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Chapter 1: The Storage Area Network

In This Chapter

- Understanding storage area networks (SANs)
- Determining whether a SAN is right for you
- Looking at SAN layers and protocols
- Discovering which operating systems benefit from SANs
- Discovering which application can use or require SANs

This chapter is dedicated to helping you get a handle on what a storage area network (SAN) is, the basics of how one works, and whether one is right for your needs. You’ll discover all the parts that make up a SAN, the things that make one run, and who actually makes all the different parts that you can buy. Putting a SAN together is somewhat like putting together one of those high-end stereo systems. You have many components and many different manufacturers to choose from. This chapter gives you the basic understanding to help you choose correctly to suit your needs and create something that you can be proud of.

These days, becoming proficient with SANs can mean a major boost to your career. Perhaps you’re bored to death in your current position and would like a change of pace. SAN administration is one of the highest-paying jobs in Information Technology (IT) today. If you add storage area networking to your résumé, your phone will be ringing off the hook by headhunters — who are likely willing to pay you a six-figure income.

Defining a SAN

First, the basics. In today’s terms, the technical description of a SAN is a collection of computers and storage devices, connected over a high-speed optical network and dedicated to the task of storing and protecting data.

In a nutshell, you use a SAN to store and protect data.

Today, that high-speed network usually consists of optical fiber cables and switches that use light waves to transmit data with a connection protocol known as Fibre Channel. (A protocol is a set of rules used by the computer devices to define a common communication language.) More and more, regular Internet provider (IP)-based networks, such as the Internet, are being used as the network part of a SAN.

The act of using a network to create a shared pool of storage devices is what makes a SAN different. The network is used to move data among the various storage devices, allows sharing data between different network servers, and provides a fast connection medium for data backup and restoration and data archiving and retrieval. Devices in a SAN are usually bunched closely together in a single room, but the network allows the devices to be connected over long distances. The ability to spread everything out over long distances makes a SAN very useful to large companies with many offices.

Many of today’s SAN components are becoming pretty much plug-and-play. To create a simple hub-based SAN, you just connect everything with cables, and off you go. Creating larger SANs with
many storage switches can become complex, though, and that’s the reason for this book. We’re going to take you through the things that you need to know about large, complex SANs.

**Fiber versus Fibre**

Networking geeks chose to use the word *fibre* to describe the fiber (notice the reversal of the *er* portion of the word *fiber*) optic cables used in a SAN. They did this differentiate them from the optical cables used in other networks, such as the Internet. Also, the word *fibre* is used because SAN devices use a different language to communicate with each other than do the devices in other networks. The protocol used in a SAN is called *Fibre Channel*.

**Technical Stuff**

All network protocols are divided into layers, like a layer cake. All the layers in the cake are logically tied together into a *stack*. Each layer of the stack provides different functionality, and each device in the network uses all the parts of the stack to communicate with one another.

The physical layer is at the bottom and consists of all the hardware stuff, such as cables, switches, and connectors. This is where the fiber optic cables are. On top of the physical layer are the software layers that make up the protocol stack. In an FC SAN, those layers make up the Fibre Channel protocol. Every network uses a different protocol.

The Internet uses a protocol stack called the Transmission Control Protocol/Internet Protocol (TCP/IP). Both the Internet or a SAN can use fiber optic cables to transmit data. Fiber optic cables use light pulses to transmit data over the cable, which makes data move very fast. The only difference between regular fiber optic computer networks such as the Internet and a fiber optic storage area network such as a SAN is how the devices talk to each other over the network. SAN uses the Fibre Channel protocol, and the Internet uses the TCP/IP protocol.

**How SAN Makes Computing Different**

Using a SAN can really change how you think about computing. In the past, you had the *mainframe*, which was a gigantic computer that could run all the programs in a large business. All the computer stuff was gathered in one place called a *data center*. All the storage that the mainframe needs was directly connected to it. Everything was located and managed as a single, large entity.

The PC revolution changed a lot of things. Everything started to spread out. Data was moved off the mainframe and stored in server computers. The servers were then dispersed throughout the enterprise to bring computing power closer to the actual users. The servers became connected by a network, called a *local area network*, or LAN. This was cool because now the compute power was spread out and made more available to end users. Eventually, LANs were connected to create the Internet.

Networks enable people using computers in far-flung places to communicate and share information with each other. In business, problems arose when inter-networking finally took off. A great deal of data was now being stored with no effective way to manage it all. Everything was scattered everywhere, and managing all the data dispersed throughout the network became a nightmare.

Because all data storage was located inside each individual server, you had no effective way to efficiently allocate storage space between all the servers. Sure, users could share files over a LAN, but you still needed a way to share access to the physical disks in every server.

Hence the advent of the SAN.
Technical Stuff  Most high–performance applications need block–based access to store data on disk drives. The TCP/IP network protocol in a LAN does not natively provide a way to access the disk drives.

In a SAN, all the disk drives are stored in a dedicated storage device — a disk array. All the servers connect to the storage device over a high–speed network that uses the Fibre Channel protocol, which enables access to disks over a network. Using a SAN gives businesses the ability to consolidate access to data storage plus the ability to connect servers to that storage from anywhere on the network.

Putting a SAN in place makes the server computers less important. Servers become more peripheral to the data that’s stored in the SAN. After all, the data is what is important to your business. If you lose a server, you can buy a new one. If you lose your data, it’s “Adios, amigo,” for your business.

Understanding the Benefits of a SAN

The benefits of using a SAN are many because a SAN usually has a very high return on investment (ROI), makes the total cost of ownership (TCO) of computing less, and has a pay–back period (PBP) based in months instead of years. Following is a list of many of the ways that you can expect a SAN to be beneficial.

• **Removes the distance limits of SCSI–connected disks**: The maximum length of a SCSI bus is around 25 meters. Fibre Channel SANs allow you to connect your disks to your servers over much greater distances.

• **Greater performance**: Fibre Channel SANs allow connection to disks at up to 200 megabytes per second today, with speeds of up to 1 gigabyte per second in the near future.

• **Increased disk utilization**: SAN enables more than one server to access the same physical disk, which lets you allocate the free space on those disks more effectively.

• **Higher availability to storage by use of multiple access paths**: A SAN allows for multiple physical connections to disks from a single or multiple servers.

• **Deferred disk procurement**: Because you can use disk space more effectively, no space goes to waste, thus you don’t need to buy disks as often as you used to.

• **Reduced data center rack/floor space**: Because you don’t need to buy big servers with room for lots of disks, you can buy fewer, smaller servers, which takes up less room.

• **New disaster recovery capabilities**: This is a major benefit. SAN devices have the ability to mirror the data on the disks to another location. This can make your data safe if a disaster occurs.

• **Online recovery**: By using online mirrors of your data in a SAN device, you can instantly recover your data if it becomes corrupt.

• **Better staff utilization**: SANs enable fewer people to manage much more data.
• **Reduction of management costs as a percent of storage costs:** Because you need fewer people, your management costs go down.

• **Improved overall availability:** This is another big one. SAN storage is much more reliable than internal, server–based disk storage. Things break a lot less often.

• **Reduction of servers:** You won’t need as many file servers with a SAN. And because SANs are so fast, if you connect your current servers to the SAN, they run faster. This lets you get more out of your current servers so that you don’t need to buy new servers as often.

• **Improved network performance and fewer network upgrades:** A SAN lets you back up all your data over a storage network rather than a LAN. Therefore, less room is needed on the LAN, so you can get more out of it.

• **Increased input/output (I/O) performance and bulk data movement:** Yup, SANs are fast. They move data much faster than do internal drives or devices attached to the LAN.

• **Reduced/eliminated backup windows:** A backup window is the window of time that you have to back up all your data. Because backup can be done over the SAN instead of over the LAN, you can back up any time, day or night.

• **Protected critical data:** SAN storage devices use technology to ensure that your critical data remains safe and available.

• **Nondisruptive scalability:** You can add storage to a storage network at any time without affecting the devices currently using the network.

• **Easier applications development and testing:** By using SAN–based mirror copies of production data, you can easily use actual production data to test new applications while the original application stays online.

• **Supported server clustering:** Server clustering is a method of making two individual servers look like one. If one has a heart attack, the other one takes over automatically to keep the applications running. Clusters require access to a shared disk drive. A SAN makes this possible.

• **Storage on demand:** Because SAN disks are available to any server in the storage network, free storage space can be allocated on demand to any server that needs it, any time.

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**Finding Out Whether a SAN Is Right for You**

SANs aren’t for everyone. If you own a small business and need just a few computers to keep your business going, using an FC SAN is probably overkill for you. Sometimes the cost isn’t justified by the benefits. The more servers that you have in your organization and the more data that you need to store, the more benefit you will see from using a SAN. Storage networking equipment is still fairly expensive. A single host bus adapter can cost more than one thousand dollars, and a storage switch can cost $30,000.
A good guideline that we use is what we call The Rule of 16. If you have 16 or fewer servers, using a SAN probably doesn’t make sense. You can easily manage 16 or fewer servers with one person, and data storage needs shouldn’t be that high. If you use more than 16 servers, or servers that run large databases, you’re a good candidate for a SAN. If you have hundreds of servers that you’re responsible for, then using a SAN will make your life much easier and probably dramatically reduce the cost of managing data.

Who should use a SAN?

You should use a SAN if you work in a large organization (16 servers or servers that run large databases) in which data management or data backup is becoming a problem. Your servers might be running out of disk space all the time, and you might have no room left in the servers to add disk drives. This server is a typical SAN candidate. You might have way too much data to be backed up or restored in a timely fashion. Using a SAN can fix that, too.

The following checklist details the types of servers that should be included in a SAN:

- **Database servers:** Oracle, Sybase, SQL, DB2, Informix, AdaBase, and other database servers love to make use of the extremely fast disks in a SAN.

- **File–servers:** Using SAN–based storage for file–servers lets you expand file server resources quickly, makes them run better, and enables you to manage your file–based Network Attached Storage (NAS) server through the SAN, which supplies shared file–based access to storage over a standard TCP/IP network.

- **Backup servers:** Connecting all your servers to a SAN, including your backup servers, enables data backup to be done through a SAN rather than a LAN. SAN–based backup is dramatically faster than LAN–based backup.

- **Voice/video servers:** Voice and video servers tend to push large amounts of data very quickly. That’s what SANs are built to do.

- **Mail servers:** Using SAN–based storage for mail servers enables quick restoration of data in case of corruption or viruses. It also lets you back up your mail servers faster and provides the capability of using clusters for your mail servers.

- **High–performance application servers:** Applications such as document management, customer relationship management, billing, data warehouses, and other high–performance and critical applications all benefit by what a SAN can provide.

Who should not use a SAN?

You don’t really need to use a SAN if your organization is small (16 servers or fewer) or where data management, application performance, or backup is not currently a problem for you.

The following checklist details the types of servers that should not be included in a SAN. These types of servers are usually better off staying on their internal disk drives because they won’t benefit from more expensive SAN–based storage.

- **Web servers:** Web servers don’t usually have large storage needs. They are usually connected to larger servers running databases from which the Web pages are automatically built. The database servers can make better use of the SAN disks. Web servers are a good candidate for NAS.
• **Infrastructure servers:** Domain name servers (DNS), Windows Internet naming servers (WINS), Domain Controllers (DC, PDC), and others are better off left on their internal disks. They don’t need a lot of disk space, and their performance requirements are minimal.

• **All desktop PCs:** Personal computers are not good SAN candidates because they usually connect to corporate servers for any applications that require high performance. Corporate servers, however, could use a SAN.

• **Servers needing fewer than 10GB of storage:** Face it: Internal storage is cheaper than SAN storage. If your server has no performance problems and will never need more than 10GB of storage space, leave it alone.

• **Servers that don’t need fast access to data:** If performance is good already and you don’t mind maintaining the server separately, don’t bother hooking it up to a SAN.

  **Tip** Servers that need to use file sharing: Such servers are better off connected to a Network Attached Storage (NAS) server.

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**Dissecting a SAN (The Four Ps)**

We divide this section into four parts, which we call *the four Ps,* namely the parts, protocols, players, and platforms that you can choose from when creating a SAN. We don’t go into all the gory details because it would take up too much space here and most likely be better for bedtime reading (you’re getting sleeepy). We just give you a general overview of the following:

• **The parts:** All the hardware you use to create a SAN; the switches, cables, disk arrays, and so forth

• **The protocols:** The languages that the parts use to talk to each other

• **The players:** The folks who build the parts

• **The platforms:** The computer applications that benefit from using SAN

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**The Parts of a SAN**

The parts can be broken into three layers. The top layer is the *host layer,* which includes the servers and everything that goes in them. The middle layer is the *fabric layer,* which includes all the cabling and the switches that connect everything. The bottom layer is the *storage layer,* where all the storage devices are located.

**The host layer**

The major components in this layer are the servers themselves, the host bus adapters (HBAs, which include a part called the Gigabit Interface Converter, or GBIC), and all the software running on the server that enables the host bus adapter to communicate with the fabric layer.
The host bus adapter (HBA)

The server connects to the SAN through a host bus adapter. The HBA is an I/O adapter card that fits inside your server and connects it to the fabric layer.

The Gigabit Interface Connector (GBIC)

The Gigabit Interface Converter is where the cable plugs into the HBA card. Every HBA card has a GBIC that snaps into an opening in the card or is soldered into the card. The openings in the GBIC extend out the back of the server so that you can plug in the cable. The GBIC houses the laser and electronics that convert the data inside your server into the light pulses that travel over the cables. In addition to the HBA, GBICs are used in every device in the SAN. Anywhere that an optical cable needs to be plugged in, you find a GBIC.

Fiber optic cables

Fiber optic cables are unique in that they are really part of all three layers in a SAN (such as the GBICs where the cables are plugged in). These cables, which connect everything in a SAN, use glass fibers to transmit light waves from one device to another. You can use one of three optical cable types, depending on the distance between connections and the wavelength of light used in the transmission of data. (See Chapter 2 for more information.)

The fabric layer

The fabric layer, or the middle layer of a SAN, is the actual network part of a SAN. The network — where all the cables are connected — is also where you find hubs and switches, which tie all the cables together into a logical and physical network.

- **Hubs:** A hub is a simple electronic device that physically connects the cables into a logical loop of cable. This is why hub-based SANs are called SAN loops. The hub has connection points — ports — where the cables get plugged in. These ports use GBICs to connect the cables to the hub. In a hub, the light coming in from a cable can pass through the hub to a device connected to another port. The light travels around the loop to each port in the hub. Because hub ports are connected in a loop, only one device can communicate through a hub at one time.

- **Switches:** A switch is a smart electronic device that physically connects cables. Switches are the heart of a SAN network. This is where a lot of the intelligence resides. The switches reliably route your data from the host layer to the storage layer.

  - Think of a switch as being like a telephone switchboard operator. Every incoming call gets connected to its destination over the wires in the switchboard, and the operator knows which wire gets plugged in where to make this happen.

The storage layer

The storage layer is where all your data resides. This is the layer that contains all the disk drives. The storage layer devices include some intelligence, such as Redundant Array of Inexpensive (or Independent) Disks (RAID) and snapshots, to help offload some of the chores from the server layer, making storing data easier for the servers. (More about this is covered in Chapter 2.) This is why your choice of storage devices can affect what you can or cannot do in a SAN.

Storage arrays

A disk is a disk. Two disks are a couple of disks. An array of disks is just a bunch of disks all located in the same place. The latter describes a storage array, except that storage arrays add extra intelligence in the controllers within the array, which allows you to do cool stuff.
A storage array is a big box that has a bunch of disks in it, running smart code called firmware that makes it more intelligent. You could go to a computer store and buy a bunch of disks, but how would you connect them to your server? Today's storage arrays use fast microprocessors to run complex software that makes them more useful than just connecting a bunch of disks to your servers. (More on storage arrays in Chapter 2.)

The storage arrays connect to the fabric layer with cables connected from the devices in the fabric layer to the GBICs in the ports on the array. Many types of storage arrays are available in the market today, but they come in two basic flavors: modular arrays and monolithic arrays. Modular arrays have fewer port connections than do monolithic arrays, and modular arrays usually store less data and connect to fewer servers.

- **Modular arrays:** Modular arrays are designed so that you can start small, with only a few disk drives in the array. You can add more drives as your storage needs grow. Modular arrays come with shelves that hold the disk drives. Each shelf can hold between 10 to 16 drives, depending on the model and manufacturer. Modular arrays usually fit into industry standard 19” racks, so you can have your servers and SAN disks all within the same rack. Modular arrays are perfect for smaller companies looking to install a SAN on a limited budget. They're also good for large companies with many remote offices.

- **Monolithic arrays:** Monolithic arrays are those big, refrigerator–size things that you see sitting next to mainframes in a data center. These disk arrays are loaded with advanced technology that almost always prevents them from going down. With the capability to store hundreds of disk drives, monolithic arrays can store data for a lot more servers than can a modular array, and can usually connect to mainframes.

  **Tip** Modular arrays are sometimes known as midrange arrays, and monolithic arrays are sometimes known as enterprise arrays. The problem in the description here is that some enterprise class arrays might be modular in design. The way to distinguish between midrange and enterprise is the ability to connect to a mainframe. Enterprise class can store mainframe data. If it cannot store mainframe data, it's midrange class. The enterprise class arrays have a whole bunch of things built in that make them almost never go down.

Each array type has its advantages and disadvantages. Modular arrays are less expensive but can scale both storage space or performance by how many disk shelves or controller shelves are included. When you add controller shelves, you get more horsepower. When you add more disk shelves, you get more storage.

Modular arrays are designed from the ground up to be extremely fast when connected to just a few servers. If you need to add servers, you just buy more controllers. Many companies like the flexibility that the use of modular arrays brings.

Monolithic arrays can be connected to mainframe computers. They also usually have many more physical ports on them to connect to the SAN, allowing many more servers to use the array. Many companies like the approach of using monolithic arrays to help consolidate more storage into less space without losing performance when servers are added. Monolithic arrays are sometimes more expensive than modular arrays, but you get what you pay for.

### The SAN Protocols

A protocol is a type of computer language used by a computer system to communicate with other devices. By language, we don’t mean a programming language. It’s more like the spoken language — a way to communicate.

Each type of computer device uses a different language (protocol) to communicate with other devices. After two devices find a common language, they establish a communication session by
greeting each other with a friendly *handshake*. The devices have a conversation using the handshake to find things out about each other and to negotiate the best or fastest method with which to communicate.

Two major protocols are used in Fibre Channel SANs: the Fibre Channel protocol (used by the hardware to communicate) and the Small Computer System Interface (SCSI) protocol (used by software applications to talk to disks).

- **Fibre Channel protocol**: This is the language used by the HBAs, hubs, switches, and storage controllers to talk to each other. The Fibre Channel protocol is a *low−level language*, meaning that it’s just used as a language between the actual hardware and not the applications running on it.

  Actually, two protocols make up the Fibre Channel protocol: Fibre Channel Arbitrated Loop (FC−AL), which works with hubs; and Fibre Channel Switched (or FC−SW), which works with switches. (Chapter 2 has more on the Fibre Channel protocols.)

  Fibre Channel is the building block of the SAN highway. It’s like the road of the highway, where other protocols can run on top of it, just as different cars and trucks run on top of an actual highway. In other words, if Fibre Channel is the road, then SCSI is the truck that moves the data cargo down the road.

- **SCSI protocol**: This is the language used by applications on the servers to the disk drives themselves. This protocol lies on top of the Fibre Channel protocol, enabling SAN−attached server applications to talk to their disks.

  **Technical Stuff** Even though most storage array manufacturers now use Fibre Channel disks in their storage arrays, the disks themselves still use the legacy SCSI protocol to communicate with applications over the fibre network.

All the SCSI messages are *encapsulated* (packaged) into the Fibre Channel protocol. It’s kind of like writing a letter to your dear Aunt Sally. (Aunt Sally is your disk drive here.) You write a letter (your data) and address the envelope (a SCSI block) to aunt Sally (your disk). You want it to get it there fast, though, so you put the letter into a FedEx package (you encapsulate the SCSI block in the Fibre Channel frame) and send it off. The Fibre Channel switch in the SAN opens the FedEx package (Fibre Channel frame), looks at the original address on the envelope (SCSI block), and sends it along its merry way at light speed to Aunt Sally (your disk).

All Fibre Channel devices work this way. The language for communication with storage devices is SCSI. Fibre Channel is just the FedEx way of getting it there faster, like a postal deliverer running at light speed. SANs work by giving the SCSI protocol a free ride on top of the Fibre Channel protocol to make communication happen much faster.

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**How SAN devices communicate**

Using English as a metaphor, think of a typical protocol conversation like this:

HBA in the server: “Hey! How are you? I’m in this server, and I’m trying to find a disk drive to store his data. Who are you?”

Switch: “Hi. I’m a Fibre Channel switch. I see that you can speak Fibre Channel. Let’s talk using the new version 2 dialect, okay?”

HBA in the server: “Okay. Look, do you know of any good disk drives that I can use to store the data?”

Switch: “Sure, according to your address, I have been authorized to give you access to a drive on my port 3. Would you like to speak with her? Remember, SCSI drives speak a different language."
Do you speak SCSI?"

HBA in the server: “Nope, but the server’s application does! Thanks. I’ll have him send you all the data using the SCSI protocol. Can you forward this on to the disk?”

Switch: “Done deal. Hey, SCSI drive on port 3, here’s a message for you!”

At this point, the session is established, and the switch now just passes the SCSI messages through to the disk drive. The drive acknowledges the messages and does what the server tells it to do.

### The SAN Players

The players are the companies that are the driving force in the SAN industry. Hundreds of companies are selling SAN equipment these days, each selling products that fit into a particular niche. You can break the players out into the different types of products that they sell. Some companies can sell everything that you need, including servers. Server companies sometimes buy other companies’ products and resell them as their own. (You can’t be good at everything these days.)

You can get a listing of companies that develop products for SAN from the Storage Network Industry Alliance (SNIA; www.snia.org), a consortium of companies all working together creating standards for storage area networks.

### The SAN Platforms

The platforms are the servers that benefit from using a SAN. As we indicate earlier in this chapter, not all servers should be hooked up to a SAN. The operating system running on your server requires a driver. A driver is a small bit of software (drivers are discussed in Chapter 7) that enables the server to talk to the disks in the SAN. Some operating system platforms have these drivers available; some don’t. You might need the latest version of your operating system to use a SAN because of a lack of driver support in earlier versions. For example, older versions of Windows NT, such as Windows NT 3.51, don’t have SAN drivers available.

Three types of server platforms are good to use in a SAN: big, fast Intel–based servers; big, fast servers that can run the different flavors of Unix; and mainframes. In other words, the more expensive and powerful systems that need to store a lot of data.

Most server platforms have drivers that allow them to be hooked up to a SAN environment. Whether doing so makes sense depends on the type of application running on it and the amount of disk storage that the server needs.

Here is a list of the minimum operating system versions required to include in a SAN:

- Microsoft Windows NT 4.0
- Microsoft Windows 2000
- Sun Solaris versions 2.6 through 2.8
- HP–UX version 10.2 and higher
• IBM AIX version 4.2 and higher
• Compaq Tru64 Unix version 4.0F and higher
• Compaq Open VMS version 7.2 and higher
• Novell Netware version 4.11 and higher
• SGI IRIX version 6.5 and higher
• Sequent DYNIX version 4.5 and above
• The various flavors of Linux
• IBM OS/390 Mainframe MVS, or Z/OS

Applications that benefit from a SAN

Most applications running on a server would benefit from faster access to the disk drives that the application is trying to use. Using a SAN instead of disks inside the server not only makes disk access faster (SAN disk access is at light speed) but also makes managing those disks much easier.

You can use the following as a guideline when choosing which servers to hook up to the SAN.

• Any server-class computer running a high-performance application: By server class, we mean anything with at least lots of memory (1GB or more) and a fast Intel Xeon or Reduced Instruction Set Computer (RISC) class processor (not your normal desktop type PC).

• Any server-class computer with expanding disk storage needs: Using a SAN makes it easy to allocate more storage to a server without having to bring the server down.

• Any database-type application server: Databases require very fast disk access. A SAN can provide this kind of fast disk access.

• Any backup server: Backup servers have tape drives connected to them to back up your disk storage to tape so that you can restore it if your disks crash. Using SAN-connected tapes to back up your data relieves the strain of backing up your disks across your computer network and also makes backup happen much faster. Backup servers benefit greatly from SANs.

Applications that require a SAN

Only a handful of applications actually require the use of a SAN. These are usually the newer applications designed specifically for the capabilities that a SAN has to offer.
• **Cluster applications:** Cluster applications are created by tying a group of servers together via a fast network and then allowing those servers to access the same disks storage where the application is installed. This allows for very scalable and highly available applications because if one of the servers fails, another server in the cluster can pick up where the first one left off. Common cluster applications are
  ✶ IBM HACMP: [www.ibm.com](http://www.ibm.com)
  ✶ Solaris Cluster 3.0: [www.sun.com](http://www.sun.com)
  ✶ Compaq/HP TruCluster: [www.hp.com](http://www.hp.com)
  ✶ Oracle Failsafe Cluster: [www.oracle.com](http://www.oracle.com)
  ✶ Oracle Real Application Clusters: [www.oracle.com](http://www.oracle.com)
  ✶ Microsoft Cluster Server (MSCS): [www.microsoft.com](http://www.microsoft.com)
  ✶ HP MC/Serviceguard Clusters: [www.hp.com](http://www.hp.com)
  ✶ Novell Netware Cluster Services: [www.novell.com](http://www.novell.com)

• **SAN back-up applications:** SAN–based backup software is optimized for using SAN hardware. The backup software includes intelligence that takes advantage of what SAN offers. When using SAN backup software, you can back up your data directly from a disk in the SAN to a tape drive, which makes backup run much faster. Common backup software that has this capability includes
  ✶ Veritas NetBackup: [www.veritas.com](http://www.veritas.com)
  ✶ Veritas Backup Exec Enterprise Edition: [www.veritas.com](http://www.veritas.com)
  ✶ Computer Associates ARCserve with the SLO option: [www.ca.com](http://www.ca.com)
  ✶ Computer Associates ARCserveIT: [www.ca.com](http://www.ca.com)
  ✶ Legato NetWorker: [www.legato.com](http://www.legato.com)
  ✶ CommVault: [www.comvault.com](http://www.comvault.com)