-935.ibm.com/services/us/its/html/sofs-landing.html

A more detailed overview of SoFS is available in this white paper:

http://www-935.ibm.com/services/us/its/pdf/sofs-am-journal-final-070108.pdf

An ATS white paper provides an overview and sample configuration information:

http://www-03.ibm.com/support/techdocs/atsmastr.nsf/WebIndex/WP101565

Many thanks: Much of the information in this chapter was taken from the two documents referenced previously and is reproduced with the kind permission of the original authors.

For more information about GPFS, see these links:

- GPFS product home page:

  http://www.ibm.com/systems/clusters/software/gpfs/index.html

- GPFS 3.x information flyer:

  ftp://ftp.software.ibm.com/common/ssi/pm/fy/n/clf03001usen/CLF03001USEN.PDF

- Introduction to GPFS version 3.4 (current version at the time of writing):

  http://publib.boulder.ibm.com/infocenter/clresctr/vxrx/index.jsp?topic=%2Fcom.ibm.cluster.gpfs.doc%2Fgpfsbooks.html

Part 5

z/OS storage management

In Part 5 we describe the following products for z/OS storage management:

- DFSMS
- DFSORT
- z/OS storage management tools

22

Data management with DFSMS and data sorting with DFSORT

The Data Facility Storage Management Subsystem (DFSMS) is a software suite that automatically manages data from creation to expiration. DFSMS provides allocation control for availability and performance, backup/recovery and disaster recovery services, space management, tape management, and reporting and simulation for performance and configuration tuning. It offers the following benefits:

- Integrated, comprehensive data management solution
- Delivers managed, predictable service to meet Service Level Agreements for Storage
- Up to 50% increased effective storage capacity with reduced overall storage cost.

On the other hand Data Facility Sort (DFSORT) is the IBM high-performance sort, merge, copy, analysis, and reporting product. DFSORT is an optional feature of z/OS.

DFSMS is made up of the following components:

- Data Facility Product (DFSMSdfp): A base element of z/OS providing storage, data, program, and device management functions and DFSMS Copy Services capabilities.
- Data Set Services (DFSMSdss): An optional feature of z/OS providing data movement, copy, backup, and space management functions.
- Hierarchical Storage Manager (DFSMShsm): An optional feature of z/OS providing backup, recovery, migration, and space management functions.
- Removable Media Manager (DFSMSrmm): An optional feature of z/OS providing management functions for removable media.
- Transactional VSAM Services (DFSMStvs): An optional feature of z/OS that enables batch jobs and CICS® online transactions to update shared VSAM data sets concurrently

In this chapter, we briefly discuss each of those components and especially Data Facility Sort.

22.1 Data Facility Product (DFSMSdfp)

The Data Facility Product (DFSMSdfp) is the heart of the storage management subsystem; it provides the logical and physical input and output for z/OS storage, it keeps track of all data and programs managed within z/OS, and it provides data access both for native z/OS applications and other platforms such as AIX/UNIX, the Windows family, AS/400, or OS/2.

DFSMSdfp helps you store and catalog information about DASD, optical, and tape resources so that it can be quickly identified and retrieved from the system. You can use the Catalog Search Interface, now part of DFSMSdfp, to access the catalog.

DFSMSdfp includes ISMF, an interactive facility that lets you define and maintain policies to manage your storage resources on z/OS. Additionally it combines programs into executable modules, prepares them to run on the operating system, stores them in libraries, and reads them into storage for execution.

DFSMSdfp is involved in defining your input and output devices to the system and in controlling the operation of those devices in the z/OS environment.

22.1.1 DFSMS SDM Copy Services

The IBM Data Facility Storage Management Subsystem (DFSMS) System Data Mover (SDM) Copy Services are enterprise-level data duplication and disaster recovery capabilities.

Capabilities

The following capabilities are included:

- z/OS Global Mirror, also known as Extended Remote Copy (XRC)
- Peer-to-Peer Remote Copy (PPRC) including:
  - Metro Mirror, also known as synchronous PPRC
  - Global Copy, also known as PPRC-XD
  - Global Mirror
- 3-site solutions:
  - Metro/Global Copy
  - Metro/Global Mirror (M/GM)
  - Metro/zGlobal Mirror (M/zGM)
- FlashCopy
- Concurrent Copy
- Virtual Concurrent Copy
- SnapShot

Features and benefits

Here we list the main features and benefits provided:

- The product provides a comprehensive disaster recovery solution for the z/OS environment.
- Included are a range of data duplication solutions that solve the customer requirement for an immediate point-in-time copy of data.
- SDM provides TSO commands and the ANTRQST API to enable disk hardware copy services functions.

- The DFSMSdfp NaviQuest component enables you to perform SMS migration functions and many routine storage management tasks, including testing and reporting, in batch.

> **Reference:** To understand more about FlashCopy, PPRC, and other features listed previously, see the website:
>
> http://www.ibm.com/systems/storage/software/sms/sdm/index.html

22.1.2 z/OS NFS

The z/OS Network File System (NFS) is a network file system product that brings IBM leading-edge, system-managed storage to the network environment. It lets you optimize efficiency in a distributed network while still capitalizing on the capacity, security, and integrity of z/OS multiple virtual storage (MVS™).

One can use z/OS NFS for file serving (as a data repository) and file sharing between platforms supported by z/OS.

You can also use NFS to remotely access both conventional MVS data sets and UNIX files. These remote MVS data sets or z/OS UNIX files are mounted from the mainframe to appear as local directories or files on the client system. As a result, you can bring the resources of an MVS system (such as system-managed storage, high-performance storage access, file access security, and centralized data access) to client platforms.

The data set organizations that z/OS NFS supports include physical sequential (PS), direct access (DA), partitioned data sets (PDS), partitioned data sets extended (PDSE), VSAM KSDS, VSAM ESDS, VSAM RRDS, SAM extended format data sets, and multivolume data sets. Both SMS-managed and non-SMS-managed data sets are supported. z/OS NFS does not support tape and optical drives, nor does it support generation data sets or multi-volume striped data sets.

The z/OS NFS server is used with an NFS client which allows remote applications on other servers to access z/OS data. Tested clients for the z/OS NFS server include these:

- IBM RS/6000 AIX V5.3 and higher
- Sun Solaris V10
- Enterprise Linux 4

> **Platforms:** Other client platforms ought to work as well, because NFS version 4 is an industry standard protocol, but they have not been tested by IBM.

22.1.3 XRC Performance Monitor

Extended Remote Copy (XRC), also known as z/OS Global Mirror is the IBM premier disaster recovery option for zSeries storage systems.

The XRC Performance Monitor provides additional information to better manage an XRC environment and help XRC achieve the desired performance (typically measured as the latency in updating the mirrored system) at a low cost. The monitor provides information in realtime and also maintains historic records. From a very high level or from a detailed perspective, administrators can view the parameters that contribute to system performance.

Several parts of an IBM zSeries environment affect the performance of XRC. The XRC Performance Monitor gathers information from important sources. This functionality not only helps determine the optimum XRC configuration,but also helps quickly identify performance bottlenecks. The XRC Performance Monitor is also useful in spotting trends that might lead to future performance problems;thus it can also assist with capacity planning

XRC Performance Monitor comprises three separate modules, which are integrated under one user interface:

- *History monitor* summarizes how the XRC system was running at a prior point in time.
- *Realtime monitor* provides a summary of how system data movers are running.
- *Batch exception monitor* checks the monitor information at user defined intervals for predefined thresholds.

The bandwidth of the telecommunications link between the primary and secondary sites is one of the key manageable resources in an XRC system. Because of the cost of high-speed circuits, overbuying capacity can add expense without much benefit. Likewise, if the link is too slow, unacceptably long delays might be introduced when updating the mirrored system.

One of the key applications of the XRC Performance Monitor is to make sure the link is sized properly. Typically, traffic on the telecommunications link varies throughout the day. For example, batch updates to an online system at night often produce much higher traffic on the XRC link than daytime operations. Unattended charting enables administrators to see latency as it varies throughout the day so that they can size resources accordingly. Historical charts show trends, which can be useful for predicting future demands.

Reference: For more details about XRC, see the website:

`http://www.ibm.com/systems/storage/software/xrc/index.html`

22.1.4 IBM TotalStorage Expert

The IBM TotalStorage ETL Expert is a program whose purpose is to help administrators manage Enterprise Tape Library (ETL) products using a web browser interface. TotalStorage ETL Expert helps with the following tasks:

- Performance management
- Asset management
- Capacity management

Performance management for ETL

System administrators might need to analyze performance information when an applications performance had been degraded. The IBM TotalStorage ETL Expert can gather performance information for the IBM TotalStorage 3494 Tape Library, IBM TotalStorage Virtual Tape Servers (VTS) or peer-to-peer VTS or any combination of the three. TotalStorage ETL Expert allows admininstrators to manage ETL's performance no matter what kind of host platform is used.

Asset management for ETL

An IBM ETL can contain up to three libraries. From a host system's viewpoint, all of these can be seen as a “tape library,” but the physical configuration varies extensively for each. For example, a VTS is comprised of VTS controller, Tape Volume Cache (TVC) and its back end native tape library. Adminstrators might want to review which VTS uses which native tape library or might want to review how many physical tape drives in a native library are allocated for a VTS's use. The TotalStorage ETL Expert shows the relationship between libraries and the configuration is made plain and simple.

Capacity management for VTS/ETL

The TotalStorage Expert can show the capacity information for VTS, for example, how much data is active in back-end tape cartridges, and how many empty tape cartridges are available for stacked logical volumes. This information is important not only from a capacity planning perspective, but also from the VTS's performance viewpoint, because the tape cartridge utilization is tightly aligned with the VTS's back-end operation.

> **Reference:** For more details on TotalStorage Expert, see the website:
>
> http://www.ibm.com/systems/storage/software/expert/index.html

22.2 Data Set Services (DFSMSdss)

Data Set Services (DFSMSdss), a component of the Data Facility Storage Management Subsystem (DFSMS), provides the following features:

- DFSMSdss offers powerful, user-friendly functions that let you move or copy data between volumes of like and unlike device types. It can also copy data that has been backed up.
- DFSMSdss can increase performance by reducing or eliminating DASD free-space fragmentation.
- DFSMSdss provides you with host system backup and recovery functions at both the data set and volume levels. It also includes an enhanced Stand-alone Restore Program that lets you restore vital system packs during disaster recovery, without a host operating system.
- DFSMSdss can convert your data sets and volumes to system-managed storage, or return your data to a non-system-managed state as part of a recovery procedure, all without data movement.

22.2.1 Concurrent Copy

Concurrent Copy (CC) is both an extended function in cached IBM Storage Controls and a component of DFSMSdss. CC enables you to copy or dump data while applications are updating the data. Both IMS/ESA® and DB2 can use CC for their backups.

Concurrent copy can dramatically reduce the amount of time that is required to back up application data, hence increasing the time available for online service. When you use concurrent copy, application processing is interrupted for only a short period while the system initializes the concurrent copy environment. After concurrent copy is active, your applications can continue to process the data while it is being backed up using concurrent copy.

Of course, online applications might need to be interrupted while batch processing takes place. Concurrent copy cannot reduce the requirement for batch processing, but it can reduce the time required for processing by allowing batch processing and backup activities to take place at the same time.

22.2.2 FlashCopy

FlashCopy provides a fast data duplication capability. This option helps eliminate the need to stop applications for extended periods of time in order to perform backups and restores. FlashCopy is automatically initiated by DFSMSdss on IBM System Storage DS8000 family with the FlashCopy feature enabled.

Types of available FlashCopy functions in System z can be summarized as follows:

- Full volume copy and nocopy
- Data set FlashCopy
- Background nocopy to copy
- Persistent FlashCopy
- Multiple relationships
- Incremental FlashCopy
- Inband FlashCopy
- Fast Reverse Restore enabled FlashCopy
- Fast Reverse Restore
- consistency group FlashCopy

Table 22-1 shows which tools and interfaces can initiate each type of FlashCopy operation.

Table 22-1 FlashCopy for System z invocation matrix

	DSS	TSO	API	DSF	DS CLI
Full volume	Yes	Yes	Yes	Yes	Yes
Nocopy - Copy	Yes	Yes	Yes	Yes	Yes
Incremental	Yes	Yes	Yes	Yes	Yes
Consistent Group	Yes	Yes	Yes	Yes	Yes
Persistent	No	No	No	No	Yes
Inband	Yes	Yes	Yes	Yes	Yes
FRR Enabled	No	Yes	Yes	Yes	Yes
FRR	No	Yes	Yes	Yes	Yes
Multiple relations	Yes	Yes	Yes	Yes	Yes
Data set	Yes	No	No	No	No

22.2.3 DFSMSdss Stand-Alone Services

DFSMSdss Stand-Alone Services was previously introduced as an APAR enhancement to all releases of DFSMS. The stand-alone restore function is a single-purpose program designed to allow the system programmer to restore vital system packs during disaster recovery without needing to rely on an OS/390 or z/OS environment.

The Stand-Alone Services function is available to all supported releases of DFSMSdss. This latest version of IBM's Stand-Alone restore function is a single-purpose program. It is designed to allow the system programmer to restore vital system packs during disaster recovery without needing to rely on a z/OS environment. Stand-Alone Services runs independently of a system environment either as a true stand-alone system or under a VM system.

Stand-Alone Services can perform either a full-volume or a tracks restore from dump tapes that are produced by DFSMSdss or DFDSS. The Stand-Alone Services function offers the following benefits:

- Provides user-friendly commands to replace the previous control statements
- Supports IBM 3494 and 3495 tape libraries and 3592 tape subsystems
- Supports IPLing from a DASD volume, in addition to tape and card readers

- Allows you to predefine the operator console to be used during Stand-Alone Services processing

> **Reference:** For more information of DFSMdss, see the website:
>
> http://www.ibm.com/systems/storage/software/sms/dss/index.html

22.3 Hierarchical Storage Manager (DFSMShsm)

The Hierarchical Storage Manager (DFSMShsm) is an automated hierarchical storage manager and productivity tool designed to support Availability Management, Space Management, and Disaster Recovery.

DFSMShsm provides space, availability, and tape mount management functions in a storage device hierarchy for both system-managed, and non-system-managed storage environments. DFSMShsm allows you to automate your storage management tasks improving the productivity by effectively managing the storage devices.

DFSMShsm ensures that space is available on your DASD volumes, so you can extend data sets and allocate new ones. DFSMShsm makes sure that backup copies of your data sets are always available in case your working copies are lost or corrupted. It relieves you from manual storage management tasks and improves DASD use by automatically managing both space and data availability in a storage hierarchy.

Eventually it is a policy-driven solution to storage management, removing the requirement for batch jobs to perform backup, migration, or space retrieval functions. DFSMShsm works by rules that you can apply and have set, but which are also dynamically adjustable to allow the flexibility required in today's constantly changing environments.

22.3.1 Storage hierarchy

A storage device hierarchy consists of a set of storage devices that have differing costs for storing data, differing amounts of data stored, and differing speeds for accessing the data. Storage devices at the lower level typically provide lower cost per byte storage and might have slower access time. These devices might be disk or tape.

22.3.2 Availability management

Availability management is the process that helps maintain a backup copy of data sets which can be easily recovered if the original copy is damaged or accidentally deleted.

DFSMShsm can automatically make backup copies of changed data sets and copies complete volumes (dumps) according to a definable schedule. DFSMShsm can also create a point-in-time copy of a set of volumes using the FlashCopy process and automatically move those copies to tape.

Availability management is the function of the DFSMShsm program that you use to ensure that your customers can retrieve usable copies of their data sets in case their online copies become lost or damaged. You can make the copies available as follows:

- Make daily incremental backup copies of changed data sets.
- Make periodic dump copies of the DFSMShsm-managed and ML1 volumes.
- Make fast replication backup versions for sets of storage groups.
- Make aggregate backup copies of data sets that your operation will need if your installation is damaged.

Functions of DSDSMShsm Availability management offer the following capabilities:

- Automatically make backup copies of individual changed data sets on DFSMShsm-managed volumes. This is known as incremental backup. You can specify how frequently to back up data sets on a data set basis for SMS-managed data sets and on a system-wide basis for non-SMS-managed volumes. You can specify on a system-wide basis how often backup runs.
- Allow customers to issue commands to recover their own data sets.
- Automatically make dump copies of DFSMShsm-managed level 0 volumes and ML1 volumes on a specified schedule for day and time. You can dump different groups of volumes on different days with different periods for the number of days between dumps.
- Allow your customer to issue the HBACKDS (inline backup) command from a batch environment.
- By command, back up data sets of an application to tape so they can be taken to another computer site for recovery.
- By command, recover user data sets or data sets of an application to their original system environment at another computer site.
- By command, restore a volume from a dump copy and update the restored volume from later incremental backup versions.
- By command, recover a specific data set from either a dump copy or an incremental backup version.
- By command, create a fast replication backup of a copy pool.
- Automatically or by command, create a dump copy of a fast replication DASD backup version.
- By command, recover volumes that have a fast replication backup version.
- By command, recover cataloged data sets from fast replication backup versions

22.3.3 Space management

Space management is a process that monitors usage to maintain enough space on user volumes for new and active data. It ensures that only active data occupies the space on a DASD. Space management allows you to keep DASD space available for users in order to meet the service-level objectives for your system. The purpose of space management is to manage your DASD storage efficiently, as follows:

- DFSMShsm uses a three-level storage device hierarchy for space management:
  - Level 0 contains data directly accessible to the end user or program.
  - Level 1 is disk containing data sets that DFSMShsm has moved from level 0 volumes.
  - Level 2 is tape containing data sets that DFSMShsm has moved from level 1 or level 0 volumes.
- DFSMShsm can automatically move (migrate and recall) data sets, which have not been referenced within a specified time, to lower cost devices. A migrated data set is one that has been moved to a Level 1 or Level 2 volume, DASD or tape, in a special space saving form on the volume.
- DFSMShsm can automatically delete data sets that have passed their expiration dates.

The major activities of Space management include these:

- Expiration
- Extent reduction
- Interval migration
- Migration
- Recall
- Recycle
- Primary space management
- Secondary space management

Space management parameters control how DFSMShsm makes space available on level 0 volumes. Space management is specified as a combination of parameters in the management classes and storage groups. In planning for space management, you want to strike a balance between having enough DASD space available for new data set allocations and having frequent recalls of migrated data sets. The management class attributes apply on a data set basis so that different data sets on a volume can be migrated based on different criteria.

22.3.4 Disaster recovery

The function is provided by Aggregate Backup And Recovery Support (ABARS). Disaster recovery is a backup and recovery process used to protect against the loss of data in a disaster. The premise is that copies of vital data sets are stored at a location separate from your computer site and that a computer system of approximately the same capabilities is available to resume operations. Because the data must be stored at another site, either it must be on a portable media (tape) or you must automatically transmit it.

Disaster recovery data must include all data sets critical to your operation, such as critical application data sets, RACF® inventory data sets, system data sets, and catalogs.

ABARS is the preferable method for disaster backup and recovery. To use ABARS, you must decide which applications and data sets are critical to your business, and how to transport backup information to the recovery site. After you have done so, ABARS can assist you in producing a selection data set to be used as input to the ABARS backup function.

Both SMS and DFSMShsm must be active to perform ABARS backup. The data sets to be backed up does not need to be SMS-managed, but they must be cataloged in an ICF catalog. The ABARS output tapes can be sent to the recovery site by physically moving them, by sending them by the NetView® file transfer program or an equivalent product, or by creating tapes remotely in automated tape libraries.

Aggregate backup is a command-driven function that can back up a user-defined group (called an aggregate group) of data sets for recovery at another computer site or at the same site. Aggregate recovery is the command-driven function that recovers the data sets that were previously backed up by aggregate backup. Aggregate groups simplify the control of backup and recovery of critical data sets and applications.

Aggregate backup and recovery is a process to back up and recover user-defined groups of data sets vital to your business. Aggregate backup can be done by TSO command or in-stream application batch jobs. DFSMShsm uses aggregate groups and management classes to manage the aggregate backup process. Data sets are identified in selection data sets and can be copied, allocated empty, or accompanied on other tapes. ABARS tracks the attributes of the aggregate group, and they can be used to create the proper environment at the recovery site.

Three types of aggregate backup tape files are created: an aggregate control file, an instruction data set, and aggregate data files. The control file contains information needed at the remote site to recover the data sets. The instruction data set is free-form text that contains information to assist in recovering and running the application. The data files contain the data sets you want to recover.

During aggregate recovery, backed-up data sets are recreated at the recovery site. If data set name conflicts arise, a large variety of resolution options are available. They include various forms of rename, replacing the existing data set with the new data set, and bypassing the recovery of certain data sets. There is also a conflict resolution data set that can be edited to handle conflicts. It can be used by aggregate recover processing to resolve conflicts.

22.3.5 List, report, query, audit

DFSMShsm can manage backed up, dumped, and migrated volumes and data sets. It can maintain an inventory and provides features so users might find information about their own volumes and data sets through LIST, REPORT, QUERY, and AUDIT functions.

The LIST command lists selected data set, aggregate, user, DFSMShsm host serialization, and volume information from the MCDS, BCDS, and OCDS. You can list the following categories of information:

- Aggregate backup and recovery activity information
- Backup volume information
- Copy pool information
- Copy pool backup storage group information
- Data set information
- Dump class information
- Dump volume information
- Host information
- Migration information
- Primary volume information
- Tape volume information
- User authorization information

The REPORT command generates reports based on DFSMShsm statistics records in the MCDS. You can get daily statistics reports and volume statistics reports for one function or for all DFSMShsm functions, for one volume or for all volumes that have statistics records in the MCDS, and for statistics that have been created on a specific date or between two specific dates. Users can restrict the report to the functions DFSMShsm performs, such as migration and backup, and you can restrict the report to specific dates. DFSMShsm allows only one REPORT command to run at a time.

The QUERY command for DFSMShsm displays the status of various operational parameters (control parameters, backup and recovery parameters, startup parameters, and so on), statistics (volume space-use, list of all statistics, and so on), and requests (storage limits, recall requests, and so on).

The AUDIT command operates differently depending on whether it is issued for a control data set or for a common queue. In normal operation, these records stay in synchronization. However, because of data errors, hardware failures, or human errors, it is possible for these records to become unsynchronized. The Audit function allows the system to cross-check the various records concerning data sets and DFSMShsm resources. Audit can list errors and propose diagnostic actions or, at your option, complete most repairs itself. The command operates differently depending on whether it is issued for a control data set or for a common queue.

Reference: IBM recently announced new, higher capacity cartridges for the IBM System Storage TS1120 tape subsystem. These new cartridges have a physical capacity of around 700 GB and a logical capacity of around 2 terabytes when compressed at 3:1. DFSMShsm can use these high capacity tapes for all tape related functions. For more details about DFSMShsm, see the website:

http://www.ibm.com/systems/storage/software/sms/hsm/index.html

22.4 Removable Media Manager (DFSMSrmm)

The Data Facility System Managed Storage Removable Media Manager (DFSMSrmm) is a full function tape management system that is available as a functional component of z/OS. It enables you to manage your removable media as an enterprise library across systems that can share disk.

DFSMSrmm can manage all of your tape volumes and the data sets on those volumes. It protects tape data sets from being accidentally overwritten, manages the movement of tape volumes between libraries and vaults over the life of the tape data sets, and handles expired and scratch tapes, all according to policies that you define. Plus DFSMSrmm manages other removable media that you define to it. For example, it can record the shelf location for optical disks and track their vital record status. DFSMSrmm does not yet automatically record information for optical volumes.

22.4.1 Management of the tape library

DFSMSrmm is an integral part of DFSMS and is shipped as part of DFSMS with the z/OS operating system. DFSMSrmm cooperates with and exploits numerous system components that are required for the complete security, management, and well being of your tape library.

22.4.2 DFSMSrmm volume retention and movement policies

DFSMSrmm volume retention and movement policies, can optionally be specified interactively with ISPF panels. This allows authorized application owners to alter existing values without contacting the tape librarian.

22.4.3 Report generator

DFSMSrmm includes the report generator which is an ISPF based tool for easily building and customizing numerous storage management reports. Sample report types and reports enable reporting based on DCOLLECT data, DFSMShsm functional statistics, and DFSMSrmm created data.

22.4.4 Full function removable media management system

DFSMSrmm is a full function removable media management system for your enterprise. DFSMSrmm supports tape volumes which are used anywhere in your enterprise, including z/VM, and those managed by the IBM Integrated Removable Media Manager for the enterprise on System z.

22.4.5 Compatibility with existing tape management systems

DFSMSrmm is functionally compatible with existing tape management systems and runs in parallel during conversion. The easy to use conversion tools and related documentation and Redbooks publications enable the easy migration of your existing tape environment to management by DFSMSrmm. The special expiration date formats of 99nnn and 98nnn are supported by DFSMSrmm.

22.5 DFSMS Transactional VSAM Services (DFSMStvs)

DFSMS Transactional VSAM Services (DFSMStvs) is an optional z/OS feature that enables batch jobs and CICS online transactions to update shared VSAM data sets concurrently. Multiple batch jobs and online transactions can be run against the same VSAM data sets. DFSMStvs helps ensure data integrity for concurrent batch updates, while CICS ensures it for online updates of these features:

- Contributes to the reduction or elimination of the batch window for CICS applications and other VSAM applications by allowing concurrent batch and online updating of VSAM recoverable data sets.
- Provides the ability to share VSAM data sets at record-level with integrity and commit and rollback functions for non-CICS applications.
- Offers Backup-while-open to be taken using DFSMSdss and DFSMShsm.
- Enables batch applications to use the same forward recovery logs.
- Delivers increased system availability with simpler, faster, and more reliable recovery operations for VSAM storage structures.
- Simplifies scheduling batch jobs because multiple batch jobs that access the same files can be run concurrently on one or more z/OS images in a Geographically Dispersed Parallel Sysplex™ (GDPS®) instead of serially on one image.

Since its introduction in the mid-1970s, VSAM has become a popular way of storing data. It has offered a number of different ways of organizing data (for example, by key, by record number, by relative byte address or in sequence) and has offered good performance and device independence.

VSAM data sets are stored on direct access storage devices (DASD). VSAM divides its data set storage into control areas (CAs), which are further divided into control intervals (CIs). Control areas are the unit of allocation; a VSAM data set will contain an integral number of control areas. Control intervals are the unit of data transmission between processor and disk storage. Each control interval is of fixed size and, in general, contains a number of records.

There have been numerous improvements to VSAM throughout its life. DFSMStvs is the most recent and builds upon VSAM Record Level Sharing (RLS).

VSAM data sets often have to be shared among several different applications in a z/OS system image, or among applications on several different z/OS system images. For example, transactions running in different CICS regions might have to access the same VSAM data set at the same time. Likewise, a CICS transaction might have to access a VSAM data set at the same time that a batch job is using the data set.

The requirements for sharing can vary. Sometimes applications only have to read the data set. Sometimes an application has to update the data set while other applications are reading it. The most complex case is when all applications have to update the data set, and all require complete data integrity.

22.6 More information

For more information about DFSMS, see the website:

`http://www.ibm.com/systems/storage/software/sms/index.html`

Also see the following Redbooks publications:

- *DFSMShsm ABARS and Mainstar Solutions*, SG24-5089
- *z/OS V1R3 DFSMS Technical Guide*, SG24-6569
- *Z/OS V1R3 and V1R5 DFSMS Technical Guide*, SG24-6979
- *DFSMStvs Overview and Planning Guide*, SG24-6971
- *DFSMSrmm Primer*, SG24-5983
- *DFSMS V1.10 and EAV Technical Guide*, SG24-7617

22.7 DFSORT

Many organizations have a "batch window," the time during which the overnight batch jobs have to perform processing related to the previous day's activity. As system capabilities and usage have increased, so too, the number of reports required and the amount of data to be processed by the batch jobs has increased. As the batch window cannot be extended, ways have to be found to process the data as quickly and efficiently as possible. As many of the batch jobs require data to be sorted, particularly those producing reports, improved sorting can make a contribution to the goal of processing more data in the same period of time.

DFSORT is IBM's high-performance sort, merge, copy, analysis, and reporting product for z/OS. With DFSORT, you can sort, merge, and copy data sets. You can use DFSORT to do simple tasks such as alphabetizing a list of names, or you can use it to aid complex tasks such as taking inventory or running a billing system. DFSORT gives you versatile data handling capabilities at the record, field and bit level.

22.7.1 Product highlights

Here we list highlights for DFSORT:

- DFSORT, together with DFSMS and RACF, form the strategic product base for the evolving system-managed storage environment.
- DFSORT adds the ability to do faster and easier sorting, merging, copying, reporting and analysis of your business information, as well as versatile data handling at the record, fixed position/length or variable position/length field, and bit level.
- DFSORT is designed to optimize the efficiency and speed with which operations are completed through synergy with processor, device, and system features (for example, memory objects, Hyperspace, data space, striping, compression, extended addressing, DASD and tape device architecture, processor memory, processor cache, and so on) and other products (for example, The SAS System, COBOL, PL/I, IDCAMS BLDINDEX, and so on).
- DFSORT includes the high-performance ICEGENER facility, the versatile ICETOOL utility, Symbols, and multiple output capability with the powerful OUTFIL feature.
- Sort, merge or copy data sets while including, excluding or reformatting records.
- Analyze data and produce detailed reports using the ICETOOL utility or the OUTFIL function. In addition, OUTFIL allows you to create various views of the data and various reports with a single pass over the data.

- Use symbols for fields and constants in DFSORT and ICETOOL statements.
- Join and match records from separate data sets in various ways.
- Convert FB data sets to VB data sets, and VB data sets to FB data sets.
- Add timestamps to records, include or omit records based on today's date, a past date or a future date, and convert SMF, TOD and ETOD date and time values to readable form.
- Collate and compare data according to your national and cultural needs using DFSORT's National Language Support.
- New ICETOOL capabilities greatly extend the variety of the batch processes where DFSORT functions are being used. DFSORT function can be directly invoked from respective ICETOOL operators

Attention: DFSORT cannot directly process database data, such as DB2 or IMS™. Such data has to be extracted to flat files first or written from flat files afterwards.

22.7.2 Data sets, records, and fields

The information that you manipulate with DFSORT is contained in data sets. The term *data set* refers to a file that contains one or more *records*. Any named group of records is called a data set. The terms data set and file are synonymous, and are used interchangeably in this document.

A data set contains the information that you want to sort, copy, or merge. For most of the processing done by DFSORT, the whole data set is affected. However, some forms of DFSORT processing involve only certain individual records in that data set.

Data sets can be cataloged, which permits the data set to be referred to by name without specifying where the data set is stored. A cataloged data set must not be confused with a cataloged procedure. A cataloged procedure is a named collection of JCL stored in a data set, and a cataloged data set is a data set whose name is recorded by the system.

The term record refers to a collection of related information used as a unit, such as one item in a data base or personnel data about one member of a department. The term *field* refers to a specific portion of a record used for a particular category of data, such as an employee's name or department.

DFSORT can sort, copy or merge fixed-length or variable-length records. The type and length of a data set is defined by its record format (RECFM) and logical record length (LRECL). Fixed-length data sets have a RECFM of F, FB, FBS, and so on. Variable-length data sets have a RECFM of V, VB, VBS, and so on. For simplicity, the terms *FB data set* and *FB records* are commonly referred as short-hand for fixed-length data sets and records, respectively, and the terms *VB data set* and *VB records* are used as short-hand for variable-length record data sets and variable-length records, respectively.

Sorting data sets

You can use DFSORT to rearrange the records in your data sets. Sorting is arranging records in either ascending or descending order within a file. Data sets can be sorted in many different formats. The most commonly used formats are:

- EBCDIC (Character)
- Binary (Unsigned Numeric)
- Fixed-point (Signed Numeric)
- Zoned Decimal (Signed Numeric)
- Packed Decimal (Signed Numeric)

- Floating Sign (Signed Numeric)
- Free Form (Unsigned Numeric)
- Free Form (Signed Numeric)

Merging data sets

Users can also use DFSORT to merge data sets. DFSORT merges data sets by combining two or more files of sorted records to form a single data set of sorted records.The data sets you merge must be previously sorted into the same order (ascending or descending).

Copying data sets

DFSORT can also copy data sets without any sorting or merging taking place. You copy data sets in much the same way that you sort or merge them.

Other DFSORT functions

While sorting, merging, or copying data sets, you can also perform other tasks such as these:

- Select a subset of records from an input data set. You can include or omit records that meet specified criteria. For example, when sorting an input data set containing records of course documents from many different school departments, you can sort the documents for only one department.
- Reformat records in a variety of ways. You can build your records one item at a time, only overlay specific columns, or reformat different records in different ways. You can edit, change, add or delete fields. |You can perform find and replace operations |on your records. You can perform various operations on groups of records. You can work with fixed position/length fields directly or convert variable position/length fields (such as comma separated values) to fixed parsed fields for further processing. You can also insert blanks, zeros, strings, current date, future date, past date, current time, sequence numbers, decimal constants, and the results of arithmetic instructions before, between, and after input fields. For example, you can create an output data set that contains character strings and only certain edited fields from the input data set, arranged differently.
- Sum the values in selected records while sorting or merging (but not while copying). In the example of a data set containing records of course books, you can use DFSORT to add up the dollar amounts of books for one school department.
- Create multiple output data sets and simple or complex reports from a single pass over an input data set. For example, you can create a different output data set for the records of each department.
- Convert VB data sets to FB data sets, or convert FB data sets to VB data sets.
- Sample or repeat records.
- Sort, merge, include or omit records according to the collating rules defined in a selected locale.
- Alter the collating sequence when sorting or merging records (but not while copying). For example, you can have the lowercase letters collate after the uppercase letters.
- Sort, merge, or copy Japanese data if the IBM Double Byte Character Set Ordering Support (DBCS Ordering) is used with DFSORT to process the records.

Reference: For more details about DFSORT, see the following website:

`http://www.ibm.com/support/docview.wss?rs=114&uid=isg3T7000077`

23

z/OS Storage Management Tools

The z/OS storage management tools are a collection of products designed to provide a comprehensive menu of solutions, in order to meet the storage management requirements of z/OS customers. The tools are positioned to complement and extend the storage management capabilities of DFSMS. In this chapter, we discuss these products.

The products allow IBM to provide a more complete suite of storage management solutions:

- Ability to predict results of alternative actions with minimum risk
- Overall ability to optimize the responsiveness of storage assets
- Better response time and throughput by elimination of easily identified bottlenecks
- A more simple, straightforward environment for storage administrators, increasing their productivity while reducing mistakes as well as potential outages
- An increased system availability from simpler, faster, and more reliable recovery operations for storage structures

The following tools can be used to manage storage on z/OS:

- IBM Tivoli Omegamon XE
- IBM DB2 Cloning Tool
- IBM Tivoli Advanced Catalog Management for z/OS
- IBM Tivoli Advanced Backup and Recovery
- IBM Tivoli Advanced Audit for DFSMShsm
- IBM Tivoli Automated Tape Allocation Manager
- IBM Tivoli Advanced Allocation Manager for z/OS
- IBM Tivoli Tape Optimizer for z/OS
- IBM Tivoli Storage Optimizer for z/OS
- DFSMS Optimizer

23.1 IBM Tivoli Omegamon XE

IBM Tivoli OMEGAMON® XE for Storage on z/OS enables you to manage elements of your mainframe storage environment — including system-managed storage (SMS) and non-SMS direct access storage device (DASD), and tape devices for optimal performance, disk use, and related administration. From a single point of control, the product's built-in tools give you the power to manage disk use down to the individual data set level. Views and reporting reveal a detailed picture of your storage environment.

The main features are as follows:

- Enables you to monitor and manage storage (including DASD and tape devices), and the analysis of two important IBM storage software components: Data Facility Systems Managed Storage and Data Facility Hierarchical Storage Manager (DFHSM).
- Provides the capability to quickly create commands or schedule actions that maintain and administer DASD storage with a new storage toolkit for DFHSM and DFDSS functions.
- Offers more versatile and granular reporting capabilities using the storage toolkit.
- Improves problem resolution with Dynamic Workspace Linking (DWL) to OMEGAMON XE on z/OS, which enables you to easily navigate between Tivoli Enterprise Portal workspaces.
- Adds enhanced problem determination capabilities with new problem-solving workspaces in the Tivoli Enterprise Portal (TEP).
- V4.1.0 is fully globalized and translated into group one languages.

In addition to using Tivoli OMEGAMON XE for Storage on z/OS to manage space, you can rely on the included online toolkit to help resolve issues rapidly. The product provides a wealth of real-time and long-term performance metrics that let you keep tabs on the overall health of those systems. You can easily tailor product views to investigate storage issues within your environment and quickly drill down to pinpoint bottlenecks and other contentions. Additionally, you can use the software to automate daily storage tasks and respond to recurring problems - and thereby help drive staff productivity.

To help you manage your most important workloads running on z/OS for maximum performance and efficiency, Tivoli OMEGAMON XE for Storage on z/OS provides granular control. Track details of all I/O to DASD used by an address space - in real time.

Other metrics provide granular performance and availability information on the volumes down to the actual data sets used by an address space to help you tune performance.

When bottlenecks or other problems slow performance, Tivoli OMEGAMON XE for Storage on z/OS pinpoints where contentions and resource locks occur. The source of those problems can be identified by application name (address space). Easily customized workspaces let you configure dynamic tables and charts to investigate related problems, then intuitively drill down to the source of slow performance.

Tivoli OMEGAMON XE for Storage on z/OS also reveals when storage access hotspots are potentially overburdened. You can see, for example, the time it takes to read or write to the hard disk. Read-hit and write-hit percentages tell you when hard drives backing up the cache are accessed too frequently - a common cause of slow performance.

Tivoli OMEGAMON XE for Storage on z/OS gives you the power to manage storage tasks with great efficiency. With it, you closely monitor space use and administer it for maximum efficiency. Detailed reports provide a thorough picture of your disk use. Included product features then facilitate actions to move, migrate, reorganize and otherwise manage precious disk space.

Additionally, the included online toolkit provides the ability to issue IBM Data Facility Storage Management Subsystem Hierarchical Storage Manager (DFSMShsm), Data Set Services (DFSMSdss), ICKDFS and IDCAMS commands. A new JCL generation capability is provided, which greatly enhances the flexibility of the tools and functions you can use with this product. Furthermore, the outcome of any toolkit-generated action is available directly from the IBM Tivoli Enterprise Portal interface. The feature includes an intuitive graphical interface to easily format related command options.

IBM Tivoli OMEGAMON products for System z include these:

- Operating systems:
  - IBM Tivoli OMEGAMON XE on z/OS
  - IBM Tivoli OMEGAMON XE for Linux on System z
  - IBM Tivoli OMEGAMON XE on z/VM and Linux
- Data management:
  - IBM Tivoli OMEGAMON XE for DB2 for Performance Expert on z/OS
  - IBM Tivoli OMEGAMON XE for DB2 for Performance Monitor on z/OS
  - IBM Tivoli OMEGAMON XE for IMS on z/OS
- Host transaction processing:

  IBM Tivoli OMEGAMON XE for CICS on z/OS
- Networking:

  IBM Tivoli OMEGAMON XE for Mainframe Networks
- Storage management:

  IBM Tivoli OMEGAMON XE for Storage on z/OS
- Integration:

  IBM Tivoli OMEGAMON DE on z/OS
- Software requirements:

  z/OS version 1.4 or higher

23.2 IBM DB2 Cloning Tool

IBM DB2 Cloning Tool for z/OS is a vendor-independent tool that provides access to data sets on replicated volumes created with point-in-time copies of Fast Data Replication tools (FlashCopy and SnapShot) or Splits of Continuous Mirrors tools (EMC TimeFinder, IBM PPRC, HDS ShadowImage, Softek TDMF®, and Fujitsu Equivalent Copy).

The clones that these tools create are not accessible due to an inherent replication problem: The target volume label, internal data, and data set names all reflect the source volume name. DB2 Cloning Tool solves these issues so that the replicated data can be utilized quickly and accessed on the same system.

DB2 Cloning Tool supports the replication of DB2 subsystems with intelligent features that condition the target environment enabling the replicated data to be made available for use within minutes.

DB2 Cloning Tool provides a way for customers to meet the demand for increased online access to databases while continuing to meet business requirements for batch and backup processing. Using the tool, customers can run processes in parallel. In addition, customers can easily create test and QA environments and refresh the data on a regular basis.

IBM DB2 Cloning Tool provides the following benefits:

- Solves the cloned data access dilemma, giving users access to datasets on target volumes created with FlashCopy or Snapshot by renaming and cataloging them.
- Resolves catalog conflicts of like-named datasets that are created by cloning a volume. It also solves internal conflicts that are created when copying a volume to another VOLSER.
- Fixes volume conflicts (VTOC, VTOCIX, and VVDS) and then renames and recatalogs the datasets.
- Has a rename capability that allows users to change any qualifier or add/delete qualifiers.
- Tracks the behind-the-scenes FlashCopy, enabling a user to know when they can start another cloning operation or withdraw from the current copy.
- Provides automatic pairing of volume characteristics.
- Provides the capability to FlashCopy or Snapshot by Storage Groups.

IBM DB2 Cloning Tool meets your requirements for a tool that quickly clones DB2 table and index spaces, or an entire DB2 subsystem, creating the equivalent of a production environment that you can use to test new features and functions.

Cloning facilitates upgrading to new versions of DB2 by allowing you to easily create a complete subsystem environment (clone) for testing an upgrade and applications before moving the production system to the new DB2 version. Users benefit from increased DB2 availability because they can query the database on the clone while the online system is down.

DB2 Cloning Tool reduces the time required to copy table or index spaces or create an entire subsystem clone from hours, even days, to minutes - and the tool does it while significantly cutting the costs of traditional methods. Fast, efficient, and easy to use, DB2 Cloning Tool gives you a cost-effective way to migrate with confidence and helps you create data warehousing systems.

23.3 IBM Tivoli Advanced Catalog Management for z/OS

IBM Tivoli Advanced Catalog Management for z/OS offers vital data protection while helping to increase data availability. With effective auditing tools, secure recovery, and improved day-to-day management, you can access your data, even in the event of problems in the IT environment ranging from simple human errors to natural disasters. Effective catalog management requires the best tools available to ensure that key data assets are protected and can be recovered in any event.

Advanced Catalog Management for z/OS is designed to provide backup and restore facilities that provide high integrity and fast processing.

23.3.1 Infrastructure benefits

Infrastructure benefits for the product are as follows:

- Backup and restore facilities that provide high integrity and fast processing.
- A forward recovery facility for BCS and VVDS catalog structures that use SMF data, merged with backup records, to update the BCS and VVDS from the time of the backup to the current time.
- A full-function backup and restore facility for VSAM files that allows attribute changes during recovery and can back up damaged KSDS data sets.
- An expanded diagnostic facility that enables frequent health checks of the BCS, VVDS, VTOC, and tape management catalog structures. This facility contains an audit-check and “fix” capability to re synchronize entries that are in error.
- A fast and safe “MERGECAT” facility that enables moving or copying of individual BCS entries, alias groups of BCS entries, or entire catalogs.
- A fast and safe split/merge facility that enables moving or copying of individual BCS entries, alias groups of BCS entries, or entire catalogs.
- “Reorg While Open” and “Repair While Open” features that reorganize and repair ICF catalogs while applications are still active. These high availability features can save hours of application downtime over traditional tools.

23.3.2 Application benefits

Applications running on the z/OS platform can benefit from these capabilities:

- A diagnostic set of commands that provides a safe and easy-to-use AMASPZAP-like facility to delete, print, and update BCS, VVDS, VTOC and VSAM data set structures.
- A powerful facility that allows users to change the VOLSER of online DASD volumes in a single command, without requiring the user to unload and reload all data on the volume.
- A set of commands that provide several BCS/VVDS facilities which include VOLSER changes to BCS records and BCS back pointer correction in the VVDS.
- Search and reporting functions that provide a powerful, high-performance search facility with extensive dataset naming and file attribute filters to identify datasets of interest.
- A simulation feature on most commands that enable users to check critical catalog changes in advance in order to determine the effect of the command before it is run.
- A journaling facility for certain critical commands which can enable a `restart` or `backout` option in the event of a failure or interruption during the execution of the command.

23.4 IBM Tivoli Advanced Backup and Recovery

IBM Tivoli Advanced Backup and Recovery for z/OS, V2.2 helps maintain a resilient z/OS environment in which complex z/OS applications can be restored quickly from either local outages or disaster situations. It monitors applications automatically, determines the critical datasets that applications use, and helps ensure the applications are backed up when and where they have to be. Advanced Backup and Recovery for z/OS, V2.2 delivers the control and visibility that might be needed to help manage critical z/OS backup and recovery activity:

- Delivers powerful function for fast, reliable, and accurate backups
- Helps identify data that is not backed up, whether by omission or due to system problems
- Provides alerts so corrective action can be taken

In addition, Advanced Backup and Recovery for z/OS, V2.2 can help reduce costs associated with remote Direct Access Storage Device (DASD) replication by helping to identify critical data for replication, providing a localized backup for recovery, and helping to eliminate duplicate backups. Automated, centralized tracking of z/OS backups, including DB2 image copies, can enable quick recovery, ranging from local outages to recovering the z/OS environment offsite. This can help to save crucial time and money and to eliminate error-prone manual processes.

23.4.1 Infrastructure benefits

Infrastructure benefits for the product are as follows:

- ABARS Manager enhances the value of DFSMShsm ABARS:
  - All backup information and backup status are accessible through one central point.
  - Backup status and details can be viewed online.
  - Online access to the full activity log and all error messages, as well as condensed status summary, makes ABARS management simple.
  - Detailed dataset inventory provides recovery capacity requirements, recovery tape VOLSER, and other key planning and operational details
- Incremental ABARS allows users to combine their disaster recovery back up strategy with an incremental backup capability. The benefits of this are a reduced backup size, improved backup and recovery performance, and reduced resources to vault and maintain the backup.
- With ABARS Manager, the value of ABARS is expanded to provide a local recovery solution that allows searching and recovering selected data sets from ABARS or DFSMShsm backups.
- Automated Critical Data Identification interfaces directly into ABARS Manager to ensure all critical assets are included in the backup.
- Critical Backup Tracking / Inventory ensures that all critical non-ABARS-managed assets have a backup, tracks and inventories all other backups in the environment and identifies duplicate backups.

23.4.2 Application benefits

Advanced Backup and Recovery can centralize and track all backups, including ICF catalogs. This enables customer environments to bounce back quickly and fully from unplanned local outages, saving crucial time and money.

Advanced Backup and Recovery for z/OS, V2.2 provides an easy-to-use GUI by TEP that can provide backup status and audit readiness at a glance. Integration with other products through the TEP helps make it easier to relate backup status to other aspects of managing the System z storage environment. Common viewing and take-action capability make it easier to transfer learning from one element of storage management to the next, which can help improve time-to-value and reduce learning costs. The TEP interface provides an easy way to capture expert knowledge directly into the product, to help reduce the constant reliance on experienced subject matter experts, and add flexibility to the user workforce.

Advanced Backup and Recovery for z/OS, V2.2 integrates with the IBM Tivoli Monitoring V6.2 infrastructure components that enable it to supply TEP with key business performance metrics for enhanced visualization and correlation within new workspaces, as well as with other IBM Tivoli Monitoring V6.2 monitored systems. This integration delivers a single GUI though TEP, which is used by many IBM Tivoli monitoring and management products, including IBM Tivoli OMEGAMON XE for Storage, to help discover and investigate problems and take immediate corrective actions. A dedicated TEP workspace for Advanced Backup and Recovery for z/OS V2.2 shares key information with IBM Tivoli OMEGAMON XE for Storage to help immediately discover and investigate problems and automatically take corrective actions.

23.5 IBM Tivoli Advanced Audit for DFSMShsm

IBM Tivoli Advanced Audit for DFSMShsm offers comprehensive and extremely fast audit support in the following areas: DFSMShsm Migration, Backup, Offline Control DataSets (MCDS, BCDS, and OCDS), and DFSMShsm owned tape.

Advanced Audit for DFSMShsm evaluates the Migration, Backup, and Offline Control DataSets (MCDS, BCDS, and OCDS) to resolve structural and logical discrepancies that might have prevented migrated data from being recalled, or backup data from being restored. Advanced Audit for DFSMShsm checks the ICF catalog relationships to assure that migrated data is cataloged, and that data cataloged as “migrated” is actually migrated. This function duplicates the DFSMShsm audit and enhanced audit commands with improved performance and flexibility.

The IBM Data Facility System Managed Storage Hierarchical Storage Manager (DFSMShsm) manages hundreds of thousands to millions of data assets, both critical and non-critical, in licensed IT environments. As businesses grow the sheer quantity of data assets stored on z/OS increases commensurately. This growth is mitigated using DFSMShsm to manage the life cycle of data assets, from creation to expiration. DFSMShsm is a complex environment requiring audit and reporting solutions that reduce resource consumption and help bridge the learning curve for new or inexperienced DFSMShsm administrators.

Advanced Audit for DFSMShsm enables customers to manage DFSMShsm environments using less time and fewer resources and provide powerful enhancements over the base DFSMShsm offering. The solution provides proactive DFSMShsm management capabilities that permit customers to produce a truly resilient DFSMShsm environment.

IBM Tivoli Advanced Audit for DFSMShsm V1.1 can help customers as follows:

- Significantly reduce the time it takes to audit, diagnose, and correct DFSMShsm control data set errors in data centers with a large number of records in the MCDS, BCDS, and OCDS.
- Proactively audit DFSMShsm control data sets and view the results in an ISPF interface.
- Select just the right fix for your environment from a variety of provided fixes.
- Automatically create FIXCDS and other fix commands directly from the panels.
- Automatically execute the FIXCDS command during the audit to resolve errors.
- Audit high-density tape media housing thousands to hundreds of thousands of individually migrated or backup data sets in a fraction of the time required by the DFSMShsm AUDITMEDIACONTROLS command.
- Resolve *failed create* and *failed recycle* error conditions.
- Rebuild broken migration and backup tapes, plus tapes that have been recycled but not written over.
- Specify corrective actions or diagnostic aids to build when errors are encountered.
- Repair tapes quickly by executing corrective commands directly from an ISPF interface.

As mentioned before, IBM Tivoli Advanced Audit for DFSMShsm V1.1 helps you audit and correct errors with your DFSMShsm migration and backup tapes. It works outside of the DFSMShsm environment to correct errors that it finds, and has customer-documented benchmark speeds of 5 to over 180 times faster than the traditional DFSMShsm AUDITMEDIACONTROLS command.

23.6 IBM Tivoli Automated Tape Allocation Manager

IBM Tivoli Automated Tape Allocation Manager for z/OS addresses tape device availability, providing automatic, unattended sharing of tape resources for across multiple images. Tivoli Automated Tape Allocation Manager helps ensure that existing tape drives are available on demand for requests from multiple images. Its tape sharing capabilities and commands can help manage tape devices across your System z environment reducing tape-related bottlenecks and job request backlogs.

23.6.1 Product benefits

By sharing the existing tape storage devices between multiple images, you can optimize the return on tape hardware investments. Tivoli Automated Tape Allocation Manager for z/OS can help you in these ways:

- Reduce delays in batch processing
- Improve use of existing devices
- Reduce operational overhead
- Enable administrators to spend less time managing tape storage needs and more time on high-value business tasks

Tivoli Automated Tape Allocation Manager for z/OS operates at the hard-ware level to provide dynamic sharing of assign-capable tape devices. Instead of relying on hooks to IBM z/OS allocation and coordination of device sharing through a shared control file, Tivoli Automated Tape Allocation Manager for z/OS exploits flags in the unit control block to determine whether a device is available for use on a given system. As a result, you can use the tool to facilitate sharing of tape resources between multiple systems without introducing a single point of failure.

Tivoli Automated Tape Allocation Manager for z/OS uses global command support, implemented through a TCP/IP-based communication infrastructure that provides users with centralized query and control. Operators have the ability to issue commands to Tivoli Automated Tape Allocation Manager for z/OS on one or all systems within the environment from any z/OS console.

23.6.2 Product features

The features of this product can help you as follows:

- Maximize use of existing tape resources before you invest in additional hardware.
- Minimize batch processing delays and operational overhead by sharing tape storage devices across a multi-system environment without the need for a shared control file.
- Automate tape resource management and minimize the need for operator intervention.
- Migrate from alternative vendor products to an IBM solution.
- New in V3.1: Enables integration with Tivoli Enterprise Portal (TEP).

- Configuration T1 parameter can be adjusted to specify particular timing intervals for various device types.
- A new “E” command shows a map of tape esoteric names and associated devices.
- Option to use the SAF security interface to help control your ability to manage tape availability by Automated Tape Allocation Manager for z/OS, V3.1.
- Enhanced ability to employ preferential tape device assignment.

Tivoli Automated Tape Allocation Manager for z/OS provides integration with IBM Tivoli Enterprise Portal (TEP), an easy-to-use, portal-based user interface that delivers real-time and historical data in one customizable workspace. Tivoli Enterprise Portal enables side-by-side data comparison for diagnostics, centralized reporting, and visibility into specific areas for more effective monitoring and troubleshooting.

23.7 IBM Tivoli Advanced Allocation Manager for z/OS

IBM systems management software for z/OS is designed to help you get the most out of your highly available z/OS environment. When you deploy IBM Tivoli Advanced Allocation Management for z/OS to address X37 abends, you can help prevent outages of your mission-critical z/OS applications. You can use Tivoli Advanced Allocation Management for z/OS to detect problems before they happen - even before you are aware that something is a miss - and correct the problems automatically, without your administrators’ beepers ever going off.

Additionally, Tivoli Advanced Allocation Management for z/OS integrates with a broad range of monitoring and management solutions through Tivoli Enterprise Portal. Bringing information from Tivoli Advanced Allocation Management for z/OS together with information from other IBM System z storage management solutions and IBM Tivoli Monitoring solutions, you can discover, investigate and correct problems more efficiently.

In addition, Tivoli Advanced Allocation Management for z/OS helps you avoid JOB FAILED Job Control Language (JCL) errors that occur due to insufficient disk space for the primary allocation. When the software determines during allocation that a new data se twill cause a JOB FAILED JCL error due to a storage issue, you can specify the amount by which Tivoli Advanced Allocation Management for z/OS automatically reduces the original allocation (up to a maximum value) until the allocation is successful. Tivoli Advanced Allocation Management for z/OS allows you to include or exclude allocations based on JCL specifications such as volume serial number (VOLSER), disposition, unit name, mount usage type, and data set organization support (DSORG).

To manage your storage-related concerns more effectively, you can use Tivoli Advanced Allocation Management for z/OS to help with the following tasks:

- Control reduction of primary space to fit existing available space.
- Automatically add a secondary allocation if one is not specified.
- Reduce secondary allocation to the largest available free extent
- Dynamically add volumes at end-of-volume (EOV) processing as needed.
- Automatically release allocated, unused data set space at data set close.
- Recover from secondary allocation space failures by reducing the allocation amount to a value consistent with the current free space on the volume.
- Increase the size of the secondary allocation as data set extends occur, both after a particular extent and at a particular volume number.

- Dynamically increase the directory space within a partitioned data set when a DIRECTORY FULL condition occurs.

Advanced volume selection capabilities in Tivoli Advanced Allocation Management for z/OS enable selection from a pool of volume groups to define volumes both at initial allocation and at end-of-volume processing. In addition, allocation direction can be flexibly controlled based on a number of variables (such as job name, data set name, program name, space and dataset attributes), as well as on resource metrics such as best fit, performance, largest single extent, and most freespace. Enhanced allocation management keywords make it possible to set allocation attributes even if they are not specified, and to override specified attributes that do not meet your installation standards. In cases where users are prohibited from specifying certain allocation attributes, an allocation termination function is included to automatically fail the allocation.

Regardless of the size of your organization and whether or not you have implemented system-managed storage (SMS), you can realize immediate benefits from Tivoli Advanced Allocation Management for z/OS. The software supports both SMS and non-SMS DASD data sets. The flexible rule definitions of Tivoli Advanced Allocation Management for z/OS enable you to specify SMS-related criteria to include or exclude SMS-managed data sets based on storage class, storage group, data class, management class, and so on.

Tivoli Advanced Allocation Management for z/OS integrates with IBM Tivoli Enterprise Portal, which offers a common user interface for managing information and tasks for a wide variety of solutions. Other offerings that can be coordinated with Tivoli Advanced Allocation Management for z/OS through Tivoli Enterprise Portal include System z storage management solutions and Tivoli Monitoring solutions.

The only requirement to run the tool just described is z/OS operating system Version 1.8 or higher.

23.8 IBM Tivoli Tape Optimizer for z/OS

IBM Tivoli Tape Optimizer on z/OS copies information from one or more tape volumes to other tapes or tape-compatible media in a single batch job, called a *copy request*.

The product can work with any source or target media that is capable of storing physical or logical tape volumes. It can copy most tape data sets; however, it cannot copy some data sets that are in a proprietary format such as HSM and FDR.

Besides copying the tape data, Tape Optimizer automatically applies the Data Facility System Managed Storage removable media manager (DFSMSrmm) tape library information to the output tape definitions to preserve this information. Tape optimizer also updates the system catalog to identify the new locations of the copied tape data sets.

Tape Optimizer is a robust tape-copy utility. It can efficiently copy a multitude of tape volumes or data sets in a single copy request. Also, it provides many copy options for tailoring copy requests and releasing copied tapes.

These are the key product features:

- Copies data sets individually, or copies entire tape chains that include the tape volumes or data sets that you specify
- Works with all tape media and tape devices that are compatible with your IBM system, including VTSs

- Runs up to 10 copy tasks concurrently for a single copy job to help you copy tape volumes or data sets much more quickly
- Provides an ISPF interface with online Help for configuring and submitting copy requests
- Enables you to define a variety of filters to specify precisely the input tapes or data sets to copy
- Optionally stacks tape volumes or data sets on output tapes to reduce the number of tapes that need to be stored and maintained
- Optionally renames tape data sets as they are copied based on the renaming criteria that you specify
- Generates a detailed copy log, online copy statistics by tape volume, and three summary reports (the Tape Selection Summary report, Request Summary report, and Stacked Tape Summary report) for each copy request
- Applies the DFSMSrmm tape library information for the input tapes to the output tape definitions to preserve this information
- Updates the system catalog information for the copied tape data sets to reflect their new tape locations
- Enables you to perform a trial run of a copy job to ensure that the correct tape volumes or data sets will be copied
- Enables you to restart copy requests from the appropriate point

Tape Optimizer enables you to use any media that is capable of storing physical or logical tape volumes and that is recognized as tape media by your IBM system as the input or output tape media for copy jobs.

Supported media types include reel tapes (IBM 3420), cartridge tapes (IBM 3480,3490, 3492, 3590, or 3592), and logical tape volumes in a VTS. Tape Optimizer can copy single- or multi-volume tapes, tapes with standard labels, unlabeled tapes, and tapes that contain either cataloged or uncataloged data sets.

Restriction: IBM Tivoli Tape Optimizer does not support copying data from HSM-managed tapes

A key feature of Tape Optimizer is its ability to copy numerous tapes in a single copy job. The product imposes no limit on the number of tapes that can be copied per job. This feature can provide the following benefits to your enterprise:

- Reduce the impact of copy operations on system performance and availability. Only one copy job is written to the JES queue, initiated, and scanned for completion status.
- Reduce the workload for tape operators and the related personnel costs
- Make recovery from a failed tape-copy operation easier. You restart just one copy job to resume copy processing from the appropriate point

To successfully implement IBM Tivoli Tape Optimizer for z/OS you have to ensure that the following software requirements are met:

- z/OS version 1.7 or higher
- Any version of TSO/E and ISPF that the operating system supports
- Any version of DFSMSrmm that the operating system supports
- JES2 or JES3

23.9 IBM Tivoli Storage Optimizer for z/OS

IBM Tivoli Storage Optimizer for z/OS automates the monitoring of storage resources across the enterprise, which increases the efficiency of existing storage to yield a higher return on your storage investment. Storage Optimizer automatically discovers your z/OS environment. Storage administrators can then use the Java-based interface to set up rules, thresholds, responses, and corrective actions to manage DASD resources proactively.

With extensive filtering capabilities, trend analysis, and root-cause analysis, administrators and operators can proactively focus on storage issues before they become storage problems. While Storage Optimizer manages resources automatically, based on site policies and best practices established by the administrator, computer operators and administrators are free to address other critical problems.

Through a Java-based graphical user interface, Storage Optimizer generates a true graphical visualization of storage assets and current status. This includes extensive drill-down capabilities to the actual metrics concerning the storage object in question, giving you advanced support for storage management. In addition, Storage Optimizer provides an optional ISPF-based interface to assist administrators in generating JCL for storage management tasks.

Storage Optimizer operates 7x24x365. Based on site policies, Storage Optimizer regularly collects measurements about your z/OS storage environment, then compares the results to previous metrics and identifies exceptions. Whether you tell Storage Optimizer to simply notify you when exceptions occur or have it automatically carry out corrective actions is your call. Storage Optimizer can do as much or as little as you need.

Storage Optimizer follows the IBM blueprint for autonomic computing:

- Collect data about the environment.
- Decide if actions are necessary.
- Control change in accordance with site policy.

Designed for storage administrators and computer operators of all skill levels, Storage Optimizer enables you to do the following tasks:

- Improve utilization, analysis, and planning for z/OS storage resources.
- Manage multiple systems and locations from a single graphical interface with a look-and-feel that is comfortable for operators, no matter what their level of mainframe experience.
- Define automatic responses with corrective actions triggered by both capacity and trend-related issues.
- Contact key personnel by email, pager, WTO, SNMP alerts, and other methods when an immediate response is required.
- View current status and historical trends that are based on usage and performance data.
- Collect storage metrics automatically and receive actionable reports where a click of the mouse displays a list of actions appropriate for that object.

Storage Optimizer uses a three-tier architecture. The product is written almost exclusively in Java, with a few modules written in Assembler or C. There are several components to Storage Optimizer:

- A server process (running on Linux or Windows) is the core component to which all agents and clients connect.
- A storage monitoring agent runs as a process under USS (OMVS). Each agent can monitor and manage all storage visible from the z/OS image that it is installed on. If you have remote, additional images with their own set of DASD volumes, you will need to run a separate agent on those images. Multiple agents can report to a single server.
- A GUI client (running on Linux or Windows) provides the interface into all of the functions provided by the server. The GUI client is where storage administrators and operators monitor storage activities.
- An optional MVS-only workbench with an ISPF interface is used to construct JCL for storage management tasks.
- TCP/IP is used to communicate requests and responses between the various components. Event notification is based on the publish/subscribe methodology.

23.10 DFSMS Optimizer

The DFSMS Optimizer solution contains two features: The Performance Analyzer uses historical and real time data to provide an overall data usage picture and the Management Class Analyzer provides cost benefit analyzes and what-if simulations of DFSMS Management Class policies. The Optimizer supports both System-Managed Storage (SMS) and non-SMS environments. The Performance Analyzer uses historical and real time data to provide an overall data usage picture and The Management Class Analyzer provides cost benefit analyzes and what-if simulations of DFSMS Management Class policies. The Optimizer supports both System-Managed Storage (SMS) and non-SMS environments.

Maximizing the use of your storage resources while helping minimize your overall storage costs. DFSMS Optimizer includes a Management Class Analyzer that provides cost-benefit analyses and what-if simulations of management class policies. DFSMS Optimizer helps you make informed, timely data management decisions for your storage system environment.

DFSMS Optimizer provides the following features:

- Graphical User Interface running on Windows or OS/2.
- Includes a Performance Analyzer that uses historical and real-time data to provide an overall data usage picture.
- Powerful SMS filtering controls.
- High compression (80-90%) of collected SMF, RMF™, CRR, and HSM data.
- Reporting and analysis for both SMS and non-SMS data.

> **Reference:** For more detailed information about all the z/OS storage management features, see this website:
>
> `http://www.ibm.com/systems/storage/software/toolkit/`

24

Smart Business Storage Cloud

The IBM Smart Business Storage Cloud (SBSC) is a range of flexible storage virtualization solutions and appliances that can help alleviate data storage challenges by enabling quick implementation of highly scalable, global, clustered network attached storage systems.

Additionally, IBM Smart Business Storage is a pre-packaged service that includes IBM hardware, software, and service components, which can be deployed on a client's site or on an IBM site. Using high speed links between the IBM data centers and the customer premise, Smart Business Storage is a highly secure, scalable data storage solution that increases instrumentation, control, and efficiencies.

Major benefits of the solution include configurations supporting multiple petabytes of capacity, support for billions of files and scale-out performance previously limited to the largest “high performance computing” systems. Also, the Storage Cloud replaces the need for large data centers, thus allowing clients to reduce data center square footage and skilled IT resources.

In this chapter, we discuss these products and illustrate their use.

24.1 Overview

IBM Smart Business Storage Cloud offers a storage virtualization solution designed to support your storage optimization efforts. IBM Smart Business Storage Cloud (sometimes referred to as storage cloud management, or cloud management) is a solution designed to help reduce your total cost of ownership and improve your time to market by. It can help to alleviate your data storage challenges by enabling quick implementation of a scalable, global file storage system with flexibility in deployment and management options. The solution provides virtualized storage to enable storage and server consolidation, a unified management platform to help reduce outages and storage management labor demands and costs, and advanced data replication for cost effective business continuity and disaster recovery. The following capabilities are provided:

- Virtualized storage that can provide for storage and server consolidation to help eliminate fragmentation and improve utilization
- A unified management platform designed to reduce storage management labor demands and costs
- Non-disruptive maintenance and dynamic node and storage capacity scaling that can help reduce outages
- Cost-effective disaster recovery and business continuity options through advanced data replication
- A full spectrum of cloud services, management, and hosting options

IBM offers several types of cloud solutions and appliances for storage and other services: Smart Business on the IBM Cloud, Smart Business Cloud services, and Smart Business Systems.

24.1.1 Public cloud scenarios versus private cloud scenarios

There are two main scenarios for storage clouds that IBM customers can choose to pursue based on their business drivers and technical strategy.

The two scenarios are defined as *pubic storage cloud* and *private storage cloud.* The key differentiators of these scenarios is that the public storage cloud is designed for customers who do not want to own, manage, or maintain the storage environment, thus reducing their capital and operational expenditures cost around storage. The public storage cloud provides for variable billing options and shared tenancy of the storage cloud, giving customers the flexibility to manage the usage and growth of their storage needs. This is the industry standard view of a storage cloud offering and is comparable to storage cloud offerings by other vendors.

The private storage cloud has fixed charges and dedicated tenancy, so it is designed for enterprise customers who want flexibility around ownership, management, and maintenance of the storage cloud.

24.1.2 Public cloud solutions

Similar to a rent model, IBM dictates the choice of technology and cloud location, shared infrastructure with variable monthly charges, dynamic physical capacity at the customer level, and security measures to isolate customer data. In a public cloud, IBM owns the physical assets, facilities, and standard contracts with multiple service level agreements (SLAs) to meet specific needs. Public cloud solutions work well for cross industry solutions that are storing from tens of terabytes (TB) to multiple petabytes (PB) of data.

24.1.3 Private cloud solutions

Similar to a purchase or lease model, with a private cloud, customers have the choice of technology and location on dedicated infrastructure with fixed monthly charges and physical capacity at the customer level.

Each application can utilize dynamic capacity by sharing the cloud storage among multiple applications. Furthermore, the private cloud provides built-in security through platform dedication, choice of asset ownership, and custom service level agreements (SLAs) to meet specific needs.

Private clouds also work well for cross industry solutions storing tens of terabytes (TB) to multiple petabytes (PB) of data.

Private storage cloud solution technology and services from IBM address multiple areas of functionality, including these:

- Dynamic storage management
- Scalable capacity and performance
- Concurrent, multiprotocol data access
- New levels of manageability

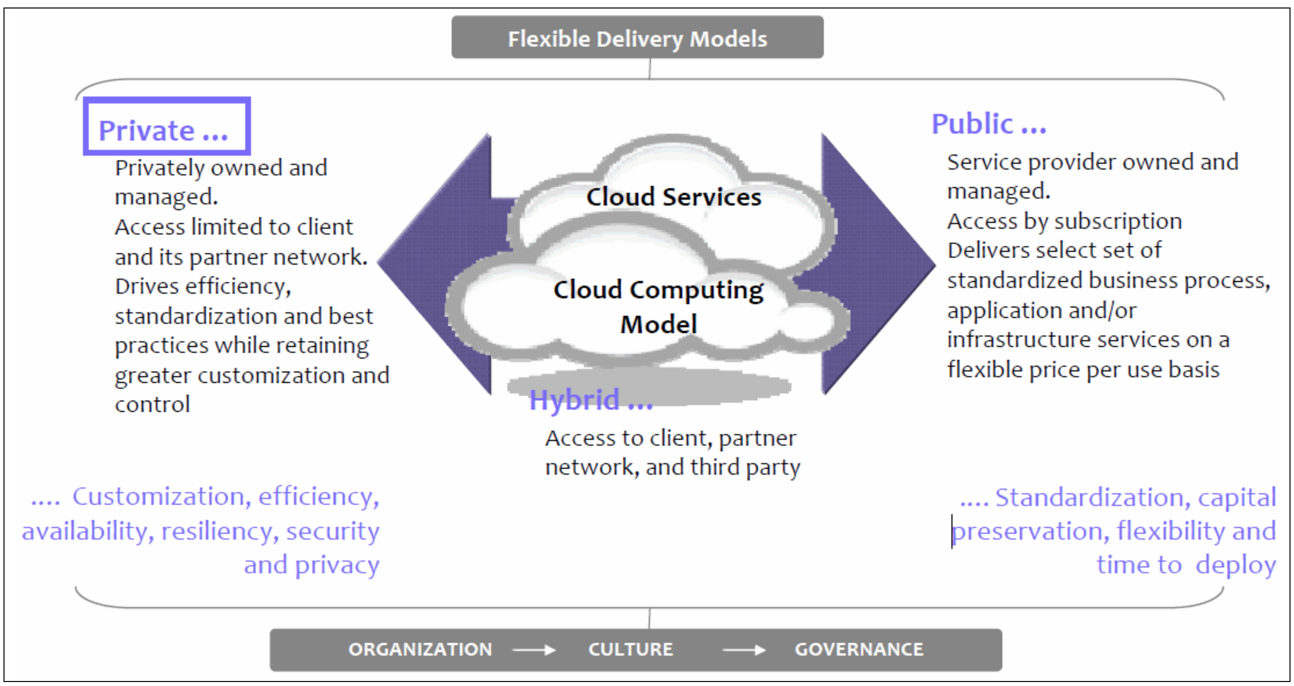


Figure 24-1 A summary of standard cloud computing deployment models

24.2 Smart Business Storage Cloud components

A Smart Business Storage Cloud is a combination of hardware and software components combined to form a system or solution.

A Smart Business Storage Cloud solution provides three key features:

- Global namespace
- Clustered file system
- Information Lifecycle Management (ILM)

As shown in Figure 24-2, virtualizing the file sharing system (NFS, CIFS, and so on) using a single, global, namespace means that an end user sees one device rather than individual servers and storage devices that comprise this virtual NAS device.

At the heart of the SBSC system is the IBM General Parallel File System (GPFS). GPFS is one of the most scalable commercial file systems available, installed in thousands of nodes and storing petabytes of data in discrete installations. SBSC enables the virtualization of the NFS service, transparently distributing service requests across multiple servers, which in turn enables the creation of a scale-out NAS farm installation.

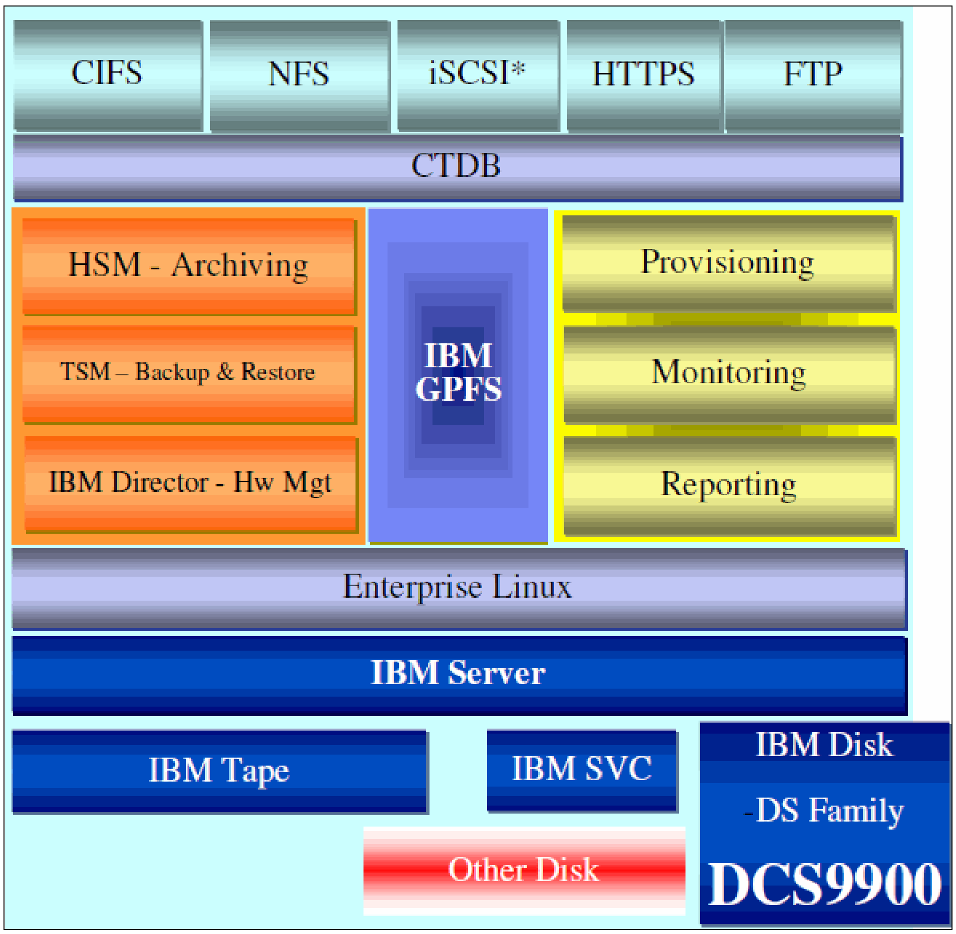


Figure 24-2 SBSC components

The SBSC solution is extremely resilient. It is designed so that there is no single point of failure in the system. It also allows for disaster recovery configurations that use the global file system, these options include synchronous and asynchronous mirroring of data either on site or between sites and cross cluster file system mounts.

SBSC supports snapshots integrated into Windows Explorer using Volume Shadow Copy Services.

The SBSC solution also supports fully configurable data lifecycle management. Data can be stored in ways relative to the data value and performance requirements. File placement can be defined by flexible policies, data can be classified according to service level agreements and placed on appropriate storage tiers automatically at creation time or moved automatically using the integrated ILM functionality. SBSC also supports LTO-4 tape backup with data encryption, this offers protection for archived data.

24.2.1 How SBSC system works

The SBSC system provides file services by implementing a *scale-out* approach. SBSC uses the wide-striping capability of IBM GPFS to spread the blocks of a single file across as many nodes as possible to combine the streaming performance of many midrange back-end storage devices. All files are accessed by all nodes, this removes the traditional NAS and earlier global namespace implementation limitations of specific files being 'pinned' to individual filers. By doing so, a bandwidth of multiple gigabytes per second is possible because the I/O performance of many disks can be combined instead of storing data only to a small RAID device as filers do today.

By fully exploiting the capabilities of GPFS, the integration of a policy-based lifecycle management interface and the possibility to place files in a directory that spans multiple independent storage classes creates a single file system with multiple storage classes. Each has its own performance, availability, and cost criteria, on a file basis, not on a filer basis, as has been done in the past.

SBSC utilizes and expands the IBM Tivoli Storage Manager and Tivoli Hierarchical Storage Manager products to integrate tape as an additional storage class inside the cloud. This allows transparent migration of data between disk and tape storage and provides end-to-end lifecycle management of the data.

The physical implementation of SBSC utilizes the IBM Bladecenter for highly efficient and scalable processing with various IBM storage devices. The Bladecenter provides a scalable platform for adding storage controllers into the SBSC pool to achieve the right performance balance. Processing blades share power, cooling, and I/O connectivity within the Bladecenter chassis and achieve very efficient performance versus stand-alone servers.

To provide a single global namespace to the user, SBSC uses virtualization and redirection technologies available within GPFS clusters. Each SBSC cluster node has internal access to all data blocks simultaneously and is able to assume the responsibility for each of the other nodes in a cluster. This provides the means for a transparent, non-disruptive protocol failover for client applications. Because none of the existing cluster technologies provides a transparent failover of network-based file systems, SBSC introduces an extremely scalable cluster suite dealing with the specifics of file systems to provide a high degree of semantic correctness while being able to scale to very high bandwidths.

24.2.2 Difference between SBSC and other clustered file systems

While other clustered file systems are just that, SBSC is more of a "storage controller in a grid," meaning that the ownership of data is handled dynamically. In many clustered file system implementations, there is one node that is the default owner of a portion of the data. To maintain this structure requires high volumes of internode communication, and in case the owning node goes down, the IP and data must be taken over by another node. Although IP takeover is not a big problem, the takeover of data often proves difficult.

As can be seen in Figure 24-3, with SBSC, this problem is completely overcome, because any node can see any data at any time.

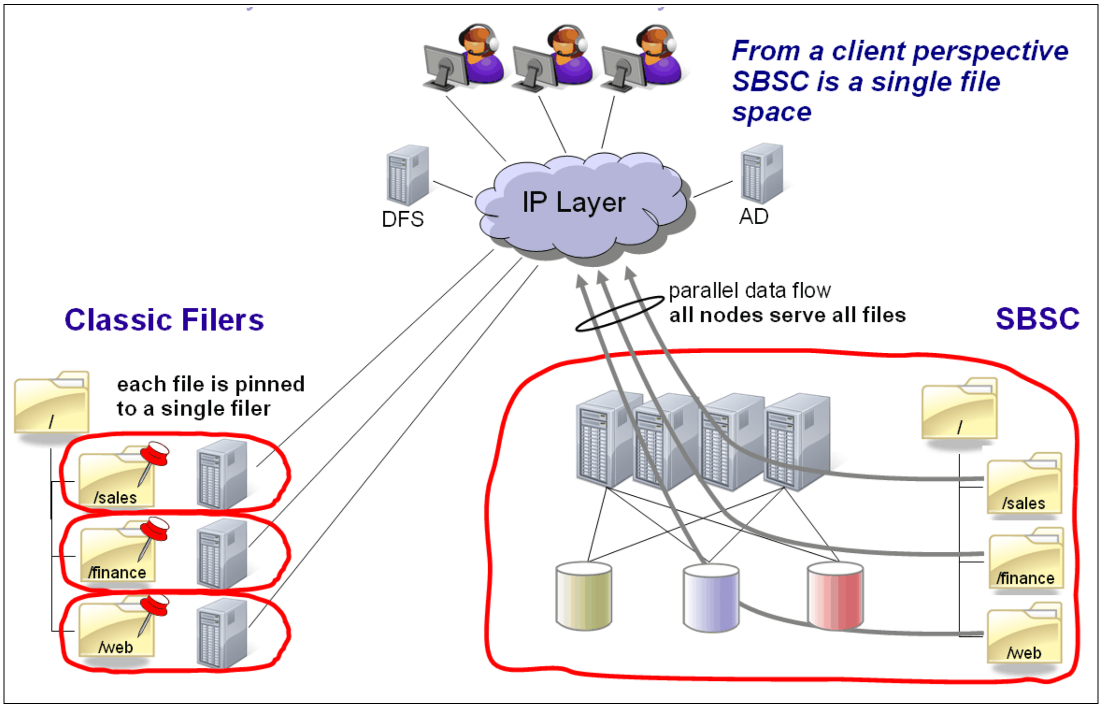


Figure 24-3 The difference between SBSC and traditional approach

24.3 Benefits of using SBSC

The efficient management of data is an ongoing struggle between access and scalability. Providing access to file-level data (that is, those files associated with individual documents, multimedia content, databases, and other applications) becomes more difficult as the number of users with access and the amount of data stored both grow.

Achieving the scalability needed to respond to the growth of data volume typically results in higher hardware and software costs and greater management challenges.

Network-attached storage (NAS) solutions provide simplicity, manageability, and access, but until now, they lacked a single capability that has kept them from playing a role beyond the departmental level: scalability.

If a traditional filer is reaching a scalability or capacity limit, users upgrade to the next higher filer level until they reach the highest available system; this is the *scale-up* approach.

Instead of scaling up in a single high-end enterprise-class server node or building failover clusters to provide high availability for the filers, the SBSC system utilizes software functions to build a global namespace and exposes to the end user *a single virtual cluster node* with very high scalability.

24.3.1 Continuous availability

SBSC allows disk subsystems to be added, removed, and migrated non-disruptively, as can be seen in Figure 24-4.

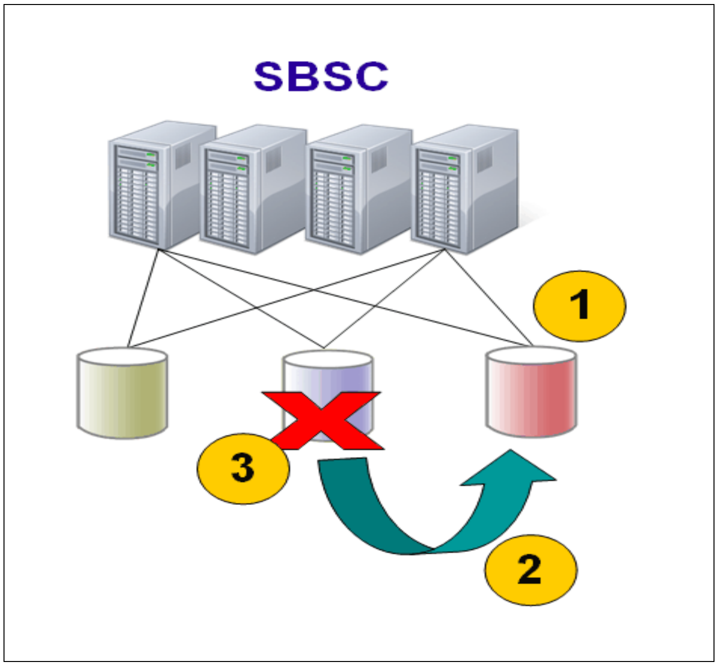


Figure 24-4 non disruptive upgrades

The numbers in this diagram indicate the following processes:

1. Add new disk subsystem.
2. Redistribute data excluding storage to be removed.
3. Remove old subsystem.

24.3.2 Online transparent data migration

Existing NAS storage can be easily integrated into a cloud by allowing existing devices to become part of the global namespace. This enables migration from old storage to be completed automatically and completely transparently as shown in Figure 24-5.

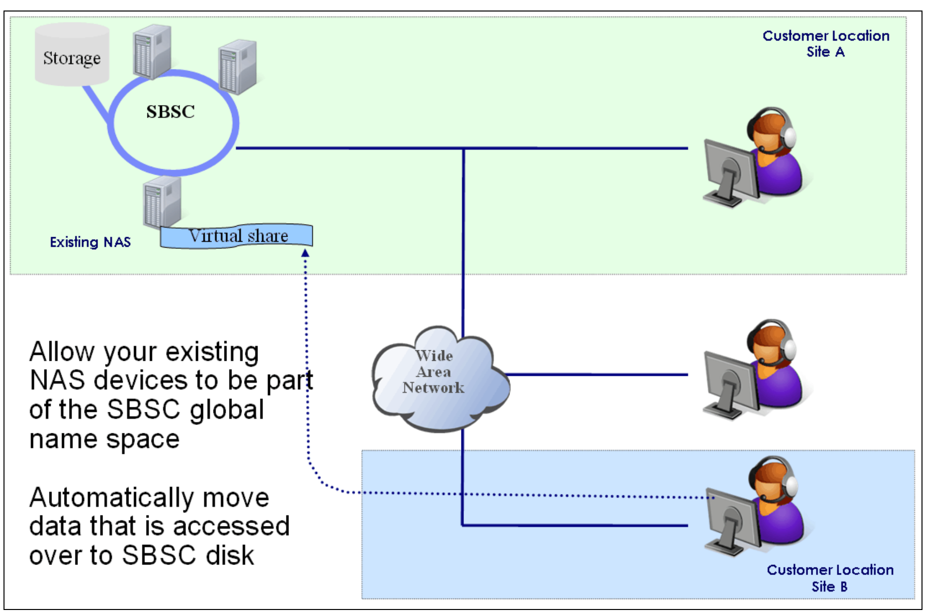


Figure 24-5 online data migration

24.3.3 What is new for IBM storage cloud solutions

IBM Scale Out Network Attached Storage offers extreme scale-out capability for very large storage infrastructures requiring high availability—IBM Information Archive, an integrated IBM Smart Business System for archive and retention management.

IBM Information Archive is a single integrated solution for both simple archive and policy-based retention for compliance support. IBM Information Archive features rapid installation, tiered storage management, built-in deduplication, and encryption—IBM Smart Business Storage Cloud, a Capacity on Demand network file service that runs behind your firewall.

IBM Smart Business Storage Cloud allows the enterprise customer to cost-effectively handle the tidal wave of information—email and email attachments, images, video, web content, presentations, CAD/CAM designs, source code, historical documents, contracts, and more.

24.3.4 Summary of benefits

Cloud computing has the potential to make an enormous impact to your business:

- Reducing IT labor cost by 50% in configuration, operations, management, and monitoring
- Improving capital utilization by 75%, significantly reducing license costs
- Reducing provisioning cycle times from weeks to minutes
- Improving quality, eliminating 30% of software defects
- Reducing end user IT support costs by up to 40%

For more information, see this website:

`http://www.ibm.com/systems/storage/solutions/cloud/index.html`

Storage services are among the easiest to adapt to the cloud computing model. IT storage teams commonly provide storage “as a service” to other departments, so Best Practices and service level agreements have become standardized over the years.

IBM offers an expanding menu of cloud storage services, available on a pay-per-use basis, delivered from state-of-the-art IBM data centers. IBM also helps clients implement public, private, and hybrid cloud storage services, with expert consulting and workload optimized systems.

The following summary lists business, operational, and technical benefits that can be delivered by a Smart Business Storage Cloud.

Business benefits

- Significant storage cost reduction
- Faster access to data
- Geographic access to data
- Smart/Green adaptability
- ‘Bottomless’ cloud storage

Operational benefits

- Simplified Infrastructure
- Single point of management
- High data availability
- Seamless scalabilty
- Better storage utilization
- Improved performance
- Greater application support

Technical benefits

- Single global namespace
- Multi-protocol data access
- Simplified administration and back-up
- Automated, policy based placement and migration of files
- Scalable to billions of files
- Faster provisioning

24.4 Components within an SBSC solution

The following sections provide a brief overview of the main components of an SBSC system.

24.4.1 Host attachment

The SBSC host attachments shown in Figure 24-6 are primarily provided through clustered CIFS and NFS services. Using the new Cluster Trivial Database (CTDB), it is possible to provide transparent, non-disruptive failover of CIFS and NFS between SBSC nodes. This also provides unparalleled aggregate performance scaling, Intelligent load balancing, and simultaneous access to a single file by heterogeneous clients.

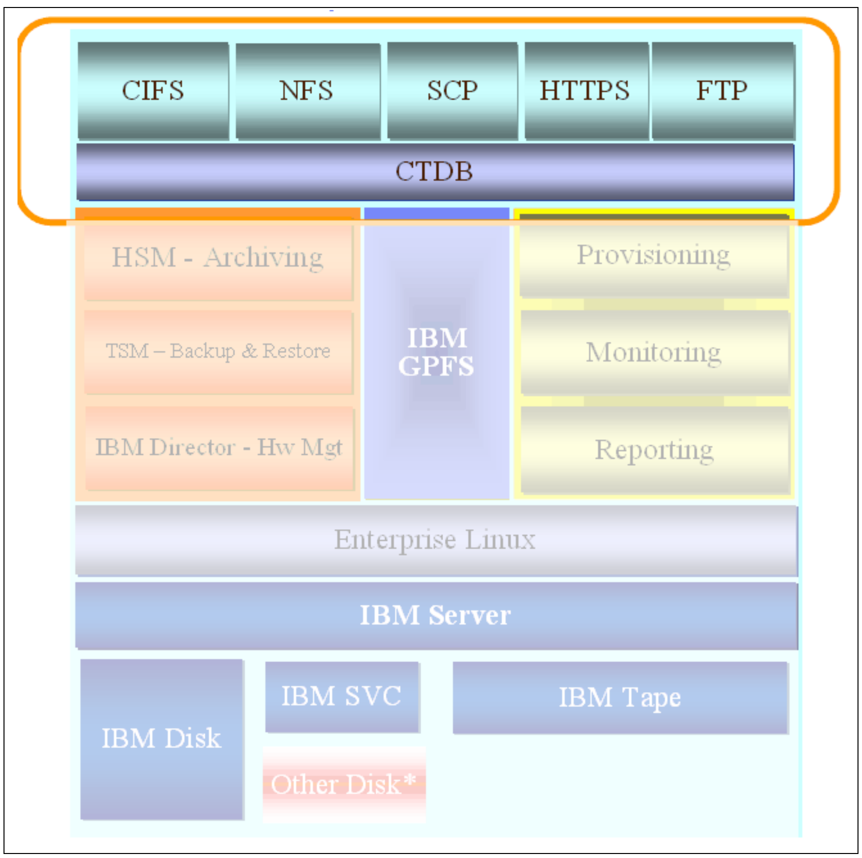


Figure 24-6 Host connectivity

24.4.2 Hardware

The hardware components of a SBSC solution consist of servers, SAN switches, and disk storage. Tape storage for archiving data is an optional part of any SBSC solution, as shown in Figure 24-7.

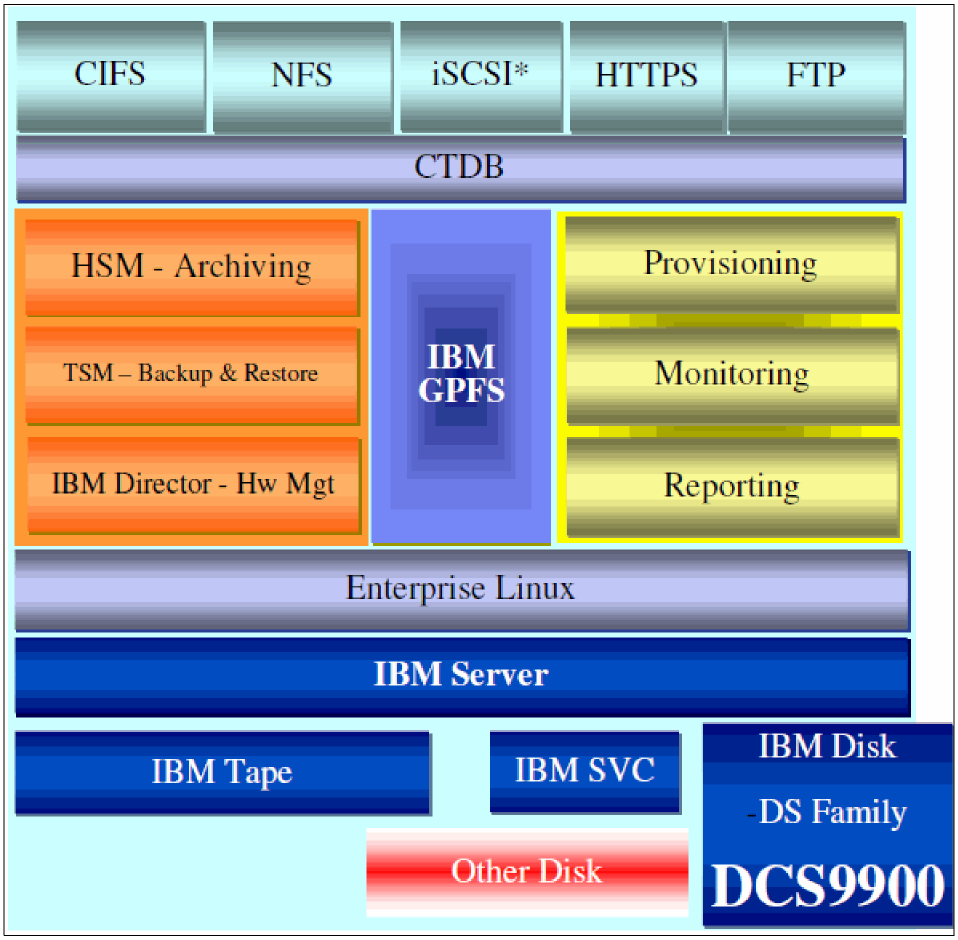


Figure 24-7 SoFS Component View

Storage server

The servers used in a SBSC solution are clusters of BladeCenter HS21 or HS21 XM blades or rack mounted X3650M2 servers. Production servers might be connected by Gigabit or 10 Gigabit Ethernet. Connectivity to the switches and storage units is by Fibre Channel only for the blades, and Fibre Channel or SAS attachment for the rack mounted servers.

As a minimum three System x servers are required. All servers in a configuration will be the same type. A separate management console might be added or that function many be located in one of the System x servers. The BladeCenter HS21 or HS21 XM blades might be housed in a BladeCenter H with Gigabit Ethernet or a BladeCenter H with 10 Gigabit Ethernet.

SAN hardware

The SAN switch hardware currently used for SBSC systems can be seen in Table 24-1. The base configuration of these switches activates less than the maximum number of Fibre Channel ports on the switch but for SBSC configurations all ports will be activated.

Table 24-1 SBSC SAN switch hardware

Switch model	Description
2005-B16	SAN16B-2, 16-port 4Gbps Fibre Channel Switch
2498-24E	SAN24B-4, 24-port 8Gbps Fibre Channel Switch
2498-40E	SAN40B-4, 40-port 8Gbps Fibre Channel Switch

Storage units

Data is stored on one or more of the IBM storage system units described in Table 24-2.

Table 24-2 SBSC storage units

Storage unit	Description
XIV (2810-A14)	This large solution provides a capacity of 180 TB and uses only 1 TB or 2 TB SATA disk drives. The system has up to 240 GB cache and 24 FC host ports and up to 6 iSCSI ports.
DS8000	SoFS will support the use of DS8100, DS8300, and DS8700 systems, but a special request must be made. Configurations will be customized to the particular solution. This large solution provides up to 512 TB using FATA disks or 307.2 TB using FC disks, up to 32 GB cache, up to 128 FC host ports
IBM SVC	SoFS will support attachment of IBM SVC managed devices, this means any devices not on the supported hardware list can be used for SoFS storage devices if they are supported by SVC.
DCS9000	SoFS will support the use of the DCS9900. This midsize solution provides up to 1.2 PB per system (2.4 TB with 2 TB using SATA disks, SAS 450 GB and 600 GB, RAID-6, 8 FC 8 GB host ports. Through its parallel, non-blocking architecture, the DCS9900 delivers up to 5.9 GBps data streaming bandwidth from/to disk media whether reading or writing data.
DS4800	This midsize solution provides up to 168 TB using SATA disks or 67.2 TB using FC disks, up to 16 GB cache, 8 FC host ports
DS4200	This midsize solution provides up to 84 TB using SATA disks, 2 GB cache, 4 FC host ports.
DS3400	This dual controller model of the DS3400 is the only one supported in SoFS configurations. Any number of DS3400 systems that can fit into the SAN network are supported in SoFS configurations. The preferred LUN configuration with 4 enclosures is RAID 5 in a 3+P arrangement so that each drive is in a separate enclosure. As a result, the system can survive the loss of a complete enclosure without losing a LUN.
DS3200	This entry-level solution provides up 14.4 TB using SAS disks, up to 1 GB cache, and 6 SAS host ports.

Support: Supported hardware device information is supplied by Techline and current at 1 October 2009. Consult your IBM or business partner sales team for updated information.

24.4.3 Software components

The IBM GPFS 3.2 product on servers running Red Hat Enterprise Linux 5 is the heart of the SBSC system; this provides the SBSC cluster nodes with a single-system view of the file system. See Figure 24-8 for an overview of the software components of the SBSC system.

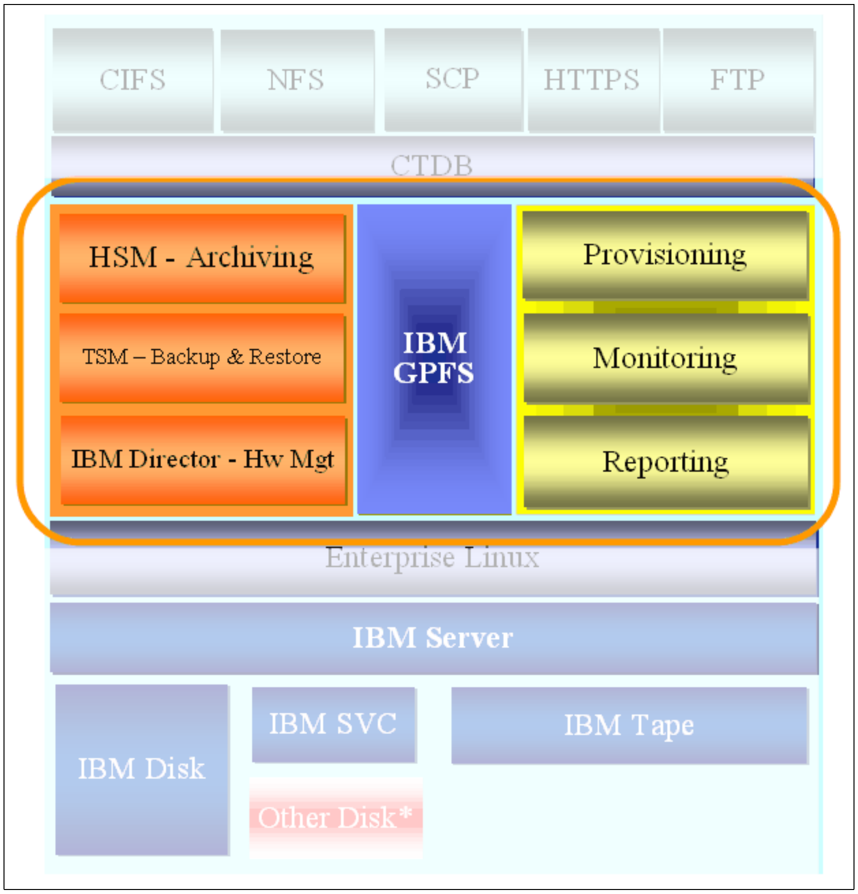


Figure 24-8 software components

Other software components included and their function are shown in Table 24-3.

Table 24-3 SBSC software components

Component	SBSC function
IBM Director	Hardware management
IBM Tivoli Storage Manager	Backup and restore
IBM Tivoli Hierarchical Storage manager	Archiving
DS Storage Manager SMclient	Storage device management
SBSC GUI	User interface
SBSC Toolset	Management of SBSC system

24.5 Data protection and disaster recovery

There are a number of choices that the operator can make in the areas of data protection and disaster recovery. SBSC allows for appropriate choices for each type of data, giving maximum flexibility to enable the right choice for each tier of data.

24.5.1 Data protection

The data protection choices match the choices available on the storage system used in the SBSC solution. These typically include RAID 5, RAID 6, RAID 10, and the unique XIV data protection algorithm.

24.5.2 Simple SBSC single site solution: No disaster recovery

A simple SBSC solution allows users to access data locally using a LAN, and remotely using a WAN. While the high availability is built into a single system, there is no disaster recovery built into this solution.

24.5.3 SBSC with synchronous replication on-site

The operator can set up synchronous replication of part or all of the data to other nodes within the same SBSC site as shown in Figure 24-9.

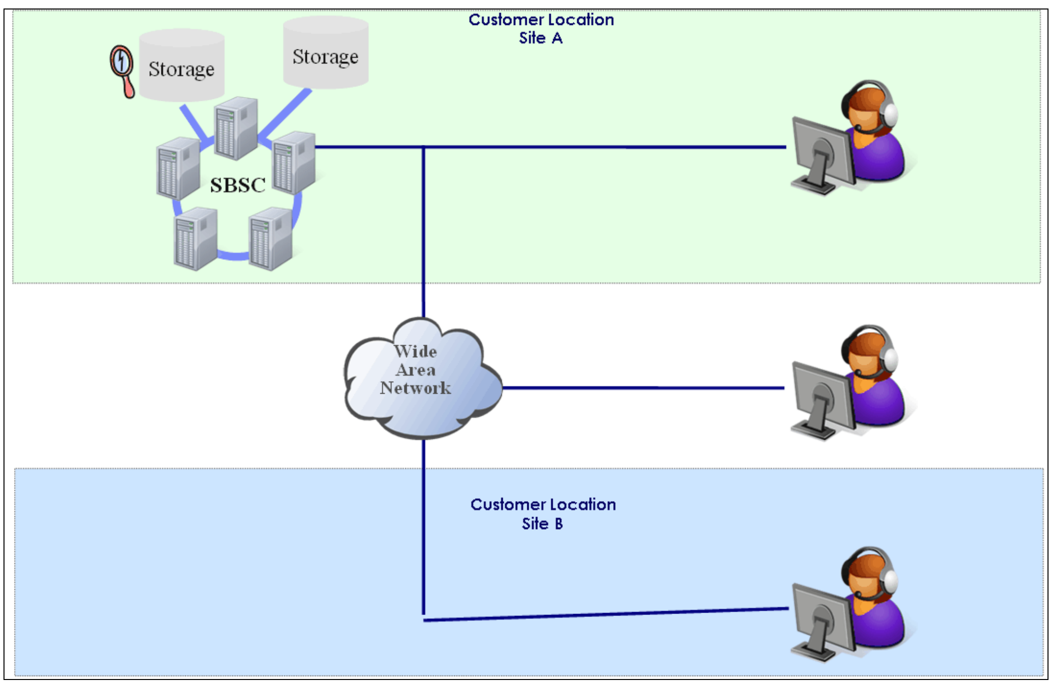


Figure 24-9 Sync replication on a single site

24.5.4 SBSC with cross site sync or async replication

The operator can set up replication of data between SBSC clusters on separate sites as shown in Figure 24-10. The replication can be synchronous if the distance can be traversed by Fibre Channel cables. It is asynchronous if the distance is longer.

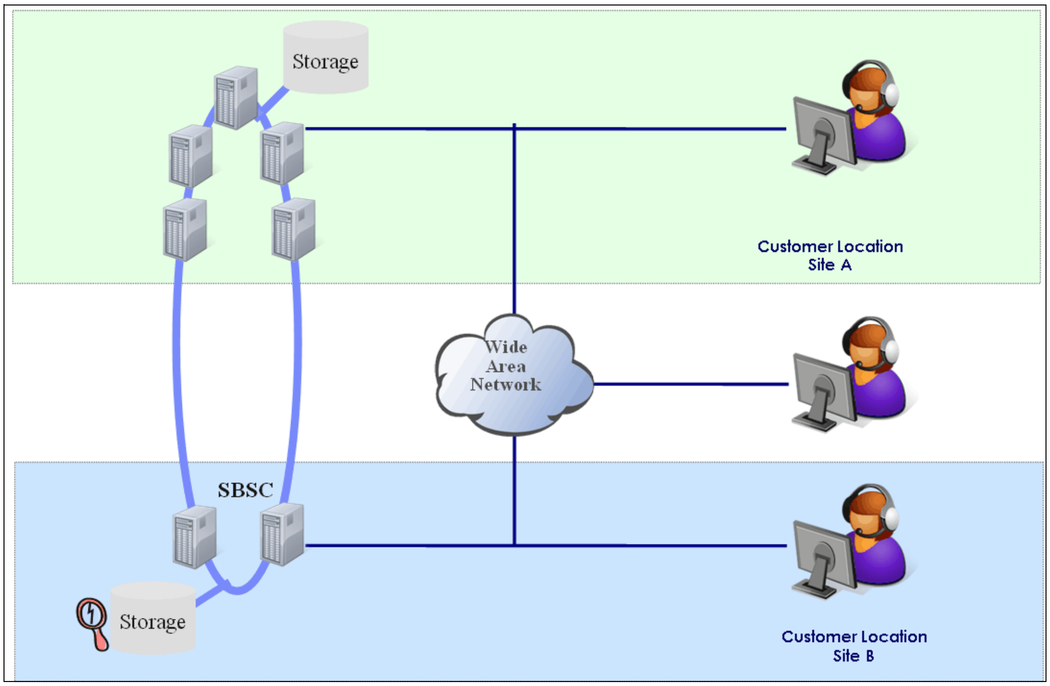


Figure 24-10 Cross site replication

24.5.5 SBSC with a cross cluster mount

Two SBSC sites can be connected and each file system mounted on the other to provide a solution that works as one large SBSC that covers two sites as shown in Figure 24-11. Within that complex, mirrors of data can be set up on separate sites within the single SBSC solution.

The cross cluster mount reuires a TCP/IP connection between the clusters. This IP connection can be used for data and metadata traffic. As an option, there is also the ability to send data traffic over a Fibre Channel (SAN) connection between the clusters.

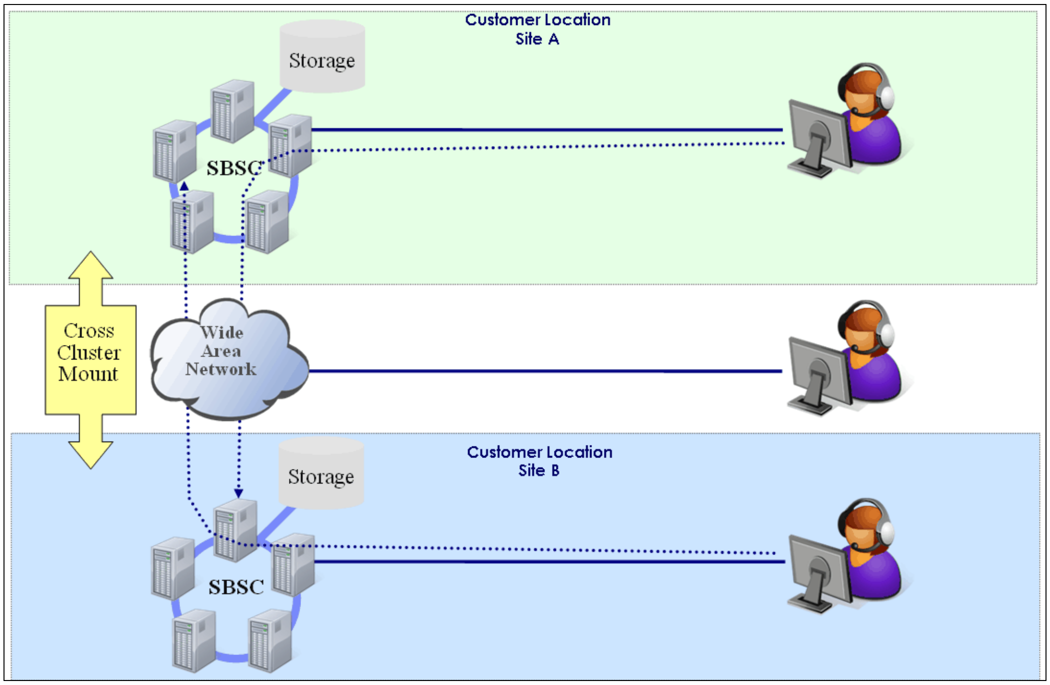


Figure 24-11 Cross cluster mounts

24.5.6 Snapshot technology

A snapshot of an entire GPFS file system (Figure 24-12) can be created to preserve the file system's contents at a single point in time. A snapshot contains a copy of only the file system data that has been changed since it was created, using a copy on write technique.

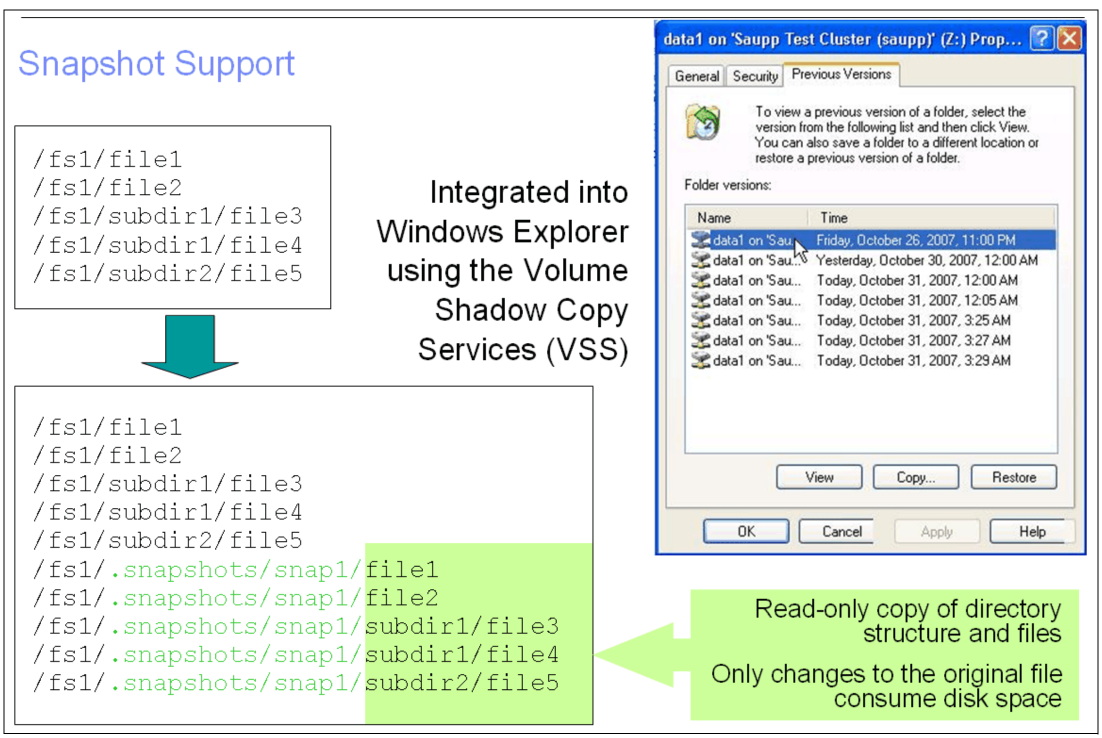


Figure 24-12 Snapshot overview

Snapshots of a file system are read-only; changes might only be made to the active (that is, normal, non-snapshot) files and directories. The snapshot function allows a backup or mirror program to run concurrently with user updates and still obtain a consistent copy of the file system as of the time that the snapshot was created. Snapshots also provide an online backup capability that allows easy recovery from common problems such as accidental deletion of a file, and comparison with older versions of a file. Because snapshots are not copies of the entire file system, they must not be used as protection against media failures.

24.6 IBM General Parallel File System (GPFS)

The IBM General Parallel File System (GPFS) is at the heart of the SBSC environment. See Chapter 21, "IBM GPFS and SoFS" on page 679 in this book for a brief overview of GPFS and its functionality.

24.7 More information

See the following websites for more information:

http://www.ibm.com/ibm/cloud/smart_business/
hhttp://www-935.ibm.com/services/us/index.wss/offering/its/a1031610
http://www-03.ibm.com/systems/storage/solutions/cloud/index.html

Included within SBSC is a CIFS component that is based on the Samba open source project and a newly developed, high speed, cluster-aware version of the TDB metadata store database used by Samba. This Cluster Trivial Database (CTDB) allows Samba to scale well across multiple cluster nodes. A more detailed explanation is available in the paper, *IBM Scale out File Services: Reinventing network-attached storage*; see the website:

http://www-935.ibm.com/services/us/its/pdf/sofs-am-journal-final-070108.pdf
http://www-05.ibm.com/il/news/events/di/downloads/track%202/2-Arie%20Blum%20IBM%20SoFS%20and%20DCS9900%20-%20Seminar.pdf

A

Simplified Storage Management

Data is recognized as one of the most important assets of businesses today. As the data demand of e-commerce systems, mission-critical database applications, and multimedia content continues to grow, there has been an exponential growth for storage required by businesses. Unfortunately, this growth in storage requirements has led to increased complexity in the management of storage resources. With this complexity, now more than ever there is a requirement for greater simplified storage management tools to alleviate the sophistication in storage resource provisioning, data disparity, and general overall storage management.

The following tools are available to help centralize, simplify, and optimize the management of your storage infrastructure:

- IBM Systems Director
- IBM Tivoli Storage Productivity Center

A.1 IBM Systems Director

IBM Systems Director is a platform management foundation that streamlines the way that physical and virtual systems are managed across a multi-system environment. Leveraging industry standards, IBM Systems Director supports multiple operating systems and virtualization technologies across IBM and non-IBM platforms.

IBM Systems Director provides multi-system support for IBM Power Systems, Systems x, BladeCenter, System z, and Storage Systems, enabling integration of IBM systems with the total infrastructure. IBM Systems Director also manages non-IBM x86-based systems through a dedicated agent, and provides facilities to manage and configure storage devices, such as disks, switches, internal RAID controllers, and RAID subsystems. This includes the use of IBM Systems Director features, SMI-S providers, and external storage applications.

IBM Systems Director is a unified platform management solution to help control costs by managing energy, virtualization and overall systems operations. This appendix describes key storage management features within IBM Systems Director 6.2.

A.1.1 Overview

In this section we provide highlights, features, and benefits of IBM Systems Director.

IBM Systems Director highlights

Here are the highlights of the IBM Systems Director:

- Unifies the essential management of IBM servers, storage, and network devices delivering a consistent look and feel for common management tasks that reduces operational complexity
- Integrates the IBM best-of-breed virtualization capabilities to provide new ways to simplify the management of physical and virtual platform resources
- Reduces energy costs and usage by monitoring and managing the energy and cooling needs of servers and storage
- Easy integration with enterprise service management tools from Tivoli as well as other third-party providers
- IBM Systems Director Editions provide options to select the level of leading management solutions based on your needs

Important: Be sure to choose the correct edition that suits your datacenter infrastructure.

Figure A-1 shows IBM Systems Director Edition features.

Choose the Edition that suits your data center infrastructure			
Features	**Express**	**Standard**	**Enterprise**
Visualize physical/virtual system relationships	✓	✓	✓
Monitor system health	✓	✓	✓
Provide threshold and error alerts	✓	✓	✓
Update operating systems and firmware	✓	✓	✓
Simplify deployment with virtual images		✓	✓
Control energy use within existing capacity		✓	✓
Monitor network system health with servers and storage		✓	✓
Automate configuration and placement for new workloads			✓
Manage workload availability end-to-end			✓
Understand capacity			✓
Analyze and report historical performance			✓

Figure A-1 IBM Systems Director Edition features

IBM Systems Director Storage features

This section describes the key features of the IBM Systems Director Storage component:

- Extends storage management of IBM Systems Director and VMControl to cover most IBM storage systems
- Storage device discovery and coverage in integrated physical and logical topology views
- Shows relationships between storage and server resources
- Ability to configure logical and physical configuration
- Ability to view controller and volume status and to set notification alerts
- Single management server deployment
- Integration with VMControl featuring the following additional functions:
  - Storage provisioning for image creation, deployment, and cloning
  - Ability to manage storage system pool lifecycle, take group actions across pool and policy-based storage placement, provisioning, and cloning actions within the pool

IBM Systems Director Storage benefits

IBM Systems Director Storage component provides the following benefits for storage environments:

- Utilizes integrated server and storage management to improve service level agreements and responsiveness to business needs
- Significantly reduces storage management cost

A.1.2 IBM Systems Director Storage Control

IBM Systems Director Storage Control enables the management of systems and storage with a single window. IBM Systems Director with Storage Control provides a single management console and system for managing both server and storage systems. Storage Control is an IBM systems Director plug-in based on IBM Tivoli Storage Productivity Center. It integrates tightly with the IBM Systems Director and VMControl environment providing integrated physical and virtual server and storage management through a single user interface.

Storage Control unifies the management of physical and virtual server and storage resources for integrated end-to-end life cycle management, including: configuration, discovery, health, capacity, inventory, provisioning, topology, updates, alerts and retirement. Storage Control is especially important for IT administration groups that have responsibility across servers and storage.

The ability to manage storage subsystems and devices is becoming an increasingly critical function for most IT organizations. With the increased number of storage systems that have adopted the Storage Management Initiative Specification (SMI-S), there exists an industry-standard way to manage these systems. IBM Systems Director employs SMI-S to manage a number of IBM storage devices from the same web console used to manage more traditional systems.

Requirement: IBM Systems Director Storage Control requires IBM DB2 (restricted-use license included at no additional cost) as the IBM Systems Director database.

A.1.3 IBM Systems Director key components

Here we can see the key areas concerning IBM Systems Director

- Supported storage devices
- SMI-S providers
- Discovering storage devices
- Viewing storage devices
- Configuration templates
- Managing storage in real-time
- External storage applications

Supported storage devices

IBM Systems Director provides lifecycle management of your physical and virtual storage systems, including discovery, health and status monitoring, configuration, updates, and virtualization. IBM Systems Director provides facilities to manage and configure storage devices such as disks, switches, internal RAID controllers, and RAID subsystems. This includes the use of IBM Systems Director features, SMI-S providers, and external storage applications. IBM Systems Director supports a wide variety of storage devices, including local storage, BladeCenter integrated storage, network storage, and storage switches.

IBM Systems Director manages a wide variety of storage devices. Supported storage devices are disks, switches, internal RAID controllers, and RAID subsystems.

Support: The degree of support that IBM Systems Director provides on these systems and products might vary. For this information, see the IBM Systems Director Release Notes.

Tip: A storage volume is similar to a logical volume.

Here we list supported storage devices, subsystems, storage modules, and their access devices:

- Controllers:
  - Dedicate Local Storage, access with Integrated RAID Controllers (IRC)
  - Legacy RAID Controller
  - Basic RAID Controller
  - Advanced RAID Controller
- IBM BladeCenter integrated storage, accessed with IBM BladeCenter S SAS RAID Controller Modules, supported only on Windows (2003 and 2008) and Linux on System x systems.
- Network Storage, which is an external SAN storage system. Network storage is accessed with storage switches, adapters, and protocols such as Fibre Channel, SAS, or iSCSI:
  - IBM System Storage DS4100, DS4300, DS4700
  - IBM System Storage DS5020, DS5100, DS5300
  - IBM System Storage DS6000
  - IBM System Storage DS3200, DS3300, DS3400, DS3500
  - IBM System Storage N series 3600
- Storage switches:
  - Brocade 2Gbit/sec and 4Gbit/sec Fibre Channel (chassis and external)
  - Qlogic 2Gbit/sec, 4Gbit/sec, and 8Gbit/sec Fibre Channel (chassis and external)
  - IBM BladeCenter SAS Connectivity Module
  - IBM BladeCenter S SAS RAID Controller Module

Figure A-2 shows storage management tasks and support devices.

	LSI SAS controllers			IBM BladeCenter SAS Modules		Fibre Channel Switches (2/4/8 GB)	IBMSystem Storage DS® and N series				Legacy Raid Controllers
Task	1064 1064e 1068	1078 Internal RAID (IR)	1078 Mega RAID (MR)	Connectivity module	RAID controller module	Brocade (2/4) and Qlogic (2/4/8)	3K 4K 5K Services	6000	N3600	DS3500	ServeRaid 6/7/8/9 and LSI 1030
Discovery	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Inventory collection	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Monitoring (alerts and status)	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Physical Topology	No	No	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No
Logical Topology	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes	No
Provisioning	No	No	No	No	Yes	Yes	Yes	Yes	No	No	No
SAS zoning	No	No	No	Yes	Yes	No	No	No	No	No	No
View and manage attached devices	Yes	Yes	Yes	Yes	Yes	No	No	No	No	No	Yes
Config uration	Yes	Yes	Yes	Yes	Yes	No	No	No	No	No	No
Update Installation	Yes	Yes	Yes	Yes	No	No	No	No	No	No	Yes
Trouble shooting	No	No	No	Yes	Yes	No	No	No	No	No	No

Figure A-2 Shows storage management tasks and supported devices

Support: IBM Systems Director now provides IPv6 support for storage devices.

IBM Systems Director now provides support in an IPv6 environment. Figure A-3 shows which storage devices have IPv6 support.

Storage device	Device type	IPv6 support
Legacy RAID Controllers	ServeRAID versions 4/5/6/7/8/9	Full compliance
Internal RAID Controllers	1064. 1064e, 1068, 1078 IR/MR	Full compliance
IBM BladeCenter SAS Modules	SAS Connectivity Module (NSSM)	Non-compliant (NSSM switches do not support IPv6)
	RAIDed SAS Switch Module (RSSM)	Not compliant (RSSM switches do not support IPv6)
Fibre Channel Switches (2GB/4GB)	QLogic 2GB/4GB	Partial compliance (QLogic Firmware version 7.4/7.8 or later supports IPv6)
	Brocade 2GB/4GB	Full compliance
IBM System Storage DS series	DS3100, DS3200, DS3300 DS3400, DS3500 DS4100, DS4300, DS4300 (DS4K)	Full compliance **Note:** Compliance statement does not include Engenio SMI Provider, which was not tested on the IBM Systems Director version 6.2 product.
	DS5020	Full compliance
	DS6K	Not compliant
IBM System Storage N series	NS3600	Not compliant

Figure A-3 Shows which storage devices have IPv6 support

SMI-S providers

The Storage Management Initiative Specification defines an interface for heterogeneous, functionally rich, reliable, and secure monitoring and control of critical global resources in complex and potentially broadly distributed, multivendor storage topologies. An SMI-S provider is the vendor-specific module that must be installed and properly configured for IBM Systems Director to manage certain storage devices. IBM Systems Director communicates with a storage device through its respective SMI-S provider.

These storage devices require an SMI-S provider in order to work with IBM Systems Director:

- IBM System Storage DS6000 devices
- IBM System Storage N series N3600 devices
- IBM TotalStorage DS4000 devices
- IBM TotalStorage DS5000 devices
- IBM TotalStorage DS3000 devices
- Brocade 2G/4G Fibre Channel (IBM BladeCenter chassis and external)

For the Qlogic 4 Gbit/sec Fibre Channel (IBM BladeCenter chassis and external) switch, the storage provider is embedded in the switch. There is no need to install or configure anything. When asked for the IP address of the SMI-S provider, use the IP address of the switch itself.

Integrated RAID Controller devices use the IBM Systems Director Platform-Agent managed system. Run Inventory Collection on the Agent to get the Integrated RAID Controller.

The IBM BladeCenter S SAS RAID Controller Module requires an SMI-S provider in order for IBM Systems Director to discover and manage the attached SAS RAID Controller Module storage. This provider is installed automatically with IBM Systems Director Server on supported operating systems. This provider has one of the following names:

- PlatformAgentSubagent IBM BladeCenter SAS RAID Controller Module 6.1.0 Linux
- PlatformAgentSubagent IBM BladeCenter SAS RAID Controller Module 6.1.0 Windows

The provider for the IBM BladeCenter SAS RAID Controller Module can work with a maximum of four IBM BladeCenter chassis. This provider can be copied to Platform-Agent managed systems if the need arises, and each of these Platform-Agent managed systems can also manage a maximum of four IBM BladeCenter chassis.

Applicable standards

For information about the standards mentioned here, see these websites:

- Storage Management Initiative - Specification (SMI-S):

  https://www.snia.org/smi/about/

- Storage Networking Industry Association (SNIA):

  https://www.snia.org

- Distributed Management Task Force (DMTF):

  http://www.dmtf.org

- Web-Based Enterprise Management (WBEM):

  http://www.dmtf.org/standards/wbem/

- Common Information Model - CIM:

  http://www.dmtf.org/standards/cim

Use the following information to obtain SMI-S providers for any IBM TotalStorage DS3000, DS4000, DS5000, or DS6000 devices, and IBM System Storage N series N3600 devices. You can also use the information to obtain providers for various switches used to manage storage devices.

IBM TotalStorage DS3000, DS4000, or DS5000

The SANtricity SMI Provider from LSI that complies with SMI-S version 1.3 is required to enable discovery of IBM System Storage DS3000, DS4000, or DS5000 devices. You can obtain this provider from the LSI website:

http://www.lsi.com/storage_home/products_home/external_raid/management_software/smi_provider_new/index.html

It is preferable to use the 10.10.G5.02 version of this provider for this version of IBM Systems Director. Any other version might not function as well.

> **Tip:** You can manually add an IBM System Storage DS3000, DS4000, or DS5000 device using IBM Systems Director. To manually add those devices, specify the IP address of the system where you installed the SANtricity SMI Provider, not the IP address of the IBM System Storage DS3000, DS4000, or DS5000 device itself.

IBM TotalStorage DS6000

To obtain the provider for the IBM TotalStorage DS6000 storage device, go to the IBM System Storage support web page. It is preferable to use the 5.2.1.139 version of this provider for this version of IBM Systems Director. Any other version might not function as well.

IBM System Storage N series N3600

You can obtain the provider for the IBM System Storage N series N3600 from this website:

http://www.ibm.com/systems/support/supportsite.wss/selectproduct?taskind=2&brandind=5000029&familyind=5364792&continue.x=1

It is preferable to use the 3.0.2 version of this provider for this version of IBM Systems Director. Any other version might not function as well.

Brocade switches

You can obtain the appropriate SMI-S version 1.2 provider for IBM Systems Director from this website:

`http://www.brocade.com/support/SMIAGENT.jsp`

It is preferable to use the 120.10.x version of this provider for this version of IBM Systems Director. Any other version might not function as well.

Qlogic switches

There is no need to obtain an SMI-S provider for the Qlogic switches. The SMI-S provider is embedded in the switch.

Storage restrictions

The following restrictions apply while managing the storage devices using the IBM Systems Director:

- You are advised *not to install* Storage Configuration Manager on a system that is running IBM Systems Director.
- Storage devices such as memory, caches, and registers are not managed by Storage Management.
- The following devices are not supported:
  - IBM System Storage N series hardware (other than the N3600)
  - IBM System Storage DS8000
  - IBM System Storage SAN Volume Controller
  - Any other storage devices not listed in Figure A-2 on page 747.
- IBM BladeCenter S SAS RAID Controller Module provider is integrated with IBM Systems Director 6.2 Platform Agent and is installed as a default with IBM Systems Director 6.2. If you want to perform a separate install of the IBM BladeCenter S SAS RAID Controller Module provider, you must ensure that the compatible IBM Systems Director Platform Agent is installed
- PlatformAgentSubagent IBM BladeCenter SAS RAID Controller Module 6.1.0 is compatible with the IBM Systems Director Core Component Services Level 1 Platform Agent
- PlatformAgentSubagent IBM BladeCenter SAS RAID Controller Module 6.2.0 is compatible with IBM Systems Director 6.2 Platform Agent

Discovering storage devices

IBM Systems Director can help you manage and provision various kinds of storage. Before you can manage your storage systems, they must be discovered and accessible in the IBM Systems Director Web interface.

The following methods are used for discovery:

- General discovery: General discovery works following the IBM Systems Director default system discovery procedure. See *Implementing IBM Systems Director 6.1*, SG24-7694 for further in-depth information
- Direct connection discovery: Direct connection discovery works to discover a storage device by searching for systems that have an installed SMI-S provider for managing storage devices. Platform Component Library (PCL) is an IBM API used for SMI-S direct connection discovery. It allows clients to locate a specified system in the network. See *Implementing IBM Systems Director 6.1*, SG24-7694 for further in-depth information.

- Advanced discovery: The direct connection discovery described in the previous section is a part of advanced discovery. Using a direct connection you can discover and manage only one SMI-S provider at a time. However, if you want to discover multiple SMI-S providers you can use multicast and broadcast modes of advanced system discovery. You can also discover multiple SMI-S providers using Directory Agent discovery. See *Implementing IBM Systems Director 6.1*, SG24-7694 for further in-depth information

Viewing storage devices

After a storage device is discovered and the inventory is collected for the device, IBM Systems Director provides you with various perspectives to view and provision storage devices. In this section we show the key perspectives that you can use to view storage devices. The key perspectives are shown next.

Figure A-4 shows the Storage Management summary panel.

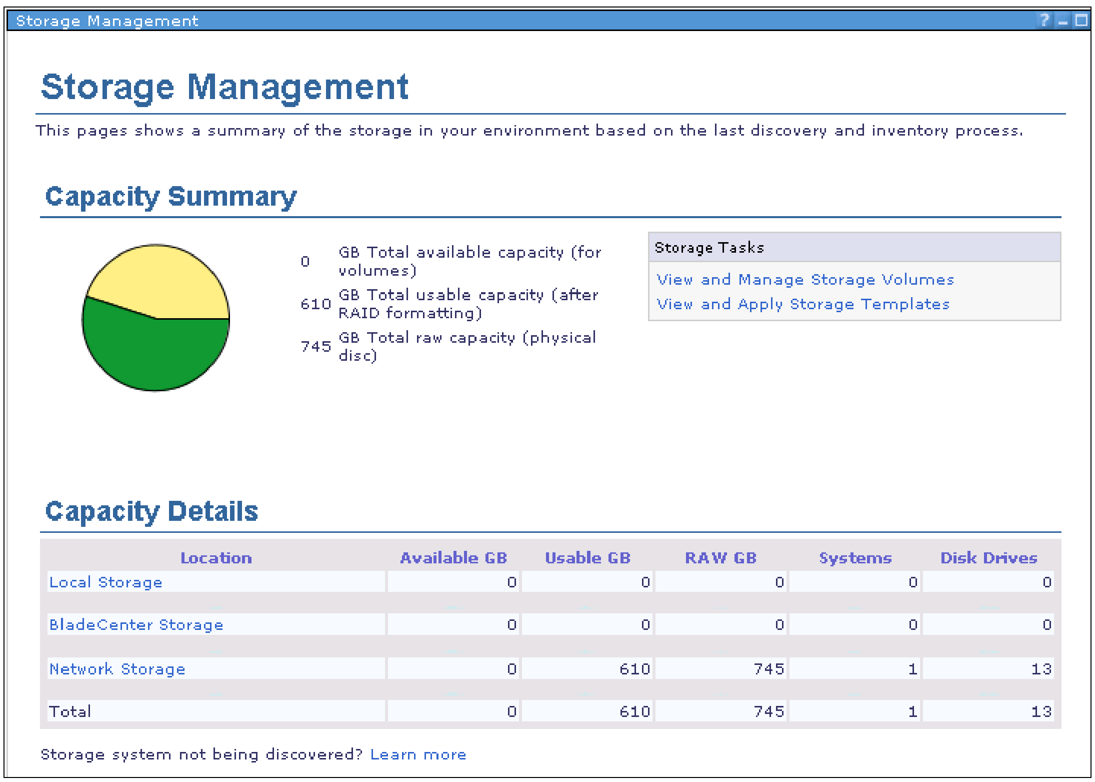


Figure A-4 Storage Management summary

Your storage devices can be viewed and managed in one central location. The Storage Management Summary page provides an introduction to your storage systems. The Storage Management Summary is invoked from the Manage tab of the Welcome page.

The Storage Management Summary page gives high-level details about your storage systems, and links to the tasks that provide more detail and administer the storage devices. Discovery and inventory collection must be run before you can display storage systems. The Storage Management Summary page is divided into these areas:

- Capacity Summary
- Storage tasks
- View and Manage Storage Volumes
- View and Apply Storage Templates
- Capacity Details
- Local Storage.
- BladeCenter Storage
- Network storage
- Total

See *Implementing IBM Systems Director 6.1*, SG24-7694 for further details.

Figure A-5 depicts storage systems and volumes information. This displays a table of all the storage volumes accessible to IBM Systems Director.

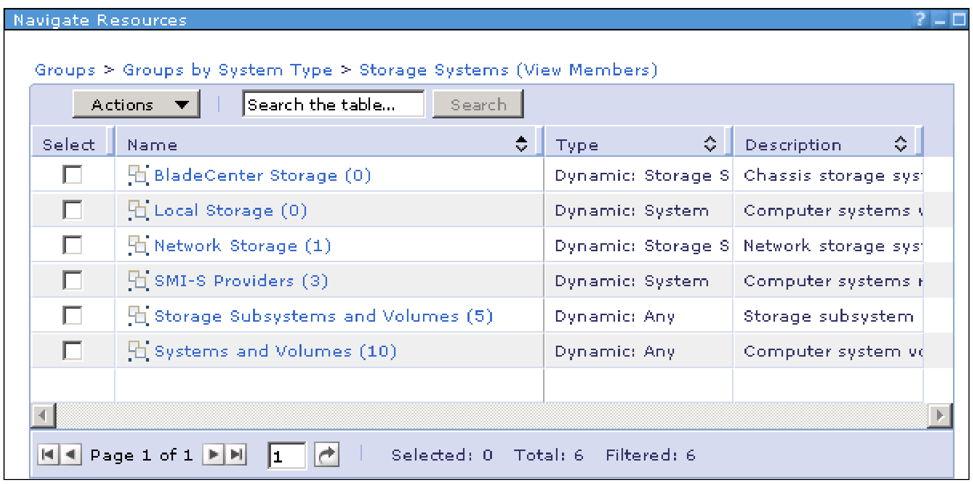


Figure A-5 Displays storage systems and volume information

Figure A-6 depicts a simple storage topology perspective. The storage topology perspective displays a topology view tailored to the storage-related resources for a system or device.

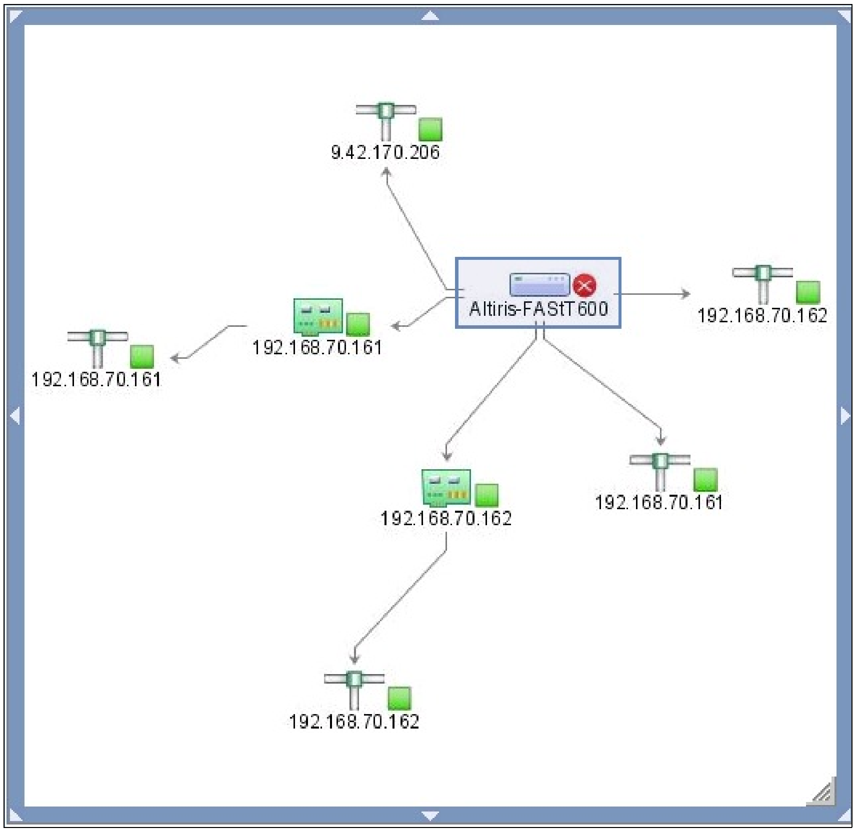


Figure A-6 A simple storage topology perspective

Figure A-7 depicts the health and status of storage devices. The status manager provides, at a glance, a view of the health of your managed resources (including systems, operating systems, applications, processes, and security).

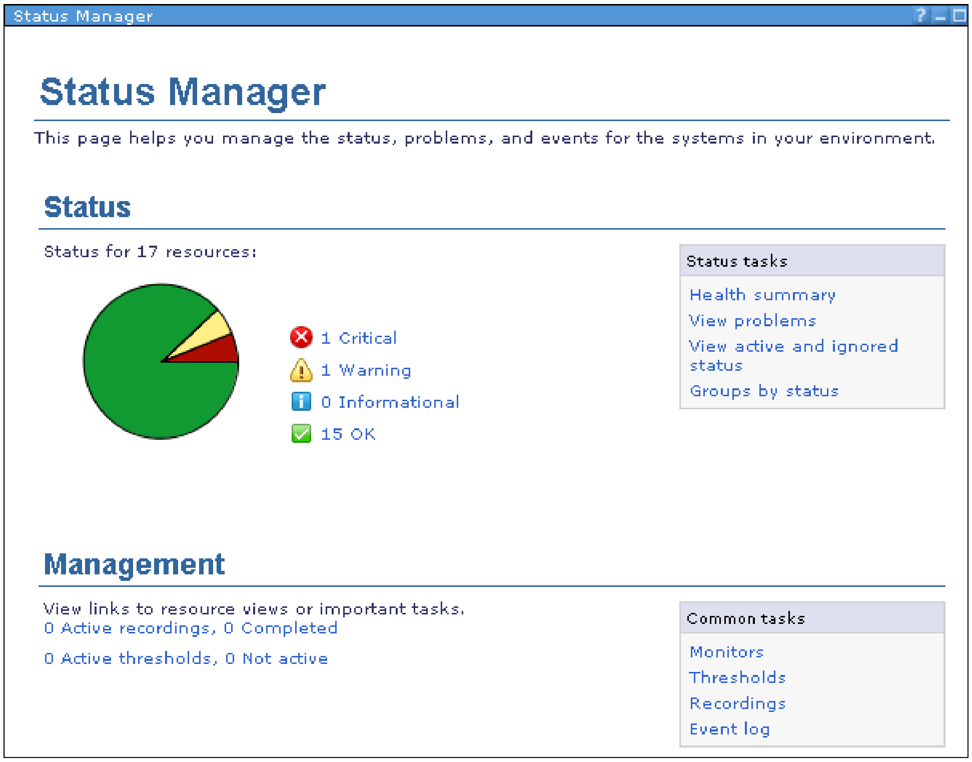


Figure A-7 Displays health and status of storage devices

The status of discovered systems is automatically retrieved and displayed, and this display can be customized in several ways—using one of the system status and health tasks, navigating to a specific resource, or using the command line interface.

Configuration templates

Storage configuration templates are used to specify storage definitions, such as storage volume definitions and SAS zoning. These configuration templates are stored by IBM Systems Director and can then be deployed to the associated storage devices. The configuration manager is used to create and manage these configuration templates. See *Implementing IBM Systems Director 6.1*, SG24-7694.

Managing storage in real-time

You can manage storage systems in real-time, without the use of configuration templates. See *Implementing IBM Systems Director 6.1*, SG24-7694.

External storage applications

External storage applications refers to all storage management and provisioning applications that can be used separately for a storage device.

We use an external storage management application to configure, control, and maintain certain storage devices and their connectivity to your network. These applications ought to be already installed, but if they are not, consult the appropriate documentation to acquire and install them.

> **Attention:** The external storage management application to be run must be installed or accessible. You must have run inventory collection on the storage devices in order to launch an external storage management application for those storage devices.

Here we list the application to be used for each storage device:

- IBM Total Storage Productivity Center for SAN-attached devices
- DS4000 Storage Manager for IBM DS3000, DS4000, and DS5000 storage devices
- IBM DS Storage Manager for DS6000 storage devices
- IBM System Storage N series N3600 features browser-based management, so no application needs to be installed
- ServeRAID Manager for Internal RAID controllers

IBM Systems Director can be used to launch an external storage management application to configure, control, and maintain certain storage devices and their connectivity to the network. See *Implementing IBM Systems Director 6.1*, SG24-7694.

Additional material

To learn more about IBM Systems Director and offerings, see the following sites:

http://www-03.ibm.com/systems/software/director/storage/index.html

http://www.redbooks.ibm.com/redbooks/pdfs/sg247694.pdf

http://publib.boulder.ibm.com/infocenter/director/v6r2x/topic/com.ibm.director.main.helps.doc/frn0_bk_compat_guide.pdf

http://publib.boulder.ibm.com/infocenter/director/v6r2x/index.jsp?topic=/com.ibm.director.plan.helps.doc/fqm0_r_hardware_compatibility_storage_devices.html

A.2 IBM Tivoli Storage Productivity Center (TPC)

The IBM Tivoli Storage Productivity Center (TPC) suite of storage infrastructure management tools can help customers improve time to value, as well as reduce the complexity of managing their storage environments by centralizing, simplifying and optimizing storage tasks associated with storage systems, storage networks, replication services, and capacity management.

A.2.1 More information

See Chapter 19, “IBM Tivoli Storage Productivity Center” on page 603 for more information.

A.2.2 Additional material

To learn more about IBM Tivoli Storage Productivity Center and offerings, see the following sites:

http://www-03.ibm.com/systems/storage/software/center/

B

Introduction to SMI-S and CIM/WBEM

In this appendix, we introduce SMI-S, CIM/WBEM, SLP, and their use, as well as the interactions among these components, and applicable standards.

B.1 Overview

In this section, we discuss SMI-S, CIM/WBEM, and SLP.

B.1.1 SMI-S

Efficiently managing multivendor Storage Area Networks (SANs) is a key concern for end-users and integrators alike. In mid-2002 the Storage Networking Industry Association (SNIA) launched the Storage Management Initiative (SMI) to create and foster the universal adoption of a highly functional open interface for the management of storage networks. The SMI's goal is to deliver open storage network management interface technology in the form of an *SMI Specification* (SMI-S).

The Storage Management Initiative Specification (SMI-S) is a design specification of the Storage Management Initiative (SMI) that is launched by the Storage Networking Industry Association (SNIA). The SMI-S specifies a secure and reliable interface that allows storage management systems to identify, classify, monitor, and control physical and logical resources in a storage area network (SAN). The interface integrates the various devices to be managed in a SAN and the tools used to manage them.

SMI-S is based on a number of existing technologies or industry standards that include these:

- Common Information Model (CIM)
- Web-Based Enterprise Management (WBEM)
- Service Location Protocol (SLP)

Intended to be an industry standard, SMI-S extends the generic capabilities of the CIM, the WBEM, and the SLP to implement storage networking interoperability. For example, the WBEM provides provisions for security, resource-locking management, event notification, and service discovery.

B.1.2 CIM

An object model for data storage and management that is developed by the Distributed Management Task Force (DMTF). CIM makes it possible to organize devices and components of devices in an object-oriented pattern.

B.1.3 WBEM

Web Based Enterprise Management (WBEM) is a set of management and Internet standard architectures developed by the Distributed Management Task Force (DMTF) to unify the management of enterprise computing environments traditionally administered through traditional management stacks like SNMP or CMIP. WBEM provides the ability for the industry to deliver a well-integrated set of standard-based management tools utilizing emerging web technologies.

The DMTF has developed a core set of standards that make up WBEM, which includes a data model, the Common Information Model (CIM) standard; an encoding specification, xmlCIM Encoding Specification; and a transport mechanism, CIM Operations over HTTP:

- *Common Interface Model (CIM) Standard:* CIM is a formal object oriented modeling language that is used to describe the management aspects of systems. The CIM provides a common conceptual framework applicable to all areas of management including systems, applications, databases, networks, and devices. The CIM specification provides the language and the methodology used to describe management data.

- *xmlCIM Encoding Specification:* This is a grammar to describe CIM declarations and messages used by the CIM protocol
- *CIM Operations over Hypertext Transfer Protocol (HTTP):* HTTP is used as a way to enable communication between a management application and a device that both use CIM. The CIM standards and the Distributed Management Task Force (DMTF) specification provide information about Web-based enterprise management (WBEM) operations over HTTP.

The WBEM architecture defines the following elements:

- *CIM Client:* The CIM Client is a management application like TotalStorage Productivity Center that uses CIM to manage devices. A CIM Client can reside anywhere in the network, because it uses HTTP to talk to CIM Object Managers and Agents.
- *CIM Managed Object:* A Managed Object is a hardware or software component that can be managed by a management application by using CIM. e.g. IBM SAN Volume Controller.
- *CIM Agent:* The CIM Agent is embedded into a device and interfaces with the management application. It interprets CIM requests and responses to it. A CIM agent provides a means by which a device can be managed by common building blocks rather than proprietary software. If a device is CIM-compliant, software that is also CIM-compliant can manage the device. Vendor applications can manage CIM-compliant devices in a common way, rather than using device-specific programming interfaces. You can perform tasks in a consistent manner across devices and vendor applications.
- *CIM Object Manager (CIMOM):* A common conceptual framework for data management that receives, validates and authenticates the CIM requests from client application. It then directs the requests to appropriate component or CIM provider.

> **Terms:** The terms CIM Agent and CIM Object Manager (CIMOM) are often used interchangeably. At this time only few devices come with an integrated CIM Agent, most devices need a external CIMOM for CIM enable management applications (CIM Clients) to be able to talk to the device.

- *Device Provider:* A CIM Provider is the element that translates CIM calls to the device specific commands, it is like a device driver. A provider is always closely linked to a CIM Object Manager.
- *CIM Server:* A CIM Server is the software that runs the CIMOM and the CIM provider for a set of devices. This approach is used when the devices do not have an embedded CIM Agent. This term is often not used, instead people often use the term CIMOM but they mean the CIM Server. When the CIM object manager (CIMOM) first starts, it registers itself to the SLP and provides information about its location (IP address and port) and the type of service it provides. A client application finds the location of the CIMOM by calling an SLP directory service. After obtaining this information, the client application opens direct communication with the CIMOM. The client sends a request to a CIMOM in the context of a CIM model. The model is defined by the CIM schema and loaded into the repository of the CIMOM

B.1.4 SLP

Service Location Protocol (SLP) is a new Internet Engineering Task Force (IETF) proposed standard protocol that was designed to simplify the discovery and use of network resources. In a corporate intranet, users need to access services and resources on the network. The SLP DA is a directory service that a client application calls to locate the CIMOM. The SLP SA is a service agent to allow discovery by a client application. Often, it is not clear to the users what useful services are available to them. These resources can include TN3270E servers, web servers, printers, fax machines, file systems, databases, that are accessible through an IP network, and any other future services that might become available. IBM Communications Server for AIX, Version 6 supports SLP in conjunction with TN3270E servers and clients such as Host On-Demand SLP clients.

Traditionally, to use a particular service, an end-user or client application needs to supply the host name or network IP address of that service. With SLP, however, the user or client no longer needs to know individual host names or IP addresses (for the most part). Instead, the user or client can search the network for the desired service type and an optional set of qualifying attributes. SLP searches the user's network for any matching services, and returns the discovered list to the user.

B.2 Typical component interaction

Figure B-1 shows typical interactions between the components in the CIM/WBEM environment. The following description explains the numbered steps involved in the interaction:

(1) The client application locates the CIMOM by calling a Service Location Protocol (SLP) directory service.

> **SLP:** The SMI-S specification introduces Service Location Protocol (SLP) as the method for the management applications (the CIM clients) to locate managed objects.
>
> For more information about SLP, see the IBM technote TIPS0523 at the following website:
>
> http://www.redbooks.ibm.com/abstracts/tips0523.html?Open

(2) When the CIMOM is first invoked, **(3)** it registers itself to the SLP and supplies its location, IP address, port number, and the type of service it provides. **(4)** With this information, the client application starts to directly communicate with the CIMOM.

The client application then **(5)** sends CIM requests to the CIMOM. As requests arrive, the CIMOM validates and authenticates each request. **(6)** It then directs the requests to the appropriate functional component of the CIMOM or to a device provider. **(7)** The provider makes calls to a device-unique programming interface on behalf of the CIMOM to satisfy **(8)**-**(9)**-**(10)** client application requests.

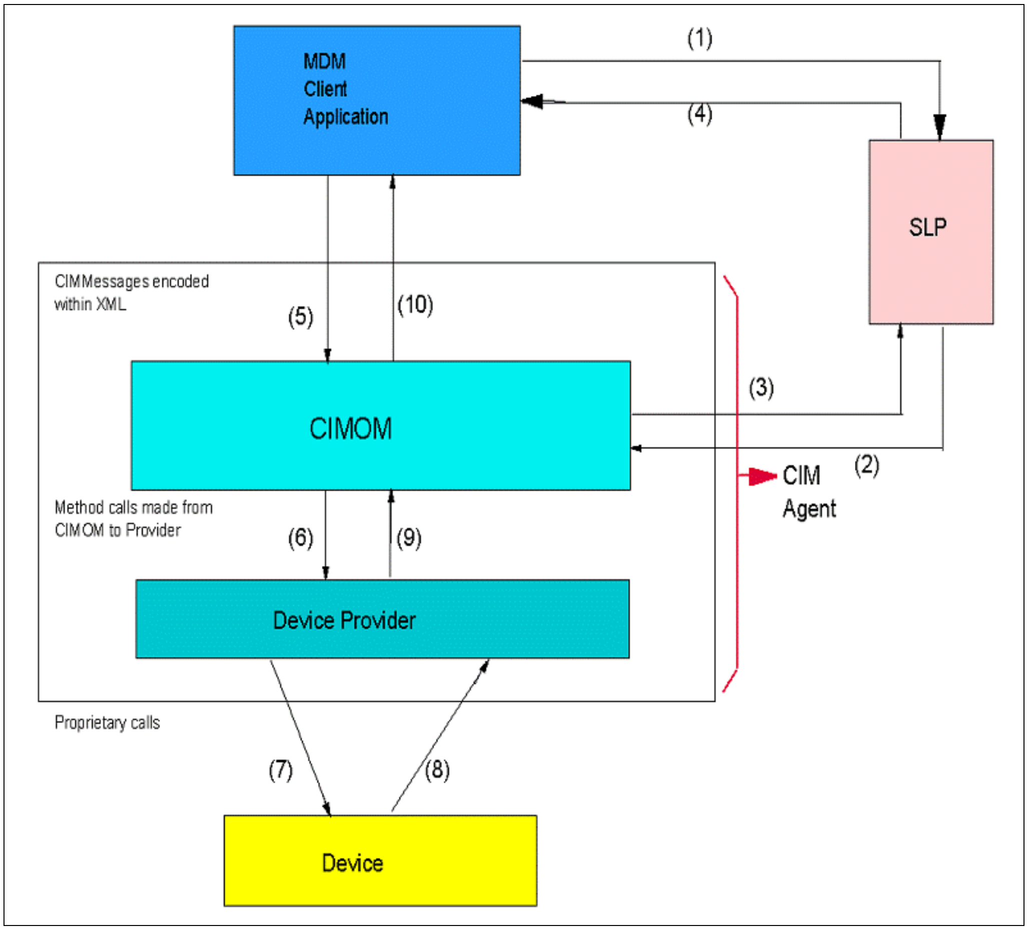


Figure B-1 Component interaction in CIM environment

B.3 Where to find SMI-S providers for IBM Systems Director

To use SMI-S providers with IBM Systems Director, you must install and configure them. They are needed only for some devices.

The Storage Management Initiative Specification defines an interface for heterogeneous, functionally rich, reliable, and secure monitoring and control of critical global resources in complex and potentially broadly distributed, multivendor storage topologies. An SMI-S provider is the vendor-specific module that must be installed and properly configured for IBM Systems Director to manage certain storage devices. IBM Systems Director communicates with a storage device through its respective SMI-S provider.

These storage devices require an SMI-S provider in order to work with IBM Systems Director:

- IBM System Storage DS6000 devices
- IBM System Storage N series N3600 devices
- IBM TotalStorage DS4000 devices
- IBM TotalStorage DS5000 devices
- IBM TotalStorage DS3000 devices
- Brocade 2G/4G Fibre Channel (IBM BladeCenter chassis and external)

For the Qlogic 4 Gbit/sec Fibre Channel (IBM BladeCenter chassis and external) switch, the storage provider is embedded in the switch. There is no need to install or configure anything. When asked for the IP address of the SMI-S provider, use the IP address of the switch itself.

Integrated RAID Controller devices use the IBM Systems Director Platform-Agent managed system. Run Inventory Collection on the Agent to get the Integrated RAID Controller.

The IBM BladeCenter S SAS RAID Controller Module requires an SMI-S provider in order for IBM Systems Director to discover and manage the attached SAS RAID Controller Module storage. This provider is installed automatically with IBM Systems Director Server on supported operating systems. This provider has one of the following names:

- PlatformAgentSubagent IBM BladeCenter SAS RAID Controller Module 6.1.0 Linux
- PlatformAgentSubagent IBM BladeCenter SAS RAID Controller Module 6.1.0 Windows

The provider for the IBM BladeCenter S SAS RAID Controller Module can work with a maximum of four IBM BladeCenter chassis. This provider can be copied to Platform-Agent managed systems if the need arises, and each of these Platform-Agent managed systems can also manage a maximum of four IBM BladeCenter chassis.

B.4 Applicable standards

For information about the standards mentioned here, see these websites:

- Storage Management Initiative - Specification (SMI-S)

  `https://www.snia.org/smi/about/`

- Storage Networking Industry Association (SNIA)

  `https://www.snia.org`

- Distributed Management Task Force (DMTF)

  `http://www.dmtf.org`

- Web-Based Enterprise Management (WBEM)

  `http://www.dmtf.org/standards/wbem/`

- Common Information Model - CIM

  `http://www.dmtf.org/standards/cim`

Use the following information to obtain SMI-S providers for any IBM TotalStorage DS3000, DS4000, DS5000, or DS6000 devices, and IBM System Storage N series N3600 devices. You can also use the information to obtain providers for various switches used to manage storage devices.

B.4.1 IBM TotalStorage DS3000, DS4000, or DS5000

The SANtricity SMI Provider from LSI that complies with SMI-S version 1.3 is required to enable discovery of IBM System Storage DS3000, DS4000, or DS5000 devices. You can obtain this provider from the LSI website:

`http://www.lsi.com/storage_home/products_home/external_raid/management_software/smi_provider_new/index.html`

It is preferable to use the 10.10.G5.02 version of this provider for this version of IBM Systems Director. Any other version might not function as well.

Tip: You can manually add an IBM System Storage DS3000, DS4000, or DS5000 device using IBM Systems Director. To manually add those devices, specify the IP address of the system where you installed the SANtricity SMI Provider, not the IP address of the IBM System Storage DS3000, DS4000, or DS5000 device itself.

B.4.2 IBM TotalStorage DS6000

To obtain the provider for the IBM TotalStorage DS6000 storage device, go to the IBM System Storage support web page. It is best to use the 5.2.1.139 version of this provider for this version of IBM Systems Director. Any other version might not function as well.

B.4.3 IBM System Storage N series N3600

You can obtain the provider for the IBM System Storage N series N3600 from this website:

http://www.ibm.com/systems/support/supportsite.wss/selectproduct?taskind=2&brandind=5000029&familyind=5364792&continue.x=1

It is best to use the 3.0.2 version of this provider for this version of IBM Systems Director. Any other version might not function as well.

B.4.4 Brocade switches

You can obtain the appropriate SMI-S version 1.2 provider for IBM Systems Director from this website:

http://www.brocade.com/support/SMIAGENT.jsp

It is best to use the 120.10.x version of this provider for this version of IBM Systems Director. Any other version might not function as well.

B.4.5 Qlogic switches

There is no need to obtain an SMI-S provider for the Qlogic switches. The SMI-S provider is embedded in the switch.

B.5 More information

For more information, see the following links:

http://www.snia.org/home
http://www.snia.org/forums/smi/tech_programs/smis_home/
http://publib.boulder.ibm.com/infocenter/director/v6r2x/index.jsp?topic=/com.ibm.director.plan.helps.doc/fqm0_r_hardware_compatibility_storage_devices.html
http://dmtf.org/standards/cim

C

High Performance Storage System (HPSS)

High Performance Storage System (HPSS) is cluster-based software that manages petabytes of data on disk and robotic tape libraries. HPSS provides highly flexible and scalable hierarchical storage management that keeps recently used data on disk and less recently used data on tape.

HPSS uses cluster, LAN, and/or SAN technology to aggregate the capacity and performance of many computers, disks, and tape drives into a single data store of exceptional size and versatility. This approach enables HPSS to easily meet otherwise unachievable demands of total storage capacity, file sizes, data rates, and number of objects stored.

In this appendix, we present an overview of the HPSS offering.

C.1 Introduction to HPSS

High Performance Storage System (HPSS) is cluster-based software that provides for stewardship and access of many petabytes of data. When properly provisioned, HPSS is capable of concurrently accessing hundreds of disk arrays and tape drives for extremely high aggregate data transfer rates, thus enabling HPSS to easily meet otherwise unachievable demands of total storage capacity, file sizes, data rates, and number of objects stored.

HPSS has been used successfully for very large digital image libraries, scientific data repositories, university mass storage systems, and weather forecasting systems, as well as defense and national security applications.

The High Performance Storage System is a Services Offering licensed and supported by IBM Global Business Services in Houston, Texas. A Statement of Work and License Agreement define the HPSS services and software provided by IBM. The contract documents are a Statement of Work and a License Agreement.

A High Performance Computing (HPC) system needs a high performance storage system, and that is what HPSS offers. HPSS is installed in some of the greatest HPC systems worldwide, like LANL Roadrunner, ORNL Jaguar, LLNL Blue Gene/L, just to name a few.

HPSS is a collaboration of these institutions:

- IBM Global Services in Houston, Texas
- Lawrence Berkeley National Laboratory
- Lawrence Livermore National Laboratory
- Los Alamos National Laboratory
- Oak Ridge National Laboratory
- Sandia National Laboratories

The collaborative development is important because the developers are users of the technology. Their focus is on what is needed.

HPSS can provide an extremely scalable repository for content management software systems including iRODS and IBM FileNet. HPSS can be used alone, with its own interfaces, or it can be used to provide space management and disaster recovery backup for the IBM General Parallel File System (GPFS).

C.2 HPSS technology

HPSS provides a disk and tape file repository, using Hierarchical Storage Management (HSM) technology with automatic migration and recall. A single instance of HPSS is capable of concurrently accessing hundreds of tapes for extremely high aggregate data transfers, making it highly scalable.

The HPSS users see it as a single UNIX file system. Its clustered architecture permits HPSS to scale horizontally almost without limits. This horizontal scaling is as easy as adding cluster components. HPSS architecture is presented in Figure C-1.

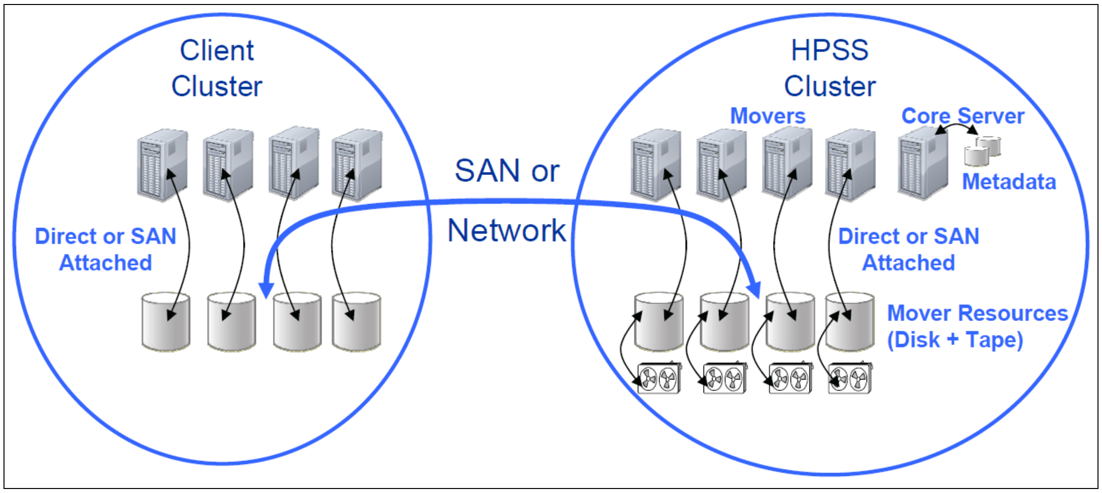


Figure C-1 HPSS architecture

HPSS is powered by a bundled IBM DB2 database engine. DB2 metadata completely characterizes all files whether on disk, single tape, striped tape, mirrored tape, shelf tape or multi-level hierarchies of disk and tape. DB2 is highly scalable and reliable, and provides its own utilities for copying, mirroring, backup, restore, and verifying.

Figure C-2 shows an example of a read on HPSS, illustrating how it works.

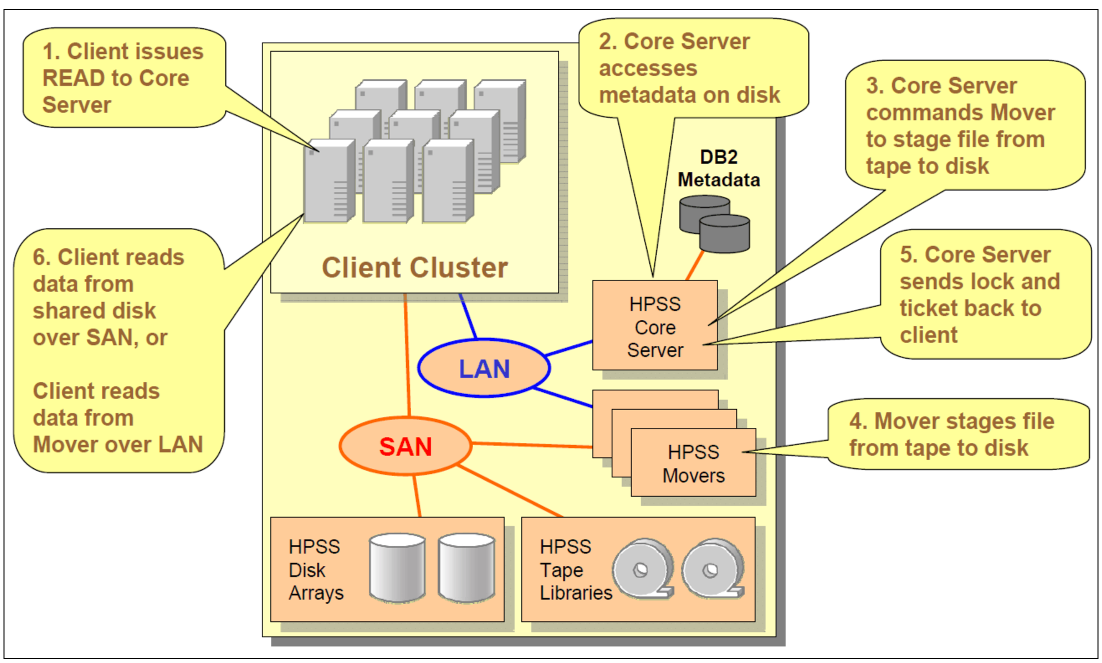


Figure C-2 HPSS read command illustration

The cluster aspect of HPSS combines the power of multiple computer nodes into a single, integrated storage system. The computers that comprise the HPSS platform can be of different makes and models, yet the storage system appears to its clients as a single storage service with a unified common name space.

With adequate provisioning, HPSS supports horizontal scaling, by adding disks, tape libraries, movers, and core servers, to 10s of petabytes, 100s of millions of files, and data rates of gigabytes per second. HPSS also provides aggregation of small files to tape, which increases performance and minimizes the tape space used for small files.

C.2.1 HPSS capabilities

Here we give an overview of the HPSS main features.

Hierarchical global file system

HPSS is hierarchical file system software designed to manage and access petabytes of data at high data rates. While appearing to the user as a disk file system, HPSS provides policy-driven tiered storage which is an important part of the data life cycle management practice. HPSS moves inactive data to tape based on data life cycle management policy and retrieves it the next time it is referenced.

Distributed, cluster architecture

The cluster aspect of HPSS combines the power of multiple computer nodes into a single, integrated storage system. The computers that comprise the HPSS platform can be of different makes and models, yet the storage system appears to its clients as a single storage service with a unified common name space.

Production multi-petabyte capability in a single name space

There are HPSS systems with twenty or more petabytes of data in a single namespace. A list of large sites and their reported size in petabytes and number of files is posted on the HPSS website: www.hpss-collaboration.org.

True SAN and virtual SAN capabilities

HPSS provides both SAN access to disks and efficient network access to disks and tape devices using HPSS Mover nodes to create SAN-like access over cost-effective TCP/IP LAN or WAN networks.

HPSS virtualizes disks and tape drives so that they appear to the user to comprise a single POSIX-like file system. This virtualization can be for a single level of tape or a hierarchy of disk and tape. The virtualization can take place over a true SAN or a virtual SAN over a LAN, with most HPC systems opting for the LAN approach.

Metadata engine with IBM DB2

HPSS uses IBM DB2 as its internal metadata repository. There is only one metadata “engine” within an HPSS subsystem (although it can be fully redundant), and this metadata engine completely characterizes the files whether on single tape, striped tape, mirrored tape, shelf tape, fast disk, high-capacity disk, or any combination of Storage Classes. DB2 is as robust as any commercial software in the world and is the product of a large development staff and a large support staff. DB2 provides its own utilities for copying, mirroring, backup, restore, and consistency checking. DB2 is distributed with HPSS at no additional charge for use as the HPSS metadata engine.

Inodes are not required

There are no inodes, stubs, or other metadata on data disks. This is an important part of the reliability and availability of HPSS. When systems with inodes lose a disk, not only is data lost but also the metadata that describes that data is lost. In HPSS, because all metadata is kept in DB2, loss of a disk only causes loss of data, and the metadata is intact. The integrity of the file system structure is thus preserved, and often HPSS can retrieve the lost data from another level of the hierarchy.

Multiple Storage Classes and Classes of Service

HPSS provides multiple pools of storage devices called Storage Classes. As storage devices are added, new Storage Classes can be configured. Storage Classes are organized into Classes of Service. HPSS files reside in a particular HPSS Class of Service which users are able to set or the system can select based on parameters such as file size and performance. A Class of Service is implemented as a storage hierarchy consisting of multiple Storage Classes and rules for migrating data among them. Storage Classes are used to logically group storage media to provide storage for HPSS files.

A Class of Service can be as simple as a single tape, or it can consist of up to five levels of disk and tape. The user can even set up classes of service so that data from an older type of tape is subsequently migrated to a newer type technology. Such a procedure allows migration to new media over time without having to copy all the old media at once.

Striped disks and tapes for higher data rates

HPSS enables disks and tapes to be striped to create files that can be accessed at high data rates through parallel I/O operations. With 16-way striping, single file disk data rates of over two gigabytes per second have been achieved.

HPSS easily accommodates insertion of new tape technology

As new types of digital storage technology are configured into the system, the HPSS Storage Class definition can be updated to the new device and media characteristics. Existing data is accessed normally, but all new media migrations will use the updated definitions and new media. Migration of existing data to the new tape media is accomplished by the Repack utility. The utility is under the control of the administrator and can be automated to run as often as the administrator desires. This process has been used at most HPSS sites in the management of the data lifecycle as customers have upgraded their media technology.

High performance data grid interfaces

For wide-area applications, HPSS includes Parallel FTP (PFTP), a parallel, multi-threaded, TCP/IP-based service with syntax similar to ftp. PFTP has achieved long-distance file transfers of 200 megabytes per second between Department of Energy national laboratories.

VFS on Linux

Red Hat Enterprise Linux applications benefit from a true POSIX standard read-write interface. This interface allows many standard commercial programs and legacy locally-written programs that include POSIX-type read-write file I/O to use HPSS as a file space, making these applications into hierarchical disk-tape applications.

With this interface, Linux applications can mount HPSS at any point in the directory tree, much as NFS can be mounted. For fine-grain access, large files can then be copied between the HPSS part of the file tree and a conventional file system using standard commands such as a cp (copy).

With this procedure, HPSS can easily be used to back up files from POSIX-compliant Linux file systems such as GPFS, Lustre, and ext3. For application systems other than Red Hat Linux, the HPSS Client API or PFTP can be used, or NFS and SAMBA can be used as described next.

Commercial and Open Source Interfaces Using VFS on Linux

Commercial and open source interfaces can be exported from a computer system employing the Linux VFS interface. Examples are NFS, Samba, Apache, and Secure ftp. HPSS services support the VFS interface to these applications, but the applications themselves are supported by the provider of the interface, whether open source or commercial.

As an example, Samba is in production with HPSS at Indiana University. IBM supports the VFS interface to Samba at IU, and Samba is supported through the open source community.

Direct SAN access to HPSS disks

In addition to the original Mover-based disk sharing, disks can be accessed directly over a SAN. This can be done with the HPSS Client API, PFTP, and the Red Hat Enterprise Linux Virtual File System interface. This capability is in addition to the popular HPSS virtual SAN architecture, where block-level data is transferred over less expensive IP networks.

High availability option

A High Availability (HA) option is available for HPSS for Linux. Based upon cluster software that is available with Red Hat Enterprise Linux (RHEL) Advanced Platform, this option provides services from IBM to set up the HPSS cluster of computers for active/passive redundancy, given adequate hardware provisioning including one or more spare computer nodes. Failover is automatic and is on a time scale of a few minutes that is barely noticeable when compared with the tape-based nature of hierarchical storage. Work requests in progress at the instant of failure are safely terminated with the emphasis on keeping HPSS and its metadata in a consistent and state. Where necessary return codes are provided that suggest application-level retries. The result is a mass storage system that remains on line, through failures of key hardware components.

Remote disks and tapes

HPSS supports remote disks and tapes connected to remote data mover computers. The remote movers are connected to the primary system using TCP/IP links which are much easier to extend to long distances than are the remote Fibre Channel links required by other solutions.

GridFTP

The open source Globus gridFTP is a high-performance, secure, reliable data transfer protocol optimized for high-bandwidth wide-area networks. Software to support gridFTP with HPSS was developed and is offered as open source by Argonne National Laboratory. The first production use has been achieved at Indiana University. GridFTP uses the PIO client interface of HPSS. PIO is supported as a standard HPSS service, and gridFTP is supported through its open source channel.

GPFS HPSS Interface (GHI)

The GPFS/HPSS Transparent HSM (GHI) capability enables HPSS to migrate files from GPFS, the most powerful IBM shared cluster file system. The combination of GPFS and HPSS provides a virtually infinite high performance file system with robust disaster protection. GHI is an additional feature not included in the standard HPSS offering. HPSS can be used alone or as an extension of GPFS, as shown in Figure C-3.

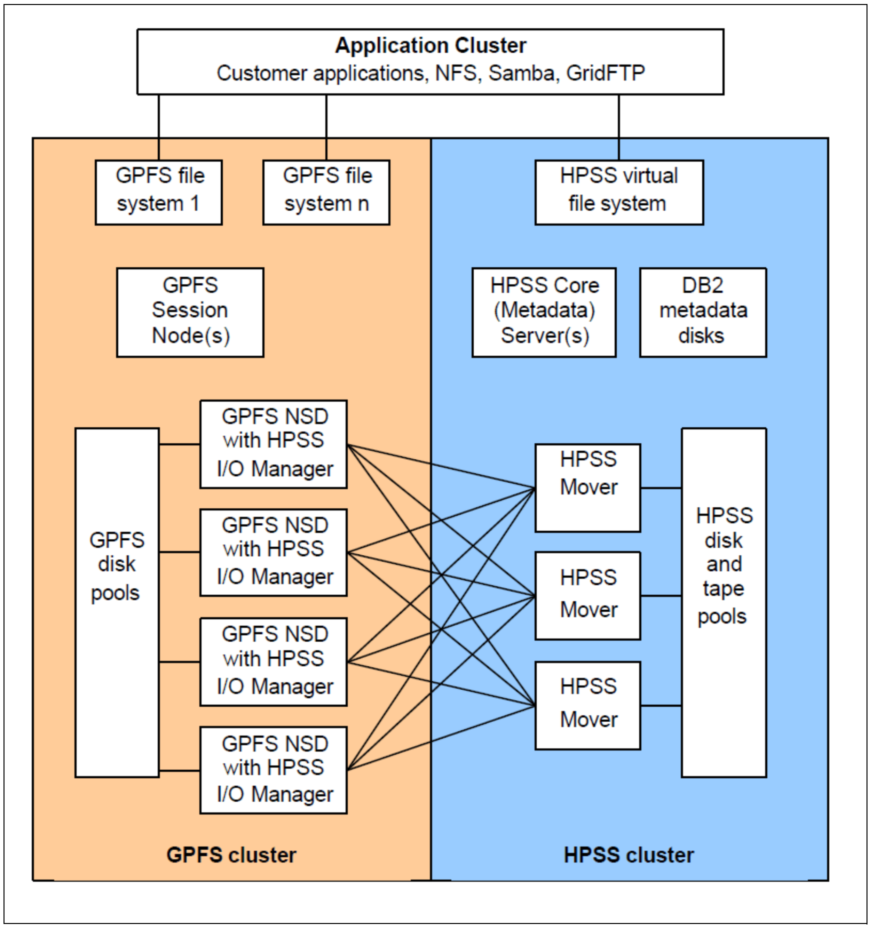


Figure C-3 GPFS and HPSS integration

Available and unrestricted data format information

Some file systems and hierarchical storage systems are licensed under rules, or are designed to disallow, physically or logically migrating data out of the system in bulk. The HPSS Collaboration members believe that the ability to efficiently take your data back out of HPSS is fundamental, in case you decide to move your data to another file system or hierarchical storage system in the future. This is particularly critical because copying individual files to effect data migration between file systems and storage systems become increasingly painful and in many cases impractical. Utilities are available to list the files stored on each tape, including such information as date and time stored, number of segments, and the location of each file or segment. This information can be used to find and read HPSS files from tape without using HPSS.

Data Migration Services

IBM offers services to migrate tapes from legacy DXUL and SAM-FS hierarchical storage systems to HPSS. After being migrated, the legacy tapes are accessed as read-only HPSS tapes.

C.2.2 HPSS interfaces

In this section we show the supported HPSS interfaces.

File Transfer Protocol (FTP)

HPSS provides an industry-standard FTP user interface. Because FTP is a serial interface, data sent to a user is received serially. This does not mean that the data within HPSS is not stored and retrieved in parallel. It simply means that the FTP daemon within HPSS must consolidate its internal parallel transfers into a serial data transfer to the user. HPSS FTP performance in many cases will be limited not by the speed of a single storage device, as in most other storage systems, but by the speed of the data path between the HPSS FTP daemon and the user's FTP client.

All FTP commands are supported or properly rejected if the HPSS Parallel FTP Daemon does not implement a specific feature. In addition, the ability to specify Class of Service is provided by the quote site or site commands. Additional site command options are provided for chgrp, chgid, chmod, chown, chuid. stage, wait, and symlink. The HPSS PFTP Daemon supports access from any FTP client that conforms to RFC-0959.

Parallel FTP (PFTP)

PFTP supports normal FTP plus extensions. It is built to optimize FTP performance for storing and retrieving files from HPSS by allowing the data to be transferred in parallel to the client. The interface presented to the user has syntax similar to FTP but with some extensions to allow the user to transfer data to and from HPSS across parallel communication interfaces. PFTP supports transfers by TCP/IP and communicates directly with HPSS Movers to transfer data.

HPSS Virtual File System (VFS) Interface

The HPSS VFS Interface is a client application that uses the VFS switch to present a standard POSIX file system interface. Users can access the HPSS disk cache as if it were a locally mounted file system. Support for getting and setting HPSS COS information is provided by file system specific ioctl() commands. Currently, this interface is only available for Linux clients.

User Utilities hacl and lshpss

The purpose of these HPSS user utilities is to provide the end user with information such as Access Control List (ACL) definitions and Class of Service definitions. In addition, the ability for a user to change ACL definitions is provided.

C.3 HPSS supported environments

HPSS supports a comprehensive list of devices and operating systems, as discussed next.

Heterogeneous computer support

The full suite of HPSS server software runs on IBM's POWER Systems computers with AIX and on System x and POWER Systems computers with Red Hat Enterprise Linux. Other platforms can be served with ftp, Secure ftp, grid FTP, NFS, and Samba.

Many tape libraries supported

HPSS supports enterprise-class tape drives from IBM, Oracle StorageTek, QualStar, Quantum, and Spectra Logic. Furthermore, HPSS supports generic SCSI Tape Libraries that use the SCSI-3 command set. For a new type of library, best support can be achieved if the vendor can provide a small but functionally equivalent library of the new type to the HPSS development and test facility. If this is not possible, then the user must allow time and access for on-site testing.

Most enterprise tape drives supported

Most current IBM, HP, and Sun StorageTek tape drives and media types are supported. HPSS can support multiple types of tape in one system using Storage Classes and Classes of Service.

C.4 More information

For more information about HPSS, see the High Performance Storage System (HPSS) website:

http://www.hpss-collaboration.org

For detailed technical information about HPSS components and installation, see HPSS Installation Guide at this website:

http://www.hpss-collaboration.org/documents/hpss732/install_guide.pdf

D

Internet Small Computer System Interface (iSCSI)

The iSCSI protocol is the encapsulation of the industry standard SCSI protocol within TCP/IP packets. This is an alternative to Fibre Channel SAN technology, which is essentially the same system of encapsulating SCSI protocol within an external “carrier.” The significant difference here is that the iSCSI SAN does not require a specialized or dedicated carrier network.

In this appendix, we present an overview of the SCSI protocol and describe its use.

D.1 Introduction to iSCSI

With an iSCSI SAN, it is possible to utilize an existing traditional networking infrastructure, thereby reducing the costs for specialized storage area networking devices, software, and licenses. ISCSI has a head start for many businesses because they already have a stable network infrastructure in place. ISCSI utilizes the reliable TCP protocol to transport SCSI I/0 commands over a network, providing block-level data access without the necessity for specialized hardware requirements; it can also operate with a variety of peripherals.

The iSCSI protocol allows for longer distances between a server and its storage, unlike the traditionally restrictive parallel SCSI solutions. ISCSI technology can use a hardware initiator—a Host Bus Adaptor (HBA)—or a software initiator to issue requests from target devices. Within iSCSI storage terminology, the initiator is typically known as a client and the target is the storage device. The iSCSI protocol encapsulates SCSI commands into Protocol Data Units (PDUs) within the TCP/IP protocol and then transports them over the network to the target device. The disk is presented locally to the client as shown in Figure D-1.

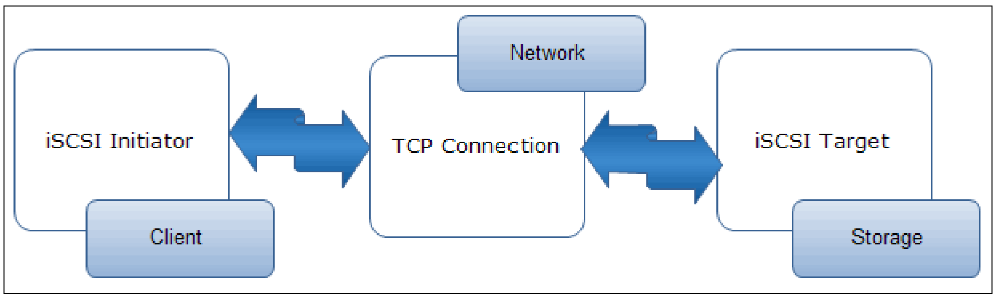


Figure D-1 iSCSI Architecture overview

D.1.1 iSCSI history

There was a time when storage equated with direct-attached storage (DAS) devices. There was little controversy in defining the straightforward DAS. Products in this category included devices such as vanilla IDE or SCSI hard drives and RAID arrays. However, problems with DAS were always the severe limitations on sharing with other machines and the physical limitations of the connection technology.

Networked storage options such as NAS and storage area networks (SAN) solved the main issues with DAS devices by farming out data storage to dedicated machines. However, NAS and SAN both have their own limitations.

NAS has the benefit that it can be deployed over existing network infrastructure and can go anywhere the network is deployed. However, protocols such as SMB or NFS do not support the block storage of DAS. This is fine for generic file or print-sharing, but many applications such as databases require block storage.

SANs allow users to consolidate storage on block devices; but this approach requires additional and often significant investment in hardware and training. SANs are also limited to the size of the network they are deployed on, due in part to stringent addressing limits of the FC switch standard and also based on the Fibre Channel distance limitations and the uniqueness of the cabling and infrastructure. Multiple distant sites often require multiple SANs. iSCSI is a potential solution to address both of these limitations.

D.1.2 iSCSI overview

The iSCSI protocol is a transport for SCSI over TCP/IP. Until recently, the standard IP protocol infrastructure (that is, Ethernet) was not able to provide the necessary high bandwidth and low latency needed for reliable storage access. A special communications infrastructure, mainly Fibre Channel running FCP (SCSI encapsulated over Fibre Channel), was developed to allow Storage Area Networks (SANs) to be developed and deployed. With the recent advances in Ethernet technology, it is now practical (from a performance perspective) to access storage devices over an IP network. 1 Gigabit Ethernet is now common, and is competitive with 1 and 2 Gigabit Fibre Channel from a performance perspective.

As the newer 10 Gb Ethernet adoption rates increase, the IP based SAN performance will be equal to any of the currently available FCP networks. iSCSI is becoming an ever more popular method of implementing a storage network and is especially suited to cases where large numbers of blade servers require SAN connectivity for storage and even boot devices.

iSCSI transactions consist of an iSCSI initiator (either hardware or software) transmitting a request (such as read/write) to an iSCSI target. This iSCSI target processes the request and responds with the appropriate information (data, sense, and so on).

iSCSI initiators are typically application servers or even end users while iSCSI targets are typically either SAN access points or actual storage controllers. Because an iSCSI request is an encapsulation of a SCSI request, the SCSI concept of command descriptor blocks (CDBs) is applicable to iSCSI. CDBs define the type of SCSI operation, the logical block address where to start, the length of data involved, and various other control parameters.

Figure D-2 gives a conceptual overview of the iSCSI protocol layers.

As the diagram illustrates, the iSCSI solution requires an initiator (host) a target (generally a storage device), and a carrier network.

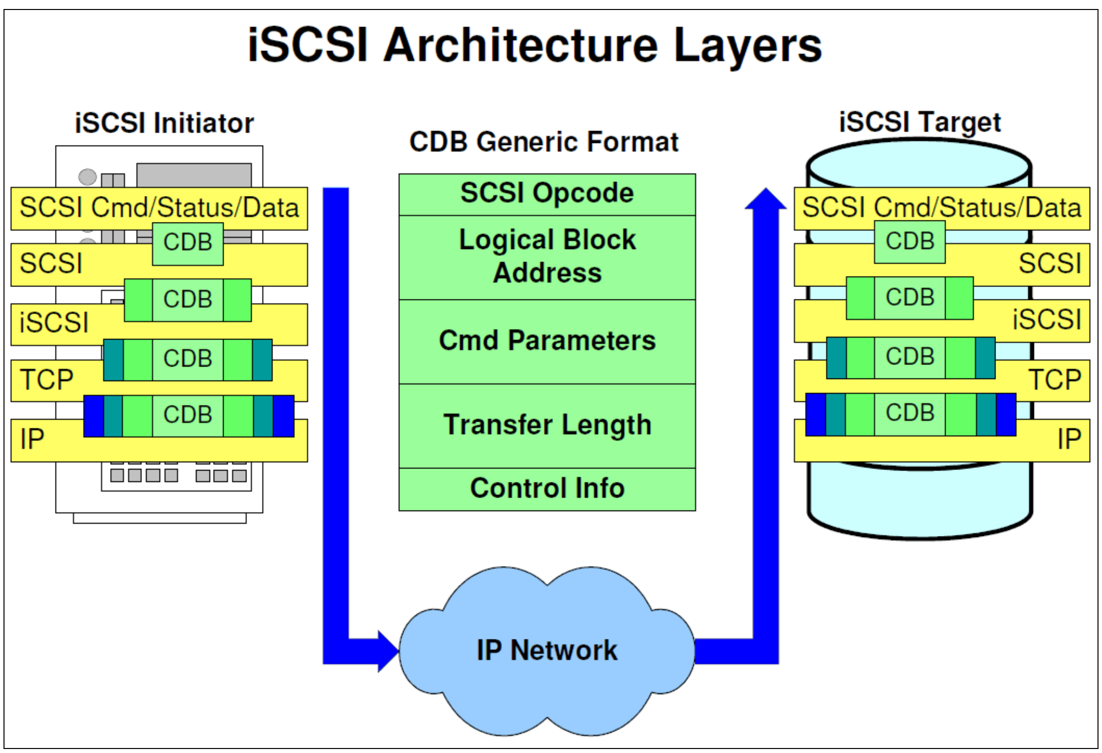


Figure D-2 iSCSI protocol layers

D.1.3 iSCSI protocol in depth

As previously mentioned, the iSCSI protocol utilizes the TCP/IP protocol to transport iSCSI protocol data units (PDUs), which are the most basic forms of message exchange between the host and the storage controller. The PDU is designed to transport both information and SCSI Command Descriptor Blocks (CDBs) between the initiator and target, where they receive the required data and response, which in turn might require a reply. The PDU also provides ordering and control information.

TCP/IP was chosen for the following reasons:

- It is field proven.
- It has the capability to reliably traverse almost any physical network media.
- It can deliver almost error free and in order data.
- It provides congestion control.
- It acknowledges packets that are received and resends unacknowledged packets.
- The benefits outweighed the use of alternative protocols.
- iSCSI supports SCSI-3 command sets.

iSCSI encapsulation shows the makeup of an iSCSI PDU, and its place within the Ethernet frame. The PDU consists of an iSCSI header where the data length is specified and iSCSI data is encapsulated and transported within the TCP/IP packet. A PDU is not restricted to one TCP segment and can span over more than one, or it is also possible to have more than one iSCSI PDU contained in a single TCP segment data area. Each TCP segment is encapsulated within an IP datagram. It is the responsibility of TCPI/IP to re-assemble the TCP segment in the correct order on the target side and deliver them to the iSCSI layer in the same order in which they were sent. After arriving at the iSCSI target or initiator, it is opened and actual iSCSI data is revealed for storage or processing.

The iSCSI protocol works effectively over TCP/IP networks, without the need for making any changes to the TCP/IP protocol. Figure D-3 shows an overview of iSCSI encapsulation.

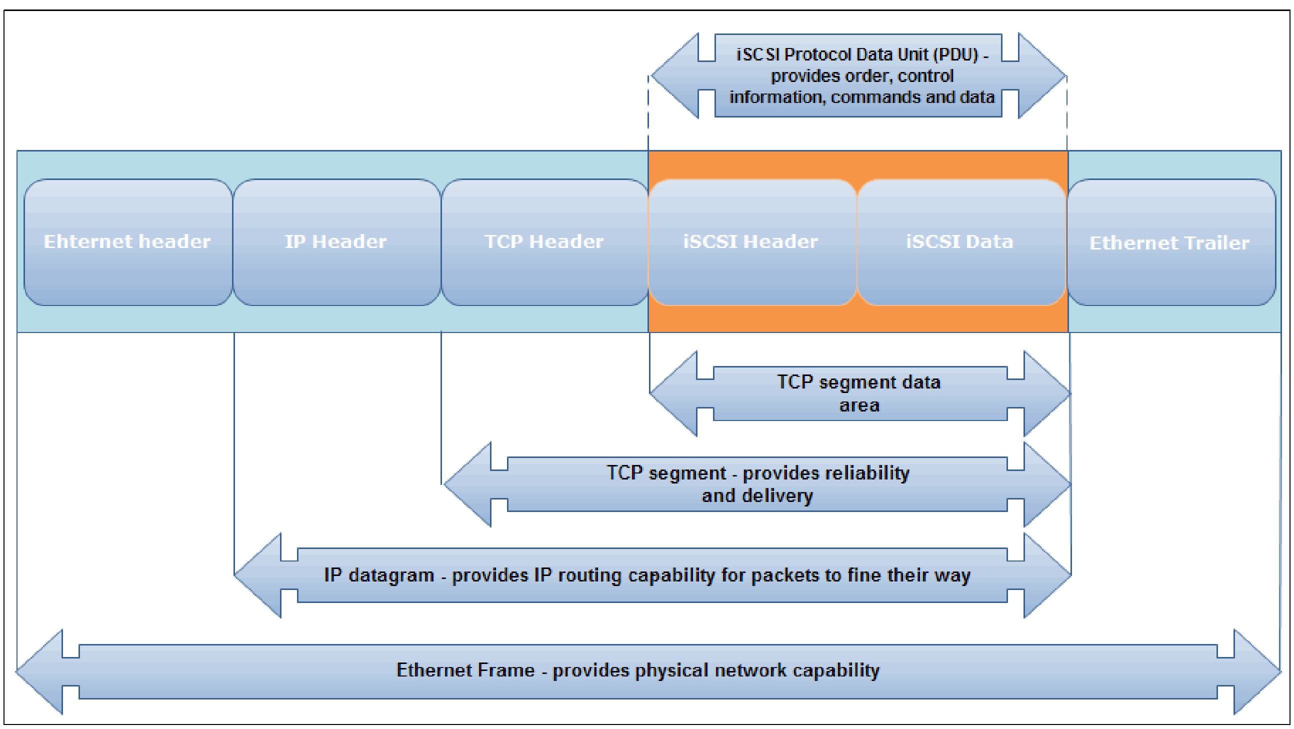


Figure D-3 iSCSI encapsulation overview

The following model illustrates in detail the full process and layers that occur from start to finish when a host tries to execute an I/0 operation. These layers show the underlying processes as represented in Figure D-4.

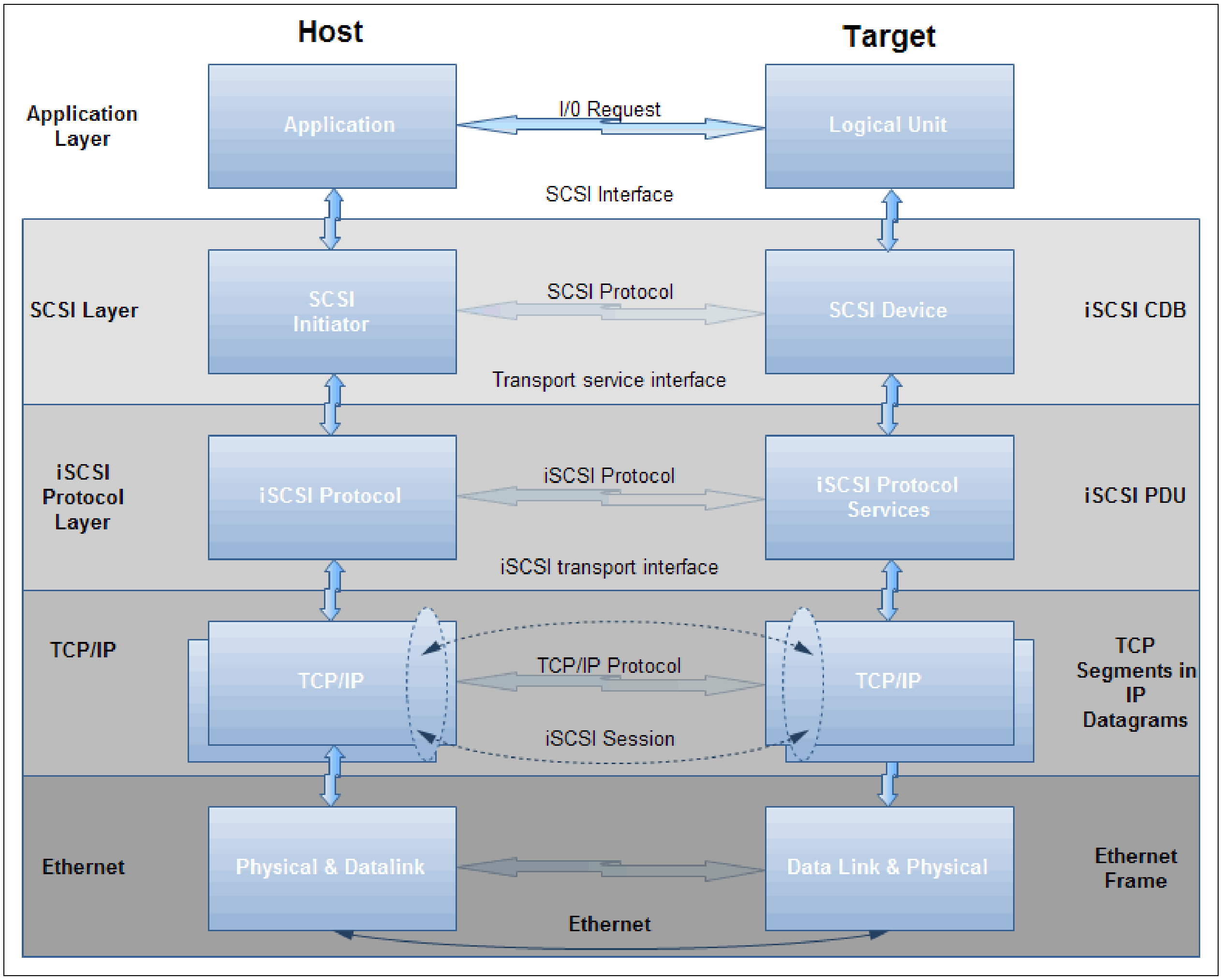


Figure D-4 iSCSI Layer Model Overview

Here we summarize some important components, key processes, and iSCSI terminology.

Initiator-target interaction process

iSCSI consists of a number of components that consist of the naming and addressing, session management, error handling, and security.

Naming and discovery

The Logical Unit (LU) naming convention consists of its IP address/domain name system and iSCSI device name. The iSCSI device name is that of the logical unit that has a unique target name.

iSCSI naming format

An iSCSI naming structure was created to help manufacturers and customers have a uniquely defined worldwide iSCSI network entity for their SAN.

iSCSI qualified name

The iSCSI qualified name (IQN) is expected to be unique worldwide and in a recognizable human readable format for the initiator:

iqn.yyyy-mm.dns_name_of_the_manufacturer_in_reverse:unique_name

Enterprise unique identifier

The Enterprise unique identifier (EUI) format is also usually referred to as EUI-64 for identifying the targets. It consists of a manufacturer's IEEE assigned company ID, which is a specified value assigned by the IANA registration authority:

```
eui.test125555555test
```

The format utilized for 'EUI' has 16 hex digits (64 bits). Those 64 bits are expected to be unique around the world. The first 24 bits (that is, test12) is the unique company ID. The subsequent 40 bits are generated exclusively by the manufacturer.

Session establishment and management

A session is the creation of a communication tunnel between the iSCSI initiator to the iSCSI target. An iSCSI session consists of an iSCSI Login Phase and a Full Feature Phase. At least one session between the initiator and the target needs to be enabled through an iSCSI login process. A login PDU is used to negotiate any variable parameters between the two parties and can invoke a security routine to authenticate permissible connectivity. When the login is successful, the target will issue a login success to the initiator, otherwise it will issue an unsuccessful login. ISCSI has the capability to support "Multiple Connections per Session" or "MCS" to increase aggregate bandwidth or in the case of several links to improve reliability.

PDU structure

A PDU is the basic message packets that travel between a client and target. It consists of a basic header segment (BHS), additional headers segments (AHS) and optional parameters such as cyclic redundancy check (CRC) data segments and data digests.

iSCSI error handling

An IP network is susceptible to the high probability of errors in data delivery. The iSCSI protocol provides a number of measures to counter potential errors. The design required that iSCSI performs its functions within a TCP/IP network safely and utilize proper QoS procedures.

iSCSI security

As the iSCSI can be used in networks where unauthorized data can be accessed, the specification allows for different security methods. Such encoding means as IPSec which use lower levels do not require additional matching because they are transparent for higher levels, and for the iSCSI as well. Various solutions can be used for authentication, for example, Kerberos or Private Keys Exchange, an iSNS server can be used as a repository of keys.

D.2 Benefits of iSCSI

The benefits of iSCSI over the more traditional Fibre Channel SAN is that an iSCSI SAN does not require a dedicated, specialized carrier network. iSCSI is a low-cost data transport solution that enables organizations of all sizes to create Storage Area Networks (SANs) using standard IP protocol instead of Fibre Channel protocol. Thanks to recent advances, an iSCSI network built with 10 Gbit Ethernet components now has the necessary high bandwidth and low latency to create a network that can be competitive with any currently available Fibre Channel SAN in terms of latency and performance.

The cost benefit case for implementing iSCSI is strong. It is especially well suited to environments where large numbers of small servers need to be attached to storage. iSCSI servers do not require expensive host adaptors, or in the case of software initiators *any* additional adaptors. They do not take up expensive, and restricted, Fibre Channel SAN ports and do not require additional skills outside of the existing network support staff arena to maintain. Additionally FC SANs and iSCSI can be complementary.

IBM offers a variety of iSCSI components and solutions, which include Ethernet adaptors, host bus adaptors (HBAs), and iSCSI storage systems.

To learn more about the IBM iSCSI solutions and offerings, see the following websites:

http://www-947.ibm.com/systems/support/supportsite.wss/allproducts?brandind=5000029&taskind=1

http://www-03.ibm.com/systems/bladecenter/hardware/openfabric/virtualfabric.html

http://www-03.ibm.com/systems/i/advantages/integratedserver/iscsi/advancedtasks.html

E

Redundant Arrays of Independent Disks (RAID)

RAID is a collection of techniques that treats multiple disks as combined units (arrays) and allows various levels of fault tolerance to be implemented in the disk subsystem.

RAID stands for *redundant array of independent disks*. It is a strategy created to bridge the gap between computer I/O requirements and the latency and throughput restrictions of single disk drives, while also allowing for greater degrees of fault tolerance.

RAID is the technology of grouping several physical drives in a computer into an array that can be defined as one or more logical drives. Each logical drive appears to the operating system as a single drive. This grouping technique greatly enhances logical drive capacity and performance.

SCSI has the ability to process multiple, simultaneous I/O requests. With RAID, I/O performance is improved because all drives can contribute to system I/O throughput.

In order to know RAID strengths and limitations, a clear understanding of the various RAID architectures is required. In this appendix, we present an overview of RAID and illustrate the use of this strategy.

E.1 Overview

The most commonly used current RAID levels are as follows:

- 0, 1, 3, 5, 6
- Enhanced 1, Enhanced 5
- 00, 10, 50

E.1.1 Data striping

Data striping is the process of storing data across all the disks in an array:

- A data stripe is the collection of stripe units across the array. A stripe unit is the amount of data written on a disk before writing on the next disk.
- Choosing the correct stripe unit size will maximize the performance of the ServeRAID adapter, improving overall server performance.
- Common RAID levels that use striping are 0, 1 Enhanced, 5, and 5 Enhanced.

Parity is defined as redundant information about user data, which allows it to be regenerated in the event of a disk failure. In the following illustrations, data can mean a byte or block, not necessarily an entire file.

E.1.2 RAID levels

In this section we describe the various RAID levels.

RAID 0: Data striping, no parity

This RAID level has the following characteristics:

- Distributes (stripes) the data evenly across all disks in the array
- Offers the fastest performance for multiple concurrent requests
- Does not provide any level of fault tolerance
- Offers most storage capacity of all the RAID levels
- Has a total disk capacity of n (where n is the number of drives)

As shown in Figure E-1, in the event of a single disk failure, the data residing on the disk cannot be regenerated, and because of data striping, all of the striped data becomes unavailable.

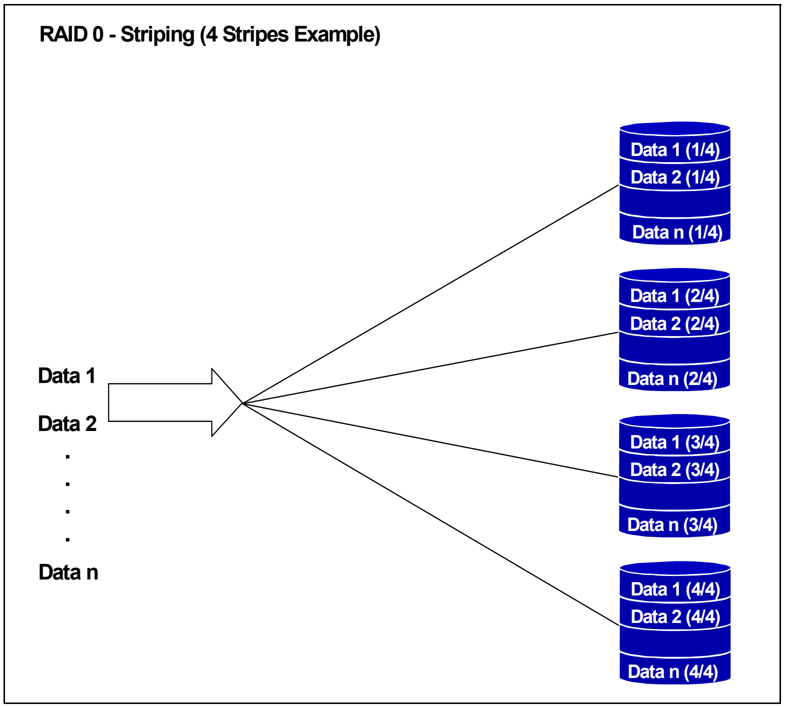


Figure E-1 RAID 0

Tip: Never use RAID level 0 for critical applications requiring high data availability. Consider it only for applications that benefit from the performance capabilities of this level.

RAID 1: Data mirroring

This RAID level has the following characteristics:

- Data written simultaneously to two drives
- RAID-1 can be faster than a single drive
- High cost of implementation
- Allows for the loss of one disk in the array
- Total disk capacity of n/2 (where n is the number of disks)

The RAID 1 implementation (Figure E-2) employs data mirroring to achieve redundancy.

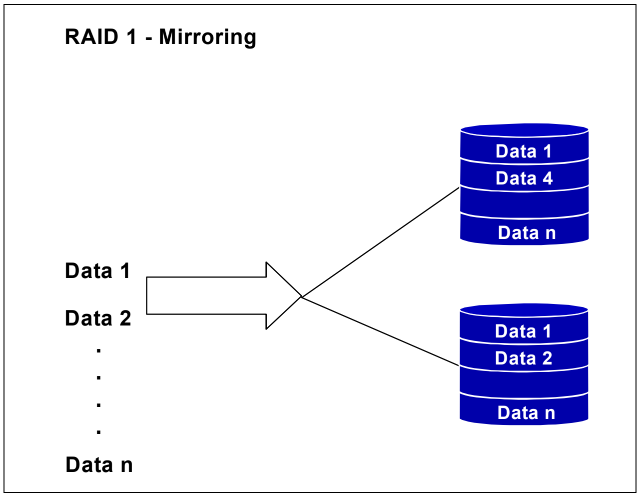


Figure E-2 RAID 1

> **Tip:** Consider RAID 1 when cost is not a factor for applications requiring high data availability and high performance.

IBM Enhanced RAID-1

RAID-1 Enhanced (RAID-1E) is an IBM exclusive that combines data mirroring and data striping:

- Mirrors and stripes data across all disks (mirrored stripe)
- Allows disk mirroring with 3 or more disk drives
- Approximates RAID-0 performance for reads
- Allows for the loss of 1 disk in the array
- Total disk capacity of n/2 (n is the number of disks)

RAID 3: Sequential access to large files

RAID-3 is a parallel process array mechanism, where all drives in the array operate in unison. Similar to data striping, information to be written to disk is split into chunks (a fixed amount of data), and each chunk is written out to the same physical position on separate disks (in parallel). This architecture requires parity information to be written for each stripe of data.

Performance is very good for large amounts of data, but poor for small requests because every drive is always involved, and there can be no overlapped or independent operation. It is well suited for large data objects such as CAD/CAM or image files, or applications requiring sequential access to large data files. Select RAID-3 for applications that process large blocks of data. It provides redundancy without the high overhead incurred by mirroring in RAID-1

RAID-Double Parity based on RAID 4

Each traditional RAID4 group has a number of data disks and one parity disk, with aggregates and volumes containing one or more RAID4 groups, whereas the parity disk in a RAID4 volume stores row parity across the disks in a RAID4 group. See Figure E-3.

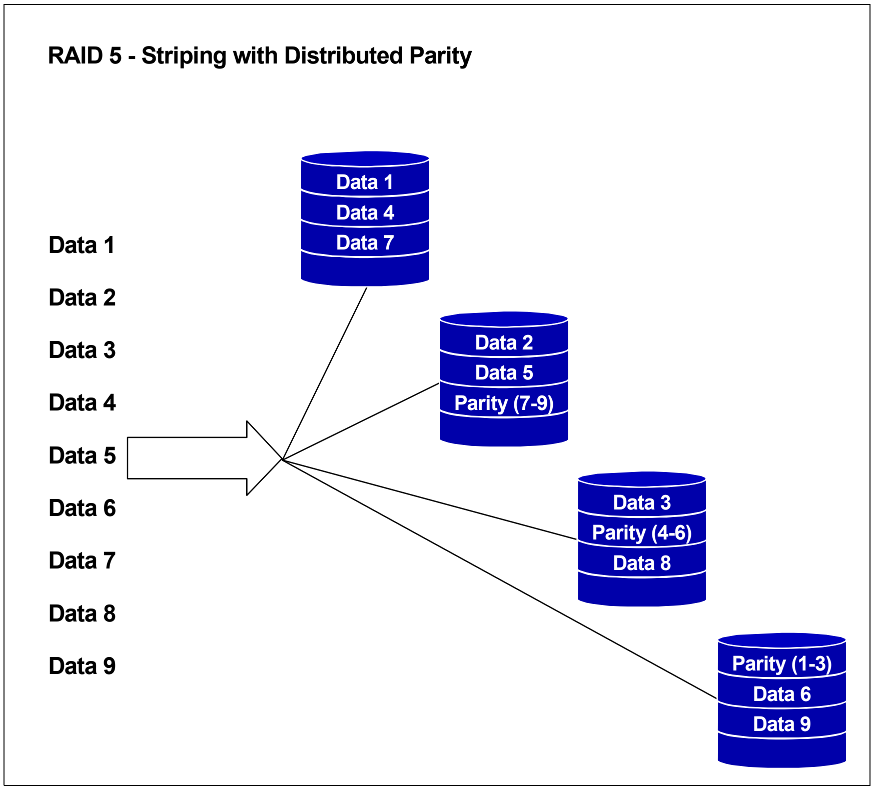


Figure E-3 RAID 4

In short, given the current landscape, with larger disk drives affecting data protection, customers and analysts demand a better story about affordably improving RAID reliability from storage vendors. To meet this demand, IBM System Storage N series uses a new type of RAID protection named RAID-DP™. RAID-DP stands for RAID Double Parity, and it significantly increases the fault tolerance from failed disk drives over traditional RAID.

When all relevant numbers are plugged into the standard mean time to data loss (MTTDL) formula for RAID-DP versus single-parity RAID, RAID-DP is more reliable on the same underlying disk drives. With this reliability, RAID-DP approaches RAID1 mirroring for fault tolerance, but at RAID4 pricing. RAID-DP offers businesses the most compelling total cost of ownership storage option without putting their data at an increased risk.

At the most basic layer, RAID-DP adds a second parity disk to each RAID group in an aggregate or traditional volume. The additional RAID-DP parity disk stores diagonal parity across the disks in a RAID-DP group. With these two parity stripes in RAID-DP, one the traditional horizontal, and the other diagonal, data protection is obtained even in the event of two disk failure events occurring in the same RAID group.

See Figure E-4 for a representation of RAID-DP.

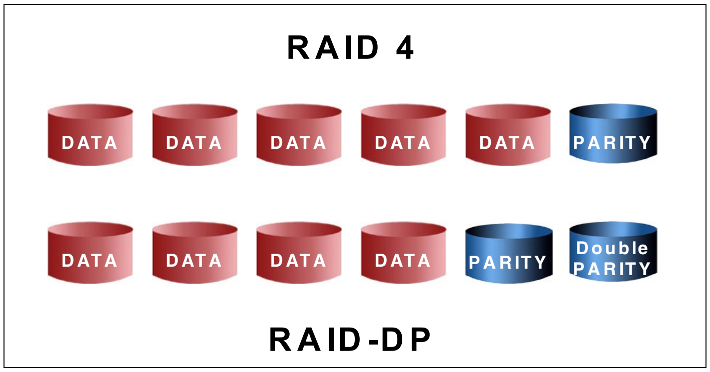


Figure E-4 RAID4 and RAID-DP comparison

So, with RAID-DP, the traditional RAID4 horizontal parity structure still gives these benefits:

- Offers optimal balance between price and performance
- Cost of RAID-DP is the capacity of 2 disk
- Allows for the loss of 2 disks in the array
- Protects against a single bad block failure while operating in a degraded mode
- Read performance approximates RAID-0
- Data and checksum (parity) are stored on 2 disks
- Requires a minimum of 4 disks
- Total capacity of n-2 (n is number of disks)

RAID 5: Independent access, data striping with distributed parity

This RAID level has the following characteristics:

- Offers optimal balance between price and performance
- Cost of RAID-5 is the capacity of 1 disk
- Allows for the loss of 1 disk in the array
- Loss of a drive will cause system degradation
- Read performance approximates RAID-0
- Data and checksum (parity) are evenly spread across drives
- Requires a minimum of 3 disks
- Total capacity of n-1(n is number of disks)

In RAID 5, the access arms can move independently of one another (Figure E-5). This enables multiple concurrent accesses to the array devices, thereby satisfying multiple concurrent I/O requests and providing higher transaction throughput. RAID 5 is best suited for random access data in small blocks.

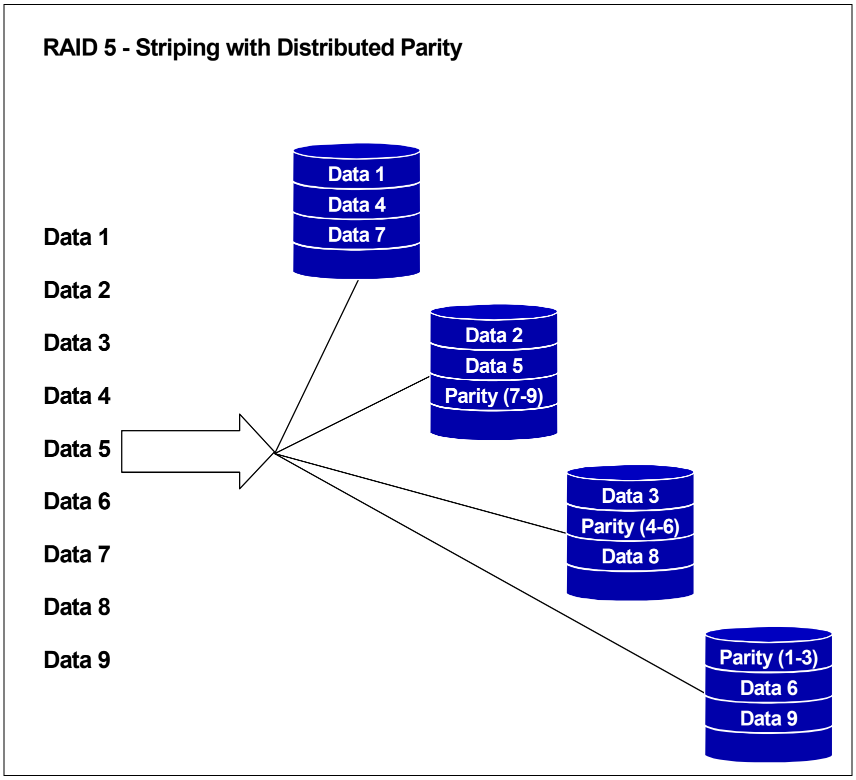


Figure E-5 RAID 5

Tip: Consider RAID 5 for environments requiring high data availability and with applications that process relatively short data records or a mixture of large sequential records and short random blocks.

RAID 5 Enhanced

This RAID level has the following characteristics:

- RAID-5E is standard RAID-5 with a hot spare built into the array (distributed hot spare):
  - RAID-5 uses a physical dedicated hot-spare disk.
  - RAID-5E uses a logical spare.
  - The once-dedicated hot spare is now distributed across the array.
- RAID-5E works with a minimum of 4 disks.
- Performance is good (better than RAID-5 with hot spare defined when compared with same number of total disks):
  - No idle hot-spare disk needed; provides an additional drive to stripe data across.
  - Up to 20% faster in small RAID-5 configurations.

RAID 6: Independent access, data striping with two distributed parities

This RAID level has the following characteristics:

- Offers optimal balance between price and performance, but needs more complex controller design compared to RAID5
- Cost of RAID-6 is the capacity of 2 disks
- Allows for the loss of 2 disks in the array
- Protects against a single bad block failure while operating in a degraded mode
- Read performance approximates RAID-0
- Data and checksum (parity) are evenly spread across drives
- Requires a minimum of 4 disks
- Total capacity of n-2 (n is number of disks).

RAID 6 allows for additional fault tolerance by using a second independent distributed parity scheme (dual parity). Data is striped on a block level across a set of drives (Pn), similar to RAID 5 configurations, and a second set of parity is calculated and written across all the drives (Qn), as illustrated in Figure E-6.

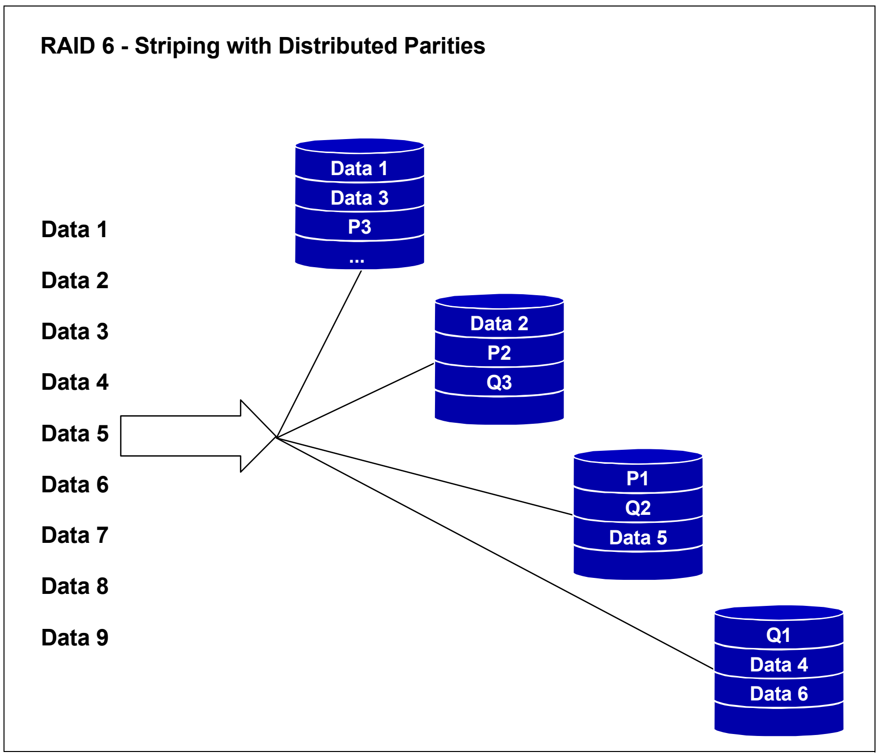


Figure E-6 RAID6

RAID 6 protection provides more fault tolerance than RAID 5 in the case of disk failures and uses less raw disk capacity than RAID 10.

Comparing RAID 6 to RAID 5 performance, gives about the same results on reads. For random writes, the throughput of a RAID 6 array is around only two thirds of a RAID 5, given the additional parity handling. Workload planning is especially important before implementing RAID 6 for write intensive applications including copy services targets and FlashCopy SE repositories. Yet, when properly sized for the I/O demand, RAID 6 is a considerable reliability enhancement.

RAID-00

RAID-00 is RAID-0 plus RAID-0:

- RAID-00: Works with a minimum of two disks
- Performance: Excellent
- Protection: None
- Capacity: All
- Maximum configuration: 60 disks (ServeRAID-4H)

RAID-00 (Figure E-7) is a combination of multiple, local RAID-0 arrays.

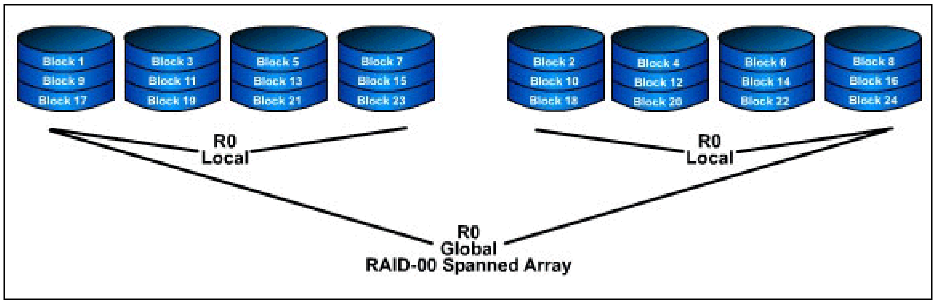


Figure E-7 RAID-00

RAID-10

RAID-10 is RAID-1 plus RAID-0:

- RAID-10: Works with a minimum of four disks
- Performance: Very good
- Protection: One drive in each local array might fail
- Capacity: n/2
- Maximum configuration: 16 disks (ServeRAID-4H)

RAID 10 (Figure E-8) consists of a set of disks for user data plus their mirrored disks counterparts. There is no parity disk to rebuild a failed disk. In case one disk becomes unusable, then its mirror will be used to access the data and also to build the spare.

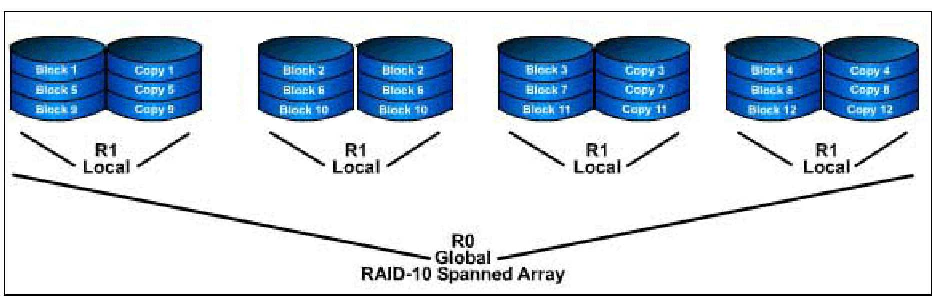


Figure E-8 RAID-10

RAID 10 is also known as RAID 0+1, because it is a combination of RAID 0 (striping) and RAID 1 (mirroring). The striping optimizes the performance by striping volumes across several disk drives (for example, in the ESS Model 800 implementation, three or four DDMs). RAID 1 is the protection against a disk failure by having a mirrored copy of each disk. By combining the two, RAID 10 provides data protection with I/O performance.

RAID-50

RAID-50, as shown in Figure E-9, is RAID-5 plus RAID-0:

- RAID-50: Works with a minimum of 6 disks
- Performance: Good (improves with size of local array)
- Protection: One drive in each local array might fail
- Capacity: n-x (where x = number of local arrays in RAID-0 stripe)
- Maximum configuration: 60 disks (SERVERAID-4H)

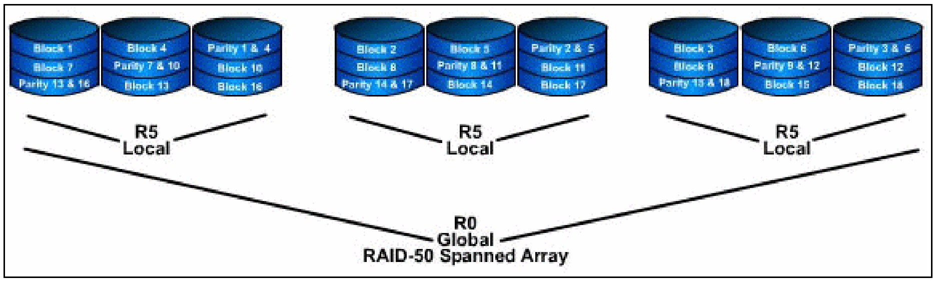


Figure E-9 RAID-50

For more information about RAID levels, see this website:

http://www.acnc.com

E.2 Summary

In this appendix, we have described the various levels of RAID and illustrated the use of this strategy. The RAID grouping technique greatly enhances logical drive capacity and performance. With RAID, I/O performance is improved because all drives can contribute to system I/O throughput.

F

Withdrawn products

In this appendix, we present a list of the most recent withdrawn products in the IBM System Storage family.

F.1 List of withdrawn products

A list of the most recent System Storage withdrawals is presented here. This list considers a time period of a year back from the moment of writing this book.

Table 24-4 System Storage product withdrawal list

Description	Type	Model	Withdrawal date	Announcement number
SVC Storage Engine	2145	8G4	Dec 11, 2009	909-178
DS4000 EXP420 Expansion Unit	1812	8VA	Dec 11, 2009	909-218
McDATA EFCM 9.0	2028	E09	Jan 30, 2010	909-242
3494 Enterprise Tape Library	3494	D22, D24	Dec 31, 2009	909-244
TS3200 Tape Library	3573	F3H, L3H	Dec 31, 2009	909-244
400GB Ultrium Tape WORM Cartridges	3589	028, 029	Dec 31, 2009	909-244
3592 Silo Compatible Tape Drive Frame	3592	C20	Dec 31, 2009	909-244
Tape Cart 3592 Extended WORM Data	3599	024, 025, 026	Dec 31, 2009	909-244
Cisco MDS 9134 Multilayer Fabric Switch	2053	S34	Dec 26, 2009	909-268
Tape and DVD Enclosure Express Model	7212	103	Feb 26, 2010	909-306
DS4700 Express Model 70	1814	70A	Jul 9, 2010	910-011
DS4700 Express Model 72	1814	72A	Jul 9, 2010	910-011
System Storage DR550	2233	DR2	Feb 26, 2010	910-013
IBM System Storage DS6800	1750	522	Jun 11, 2010	910-032
Tape/Optical Device Table-top Enclosure	7214	TT2	Apr 2, 2010	910-045
DS8100 Turbo Model	2421	931	Oct 29, 2010	910-088
DS8100 Turbo Model	2422	931	Oct 29, 2010	910-088
DS8100 Turbo Model	2423	931	Oct 29, 2010	910-088
DS8100 Turbo Model	2424	931	Oct 29, 2010	910-088
DS8300 Turbo Model	2421	932	Oct 29, 2010	910-088
DS8300 Turbo Model	2422	932	Oct 29, 2010	910-088
DS8300 Turbo Model	2423	932	Oct 29, 2010	910-088
DS8300 Turbo Model	2424	932	Oct 29, 2010	910-088
TS7520 Cache module	3955	SX6	Jun 25, 2010	910-091
System Storage TS3400 Tape Library	3577	L5U	Sep 24, 2010	910-154
System Storage Multilevel Grid Access Manager	5639	GA2	Oct 26, 2010	910-156
System Storage DR550	2233	DR1	Nov 12, 2010	910-159
IBM System Storage SAN04B-R	2005	R04	Nov 27, 2010	910-167
IBM TotalStorage SAN256B	2109	M48	Dec 18, 2010	910-187

Description	Type	Model	Withdrawal date	Announcement number
SVC Storage Engine	2145	8A4	Nov 5, 2010	910-213
DS3200 Single Controller	1726	21X	Jan 15, 2011	910-217
DS3200 Dual Controller	1726	22X	Jan 15, 2011	910-217
DS3300 Single Controller	1726	31X	Jan 15, 2011	910-217
DS3300 Dual Controller	1726	32X	Jan 15, 2011	910-217
DS3400 Single Controller	1726	41X	Jan 15, 2011	910-217
EXP420 Expansion Unit	1812	8VH	Jan 15, 2011	910-217
DS-RSM Model RS2	1818	RS2	Nov 19, 2010	910-220
TS2340 Tape Drive with LT04 SAS Tape Drive	3580	S43	Nov 26, 2010	910-229
IBM TotalStorage 3580 Ultrium 3 LTO Tape Drive	3580	L33	Nov 26, 2010	910-230
IBM Storage System TS2230 Tape Drive	3580	H3L	Nov 26, 2010	910-230
IBM System Storage TS2340 Tape Drive Express	3580	S43	Nov 26, 2010	910-230
IBM TotalStorage Ultrium Tape Cartridge	3589	008, 009	Nov 26, 2010	910-230
IBM 3589 Ultrium Tape Cartridge	3589	032, 033	Nov 26, 2010	910-230
TS7650G Server	3958	DD3	Dec 3, 2010	910-252
TS2230 Tape Drive Express	3580	S3E, H3S	Dec 3, 2010	910-271
TS2240 Tape Drive Express	3580	S4E, H4S	Dec 3, 2010	910-271

For detailed information about any product withdrawal, see the Withdrawal Announcement Letter. For each product withdrawal, the table gives the announcement number in the last column. To access the announcement letter by the number, go to the Offering Information website:

http://www.ibm.com/common/ssi/index.wss

Then insert the number in the “Keywords” field if you are in the simple search view, or directly in the “Letter number” field if you are in the advanced search view.

Related publications

The publications listed in this section are considered particularly suitable for a more detailed discussion of the topics covered in this book.

IBM Redbooks

The following IBM Redbooks publications provide additional information about the topic in this document. Note that some publications referenced in this list might be available in softcopy only.

- *Deployment Guide Series: IBM TotalStorage Productivity Center for Data*, SG24-7140
- *Designing an IBM Storage Area Network*, SG24-5758
- *DS8000: Introducing Solid State Drives*, REDP-4522
- *DS8000 Thin Provisioning*, REDP-4554
- *IBM b-type Data Center Networking: Design and Best Practices Introduction*, SG24-7786
- *IBM b-type Data Center Networking: Product Introduction and Initial Setup*, SG24-7785
- *IBM j-type Data Center Networking Introduction*, SG24-7820
- *IBM j-type Ethernet Switches and Routers Implementation*, SG24-7882
- *IBM j-type Ethernet Appliance Implementation*, SG24-7883
- *IBM/Cisco Multiprotocol Routing: An Introduction and Implementation*, SG24-7543
- *IBM Midrange System Storage Implementation and Best Practices Guide*, SG24-6363
- *IBM System Storage DS Storage Manager Copy Services Guide*, SG24-7822
- *IBM Midrange System Storage Hardware Guide*, SG24-7676
- *IBM SAN Survival Guide*, SG24-6143
- *IBM System Storage DS3000: Introduction and Implementation Guide*, SG24-7065
- *IBM System Storage DS3500: Introduction and Implementation Guide*, SG24-7914
- *IBM System Storage DS4000 and Storage Manager V10.30*, SG24-7010
- *IBM System Storage DS8000: LDAP Authentication*, REDP-4505
- *IBM System Storage DS8000: Remote Pair FlashCopy (Preserve Mirror)*, REDP-4504
- *IBM System Storage DS8000 Series: IBM FlashCopy SE*, REDP-4368
- *IBM System Storage DS8700 Architecture and Implementation*, SG24-8786
- *IBM System Storage DS8700 Disk Encryption*, REDP-4500
- *IBM System Storage DS8800 Architecture and Implementation*, SG24-8886
- *IBM System Storage DS8700 Easy Tier*, REDP-4667
- *IBM SAN Volume Controller and IBM Tivoli Storage FlashCopy Manager*, REDP-4653
- *IBM System Storage Tape Library Guide for Open Systems*, SG24-5946
- *IBM System Storage TS7650,TS7650G and TS7610*, SG24-7652
- *TS7680 Deduplication ProtecTIER Gateway for System z*, SG24-7796

- *IBM Information Archive Architecture and Deployment*, SG24-7843
- *IBM System Storage Data Encryption*, SG24-7797
- *Using IBM Tivoli Key Lifecycle Manager: Business Benefits and Architecture Overview*, REDP-4529
- *IBM Tivoli Key Lifecycle Manager for z/OS*, REDP-4472
- *IBM Tivoli Storage Productivity Center V4.1 Release Guide*, SG24-7725
- *IBM TotalStorage Virtual Tape Server: Planning, Implementing, and Monitoring*, SG24-2229
- *IBM TotalStorage 3494 Tape Library: A Practical Guide to Tape Drives and Tape Automation*, SG24-4632
- *IBM Virtualization Engine TS7500: Planning, Implementation, and Usage Guide*, SG24-7520
- *IBM Virtualization Engine TS7510: Tape Virtualization for Open Systems Servers*, SG24-7189
- *IBM Virtualization Engine TS7700 with R1.7*, SG24-7712
- *IBM XIV Storage System: Architecture, Implementation, and Usage*, SG24-7659
- *Implementing an IBM b-type SAN with 8 Gbps Directors and Switches*, SG24-6116
- *Implementing an IBM/Cisco SAN*, SG24-7545
- *Implementing the IBM System Storage SAN Volume Controller V5.1*, SG24-6423
- *Implementing the IBM System Storage SAN Volume Controller V6.1*, SG24-7933
- *Implementing the IBM Storwize V7000*, SG24-7938
- *Introducing the IBM Grid Access Manager*, SG24-7612
- *Introduction to Storage Area Networks*, SG24-5470
- *IP Storage Networking: IBM NAS and iSCSI Solutions*, SG24-6240
- *IBM System Storage N Series Hardware Guide*, SG24-7840
- *IBM Scale Out Network Attached Storage Concepts*, SG24-7874
- *IBM Scale Out Network Attached Storage: Architecture, Planning, and Implementation Basics*, SG24-7875
- *The IBM TotalStorage NAS Integration Guide*, SG24-6505
- *The IBM Virtualization Engine TS7510: Getting Started with i5/OS and Backup Recovery and Media Services*, SG24-7510
- *An Introduction to Fibre Channel over Ethernet, and Fibre Channel over Convergence Enhanced Ethernet*, REDP-4493

You can search for, view, or download Redbooks, Redpapers, Technotes, draft publications and Additional materials, as well as order hardcopy Redbooks publications, at this website:

ibm.com/redbooks

Online resources

These websites are also relevant as further information sources:

- IBM System Storage: Hardware, Software, and Service Solutions:

  http://www.ibm.com/systems/storage/
- IBM Product Information centers:

  http://www.ibm.com/support/publications/us/library/
- Storage Networking Industry Association:

  http://www.snia.org

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IBM System Storage Solutions Handbook

(1.5” spine)
1.5”<-> 1.998”
789 <->1051 pages

IBM System Storage Solutions Handbook

Learn about IBM storage products and solutions

Get flexible, scalable storage solutions for the on demand world

Find the products that answer your business needs

This IBM Redbooks publication provides overviews and pointers for information about the most current IBM System Storage products, showing how IBM delivers the right mix of products for nearly every aspect of business continuance and business efficiency. IBM System Storage products can help you store, safeguard, retrieve, and share your data. We cover the following topics:

First, we introduce the IBM Dynamic Infrastructure and the Smarter Planet Strategy.

Part 1 describes disk products that include IBM System Storage DS Series (entry-level, midrange, and enterprise offerings), IBM XIV Storage System, IBM System Storage N Series, and the IBM Information Archive.

Part 2 presents an overview of the IBM TotalStorage and System Storage Tape Drives, IBM Tape Automation Products, and IBM Tape Virtualization Solutions Products.

Part 3 describes storage networking infrastructure and presents the switches and directors to form SAN solutions. Also provided is an overview of the recently introduced IBM Ethernet switches and routers.

Part 4 discusses the IBM System Storage software portfolio.

Part 5 describes the z/OS storage management software and tools.

This book is intended as a reference for basic and comprehensive information about the IBM System Storage products portfolio. The book provides a starting point when establishing your own enterprise storage environment.

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