

Take a Byte Out of Your Storage Problems

by Cheryl Walton

information Age: People, Information, & Technology, a Smithsonian National Museum of American History exhibit, places the dawn of the information age in 1837 when Samuel Morse developed the telegraph. As the exhibit explains, the telegraph was the first device to convert information to an electronic form and to transmit this information over a long distance. (To view photographs of this exhibit, visit <http://photo2.si.edu/infoage/infoage.html>.)

Because the information age is all about electronic information, you may wonder just how much electronic information this age is generating. According to a study completed by the School of Information Management and Systems at the University of California, Berkeley, we inmates of the information age produce an estimated 635,480 to 2,120,539 TB of unique information a year worldwide.

Of this information, departmental and enterprise servers produce an estimated 269,550 to 627,000 TB of this data. (Other sources of information include print publications, photographs, moving pictures, and music CDs. For more information, see the "How Much Information?" study at www.sims.berkeley.edu/research/projects/how-much-info/summary.html.) As a network administrator, you must not only maintain the servers that produce this information but also cope with the problems of storing this information.

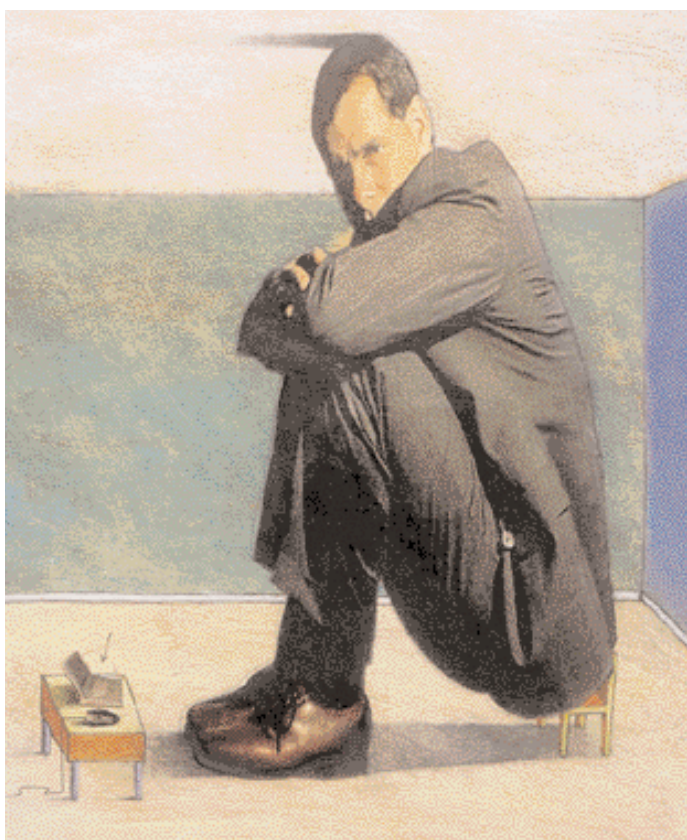
Managing stored information is particularly problematic because this task can be time-consuming and, therefore, costly. In fact, according to Gartner Group Inc., the cost of managing storage exceeds the cost of purchasing storage by at least 40 percent and by as much as 300 or 400 percent. (For more information about Gartner Group, visit www3.gartner.com/Init.) In other words, the cost of managing your company's storage is serious business.

How will you store and manage your company's electronic information as the information age progresses and that information grows from gigabytes to terabytes to exabytes and beyond?

Rather than providing a definitive answer to this question, this article explains several technologies your company can use to manage online storage. (For information about offline and nearline storage, see "Near and Far" on p. 8.)

ONLINE STORAGE SOLUTIONS

The following storage topologies comprise popular options for your company's online data storage:



- Direct-Attached Storage (DAS)
- Storage Service Provider (SSP)
- Network Attached Storage (NAS)
- Storage Area Network (SAN)

Map of Your Company's Storage Solution: You Are Here

If your company has not begun to explore NAS and SAN storage options, you are still using DAS to store online data. DAS, as its name suggests, comprises storage attached directly to network servers.

Because your company has used and may still be using DAS, you are probably familiar with its limitations. For example, one of the more noticeable limitations of DAS is that users cannot access their data unless the server where that data resides is up.

Furthermore, with DAS, when your company's needs exceed the storage limits available on a particular server, you must either purchase an additional server or a DAS device to attach to the storage-challenged server. (A DAS device is usually an enclosure that contains hard disk drives [HDDs]—such as a Redundant Array of Independent Disks [RAID] or Just a Bunch of Disks [JBOD] enclosure.)

A new server can cost your company from a few thousand dollars to tens of thousands of dollars (or more), depending on the processing power and storage capacity of that server. A DAS device can also cost several thousand dollars. When your company's storage requirements exceed the storage limitations of the new server or DAS device, your company is then faced with purchasing yet another server or DAS device.

Regardless of the storage solution you select, your company will need to purchase new hardware when users' demands exceed the storage capacity on existing hardware. However, DAS solutions pose uniquely frustrating storage management problems.

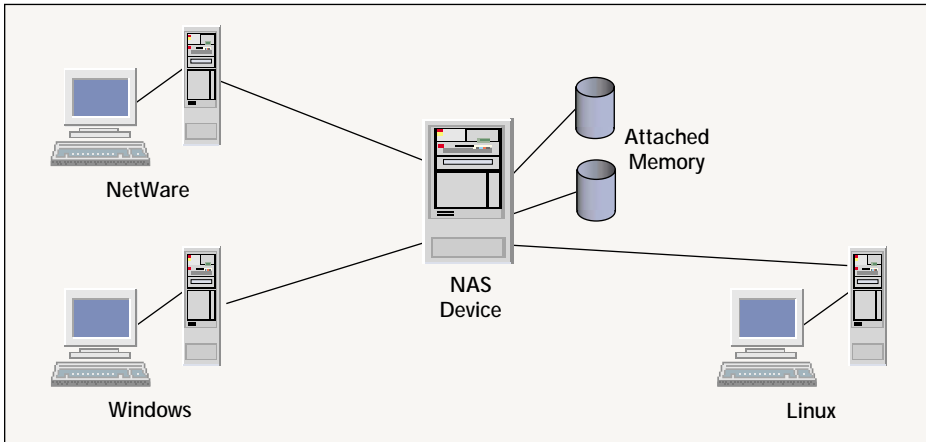


Figure 1. NAS devices attach directly to your company's Ethernet LAN and provide centralized storage for one or more server operating systems.

With a DAS solution, for example, your company may have to purchase new hardware before users' demands exceed the storage capacity available.

For example, suppose you had 8 GB of unused disk space on your company's file server and no free space at all on the database server that stored your company's employee resource management (ERM) data. The result? You must purchase additional hardware, and meanwhile 8 GB of free space would sit around unused for months or even years because it happened to be in the wrong place.

DAS devices also pose an even bigger management problem: You must manage your company's data on a server-by-server basis. You must create and manage the

volumes on each server separately, back up the volumes on each server separately, and assign users access rights to the data that resides on each server separately. These limitations add up to a storage solution that is time-consuming and, therefore, costly to manage.

If you are tempted to shrug off the inherent expense of managing DAS devices, remember the hundreds of thousands of TB of data that companies generate each year. Then remember that you, the network administrators of the world, must then store and manage this data. (See the "How Much Information?" study.)

As the GB of data that you must store double and double again, storage management costs may begin to eat into your

company's bottom line. At some point in this upward spiral of storage and management costs, you will inevitably consider adopting a storage solution that is easier and cheaper to manage than DAS is. You will undoubtedly consider one of the following:

- Contracting with an SSP to store your company's data
- Detaching your company's storage from servers and consolidating that storage in a NAS or SAN (or in both)

Send Storage Problems Packing

Like any other storage solution, an SSP has an upside and a downside. On the upside, outsourcing your company's storage to an SSP often eliminates the need to purchase specialized storage hardware and software. In most cases, SSPs own the storage infrastructure upon which your company's data resides. (Some SSPs—such as IBM—offer on-site storage management. In this case, your company may need to purchase its own storage infrastructure.)

Because SSPs are in the storage business, they also upgrade or replace obsolete storage hardware and software. As a result, you do not need to keep up to date with (and purchase) significant advances in storage technology. In addition, your company can avoid the training and management costs associated with implementing its own storage solution.

Near and Far

Naturally, the storage options you select depend entirely on the type of storage your company needs. For example, if your company needs to store seldom-used data off of the network (called *offline* or *nearline* storage), you may want to purchase a removable-media drive, such as a tape drive or an optical drive.

Removable-media devices offer a wide range of storage capacities. For example, tape media have storage capacities that range from less than 2 GB to more than 100 GB of uncompressed data. Optical media—which includes magneto optical (MO) cartridges, compact disks (CDs) and Digital Video Disks (DVDs)—have storage capacities that range from 230 MB to 5.2 GB of uncompressed data. (For more information about storage technologies such as tape and optical media, see "Storage Space: Will Bigger and Faster Mass Storage Solutions Be Enough?," *Novell Connection*, Nov. 1997, pp. 6–21. You can download this article from www.ncmag.com/past.)

If you need an offline storage solution, you can purchase a tape drive such as the DLT LibraryXpress LXN2000 tape drive from Overland Corp. The DLT LibraryXpress LXN2000 works with Net-

Ware servers and can store up to 2.86 TB of uncompressed data per storage module. (For more information, visit www.overlanddata.com/Overland.nsf/Pages/prd_frame.htm and select DLT LibraryXpress LXN2000 from the Scalable Libraries pull-down menu.)

If you want a nearline storage solution, you can purchase libraries or drives such as an SSL2020 Advanced Intelligent Tape (AIT) Library from Compaq Computer Corp. or a Maxoptix T6-5200 MO drive from Maxoptix Corp. The SSL2020 AIT Library stores 50 GB of uncompressed data per AIT cartridge. The Maxoptix T6-5200 works with NetWare servers and stores up to 5.2 GB of uncompressed data per MO cartridge. (For more information about the SSL2020 AIT Library, visit www.directplus.compaq.com and select Storage. For more information about the Maxoptix T6-5200, visit www.maxoptix.com/StarSeries/StarSeries.htm.)

On the other hand, if your company needs to store its data on the network (called *online* storage), you probably want to store that data on hard disk drives (HDDs)—the media of choice for online storage. HDDs have storage capacities that range from 15.3 to 181.6 GB (recently released). However, online storage options are not driven as much by the storage media you select as they are by the networking topography in which you deploy these media. ●

What You Need in a NAS

Suppose your company were looking for a Network Attached Storage (NAS) device that it could deploy in 100 branch offices. Because the users in any given branch office needed to access data from the NAS devices in all of the branch offices, the NAS device needed to provide secure access to data. Furthermore, the NAS device must enable you to manage user accounts centrally. Finally, because your company's data must be accessible all day every day, the data residing on this NAS device must be highly available.

If your company were looking for a NAS device that met all of these criteria, it would need to look no farther than Novell NetDevice NAS120, Novell's new NAS device. Built on a highly specialized version of the NetWare 5.1 kernel, Novell NetDevice NAS120 uses the same renowned encryption engine that NetWare 5.1 servers use: Novell International Cryptographic Infrastructure (NICI). As the name suggests, NICI provides the cryptographic infrastructure that secures user authentication, management, and file access for Novell NetDevice NAS120. (For more information about NICI, see "With NICI It's All Holes Barred," *Novell Connection*, Dec. 1998, pp. 8–20. You can download this article from www.ncmag.com/past/.)

For example, because NICI provides Secure Sockets Layer (SSL) encryption, Novell NetDevice NAS120 includes a secure management port, which enables you to manage the appliance via a browser. NICI also provides SSL encryption for web-based file access and Rivest Shamir Adleman (RSA) encryption for NDS eDirectory 8.5, which is embedded in Novell NetDevice NAS120.

As you may expect, NDS eDirectory provides user authentication and access control. You can also use NDS eDirectory to manage user accounts for Novell NetDevice NAS120 centrally.

MAKE IT EASY ON YOURSELF, OR DON'T

As you probably know, Novell's goal is to provide Net services software, which works across all networks and all major operating systems. Novell has extended this goal to its NetDevice NAS120, which includes support for all major file-sharing protocols, including Internet protocols such as HTTP and FTP. Novell NetDevice NAS120 also supports NetWare Core Protocol (NCP), Common Internet File Services (CIFS), and Network File System (NFS). In the future, Novell plans to add support for AppleTalk File Protocol (AFP) and Web-based Distributed Authoring and Versioning (WebDAV).

In addition, Novell NetDevice NAS120 includes namespace support for Windows Domain Controllers, Windows Workgroups, and UNIX Network Information Services (NIS). That is, you can either manage user accounts for your company's UNIX and Windows users separately, or you can create NDS eDirectory accounts for those users and manage user accounts centrally. It's up to you. Either way, users can access files from Novell NetDevice NAS120 using CIFS or NFS, the file-sharing protocols used by Windows and UNIX operating systems.

MANAGEMENT OPTIONS

If you choose to manage user accounts and access rights centrally through NDS eDirectory, you can use the browser-based management tool that is included with Novell NetDevice

NAS120. Using this management tool's GUI, you can configure Novell NetDevice NAS120 and manage access rights for NDS users and groups. For example, you can use this management tool to specify the IP address of Novell NetDevice NAS120. (See Figures 4 and 5 on p. 14.)

Alternately, you can use FTP and ConsoleOne to manage a Novell NetDevice NAS120. For example, you can upload configuration information—such as the protocols that you want to enable on a particular IP address—through FTP. To manage users and groups, you can also use ConsoleOne.

LET THE SOFTCHIPS FALL WHERE YOU WANT THEM TO

In addition, you can manage software updates for Novell NetDevice NAS120 through Novell's Softchip technology. This technology, which is embedded in Novell NetDevice NAS120, enables you to direct those appliances to a specified location for automated software updates, such as service packs. Novell will make these software updates available as a specialized file, which Novell calls a *Softchip* file.

For example, you can configure all of the Novell NetDevice NAS120 devices in each of your company's branch offices to query a particular URL at specified intervals for a Softchip file. You can then download a Softchip file from Novell and make that Softchip file available at the specified URL. The next time your company's Novell Network Storage Appliances query that URL, they automatically download and install the Softchip file. In a word, Softchip technology makes the task of updating large numbers of Novell NetDevice NAS120 devices "easy," says Novell product manager Dan Lawyer.

HIGH-AVAILABILITY STORAGE IN A SNAP

Novell NetDevice NAS120 devices are easy to deploy. In fact, Lawyer says, "You can go from opening up the crate Novell NetDevice NAS120 ships in to having file service in about five minutes."

To deploy Novell NetDevice NAS120, you simply plug in the device and connect it to your company's Ethernet LAN. You then point your browser to the device, which prompts you to provide configuration information. For example, the device prompts you to provide its IP address, specify the file-sharing protocols you want to enable, and provide a default gateway. If you are plugging this device in to an existing NetWare network, you then simply merge the device with the existing NDS tree and "you're up and running," Lawyer declares.

After Novell NetDevice NAS120 is running, you have from 144 to 365 GB of raw storage, depending on the capacity of the device you purchase. (Novell NetDevice NAS120 devices hold up to five 36- or 73-GB hard disk drives (HDDs). You can also purchase an add-on storage chassis that enables you to scale a Novell NetDevice NAS120 device up to 1.2 TB.

If your company needs a high-availability storage solution, you can then configure Redundant Array of Independent Disks (RAID) level 0, 1, 5, or 0+1 (also called RAID 10) on this raw storage. To further ensure that your company's data is available 24 x 7 x 365, Novell NetDevice NAS120 devices include redundant hardware, such as power supplies, fans, and network interface cards (NICs). Novell plans to add clustering support in future releases of Novell NetDevice NAS120. ●

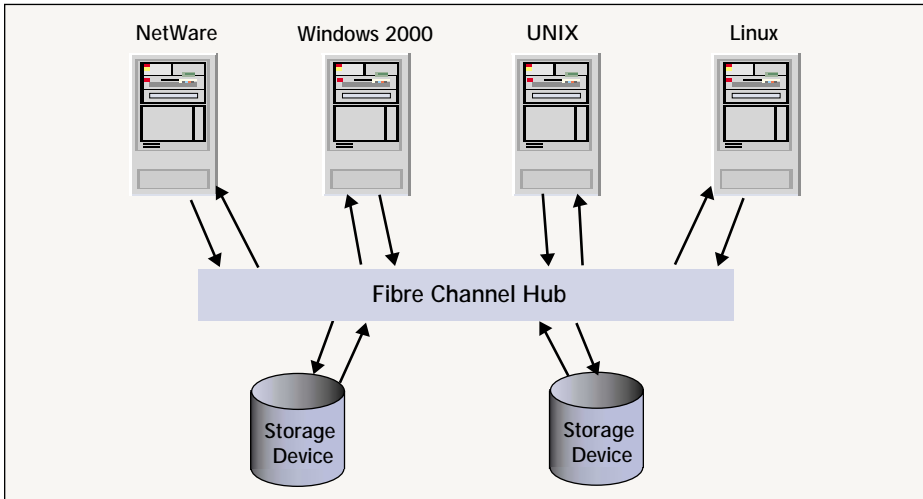


Figure 2. You can use the arbitrated loop topology to interconnect up to 127 devices. Using this SAN topology, servers must share the total bandwidth available on the loop.

Finally, SSPs often provide additional services. For example, Scale Eight—an SSP that specializes in media (video and audio) storage—provides data-mirroring services. (For more information about Scale Eight, visit www.s8.com.) Many SSPs also perform full and incremental tape backups and provide offsite storage for backup tapes and other removable storage media. (For a summary of additional services that selected SSPs provide, see “When Using an SSP Makes Sense” at www.ncmag.com.)

On the downside, outsourcing your company’s data storage to an SSP puts its data outside of your direct control. Although some SSPs (such as Storage-Network) include web-based management software that enables you to view and manage your company’s data, that

data is ultimately under the direct control of the SSP. Although most SSPs pride themselves on their ability to secure your company’s data, if you are uncomfortable with this arrangement, outsourcing data storage probably isn’t for you.

In addition, migrating your company’s existing data to an SSP could be costly and time-consuming, depending on how much data your company has accumulated. Generally, the more data you need to migrate, the more difficult and costly it is to outsource that data to an SSP.

File This

If using an SSP isn’t the right solution for your company, perhaps using one or more NAS devices is. Unlike DAS devices, which attach to a particular server, NAS devices attach to

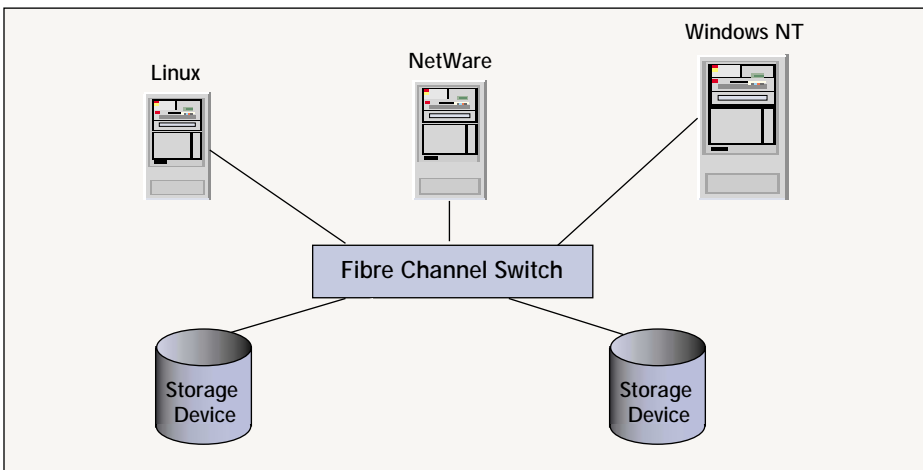


Figure 3. Fibre Channel switches can interconnect up to 64,000 devices. Using this SAN topology, servers share bandwidth only when other servers need simultaneous access to the same storage device.

your company’s network. (See Figure 1 on p. 8.)

As a result, NAS devices can help you avoid some of the problems that using DAS devices can cause. For example, NAS devices can provide cross-platform access to a central data store, potentially eliminating the problem of having too much storage on one server and not enough storage on another. Furthermore, NAS devices typically have higher storage capacities—more than 2 TB—than DAS devices have.

NAS devices typically comprise a number of HDDs and a specialized file system, which emulates the file systems of one or more network operating systems. For example, Novell NetDevice NAS120, Novell’s new NAS device, which will be available this summer, uses a version of the NetWare 5.1 kernel that is streamlined for file services. This NAS device supports file-sharing protocols for virtually all major operating systems—including, of course, NetWare. (For more information about Novell NetDevice NAS120, see “What You Need in a NAS,” on p. 10.)

NAS devices come in a variety of storage capacities and capabilities. For example, NAS storage capacities range from 20 GB to more than 2 TB. Prices can range from less than U.S. \$1,000 to more than U.S. \$50,000, depending on the processing power, storage capacity, and other capabilities of the NAS device. (As a general rule, NAS devices that simply provide network storage are less expensive than NAS devices that provide other capabilities such as high-availability storage.)

In addition, some NAS devices are plug-and-play appliances that function simply as servers and require little configuration. Others include capabilities that require more configuration. For example, the T-Rex Data Management appliance from CaminoSoft is a software-based NAS device that automates the task of moving old or seldom-used files from its RAID 5 cache storage system to removable media. (CaminoSoft calls this capability *Intelligent Capacity Management*. For more information about T-Rex, visit www.camino.com.)

Some NAS devices use proprietary security mechanisms; other NAS devices support directory services that provide security. In fact, a number of NAS devices—such as RAPtor RAID IDE and Universal



Figure 4. The Novell Network Storage Appliance includes a GUI management tool. This figure shows a sneak peek at a beta version of the IP Access configuration page, through which you select the protocols that you want to use to manage the appliance and access data.

NAS Z—support NDS eDirectory. (RAP-tor RAID IDE is a RAID level 5 NAS appliance from JES Hardware Solutions. Universal NAS Z is a NAS appliance from Excel/Meridian Data that supports RAID levels 0, 1, and 5. For more information about these and other NAS devices that support NDS eDirectory, see “Are You Getting Attached?” at www.ncmag.com.)

As you may expect, the degree to which these NAS devices support NDS eDirectory varies widely. Some NAS devices that claim to support NDS eDirectory merely emulate a NetWare bindery. Other NAS devices interact with

NDS eDirectory similar to the way Novell client software for NetWare 5.1 interacts. For example, just as you cannot merge a Novell client into the NDS eDirectory tree as if that client were a server, you cannot merge these NAS devices into the NDS tree as if they were servers. Therefore, you cannot manage these NAS devices through the NDS tree. Furthermore, these NAS devices can set security policies, such as access control lists, only at the volume level.

In contrast, you can merge Novell NetDevice NAS120 with your company's NDS tree as if this appliance were a server. Consequently, you can manage Novell

Network Storage Appliances through NDS eDirectory—which not surprisingly is embedded in Novell Network Storage Appliances. You can also set securities for Novell Network Storage Appliances at the file level. (See “What You Need in a NAS” on p. 10.)

Given the variety of storage capacities and capabilities available in NAS devices, you may think that NAS devices are the answer to all of your company's storage prayers. If so, you may or may not be right, depending on the particular NAS device you select and what, exactly, your company's storage needs are.

For example, if you select a NAS device that cannot support all of the operating systems on your company's network, you greatly reduce the management benefits of deploying a NAS device because you must still manage storage on the unsupported servers separately. Even if you do select a NAS device that works with all of the operating systems on your company's network, you may run into some of the same difficulties that you have experienced with DAS devices. Namely, most NAS devices support a finite amount of storage. When you exceed this storage capacity, you must then add another NAS device, which in most cases you must then manage separately. (You can, however, manage several Novell NetDevice NAS120 devices as one appliance. See “What You Need in a NAS” on p. 10.)

Regardless of these limitations, however, if you need storage for applications that deal with files rather than records, a NAS device is often the best solution. For example, because NAS devices specialize in managing, retrieving, and storing files, they are well-suited for web servers, software development applications, and word-processing applications.

A “What I Mean” Storage Solution

On the other hand, if your company needs storage for applications that share records rather than files, a NAS device probably won't do the trick. Applications such as databases, groupware, and customer relationship management (CRM) applications work best with storage solutions that use block-level storage, as SANs do.

Most SANs are composed of one or more SAN systems, which usually include a number of HDDs and a specialized operating system for managing, retrieving,



Figure 5. The Novell NetDevice NAS120 management tool's File Access administration page is similar to Windows Explorer. This page is the only page that end users can access.

Loop the Loop

You can deploy an arbitrated loop SAN topology in two ways:

- Using Fibre Channel input and output connections, you can daisy chain cables from device to device. However, this configuration can be impractical for several reasons, not the least of which is physical complexity. In addition, if one device on the loop goes down, that device breaks the communication loop. As a result, the surviving devices are unable to communicate.

protecting, and storing data on these HDDs. For example, the Symmetrix and CLARiiON SAN systems from EMC Corp. include a proprietary storage operating system called *microcode*, which is built into these systems. (For information about Symmetrix, CLARiiON, and other selected SAN systems that support NetWare servers, see the “SAN-Which?” section in “Product Focus” on p. 43.) In addition, many SAN systems and other devices that comprise SANs—such as SAN switches—support several network operating systems, enabling servers in heterogeneous networks to access a shared pool of storage.

SAN systems and SAN devices use channel interfaces—which are high-bandwidth interfaces. For example, SAN sys-

- You can connect cables from the devices’ Fibre Channel input and output connections into a Fibre Channel hub. (See Figure 2 on p. 12.) This configuration centralizes management of the arbitrated loop.

Furthermore, most hubs automatically bypass a device that goes down, enabling surviving devices to continue to communicate. This capability also enables you to add and remove devices without bringing down the entire loop. (For a selection of Fibre Channel hardware, including hubs, see “For Those Who SAN,” section of “Product Focus” on p. 44.)

tems and SAN devices can use any of the following channel interfaces to communicate with other SAN systems and devices:

- Fibre Channel
- SCSI
- Enterprise System Connections (ESCON)

(For a brief discussion of the relative advantages of these channel interfaces, see “Channeling Storage” on p. 20.)

In the near future, SAN systems and SAN devices will also be able to communicate over the Internet or Gigabit Ethernet using iSCSI or Fibre Channel over TCP/IP (FCIP). iSCSI is a protocol for transporting SCSI commands over TCP; FCIP is a protocol for transporting

Fibre Channel commands over TCP/IP. Both of these transport protocols are currently in the draft stages of the Internet Engineering Task Force (IETF) standardization process. (For more information about iSCSI and FCIP, visit www.ietf.org/ids.by.wg/ips.html.)

Many of the applications that require the kind of block-level storage that SANs provide also require speed. For example, many e-business systems use transactional applications to facilitate online purchases. If potential customers have to wait too long for these applications to access your company’s SAN for data, these customers are likely to abandon their online purchases. (For more information about the behavior of online customers, see “Estimated \$4.35 Billion in Ecommerce Sales at Risk Each Year” at www.zonaresearch.com/info/press/99-jun30.htm.)

Of the standards-based channel interfaces that are widely available, only Fibre Channel has the speed these types of applications need. Fibre Channel is a set of hardware and software standards from the American National Standards Institute (ANSI) and International Organization for Standardization (ISO). These standards specify data transfer rates that range from 12.5 MBps to 4.25 GBps over a distance of up to 10 km.

Most Fibre Channel implementations have a data transfer rate of 1 GBps. Transmission distances typically range from 30 m to 10 km, depending on the type of cabling you use.

LOOP? FABRIC? BOTH?

You can deploy Fibre Channel SANs in one or both of the following topologies:

- Arbitrated loop
- Fabric (also called *switched fabric*)

In the Loop

The arbitrated loop topology enables you to connect up to 127 Fibre Channel-enabled devices. (See Figure 2 on p. 12.) For example, you can use a Fibre Channel hub to connect 100 network servers to 27 storage devices. (For information about deploying the arbitrated loop topology, see “Loop the Loop.”)

The arbitrated loop topology is similar to the token ring networking topology. Each device on the loop must arbitrate with the other devices to gain control of the transmission medium. When one device gains control, other devices are

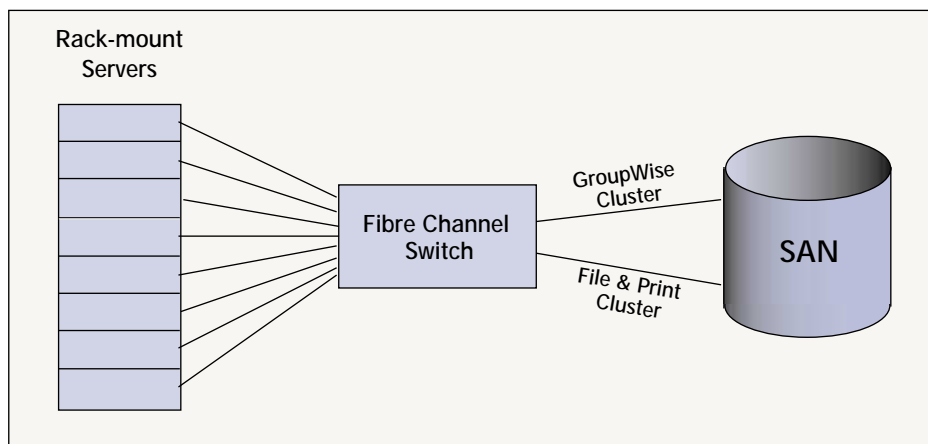


Figure 6. By deploying a SAN solution, the Texas Office of the Attorney General replaced 14 Compaq ProLiant 6000 servers (which each had 60 GB of RAID 5 storage) and 7 Compaq ProLiant 4500 servers (which each had 20 GB of RAID 5 storage) with only eight Dell PowerEdge 2450 rack-mount servers. The Dell servers have two internal drives, which are used only for NetWare system files. These servers are connected via Qlogic 2200F Fibre Channel HBAs through a Dell PowerVault 51F Fibre Channel switch to a XIOtech MAGNITUDE SAN system.

A Texas SAN Solution

It's no accident that Novell has teamed up Novell Cluster Services 1.6 and Novell Storage Services (NSS) 3.0 to manage storage on SANs: High-availability solutions rely on shared storage, and shared storage is what SANs are all about. As Jason Razien, a Novell systems engineer for the State of Texas government, explains, "The Storage Area Network is the biggest consideration you have when you're looking at high-availability services."

Novell's high-availability services—namely, Novell Cluster Services—are particularly good at managing storage on SANs. "Novell Cluster Services and SANs are mutually inclusive to any high-availability solution," Razien concludes.

However, the ability to manage SAN storage with Novell Cluster Services isn't new with Novell Cluster Services 1.6 and NSS 3.0. You can also manage SAN storage using NSS 2.96 and Novell Cluster Services 1.0.1—both of which run on NetWare 5.1—as the Texas Office of the Attorney General (OAG) demonstrates with its SAN implementation. (See Figure 6 on p. 16.)

The Texas OAG is using NSS 2.96 and Novell Cluster Services

1.0.1 to manage storage on a XIOtech MAGNITUDE SAN system for two separate four-node clusters: a GroupWise cluster and a NetWare file-and-print-services cluster, which manages the remaining data on the Texas OAG's NetWare servers. The Texas OAG decided to put GroupWise on its own cluster because, as Trey Blundell, Texas OAG system administrator, explains, "GroupWise was such a large part of our organization's pulse, that when it was down, people felt like they didn't have the ability to work."

The Texas OAG is also using its MAGNITUDE SAN system to store data for Windows NT, Solaris, and SGI IRIX servers. In the absence of Novell Native File Access components and NSS 3.0, the Texas OAG is using XIOtech's storage virtualization software and SAN zoning at the switch level to manage storage for these servers.

Even if the Texas OAG were now running NetWare 6 with Novell Cluster Services 1.6, the Texas OAG may need to continue using XIOtech's management software to manage SAN storage for its non-NetWare servers. For example, if the Texas OAG determined that some of its Windows NT applications needed a clustered environment, the Texas OAG would still need to use XIOtech's management software to manage the shared storage for this cluster. ●

blocked from transmitting data until that device's I/O cycle is complete (no matter how long that cycle takes).

However, devices in an arbitrated loop do not pass tokens to determine which device can transmit data, as devices in a token ring networking topology do. Instead, devices in an arbitrated loop transmit a signal that tells other devices that they want to gain control of the loop. This signal contains the address of the device and an x value, which determines the order in which arbitration signals are forwarded through the loop. When a device receives its own signal back again—that is, after this signal has been forwarded all the way around the loop—that device gains control of the loop.

The main advantage of deploying the arbitrated loop topology is cost: In a Fibre Channel loop, you can use hubs, which are significantly less expensive than Fibre Channel switches. For example, a seven-port Fibre Channel hub from Compaq retails for U.S. \$1,477. In contrast, a Compaq eight-port Fibre Channel Arbitrated Loop switch retails for U.S. \$5,398. (For information about selected Fibre Channel hubs, switches, and host bus adapters, see the "For Those Who San" section in "Product Focus" on p. 44.)

The main disadvantage of deploying the arbitrated loop technology is that servers connected in this topology must share the available bandwidth. For example, if the arbitrated loop has a total available

bandwidth of 1 GB and ten servers are attached to the loop, each server has an available bandwidth of only 100 MB.

Switch to High Gear

Just as Ethernet switches provide a virtual dedicated connection between devices on a LAN, so Fibre Channel fabric switches provide a virtual dedicated connection between network servers and the SAN. (See Figure 3 on p. 12.) That is, the fabric topology (which is sometimes called a *switched or switched fabric* topology) does not preclude several servers asking for, and receiving, access to the SAN simultaneously—even if these servers are requesting access to the same storage device.

If several servers request access to a particular storage device—such as a RAID controller—the Fibre Channel fabric switch interleaves requests from and responses to these servers. For example, if ten servers want to access a storage device that has a 1 GB connection, each server receives 100 MB of bandwidth.

On the other hand, if each of these servers wants to access a separate storage device, each server can use the full 1 GB of bandwidth. In other words, in the worst case—when all of the servers want to access the same storage device at the same time—the fabric topology gives each server a portion of the available bandwidth. (However, these servers still would not have to arbitrate for control of the loop, as they would if they were deployed in an arbitrated loop topology.) In the best

case—when all of these servers want to access different storage devices—these servers have the entire bandwidth available on the Fibre Channel connection.

In either case, the fabric topology offers better SAN performance than the arbitrated loop topology offers. Therefore, if your company has applications that need fast, highly available access to storage, you probably need to deploy a fabric topology.

However, the fabric topology has some disadvantages, including the cost of Fibre Channel fabric switches and directors. In addition, using Fibre Channel switches, you can connect only as many network devices as the switch has ports. Of course, if your switch supports cascading, you can extend this number of connections by simply connecting additional switches to one or more of these ports.

You can also extend the number of connections by connecting an arbitrated loop to one of these ports. In fact, you can add switches and loops to support an almost unlimited number of connections. To the extent you do this, however, you increase both the cost and complexity of managing the resulting SAN.

THE SAN ZONE AND OTHER MANAGEMENT TECHNOLOGIES

In fact, you could say that the ultimate cost of deploying and managing a SAN is a function of that SAN's complexity. Most SAN systems and some SAN devices—such as switches and hubs—include management software. With this software, you

can use technologies such as Logical Unit Number (LUN) masking, SAN zoning, or storage virtualization to manage storage for heterogeneous networks.

As you probably know, SCSI buses use LUNs to identify peripheral devices (such as DAS devices) that are attached to computers. Some Fibre Channel devices—such as host bus adapters (HBAs)—enable you to map LUNs to specific blocks of storage. Fibre Channel devices (such as RAID controllers) that support LUN masking can then use these LUNs to ensure that a particular server sees only the LUNs that are assigned to it.

Like LUN masking, SAN zoning enables you to carve out blocks of storage for particular servers or applications. Using Fibre Channel devices that support SAN zoning, you can group servers or applications that share storage into a zone. These servers and applications can then see only the storage that resides in that zone.

As you may imagine, carving out storage using individual devices such as HBAs, hubs, and switches can be complicated, time-consuming, and costly. Consequently, many companies offer software to simplify these management tasks. For example, the XIOtech REDI storage management suites use storage virtualization to enable you to carve out and manage storage for one or more XIOtech MAGNITUDE SAN systems. (See the “SAN-Which?” section in “Product Focus” on p. 43.)

As Dick Blaschke, XIOtech vice president of Marketing, explains, when XIO-

tech says its management software virtualizes storage, it “simply means that the device characteristics of the disk drives are completely transparent to the administrator, which means you can now manage space rather than disk drives.” (Although storage virtualization technologies vary from company to company, most of these technologies have the same goal: to enable you to create storage for servers and applications without having to know which physical devices hold that storage.)

On the other hand, EMC Enterprise Storage Network (ESN) Manager uses SAN zoning to enable you to configure access to storage on its Symmetrix SAN systems and to storage on Compaq, Hewlett-Packard, and Hitachi SAN systems. (For more information about the REDI line of SAN management suites, visit www.xiootech.com/REDI_solution_program.shtml. For more information about EMC ESN Manager, visit www.emc.com/products/software/esn_manager.jsp.)

However, for the most part, the storage management software you purchase to help manage storage on a particular SAN system works only for that system. If your company’s SAN solution includes SAN systems from several different companies, you must manage storage on each of these systems separately. To further complicate the SAN management matter, not all SAN management software supports all SAN devices. For example, SAN management software often does not support all major Fibre Channel switches and hubs.

To prevent this potential management problem, you can choose a particular SAN system and stick with that system. For example, you can use REDI SAN Links and REDI SAN Link Replicator to manage several MAGNITUDE systems. (For more information about REDI SAN Links and REDI SAN Link Replicator, visit www.xiootech.com/products.shtml.)

BRIDGING THE SAN MANAGEMENT GAP

In the near future, you will also be able to prevent many SAN management problems by using NetWare 6 and Novell Cluster Services 1.6 to manage storage on your company’s SAN. As you may know, NetWare 6 includes Novell Native File Access components. These components enable users and applications to use any of several file-sharing protocols to access files stored on a NetWare server. (For more information about Novell Native File Access, see the “Go Native” section in “More To Store? NetWare 6 and NSS 3.0 Can Handle It,” *Novell Connection*, April 2001, p. 16. You can download this article from www.ncmag.com/past/.)

For example, an application running on a Windows NT server can use the Common Internet File System (CIFS) protocol to access storage on a NetWare 6 server. To do this, you simply “map a drive from an NT server to storage on a NetWare 6 server,” explains Dan Lawyer, Novell product manager.

NetWare 6 also includes Novell Storage Services (NSS) 3.0, which uses NSS storage pools and logical volumes to virtualize storage management for a NetWare 6 server. NSS storage pools are areas of storage collected from one or more storage devices. Logical volumes, which expand and contract according to the amount of storage they are actually consuming, are built upon these storage pools. (For more information about NSS 3.0 logical volumes and storage pools, see “More To Store? NetWare 6 and NSS 3.0 Can Handle It.”)

NSS 3.0 enables you to extend NSS storage management from a single server to up to 32 servers—all of which can then share storage on one or more SAN systems. NSS 3.0 includes a flag that marks a storage pool as sharable for clustering. When you set this flag, NSS 3.0 cannot activate a storage pool unless Novell Cluster Services 1.6 is running on the server.

Novell Cluster Services 1.6 then uses a Novell technology called the *Cluster*

Channeling Storage

If you implement a SAN on your company’s network, that SAN will probably use one of the following three channel interfaces: Fibre Channel, SCSI, or Enterprise System Connections (ESCON). Each of these interfaces has advantages.

For example, Fibre Channel is an industry standard technology that delivers high bandwidth over long distances. (Most Fibre Channel implementations have a data transfer rate of 1 GBps. Transmission distances typically range from 30 m to 10 km, depending on the type of cable used.)

SCSI data transfer rates are lower than Fibre Channel rates (typically up to 80 MBps at distances up to 25 m for parallel SCSI 3). You can also connect fewer devices with SCSI (16) than you can with Fi-

bre Channel (up to 127 using arbitrated loop and 64,000 using switched fabric). Nevertheless, SCSI has one distinct advantage over Fibre Channel: familiarity. In the likely event that you have ever attached a peripheral device to a computer, you are probably already familiar with SCSI.

ESCON uses data transfer rates of up to 2 GBps over distances of up to 37.3 miles. ESCON, as you may know, is de rigueur for connecting IBM S/390 mainframe computers with other computing devices such as storage and LAN workstations. If your company has mainframe computers, you are already familiar with ESCON.

If your company’s network does not include mainframe computers, however, you may not even be aware that ESCON exists, since ESCON support for Intel-based computers is limited. ●

Volume Broker to grant or deny access to storage. To prevent one node from corrupting another node's data, the Cluster Volume Broker allows only one node in the cluster to access the volumes on a storage pool at a time. Novell includes the Cluster Volume Broker in Novell Cluster Services 1.6 rather than offering this type of technology as a standalone product, as other companies do. (For more information about using Novell Cluster Services 1.6 to manage storage on a SAN, see "Novell Cluster Services 1.6: Keep the Server Side Up, and the SAN Side Simple" on p. 22.)

You can use Novell Cluster Services 1.6 to manage storage for various network operating systems simply by hosting Novell's renowned file and print services on a NetWare cluster. You can then map drives from servers and clients to this NetWare cluster, which accesses and stores the requested data on the SAN. For example, you can map drives from Windows 2000 and NT clients and servers, or you can mount UNIX and Macintosh volumes.

Furthermore, because NSS 3.0 storage pools can draw storage from one or several storage devices, NetWare 6 and Novell Cluster Services 1.6 can manage SAN storage across one or several different types of SAN systems.

You can also manage SAN storage to a lesser degree today using NetWare 5.1 and Novell Cluster Services 1.0.1, which the Texas Office of the Attorney General (OAG) demonstrates with its new SAN implementation. The Texas OAG is currently using these versions of NetWare and Novell Cluster Services to manage SAN storage for GroupWise and NetWare file and print services. (See "A Texas SAN Solution" on p. 18.)

CONCLUSION

Did you notice that you can use Novell Cluster Services 1.6 and NetWare 6 to manage both file-level and block-level storage? That's because Novell Cluster Services 1.6 and NSS 3.0 can virtualize the type of storage that SANs provide as well as the physical devices that comprise that storage—at least as far as NetWare storage is concerned.

As the information age progresses, technologies that virtualize—or blur the distinctions between—particular types of storage will continue to emerge. In the end, one storage solution may fit all. In

the meantime, however, you may need to deploy a combination of storage solutions to manage your company's ballooning storage needs.

For example, if your company needs both block-level and file-level storage, you may need to deploy both a NAS and a SAN. On the other hand, if your company is already storing a large amount of old data and is generating vast amounts of new data every day, you may want to

consider having an SSP store only the new data.

In other words, until a one-size-fits-all storage solution emerges (if such a solution ever does), your company's storage solution will probably end up being as unique as your company's storage needs are.

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