Recent Trends of Storage System Technologies

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OVERVIEW: In conventional systems, data storage is distributed among individual servers, but storage networking technology such as the SAN (storage area network) and storage virtualization technology enable storage to be virtually consolidated on multiple storage devices in a storage network (virtual consolidation of devices). In this way, a corporate IT system administrator sees fewer storage devices to be managed, which can reduce the cost of managing storage equipment. Storage virtualization technology can be classified into four schemes according to the form of implementation. Hitachi has introduced a new version of enterprise storage that adopts high-performance, high-availability storage-based virtualization technology with proven functions from the existing product series. Storage consolidation can be expected to expand from virtual consolidation of devices within a single site to "wide area device consolidation" that can uniformly manage devices across multiple sites. In addition to storage system technology, Hitachi plans to continue its R&D (research and development) efforts in tiered storage management that manages consolidated devices according to their individual characteristics.

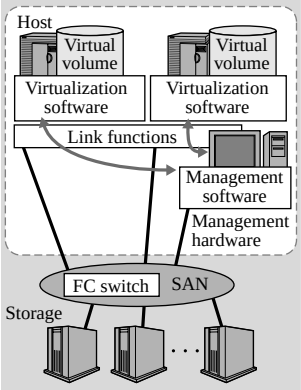
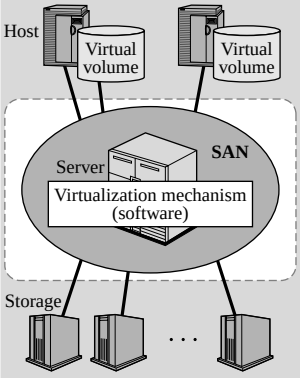
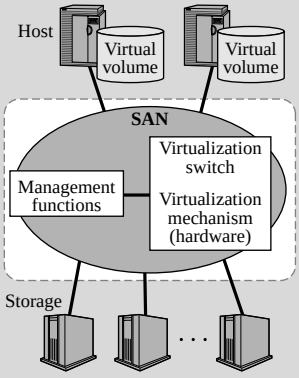
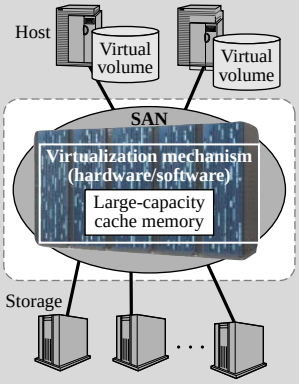
INTRODUCTION

THE 1990s saw an explosive growth in the storage capacities of corporate IT systems, and during this time, the cost of managing and operating storage came to surpass the cost of purchasing storage by a significant amount. In addition, the number of IT system administrators failed to keep up with this growth in storage capacity, and the amount of managed storage per administrator increased dramatically[1)]. Against this background, it first became possible to consolidate storage distributed over a number of servers onto one storage device connected to the network (physical consolidation of devices). This decreased the number of storage devices that had to be managed by any one IT system administrator and reduced the cost of managing and operating storage equipment.

Next to come was the spread of storage virtualization technology that can consolidate a group of storage devices on a network by the application of virtual address management. This "virtual consolidation of devices" enabled IT system administrators to construct an IT system having a mixture of storage devices from different vendors and to manage storage independent of individual device characteristics and physical device arrangement. Furthermore, the unity of additional functions like remote copy enabled them to be used across diverse types of equipment.

A system with such an intermix of storage types requires tiered storage management, which takes into account the characteristics of each storage device such as performance, reliability, and cost, and the provision of support functions such as for transferring data between different types of storage. In particular, a successful implementation of DLCM (data life cycle management), which is attracting attention as a means of achieving long-term retention of corporate data as prescribed by law, requires that the placement of data on storage devices and the cost of maintaining and managing data be optimized according to data value that changes over time and to the characteristics of individual storage devices.

From here on, storage consolidation is expected to expand from the consolidation of storage within a single site to "wide area device consolidation" that targets storage across multiple sites. This is because of the growing need for consolidated and uniform

Name	Out-of-band technology	In-band technology		
		Server-based	Switch-based	Storage-based
Outline	 • Achieved by virtualization software on hosts	 • Achieved by virtualization software loaded on virtualization server	 • Achieved by packet-routing hardware of virtualization switch	 • Achieved by virtualization mechanism (hardware/software) on storage
Deployment	× Hard to deploy (each host requires specialized software)	◎ Easy to deploy (host-independent)	◎ Easy to deploy (host-independent)	◎ Easy to deploy (host-independent)
Functionality	○ High functionality (copy-system functions)	○ High functionality (copy-system functions)	△ Low functionality (no cache)	◎ High functionality (cache available)
Performance	○ High performance (direct connection with host storage)	× Low performance (bottleneck at server CPU)	○ High performance (wire speed)	◎ High performance (cache available)
Vender/ product	VERITAS*1, IBM*2, others	DataCore*3, HP*4, IBM, others	Cisco*5, Sun*6, Brocade*7, EMC*8 (development announced), others	Hitachi enterprise storage

◎ : superior ○ : good △ : acceptable × : unacceptable

SAN: storage area network
CPU: central processing unit

*1 VERITAS is a registered trademark of VERITAS Operating Corporation.
*2 IBM is a registered trademark of International Business Machines Corporation.
*3 DataCore is a trademark of Datacore Software Corporation.
*4 HP is another name for the Hewlett-Packard Company.
*5 Cisco is a registered trademark of Cisco Systems, Inc. and/or its affiliates in the U.S. and certain other countries.
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Fig. 1—Outline of Storage Virtualization Technology.
Virtualization storage technology, which has been spreading since around 2000, can be roughly classlified into four implementation forms. A variety of storage vendors have developed or intend to develop storage virtualization products using each of these forms. This field is expected to expand steadily in the years to come.

management of storage resources across multiple sites as disaster-recovery measures take on new importance and as more companies are reorganized through M&A (merger and acquisition). There is therefore a need to provide storage systems with means for expanding consolidation and making the management of that data more secure.

If consolidated storage is to be shared by multiple users (such as various departments in a company), the design of storage systems in accordance with the service levels required by those users must also be supported.

This article describes recent trends in new technologies for storage systems, management software, and services in relation to storage consolidation.

TRENDS IN STORAGE SYSTEMS

Storage-based Virtualization

Storage virtualization can be achieved by an "out-of-band" technology that loads virtualization software on each host or an "in-band" technology that installs a device incorporating a virtualization mechanism between the host and storage. The in-band technology, in turn, can be classified into three schemes according to the implementation form of the virtualization device, that is, server-based, switch-based, or storage-based (see Fig. 1). Various storage vendors have developed

or intend to develop products that adopt the out-of-band technology or one of the three in-band forms. In September 2004, Hitachi introduced its latest version of enterprise storage featuring a storage-based virtualization function called Universal Volume Manager. This function uses virtualization technology to extend the Hitachi enterprise storage series product concept of "high scalability" and can achieve storage consolidation up to several tens of petabytes. In addition to high-performance, high-reliability storage virtualization, storage-based virtualization gives users access to additional functions having a proven track record in the series products such as asynchronous remote copy. Hitachi enterprise storage also provides functions for dividing consolidated storage into a number of independent virtual storage devices for data I/O (input/output) processing, management operations, and other tasks. This means that an IT system administrator can provide each business department in a company with its own set of virtual storage devices having no interference with that of other departments.

Storage System Supporting Changes in Consolidation Form

To achieve reliable DLCM, a storage system must be provided with the means of consolidating storage devices having different characteristics and the means of performing data replacement in a manner transparent to hosts. These means enable a storage system to support data replacement based on data value in conjunction with tiered storage management (see Fig. 2). And to support the expansion of consolidation range as in wide area device consolidation that spans multiple sites, a storage system will need a low-cost means of remote backup or archiving data using wide area IP network, highly secure data control and management using encryption technologies, etc. For the last of these needs, it is important that studies be performed on technologies targeted for standardization such as FC-SP (fibre channel security protocols) and IPsec (Internet Protocol—security).

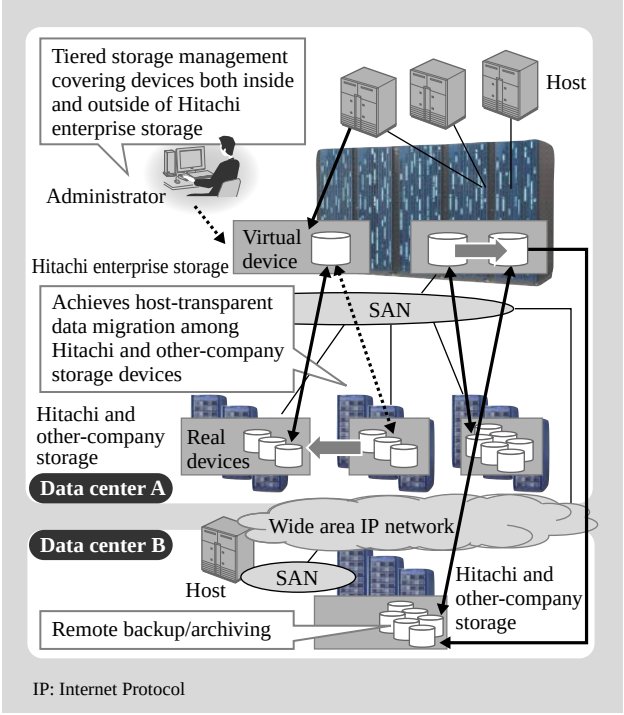

Fig. 2—Storage System Supporting Changes in Consolidation Forms.
Our storage system support changes in storage consolidation through function extensions that raise the level of security and optimize arrangement of storage devices.

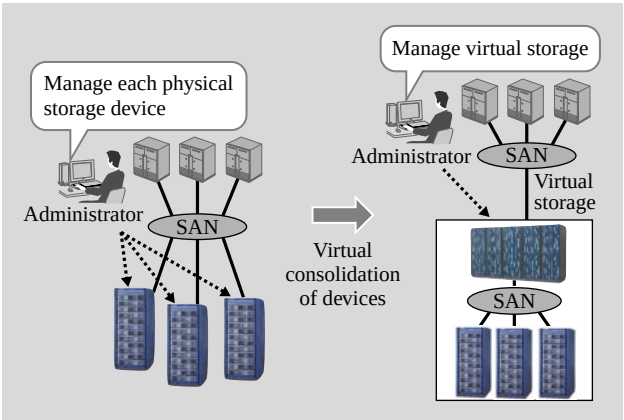

Fig. 3—Outline of Virtual Consolidation of Devices.
Virtual storage is constructed and managed by storage virtualization technology.

TRENDS IN SOFTWARE MANAGEMENT SOFTWARE

Function Extensions as Consolidation Form Changes

To increase the adoption of new consolidation forms, management software is being provided with new management functions that enable a system administrator to make efficient use of hardware technologies (virtualization, partitioning, etc.) in storage equipment [including SAN and NAS (network attached storage)]. In virtual consolidation of devices, the aim is to construct virtual storage that consolidates multiple physical storage devices in a virtual manner. This results in an apparent reduction in the number of devices to be managed thereby reducing the management load on the system administrator. To

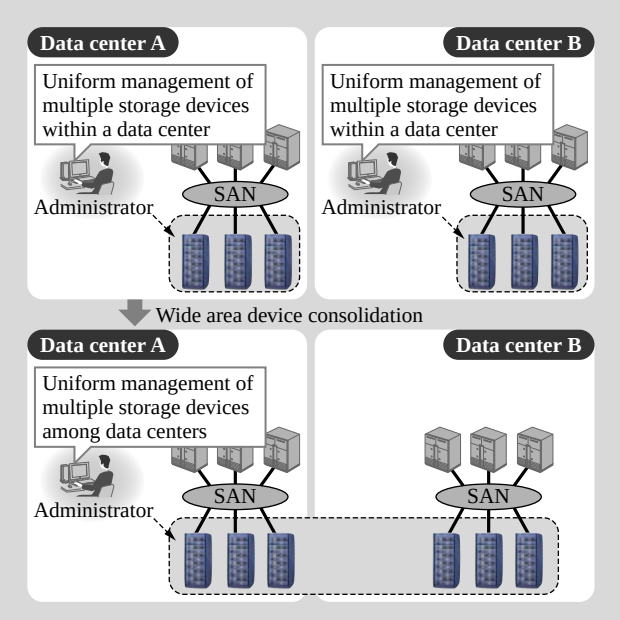

Fig. 4—Concept of Wide Area Device Consolidation.
Storage devices at multiple data centers are uniformly managed.

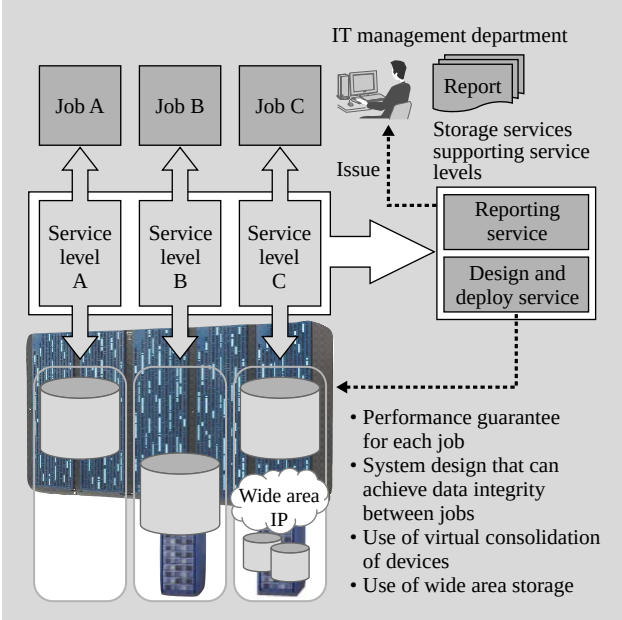

Fig. 5—Concept of Storage Services Supporting IT Management Department.
An IT management department must be able to manage the storage system so that defined service levels can be guaranteed. The deployment of storage services can reduce management worker-hours.

accommodate this change, management software is provided with management functions that mimic those of conventional physical storage devices such as device configuration and fault management (see Fig. 3).

Next, in wide area device consolidation, the aim is to broaden the range of storage devices to be managed across multiple operational sites. This requires integrated management functions that bind together the management of each site and manage the entire range of storage (see Fig. 4). It also requires that management software, which up to now has been used within a closed site that is relatively easy to secure, be provided with security functions to enable its use in a high-risk wide-area network environment, and that the software itself be made more secure (through data encryption, access control, etc.)

Function Extensions for DLCM

To achieve efficient management of a DLCM platform, tiered storage management based on management software is indispensable. To be more specific, it must be possible to manage consolidated storage devices in a hierarchical manner based on their storage characteristics including performance, reliability, and bit cost. For example, on receiving instructions from a user for data replacement, the system must be able to search for storage devices that satisfy the specified conditions and decide on a device as a destination for that data replacement. In addition, for a storage system constructed by virtual consolidation of devices, it must be possible to optimize the placement of data according to data value through the use of host-transparent data replacement functions. There will also be a need for tiered storage management of storage devices across multiple sites in order to cope with the expected growth of wide-area corporate activities.

TRENDS IN STORAGE SERVICES

IT Management Department and Service Levels

An IT management department that manages a consolidated storage system in a company must allocate appropriate resources to each job unit and manage the system so that the execution of job units work without disruption and work gets completed. It must also define service levels and manage the system so that the service level appropriate for each job is satisfied. Service levels come in various forms such as performance, availability, and data integrity level (security level). To guarantee service levels that an IT management department must provide, storage services that support storage management must be provided. These include a design and deploy service

that breaks down the service levels to be defined by the IT management department for specific storage systems, and a reporting service that periodically audits service levels (see Fig. 5).

Storage Services for IT Management

It is not difficult to satisfy multiple service levels simultaneously if hardware resources happen to be inexhaustible. In an environment of limited hardware resources, however, attaining a system configuration that can guarantee multiple service levels requires hardware that allows for an intermix of various service levels and a system design that exploits the positive features of hardware.

For the future, service levels are expected to become more detailed and quantitative in nature, which will significantly increase the load on the IT management department. Considering that a hardware configuration that could provide sufficient margin will lead to higher costs, service levels with a high degree of reliability must be guaranteed within a limited hardware configuration. This will require the use of functions that can partition hardware resources and make exclusive use of them, the use of even larger wide-area networks, and an understanding of application access characteristics with respect to storage.

CONCLUSIONS

This article described recent trends in storage systems, management software, and storage services in Hitachi.

Up until recently, the target of storage consolidation has been server storage within a single data center. However, the spread of IP storage technology, the diffusion of broadband connections to general households, and the increase in personal digital data are expected to shift the target of consolidation to office PCs storage and personal storage devices. This will require storage consolidation on an even larger scale with even more security features.

To provide storage systems, management software, and storage services that better satisfy customer needs of the future, Hitachi will endeavor to analyze and accumulate best practices and will continue to research and develop storage-related technology.

REFERENCES

(1) T. Oeda et al., "Future Trends in Storage System Technologies," *Hitachi Hyoron*, **85**, pp. 277-282 (Mar. 2003) in Japanese.
(2) FC-SP (Fibre Channel Security Protocols, REV 1.6) site: http://www.t11.org/

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