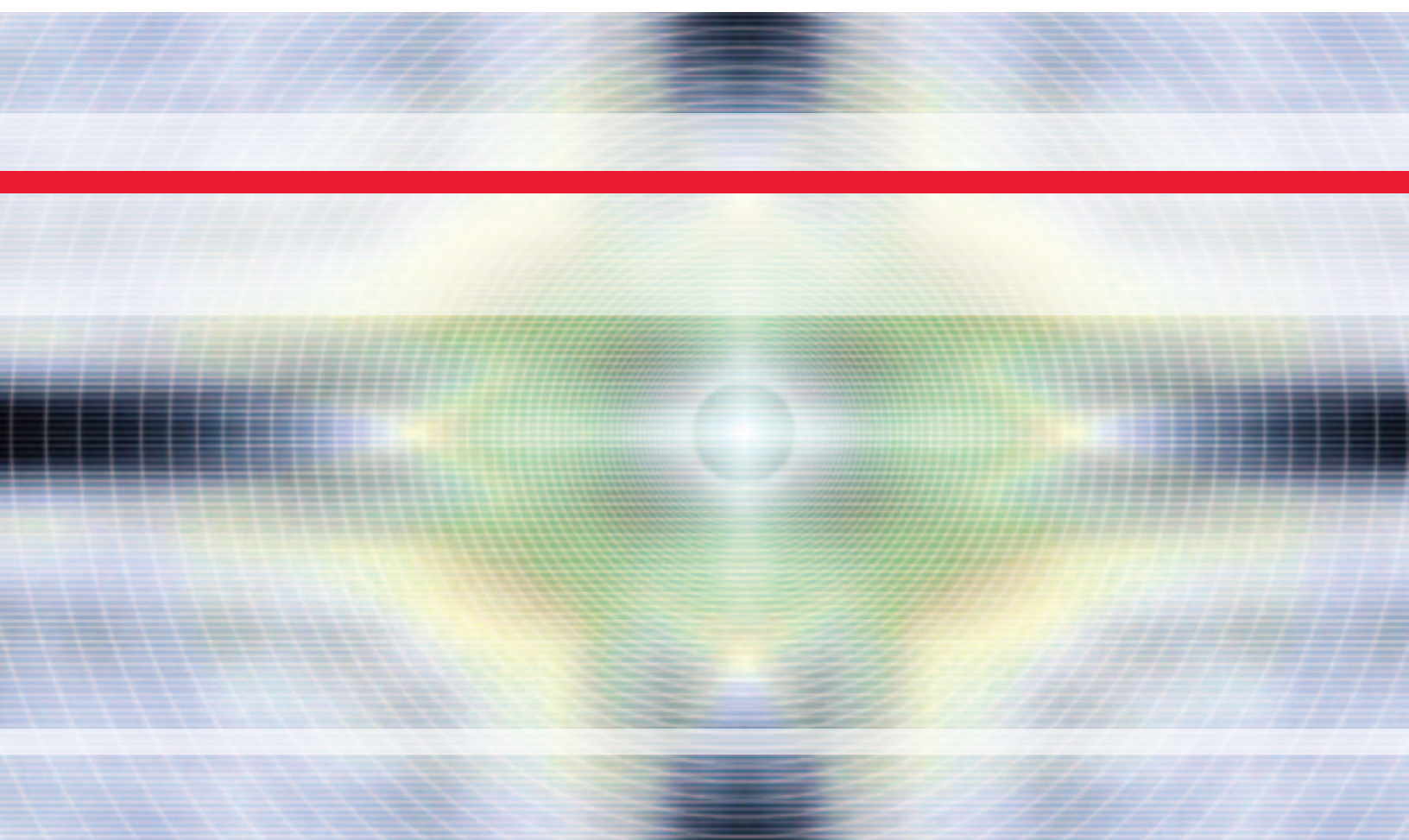


Hitachi Universal Storage Platform™ V and Hitachi Universal Storage Platform VM



Executive Summary

Services Oriented Storage is an approach to architecting the storage infrastructure that emphasizes flexibility and responsiveness.

Unprecedented increases in enterprise storage capacity are straining the ability of the Information Technology (IT) infrastructure to respond to the needs of business. Traditional storage system architectures have not changed significantly in 20 years. These systems are now ill equipped to meet today's IT needs and have little hope in satisfying tomorrow's challenges. Responsible for silos of dedicated capacity in the data center, traditional storage systems are complex to manage, costly to maintain and do not respond fast enough to changing business requirements.

Services Oriented Storage is an approach to architecting the storage infrastructure that emphasizes flexibility and responsiveness. Just as Service Oriented Architecture (SOA) leverages commonly reusable code to speed the development of business applications, Services Oriented Storage provides a set of commonly reusable storage services that can be rapidly reassembled and adapted to meet specific needs. Services Oriented Storage gives IT the flexibility to respond quickly to any new business challenge.

Storage virtualization is a key enabler of Services Oriented Storage. Advanced controller-based virtualization is able to aggregate heterogeneous storage in a common pool of capacity. File, object and block data services can then be assembled and applied to capacity in the common pool. Together, Services Oriented Storage and controller-based virtualization enable enterprise-class functionality to be extended to any storage system in the data center, including legacy, modular and less functional systems.

The Hitachi Universal Storage Platform™ V and Hitachi Universal Storage Platform VM are fundamental to a Services Oriented Storage strategy. The Universal Storage Platform V is the most advanced storage services platform in the industry. It is designed around an intelligent clustered storage controller and massively parallel crossbar switch architecture. Together, these capabilities deliver the scalability, performance, high availability and advanced storage functionality to satisfy all data center file, object and block storage needs.

Universal Storage Platform V and Universal Storage Platform VM provide unique controller-based virtualization that aggregates all storage, including internal and externally attached Hitachi branded and third-party storage, to create a common pool of capacity. Reusable storage services, including thin provisioning, host port virtualization and nondisruptive heterogeneous data migration, can then access all storage in the virtual pool.

Services Oriented Storage enables fully integrated storage management of multivendor storage systems. The Hitachi Storage Command Suite is an open, SMI-S standards-based suite of tools providing comprehensive management, control and reporting for all file, object and block services. Hitachi Storage Command Suite enables "single pane of glass" management of all virtualized internal and external storage attached to the Universal Storage Platform V and Universal Storage Platform VM.

Services Oriented Storage from Hitachi Data Systems enables organizations to reduce complexity, costs and risk in the storage infrastructure and dynamically align IT resources with the needs of the business.

Table of Contents

Chapter 1: Services Oriented Storage

Defining Storage Services	2
Mapping Hitachi Data Systems Solutions to Storage Services	3
Hitachi Storage Command Suite	4
Hitachi Basic Operating System and Hitachi Basic Operating System V	5
Hitachi Virtual Partition Manager Software	6
Hitachi Universal Volume Manager Software	6
Hitachi Dynamic Provisioning Software	6
Hitachi Tiered Storage Manager Software	6
Business Continuity Solutions	7
Hitachi Universal Replicator Software	7
Hitachi High-performance NAS Platform, powered by BlueArc®,	7
Hitachi Essential NAS Platform®	7
Hitachi Content Archive Platform	8
Hitachi Data Discovery Suite	8
The Hitachi Universal Storage Platform Family	8
What Is Storage Virtualization?	8
Part 1	8
Part 2	8
A Brief History of Controller-based Storage Virtualization	9
Intelligent Controller-based Virtualization	9
How Controller-based Virtualization Works	9
One Platform for All Storage Services	10
Operational Simplicity	10
Dynamic Provisioning	11
How Dynamic Provisioning Works	11
Test Results: Improved Throughput and Improved Response Time	12
Quality of Service	12
End-to-end Secure Virtualization for VMware	14
Host Storage Domains	14
Tiered Storage	15
Mainframe Storage Virtualization	15
Business Continuity	16
Surviving Link Failure	16
Three Data Center Business Continuity Solution	17
Security and Compliance	17
The Green Data Center	17
Hitachi Data Systems Global Solution Services and Best Practices	18

Table of Contents (continued)

Chapter 2: Hitachi Universal Storage Platform V and Hitachi Universal Storage Platform VM Architecture

Overview	19
Hitachi Universal Star Network™ — the Industry's Highest Performing Storage Architecture . . .	19
Massively Parallel Crossbar Switch Architecture	20
Cache–Hierarchical Star Network (C-HSN)	21
Control Memory–Hierarchical Star Network	21
Non-blocking Switched Access to Cache.	22
Advanced Data Cache Algorithms Provide Read-ahead for High-performance Sequential Reads . . .	22
Hitachi Cache Residency Manager Software Allows Datasets to be Permanently Placed in Data Cache.	22
Front-end Design	22
Connecting to Mainframe Hosts.	23
High-performance, High-capacity All Fibre Channel Back-end Design	25
RAID Implementation Advantages	25
RAID-1+.	25
RAID-5 Distributed Parity	26
Concatenated RAID-5 Array Groups	26
RAID-6 Redundant Distributed Parity	27
RAID Rebuild	27
Connecting External Storage	27
Packaging and Configuration	29
The Control Frame and Array Frames.	31
Power Subsystem	33
The System Monitoring Network	33
High Availability	34

Chapter 3: A Case Study of Thin Provisioning Benefits

Objectives for Dynamic Provisioning.	35
Disk Space Reduction	35
Performance Improvement.	36
Ease of Management	36
Improved Utilization	36
Financial ROI Benefits	37
The Bottom Line	37

Appendix

The Evolution of Hitachi Storage Virtualization	39
---	----

Services Oriented Storage

Services Oriented Storage is a way of architecting the enterprise storage infrastructure to meet the need for enormous capacity growth and constantly changing business requirements. Traditional approaches to storage create single purpose silos of capacity. Examples include thin provisioning, network attached storage (NAS), virtual tape libraries (VTL) and content archives. These dedicated systems are fundamentally inflexible. When business needs inevitably change, it can take IT months, if not years, of planning, funding, provisioning and migrating before they can respond to the new requirements. A Services Oriented Storage approach to storage anticipates the need to adapt quickly to change and accommodates massive capacity growth.

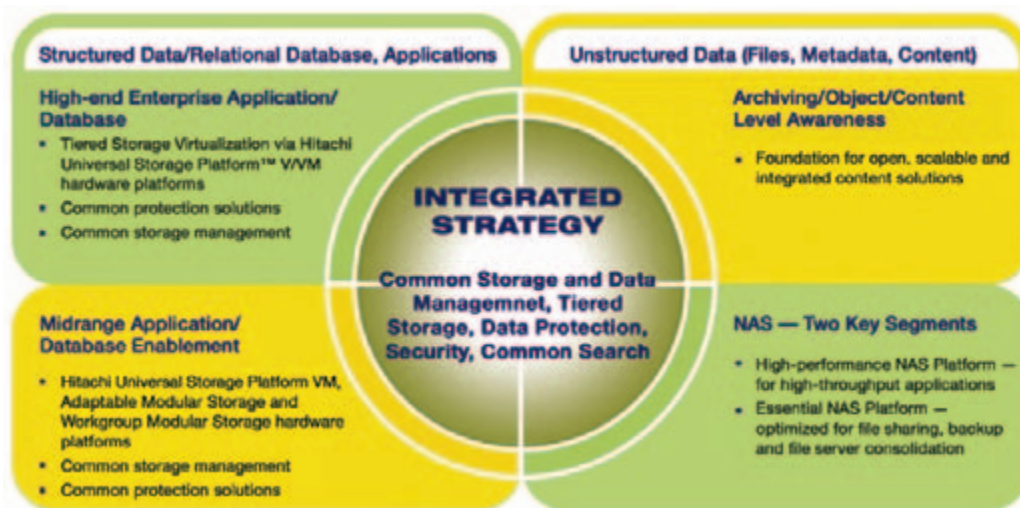
Using services to speed IT responsiveness is nothing new. In application development circles, Service Oriented Architecture (SOA) has reduced the time it takes for IT to respond to demands for new business applications. SOA packages reusable code modules as interoperable services. Developers then rapidly assemble different services to meet demand for new business process functionality.

Services Oriented Storage extends the philosophy of reusable services to the storage infrastructure. Using commonly reusable services, open interfaces and a single pool of heterogeneous storage capacity, Services Oriented Storage gives IT the ability to quickly assemble storage services to meet any new business need.

CHAPTER 1

A Services Oriented Storage approach to storage anticipates the need to adapt quickly to change and accommodates massive capacity growth.

Figure 1. Services Oriented Storage from Hitachi Data Systems offers an integrated strategy.



Virtualization technology provides a unified platform, enabling any service to run on any storage, regardless of vendor.

A common pool of virtualized heterogeneous storage capacity is essential to a Services Oriented Storage strategy. Virtualization technology provides a unified platform, enabling any service to run on any storage, regardless of vendor. This includes running advanced storage functionality on virtualized modular, legacy and less functional storage systems. Services can also operate standalone, on nonvirtualized storage. The storage can seamlessly move to a virtualized environment at any time, to benefit from being assembled with other common services.

Defining Storage Services

Services Oriented Storage includes all services that satisfy enterprise file, object and block storage needs.

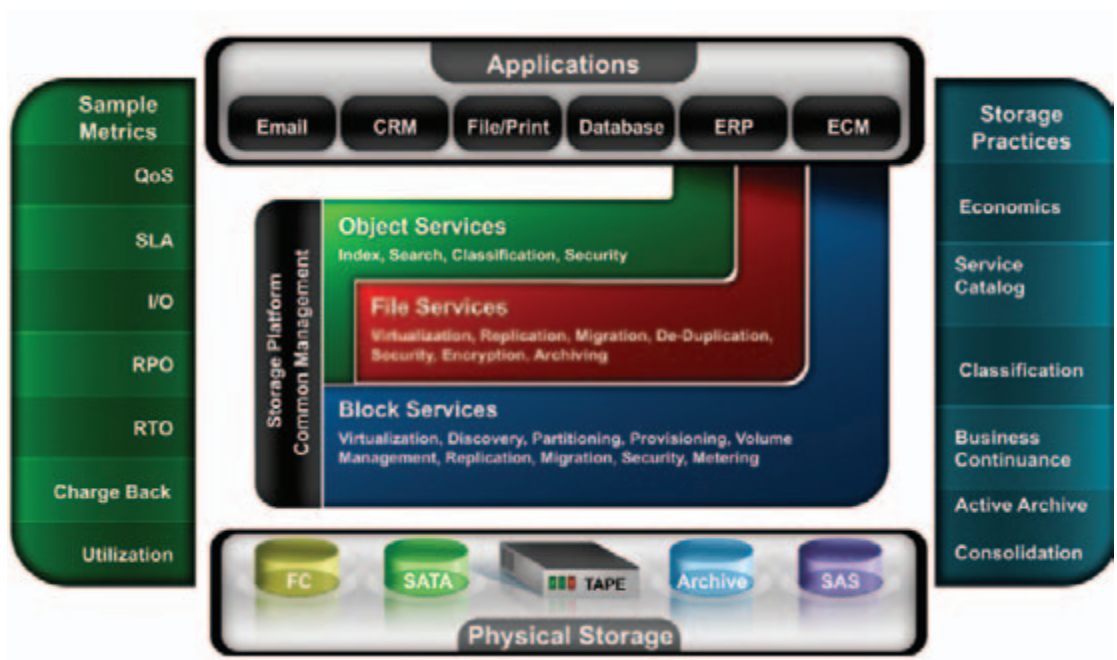
File services deliver the file-based functionality associated with NAS storage.

Object services address the need for long-term archival, indexing, search and retrieval of unstructured content, including security services that provide immutability, logging, auditing and data shredding. Object services also provide data discovery, de-duplication and data classification.

Block services provide the advanced storage functionality associated with high-performance, highly available enterprise-class storage systems, including port virtualization, port priority, safe multitenancy, cache partitioning for quality of service (QoS), heterogeneous volume management, nondisruptive data migration, heterogeneous data replication, business continuity, external storage virtualization, thin provisioning and I/O load balancing.

Storage services are reusable and interoperable. This allows IT to quickly reassemble and adapt services to deliver unique storage solutions. For example, an application requiring nondisruptive backup can begin by combining a snapshot service and a backup service; this can then be augmented with a thin provisioning service, to reduce the volume of data being backed up; a VTL service can be added to speed recovery from the backup; and a de-duplication service can reduce the amount of backup data stored in the VTL.

Figure 2. The Services Oriented Storage platform from Hitachi Data Systems supports reusable and interoperable services.



Note that Services Oriented Storage should not to be confused with professional services, storage or software as a service (SaaS) or utility storage.

Storage services are reusable and interoperable. This allows IT to quickly reassemble and adapt services to deliver unique storage solutions.

Mapping Hitachi Data Systems Solutions to Storage Services

Hitachi Data Systems storage solutions support a full range of file, object and block storage services. The solutions give IT the ability to mix and match services to satisfy a desired goal. All solutions use open protocols, rather than proprietary APIs, to promote interoperability and maintain scalability.

Table 1. Hitachi Data Systems Solutions Providing File, Object and Block Services

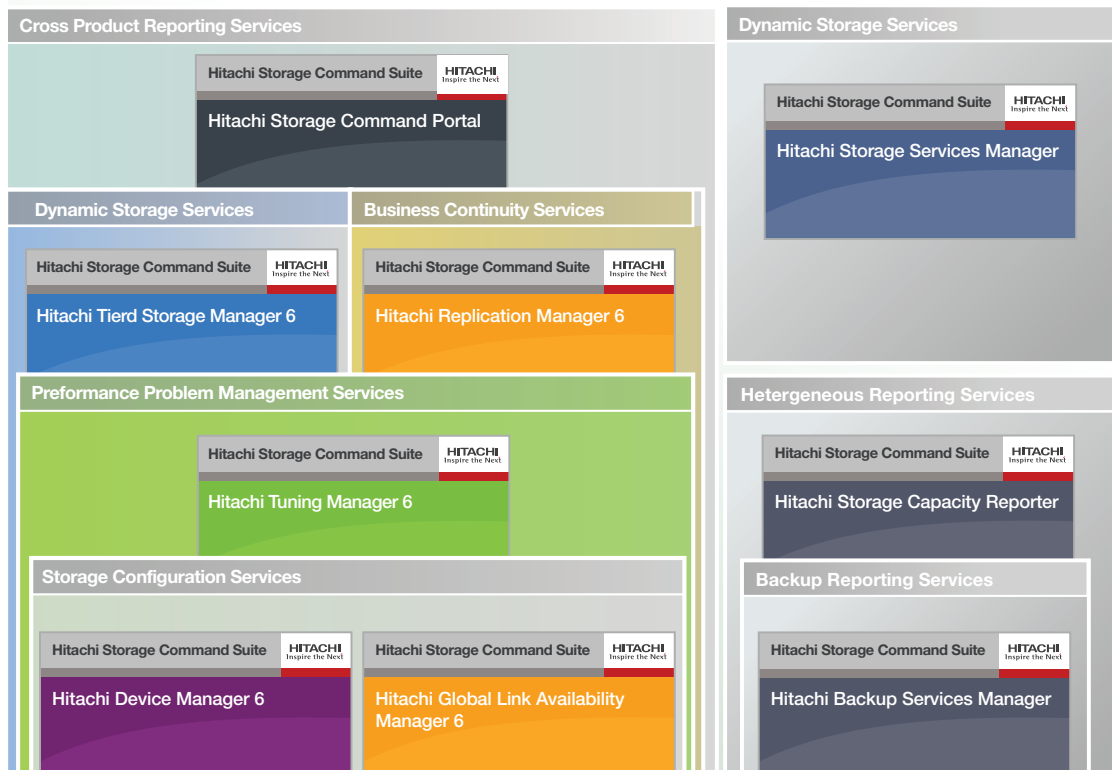
Hitachi Data Systems Services	File	Object	Block
Storage Software			
Hitachi Basic Operating System	X		X
Hitachi Basic Operating System V			X
Hitachi Dynamic Link Manager Advanced			X
Hitachi Dynamic Provisioning			X
Hitachi Storage Services Manager	X		X
Hitachi Tiered Storage Manager			X
Hitachi Tuning Manager			X
Hitachi Data Discovery Suite	X	X	
Hitachi ShadowImage® Heterogeneous Replication			X
Hitachi TrueCopy® Synchronous remote replication			X
Hitachi Universal Replicator			X
Hitachi Replication Manager			X
Hitachi Business Continuity Manager			X
Virtual Tape Library Solutions by Hitachi Data Systems			
Hitachi Data Protection Suite, powered by CommVault®	X	X	X
Hitachi Copy-on-Write Snapshot			X
Hitachi Storage Capacity Reporter, powered by APTARE®			X
Storage Platforms			
Hitachi High-Performance NAS Platform, powered by BlueArc®	X		X
Hitachi Essential NAS Platform®	X		
Hitachi Content Archive Platform	X	X	
Hitachi Universal Storage Platform™ V and Universal Storage Platform VM	X	X	X
Hitachi Adaptable Modular Storage 2000 family	X	X	X
Hitachi Adaptable Modular Storage family	X	X	X
Hitachi Workgroup Modular Storage	X	X	X

Hitachi Data Systems storage solutions give IT the ability to mix and match services to satisfy a desired goal.

Hitachi Storage Command Suite

Hitachi Storage Command Suite is an application-centric storage management solution that incorporates the internationally recognized Information Technology Infrastructure Library (ITIL) services management best practices to simplify administration of a common pool of multivendor storage. Storage Command Suite gives administrators the tools to deliver dependable storage system availability and performance. The software offers comprehensive management, control and discovery for file, object and block storage services and reduces complexity, costs and risk in the storage infrastructure.

Figure 3. Hitachi Storage Command Suite provides single-pane-of-glass management for all file, object and block data virtualized by the Universal Storage Platform V and Universal Storage Platform VM.



Storage Command Suite, formerly known as the Hitachi HiCommand® Storage Management Suite, is a key enabling technology for Services Oriented Storage. The software eliminates the need for separate and isolated tools to manage each vendor's storage. The Storage Command Suite management framework improves operational efficiency and resilience, and integrates solutions for storage resource management, tiered storage and business continuity. The software gives administrators immediate access to critical QoS, service level agreement (SLA), recovery point objective (RPO) and recovery time objective (RTO) metrics.

Hitachi Storage Command Suite tools include:

- Hitachi Basic Operating System software
- Hitachi Basic Operating System V software
- Hitachi Dynamic Provisioning software
- Hitachi Storage Services Manager software
- Hitachi Tiered Storage Manager software
- Hitachi Data Discovery Suite software
- Business Continuity solutions

Hitachi Storage Command Suite is a key enabling technology for Services Oriented Storage. The software eliminates the need for separate and isolated tools to manage each vendor's storage.

Hitachi Basic Operating System and Hitachi Basic Operating System V

The Hitachi Basic Operating System software and Hitachi Basic Operating System V software are packages of integrated tools that simplify storage management of all resources virtualized by the Universal Storage Platform V and Universal Storage Platform VM. Basic Operating System software includes tools to manage, provision, optimize and automate all storage management tasks. Basic Operating System V software is an upgrade add-on to Basic Operating System software and simplifies storage management by letting users take full advantage of the partitioning and heterogeneous storage virtualization capabilities of the Universal Storage Platform V and Universal Storage Platform VM systems.

Table 2. Hitachi Basic Operating System Software's Integrated Tools

Software Title	Function
Hitachi Device Manager software	The primary control point for the Basic Operating System. It provides a single management interface for physical and virtual storage attached to the Universal Storage Platform V and Universal Storage Platform VM.
Hitachi Storage Navigator software	Used by Device Manager to show individual physical storage system configuration and status information, and to send administrative commands to the Universal Storage Platform V and Universal Storage Platform VM.
Hitachi Virtual Partition Manager software	Performs logical partitioning of controllers, ports and cache on the Universal Storage Platform V and Universal Storage Platform VM. Up to four partitions are supported.
Hitachi Performance Monitor software	Intuitive, graphical interface to performance and capacity management information. It is designed to assist with configuration planning, workload balancing and optimizing storage system performance.
Hitachi LUN Manager/LUN Expansion software	Provides tools to define, configure, add, delete, revise and reassign LUNs to specific paths, without having to re-boot the system. It also supports alternative path failover, path load balancing and clustered servers.
Logical Unit Size Expansion (LUSE)	Creates virtual, expandable LUs from physical LUs, to support LUN expansion.
Virtual LVI /LUN Manager	Tool to create custom-sized logical volumes. It eliminates the need to copy large, partially used volumes to improve storage system utilization and boosts remote copy performance.
SAN Security software	Ensures security in SAN environments by denying port access to unauthorized users.
Hitachi Server Priority Manager software	Gives administrators the tools to fine tune access to storage resources, ensuring specific servers and applications get the storage bandwidth they need.
Hitachi Cache Residency Manager software/feature: Cache Management Host Agent	Tool to lock and unlock data in cache, in real time. This can help optimize access and speed performance for the most frequently accessed datasets.
Hitachi Data Retention Utility for Open Systems and IBM® z/OS®	A virtual, disk-based “write once, read many” (WORM) capability. This can help with regulatory compliance, by making archived data nonerasable and nonrewritable for a prescribed period.
Volume Shredder software	The tool is used in combination with the Data Retention Utility to erase sensitive data at the end of the prescribed retention period.
Volume Shadow Copy Services (VSS) Hardware Provider	Support for direct, storage system-based, point-in-time copies with Hitachi In-System Heterogeneous Replication software bundle or Hitachi TrueCopy® Remote Replication software bundle for Microsoft VSS-enabled applications.
SNMP Agent	Provides MIBs for reporting Universal Storage Platform V and Universal Storage Platform VM status and alerts to an enterprise network management system.
NDMP Agent	Supports open standard for enterprise-wide backup of heterogeneous network attached storage.

The Hitachi Basic Operating System software and Hitachi Basic Operating System V software are packages of integrated tools that simplify storage management of all resources virtualized by the Universal Storage Platform V and Universal Storage Platform VM.

Table 3. Hitachi Basic Operating System V Software: An Upgrade Add-on to Hitachi Basic Operating System Software

Software Title	Function
Hitachi Virtual Partition Manager software	The primary control point for the Basic Operating System. It provides a single management interface for physical and virtual storage attached to the Universal Storage Platform V and Universal Storage Platform VM.
Hitachi Universal Volume Manager software	Universal Volume Manager software provides the tools to virtualize heterogeneous storage devices and create multiple tiers of pooled storage. The software offers common storage management, data migration and lifecycle management tools.

Hitachi Dynamic Provisioning software, administrators do not need to micro-manage application storage allocations or perform complex, manual performance tuning.

Hitachi Virtual Partition Manager Software

Hitachi Virtual Partition Manager software logically partitions Universal Storage Platform V and Universal Storage Platform VM cache, ports and disk capacity, including capacity on externally attached storage systems. The software enables administrators to create Hitachi Virtual Storage Machines (formerly called Private Virtual Storage Machines). Each machine is an isolated group of storage resources, with their own storage partition administrator. Logical partitioning guarantees data privacy and QoS for applications sharing the same storage platform.

Hitachi Universal Volume Manager Software

Universal Volume Manager software simplifies migration of applications using third-party storage to the Universal Storage Platform V and Universal Storage Platform VM. The software eliminates the need to reformat LUNs or perform complex extent mapping, providing a minimally disruptive migration process. Once virtualized behind the Universal Storage Platform V or Universal Storage Platform VM, external LUNs gain access to all Hitachi storage services.

Hitachi Dynamic Provisioning Software

Hitachi Dynamic Provisioning software provides the Universal Storage Platform V and Universal Storage Platform VM with thin provisioning services. Thin provisioning gives applications access to virtual storage capacity. Applications accessing virtual, thin provisioned volumes are automatically allocated physical disk space, by the storage system, as they write data. This means volumes use enough physical capacity to hold application data, and no more.

All thin provisioned volumes share a common pool of physical disk capacity. Unused capacity in the pool is available to any application using thin provisioned volumes. This eliminates the waste of overallocated and underutilized storage.

Dynamic Provisioning software also simplifies storage provisioning and automates data placement on disk for optimal performance. Administrators do not need to micro-manage application storage allocations or perform complex, manual performance tuning. In addition, physical storage resources can be added to the thin provisioning pool at any time, without application downtime.

Hitachi Tiered Storage Manager Software

Hitachi Tiered Storage Manager software provides the unique ability to migrate data between heterogeneous tiers of storage, without affecting application access to data. The software supports up to 64 simultaneous migrations, using 64 processor threads, and it offers a single interface for all data movement between storage virtualized by the Universal Storage Platform V and Universal Storage Platform VM.

Business Continuity Solutions

Storage Command Suite software offers a comprehensive range of business continuity and data protection tools, including:

- Hitachi ShadowImage® Heterogeneous Replication software, for full volume local replication of data
- Hitachi TrueCopy® Synchronous remote replication software
- Hitachi Universal Replicator software, for efficient, cost-effective replication and recovery of data hosted on multivendor storage attached to the Universal Storage Platform family
- Hitachi Device Manager, Hitachi Replication Manager and Hitachi Business Continuity Manager software, for common access to data movement products
- Virtual Tape Library Solutions by Hitachi Data Systems, for disk-based backup on the Universal Storage Platform family, without the need to change established backup policies or procedures
- Hitachi Data Protection Suite, powered by CommVault®, an integrated portfolio of storage services to automate and simplify data and storage management tasks
- Hitachi Copy-on-Write Snapshot software, for local volume snapshots
- A global file name space, for seamless file migration across heterogeneous storage systems without the need to remount files

Hitachi Universal Replicator Software

Universal Replicator software is the industry's first multiplatform, multivendor, remote copy capability. Supporting asynchronous, real time replication of data from one Universal Storage Platform V or Universal Storage Platform VM to another, the software gives storage administrators a consistent replication approach, using a common set of procedures, tools and skills, for all data center storage.

Unlike conventional replication solutions, which push updates from the primary storage system to a remote location, Universal Replicator software runs on Universal Storage Platform V or Universal Storage Platform VM at the remote site and pulls changes from journal volumes maintained by the Universal Storage Platform V or Universal Storage Platform VM at the primary site. This approach offloads replication overhead from the primary storage system and dramatically reduces the impact of replication on the business application.


Universal Replicator software uses the same proven replication technology from Hitachi TrueCopy Asynchronous remote replication software and Hitachi Compatible Replication software for IBM XRC® (formerly Extended Remote Copy or HXRC). Transmitted record sets include a time stamp (mainframe only) and sequence number, enabling the replication engine to verify receipt of all records at the remote site and to sequence writes in the correct order for storage.

Hitachi High-performance NAS Platform, powered by BlueArc®

Hitachi High-performance NAS Platform offers exceptional performance and scalability for file-based data. Using advanced file virtualization, the High-performance NAS Platform enables consolidation of existing file services. The High-performance NAS Platform can be virtualized behind the massively scalable Universal Storage Platform V and Universal Storage Platform VM storage systems for access to advanced storage services, such as nondisruptive data migration between tiers of Fibre Channel and SATA storage, block- and file-level replication for business continuity, and policy-based hierarchical storage management.

Hitachi Essential NAS Platform®

The Hitachi Essential NAS Platform delivers a cost-effective NAS solution as a standalone filer. The Essential NAS Platform can be combined with the Hitachi Adaptable Modular Storage systems or attached via Fibre Channel to any Hitachi storage system, including the Universal Storage Platform V and Universal Storage Platform VM, as an integrated NAS gateway. The platform supports CIFS and NTFS access control lists (ACL), for fine grained security and greater concurrency.



Hitachi Universal Replicator software is the industry's first multiplatform, multivendor, remote copy capability.

Hitachi Universal Storage Platform core technologies have been developed through multiple generations with the overriding goal of providing a highly scalable, high-performance platform for storage services.

Hitachi Content Archive Platform

Regulatory compliance and the threat of legal discovery now require that companies prove the authenticity of stored data, give assurances that data has not been altered and provide access to archived data on demand. To do this, an archiving platform must offer encryption for data at rest, secure role-based access and access logs for audit and forensics. Further, it must have the ability to retain records in a protective storage environment for many years across technology refreshes and ensure the destruction of data when the retention data has expired.

The Hitachi Content Archive Platform offers SAN-based digital archiving, backed by the Universal Storage Platform family for scalability, availability and performance of long-term, fixed content storage. The archiving solution offers automated policy-based authentication, protection, retention and destruction to ensure content integrity — with integrated indexing, search and retrieval.

The Hitachi Content Archive Platform uses standard file and Internet protocols to ingest the data and meta-data developed by independent software vendors (ISV). The metadata from different data types — like files, documents, e-mail, Web content and PACS — is stored in a common repository. The data object itself is stored in bitmap format so that it is searchable and independent of formatting constraints. The Universal Storage Platform V and Universal Storage Platform VM enable Hitachi Content Archive Platform storage to scale to petabytes of data and billions of objects. In addition, virtualization offers seamless migration of archived content across generations of storage systems.

Hitachi Data Discovery Suite

Hitachi Data Discovery Suite provides federated search across multiple file instances, simplifying hierarchical storage management (HSM) functions. The software helps administrators understand the discovery risks of files stored across the Hitachi High-performance NAS Platform and Hitachi Content Archive Platform. Solving the complexities of rogue or orphaned data, the Hitachi Data Discovery Suite allows end users and ISVs to contain the problem of unmanaged, unstructured data. The software treats the entire file storage infrastructure as a single entity and supports indexing and searching for files and other unstructured data.

The Hitachi Universal Storage Platform Family

The technologies at the core of the Hitachi Universal Storage Platform V and Hitachi Universal Storage Platform VM have been developed through multiple generations and over many years with the overriding goal of providing a highly scalable high-performance platform for storage services. The strategy driving this development has had three basic tenets:

- Use control unit virtualization to support massive consolidation of storage services on a single platform
- Offer comprehensive solutions for storage management, business continuity, data mobility and advanced storage functionality
- Provide a common storage management suite with access to the metrics necessary to measure and automate storage services

What Is Storage Virtualization?

The Storage Networking Industry Association (SNIA) defines storage virtualization in two parts:

Part 1

The act of abstracting, hiding, or isolating the internal function of a storage (sub) system or service from applications, compute servers or general network resources for the purpose of enabling application and network independent management of storage or data.

Part 2

The application of virtualization to storage services or devices for the purpose of aggregating, hiding the complexity, or adding new capabilities to lower level storage resources.

While many storage virtualization solutions address part one of the SNIA definition, the controller-based storage virtualization solution developed by Hitachi Data Systems for the Universal Storage Platform V and Universal Storage Platform VM is unique in its ability to satisfy the second part.

A Brief History of Controller-based Storage Virtualization

The Universal Storage Platform family storage virtualization technology has been in continuous development since 1995, when Hitachi Data Systems debuted the Hitachi Freedom 7700, with the ability to consolidate storage for mainframe, UNIX and Microsoft® Windows servers on a single platform. Hosting multiple operating platforms was achieved by separating control information and application data in the storage controller. Three years later, the controller technology was refined to enable the dynamic movement of LUNs between RAID groups — functionality that is still unique to Hitachi Data Systems almost 15 years after it was introduced.

The Hitachi Lightning 9900™ series enterprise storage systems introduced the first generation of the Hitachi Universal Star Network™ crossbar switch architecture in 2000. The revolutionary crossbar switch dramatically increased scalability and connectivity. This was enhanced two years later with the ability to support virtual Fibre Channel ports.

In 2004, Hitachi Data Systems introduced the first-generation Hitachi Universal Storage Platform, with the ability to virtualize third-party storage through standard Fibre Channel port connections. Now, with the technology in its second generation, the Universal Storage Platform V and the Universal Storage Platform VM are widely recognized as offering the most complete, most inclusive and most sophisticated implementations of storage virtualization, to date.

Powered by the fourth-generation Hitachi Universal Star Network V crossbar switch architecture, the Universal Storage Platform V and Universal Storage Platform VM, which were both introduced in 2007, deliver high performance, massive scalability and total security. With two platform solutions to choose from users can scale from very small to very large implementations, using the same architecture and the same single-pane-of-glass management strategy.

Intelligent Controller-based Virtualization


Intelligent, controller-based storage virtualization provides a platform for aggregating all file, object and block storage services and all heterogeneous storage hardware. This is the only approach to storage virtualization that gives lower level and legacy storage systems access to enterprise-class performance, functionality and services, in accordance with the SNIA definition of storage virtualization.

The Universal Storage Platform V and Universal Storage Platform VM crossbar switch architecture allows direct access to application data in global cache. Unlike other storage architectures, the crossbar switch maintains mappings that describe global cache data in separate control stores. The control stores are networked directly to each processor in the storage controller, giving application data full access to the capacity and bandwidth of the global cache. Separating control information from data in the global cache also allows mappings to change, dynamically altering the data configuration. This process provides the basis for controller-based virtualization.

How Controller-based Virtualization Works

To virtualize storage with the Universal Storage Platform V and Universal Storage Platform VM, the Fibre Channel host ports of the external storage systems are connected to the Fibre Channel front-end director ports of the Universal Storage Platform V or Universal Storage Platform VM. The ports on the Universal Storage Platform V or Universal Storage Platform VM are then reconfigured to change their behavior from SCSI targets — storage as viewed from the application server — to SCSI initiators — the application server view of storage.

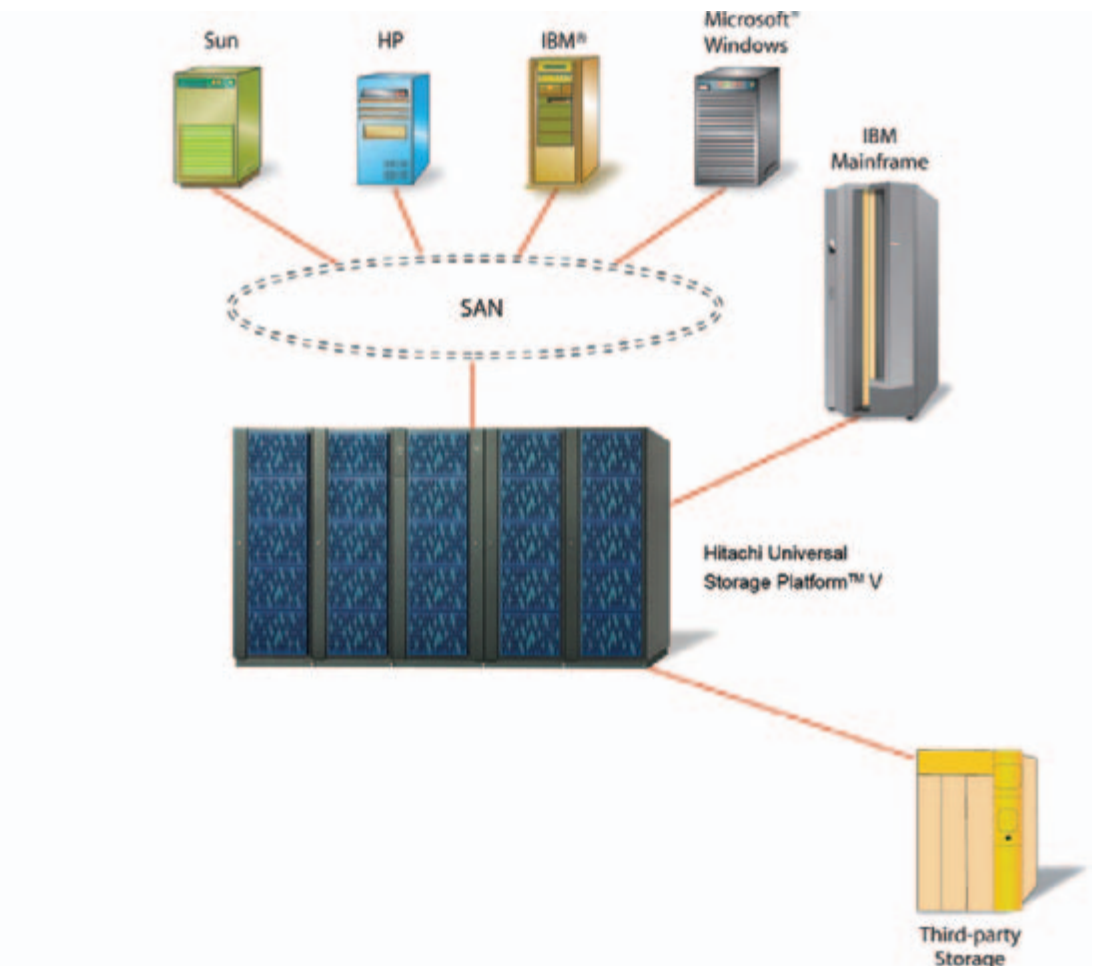
Hitachi Universal Volume Manager software administers connectivity between the Universal Storage Platform V or Universal Storage Platform VM and external storage devices. When a storage system is connected to the Universal Storage Platform V or Universal Storage Platform VM, the software queries the Fibre Channel attachment to discover existing LUNs. These can then be reconnected to application host servers, without compromising file system consistency or integrity.



The Universal Storage Platform V and Universal Storage Platform VM crossbar switch architecture allows direct access to application data in global cache.

Figure 4. The Hitachi Universal Storage Platform V supports up to 247PB of internal and externally attached storage, combined. The Hitachi Universal Storage Platform VM supports up to 96PB of internal and externally attached storage, combined. Both platforms offer common data management and services for all internal and externally attached storage.

Controller-based storage virtualization is a key enabling technology for Services Oriented Storage.



One Platform for All Storage Services

Controller-based storage virtualization is a key enabling technology for Services Oriented Storage. It provides the flexibility to mix and match front-end and back-end storage services to rapidly achieve a desired goal. Consolidated and aggregated multivendor storage resources provide a single platform of enterprise capacity for all file, object and block services functionality.

Operational Simplicity

Hitachi controller-based storage virtualization dramatically simplifies the enterprise storage infrastructure. Virtualization enables the consolidation and aggregation of all multivendor storage resources in a single pool of enterprise storage capacity.

The Universal Storage Platform V and Universal Storage Platform VM are massively scalable. In addition to supporting direct attached Fibre Channel, FICON®, and ESCON® storage, including virtual tape libraries, the storage platforms support NAS and SAN, offering 100 percent data integrity and privacy protection for all attached storage. Existing LUNs and data on externally attached storage systems are automatically discovered, by Universal Volume Manager software, and presented through global cache as if they were still connected to the application server.

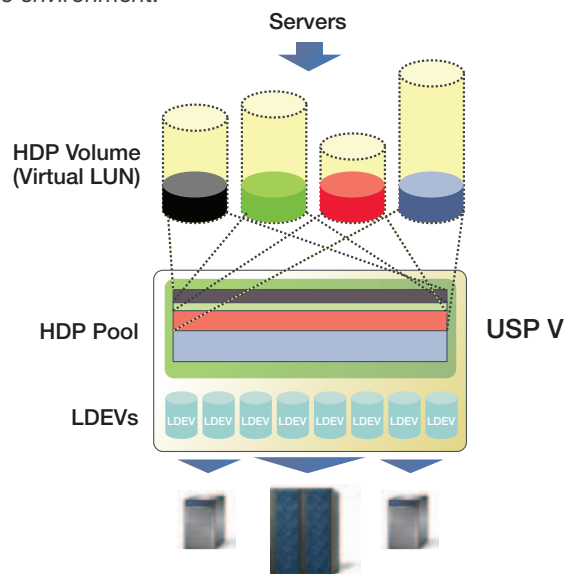
The Hitachi storage controller provides a common storage management platform for all virtualized multivendor storage. Storage Command Suite offers a comprehensive set of management, control and discovery tools for file, object and block storage services, and supports open systems and mainframe environments. The software integrates solutions for storage resource management, tiered storage, business continuity and thin provisioning, giving storage managers a single-pane-of-glass management solution for all enterprise storage.

Dynamic Provisioning

The Universal Storage Platform V and Universal Storage Platform VM offer the first ever implementation of a large-scale, enterprise-class virtualization layer with thin provisioning. Dynamic Provisioning software uses thin provisioning techniques to give applications access to virtual storage capacity. As an application writes data to a virtual volume, the storage system dynamically allocates physical disk space from a common pool. Unused capacity in the pool is available to any application that needs it. This eliminates the waste of overallocated and underutilized application storage capacity. The automated allocation of application storage capacity also dramatically simplifies the storage provisioning process.

Dynamic Provisioning software reduces the need to perform complex storage system tuning to improve I/O performance. The Universal Storage Platform V and Universal Storage Platform VM automatically stripe thin provisioned volumes across the entire width of the physical pool of disks. This wide striping balances the I/O load across many disk spindles, giving consistently high performance for all I/O.

Figure 5. Hitachi Dynamic Provisioning software reduces the size, cost and complexity of the enterprise storage environment.



The Universal Storage Platform V and Universal Storage Platform VM implementation of thin provisioning is unique. All internal and externally attached storage resources virtualized by the Hitachi storage controller can participate in the common physical pool used by thin provisioned volumes.

How Dynamic Provisioning Works

Dynamic Provisioning software uses a paging technique that lets administrators provision application storage without actually allocating physical disk capacity. Dynamically provisioned volume capacity is virtual. As an application writes data to the virtual volume, disk space is assigned in 42MB page increments from a common pool of capacity. Once allocated, pages are striped across the pool of logical devices, which can span hundreds of physical disk spindles. The storage system manages wide striping dynamically, reducing the need for storage administrators to manually tune I/O for performance.

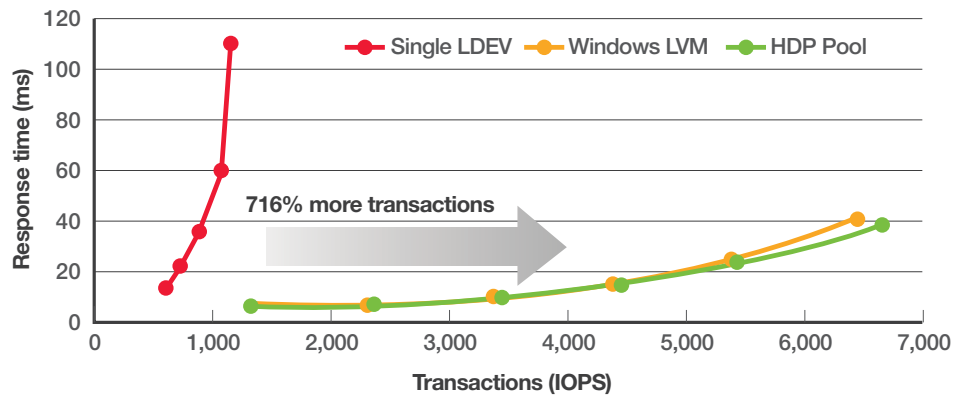
The Universal Storage Platform V and Universal Storage Platform VM offer the first ever implementation of a large-scale, enterprise-class virtualization layer with thin provisioning.

Test Results: Improved Throughput and Improved Response Time

According to an independent lab assessment of Universal Storage Platform V and Dynamic Provisioning software performance, the combination of thin provisioning and wide striping enables the storage system to perform significantly more work while responding faster.

In testing to simulate a random access workload, using an 8KB block size with 75 percent reads, a Windows server was connected to a Universal Storage Platform V over a 4Gb/sec Fibre Channel interface. Thirty-two 146GB 15,000RPM Fibre Channel disks were configured as eight array groups. The tests compared a wide striped volume, created by Dynamic Provisioning software and defined over eight array groups, with a Windows Logical Disk Manager (LDM) volume, also defined over eight array groups. A single LDEV volume was also tested to provide a baseline.

Figure 6. Enterprise Strategy Group tested the Universal Storage Platform V and Hitachi Dynamic Provisioning software against the previous-generation Universal Storage Platform.



The test results show that a wide striped volume can do significantly more in-parallel work than an LDEV configured over a single array group, performing 716 percent more transactions at a response time of 15ms or less. The wide striped volume also responded 118 percent faster than the LDEV volume, at the first data point.

Unlike other thin provisioning solutions, which confine benefits to a proprietary storage frame, the Universal Storage Platform V and Universal Storage Platform VM make dynamic provisioning available as a service to any storage resources attached to the storage system. This unique capability extends the benefits of thin provisioning to legacy and less functional storage systems.

Quality of Service

A prerequisite for any storage consolidation strategy is the ability to host multiple applications on a single storage platform, without allowing the actions of one set of users to affect quality of service (QoS) of others. Potential problem areas for shared storage access include:

- Workloads with I/O and cache conflicts, such as online transaction processing (OLTP) and data warehousing
- Tiered storage access restrictions, such as development and production applications
- Peak processing demands of critical applications versus maintenance activities like backup or a database reorganization

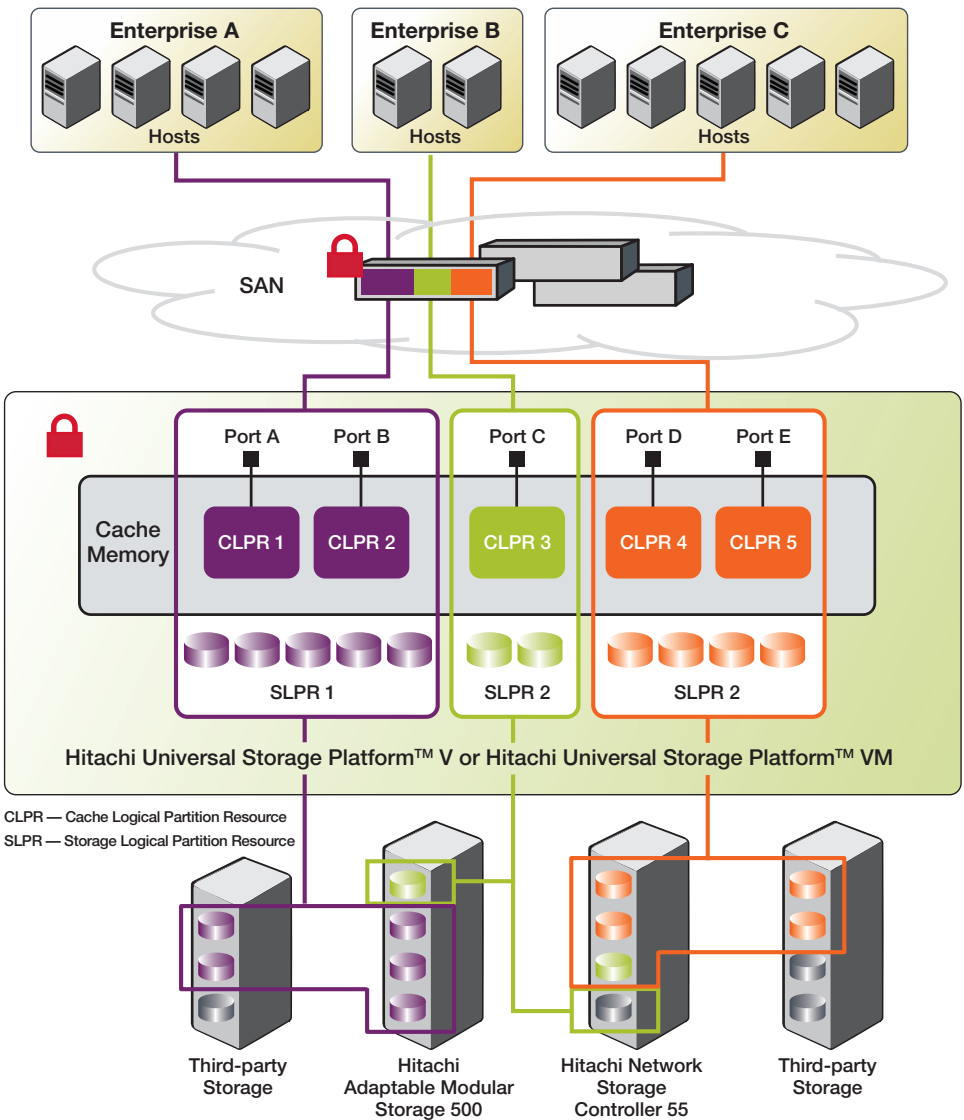
Unlike other thin provisioning solutions, which confine benefits to a proprietary storage frame, the Universal Storage Platform V and Universal Storage Platform VM make dynamic provisioning available as a service to any storage resources attached to the storage system.

The Universal Storage Platform family supports logical partitioning of cache, port and disk resources to create multiple Hitachi Virtual Storage Machines. Each Virtual Storage Machine is a fully autonomous environment, with its own cache, ports, disks, storage administrator and serial number, with support for logging to a SYSLOG server for auditing.

The characteristics of each Virtual Storage Machine can be dynamically adjusted using policies. For example, this enables an application to receive more resources during peak processing and fewer resources during off-peak periods.

Virtual Storage Machines allow multiple users to safely share the resources of the Universal Storage Platform V and Universal Storage Platform VM, including all attached and virtualized multivendor capacity, without the risk of activities in one region affecting the performance, availability or privacy of other users.

Figure 7. Hitachi Universal Storage Platform V and Universal Storage Platform VM Virtual Storage Machines provide fully secure multitenancy for massive infrastructure consolidation.



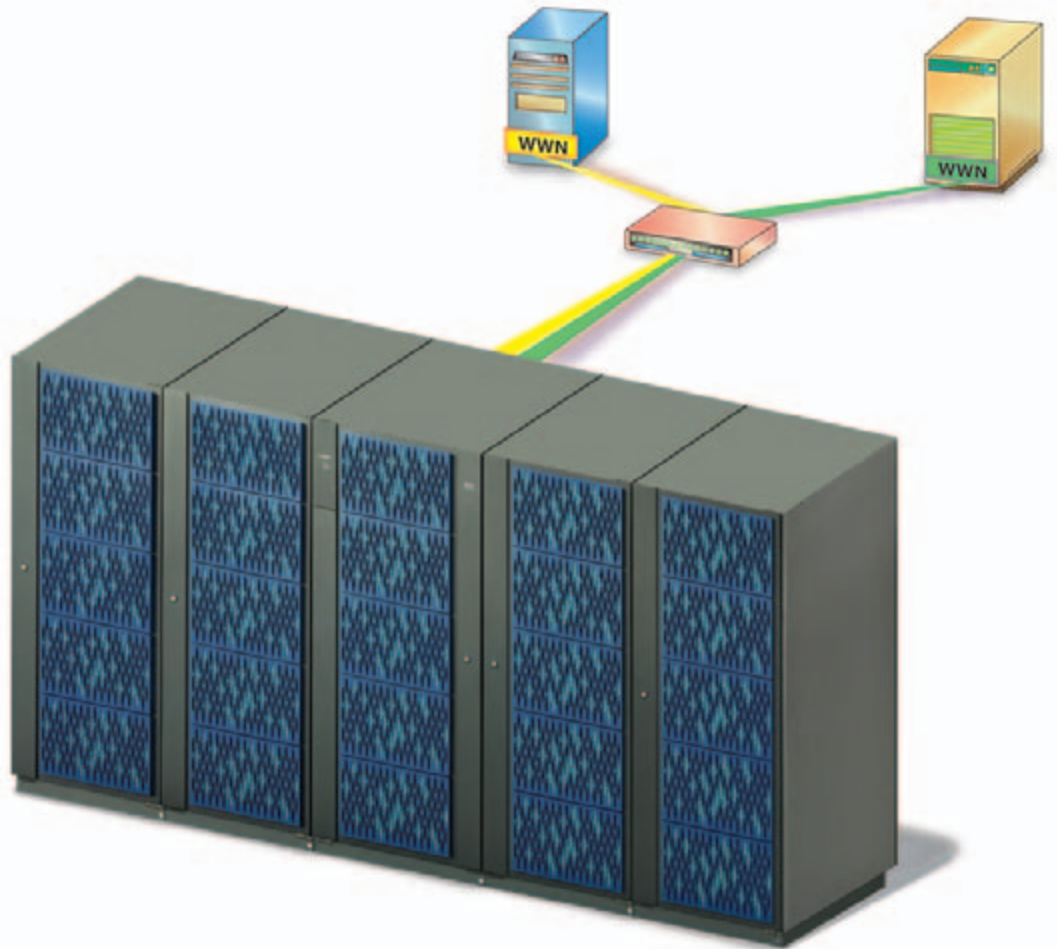
End-to-end Secure Virtualization for VMware

The Universal Storage Platform V and Universal Storage Platform VM were the first external storage virtualization platforms certified to work with VMware ESX Server. The ability to securely partition port, cache and disk resources, and to mask the complexity of a multivendor storage infrastructure, make the Universal Storage Platform V and Universal Storage Platform VM ideal complements to a VMware ESX Server environment.

With up to 1024 virtual ports for each physical Fibre Channel port, the Universal Storage Platform V and Universal Storage Platform VM provide the connectivity to support large VMware server farms. Each virtual port is allocated a storage partition, called a Host Storage Domain. The fully secure Host Storage Domains ensure applications in one VMware guest cannot access data belonging to another guest machine.

Figure 8. The Universal Storage Platform V and Universal Storage Platform VM support 1,024 virtual ports for each Fibre Channel port.

With up to 1024 virtual ports for each physical Fibre Channel port, the Universal Storage Platform V and Universal Storage Platform VM provide the connectivity to support large VMware server farms.



Host Storage Domains

Host Storage Domains are created from the common pool of virtualized Hitachi and third-party storage attached to the Universal Storage Platform V and Universal Storage Platform VM. This gives VMware guests access to a wide range of storage with different price, performance and functionality profiles. Partitions allocated to a VMware guest, through its Host Storage Domain, can be migrated between different tiers of storage, according to the needs of the business application. Data can also be replicated locally, or remotely, to accommodate business continuity needs. Movement and replication of Host Storage Domain partitions is nondisruptive and totally transparent to applications running in the VMware guest machine.

Each Host Storage Domain has unique LUN addressing, including a bootable LUN0. This enables VMware guests with different host operating systems to securely share a single physical port without risking LUN and data integrity. Universal Storage Platform V and Universal Storage Platform VM cache can also be partitioned. Hitachi Virtual Storage Machines support logical partitioning of ports, cache and disks and have the added benefit of their own storage partition administrator and virtual serial number, for chargeback.

The Universal Storage Platform V and Universal Storage Platform VM give applications running on VMware guest machines access to the most advanced storage system functionality available, including thin provisioning, single-pane-of-glass management of all virtualized storage, content management services and storage security services. Combining VMware ESX Server and the Universal Storage Platform V or Universal Storage Platform VM overcomes physical infrastructure inflexibility and delivers true end-to-end virtualization.

Tiered Storage

Tiered storage delivers substantial infrastructure cost savings by matching storage system capabilities and application sensitivity to performance, availability, price and functionality. For example, a tiered storage configuration enables non-essential copies of primary application data — point-in-time snapshots, replication copies and data mining — to be hosted on legacy and low-cost storage systems. This frees capacity on high-end storage for critical data.

Although the benefits of tiered storage are widely recognized, implementation has lagged due to problems performing nondisruptive data movement between heterogeneous tiers. The Universal Storage Platform family virtualization engine solves this problem by providing a single interface to all multivendor tiered storage resources through the Hitachi Universal Volume Manager software.

Tiered Storage Manager software is unique in its ability to migrate data between heterogeneous tiers of storage, without affecting application access to data. The software supports up to 64 simultaneous migrations, using 64 processor threads, and offers a single interface for all data movement between storage virtualized by the Universal Storage Platform V and Universal Storage Platform VM.

Tiered Storage Manager software manages groups of volumes. Migration Groups are typically associated with a single business application and represent a list of volumes requiring similar storage resources. Storage Tier is a logical label given to a group of storage resources that match a predefined set of capabilities, such as minimum I/O response time. During data migration, a Migration Group is moved between one Storage Tier and another. Migration copies the contents of a source LDEV to a target LDEV. When the two LDEVs are fully synchronized, Tiered Storage Manager software swaps the LDEV identifiers. Hosts accessing the LDEV will not notice any change. The LUN address path, as seen by the host, remains constant. In addition, source and target LDEVs are not required to have the same RAID configuration.


Mainframe Storage Virtualization

The Universal Storage Platform family gives mainframe users access to the same virtualization technology available to open systems platforms. The Universal Storage Platform V and Universal Storage Platform VM offer both ESCON and FICON connectivity. This gives mainframe users access to virtualized Fibre Channel and SATA storage solutions, without requiring expensive protocol converters and network extenders.

For example, SATA storage capacity is generally unavailable to mainframe applications, because the modular systems hosting SATA disks do not support ESCON or FICON. Using Hitachi Data Systems 3390-M emulation mode, the Universal Storage Platform V and Universal Storage Platform VM provide mainframe users with access to low-cost SATA storage. This enables dataset migration processes, which would otherwise consume costly mainframe processing cycles performing compression, to write directly to SATA storage. Note: Hitachi Data Systems refers to IBM 3390-9 (54GB, 65,536 cylinders) emulation as 3390-M emulation.

With the availability of cost-effective SATA storage, mainframe migration solutions, such as data facility hierarchical storage manager (DFHSM), can target SATA disks instead of tape. This eliminates tape handling and latency issues and provides greater responsiveness during recalls and restores. ShadowImage Heterogeneous Replication software also offers a DFHSM alternative, offloading mainframe processing cycles by archiving volumes in the storage controller.

The Universal Storage Platform family also gives mainframe users access to controller-based, Fibre Channel data replication technology. This can substantially reduce mainframe business continuity costs by eliminating the need for expensive ESCON and FICON extenders between local and remote data centers. Similarly, mainframe-based virtual tape solutions that currently rely on ESCON or FICON for connectivity can direct writes to any virtualized local or remote Fibre Channel-based storage system.

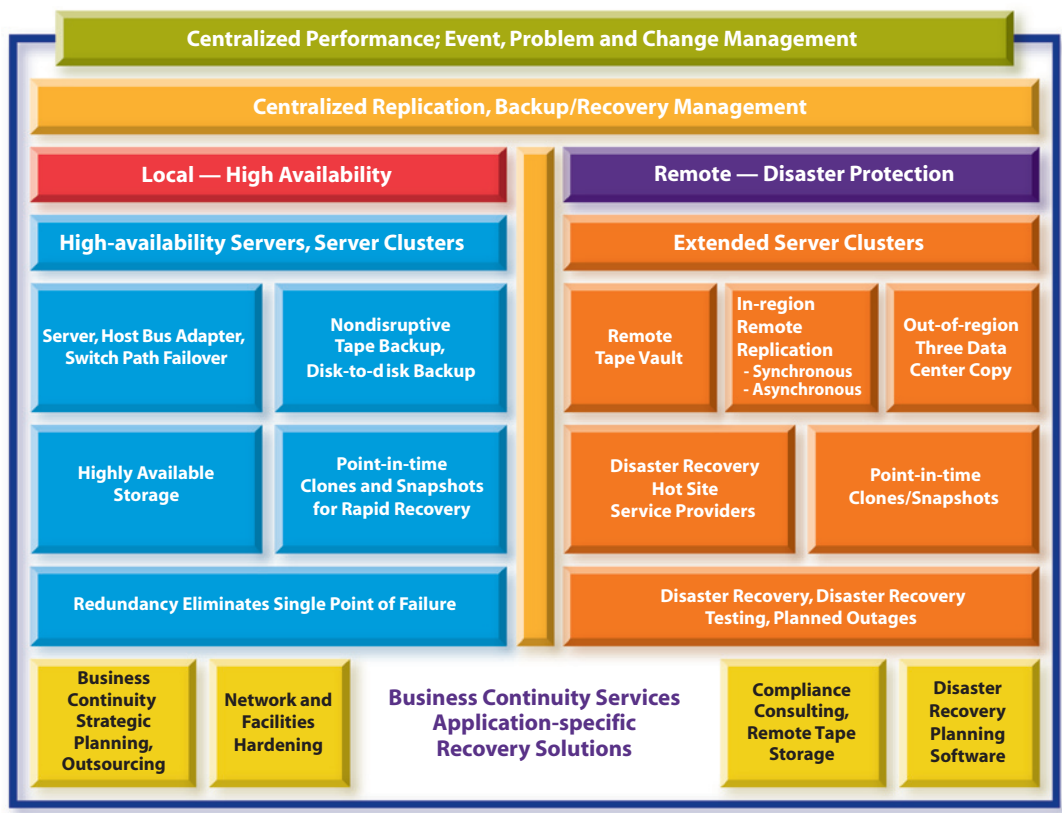


Hitachi Tiered Storage Manager software is unique in its ability to migrate data between heterogeneous tiers of storage, without affecting application access to data.

Business Continuity

Virtualization brings the availability benefits of data replication technology within reach of more enterprise applications. The Universal Storage Platform V and Universal Storage Platform VM support a single suite of replication tools for all virtualized multivendor storage. This enables data stored on a high-end storage system at a primary site to be cost-effectively replicated to a modular SATA storage system at a remote site. Similarly, performing in-system mirroring of data on tier-one storage to a legacy device can speed local recovery. By lowering the cost of business continuity, the Universal Storage Platform V and Universal Storage Platform VM make these solutions available to more enterprise applications.

Figure 9. Hitachi Business Continuity Framework supports a centrally managed infrastructure.



The Hitachi Business Continuity Framework combines local high-availability and remote disaster recovery capabilities in a centrally managed infrastructure. Universal Replicator software performs asynchronous replication of any storage system virtualized by the Universal Storage Platform family, across any distance. TrueCopy Synchronous software supports synchronous remote replication between Hitachi storage systems, ShadowImage Heterogeneous Replication software delivers fast, nondisruptive full volume copy to mirror mission critical data locally, and Tiered Storage Manager software provides policy-based data life-cycle management across all tiers of storage.

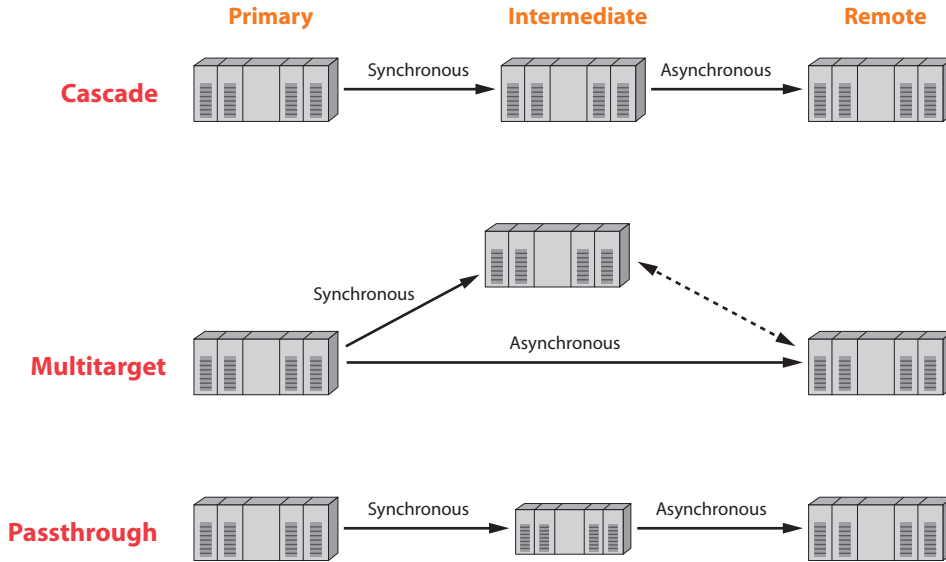
Surviving Link Failure

Universal Replicator uses disk-based journaling and pull style replication, enabling it to survive temporary communication interruptions for long periods, without the risk of data loss. If the replication link between the primary and remote sites fails, changes are still logged in the local journal. When the replication link is restored, changes are transmitted, without interrupting the protection process or the application. The Universal Storage Platform V and Universal Storage Platform VM preserve data consistency and support more current recovery point objectives, even during outage situations. These processes also help when balancing replication bandwidth against data currency objectives.

Three Data Center Business Continuity Solution

The Universal Storage Platform V and Universal Storage Platform VM make three data center business continuity an affordable reality for a broad range of enterprises and applications. Using a combination of TrueCopy Synchronous software and Universal Replicator software, cascade, passthrough and multitarget replication configurations are possible.

Figure 10. Three data center replication configurations ensure data is always available.



The Universal Storage Platform V and Universal Storage Platform VM make three data center business continuity an affordable reality for a broad range of enterprises and applications.

Cascade configurations provide complete copies of application data at an intermediate data center, to support server clusters and application failover. Passthrough configurations store only journal volumes at the intermediate site, reducing business continuity cost. Multitarget configurations offer the best protection against local and regional disasters, albeit at higher cost.

Security and Compliance

The Universal Storage Platform V and Universal Storage Platform VM support the Fibre Channel Security Protocol (FC-SP) for end-to-end authentication of application data. Hitachi Virtual Storage Machines further enhance security by offering rigid segregation of individual user and application cache, port and disk resources. These features are being evaluated for the Common Criteria EAL2 certification. Common Criteria certification gives organizations the assurance that these solutions conform to the highest internationally recognized standards for security.

The Green Data Center

The Universal Storage Platform V and Universal Storage Platform VM offer a highly effective foundation for a multifaceted, environmentally friendly data storage strategy. The two platforms enable massive infrastructure consolidation, with full data, cache and network privacy for shared users. Consolidation and distribution of external storage substantially reduces infrastructure requirements, lowering data center energy, cooling and floor space needs.

Storage utilization for open systems is often as low as 20 percent. This means that power, cooling and floor space are consumed for storage resources that are never used. The Universal Storage Platform V and Universal Storage Platform VM are uniquely able to increase utilization through multivendor storage virtualization and thin provisioning. Thin provisioning dramatically raises storage utilization rates by allocating virtual storage capacity to applications and provisioning physical disk space only when needed. This reduces the physical storage needs of enterprise applications.

Unique Hitachi Data Systems data migration solutions offer further scope for data center carbon footprint reduction. Storage managers can move data to tiers of storage that draw less power, move data to temporary storage while the original storage system is repositioned — for example, to eliminate hot spots — and move data to archival systems like the Hitachi Adaptable Modular Storage system, which can be powered down during periods of inactivity. Data migration between multivendor storage systems takes place without interfering with application access.

Hitachi Data Systems Global Solution Services and Best Practices

Hitachi Data Systems Global Solution Services (GSS) has developed specific services to help IT staff install, configure and customize the technologies and services associated with Services Oriented Storage and the Universal Storage Platform family. With the help of GSS, IT staff can plan, design, implement, integrate, optimize and manage new solutions to meet specific business requirements, upgrade existing technologies to accommodate changing workloads, solve performance problems and perform capacity planning to ensure future growth is accommodated without infrastructure disruption.

Services for the Universal Storage Platform V and Universal Storage Platform VM include:

- Storage Economics Strategy Service
- Risk Analysis Workshop
- Storage Virtualization and Tiered Storage Services
- Backup Assessment Services
- Implementation Services for Storage and Software
- Data Migration Services
- Storage Consolidation Services

Hitachi Universal Storage Platform™ V and Hitachi Universal Storage Platform VM Architecture

Overview

The Universal Storage Platform V is the most powerful and intelligent enterprise storage system in the industry. The Universal Storage Platform V and the smaller footprint Universal Storage Platform VM are based on the Universal Star Network™ architecture: a fourth-generation implementation of the massively parallel crossbar switch architecture first introduced in the Hitachi Lightning 9900™ Series enterprise storage systems. With this architecture as its engine, the Universal Storage Platform V delivers unprecedented performance, supporting over 4.0 million I/O per second (IOPS), up to 247PB of internal and external virtualized storage capacity and 512GB of directly addressable cache.

Hitachi Universal Star Network — the Industry's Highest Performing Storage Architecture

The Universal Star Network is the industry's highest performing storage architecture. A radical departure from the monolithic designs of competing storage systems, the Universal Star Network uses non-blocking crossbar switches and a parallel switch fabric to deliver the scalability, performance and fault tolerance essential for enterprises facing double digit compound annual growth in storage capacity.

With faster processors, more control and data paths and an enhanced symmetric multiprocessing (SMP) design, the latest generation of the Hitachi crossbar switch architecture performs up to 320 concurrent memory operations with an unparalleled aggregate internal bandwidth of 106GB/sec in the Universal Storage Platform V. Internal aggregate bandwidth for the Universal Storage Platform VM is 13.3GB/sec.

The Universal Star Network crossbar switch architecture uses multiple independent point-to-point data and command paths, providing redundancy and improved performance. The architecture has no common buses. This eliminates the contention and performance degradation that occur in conventional bus architectures.

CHAPTER 2

With faster processors, more control and data paths and an enhanced symmetric multiprocessing (SMP) design, the latest generation of the Hitachi crossbar switch architecture performs up to 320 concurrent memory operations with an unparalleled aggregate internal bandwidth of 106GB/sec in the Universal Storage Platform V.

Table 4. Universal Storage Platform V and Universal Storage Platform VM Specifications

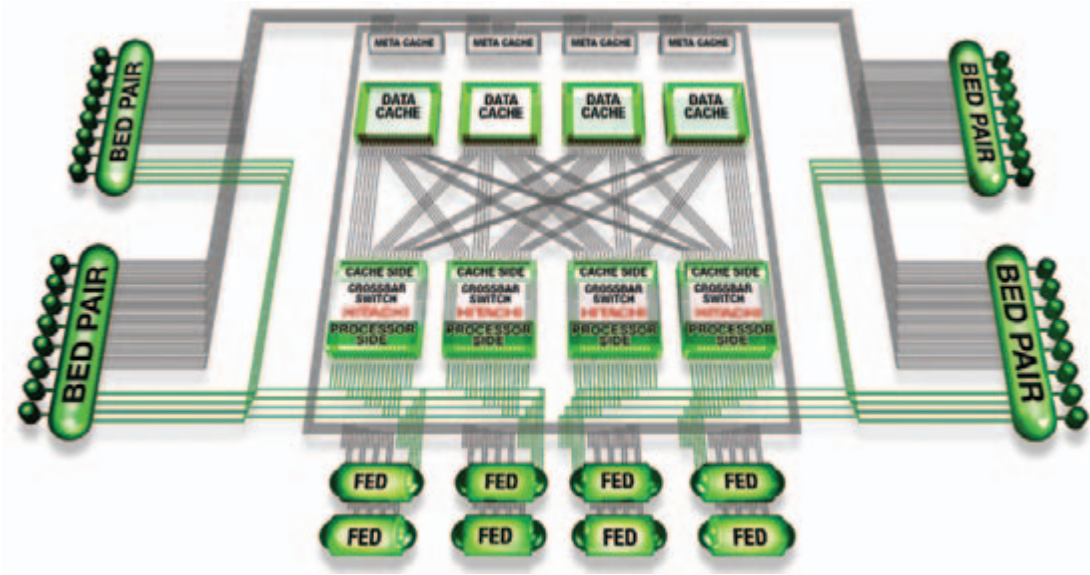
Characteristics	Universal Storage Platform V	Universal Storage Platform VM
Number of Cabinets (basic unit plus optional array frames or racks)	1–5	1–2
Number of Universal Star Network™ Switches	8	2
Aggregate Bandwidth (GB/sec)	106	13.3
Aggregate IOPS	Over 4 million	1.2 million
Max. Data Cache (GB)	512	128
Max. Control/Shared Memory (GB)	24	16
Front-end Directors (modules)	1–14	1–3
Fibre Channel Port Performance	4Gb/sec	4Gb/sec
Max. Fibre Channel Host Ports	224	48
Virtual host ports per Physical Port	1,024	1,024
Max. IBM® ESCON® Host Ports	112	24
Max. Supported Logical Devices (LUNs)	65,536	65,536
Number of Disks per System (min./max.)	4–1,152	0–240
Number of Spare Disks per System (min./max.)	1–40	1–16
Max. Internal Raw Capacity (TB) — 1TB Disks	1,134.5	236.3
Max. Internal and External Capacity (PB)	247	96
Max. Useable Internal capacity (TB) Open Systems RAID-5, 1TB Disks	986	193.0
Max. Useable Internal Capacity (TB) Open Systems, RAID-6, 1TB Disks	845	165.5
Max. Useable Internal Capacity (TB) Open Systems, RAID-1+, 1TB Disks	565.3	116.2
Max. Useable Internal Capacity (TB) Mainframe, RAID-5, 1TB Disks	931.7	182.4
Max. Useable Internal Capacity (TB) Mainframe, RAID-6, 1TB Disks	796.4	155.9
Max. Useable Internal Capacity (TB) Mainframe, RAID-1+, 1TB Disks	527.4	108.47
Max. Hitachi Virtual Storage Machines	32	8
Back-end Directors	1–8	1

The Universal Star Network manages data and control information from storage requests separately. Two distinct networks support 64 concurrent data operations and 256 concurrent control operations on the Universal Storage Platform V.

Massively Parallel Crossbar Switch Architecture

Unlike conventional storage system designs, the Universal Star Network manages data and control information from storage requests separately. Two distinct networks — the Cache–Hierarchical Star Network (C-HSN) and the Control Memory–Hierarchical Star Network (CM-HSN) — support 64 concurrent data operations and 256 concurrent control operations on the Universal Storage Platform V. The Universal Storage Platform VM supports 8 concurrent data operations and 32 concurrent control operations.

Figure 11. The Hitachi Universal Storage Platform V employs the Hitachi Universal Star Network™ massively parallel crossbar switch architecture.



Note: The Hitachi Universal Storage Platform VM includes three front-end directors and one back-end director.

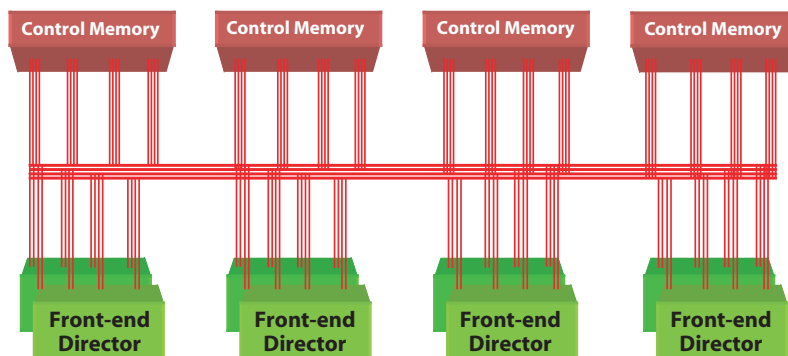
Cache–Hierarchical Star Network (C-HSN)

The C-HSN is used by the switch architecture to transfer data in and out of the main global data cache. There are two components to the C-HSN: the processor paths to the C-HSN and the C-HSN itself.

Control Memory–Hierarchical Star Network (CM-HSN)

The internal system control network of the crossbar switch architecture manages the exchange of control data between the processors and control memory. Control memory is separate from global cache, and it contains information about the status, location and configuration of the cache, the data in the cache and the configuration of the Universal Storage Platform V or Universal Storage Platform VM. Control memory is mirrored for redundancy.

Figure 12. The CM-HSN handles the exchange of control information between processors and data cache memory.



By using the CM-HSN and a separate control information out-of-band, the Hitachi crossbar switch is able to process control information out-of-band. This gives application data full, unimpeded access to the capacity and bandwidth of the global cache and the C-HSN.

By using the CM-HSN and a separate control memory area, the Hitachi crossbar switch is able to process control information out-of-band. This gives application data full, unimpeded access to the capacity and bandwidth of the global cache and the C-HSN.

The CM-HSN is a high-performance, hard-wired point-to-point network, with each path operating at 150MB/sec. It uses narrower data paths than the C-HSN, and more of them. Only the C-HSN uses the crossbar topology for its interconnecting network.

Non-blocking Switched Access to Cache

The Universal Star Network architecture uses eight non-blocking crossbar switches on the Universal Storage Platform V and two on the Universal Storage Platform VM along with a parallel switch fabric. The crossbar switches function as combination multiplexers, path arbitrators and non-blocking network switches. Each path operates in full duplex mode at 1,064MB/sec. The multiplexer functionality supports 16 paths to the processor side of each switch and 16 paths to the cache modules. On the Universal Storage Platform V this gives 64 paths at the processor side of the fabric network and 64 paths to the cache modules from the cache side of the fabric network. The Universal Storage Platform VM has 8 paths at the processor side of the fabric network and 8 paths to the cache modules from the cache side of the fabric network.

Advanced Data Cache Algorithms Provide Read-ahead for High-performance Sequential Reads

The Universal Storage Platform V and Universal Storage Platform VM have a variety of advanced cache algorithms and software that combine to deliver exceptional performance. Read clustering uses built-in heuristics to determine whether data is being accessed sequentially. If sequential reads are detected, the Universal Storage Platform V and Universal Storage Platform VM automatically bring data into cache so that subsequent read requests will be satisfied immediately from memory, speeding I/O.

Hitachi Cache Residency Manager Software Allows Datasets to be Permanently Placed in Data Cache

The Hitachi Cache Residency Manager software (formerly FlashAccess) allows administrators to dynamically lock and unlock data in cache in real time. The software makes it possible to allocate a portion of cache to specific data. When activated, read and write functions are performed from cache, eliminating performance delays from disk latency. Administrators can add, delete or change which datasets Cache Residency Manager software manages at any time.

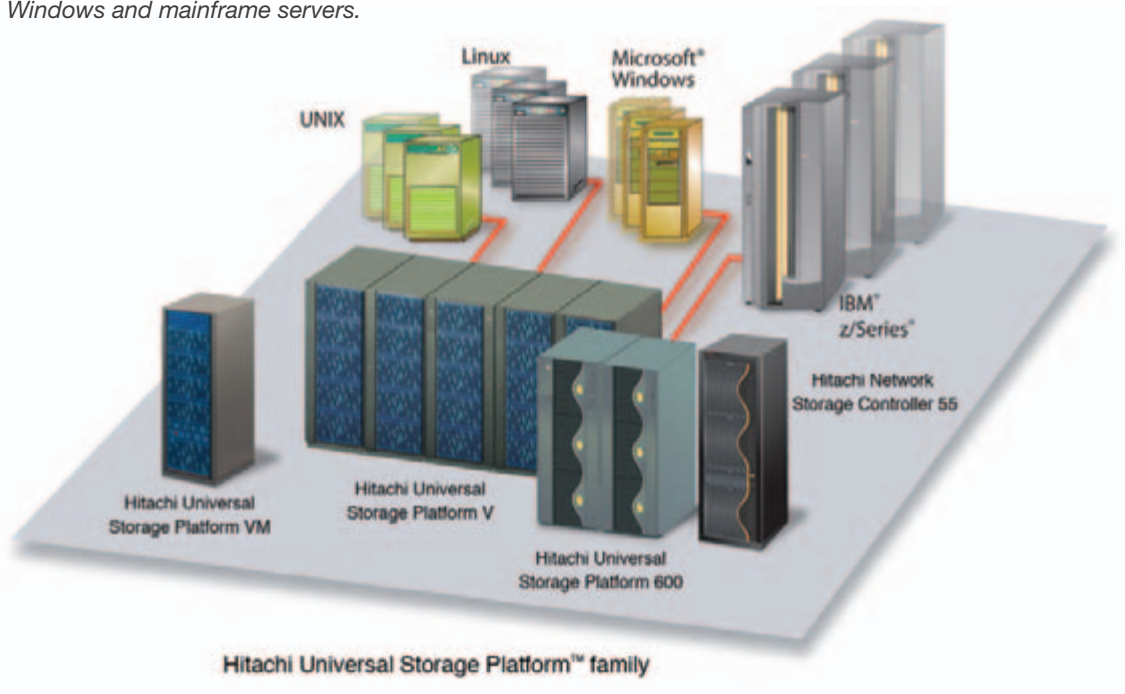
In IBM mainframe environments defined by the Logical Volume Image (LVI), cache data can be as small as a single track or as large as a full disk volume. Using Cache Residency Manager software in conjunction with Hitachi Cross-OS File Exchange software increases data transfer speed, improving the performance of mainframe-to-open-systems data exchange.

Front-end Design

The Universal Storage Platform V and Universal Storage Platform VM support Fibre Channel for open systems and SAN connectivity and ESCON and FICON for IBM z/OS-compatible platform connectivity. The Universal Storage Platform V supports up to 224 Fibre Channel ports from up to 14 front-end director modules. The Universal Storage Platform VM supports up to 48 Fibre Channel ports from up to three front-end director modules. Fibre Channel ports support industry standard 1, 2, and 4Gb/sec transfer rates.

Unique port virtualization technology dramatically expands connectivity from open systems platforms to the Universal Storage Platform V and Universal Storage Platform VM.

Figure 13. Universal Storage Platform V supports front-end connectivity to UNIX, Linux, Windows and mainframe servers.



Open systems and mainframe hosts can connect simultaneously to the Universal Storage Platform V and Universal Storage Platform VM.

Unique port virtualization technology dramatically expands connectivity from open systems platforms to the Universal Storage Platform V and Universal Storage Platform VM. Each physical Fibre Channel port supports 1,024 virtual ports. Each virtual port has access to a private storage partition called a Host Storage Domain, which includes a bootable LUN0.

Connectivity from all major open systems hosts is supported, including:

- HP: HP-UX, Tru64 UNIX, OpenVMS
- IBM: AIX®
- Microsoft: Windows Server (2000, 2003, 2008)
- Novell: NetWare, SUSE Linux Enterprise Server
- SUSE: NetWare
- Red Hat: Enterprise Linux
- SGI: IRIX
- Sun Microsystems: Solaris
- VMware: ESX Server

Connecting to Mainframe Hosts

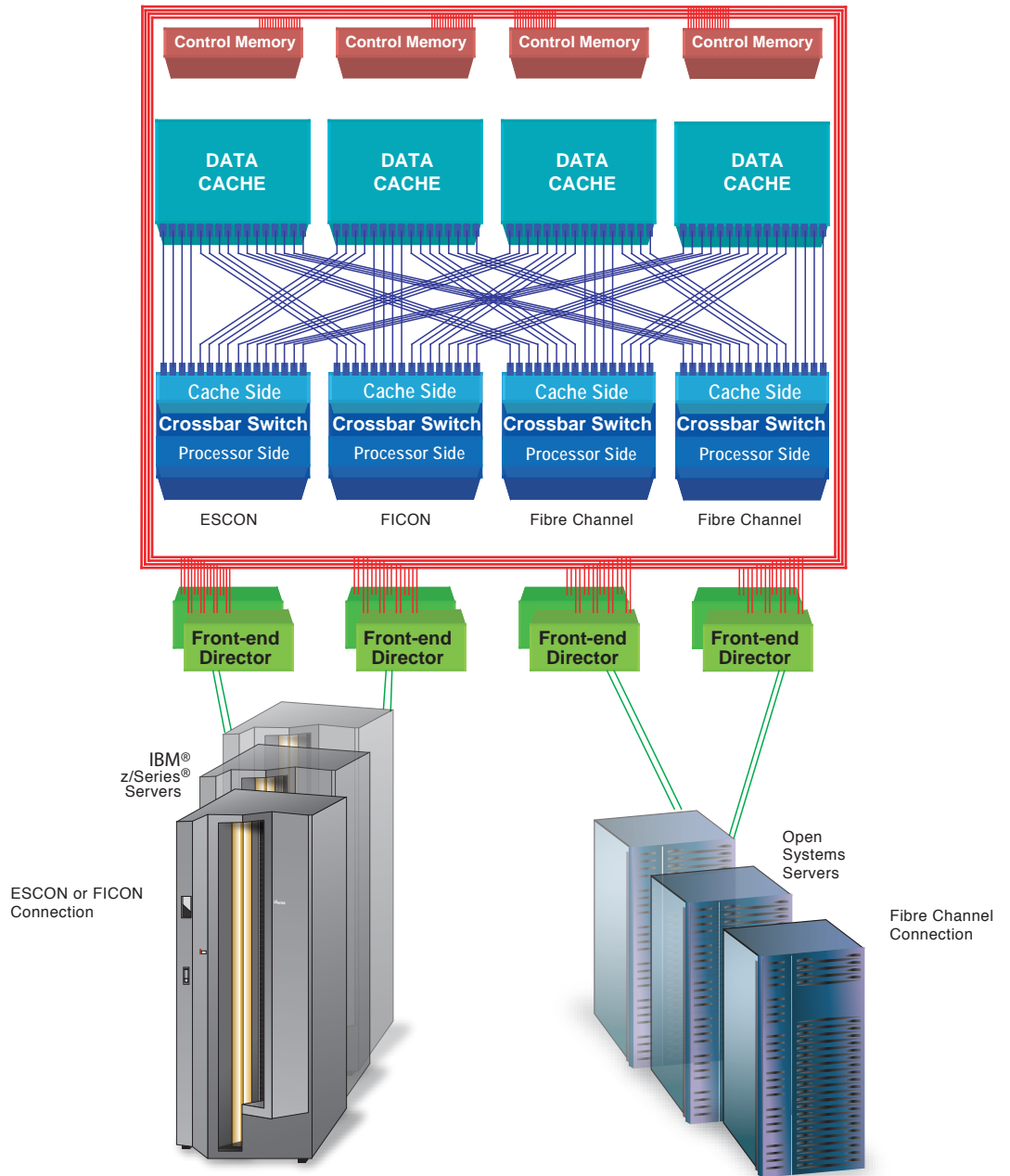
Both ESCON and FICON connectivity are supported for direct connectivity to mainframe hosts. Each ESCON front-end director on the Universal Storage Platform V supports eight ports, for a maximum of 112 host interface connections at 17.5MB/sec. The Universal Storage Platform VM supports a maximum of 24 ESCON host interface connections at 17.5MB/sec.

Each FICON front-end director module on the Universal Storage Platform V supports eight ports, for a maximum of 112 host interface connections. The Universal Storage Platform VM supports a maximum of 24 FICON host interface connections. FICON front-end director modules feature negotiating logic that automatically sets the port speed to match the host's host bus adapter (HBA). 1, 2 and 4Gb/sec speeds are supported.

Open systems and mainframe hosts can connect simultaneously to the Universal Storage Platform V and Universal Storage Platform VM. Supported mainframe host operating environments include:

- Fujitsu: MSP
- IBM: z/OS®, z/OS.e, z/VM®, z/VSE™, SUSE Linux Enterprise Server for System z, Red Hat Linux for S/390® and z/Series®, TPF.

Figure 14. The Universal Storage Platform V and Universal Storage Platform VM provide Fibre Channel, ESCON and FICON attachment to open systems and mainframe hosts.



Notes

- The Hitachi Universal Storage Platform VM includes a maximum of three front-end directors compared with a maximum of fourteen front-end directors on the Universal Storage Platform V.
- The Hitachi Universal Storage Platform VM includes a maximum of two Universal Star Network Crossbar Switches compared with eight on the Universal Storage Platform V.
- The Universal Storage Platform VM supports up to 48 Fibre Channel ports from up to three front-end director modules.

High-performance, High-capacity All Fibre Channel Back-end Design

The Universal Storage Platform V and Universal Storage Platform VM are available with a choice of high-performance and high-capacity disk drives. Low profile (3.5-inch by 1-inch) Fibre Channel and SATA drives support a variety of RAID levels, and can be mixed and matched within the same system.

The Universal Storage Platform V and Universal Storage Platform VM feature Command Tag Queuing to offload much of the seek optimization processing from the storage system to the disk drives. This allows more simultaneous back-end I/O operations and offers greatly improved back-end performance.

Back-end directors control the transfer of data between disk drives and cache. The back-end directors comprise pairs of boards for redundancy and performance. The Universal Storage Platform V supports up to eight back-end directors, which are available in groups of two, providing 64 4Gb/sec switched Fibre Channel Loop concurrent data transfers to and from the disk drives. The Universal Storage Platform VM is configured with one back-end director, which provides eight concurrent 4Gb/sec switched Fibre Channel Loop data transfers to and from the disk drives. A dedicated high-speed VLSI processor drives each Fibre Channel arbitrated loop (FC-AL) path.

RAID Implementation Advantages

Hitachi back-end directors are the most advanced in the enterprise storage industry and employ advanced algorithms to manage performance. The intelligent controllers provide disk-interface and RAID management circuitry, offloading these tasks to dedicated embedded processors. Each Universal Storage Platform V and Universal Storage Platform VM back-end director supports RAID-1+, RAID-5 (parity RAID) and RAID-6. All user data disks in the system are defined as part of a RAID array group of one type or another.

The Universal Storage Platform V and Universal Storage Platform VM feature Command Tag Queuing to offload much of the seek optimization processing from the storage system to the disk drives. This allows more simultaneous back-end I/O operations and offers greatly improved back-end performance.

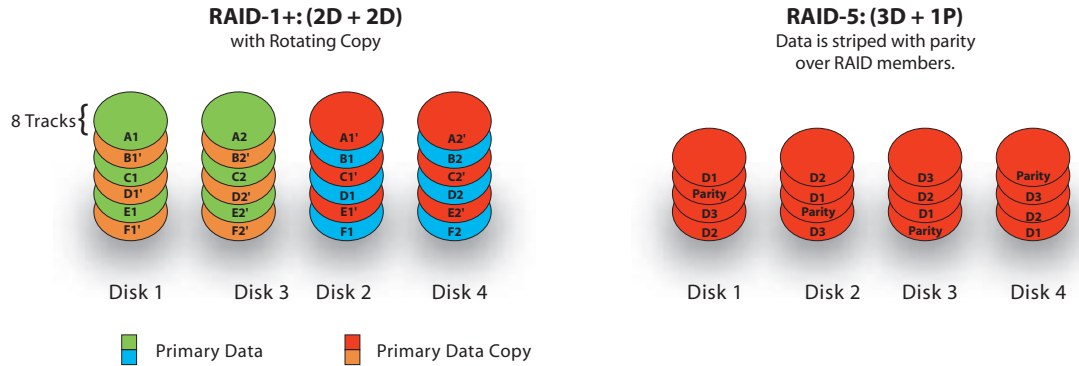
Table 5. Universal Storage Platform V and Universal Storage Platform VM Back-end Director Support of RAID Configurations

RAID Type	Supported Disk Configuration
RAID-1+ Mirroring	2D+2D 4D+4D
RAID-5 Distributed Parity	3D+1P 7D+1P
RAID-6 Redundant Distributed Parity	6D+2P

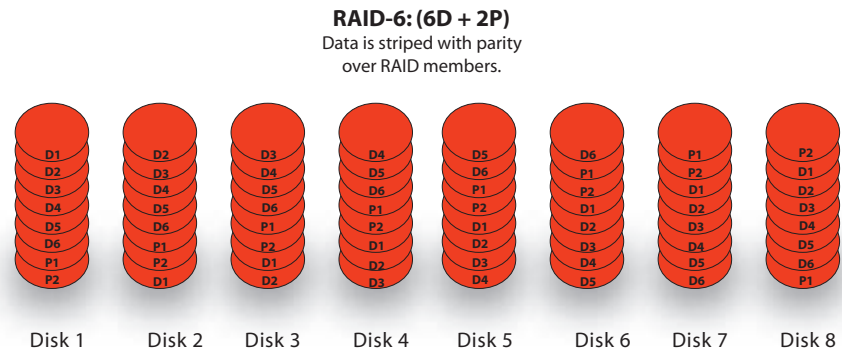
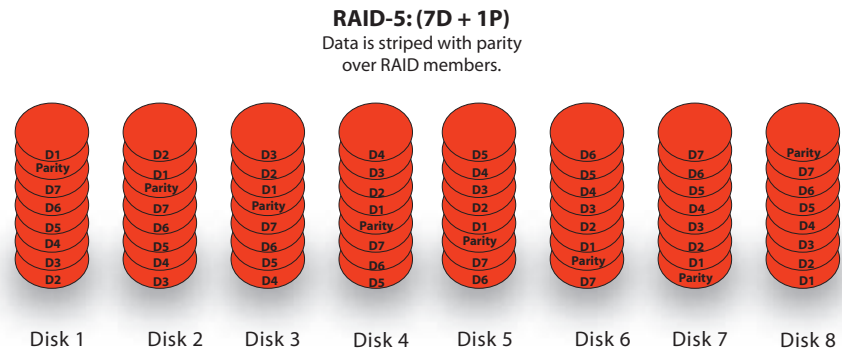
RAID-1+

RAID-1+ is available in two data plus two data (2D+2D) and four data plus four data (4D+4D) disk configurations. The configurations include a rotating copy, where the primary and secondary stripes are toggled back and forth across the physical disk drives for performance. RAID-1+ is best suited to applications with low cache-hit ratios, such as random I/O activity, and with high write to read ratios.

Figure 15. Universal Storage Platform V and Universal Storage Platform VM are available with RAID-1+, RAID-5 and RAID-6.



Concatenated Array Groups enable users to stripe LDEVs across more disks than are in a single RAID-5 array group for better performance.



RAID-5 Distributed Parity

RAID-5 disk arrangements consist of four disks (3D+1P) or eight disks (7D+1P). Data is striped across disks similar to RAID-1+. However, RAID-5 keeps parity information on each stripe of data for fault resilience. If a failure occurs, the contents of the failed block can be recreated by reading back other blocks in the stripe and the parity. Parity information is distributed throughout the array to minimize bottlenecks when rebuilding data from a failed disk. The overhead of RAID-5 is equivalent to one disk drive, regardless of the size of the array. RAID-5 is best suited to applications using mostly sequential reads.

Concatenated RAID-5 Array Groups (supported on the Universal Storage Platform V only)

Concatenated Array Groups enable users to stripe LDEVs across more disks than are in a single RAID-5 array group for better performance. The feature supports the concatenation of two or four RAID-5 7D+1P array groups. An LDEV created on a standard RAID-5 array group becomes a LUN when it is mapped to a host port. For Concatenated Array Groups, the LDEV, striped across multiple elements in the joined array groups, forms a Virtual Device (VDEV). Mapping the VDEV to a host port creates the LUN.

RAID-6 Redundant Distributed Parity

Like RAID-5, RAID-6 stripes blocks of data and parity across an array of drives. However, RAID-6 maintains redundant parity information for each stripe of data. This redundancy enables RAID-6 to recover from the failure of up to two drives in an array: a double fault. Other RAID configurations can only tolerate a single fault. As with RAID-5, performance is adjusted by varying stripe sizes. RAID-6 is good for applications using the largest disks and performing many sequential reads.

RAID Rebuild

If a disk in a RAID group fails, the information on the failed drive is rapidly and automatically rebuilt on a hot spare drive. The Universal Storage Platform V and Universal Storage Platform VM also allow logical volumes to be expanded online, and for administrators to set rebuild priority, based on the daily processing cycle and RAID configuration installed.

Connecting External Storage

One of the most significant advances offered by the Universal Storage Platform V and Universal Storage Platform VM is the ability to connect external, multivendor storage. This creates a single virtualized pool of capacity for administrators to centrally manage using Hitachi storage management software. The Universal Storage Platform V and Universal Storage Platform VM support a wide range of third-party storage systems.

RAID-6 maintains redundant parity information for each stripe of data. This redundancy enables RAID-6 to recover from the failure of up to two drives in an array: a double fault.

Table 6. Universal Storage Platform V and Universal Storage Platform VM Specifications²

Vendor	Product
Hitachi	<ul style="list-style-type: none"> ■ Adaptable Modular Storage ■ Workgroup Modular Storage ■ Thunder 9500™ V series ■ Thunder 9200 ■ Lightning 7700 Series ■ Lightning 9900™ Series ■ Lightning 9900 V Series ■ Universal Storage Platform™ ■ Universal Storage Platform V ■ Universal Storage Platform VM ■ Network Storage Controller
3PARdata	<ul style="list-style-type: none"> ■ InServ S400
ADTX	<ul style="list-style-type: none"> ■ Array MasStor L
EMC	<ul style="list-style-type: none"> ■ Symmetrix 3830 ■ Symmetrix 3930 ■ Symmetrix DMX-3 ■ Symmetrix DMX800 ■ Symmetrix DMX1000 ■ Symmetrix DMX2000 ■ Symmetrix DMX3000 ■ Symmetrix DMX800 ■ CLARiiON CX3 ■ CLARiiON CX200 ■ CLARiiON CX300 ■ CLARiiON CX400 ■ CLARiiON CX500 ■ CLARiiON CX600 ■ CLARiiON CX700
Fujitsu	<ul style="list-style-type: none"> ■ Eternus3000 ■ Eternus4000 ■ Eternus8000
Gateway	<ul style="list-style-type: none"> ■ 840FC

² For the latest information about supported third-party storage systems, visit <http://www.hds.com/products/storage-software/supported-external-storage.html>.

Table 6. Universal Storage Platform V and Universal Storage Platform VM Specifications (continued)

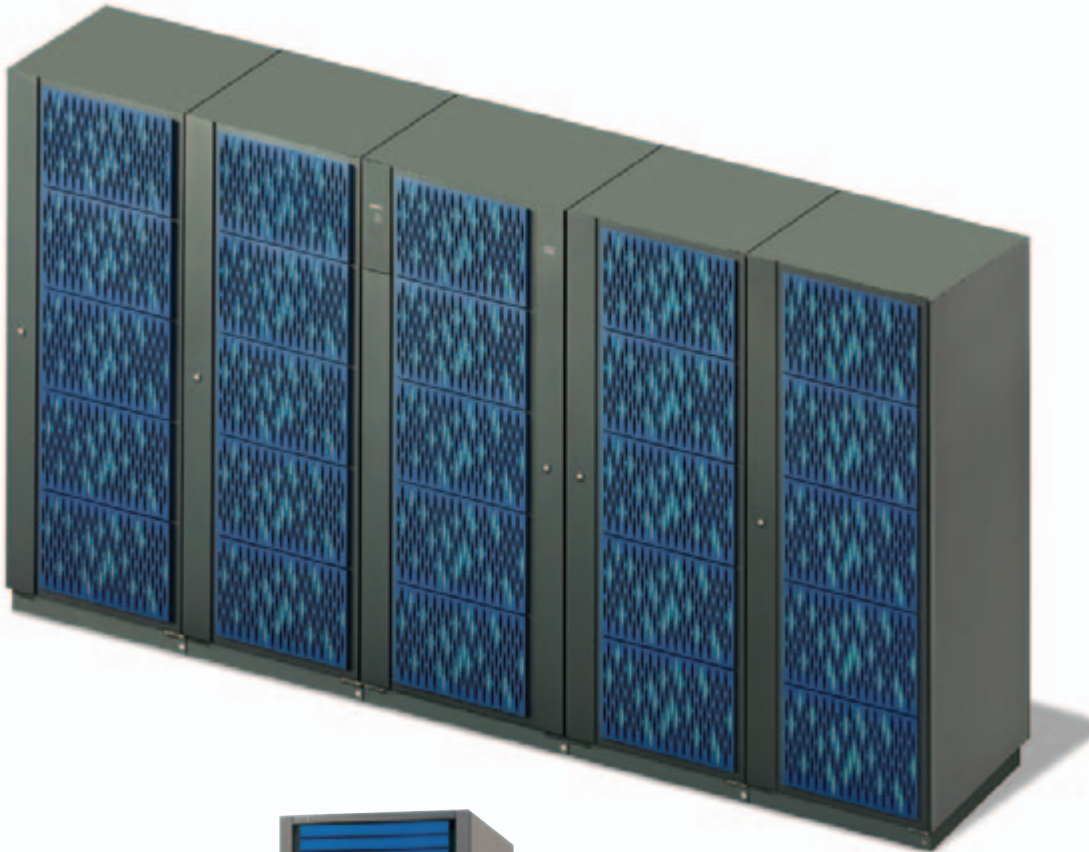
Vendor	Product	
HP	■ StorageWorks EVA3000	■ StorageWorks XP12000
	■ StorageWorks EVA4000/4100	■ StorageWorks XP128
	■ StorageWorks EVA5000	■ StorageWorks XP20000
	■ StorageWorks EVA6000/6100	■ StorageWorks XP24000
	■ StorageWorks EVA8000/8100	■ StorageWorks XP48
	■ StorageWorks XP10000	■ StorageWorks XP512
	■ StorageWorks XP1024	■ SVS200
	IBM	■ TotalStorage ESS 2105
■ System Storage DS4700		■ System Storage DS4800
■ System Storage DS4500 (FAStT900)		■ System Storage DS6000
■ System Storage DS4400 (FAStT700)		■ System Storage DS8000
■ System Storage DS4300 (FAStT600)		
■ NexSAN Technologies SATAbeast		
Pillar Data systems		■ Axiom 300
	■ Axiom 500	
Sun Microsystems	■ StorEdge T3B (T3BES and T3BWG)	■ StorageTek D178
	■ StorEdge 6120/6320	■ StorageTek FlexLine 240
	■ StorEdge 3510	■ StorageTek FlexLine 280
	■ StorEdge 3511	■ StorageTek FlexLine 380
	■ StorEdge 6130	■ StorageTek 9960/9910
	■ StorEdge 6140	■ StorageTek 9980/9970
	■ StorEdge 6540	■ StorageTek 9990/9985
	■ StorageTek BC82	■ StorageTek 9990V
	■ StorageTek D240	■ StorageTek 2540
	■ StorageTek D280	■ StorageTek V2X2/V2X4f

One of the most significant advances offered by the Universal Storage Platform V and Universal Storage Platform VM is the ability to connect external, multivendor storage, creating a single virtualized pool of capacity that can be centrally managed.

Packaging and Configuration

The Universal Storage Platform V is available in one to five cabinet configurations, depending on capacity, performance and connectivity needs. Base configurations are easily and nondisruptively upgraded by adding power supplies, battery modules, control logic and additional cabinets with disk modules. An integrated control/array frame serves as the base configuration and manages up to four array frames connected via high-speed Fibre Channel links.

Figure 16. Hitachi Universal Storage Platform V is available in one cabinet to five cabinet (shown here) configurations.



Hitachi Universal Storage Platform VM includes one control rack and one optional disk chassis

Base configurations are easily and nondisruptively upgraded by adding power supplies, battery modules, control logic and additional cabinets with disk modules.

Deploying the rack-mountable Universal Storage Platform VM storage controller in a standalone, diskless configuration provides support for storage virtualization and data migration. The diskless Universal Storage Platform VM can be upgraded to include internal disks as needed.

Figure 17. Universal Storage Platform VM is a rack mountable controller.

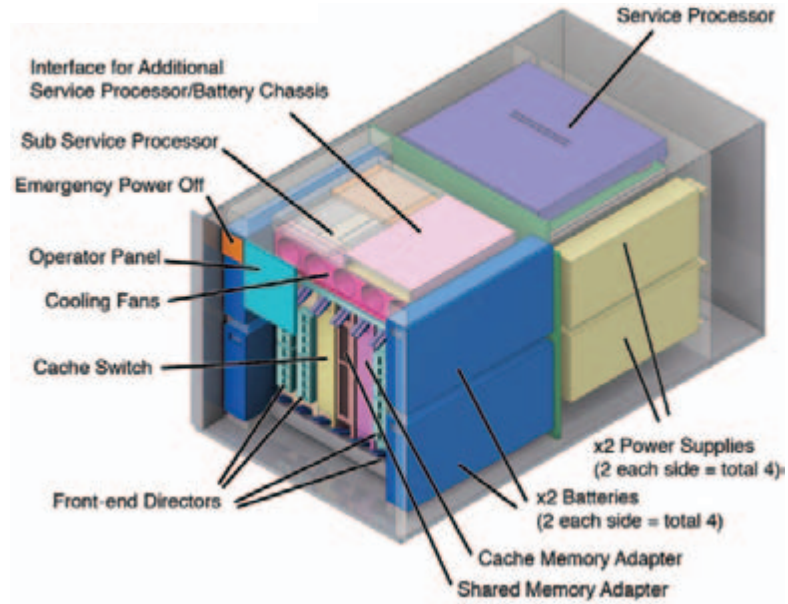
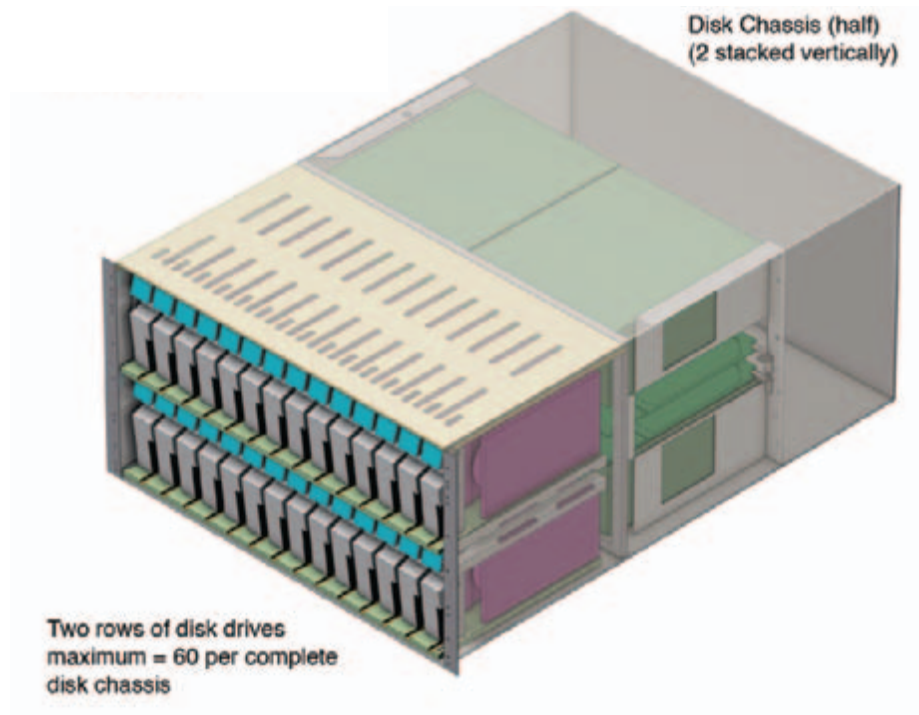


Figure 18. The Universal Storage Platform VM disk chassis is optional.

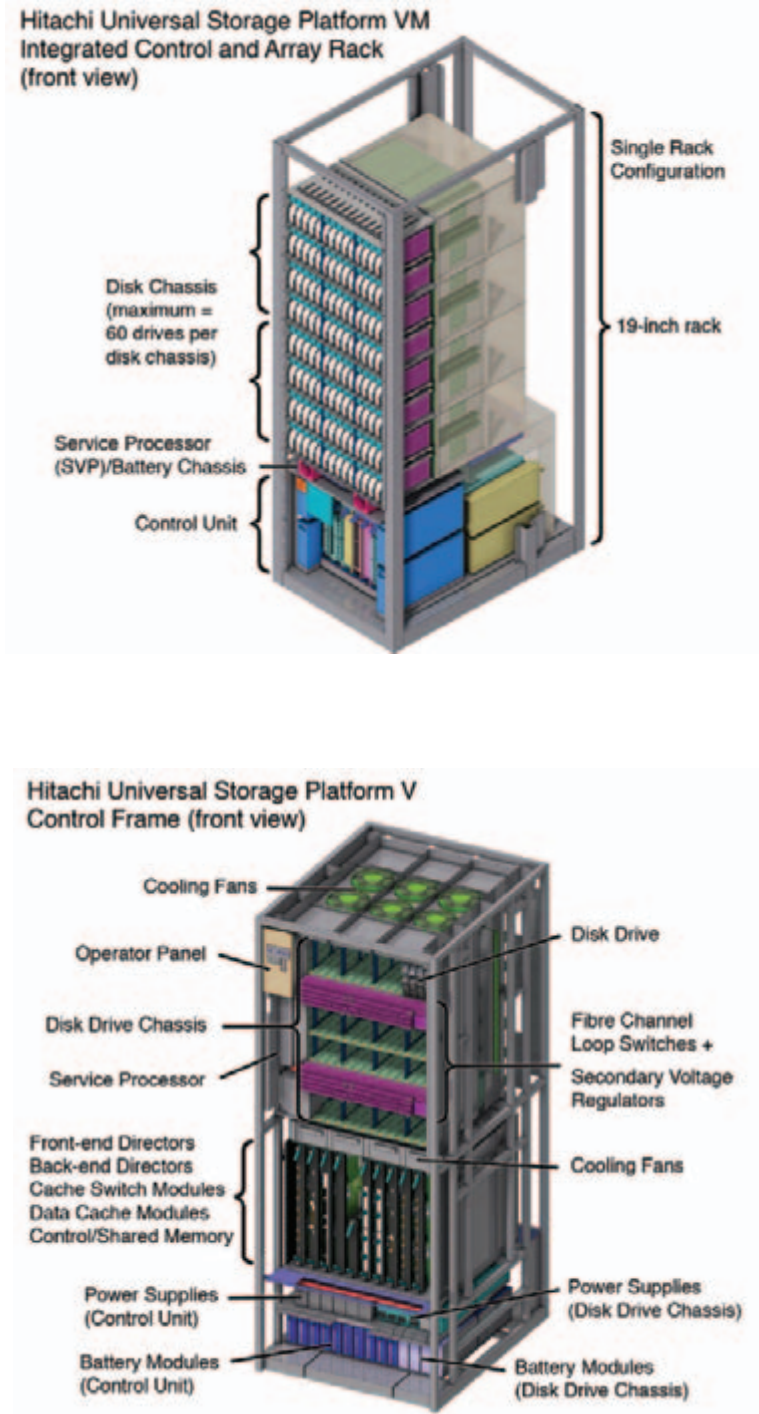


The Universal Storage Platform V and Universal Storage Platform VM system monitoring network enables efficient predictive maintenance, so that components can be replaced before they fail.

The Control Frame and Array Frames

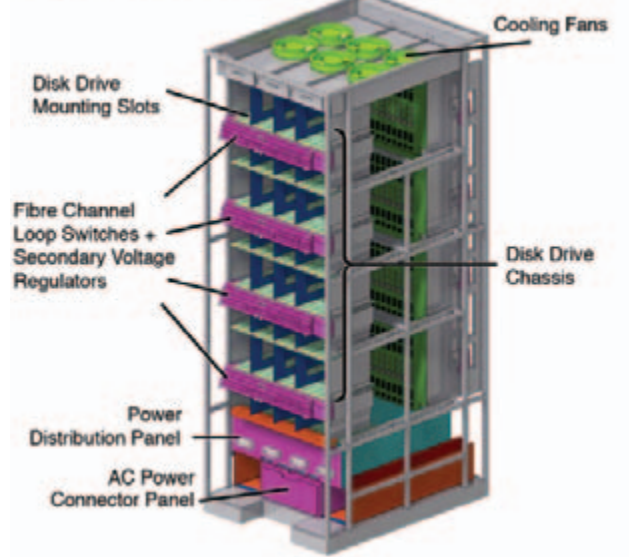
The control frame of the Universal Storage Platform V and control rack for Universal Storage Platform VM contain the service processor (SVP), front-end directors, back-end directors, cache switch modules, cache memory modules, control memory modules, disk drives, power supplies, battery modules and cooling fans.

Figure 19. The Hitachi Universal Storage Platform V array frame is shown with the Hitachi Universal Storage Platform VM array rack.

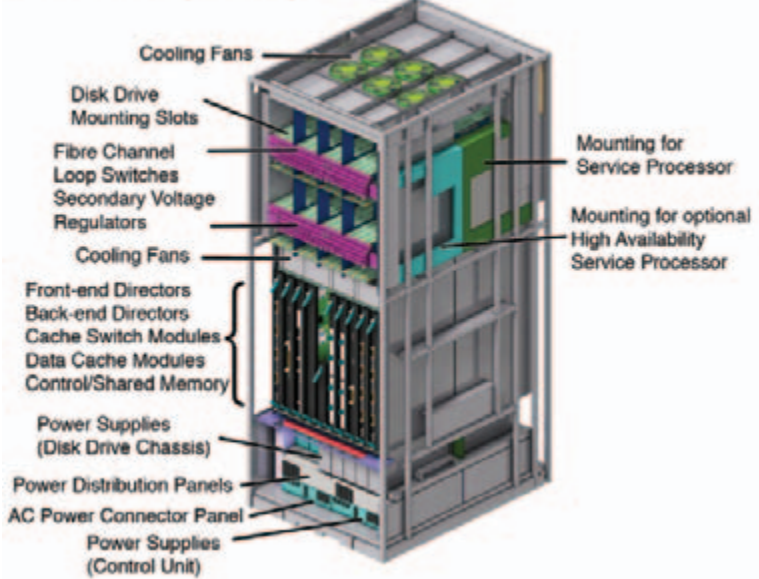


Each storage cluster contains all physical and logical elements needed to sustain processing. Both storage clusters support alternate connection path schemes, so if one cluster fails, the other cluster can continue processing for the entire storage system.

Hitachi Universal Storage Platform V
Array Frame (rear view)



Hitachi Universal Storage Platform V
Control Frame (rear view)



Each array frame of the Universal Storage Platform V and array rack of the Universal Storage Platform VM contains the hard disk drives, power supplies, battery modules, cooling fans and communication interfaces.

Power Subsystem

The power subsystems used in the Universal Storage Platform V and Universal Storage Platform VM have redundant power supplies and batteries in the control frames and control racks and in the array frames and array racks. The power supplies are hot-pluggable, hot-swappable and N+1 redundant. This means power supplies can be removed or installed without affecting system operation.

Each storage controller in the Universal Storage Platform V and Universal Storage Platform VM consists of two redundant controller halves, called storage clusters. Each storage cluster contains all physical and logical elements needed to sustain processing. Both storage clusters support alternate connection path schemes, so if one cluster fails, the other cluster can continue processing for the entire storage system.

Each cluster is powered by its own power supplies and batteries. The power supplies and batteries are capable of providing power for the entire system, in the event of a power supply failure.

Universal Storage Platform V and Universal Storage Platform VM cache memory is divided into two equal areas, and data is always duplicated across logic and power boundaries. This redundancy ensures full data integrity in the event of a power-related failure. If a power failure does occur, data is securely locked in cache.

AC power supplied to the Universal Storage Platform V is converted by the AC-DC power supplies into 12V DC power for the control frame and into 56V DC for the disk array frames. Each component inside the disk array frames generates its own 12V DC via 56V DC to 12V DC DC-DC converters.

In the Universal Storage Platform VM, AC power is converted by the AC-DC power supplies into 12V DC power and supplied to each component inside the control rack and disk array rack, if present. Each component inside the control rack and disk array rack generates its own 12V DC via 12V DC to 12V DC DC-DC converters.

The System Monitoring Network

The Universal Storage Platform V and Universal Storage Platform VM system monitoring network connects to all cabinets and reports on a variety of system parameters, such as component failure, fan speed, power, voltages and temperature. The network enables efficient predictive maintenance, so that components can be replaced before they fail. It also expedites system repair after a failure, through the failure alert system.

The system monitoring network passes information to the Control Frame, where it can be viewed either locally by the Service Processor or remotely across a private LAN on a UNIX or Microsoft Windows console. Failure information is also available via Simple Network Management Protocol (SNMP). Copies of all system status and alerts are sent to Hitachi Data Systems Customer Support Centers via the Hi-Track[®] Monitor “call home” service/remote maintenance tool.



The Universal Storage Platform V and Universal Storage Platform VM place maximum emphasis on high-availability computing, to satisfy the needs of the most demanding enterprise applications.

High Availability

In addition to offering the most scalable and highest performing platform for enterprise storage, the Universal Storage Platform V and Universal Storage Platform VM place maximum emphasis on high-availability computing, to satisfy the needs of the most demanding enterprise applications. Hitachi Data Systems offers a combination of industry unique solutions and best-in-class third-party software integration to deliver unbeatable resilience and availability.

- Heterogeneous asynchronous remote replication over any distance
- Disaster recovery
- Copy-on-write snapshots
- Mainframe replication for IBM Geographically Dispersed Parallel Sysplex™ (GDPS™)
- Nondisruptive microcode upgrades
- Automatic failover architecture with redundant, hot-swappable components
- Dual data paths and dual control paths connecting every component
- Active/active dual-ported disk drives
- Mirrored cache for all write data
- Hi-Track Monitor notifies the Hitachi Data Systems support center immediately of any incident that may affect availability.

A Case Study of Thin Provisioning Benefits

CHAPTER 3

The major corporation in this study is a large international air carrier, operating thousands of flights a day to more than 200 destinations. The airline's IT infrastructure is critical to its operations. Data center applications support reservation systems, Web sites, cargo operations, staff and equipment scheduling, real time maintenance information, office functions, and accounting and finance records. Reliability, availability and high-performance access to data are critical to day-to-day business operations.

The airline maintains several hundred terabytes of data storage, hosted primarily on Hitachi storage systems. The company was one of the first customers to adopt the Hitachi Universal Storage Platform™, and implemented a tiered storage architecture using Universal Storage Platform virtualization.

"The Hitachi Universal Storage Platform V and Dynamic Provisioning software have dramatically improved our ability to respond to our users' storage demands and at the same time simplified the management of our storage infrastructure. We intend to allocate all new storage using Dynamic Provisioning. We love it!"

— Director, Enterprise Architecture, The Major Airline Corporation

Objectives for Dynamic Provisioning

As with most enterprise storage users, the airline faced rapidly growing demand for storage capacity and increasing pressure to minimize IT expenditures. This required that they continually search for ways to improve storage utilization efficiency, defer purchases and raise administrator productivity. With Hitachi Dynamic Provisioning software, the airline anticipated reducing the gap between actual capacity used by databases and applications and the capacity allocated. The ability to dynamically grow volumes, without taking applications offline, was also a goal.

Disk Space Reduction

After implementing Dynamic Provisioning software for a Microsoft SQL Server database data warehousing application, the airline gained immediate capacity savings. By migrating standard database volumes to Dynamic Provisioning volumes, capacity utilization was reduced by almost 50 percent, from 500GB allocated on conventional volumes to 264GB on the thin provisioned volumes.

The airline plans to provision very large virtual data volumes for all future applications, knowing that the application will not consume all disk space. As a result of testing Dynamic Provisioning software, the airline anticipates reducing the rate at which they purchase new disk capacity. Overall storage capacity utilization is expected to increase by at least 20 to 30 percent within the first year, with a corresponding reduction of new disk purchases. Further utilization improvements are expected in the long run.

With Hitachi Dynamic Provisioning software, the airline anticipated reducing the gap between actual capacity used by databases and applications and the capacity allocated.

Performance Improvement

One of the biggest surprises for the airline's storage team came from the dramatic improvement in storage performance for applications using volumes created with Dynamic Provisioning software. When compared to standard volumes on the Universal Storage Platform V, volumes created by Dynamic Provisioning software improved storage performance by 30 percent.

Dynamic Provisioning software automatically spreads I/Os over a much larger number of physical disk drives than conventional volume allocations. Using automated wide striping, the Universal Storage Platform V is able to balance the I/O load across multiple physical disks and multiple back-end director processors. This takes full advantage of the processing power of the Universal Storage Platform V and delivers substantial performance improvements.

Ease of Management

"Once it was explained, creating and maintaining an HDP pool was quite simple. Creating Hitachi Dynamic Provisioning volumes is as easy as a standard data volume, but without having to be concerned about how much space is available in individual array groups or worrying about how much capacity is being wasted due to over-provisioning for future growth. All I need to do is check the total available capacity in the pool."

— Storage Administrator, The Major Airline Corporation

The most significant benefit the major airline corporation experienced from deploying Dynamic Provisioning software was in managing storage allocations. The airline's storage team summed the benefits up as follows:

- No more micro-management of data volumes
- No more worrying about moving volumes around to allow adequate disk space for new data
- No more re-allocating and re-provisioning of existing data volumes as they run out of space
- No more putting too many volumes on the same drive group that might affect application performance
- No more allocating disk space that is unlikely to be used for months, if not years.

Moving forward, the airline plans to put all data on the Universal Storage Platform V in Dynamic Provisioning volumes. Many applications will benefit from disk capacity savings, most will benefit from performance improvements and all will make allocating and provisioning storage much simpler and easier.

Improved Utilization

Overall, Dynamic Provisioning software gives the airline confidence that all of the Universal Storage Platform V's resources are being used efficiently. Wide striping of data across the entire pool will mean a much more effective utilization of all of the disks in the storage system rather than a smaller number of array groups being "hammered" while others are accessed much less frequently.

Dynamic Provisioning software automatically spreads I/Os over a much larger number of physical disk drives than conventional volume allocations.

Financial ROI Benefits

The financial return on investment (ROI) benefits from deploying the Universal Storage Platform V and Dynamic Provisioning software have been significant. The major airline corporation anticipates an immediate reduction in disk usage with substantial future savings, when volumes are provisioned for future growth. The net effect will be a reduction in planned disk purchases.

The decrease in planned disk purchases produces immediate capital expenditure (CAPEX) savings. In addition, a smaller storage footprint in the data center will deliver operating expenditure (OPEX) savings from reduced power, cooling, software licensing and maintenance costs. Also, by improving the performance of existing storage hardware, Dynamic Provisioning software will help further defer future storage purchases.


Possibly the most significant financial benefit anticipated by the airline accrues from the ease of managing volumes created by Dynamic Provisioning software. Ongoing requests for additional application storage will take much less administrative effort, and storage managers expect to see fewer requests from users for volume size increases. Daily monitoring and reporting on storage capacity will change from micro-management of individual volumes to management of the entire storage system as a single entity. The airline estimates that these benefits will enable each storage administrator to manage between 20 and 30 percent more storage capacity.

The financial benefits from the single SQL Server data mining application, used by the airline to test Dynamic Provisioning software, offer an ROI example and give an indication of the magnitude of potential savings from a full implementation of the technology. The data warehousing application was allocated 500GB and expected to grow to 2TB within the coming year. Using the 50 percent capacity savings from Dynamic Provisioning software as a base, the airline expects actual disk usage will be 1TB. With a fully loaded cost estimate of \$18,000 per TB, which includes hardware, software, maintenance, building and utility costs, savings over the next three years will exceed \$50,000. The airline also anticipates savings from storage management efficiencies and application performance improvements. The savings from this one application alone have offset the cost of the Dynamic Provisioning software. The savings from converting hundreds of applications to Dynamic Provisioning software will be dramatic.

The Bottom Line

“Now that we’ve completed our initial tests, we can see how much simpler it will be to allocate and provision storage and how it will improve storage performance and disk utilization. We can reduce the mundane, day-to-day provisioning burden on our storage administrators and allow them to proactively manage our storage infrastructure.”

— Director of Enterprise Architecture,
The Major Airline Corporation



Using the 50 percent capacity savings from Dynamic Provisioning software as a base, the airline expects actual disk usage will be 1TB. With a fully loaded cost estimate of \$18,000 per TB, savings over the next three years will exceed \$50,000.



Appendix

The Evolution of Hitachi Storage Virtualization

The storage virtualization engine used by the Universal Storage Platform family is a result of evolutionary development through successive product iterations and technology refreshes. This unique solution offers unparalleled scalability, performance, manageability, security and functionality, and makes it possible to deliver storage functionality to business users as a service.

In 1995, Hitachi Data Systems introduced the Hitachi Freedom 7700. This storage system uniquely separated control information and data by placing them in different caches accessed across different busses. This enabled support of multiple server platforms, including, mainframes, UNIX and Microsoft Windows.

In 1998 Hitachi Data Systems introduced Dynamic Optimizer, which enabled the Hitachi CruiseControl™ software feature to dynamically change the configuration mapping in cache to move LUNs between RAID groups (LDEVs) in the storage system. This functionality, now known as Hitachi Volume Migration software, is still unique to Hitachi Data Systems, and it laid the foundation for virtualization in the storage control unit.

In 2000, Hitachi Data Systems introduced the Hitachi Lightning 9900 Series enterprise storage systems and the revolutionary Universal Star Network crossbar switch architecture. The crossbar switch increased connectivity between storage ports, data cache modules and Array Control Processors (back-end directors), increasing scalability and connectivity. This enabled a Lightning 9900 storage system to replace between six and eight competing storage systems. In the eight years since the revolutionary crossbar switch debuted, major storage vendors have yet to match this innovative technology.

In 2002, the Hitachi Lightning 9900 V Series added support for up to 128 virtual ports for each Fibre Channel port, increasing SAN connectivity. Each virtual port supported a dedicated address space. This guaranteed no data leaks between applications sharing the same physical port. Virtual ports also simplified LUN management and enabled multiple applications to securely share a single physical storage device through safe multitenancy. Virtual ports also enabled shared access to a single storage system from applications running on different operating environments. UNIX, Linux and Windows applications could share a single storage system and each maintain different levels of RAID protection, different performance disks and different port access priorities.

2004 saw the introduction of the Hitachi Universal Storage Platform. The Universal Storage Platform enabled lower cost and legacy external storage systems, from different vendors, to attach to the storage system through standard Fibre Channel ports. This let users move data across internal and external tiers of storage, migrate data from old to new storage systems and replicate copies across different cost tiers, without disrupting business applications. Port virtualization was extended to 1024 virtual ports per physical port, and the policy-based Hitachi Tuning Manager software and Hitachi Tiered Storage Manager software enabled nondisruptive data movement triggered by time, events and alerts.

In 2007, Hitachi introduced the Universal Storage Platform V and the Universal Storage Platform VM. These advanced storage systems incorporated higher performance front-end storage ports, flash memory in the port processors, the next generation crossbar switch and higher performing control memory and data cache. Dynamic provisioning capabilities were added, extending the benefits of storage virtualization all the way to the business application by creating virtual storage capacity and automated wide striping for performance.

Corporate Headquarters 750 Central Expressway, Santa Clara, California 95050-2627 USA
Contact Information: + 1 408 970 1000 www.hds.com / info@hds.com

Asia Pacific and Americas 750 Central Expressway, Santa Clara, California 95050-2627 USA
Contact Information: + 1 408 970 1000 www.hds.com / info@hds.com

Europe Headquarters Sefton Park, Stoke Poges, Buckinghamshire SL2 4HD United Kingdom
Contact Information: + 44 (0) 1753 618000 www.hds.com / info.emea@hds.com

Hitachi is a registered trademark of Hitachi, Ltd., in the United States and other countries. Hitachi Data Systems is a registered trademark and service mark of Hitachi, Ltd., in the United States and other countries.

All other trademarks, service marks and company names mentioned in this document or web site are properties of their respective owners.

Notice: This document is for informational purposes only, and does not set forth any warranty, express or limited, concerning any equipment or service offered or to be offered by Hitachi Data Systems. This document describes some capabilities that are conditioned on a maintenance contract with Hitachi Data Systems being in effect, and that may be configuration dependent and features that may not be currently available. Contact your local Hitachi Data Systems sales office for information on feature and product availability.