BASICS OF STORAGE TECHNOLOGY

This will also cover NetApp specific storage concept & General Storage as well

Abstract

This document briefs about the general storage concepts, NetApp Storage Concepts

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Contents

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What is STORAGE:

a. A storage device is any computing hardware that is used for storing, porting and extracting data files and objects. It can hold and store information both temporarily and permanently, and can be internal or external to a computer, server or any similar computing device.
b. A storage device may also be known as a storage medium or storage media.

Storage Device:

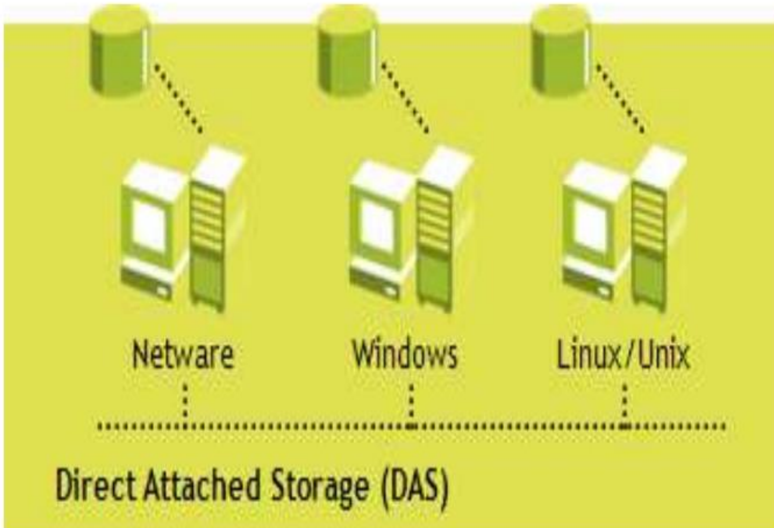
c. Storage devices are one of the core components of any computing device. They store virtually all the data and applications on a computer, except hardware firmware. They are available in different form factors depending on the type of underlying device.
    i. Example: RAM, cache, a hard disk, an optical disk drive and externally connected USB drives.
d. There are two different types of storage devices:
    i. Primary Storage Devices:
        1. Generally smaller in size, are designed to hold data temporarily and are internal to the computer. They have the fastest data access speed and include RAM and cache memory.
    ii. Secondary Storage Devices:
        1. These usually have large storage capacity, and they store data permanently. They can be both internal and external to the computer, and they include the hard disk, compact disk drive and USB storage device.

Types of Storage:

e. The three fundamental types of storage are: All three Storage types evolved over the years, Storage requirements and technology advancement led to one another. In other words, DAS led to -> NAS and in turn NAS led to -> SAN.
    i. DAS (Direct Attached Storage)
    ii. NAS (Network Attached Storage)
    iii. SAN (Storage Area Network)

Details of Types of Storage:

Typical **DAS** Storage solution



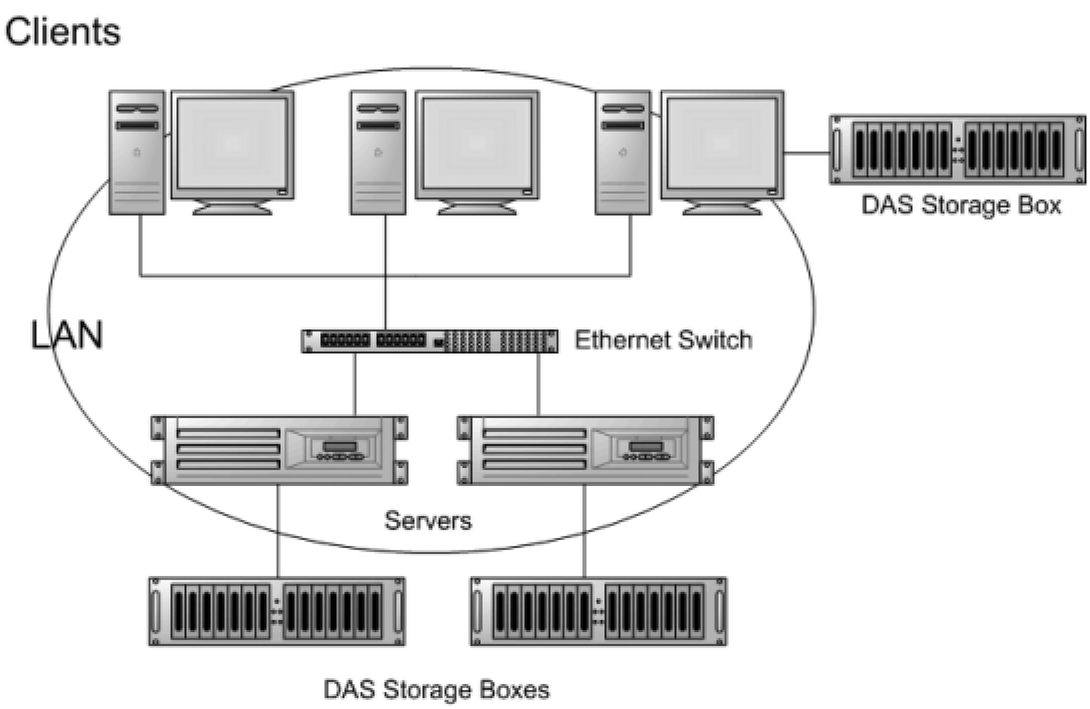
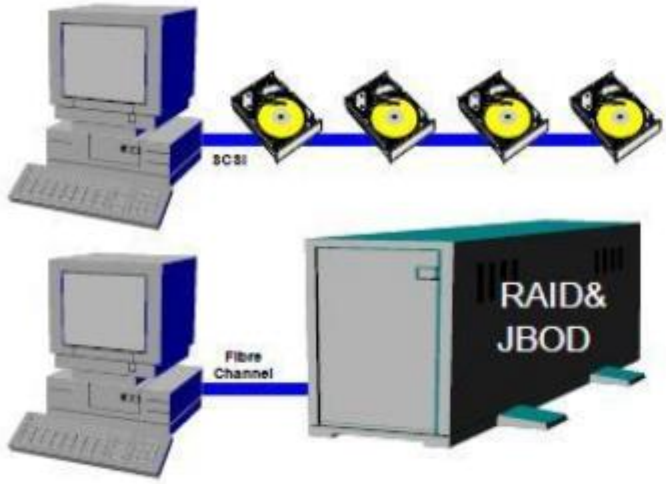
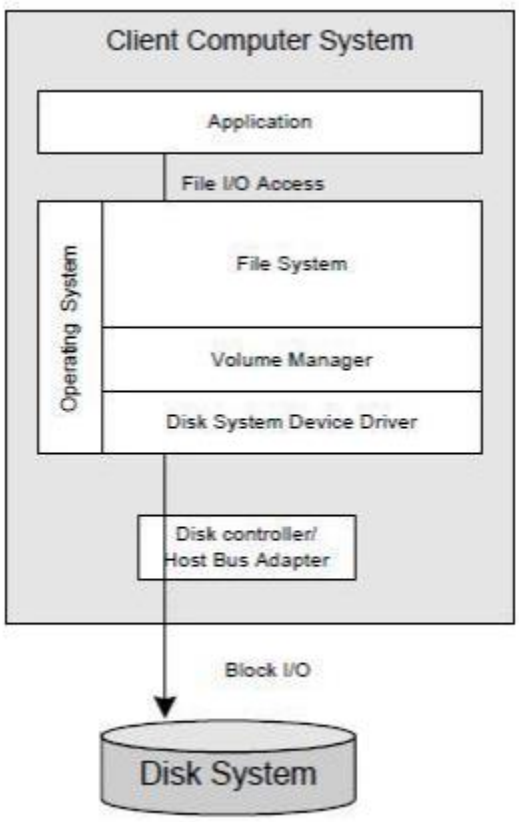


Figure 2 - Example 1 with DAS





DAS Software Architecture

DAS (Direct Attached Storage):

DAS is storage that is attached directly to a computer or server. Unlike the others systems, DAS isn't part of a storage network. In a DAS configuration, storage devices such solid state drives (SSD) and hard drives are attached directly to the system through accessing them. It is called 'direct' as the connection between device and the server is typically achieved using a storage device interface such as Integrated Drive Electronics, or the Small Computer Systems Interface (SCSI). The storage devices are either physically inside the server to which they are attached or in external housings connected by a cable. DAS drawbacks include resource contention. The server hosting the data may be better employed crunching numbers or providing raw compute power than merely serving up files. There can also be a licensing issue. You need far more licenses with a lot of data on DAS than you would hosting them on some kind of network storage.

DAS as its name implies is simply primary storage that is designed to be used by one and only one computer. Advantages: Great for Mainframes and OLTP type high data intensive requirement. Disadvantages: DAS cannot share unused resources or data with other servers, and therefore it is also called island of information. DAS typically have limited scalability, Server has to be rebooted, creating downtime during the installation process.

Protocols: FC, or SATA, or SCSI, or PATA, or SASA.

The directly attached storage disk system is managed by the client operating system. Software applications access data via file I/O system calls into the Operating System. The file I/O system calls are handled by the File System, which manages the directory data structure and mapping from files to disk blocks in an abstract logical disk space. The Volume Manager manages the block resources that are located in one or more physical disks in the Disk System and maps the accesses to the logical disk block space to the physical volume/cylinder/sector address. The Disk System Device Driver ties the Operating System to the Disk controller or Host Bus Adapter hardware that is responsible for the transfer of commands and data between the client computer and the disk system. The file level I/O initiated by the client application is mapped into block level I/O transfers that occurred over the interface between the client computer and the disk system.

Protocols used by a DAS storage subsystem:

SCSI:

Small computer system interface is one of the oldest forms of storage interfaces traditionally used in server or workstation class computers.
Most recent versions of SCSI can handle up to 15 hard drives.

PATA:

Parallel advanced technology attachment (originally called ATA and sometimes known as IDE or ATAPI) was the most dominant desktop computer storage interface from the late 1980s until recently, when the SATA interface took over. PATA hard drives are still being utilized today, especially in external hard drive boxes, but they're becoming rare. Some cheaper high-end server storage devices have also used PATA. Like SCSI, PATA has also gone through many revisions. The most recent version of PATA is UDMA/133 which supports a throughput of 133 MB/s.

SATA –

Serial advanced technology attachment is the official successor to PATA. So far, there have been two basic versions of SATA, with SATA-150 and SATA-300. The numbers 150 and 300 represent the number of MB/s that the interfaces support. SATA doesn't have any performance problems due to cable/port sharing, but that's because it doesn't permit sharing at all. One SATA port permits one device to connect to it. The downside is that it's much more expensive to buy an eight-port SATA controller than an Ultra-320 SCSI controller that allows 15 devices to connect to it. The upside is that each drive gets a theoretical 300 MB/s. Current SATA hard drives, however, barely get 80 MB/s, so the bus interface is a bit of overkill for now.

SAS:

Serial attached SCSI is the latest storage interface that's gaining dominance in the server and storage market. SAS can be seen as a merged SCSI and SATA interface, since it still uses SCSI commands yet it is pin-compatible with SATA.

FC:

Fibre channel is both a direct connect storage interface used on hard drives and a SAN technology. FC offers speeds of 100, 200, and 400 MB/s. Native FC interface hard drives are found in very high-end storage arrays used in SAN and NAS appliances, although the technology may ultimately give way to SAS.

Flash:

Flash memory isn't a storage interface, but it is used for very high-end storage applications because it doesn't have the mechanical latency issues of hard drives. Flash memory can be packaged into the shape of a hard drive with any of the above interfaces so that it can be used in a storage array. The benefit of flash memory is that it can offer more than 100 times the read IOPS (input output per second) and 10 times the write IOPS performance of hard drives, which is extremely valuable to database applications

Advantages:

In a DAS system the storage resource is dedicated, and besides the solution is inexpensive. Disadvantages DAS has been referred to as "Islands of Information”.

Disadvantages:

The disadvantages of DAS include its inability to share data or unused resources with other servers. Both NAS and SAN architectures attempt to address this, but introduce some new issues as well, such as higher initial cost, manageability, security, and contention for resources.

Network Attached Storage (NAS):

NAS is a dedicated storage device, and it operates in a client/server mode.

Network-attached storage (NAS) is basically a LAN-attached file server that serves files by using a network protocol, such as Network File System (NFS). NAS refers to storage elements that connect to a network and provide file access services to computer systems. An NAS storage element consists of an engine that implements the file services (by using access protocols, such as NFS or Common Internet File System (CIFS)) and one or more devices, on which data is stored. NAS elements might be attached to any type of network.

With an NAS device, storage is not a part of the server. Instead, in this storage-centric design, the server still handles all of the processing of the data, but an NAS device delivers the data to the user. An NAS device does not need to be located within the server, but an NAS device can exist anywhere in the LAN. An NAS device can consist of multiple networked NAS devices. These units communicate to a host by using Ethernet and file-based protocols. This method is in contrast to the disk units that are already described, which use Fibre Channel Protocol (FCP) and block-based protocols to communicate. NAS storage provides acceptable performance and security, and it is often less expensive for servers to implement (for example, Ethernet adapters are less expensive than Fibre Channel adapters).

NAS is an ideal solution for serving files that are stored on the SAN to users in cases where it is impractical and expensive to equip users with Fibre Channel adapters. NAS allows those users to access your storage through the IP-based network that they already have.

A NAS (Network Attached Storage) is designed to provide shared access to storage across a standard TCP/IP network.
Sharing data across TCP/IP is accomplished by converting block-level SCSI commands to file sharing protocols.
Common file sharing protocols include the UNIX Network File System (NFS) and the Windows Common Internet File System (CIFS).
Linux or Windows servers may be used to share network files. However, “Appliance” servers are becoming readily available that offer better performance.
These servers utilize a stripped-down operating system that is built to optimize file protocol management, and commonly support multiple file sharing protocols.

Unlike DAS or SAN, there is no RAID Controller or HBA on the server. Instead, a Network Interface Card is used to communicate with the NAS “server” across the TCP/IP network. The NAS server also utilizes a TCP/IP card. The Ethernet network can be either a private or public network. Due to the data traffic and security concerns, a VLAN is preferred when using the public network.

Native SCSI commands address storage at the block level. However, native TCP/IP can only communicate storage information at a higher logical level – the file protocol level. This means that a server must send file level requests over TCP/IP to the NAS “server”, which must convert file protocol information to block level SCSI information in order to talk to the disks. Returning data must be converted from block level disk information to file protocol once again and send it across the network cable in TCP/IP packets. Although a Gigabit Ethernet network is fast, all of this protocol conversion incurs significant overhead. The situation is even worse for database requests, because the database “talks” only in block level format to the database server, so protocol conversion must occur coming and going. Because of this, NAS may not be appropriate for all databases. Read-only databases may offer acceptable performance on NAS, as well as relatively small transactional databases. However, large transactional databases are rarely placed on NAS, due to perceived performance reasons.

Despite the potential drawbacks, a NAS system may offer good performance at a good price, depending on your situation. A high end NAS appliance over a 1 Gigabit Ethernet network can offer performance similar to a SAN. The advent of 10 Gigabit Ethernet should alleviate any performance concerns.

Simplest way to think of NAS is as a specialized kind of file server. Anyone who has used a server as a repository for user files should be able to easily grasp the concept of NAS. Instead of writing a file to the C drive on a local desktop, it is written to another drive – perhaps the N drive – which means the files are saved directly onto the NAS box (also known as a filer, or NAS filer).

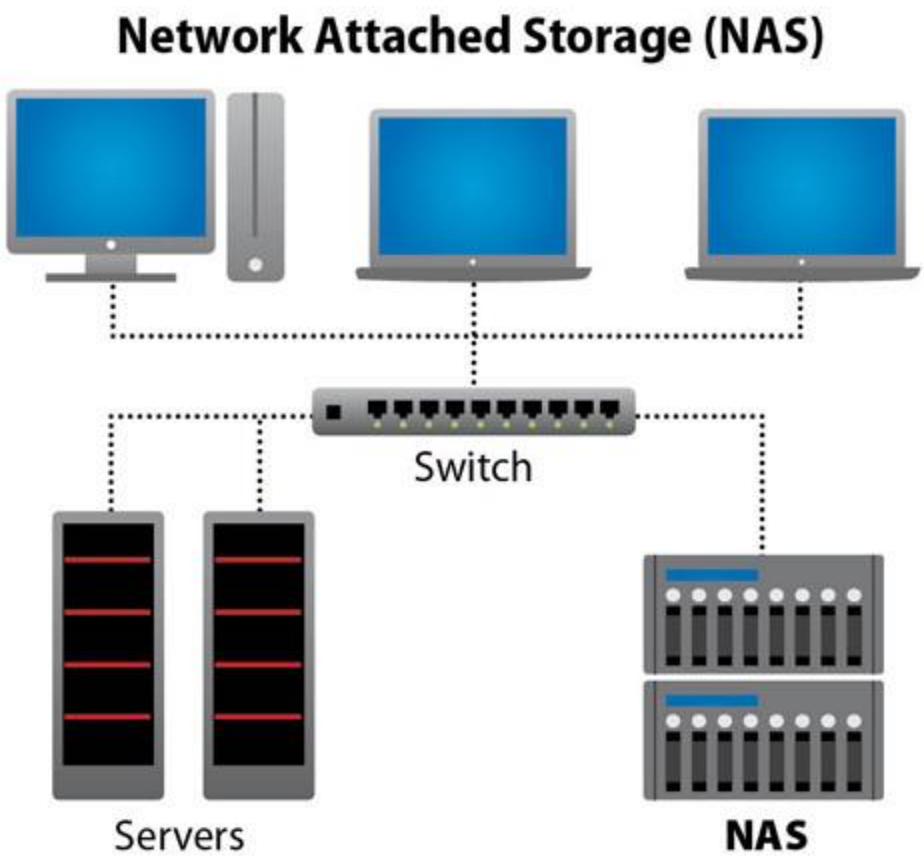
While a file server has a limited supply of storage, NAS storage can provide you with terabytes (TB) of space that is instantly accessible to anyone over a standard Ethernet connection. Compared to a general-purpose server serving files, NAS offers faster data access and easier administration. It also offers:

· **A simpler configuration** Think of it as having to access each individual server to find files, versus having all files in one large NAS pool with a global namespace. This enables anyone to find and open files rapidly.

· **Data manageability** NAS has historically been the preferred means of network storage where data manageability was a higher priority than raw performance. Data manageability was particularly important for those with large files or large numbers of files. However, the advent of SSDs now enables NAS to deliver levels of performance traditionally only available from block-based Storage Area Network (SAN) systems.

Less expensive than SAN NAS provides a cheaper network storage system than a SAN. According to IDC, file-based data storage accounts for two thirds of the total storage capacity shipped each year. Part of the reason for this is simplicity and the other is cost. By deploying NAS, organizations avoid the need to purchase expensive storage arrays, an extensive Fibre Channel (FC) fabric and import SAN specialists to manage what is a highly technical infrastructure.

The simplicity associated with NAS storage, however, has changed somewhat in recent years. Modern day enterprise NAS tools now come prepackaged with all manner of bells and whistles. This might include dynamic point-in-time snapshots, replication, thin provisioning, deduplication and compression as well as faster speeds and larger capacities.



Networked attached storage is a fundamental element of data storage infrastructure.

NAS: 3 Key Considerations

Realize that when deploying NAS, your business must weigh three core considerations.

- **Security** From a security standpoint, NAS devices either provide file system security capabilities of their own, or allow user databases to be used for authentication purposes. Further NAS benefits include devices being located close to the users thereby reducing network traffic. Another advantage of NAS is that it offers platform independent access. For instance, as many environments now use more than one operating system, enterprise NAS provides a mechanism that allows users to access data irrespective of what OS is used to authorize them on the network. NAS, though, is not faster than DAS. Many times, the speed of the network impedes data retrieval. Even if NAS is armed with SSDs, it is unlikely to outperform a server using flash.

- **NAS is also cheap** Starting from just a few hundred dollars, NAS is available as free-standing or rack-mounted units that can accommodate storage devices of all types and all capacities. Many NAS devices also incorporate technologies such as RAID and provide UPS capabilities as well. When you need network storage, but you don't want to get involved with the complexity and expense of a SAN, NAS is the way to go. All it takes to start can be as simple as plugging a NAS box into the network and away you go.
- **The database question** NAS, though, doesn’t do particularly well with databases. And large enterprises or those with the need for the highest possible network performance should probably stick to a SAN. But the firm line of separation that used to exist between NAS and SAN is changing due to convergence. Many recent NAS offerings support the NAS protocols (NFS, CIFS/SMB) and the SAN protocols (iSCSI, Fibre Channel) from a single piece of hardware.

In Nutshell:

- NAS is connected to the file server via LAN.
    - Protocol:
        - NFS (or CIFS) over an IP Network, (This is nothing but file sharing protocols like Unix NFS and Windows CIFS) and
        - NAS Utilizes a TCP/IP network to “share” data.

– Network File System (NFS) – UNIX/Linux

– Common Internet File System (CIFS) – Windows Remote file system (drives) mounted on the local system (drives)

- Evolved from Microsoft NetBIOS, NetBIOS over TCP/IP (NBT), and Server Message Block (SMB)
  – SAMBA: SMB on Linux (Making Linux a Windows File Server)
- Storage “Appliances” utilize a stripped-down OS that optimizes file protocol performance.

- NAS has been also been embraced by cloud providers such as Google, Microsoft and Amazon. They have incorporated NAS into their cloud storage architectures.
- NAS incorporates far more analytics capabilities. Metadata analytics, for example, like those offered through data virtualization, are being packaged with NAS solutions to let users better search and utilize their data.
- Machine learning is another area where NAS deployment is on the increase.

Advantage:

No distance limitation

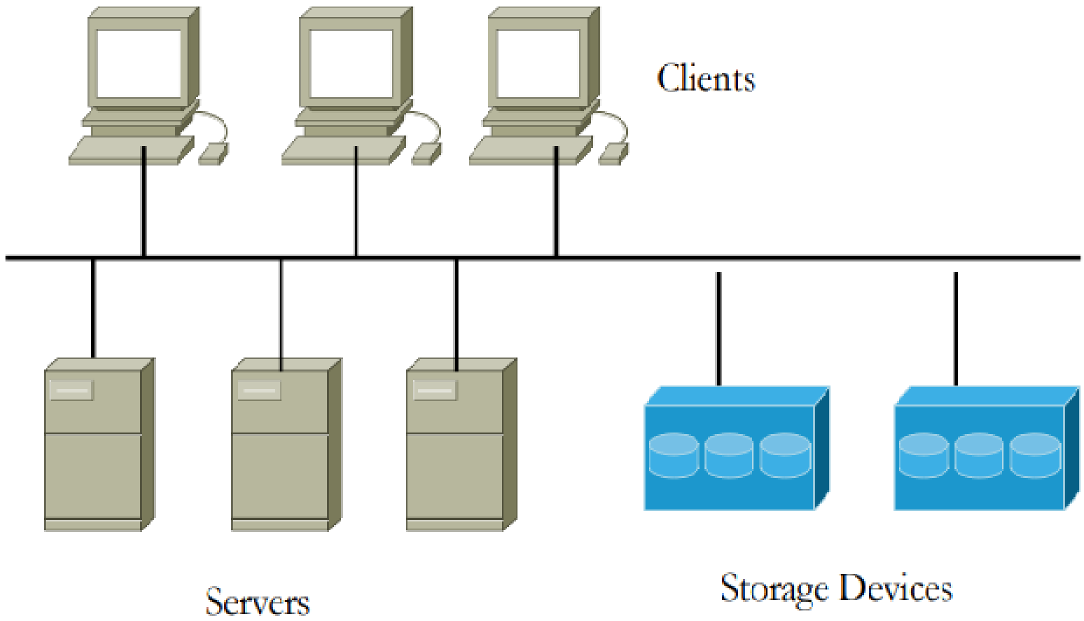
Disadvantage:

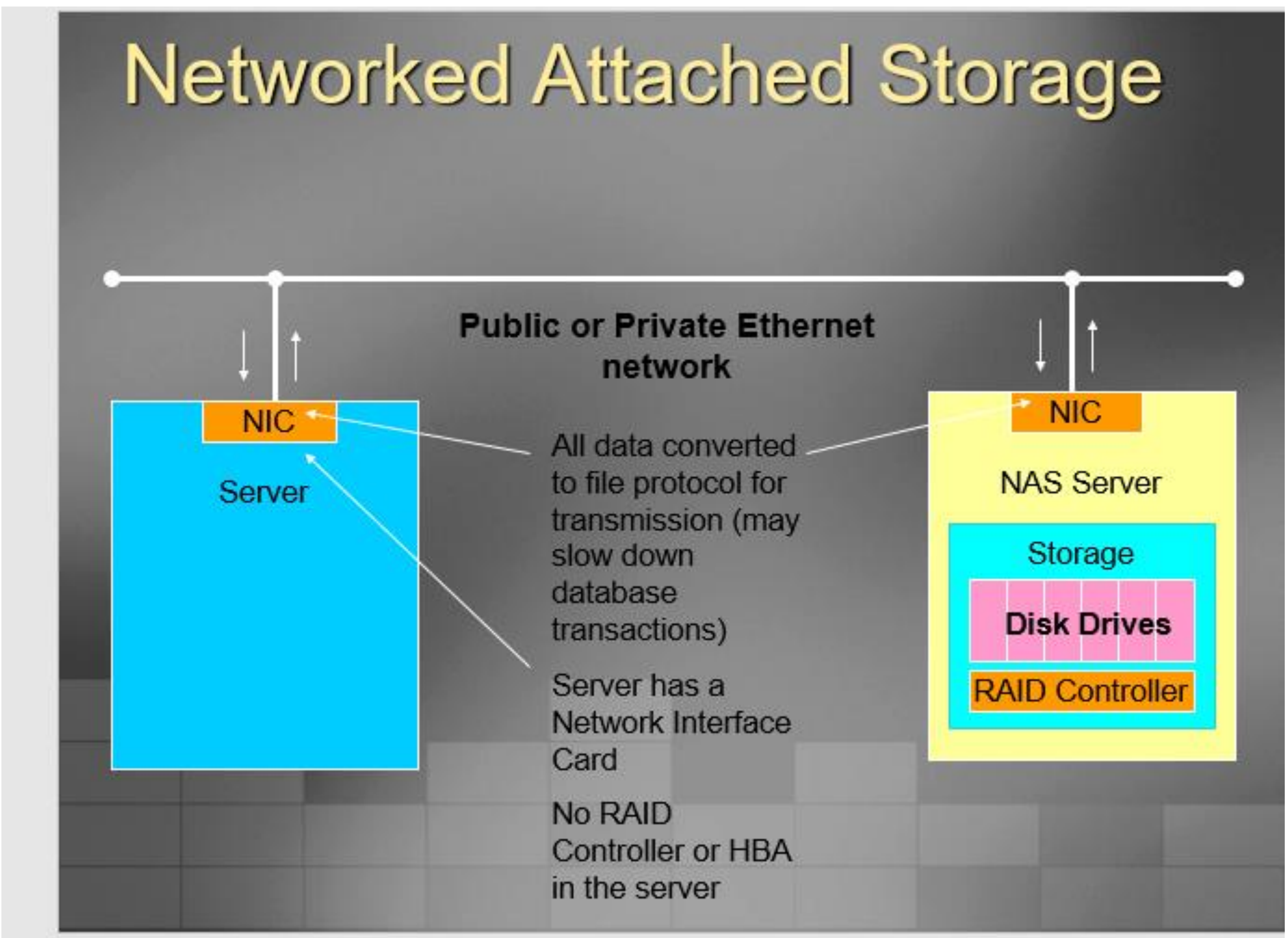
Speed and Latency

Weakness:

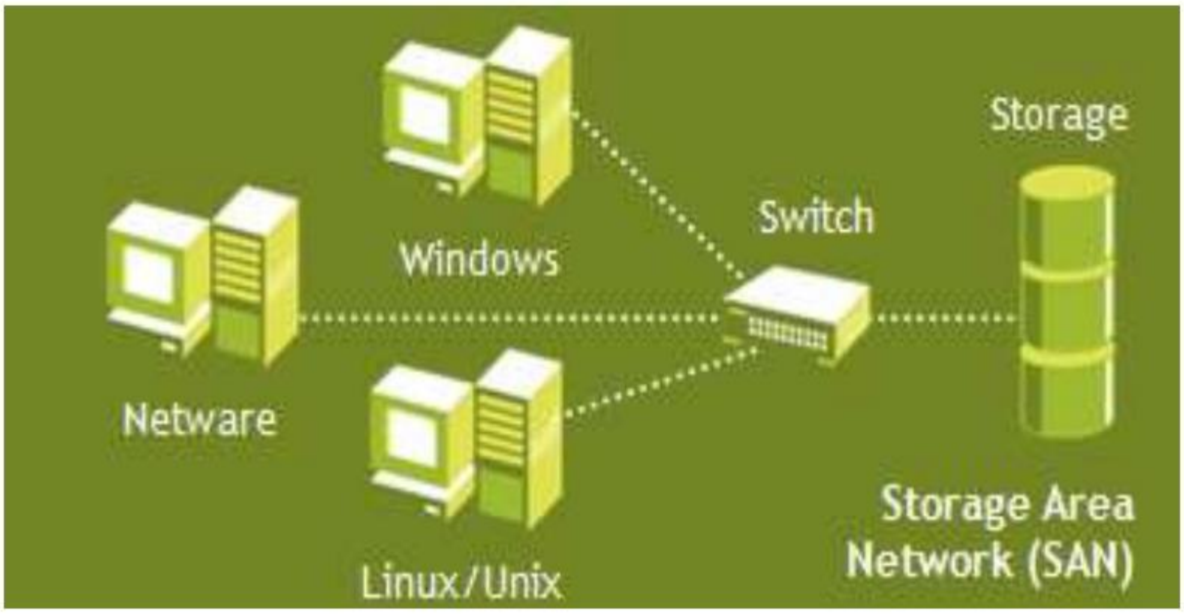
Security

Specialized storage device or group of storage devices providing centralized fault-tolerant data storage for a network.





Storage Area Network (SAN):



A SAN (storage area network) is a network of data storage devices. By taking storage devices and storage traffic off the Local Area Network (LAN), another network is created specifically for storage data. SAN storage solutions can range from a few servers accessing a central pool of storage devices to thousands of servers accessing TBs or more of storage.

In a SAN, data is presented from storage devices to a host so that the storage looks like it is locally attached. This is achieved through various types of data virtualization. SAN storage, then, is a high-speed network that provides network access to storage. In some cases, SANs can be so large that they span multiple sites, as well as internal data centers and the cloud.

Storage Area Networks differ from Direct Attached Storage (DAS). In DAS, the data is directly attached to one server. A SAN, on the other hand, presents storage devices to a host such that the storage appears to be locally attached. This simplified presentation of storage to a host is accomplished through the use of different methods of virtualization.

SANs are also different from Network Attached Storage (NAS). While NAS also takes storage devices away from the server to create a central pool of data, NAS storage connects directly to the network (LAN). In SAN storage, capacity is pooled and provided with a dedicated network. This enables faster communication over faster media.

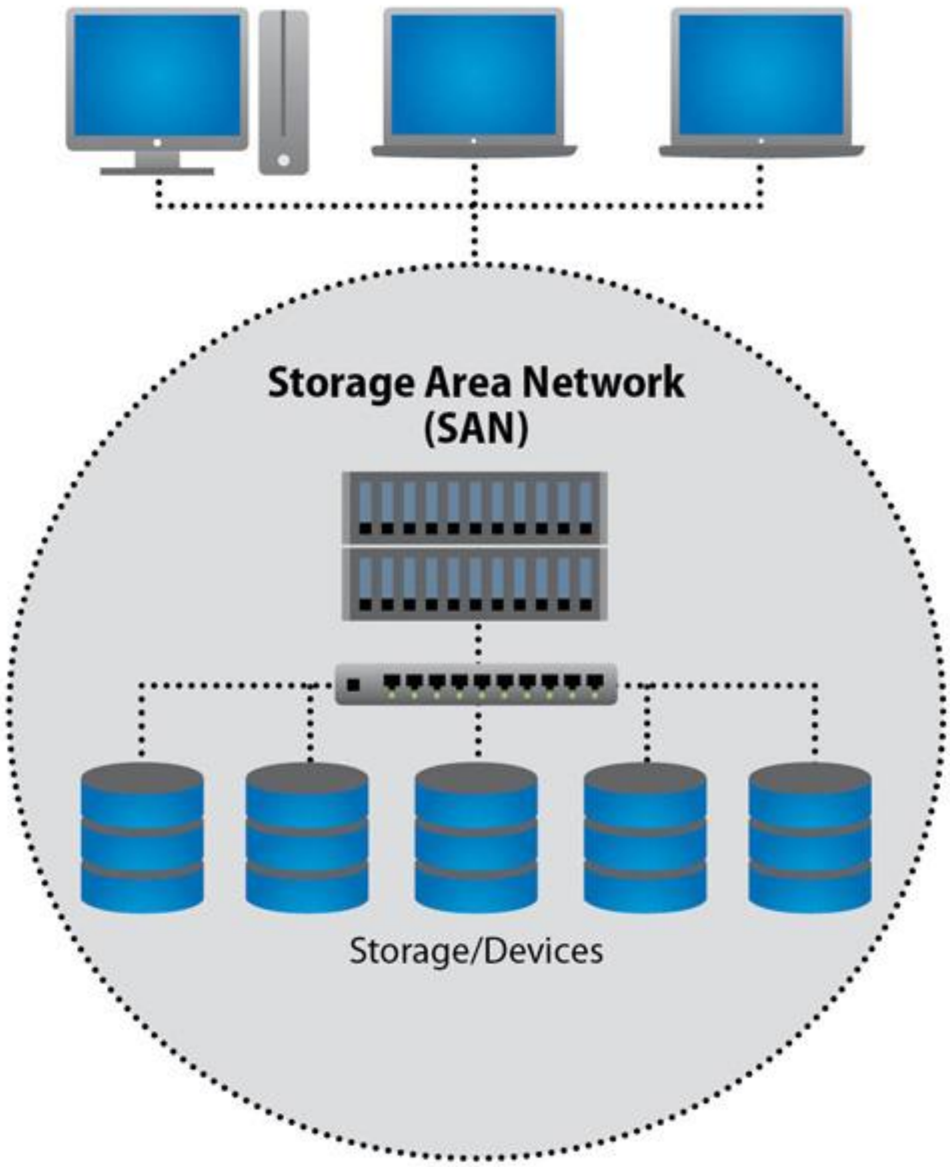
A Storage Area Network (SAN) is a specialized, dedicated high speed network joining servers and storage, including disks, disk arrays, tapes, etc.
A SAN is a specialized high-
speed network of storage devices and switches connected to computer systems.

- Storage Area Network
- A network whose primary purpose is the transfer of data between storage systems and computer systems
- Fibre Channel is the primary technology utilized for SANs
- Recently, SANs have been implemented with dedicated iSCSI networks

- Storage (data store) is separated from the processors (and separated processing).
- High capacity, high availability, high scalability, ease of configuration, ease of reconfiguration.
- Fiber Channel is the de facto SAN networking architecture, although other network standards could be used.

The Advantage of SAN Storage

- Elimination of bandwidth bottlenecks associated with LAN-based server storage
- No scalability limitations imposed by SCSI bus-based implementations.
- High availability
- Greater fault tolerance
- Centralized storage management.
- Faster backups
- Global file systems
- Rapid data migration
- Fault tolerance
- Better data security
- Improved storage utilization
- Greater scalability
- Greater Improve application availability such as multiple data paths
- Enhanced application performance by offload storage functions or segregating networks.
- Better data protection and Disaster Recovery (DR)
- For SAN advantages, take the case of storage migration. If data is sitting on many servers, it is a laborious process for the storage administrator to take if off each server and transfer it to a new home. This might involve steps such as unmounting the file systems using the storage, unplugging the unit, moving it, then connecting it to a different host, and bringing up the file systems on the new machine. In a SAN storage solution, it is a simple matter to move an entire large storage array from one host to another. All you have to do is unmount the file system, quickly reconfigure the SAN then bring up the data on the new host. This saves an enormous amount of time for a storage administrator.
- This architecture becomes more and more vital as the size of the amount of storage grows. It is much too cumbersome to attempt to manage multiple TBs of data on a server by server basis. It takes a storage network to do the heavy lifting and remove the drudgery. For instance, if you need to add storage from another array to a server, a SAN-attached architecture enables you to allocate logical unit numbers (LUNs) from multiple arrays to that one server.
- What is a LUN? A LUN is a unique identifier that designates an individual storage device or a collection of physical or virtual storage elements execute I/O commands with a host computer. The logical unit that is identified might be a block of capacity on a storage drive, the entire drive, or part of several hard drives, SSDs or tape storage residing on one or several storage systems. As such, a LUN might refer to an entire RAID set, a single hard drive, or a partition on a drive.



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- *The storage area network combines an array of storage devices and enables faster communication.*

File versus Block:

There is another key difference between data storage on a server (or NAS box), and how data is stored in a SAN. The former uses file level storage and the latter uses block level storage.

- File level storage is found in hard drives and NAS systems. The storage disk is configured with a protocol such as NFS or CIFS so that files are stored and accessed in bulk, for instance, on a file by file basis. This approach is simple and easy to implement.
- Block Level Storage creates raw volumes of storage where each block of data is controlled by the operating system as though it were an individual hard drive. These blocks of data are not tied to specific files. Block storage, then, manages LUNs as opposed to the individual files that are managed in NAS systems.

The advantages of block level storage include:

Management flexibility

- Easy storage management of databases
- Faster and more reliable data transportation
- The ability to treat each storage volume as an independent disk drive controlled by an external server operating system.
- Access and control privileges are easier to manage.

It used to be an either/or proposition – block storage or file storage. But more recently, storage systems have been developed which can deal with file storage and block level within a single appliance. These unified storage systems and hyper converged systems are becoming more common.

Storage Area Network Technology

Many SANs use the Fibre channel (FC) standard, which is a high-performance data communications technology supporting very fast data rates. FC SAN switches are used to connect devices within a SAN to create what is called the SAN fabric. These switches are somewhat similar to those functioning on regular Ethernet networks in that they act as points of connectivity for the network. By using FC SAN switch technology, dedicated paths are established between devices in the fabric to harness high bandwidth.

SANs are typically composed of elements such as:

- Fiber optic cables
- Disk or solid state drive (SSD) arrays
- Disk array (or flash) controllers
- Host Bus Adapters (HBAs). An HBA is basically an I/O adapter sitting between the bus of the host computer and the FC fabric. It is there to manage information transfer, and reduces the impact of the SAN on the performance of the host processor.
- FC switches

Fibre Channel network often have core and edge switches. Core switches are generally known as Director switches. They are often rack mounted chassis and have no single points of failure. Edge switches are smaller, simpler and don’t usually have as many redundancy features.

The problem with huge networks, of course, is that one small problem can impact the whole network. SANs get around this it to create smaller fabrics within the larger SAN. This is done using a variety of routing methods, some of which are vendor specific. SAN switches, for example, typically use Inter Switch Linking (ISL) to enable data to be transferred from one switch to another.

In addition to FC, some SANs utilize Fibre Channel over Ethernet (FCoE). This enables FC traffic to be moved across high speed Ethernet infrastructures. The advantages of this approach include the ability to converge storage and IP protocols onto a single cable.

iSCSI SAN

As well as the FC SAN, there is also Internet Small Computing System Interface (iSCSI) SAN (also sometimes known as the IP SAN). iSCSI storage enables data to be transported to and from storage devices over an IP network by serializing traffic from a SCSI connection. Normally used in small and medium-sized businesses as a cheaper alternative to FC, the iSCSI SAN has grown in prominence over the past decade. This is due to FC SANs having a reputation as being complex, difficult to manage, requiring highly trained (and well paid) specialists and overall being expensive. By using

Ethernet, the iSCSI SAN can transmit SCSI commands in IP packets so that there is no longer any need for an FC connection.

- Advantages: no need to learn, build and manage an FC network; using the same cabling for both the Ethernet-based LAN and storage.
- Disadvantages: the potential to clog up the LAN with too much traffic – thus iSCSI storage is used more by small and mid-sized organizations.

FC SANs, on the other hand, are mostly used by large organizations, as well as those who have distributed applications requiring fast local network performance. By offering multiple data paths, FC SANs offer better application performance and offload storage functions from IP networks.

Whether the organization uses an iSCSI SAN or an FC SAN, the effectiveness and use of storage is improved as administrators can consolidate resources and establish tiered storage:

- A top tier of super-fast storage for smaller data datasets and mission critical applications.
- Followed by successive tiers of slower storage and higher capacity.

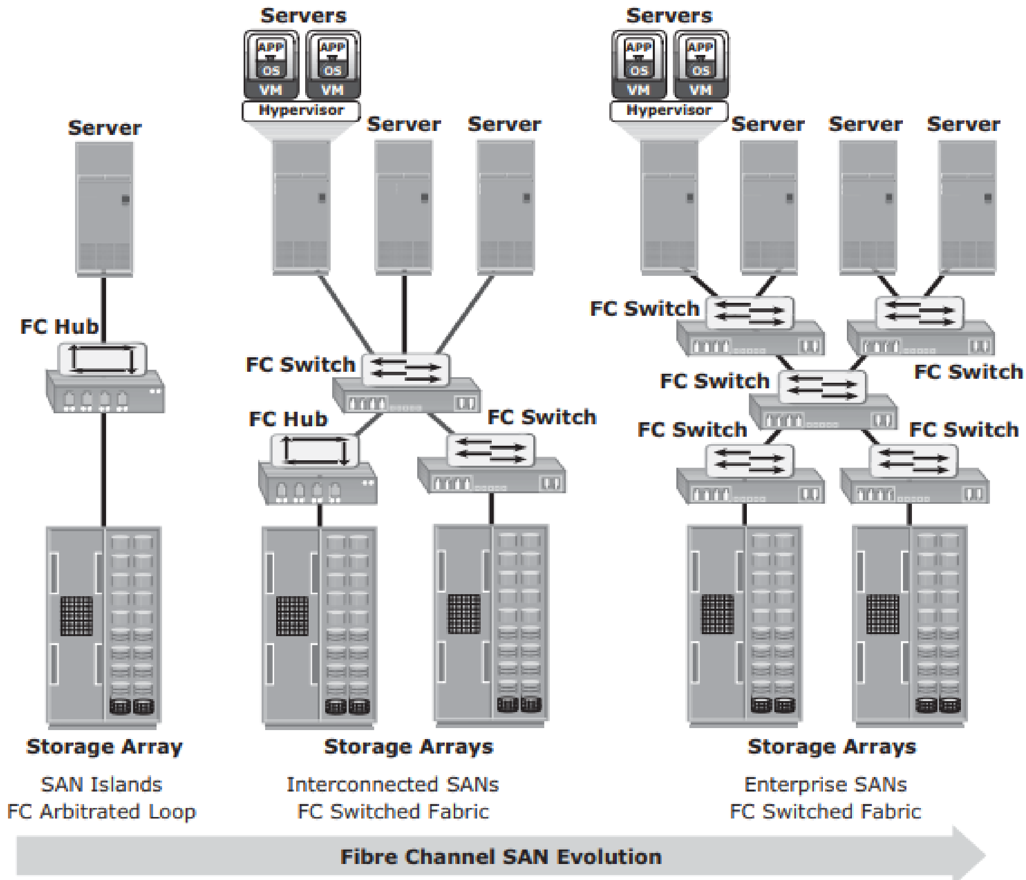
SAN software, of course, is also needed to organize servers, storage devices and network for functions such as data transfer. To move LUNs and add storage to existing file systems, volume management software is required. RAID is also used in SANs such as software-level RAID to provide a RAID 0 stripe.

A SAN (Storage Area Network) is designed to provide access to storage over a dedicated private fibre channel network. Fibre Channel networks can connect multiple hosts and multiple storage devices, and can even incorporate fibre channel switches for enhanced connectivity. SAN solutions are implemented more widely than any other networked storage solution.

A SAN presents shared pools of storage devices to multiple servers. Each server can a ccess the storage as if it were directly attached to that server. A SAN supports centraliz ed storage management.
SANs make it possible to move data between various storage devices, share data betw een multiple servers, and back up and restore data rapidly and efficiently.
In addition, a properly configured SAN facilitates both disaster recovery and high availa bility.

The physical components of a SAN can be grouped in a single rack or data center or co nnected over long distances.
This makes a SAN a feasible solution for businesses of any size: the SAN can grow eas ily with the business it supports.

Common SAN deployments are Fibre Channel (FC) SAN and IP SAN.
Fibre Channel SAN uses Fibre Channel protocol for the transport of data, commands, and status information between servers (or hosts) and storage devices.
IP SAN uses IP-based protocols for communication.



SAN Component Overview:

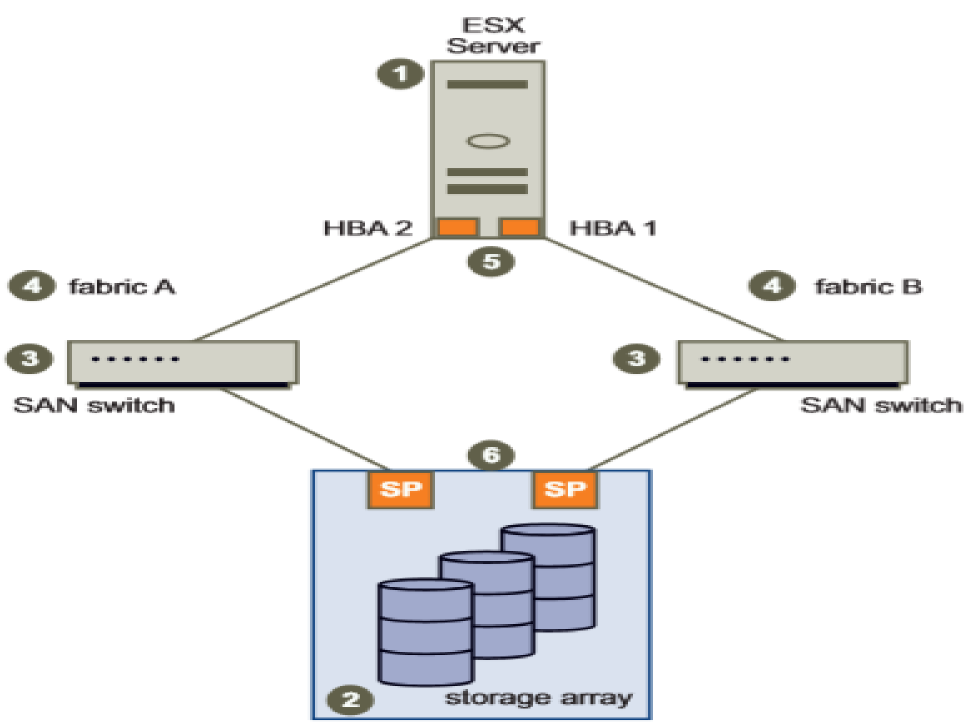


Figure1

This section gives an overview of SAN components. The numbers in the text correspond to numbers in **Fi gure1**, SAN Components.

In its simplest form, a SAN consists of one or more servers (1) attached to a storage array (2) using one o r more SAN switches. Each server might host numerous applications that require dedicated storage for

applications processing. The following components, discussed in more detail in SAN Components are inv olved:

- SAN Switches (3) SAN switches connect various elements of the SAN. In particular, they might connect hosts to storage arrays.

SAN switches also allow administrators to set up path redundancy in the event of a path failure from host server to switch or from storage array to switch.

- Fabric (4) The SAN fabric is the actual network portion of the SAN. When one or more SAN switches are connected, a fabric is created. The FC protocol is used to communicate over the entire network.

A SAN can consist of multiple interconnected fabrics. Even a simple SAN often consists of two fabrics for redundancy.

- Connections: Host Bus Adapters (5) and Storage Processors (6) Host servers and storage systems are connected to the SAN fabric through ports in the fabric.
  A host connects to a fabric port through an HBA.
  Storage devices connect to fabric ports through their storage processors.

How a SAN Works:

The SAN components interact as follows:

1. When a host wants to access a storage device on the SAN, it sends out a block-based access request for the storage device.
2. SCSI commands are encapsulated into FC packets. The request is accepted by the HBA for that host and is converted from its binary data form to the optical form required for transmission on the fiber optic cable.
3. At the same time, the request is packaged according to the rules of the FC protocol.
4. The HBA transmits the request to the SAN.
5. Depending on which port is used by the HBA to connect to the fabric, one of the SAN switches receives the request and sends it to the storage processor, which sends it on to the storage device.
   The remaining sections of this white paper provide additional information about the components of the SAN and how they interoperate.
   These sections also present general information on configuration options and design considerations.

SAN Components:

Figure 2 shows the SAN component layers.

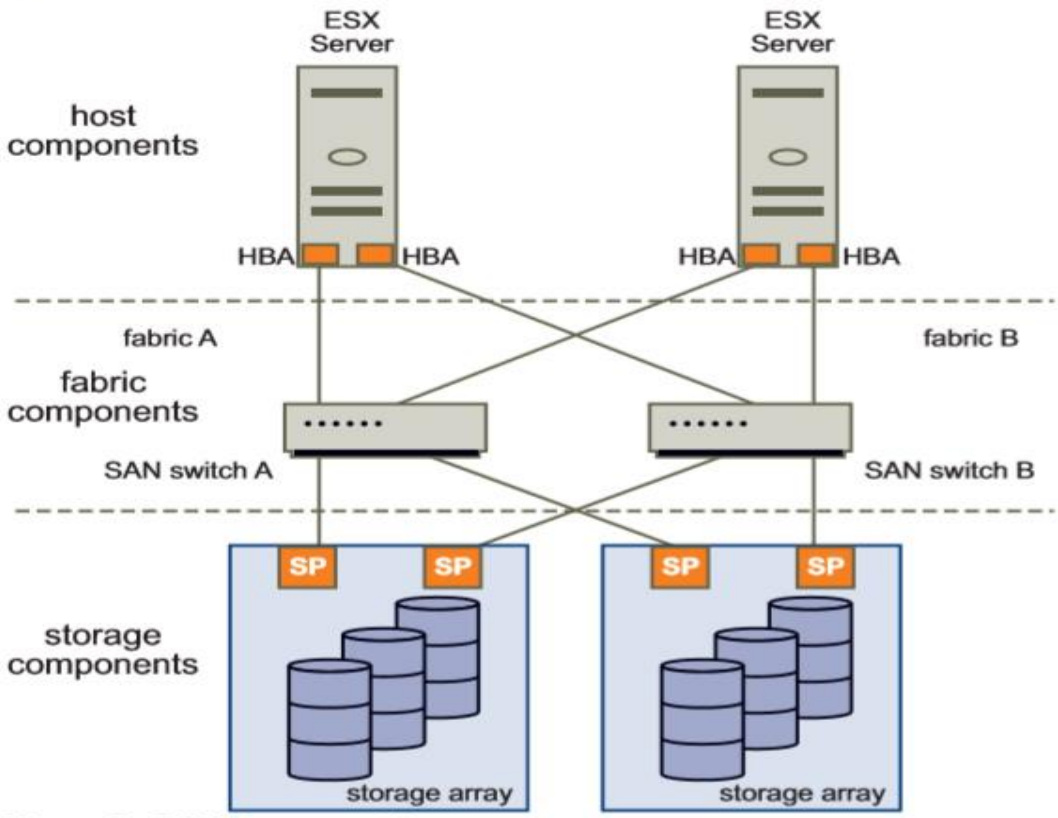


Figure 2. SAN Component Layers

The components of an FC SAN can be grouped as follows and are discussed below:

1. **Host Components**
2. **Fabric Components**
3. **Storage Components**

Host Components:

The host components of a SAN consist of the servers themselves and the components that enable the se rvers to be physically connected to the SAN.!
HBAs are located in the servers, along with a component that performs digital-to- optical signal conversion. Each host connects to the fabric ports through its HBAs.
HBA drivers running on the servers enable the servers operating systems to communicate with the HBA.

Fabric Components:

All hosts connect to the storage devices on the SAN through the SAN fabric. The network portion of the SAN consists of the following fabric components:

- **SAN Switches: -**
  - SAN switches can connect to servers, storage devices, and other switches, and thus prov ide the connection points for the SAN fabric.

  The type of SAN switch, its design features, and its port capacity all contribute to its overall capa city, performance, and fault tolerance.
  The number of switches, types of switches, and manner in which the switches are interconnecte d define the fabric topology.

  - **For smaller SANs**, the standard SAN switches (called modular switches) can typi cally support 16 or 24 ports (though some 32- port modular switches are becoming available). Sometimes modular switches ar e interconnected to create a fault-tolerant fabric.

- **For larger SAN fabrics**, director-class switches provide a larger port capacity (64 to 128 ports per switch) and bui lt-in fault tolerance.

- **Data Routers:**
  - Data routers are intelligent bridges between SCSI devices and FC devices in the SAN. Servers in the SAN can access SCSI disk or tape devices in the SAN through the data routers in the fa bric layer. !
- **Cables:**
  - SAN cables are usually special fiber optic cables that are used to connect all of the fabric co mponents. The type of SAN cable and the fiber optic signal determine the maximum distanc es between SAN components and contribute to the total bandwidth rating of the SAN. !
- **Communications Protocol:**
  - Fabric components communicate using the FC communications protocol. FC is the storage in terface protocol used for most of todays SANs. FC was developed as a protocol for transferri ng data between two ports on a serial I/O bus cable at high speeds. FC supports point-to-point,
    arbitrated loop, and switched fabric topologies. Switched fabric topology is the basis for mos t current SANs.

Storage Components:

The storage components of a SAN are the storage arrays. Storage arrays include storage processors (SPs) . The SPs are the front end of the storage array.
SPs communicate with the disk array (which includes all the disks in the storage array) and provide the R AID/LUN functionality.

Storage Processors:

SPs provide front-
side host attachments to the storage devices from the servers, either directly or through a switch.
The server HBAs must conform to the protocol supported by the storage processor. In most cases, this is the FC protocol.

Storage Devices:

Data is stored on disk arrays or tape devices (or both).
Disk arrays are groups of multiple disk devices and are the typical SAN disk storage device. They can vary greatly in design, capacity, performance, and other features.
Storage arrays rarely provide hosts direct access to individual drives. Instead, the storage array uses RAI D (Redundant Array of Independent Drives) technology to group a set of drives.
RAID uses independent drives to provide capacity, performance,
and redundancy. Using specialized algorithms, several drives are grouped to provide common pooled st orage.
These RAID algorithms, commonly known as RAID levels,
define the characteristics of the particular grouping.
In simple systems that provide RAID capability, a RAID group is equivalent to a single LUN. A LUN is a sin gle unit of storage. Depending on the host system environment,
a LUN is also known as a volume or a logical drive. From a VI Client, a LUN looks like any other storage u nit available for access. In advanced storage arrays,
RAID groups can have one or more LUNs created for access by one or more servers. The ability to create more than one LUN from a single RAID group provides fine granularity to the storage creation process. You are not limited to the total capacity of the entire RAID group for a single LUN.

Most storage arrays provide additional data protection and replication features such as snapshots, inter nal copies, and remote mirroring.

- A snapshot is a point-in-time copy of a LUN. Snapshots are used as backup sources for the overall backup procedures defined for the storage array.
- Internal copies allow data movement from one LUN to another for an additional copy for testing.
- Remote mirroring provides constant synchronization between LUNs on one storage array and a second, independent (usually remote) storage array for disaster recovery.

Understanding SAN Interactions

1. Here we will discuss how SAN components interact:
2. SAN Ports and Port Naming
3. Multipathing and Path Failover
4. Active/Active and Active/Passive Disk Arrays
5. Zoning

SAN Ports and Port Naming:

- A port is the connection from a device into the SAN. Each node in the SAN each host, storage device, and fabric component (router or switch) has one or more ports that connect it to the SAN.

Ports can be identified in a number of ways:

- WWPN World Wide Port Name. A globally unique identifier for a port which allows certain applications to access the port.

The FC switches discover the WWPN of a device or host and assign a port address to the device.

- Port_ID (or port address) Within the SAN, each port has a unique port ID that serves as the FC address for the port. This enables routing of data through the SAN to that port.

The FC switches assign the port ID when the device logs into the fabric. The port ID is valid only while the device is logged on.

In-depth information on SAN ports can be found at http://www.snia.org, the Web site of the Storage Networking Industry Association.

Multipathing and Path Failover:

An FC path describes a route:

- From a specific HBA port in the host,
- Through the switches in the fabric, and
- Into a specific storage port on the storage array.

A given host might be able to access a LUN on a storage array through more than one path. Having more than one path from a host to a LUN is **called multipathing.**

By default, VMware ESX Server systems use only one path from the host to a given LUN at any time. If the path actively being used by the VMware ESX Server system fails,
the server selects another of the available paths. The process of detecting a failed path and switching to another is called **path failover.**

A path fails if any of the components along the path HBA, cable, switch port, or storage processor fails.

Active/Active and Active/Passive Disk Arrays:

- It is useful to distinguish between active/active and active/passive disk arrays:
  An active/active disk array allows access to the LUNs simultaneously through all the storage proc
  essors that are available without significant performance degradation.
  All the paths are active at all times (unless a path fails).

- In an active/passive disk array, one SP is actively servicing a given LUN. The other SP acts as back
  up for the LUN and may be actively servicing other LUN I/O.
  I/O can be sent only to an active processor. If the primary storage processor fails, one of the sec
  ondary storage processors becomes active, either automatically or through administrator interv
  ention.

In Figure one storage processor is active, the other is passive. Data arrives through the active array only.

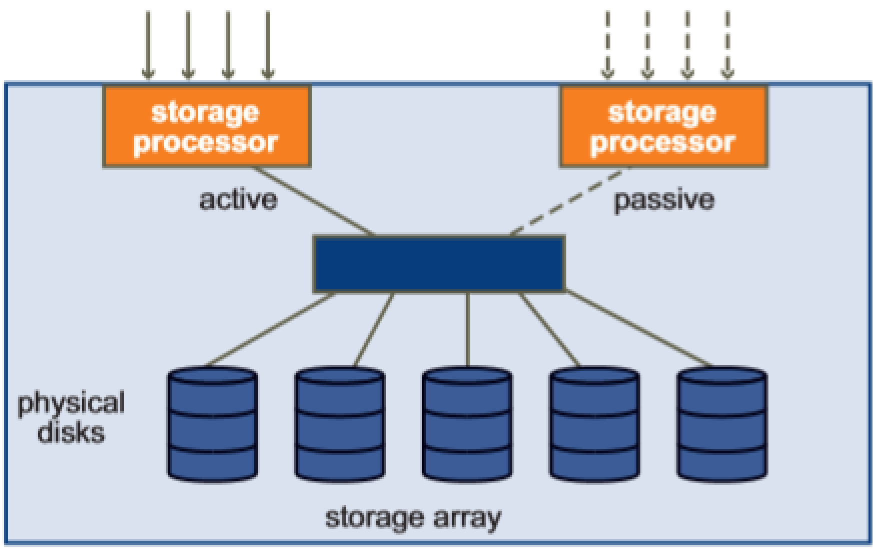


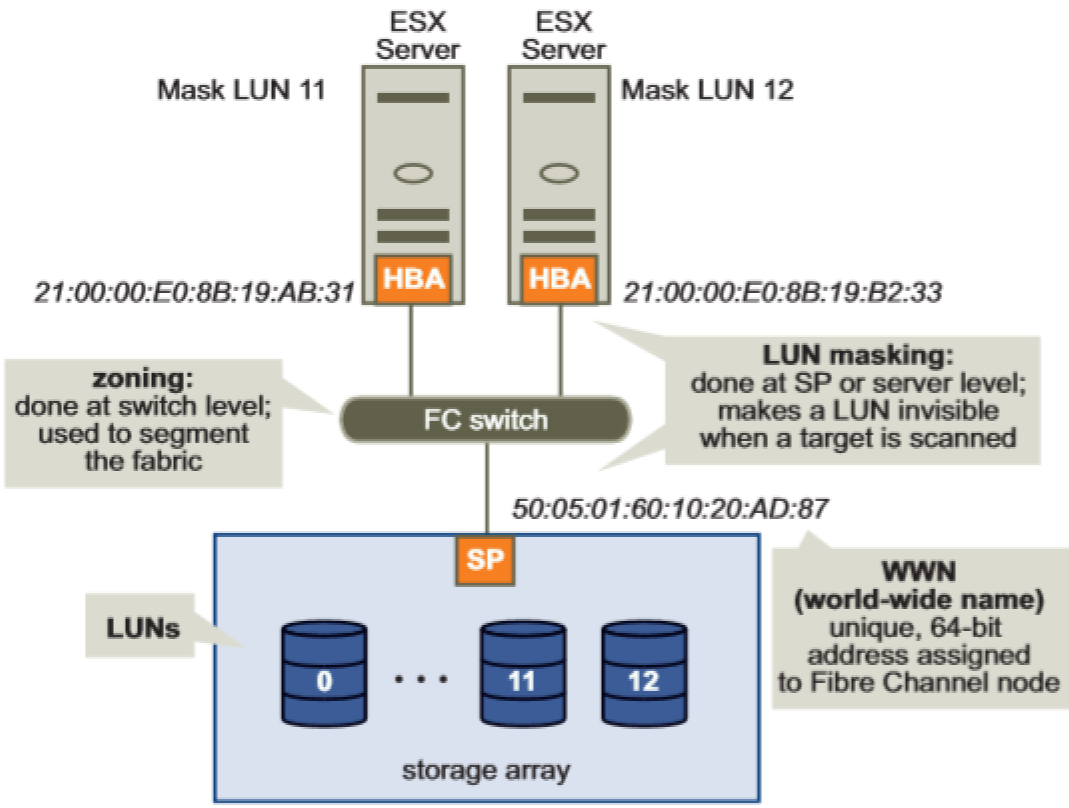
Figure Active/passive Storage Array

Zoning:

Zoning provides access control in the SAN topology; it defines which HBAs can connect to which SPs. You
 can have multiple ports to the same SP in different zones to reduce the number of presented paths.
When a SAN is configured using zoning, the devices outside a zone are not visible to the devices inside t
he zone. In addition, SAN traffic within each zone is isolated from the other zones
Within a complex SAN environment, SAN switches provide zoning. Zoning defines and configures the nec
essary security and access rights for the entire SAN.

LUN Masking:

LUN masking is commonly used for permission management. LUN masking is also referred to as selectiv
e storage presentation, access control, and partitioning,
depending on the vendor. LUN masking is performed at the SP or server level; it makes a LUN invisible
when a target is scanned. The administrator configures the disk array so each server or group
of servers can see only certain LUNs. Masking capabilities for each disk array are vendor specific, as are t
he tools for managing LUN masking



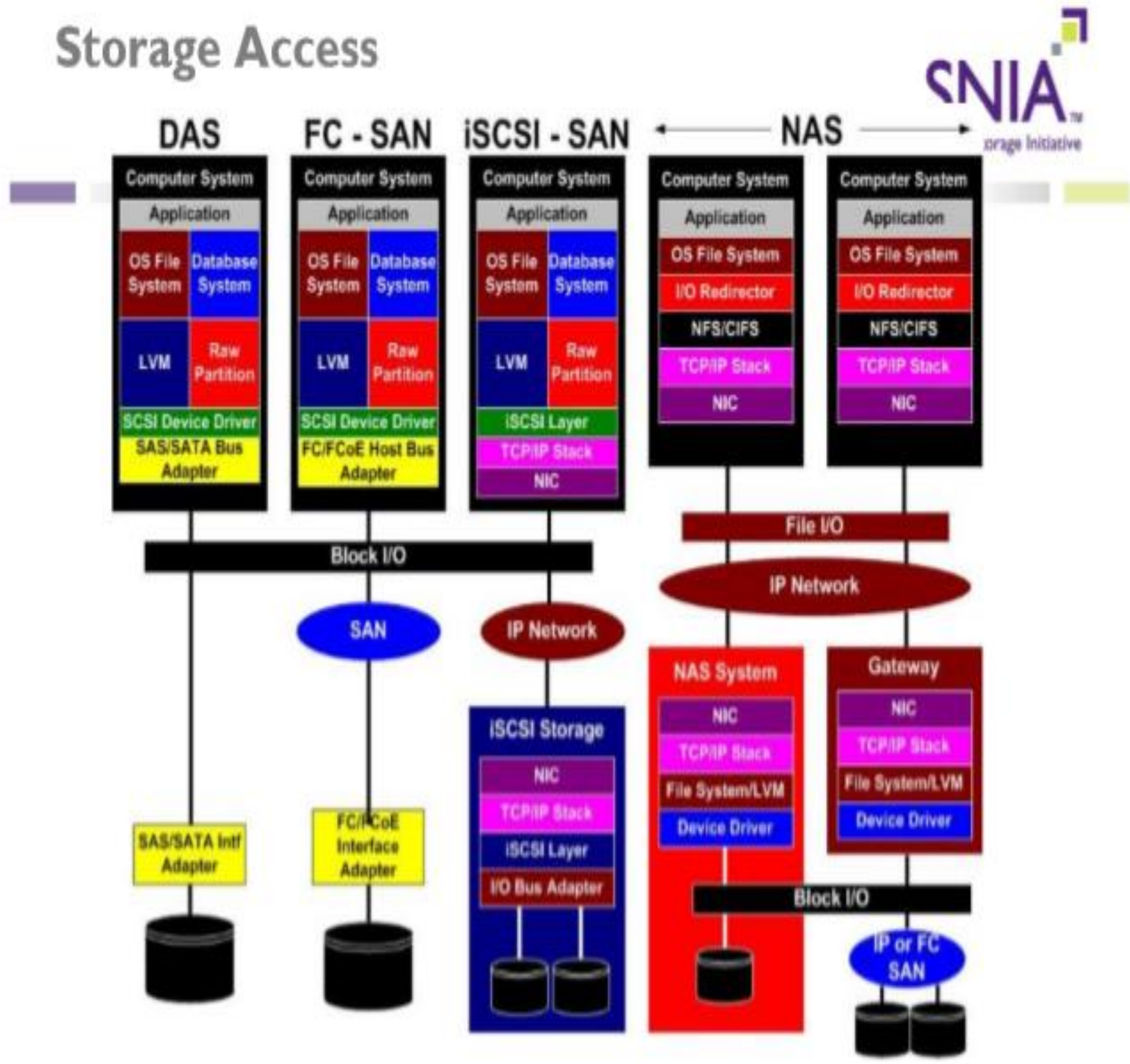
Benefits of SAN/Consolidated Storage:

- Storage consolidation
- Data sharing
- Non-disruptive scalability for growth
- Improved backup and recovery
- Tape pooling
- LAN-free and server-free data movement
- High performance
- High availability server clustering
- Data integrity
- Disaster tolerance
- Ease of data migration
- Cost-effectives (total cost of ownership)
- Reduce cost of external storage
- Increase performance
- Centralized and improved tape backup
- LAN-less backup
- High-speed, no single-point-of-failure clustering solutions
- Consolidation with > 70TB of storage

Difference between NAS & SAN

NAS	SAN
Almost any machine that connects to LAN (or interconnected to LAN via WAN) may utilize NFS,CIFS,HTTP Protocol to connect to NAS.	**Server class device that are equipped with SCSI fibr channel adapter connect to SAN. A Fibre Channel bases solution has a distance limit of approximately 6 miles.**

NAS identifies the data by the file name and byte offset, transfer file data or metadata, and handles security, user authentication, file locking	**A SAN Address the data by logical block numbers, and transfer the data in RAW disk blocks**
A NAS allows greater sharing of information, especially among different os.	
File system is managed by NAS head unit	
Backup and mirrors are generated on files.	



How a SAN Works The SAN components interact as follows:?

- When a host wants to access a storage device on the SAN, it sends out a block-based access request for the storage device.
- SCSI commands are encapsulated into FC packets.
  The request is accepted by the HBA for that host and is converted from its binary data form to th e optical form required for transmission on the fiber optic cable.
- At the same time, the request is packaged according to the rules of the FC protocol.
- The HBA transmits the request to the SAN.
- Depending
  on which port is used by the HBA to connect to the fabric, one of the SAN switches receives the r equest and sends it to the storage processor, which sends it on to the storage device.

NAS and SAN Use Cases

NAS and SAN serve different needs and use cases. Understand what you need and where you need it.

NAS: When you need to consolidate, centralize, and share.

- **File storage and sharing.** This is NAS major use case in mid-sized, SMB, and enterprise remote offices. A single NAS device allows IT to consolidate multiple file servers for simplicity, ease of management, and space and energy savings.
- **Active archives.** Long-term archives are best stored on less expensive storage like tape or cloud-based cold storage. NAS is a good choice for searchable and accessible active archives, and high capacity NAS can replace large tape libraries for archives.
- **Big data.** Businesses have several choices for big data: scale-out NAS, distributed JBOD nodes, all-flash arrays, and object-based storage. Scale-out NAS is good for processing large files, ETL (extract, transform, load), intelligent data services like automated tiering, and analytics. NAS is also a good choice for large unstructured data such as video surveillance and streaming, and post-production storage.
- **Virtualization.** Not everyone is sold on using NAS for virtualization networks, but the usage case is growing and VMware and Hyper-V both support their datastores on NAS. This is a popular choice for new or small virtualization environments when the business does not already own a SAN.
- **Virtual desktop interface (VDI).** Mid-range and high-end NAS systems offer native data management features that support VDI such as fast desktop cloning and data deduplication.

SAN: When you need to accelerate, scale, and protect.

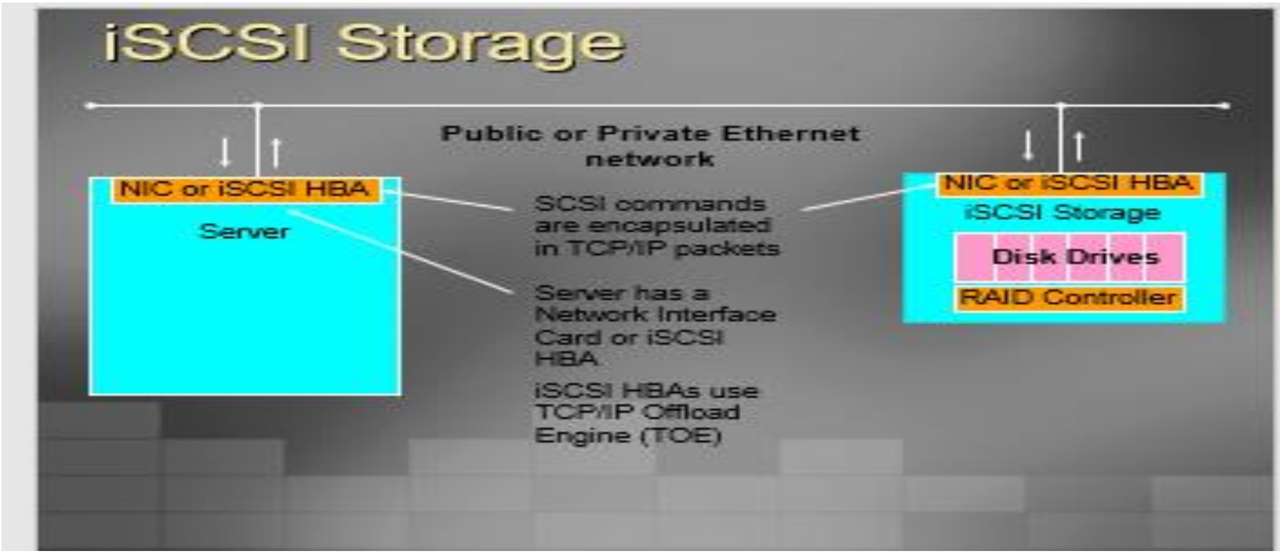
- **Databases and ecommerce websites.** General file serving or NAS will do for smaller databases, but high-speed transactional environments need the SAN's high I/O processing speeds and very low latency. This makes SANs a good fit for enterprise databases and high traffic ecommerce websites.
- **Fast backup.** Server operating systems view the SAN as attached storage, which enables fast backup to the SAN. Backup traffic does not travel over the LAN since the server is backing up directly to the SAN. This makes for faster backup without increasing the load on the Ethernet network.
- **Virtualization.** NAS supports virtualized environments, but SANs are better suited to large-scale and/or high-performance deployments. The storage area network quickly transfers multiple I/O streams between VMs and the virtualization host, and high scalability enables dynamic processing.
- **Video editing.** Video editing applications need very low latency and very high data transfer rates. SANs provide this high performance because it cables directly to the video editing desktop client, dispensing with an extra server layer. Video editing environments need a third-party SAN distributed file system and per-node load balancing control.

SAN and NAS Convergence

Unified (or multi-protocol) SAN/NAS combines file and block storage into a single storage system. These unified systems support up to four protocols. The storage controllers allocate physical storage for NAS or SAN processing.

They are popular for mid-range enterprises who need both SAN and NAS, but lack data center space and specialized admins for separate systems. Converged SAN/NAS are a much smaller part of the market than distinct deployments but show steady growth

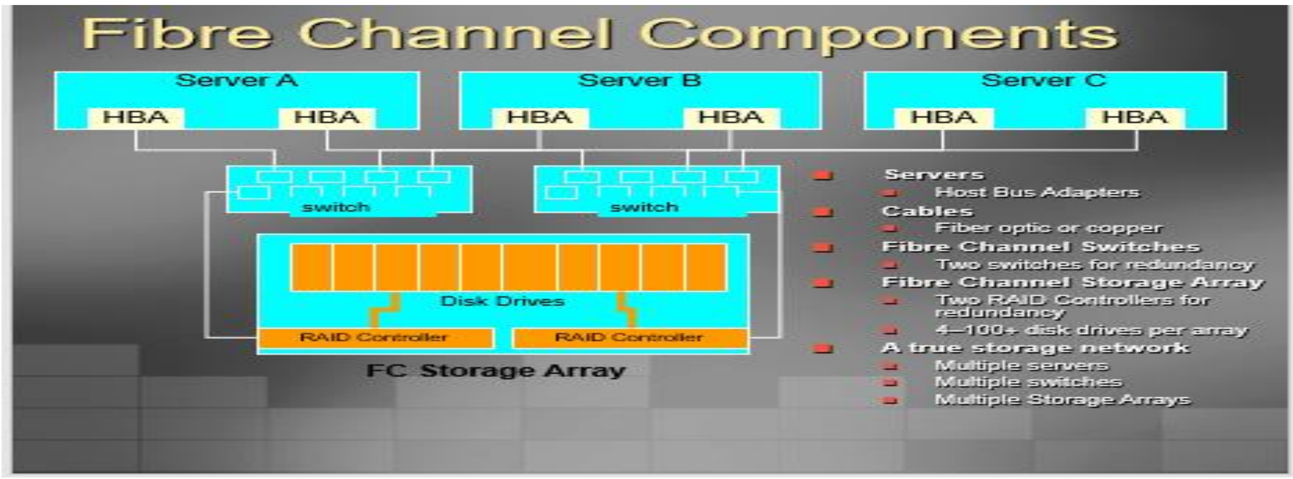
iSCSI: What is it?



- An alternate form of networked storage
- Like NAS, also utilizes a TCP/IP network
- Encapsulates native SCSI commands in TCP/IP packets
- Supported in Windows 2003 Server and Linux
- TCP/IP Offload Engines (TOEs) on NICs speed up packet encapsulation
- iSCSI (Internet SCSI) storage systems are similar to NAS in that communication between servers and storage is accomplished over standard TCP/IP networks. However, iSCSI does not utilize file protocols for data transport. Instead, SCSI commands are encapsulated in TCP/IP packets and sent over the network (encryption may also be performed). iSCSI is supported through the operating system. Both Windows 2003 Server and Linux support iSCSI.

iSCSI communication can occur through standard Network Interface cards. However, the OS then incurs substantial overhead in managing TCP/IP encapsulation. A new type of NIC for storage is arriving on the market, sort of an iSCSI HBA. These cards use an onboard TCP/IP Offload Engine (TOE). TOEs perform encapsulation at the hardware level, freeing processor cycles on the server.
Although the performance of iSCSI is not yet up to the speed of SCSI or SAN storage, the pace of improvement is rapid. The performance is perfectly acceptable for Small to Medium sized Businesses, and works well with non-mission critical databases. With the adoption of 10 Gigabit networks, iSCSI will become increasingly attractive, even for mission critical applications. Recently, high-performance iSCSI systems have been benchmarked at 90% of the performance of Fibre Channel SANs, at an attractive price/performance ratio.

Fibre Channel: What is it?



- Fibre Channel is a network protocol implemented specifically for dedicated storage networks
- Fibre Channel utilizes specialized
- Switches
- Host Bus Adapters
- RAID controllers
- Cables
- Provides concurrent communications between servers, storage devices, and other peripherals
- A gigabit interconnect technology
- FC1: Over 1,000,000,000 bits per second
- FC2: Over 2,000,000,000 bits per second
- A highly reliable interconnect
- Up to 127 devices (SCSI: 15)
- Up to 10 km of cabling (3-15 ft. for SCSI)
- Physical interconnect can be copper or fiber optic
- Hot-pluggable - Devices can be removed or added at will with no ill effects to data communications
- Provides a data link layer above the physical interconnect, analogous to Ethernet
- Sophisticated error detection at the frame level
- Data is checked and resent if necessary

A Fibre Channel SAN is a true network for storage. A SAN consists of one or more servers, one or more switches, and one or more Fibre Channel Storage Arrays. Components are connected by fiber optic cables (copper cabling may also be used). For redundancy and fail-over capabilities, many components may be doubled. This includes HBAs, switches, and RAID Controllers.
The most widely implemented SAN technology is currently based on the Fibre Channel protocol. Fibre channel features up to 127 devices within a network, with up to 10 KM of cabling. This is substantially more than SCSI offers. FC2 can operate at two gigabit speed, making it faster than the Ethernet networks implemented at most sites.

As quoted from the Garner Group in October of 1999, the benefits of using Fibre Channel storage include:

- Greater distance between servers and storage (as much as 10km)
- Links are simpler and more reliable than SCSI
- Disk storage consolidation is facilitated
- Tape resources can be shared on loops and switched fabrics in conjunction with resource serialization storage management software

- FC-connected disk storage and tape libraries, combined with FC switches and appropriate software in a SAN will allow Windows NT servers to support outboard backup. Data moves form disk to tape over the SAN, unloading the servers and eliminating server bus bandwidth as a constraint on backup speed.

SCSI vs. Fibre Channel *Protocol:*

- SCSI
    - SCSI protocol vs. SCSI device
    - SCSI is an established, tried and true protocol
    - Provides services analogous to TCP/IP
    - Supported in every major OS on market
- Fibre Channel
    - Fibre Channel runs on top of SCSI
    - No re-inventing the wheel
    - Immediate OS support

Sometimes the term “SCSI” refers to the SCSI protocol and sometimes it is used to refer to a SCSI device. We’ll discuss the protocol first. SCSI is a protocol and command set that provides services similar to TCP/IP. It’s been in use for a long time and when Fibre Channel was introduced, there was no reason to change the protocol that is used to communicate between devices. (Why re-invent the wheel? SCSI was already tested and accepted w/ every major operating system on the market.) So the *protocol* that Fibre Channel uses is SCSI.

SCSI vs. Fibre Channel

<table>
<tr><th colspan="2"><u>SCSI vs. Fibre Channel</u></th></tr>
<tr>
<td>■ Interface for internal storage to external disks
■ Potential down time w/ SCSI
■ Single bus
■ RAID controller is SCSI hardware
■ Standards:
    ■ Ultra2 (80 MB/sec)
    ■ Ultra 160 (160 MB/sec)
    ■ Ultra 320 (320 MB/sec)
■ Media specific (copper only)
■ SCSI Limitations:
    ■ Cables can’t be any longer than 3 feet for single ended; 15 feet for LVD (low voltage differential)
    ■ No more than 15 devices on a SCSI bus
    ■ # of disk drives</td>
<td>■ Used with SAN
■ Lots of built-in redundancy with connections
■ Redundant network
■ HBA is fibre channel hardware
■ Standards:
    ○ FC1: 100 MB/sec
    ○ FC2: 200 MB/sec
■ Provides a data link layer above the physical interconnect
    ○ Analogous to Ethernet
    ○ FC is a network of devices
    ○ It can be media independent- copper or fibre optic
■ Fibre Channel limitations:
    ○ Cable length: Up to 10 kilometers (more a limitation of cable than FC itself)
    ○ Up to 127 devices
    ○ # of disk drives</td>
</tr>
</table>

The biggest difference between SCSI and Fibre Channel is availability. Fibre Channel was designed w/ all sorts of built-in redundancy. Part of the reason Fibre Channel came about was that people were looking to overcome downtime associated with SCSI. For example, with SCSI, if you break a cable, SCSI is going to die. Unlike SCSI, Fibre Channel is not limited to a single physical loop. A break on one cable in an FC network will not automatically disable devices connected to other cables. In addition, multiple Fibre Channel connections may be utilized between FC devices. This allows for virtually unlimited redundancy, so that the loss of one cable need not disrupt communications at all.

SCSI is single bus – FC is redundant network for all components to talk to each other.

SCSI hardware: Disk drives and controller – e.g. raid controller is SCSI hardware
With fibre channel, you still have a RAID controller, but, by definition, it will be on the external storage. It will do the logical to physical translation of data, but the physical transfer from the internal system to the external storage will be handled by an HBA.

3 predominant SCSI standards:

– Ultra2 (80 megabytes/sec)
– Ultra 160 – 160 MB per sec
– Ultra 320 – 320 MB per sec

Fibre Channel standards:

- FC1 – 100 MB/sec
- FC2 – 200 MB/sec

So how important is this difference in bandwidth? It depends on what you're doing. When you're talking about database applications, you usually never come close to using the entire bandwidth – it's hardly ever the limiting factor.

Fibre Channel provides a data link layer above the physical interconnect; analogous to Ethernet. This is completely different from SCSI. FC is network of devices that can be media independent – that's why it can run on copper or fibre optic. SCSI has to run on copper

Fibre channel is closer to a network. Devices talk either fiber optic or copper. Fibre channel changes the network – the physical layer - that things run across. There's no way to run on a different medium on SCSI. SCSI is media specific.

The limitations with SCSI and FC are also different. Cables have to be certain length: With SCSI, no more than 3 feet. No more than 15 devices on a SCSI bus (bus sort of analogous to FC loop – which can have 127 devices). SCSI pins have to be a certain way. IF SCSI were to change, then have to change every device to accommodate. With FC, if ran diff media – would have to change cables, but not devices.
The number of disk drives that you can connect with SCSI is going to be less than with Fibre Channel. Lets say that you have 4 SCSI buses with 15 devices (a controller or a disk) on each, then you can have 60 devices.

Whereas you can get 127 devices on a fibre channel loop. (Assuming no other devices on that loop.)

SCSI Storage Characteristics

The average SCSI clustered solution allows at most two RAID controllers for clustered disks. For most SCSI systems on the market, this results in a maximum of 24 - 48 disk drives for the cluster's shared disks. If that amount of storage is not sufficient for the customer's current and future growth needs, then Fibre Channel solutions should be considered.

Fibre Channel

Like SCSI, Fibre Channel is another means of attaching storage to a computer. The big differences between Fiber Channel and SCSI is the redundancy that it allows you and the higher availability (don't know if we want to get into needing terminal on SCSI, etc.) A common misconception about Fiber Channel is that it is faster than SCSI. In reality, it's not necessarily faster, but may allow more I/Os (and the increased redundancy & higher availability).

Fibre Channel Characteristics

Fibre Channel provides high availability through redundant Fibre Channel host bus adapters (HBAs) in the servers and dual storage processors in the storage system.
Fibre Channel also requires dual standby power supplies (SPS) in the storage system, which provides integrity of the storage processor write-cache in case one power supply fails. Thus write-caching may be enabled, which will improve disk write performance. With SCSI, write-caching may not be used with a failover cluster.

Fibre Channel allows for easy storage subsystem growth. It is relatively easy to add disks to Fibre Channel storage system without having to shutdown the system. A directly connected Fibre Channel solution can support greater than 200 disks on one array. For a Storage Attached Network (SAN) solution, it is possible to have greater than 900 disks on one cluster connecting through a Fibre Channel switch. The same switch can also support additional stand-alone systems and clusters.

Although Fibre Channel systems are typically more expensive than SCSI, the expandability and flexibility is much greater than SCSI.

Fibre Channel vs. iSCSI

Fibre Channel vs. iSCSI	
Fibre Channel	**iSCSI**
■ The current market leader for shared storage technologies ■ Provides the highest performance levels ■ Designed for mission-critical applications ■ Cost of components is relatively high, particularly per server HBA costs ■ Relatively difficult to implement and manage	■ Relatively new, but usage is increasing rapidly ■ Performance can approach Fibre Channel speeds ■ A better fit for databases than NAS ■ A good fit for Small to Medium Size Businesses ■ Relatively inexpensive, compared to Fibre Channel ■ Relatively easy to implement and manage

Storage types

- Single Disk Drive
- JBOD
- Volume
- Storage Array
- SCSI device
- DAS
- NAS
- SAN
- iSCSI

How data is stored once it gets to the storage disk drive(s) depends on the type of storage selected. Data storage comes in many different formats. We're all familiar with what it's like save a file to our hard drive or to a floppy or CD. Those are all forms of storage. Obviously, it can get a lot more complicated than that. Following is a list of the most common types of data storage:
Single disk drive (self-explanatory)

JBOD –

just a bunch of disks. This is collection of disk drives pooled together for storage, but without any RAID, striping, etc.

Volume –

a "logical" disk drive. A concatenation of drives. When one fills up, it goes to the next one. No RAID, no striping. To the OS, a logical volume looks like one disk drive.

Storage Array –

Also a group of more than one disk joined together – but can do striping and/or redundancy. Implies some type of RAID (whatever the level).

SCSI –

SCSI stands for Small Computer System Interface. It is a means of attaching additional storage to a computer. For example, a typical RAID Controller is a SCSI device that allows connection to an external storage enclosure with multiple drives.
The **SCSI** standards define commands, protocols, electrical, optical and logical interfaces. **SCSI** is most commonly used for hard disk drives and tape drives, but it can connect a wide range of other devices, including scanners and CD drives, although not all controllers can handle all devices

NAS –

Network Attached Storage. Sometimes rather than simply attaching storage to one machine, it is attached to the computer network. That way, multiple machines can access the storage.
A file protocol must be used to communicate across the network.

ISCSI –

Internet/SCSI protocol. Another approach to offering storage on a network. Rather than using file protocols to communicate across a TCP/IP network, native SCSI commands are "encapsulated" in TCP/IP packets. An evolving standard that has already been adopted in Windows 2003 Server.

SAN –

Storage Area Network. Whereas a NAS is storage that is attached to a network, SAN is a storage network in and of itself that can be attached to multiple machines. SAN is an industry-wide term for both the storage and the switching network. A SAN does not have the protocol conversion overhead of NAS or ISCSI, and tends to offer better performance. However, a SAN may require a higher initial investment in infrastructure.

Data Protection: RAID

- Software RAID:
    - Software RAID uses host-based software to provide RAID functions. It is implemented at the operating-system level and does not use a dedicated hardware controller to manage the RAID array.
- Hardware RAID:
    - In hardware RAID implementations, a specialized hardware controller is implemented either on the host or on the array. Controller card RAID is a host-based hardware RAID

implementation in which a specialized RAID controller is installed in the host, and disk drives are connected to it. Manufacturers also integrate RAID controllers on motherboards. A host-based RAID controller is not an effi cient solution in a data center environment with a large number of hosts.

RAID Array Components:

A RAID array is an enclosure that contains a number of disk drives and supporting hardware to implement RAID. A subset of disks within a RAID array can be grouped to form logical associations called logical arrays, also known as a RAID set or a RAID group (see Figure)

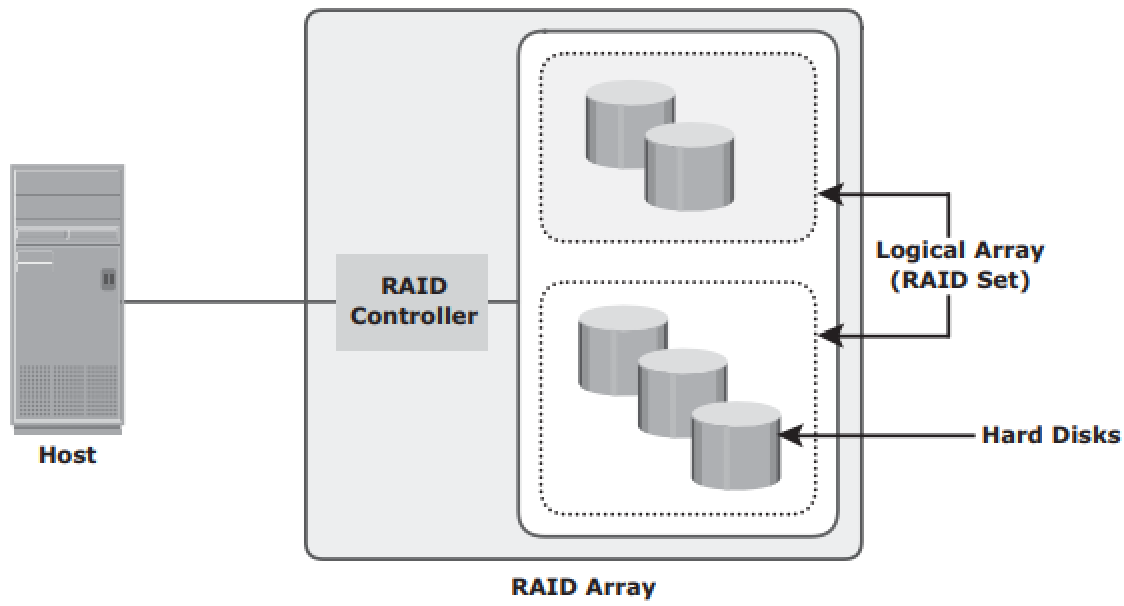


Figure : Components of a RAID array

RAID Techniques:

RAID techniques — Striping, mirroring, and parity — form the basis for defining various RAID levels. These techniques determine the data availability and performance characteristics of a RAID set.

Striping:

a. Striping is a technique to spread data across multiple drives (more than one) to use the drives in parallel. All the read-write heads work simultaneously,
b. Allowing more data to be processed in a shorter time and increasing performance, compared to reading and writing from a single disk. Within each disk in a RAID set, a predefined number of contiguously addressable disk blocks are defined as a strip. The set of aligned strips that spans across all the disks within the RAID set is called a stripe. Figure 3 shows physical and logical representations of a striped RAID set.

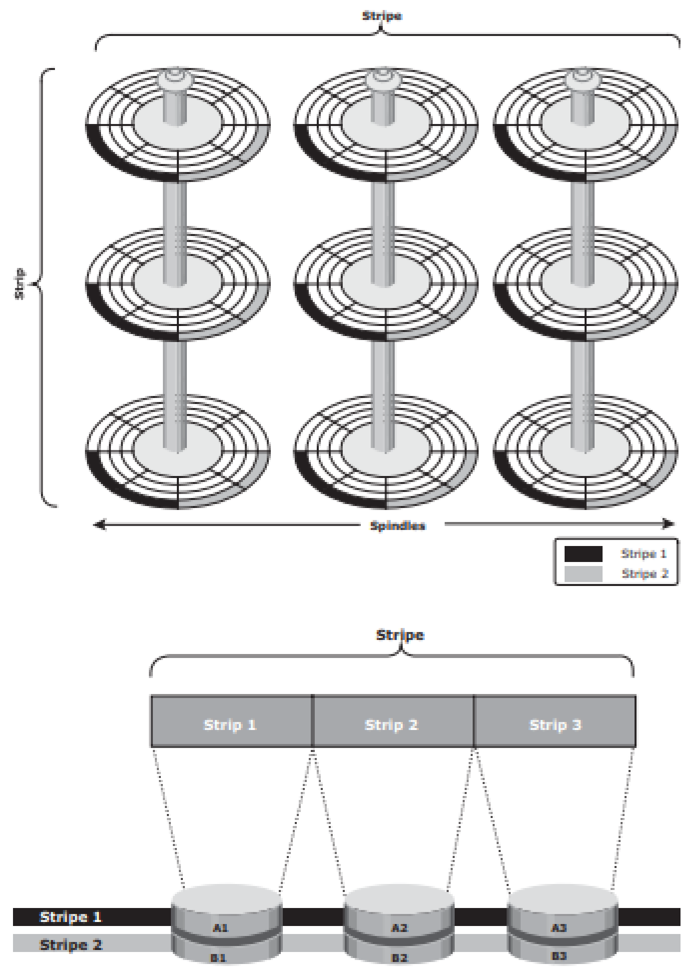


Figure 3 : Striped RAID set

Mirroring:

c. Mirroring is a technique whereby the same data is stored on two different disk drives, yielding two copies of the data. If one disk drive failure occurs, the data is intact on the surviving disk drive (see Figure 3-3) and the controller continues to service the host's data requests from the surviving disk of a mirrored pair. When the failed disk is replaced with a new disk, the controller copies the data from the surviving disk of the mirrored pair. This activity is transparent to the host. In addition to providing complete data redundancy, mirroring enables fast recovery from disk failure. However, disk mirroring provides only data protection and is not a substitute for data backup. Mirroring constantly captures changes in the data, whereas a backup captures point-in-time images of the data. Mirroring involves duplication of data — the amount of storage capacity needed is twice the amount of data being stored. Therefore, mirroring is considered expensive and is preferred for mission-critical applications that cannot afford the risk of any data loss. Mirroring improves read performance because read requests can be serviced by both disks. However, write performance is slightly lower than that in a single disk because each write request manifests as two writes on the disk drives. Mirroring does not deliver the same levels of write performance as a striped RAID.

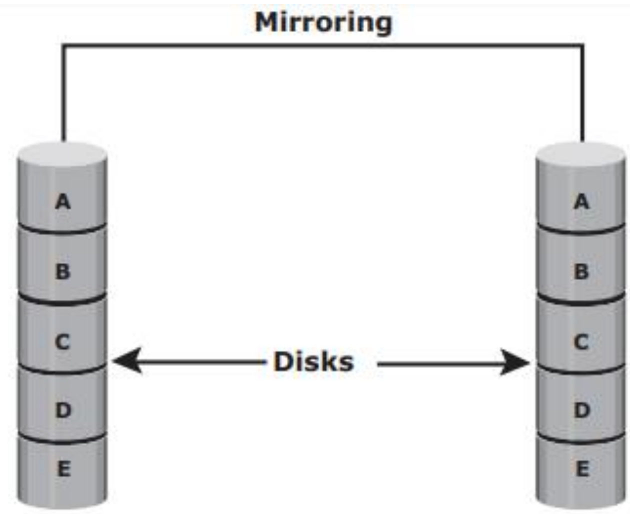


Figure Mirrored disks in an array

Parity:

d. Parity is a method to protect striped data from disk drive failure without the cost of mirroring. An additional disk drive is added to hold parity, a mathematical construct that allows re-creation of the missing data. Parity is a redundancy technique that ensures protection of data without maintaining a full set of duplicate data. Calculation of parity is a function of the RAID controller. Parity information can be stored on separate, dedicated disk drives or distributed across all the drives in a RAID set. **Figure** below shows a parity RAID set. The first four disks, labeled “Data Disks,” contain the data. The fifth disk, labeled “Parity Disk,” stores the parity information, which, in this case, is the sum of the elements in each row. Now, if one of the data disks fails, the missing value can be calculated by subtracting the sum of the rest of the elements from the parity value. Here, for simplicity, the computation of parity is represented as an arithmetic sum of the data. However, parity calculation is a bitwise XOR operation.

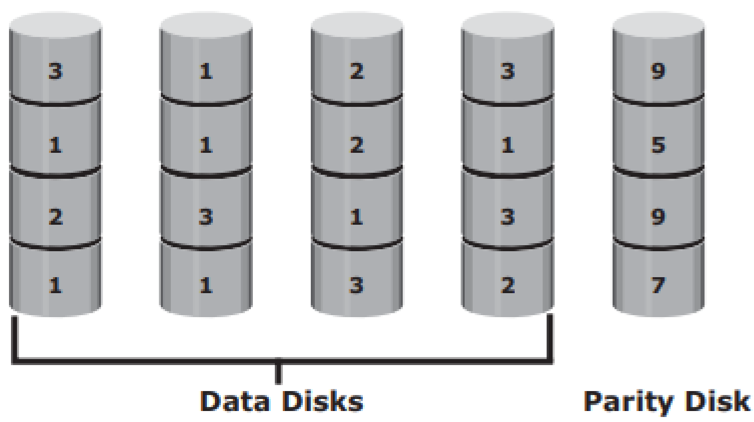


Figure : Parity RAID

RAID Levels:

Application performance, data availability requirements, and cost determine the RAID level selection. These RAID levels are defined on the basis of striping, mirroring, and parity techniques. Some RAID levels use a single technique, whereas others use a combination of techniques. Table 3-1 shows the commonly used RAID levels.

Table 3-1: Raid Levels

LEVELS	BRIEF DESCRIPTION
RAID 0	Striped set with no fault tolerance

RAID 1	Disk mirroring
RAID 2	Combinations of RAID levels. Example: RAID 1 + RAID 0
RAID 3	Striped set with parallel access and a dedicated parity disk
RAID 4	Striped set with independent disk access and a dedicated parity disk
RAID 5	Striped set with independent disk access and distributed parity
RAID 6	Striped set with independent disk access and dual distributed parity

Traditional RAID levels

LEVEL	DESCRIPTION
RAID 0	■ Data striped across hard disk drives for maximum write performance ■ No actual data protection
RAID 1	■ Synchronously mirrors all data from each HDD to an exact duplicate HDD ■ No data lost if HDD faults or fails ■ Typically highest-performing RAID level at the expense of lower usable capacity
RAID 2	■ Data protected by error correcting codes ■ Parity HDD requirements proportional to the log of HDD number ■ Somewhat inflexible and less efficient than RAID 5 or RAID 6 with lower performance and reliability ■ Not widely used
RAID 3	■ Data is protected against the failure of any HDD in a group of N+ ■ Similar to RAID 5, but blocks are spread across HDDs ■ Parity is bitwise vs. RAID 5 block ■ Parity resides on a single HDD rather than being distributed among all disks ■ Random write performance is quite poor, and random read performance fair at best
RAID 4	■ Similar to RAID 3, stripes data across many HDDs in blocks instead of RAID 3 bytes to improve random access performance ■ Data protection is provided by a dedicated parity HDD ■ Similar to RAID 5 except uses dedicated parity instead of distributed parity ■ Dedicated parity HDD remains a bottleneck, especially for random write performance
RAID 5	■ Most common RAID ■ Provides RAID 0 performance with more economical redundancy ■ Stripes block data across several HDDs while distributing parity among the HDDs ■ Uses HDDs more efficiently, providing overlapped read/write operations ■ Provides more usable storage than RAID 1 or RAID 10 ■ Data protection comes from parity information used to reconstruct data of a failed drive ■ Minimum of three and usually five HDDs per RAID group ■ Rebuilds cause lower storage system performance ■ Potential total RAID group data loss if second drive fails during rebuild ■ Read performance tends to be lower than other RAID types because parity data is distributed on each HDD
RAID 6	■ Similar to RAID 5, but includes a second parity scheme distributed across the HDDs of the RAID group ■ Dual parity protects against data loss if second HDD fails ■ Tends to have lower storage system performance than RAID 5 and can plummet during dual HDD rebuilds
RAID 10 (RAID 1 + RAID 0)	■ RAID 1 striped ■ Improves write performance
RAID 50 (RAID 5 + RAID 0)	■ RAID 5 striped ■ Improves write performance closer to RAID 1
RAID 60 (RAID 6 + RAID 0)	■ RAID 6 striped ■ Improves write performance closer to RAID 1

RAID is a technology that is used to increase the performance and/or reliability of data storage. The abbreviation stands for either *Redundant Array of Inexpensive Disks* or *Redundant Array of Independent Drives*. A RAID system consists of two or more drives working in parallel. These can be hard discs, but there is a trend to also use the technology for SSD (Solid State Drives). There are different RAID levels, each optimized for a specific situation. These are not standardized by an industry group or standardization committee. This explains why companies sometimes come up with their own unique numbers and implementations.

- **RAID 0** – striping
- **RAID 1** – mirroring
- **RAID 5** – striping with parity
- **RAID 6** – striping with double parity
- **RAID 10** – combining mirroring and striping

The software to perform the RAID-functionality and control the drives can either be located on a separate controller card (a hardware RAID controller) or it can simply be a driver. Some versions of Windows, such as Windows Server 2012 as well as Mac OS X, include software RAID functionality. Hardware RAID controllers cost more than pure software, but they also offer better performance, especially with RAID 5 and 6.

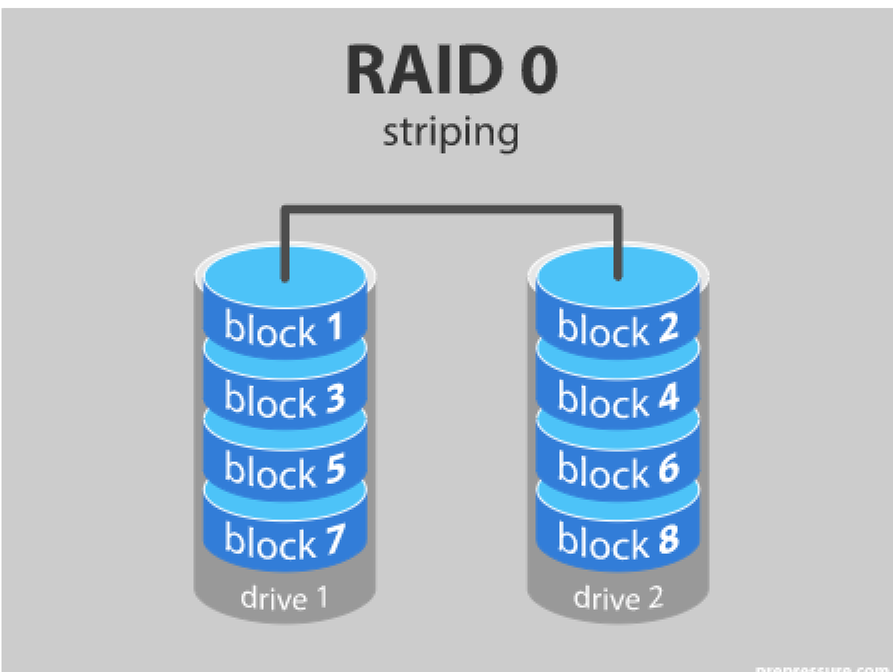
RAID-systems can be used with a number of interfaces, including SCSI, IDE, SATA or FC (fiber channel.) There are systems that use SATA disks internally, but that have a FireWire or SCSI-interface for the host system.

Sometimes disks in a storage system are defined as JBOD, which stands for *'Just a Bunch Of Disks'*. This means that those disks do not use a specific RAID level and acts as stand-alone disks. This is often done for drives that contain swap files or spooling data.

Below is an overview of the most popular RAID levels:

RAID level 0 – Striping

In a RAID 0 system data are split up into blocks that get written across all the drives in the array. By using multiple disks (at least 2) at the same time, this offers superior I/O performance. This performance can be enhanced further by using multiple controllers, ideally one controller per disk.



Advantages

- RAID 0 offers great performance, both in read and write operations. There is no overhead caused by parity controls.
- All storage capacity is used, there is no overhead.
- The technology is easy to implement.

Disadvantages

- RAID 0 is not fault-tolerant. If one drive fails, all data in the RAID 0 array are lost. It should not be used for mission-critical systems.

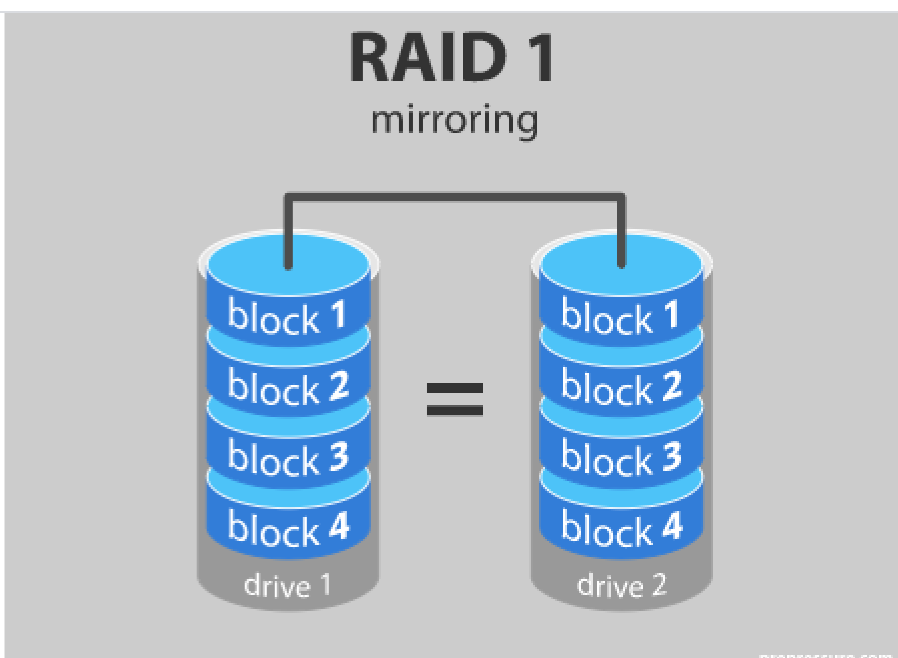
Ideal use

RAID 0 is ideal for non-critical storage of data that have to be read/written at a high speed, such as on an image retouching or video editing station.

If you want to use RAID 0 purely to combine the storage capacity of twee drives in a single volume, consider mounting one drive in the folder path of the other drive. This is supported in Linux, OS X as well as Windows and has the advantage that a single drive failure has no impact on the data of the second disk or SSD drive.

RAID level 1 – Mirroring

Data are stored twice by writing them to both the data drive (or set of data drives) and a mirror drive (or set of drives). If a drive fails, the controller uses either the data drive or the mirror drive for data recovery and continues operation. You need at least 2 drives for a RAID 1 array.



Advantages

- RAID 1 offers excellent read speed and a write-speed that is comparable to that of a single drive.
- In case a drive fails, data do not have to be rebuild, they just have to be copied to the replacement drive.
- RAID 1 is a very simple technology.

Disadvantages

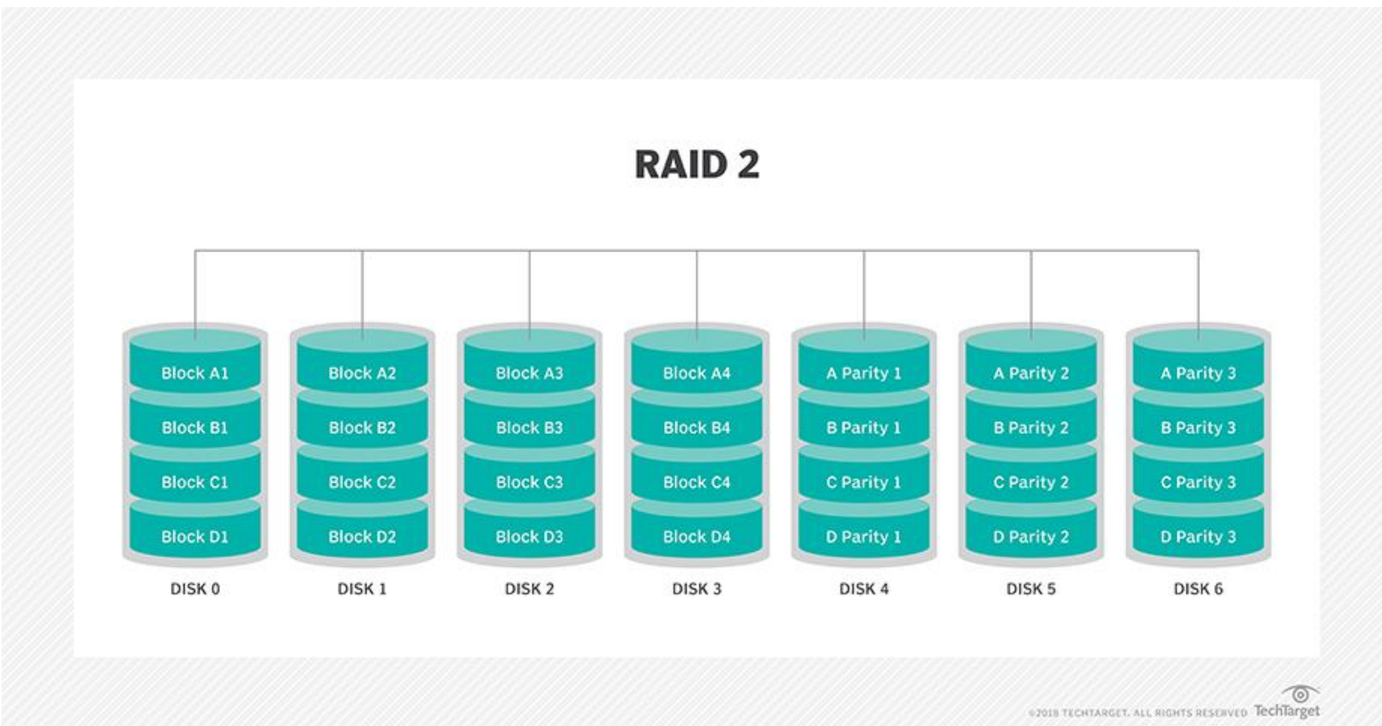
- The main disadvantage is that the effective storage capacity is only half of the total drive capacity because all data get written twice.
- Software RAID 1 solutions do not always allow a hot swap of a failed drive. That means the failed drive can only be replaced after powering down the computer it is attached to. For servers that are used simultaneously by many people, this may not be acceptable. Such systems typically use hardware controllers that do support hot swapping.

Ideal use

RAID-1 is ideal for mission critical storage, for instance for accounting systems. It is also suitable for small servers in which only two data drives will be used.

RAID 2:

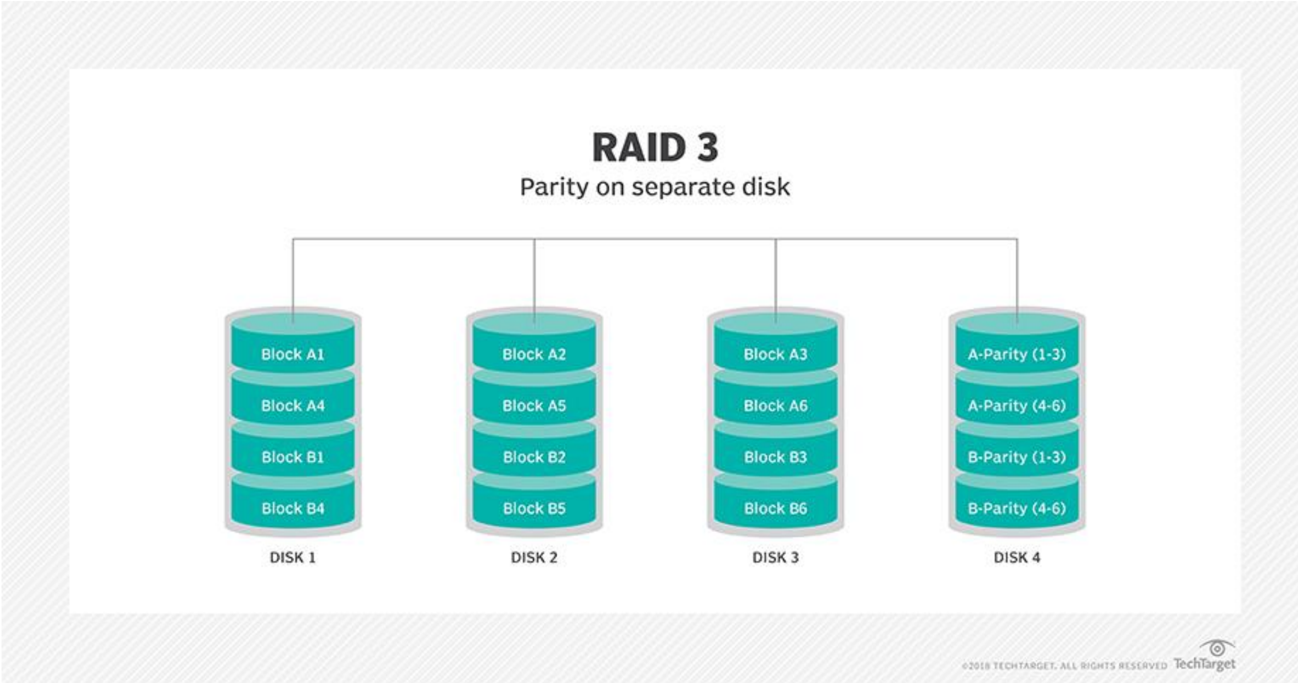
RAID 2 striped data at the bit level by using a Hamming code. These days, Hamming codes are already used in the error correction codes of hard drives, so RAID 2 is no longer used.



RAID 3:

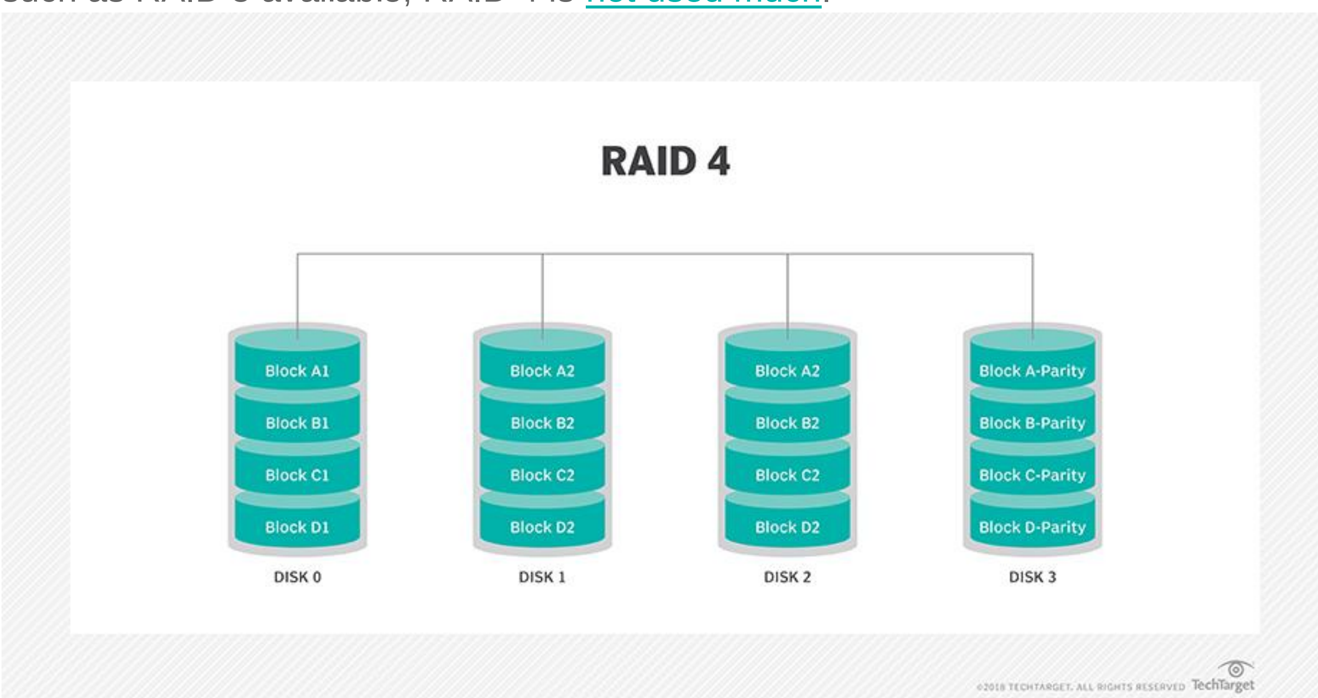
RAID 3 uses a parity disk to store the parity information generated by a RAID controller on a separate disk from the actual data disks instead of striping it with the data, as in RAID 5.

This RAID type performs poorly when there are a lot of requests for data, as with an application such as a database. RAID 3 performs well with applications that require one long, sequential data transfer, such as video servers. RAID 3 requires a minimum of three physical disks.



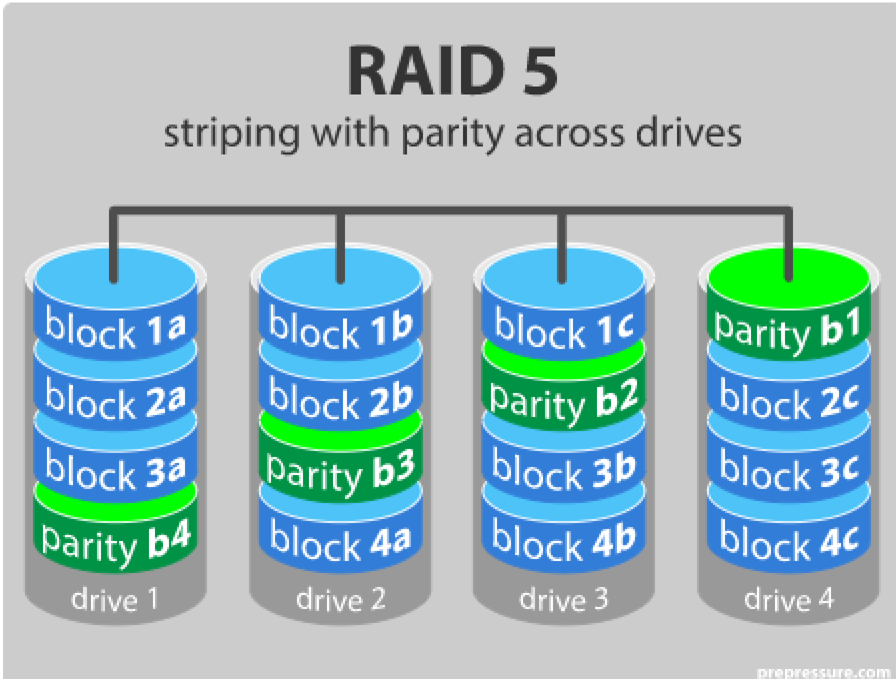
RAID 4:

RAID 4 uses a dedicated parity disk along with block-level striping across disks. While it is good for sequential data access, the use a dedicated parity disk can cause performance bottlenecks for write operations. With alternatives such as RAID 5 available, RAID 4 is not used much.



RAID level 5

RAID 5 is the most common secure RAID level. It requires at least 3 drives but can work with up to 16. Data blocks are striped across the drives and on one drive a parity checksum of all the block data is written. The parity data are not written to a fixed drive, they are spread across all drives, as the drawing below shows. Using the parity data, the computer can recalculate the data of one of the other data blocks, should those data no longer be available. That means a RAID 5 array can withstand a single drive failure without losing data or access to data. Although RAID 5 can be achieved in software, a hardware controller is recommended. Often extra cache memory is used on these controllers to improve the write performance.



Advantages

- Read data transactions are very fast while write data transactions are somewhat slower (due to the parity that has to be calculated).
- If a drive fails, you still have access to all data, even while the failed drive is being replaced and the storage controller rebuilds the data on the new drive.

Disadvantages

- Drive failures have an effect on throughput, although this is still acceptable.
- This is complex technology. If one of the disks in an array using 4TB disks fails and is replaced, restoring the data (the rebuild time) may take a day or longer, depending on the load on the array and the speed of the controller. If another disk goes bad during that time, data are lost forever.

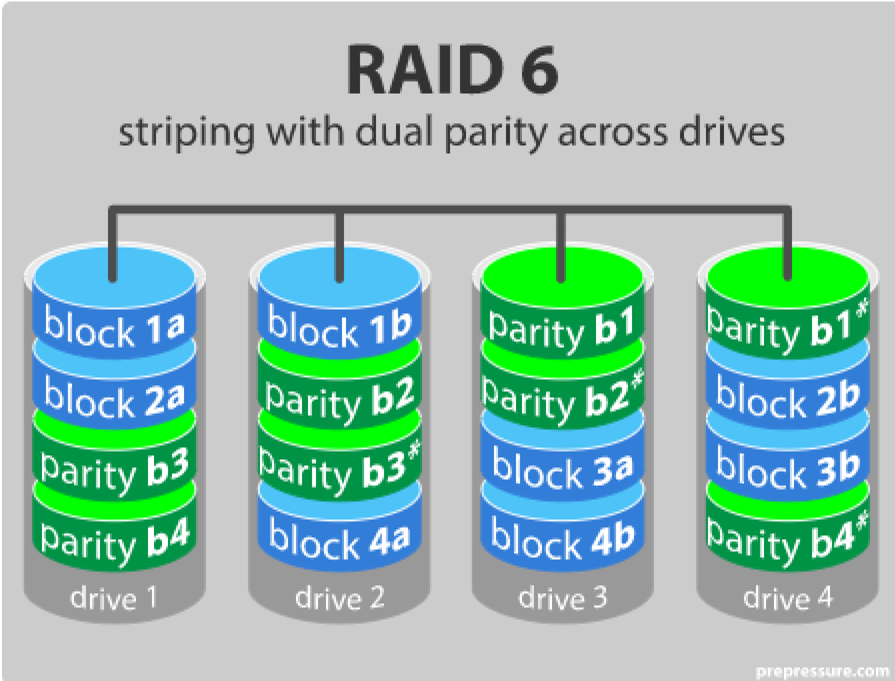
Ideal use

RAID 5 is a good all-round system that combines efficient storage with excellent security and decent performance. It is ideal for file and application servers that have a limited number of data drives.

RAID level 6

Striping with double parity

RAID 6 is like RAID 5, but the parity data are written to two drives. That means it requires at least 4 drives and can withstand 2 drives dying simultaneously. The chances that two drives break down at exactly the same moment are of course very small. However, if a drive in a RAID 5 systems dies and is replaced by a new drive, it takes hours or even more than a day to rebuild the swapped drive. If another drive dies during that time, you still lose all of your data. With RAID 6, the RAID array will even survive that second failure.



Advantages

- Like with RAID 5, read data transactions are very fast.
- If two drives fail, you still have access to all data, even while the failed drives are being replaced. So RAID 6 is more secure than RAID 5.

Disadvantages

- Write data transactions are slower than RAID 5 due to the additional parity data that have to be calculated. In one report I read the write performance was 20% lower.
- Drive failures have an effect on throughput, although this is still acceptable.
- This is complex technology. Rebuilding an array in which one drive failed can take a long time.

Ideal use

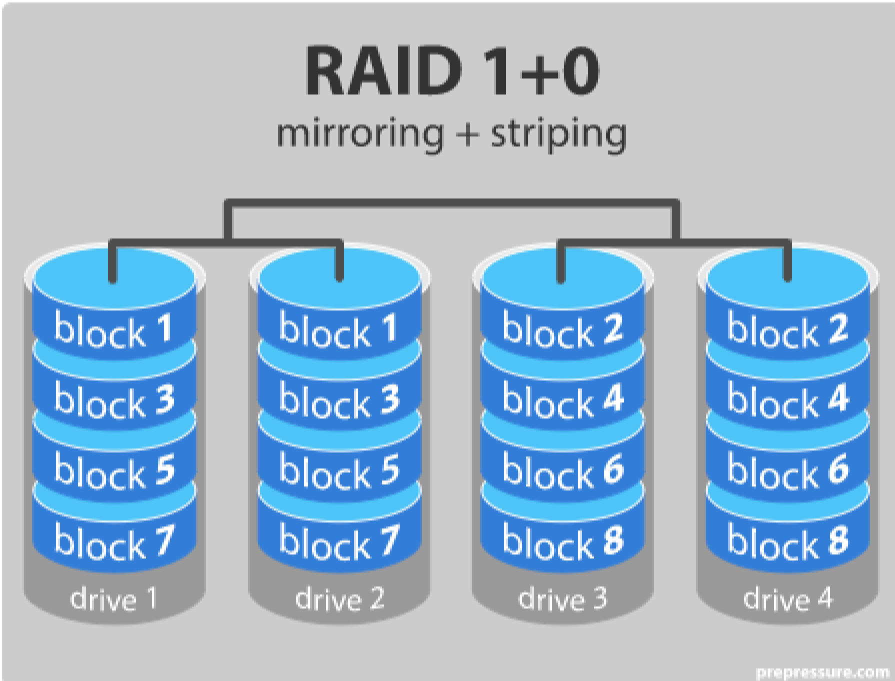
RAID 6 is a good all-round system that combines efficient storage with excellent security and decent performance. It is preferable over RAID 5 in file and application servers that use many large drives for data storage.

RAID 7.

A nonstandard RAID level based on RAID 3 and RAID 4 that adds caching. It includes a real-time embedded OS as a controller, caching via a high-speed bus and other characteristics of a stand-alone computer.

RAID level 10 – combining RAID 1 & RAID 0

It is possible to combine the advantages (and disadvantages) of RAID 0 and RAID 1 in one single system. This is a nested or hybrid RAID configuration. It provides security by mirroring all data on secondary drives while using striping across each set of drives to speed up data transfers.



Advantages

- If something goes wrong with one of the disks in a RAID 10 configuration, the rebuild time is very fast since all that is needed is copying all the data from the surviving mirror to a new drive. This can take as little as 30 minutes for drives of 1 TB.

Disadvantages

- Half of the storage capacity goes to mirroring, so compared to large RAID 5 or RAID 6 arrays, this is an expensive way to have redundancy.

RAID is no substitute for back-up!

All RAID levels except RAID 0 offer protection from a single drive failure. A RAID 6 system even survives 2 disks dying simultaneously. For complete security, you do still need to back-up the data from a RAID system.

- That back-up will come in handy if all drives fail simultaneously because of a power spike.
- It is a safeguard when the storage system gets stolen.
- Back-ups can be kept off-site at a different location. This can come in handy if a natural disaster or fire destroys your workplace.
- The most important reason to back-up multiple generations of data is user error. If someone accidentally deletes some important data and this goes unnoticed for several hours, days or weeks, a good set of back-ups ensure you can still retrieve those files.

NetApp related Stuffs.

What Is Data Deduplication?

Data deduplication is a process that eliminates excessive copies of data and significantly decreases storage capacity requirements.

Deduplication can be run as an inline process as the data is being written into the storage system and/or as a background process to eliminate duplicates after the data is written to disk.

At NetApp, deduplication is a zero data-loss technology that is run both as an inline process and as a background process to maximize savings. It is run opportunistically as an inline process so that it doesn’t interfere with client operations, and it is run comprehensively in the background to maximize savings. Deduplication is turned on by default, and the system automatically runs it on all volumes and aggregates without any manual intervention.

The performance overhead is minimal for deduplication operations, because it runs in a dedicated efficiency domain that is separate from the client read/write domain. It runs behind the scenes, regardless of what application is run or how the data is being accessed (NAS or SAN).

Deduplication savings are maintained as data moves around – when the data is replicated to a DR site, when it's backed up to a vault, or when it moves between on-premises, hybrid cloud, and/or public cloud.

How Does Deduplication Work?

Deduplication operates at the 4KB block level within an entire FlexVol® volume and among all the volumes in the aggregate, eliminating duplicate data blocks and storing only unique data blocks.

The core enabling technology of deduplication is fingerprints — unique digital signatures for all 4KB data blocks.

When data is written to the system, the inline deduplication engine scans the incoming blocks, creates a fingerprint, and stores the fingerprint in a hash store (in-memory data structure).

After the fingerprint is computed, a lookup is performed in the hash store. Upon a fingerprint match in the hash store, the data block corresponding to the duplicate fingerprint (donor block) is searched in cache memory:

- If found, a byte-by-byte comparison is done between the current data block (recipient block) and the donor block as verification to make sure of an exact match. On verification, the recipient block is shared with the matching donor block without an actual write of the recipient block to disk. Only metadata is updated to track the sharing details.
- If the donor block is not found in cache memory, the donor block is pre fetched from disk into the cache to do a byte-by-byte comparison to make sure of an exact match. On verification, the recipient block is marked as duplicate without an actual write to disk. Metadata is updated to track sharing details.

The background deduplication engine works in the same way. It scans all the data blocks in the aggregate and eliminates duplicates by comparing fingerprints of the blocks and by doing a byte-by-byte comparison to eliminate any false positives. This procedure also ensures that there is no data loss during the deduplication operation.

Benefits of NetApp Deduplication

There are some significant advantages to NetApp® deduplication:

- Operates on NetApp or third-party primary, secondary, and archive storage
- Application independent
- Protocol independent
- Minimal overhead
- Works on NetApp AFF, FAS, hybrid, and V-Series storage systems
- Byte-by-byte validation
- Can be applied to new data or to data previously stored in volumes and LUNs
- Can run during off-peak times

- Integrated with other NetApp storage efficiency technologies
- Savings due to deduplication can be inherited when using NetApp SnapMirror® replication technology or Flash Cache™ intelligent caching
- Free of charge

Thin provisioning for volumes

When a thinly provisioned volume is created, ONTAP does not reserve any extra space when the volume is created. As data is written to the volume, the volume requests the storage it needs from the aggregate to accommodate the write operation. Using thin-provisioned volumes enables you to overcommit your aggregate, which introduces the possibility of the volume not being able to secure the space it needs when the aggregate runs out of free space.

You create a thin-provisioned FlexVol volume by setting its `-space-guarantee` option to `none`.

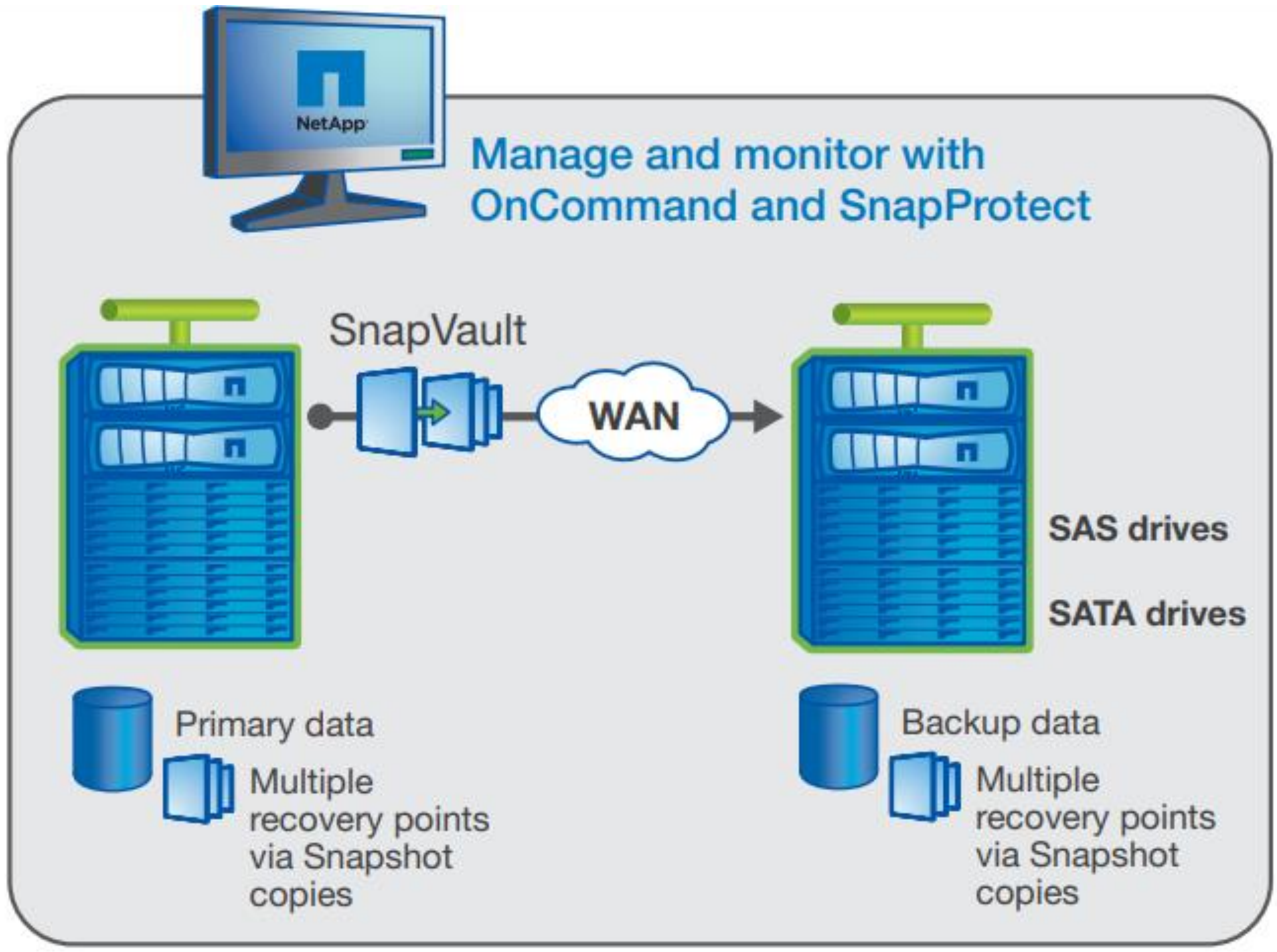
Thick provisioning for volumes

When a thick-provisioned volume is created, ONTAP sets aside enough storage from the aggregate to ensure that any block in the volume can be written to at any time. When you configure a volume to use thick provisioning, you can employ any of the ONTAP storage efficiency capabilities, such as compression and deduplication, to offset the larger upfront storage requirements.

Data protection Tool used in NetApp:

SnapVault:

- SnapVault is a disk-based storage backup feature of Data ONTAP. SnapVault enables data stored on multiple systems to be backed up to a central, secondary system quickly and efficiently as read-only Snapshot copies. SnapVault protects data on both NetApp and non-NetApp primary systems by maintaining a number of read-only versions of that data on a SnapVault secondary system and the SnapVault primary system.
- SnapVault protects data on both NetApp and non-NetApp primary systems by maintaining a number of read-only versions of that data on a SnapVault secondary system and the SnapVault primary system.
- Backup and restore in minutes and reduce storage requirements by using NetApp SnapVault disk-to-disk backup software.
- If you need to recover an entire application quickly, you can fail over to a selected Snapshot copy (that is, use in place), instead of performing a typical recovery process (such as copy and restore).



Efficient data protection with SnapVault. SnapVault backs up a primary FAS system to a secondary FAS system. NetApp SnapProtect or OnCommand software coordinates all replication-based data protection operations.

Features:

- Disk-to-Disk Backup Get highly efficient, point-in-time backup copies from a solution fully integrated with NetApp® Data ONTAP®, Snapshot™, and FAS deduplication.
- Faster Backup and Recovery Reduce backup times to minutes, even for petabytes of data. Native format backups enable end-user restore and provide fast application and virtual machine recovery, including industry leading capability to failover to a local Snapshot copy.
- Smaller Backup Footprint Transfer only new or changed blocks, compressed to minimize network traffic. Deduplication reduces storage requirements by up to 90% in virtualized environments.
- Multiuse Backup Copies Use SnapVault® backup copies for development, testing, discovery, reporting, compliance, and cloning.

SnapVault Supported Systems

• NetApp storage systems
• NetApp FAS8000 with FlexArray software integrates storage systems from other vendors

SnapMirror:

SnapMirror aims to improve data availability through the mirroring of volumes between two NetApp sites. This is primarily a disaster recovery solution, which utilizes ONTAP Snapshots to keep the second site up to date with the primary site's production data.

SnapMirror replicates data from a source volume or qtree to a partner destination volume or qtree, respectively, by using Snapshot copies. Before using SnapMirror to copy data, you need to establish a relationship between the source and the destination.

SnapMirror is used to replicate data. Its qualities make SnapMirror useful in several scenarios, including disaster recovery, data backup, and data restoration.

SnapMirror is a feature of Data ONTAP that enables you to replicate data. SnapMirror enables you to replicate data from specified source volumes or qtrees to specified destination volumes or qtrees, respectively. You need a separate license to use SnapMirror.

You can use SnapMirror to replicate data within the same storage system or with different storage systems.

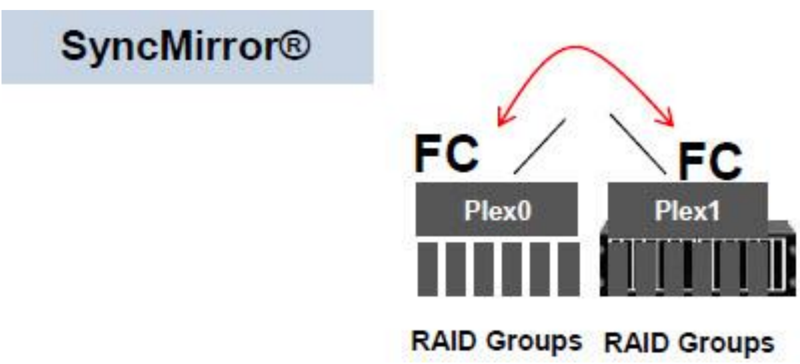
After the data is replicated to the destination storage system, you can access the data on the destination to perform the following actions:

- You can provide users immediate access to mirrored data in case the source goes down.
- You can restore the data to the source to recover from disaster, data corruption (qtrees only), or user error.
- You can archive the data to tape.
- You can balance resource loads.
- You can back up or distribute the data to remote sites.

You can configure SnapMirror to operate in one of the following modes:

- Asynchronous mode: SnapMirror replicates Snapshot copies to the destination at specified, regular intervals.
- Synchronous mode: SnapMirror replicates data to the destination as soon as the data is written to the source volume.
- Semi-synchronous mode: SnapMirror replication at the destination volume lags behind the source volume by 10 seconds. This mode is useful for balancing the need for synchronous mirroring with the performance benefit of asynchronous mirroring.

SnapMirror can be used with traditional volumes and FlexVol volumes.



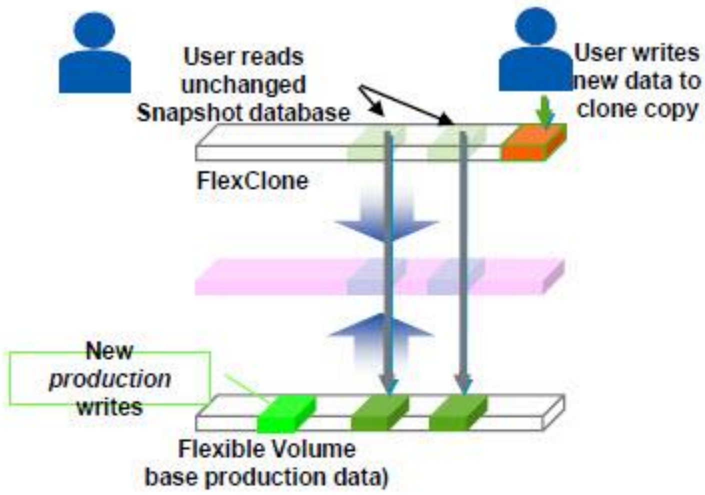
- Synchronous local mirroring from one volume to another volume attached to the same filer.
- Includes volume mirroring between two clustered nodes.

SnapMirror over Fibre Channel

SnapMirror over Fibre Channel enables you to use the SnapMirror feature over Fibre Channel in a SAN environment.

SnapMirror over Fibre Channel includes all the features that are available with SnapMirror over Ethernet. The operational concepts and the command interfaces are identical for both. However, there are a few differences between them.

NeatApp FlexClone:



FlexClone technology creates exact, virtual copies of data volumes, files, and LUNs without additional storage space.
NetApp® FlexClone® technology instantly replicates data volumes and datasets as transparent, virtual copies—true clones—without compromising performance or demanding additional storage space.

Key Points

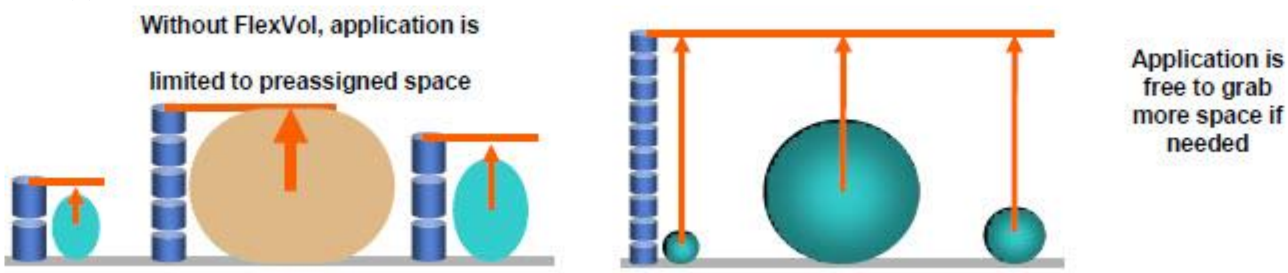
- Speed development and testing for faster time to market.
- Replicate data volumes, files, and LUNs as instant virtual copies.
- Provide instant, scalable provisioning for virtual servers and desktops.
- Reduce space, power, and cooling costs through efficient data storage.

You can use each cloned volume for essential business operations such as:

- Testing and bug fixing
- Fast, efficient provisioning of server and desktop images
- Platform and upgrade checks
- Multiple simulations against large datasets
- Remote-office testing and staging
- Creating market-specific product variations

FlexClone technology lets you create dataset replicas of entire NetApp Data ONTAP® volumes as well as individual file or LUN replicas. It reduces the cost, storage footprint, and complexity of environments that support new-product development, software and penetration testing, or deployment of virtual server infrastructures.
NetApp FlexClone efficiency and virtualization mean you can afford to create all the clones needed to improve productivity, develop and test applications faster, and get to market sooner.

NetApp FlexVol:



Use NetApp FlexVol technology to create virtual volumes; manage and move them independent of physical storage.
NetApp® FlexVol® storage-virtualization technology enables you to respond to changing storage needs fast, lower your overhead, avoid capital expenses, and reduce disruption and risk. FlexVol technology aggregates physical storage in virtual storage pools, so you can create and resize virtual volumes as your application needs change. These virtual volumes can be either thick or thin provisioned.

Key Points

- Double utilization and improve performance.
- Adapt with ease to changing data storage needs.
- Reduce acquisition costs with built-in thin provisioning.
- Add storage without disruption, according to your needs.
- Size and resize volumes dynamically according to policies.

With FlexVol thin provisioning you can improve—even double—the utilization of your existing storage and save the expense of acquiring more disk space. In addition to increasing storage efficiency, you can improve I/O performance and reduce bottlenecks by distributing volumes across all available disk drives.

- Designed to allow administrators to create multiple flexible volumes across a large pool of disks. Dynamic, non-disruptive storage (thin) provisioning; space-and time-efficiency.
- Allows applications and users to get more space dynamically and non-disruptively without IT staff intervention. Can enable more productive use of available storage and helps improve performance.
- Dynamic, non-disruptive storage (thin) provisioning; space-and time-efficiency.
- Allows users to get more space dynamically and non-disruptively.
- Enables more productive use of available storage and helps improve performance

NetApp Flash Pool:

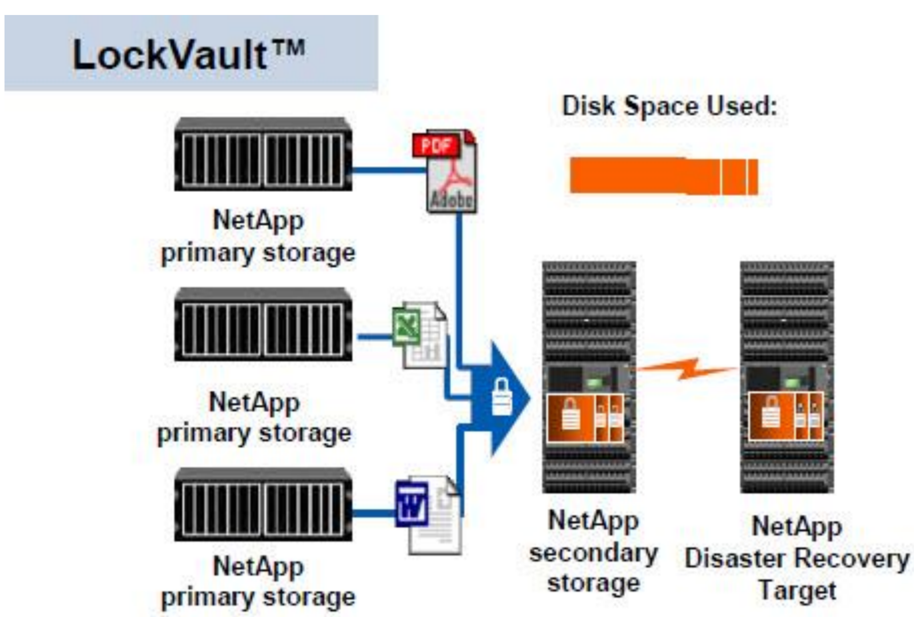
NetApp Flash Pool, a Data ONTAP feature, automates storage tiering for higher speed and efficiency at lower costs.

Key Points

- Automates the use of solid state disk (SSD) storage
- Speeds response times and reduces latency
- Improves I/O performance
- Enhances data storage efficiency
- Reduces storage acquisition, deployment, and operating costs

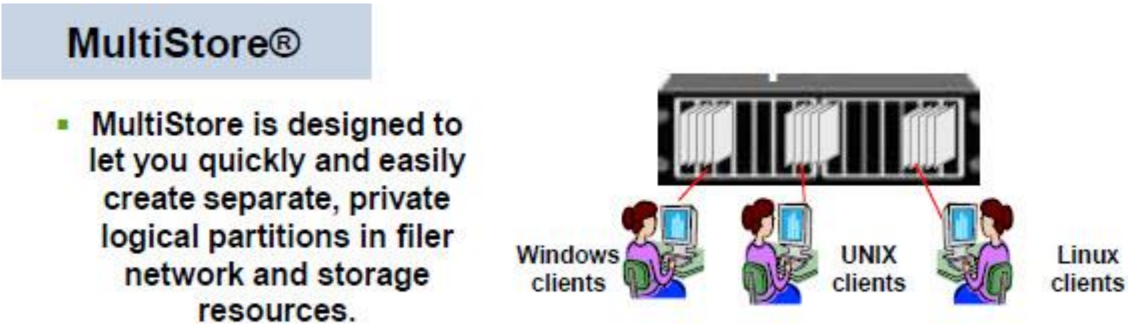
NetApp® Flash Pool, an integral component of the NetApp Virtual Storage Tier, enables automated storage tiering. NetApp Flash Pool lets you mix solid state disk (SSD) technology and hard disk (HDD) technology at the aggregate level, to achieve SSD-like performance at HDD-like prices.
Available without additional software licensing and implemented at the storage array level, this Data ONTAP® feature:

NetApp LockVault:



- Designed to enable IT administrators to “lock” a Snapshot copy in a non-erasable and non-rewriteable format for compliant retention
- Nightly Snapshot backups save only changed blocks; full backup image preserved
- ComplianceJournal™ logs changes between Snapshot copies
- Merges SnapLock and SnapVault functionality for compliant backups

NetApp MultiStore:



- Each virtual storage partition is designed to maintain separation from every other storage partition to prevent different enterprise departments that share the same storage resources from accessing or finding other partitions.
- MultiStore helps prevent information on any virtual partition from being viewed, used or downloaded by an unauthorized user.
- Similar to LUN masking on a Block Storage System

NetApp RAID-DP:

RAID-DP technology safeguards data from double-disk failure and delivers high performance. NetApp® RAID-DP® technology, a standard feature of the Data ONTAP® operating system, is a double-parity RAID 6 implementation that prevents data loss when two drives fail.

Key Points

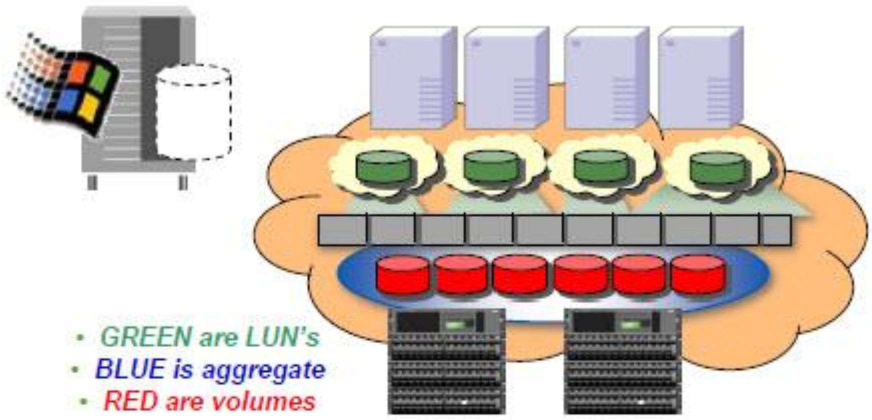
- Protect against double disk failure with Double Parity RAID 6.
- Safeguard data without sacrificing the performance you need.
- Use lower-cost SATA disk for enterprise applications, without worry.

We integrated RAID-DP with the WAFL® (Write Anywhere File Layout) file system to ensure that the dedicated parity drives don’t become a performance bottleneck. You get data protection plus the performance you need for your most demanding applications.
RAID-DP makes SATA disks an option for your enterprise storage. You can use less-expensive SATA disks without worrying about data loss, while lowering your data storage acquisition costs and boosting your storage efficiency.

Designed to survive all 2-disk failure scenarios

- Essential for SATA drives but also applicable to FC drives
- Breakthrough innovation: USENIX Best Paper in 2004
- Protects better than single-parity RAID or RAID0+1
- No performance penalty for industry-leading protection
- Traditional single-parity RAID technology offers protection from a single failed disk drive.
- The expectation is that no other disk fails nor uncorrectable bit errors not occur during a read operation while reconstruction of the failed disk is still in progress.
- If either event occurs during reconstruction, then some or all data contained in the RAID array or volume could be lost. With modern larger disk media, the likelihood of an uncorrectable bit error is fairly high, since disk capacities have increased but bit error rates have stayed the same.
- The ability of traditional single-parity RAID to protect data is being stretched beyond its limits.

NetApp SnapDrive:



- Designed to allow optimized usage in database environments
- Virtualized "local" disk to Windows® servers (FCP or iSCSI). Storage managed by SnapDrive logically appears to come from a locally attached storage subsystem.
- SnapDrive is designed to allow administrators to easily create virtual disks from pools of storage that an be distributed among several storage appliances.
- With SnapDrive you add, delete, map, unmap, and mirror virtual disks online. You can expand capacity on-the-fly with no impact to application or system performance

NetApp Snapshot

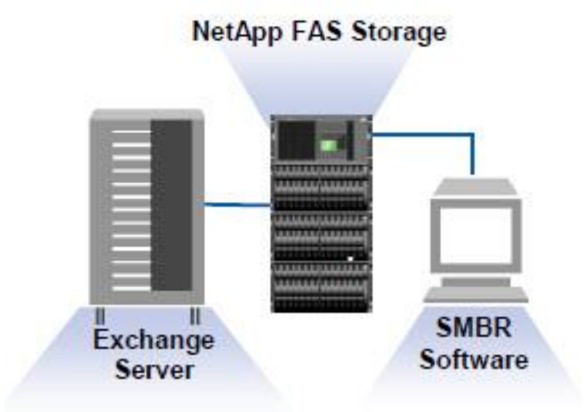
NetApp Snapshot point-in-time copy software protects data with no performance impact and uses minimal storage space.
NetApp® Snapshot™ software, the original and most functional point-in-time copy technology, enables you to protect your data with no performance impact and minimal consumption of storage space.

Key Points

- Make instant data copies while your applications run.
- Create Snapshot copies in under a second, for any volume size.
- Make up to 255 Snapshot copies per volume for online backup and recovery.

Our Snapshot technology enables you to create point-in-time copies of file systems, which you can use to protect data—from a single file to a complete disaster recovery solution.
You can use Snapshot technology while applications are running and create Snapshot copies in less than a second, regardless of volume size or level of activity on your NetApp system.
Make up to 255 Snapshot copies per volume, instantly, to create online backups for user-driven recovery. NetApp Snapshot software is the foundation for SnapManager®, SnapMirror®, SnapProtect®, SnapRestore®, and SnapVault® software. Together they create unified, all-risks protection for your valuable data.

NetApp SMBR:



- Enables the recovery of a single mailbox from a Microsoft Exchange Information Store.

- Unlike Lotus Domino where every mailbox is stored as a separate database (and therefore is implicitly recoverable as a unit by itself), Exchange clumps several mailboxes together into .edb files and .stm files.
- This makes recovery of a single user's mailbox extremely cumbersome and in most cases impossible unless there is some brick-level backup software in place.
- With SMBR, no brick-level (transaction level) backup is required.
- SMBR can extract a single mailbox or email directly and rapidly from an Exchange Information Store

Understanding the differences between SnapMirror and SnapVault

SnapMirror is disaster recovery technology, designed for failover from primary storage to secondary storage at a geographically remote site. SnapVault is archiving technology, designed for disk-to-disk Snapshot copy replication for standards compliance and other governance-related purposes.

These objectives account for the different balance each technology strikes between the goals of backup currency and backup retention:

- SnapMirror stores *only* the Snapshot copies that reside in primary storage, because, in the event of a disaster, you must be able to fail over to the most recent version of primary data you know to be good. Your organization, for example, might mirror hourly copies of production data over a ten-day span. As the failover use case implies, the equipment on the secondary system must be equivalent or nearly equivalent to the equipment on the primary system to serve data efficiently from mirrored storage.
- SnapVault, in contrast, stores Snapshot copies *whether or not* they currently reside in primary storage, because, in the event of an audit, access to historical data is likely to be as important as access to current data. You might want to keep monthly Snapshot copies of your data over a 20-year span (to comply with government accounting regulations for your business, for example). Because there is no requirement to serve data from secondary storage, you can use slower, less expensive disks on the vault system.

Of course, the different weights SnapMirror and SnapVault give to backup currency and backup retention ultimately derive from the 255-Snapshot copy limit for each volume. While SnapMirror retains the most recent copies, SnapVault retains the copies made over the longest period of time.

Cluster concepts:

A cluster consists of one or more nodes grouped together as (HA pairs) to form a scalable cluster. Creating a cluster enables the nodes to pool their resources and distribute work across the cluster, while presenting administrators with a single entity to manage. Clustering also enables continuous service to end users if individual nodes go offline.

What an HA pair is:

An HA pair is two storage systems (nodes) whose controllers are connected to each other directly. In this configuration, one node can take over its partner's storage to provide continued data service if the partner goes down.

What a Vserver is:

A Vserver is a secure virtual storage server, which contains data volumes and one or more LIFs through which it serves data to the clients.
A Vserver appears as a single dedicated server to the clients. Each Vserver has a separate administrator authentication domain and can be managed independently by its Vserver administrator.

Quotas enable you to restrict or track the disk space and number of files used by a user, group, or qtree. ... **Quotas** can be classified on the basis of the targets they are applied to. **Quota** limits. You can apply a disk space limit or limit the number of files for each **quota** type.

Disks and Aggregates

At the bottom level of the storage architecture we have our physical disks - our hard drives. Our disks get grouped into aggregates, so an aggregate is a set of physical disks. One of the attributes of our aggregates is the RAID group which defines the RAID configuration.

If you look in the System Manager GUI, you will see that there is a page for disks where you can view all of your disks, and there's a page for aggregates, where you can view and configure your aggregates. There's not a page for RAID groups however.

An aggregate is the physical storage. It is made up of one or more raid groups of disks.

Volumes:

Volumes are the lowest level that clients can access data at, so you will always have disks, aggregates and volumes on a NetApp ONTAP system. You can share (for Windows) or export (for UNIX/Linux) a volume and then clients can access it. You could have multiple volumes in the same aggregate, or maybe just one volume in the aggregate.

Your disks and your aggregates are classified by NetApp as physical resources, and volumes are classified as logical resources.

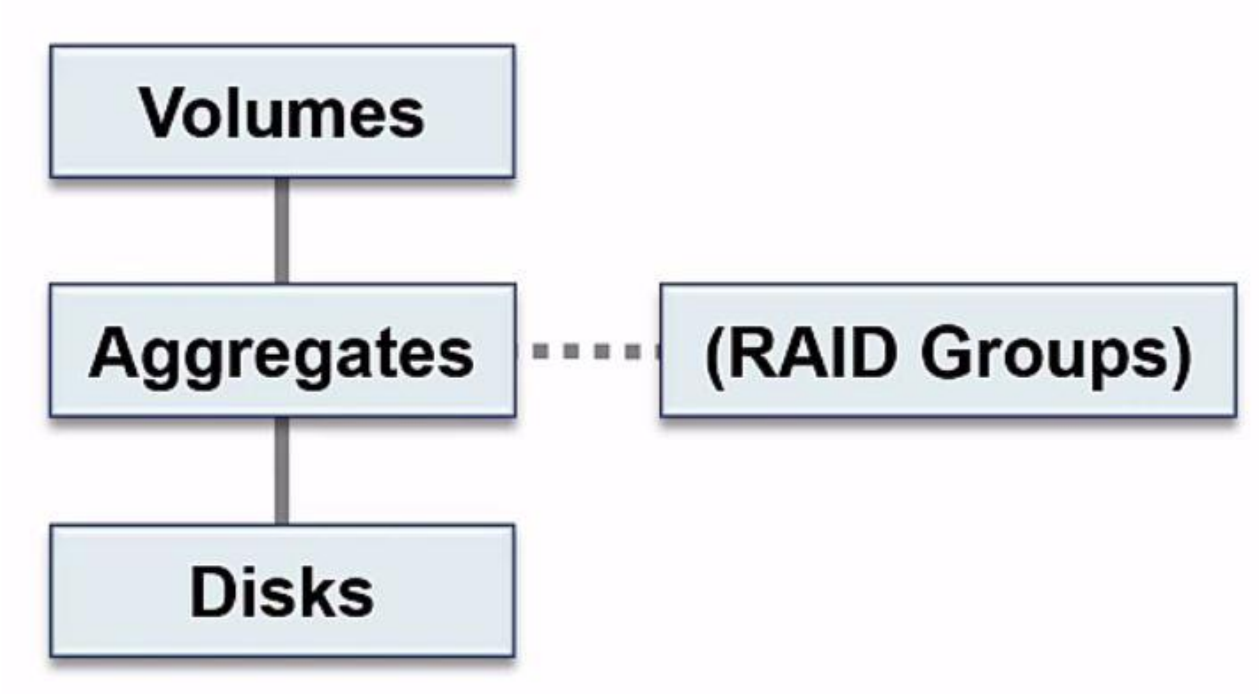
Volumes contain file systems in a NAS environment and LUNs in a SAN environment. A LUN (logical unit number) is an identifier for a device called a *logical unit* addressed by a SAN protocol.

LUNs are the basic unit of storage in a SAN configuration. The Windows host sees LUNs on your storage system as virtual disks. You can nondisruptively move LUNs to different volumes as needed.

In addition to data volumes, there are a few special volumes you need to know about:

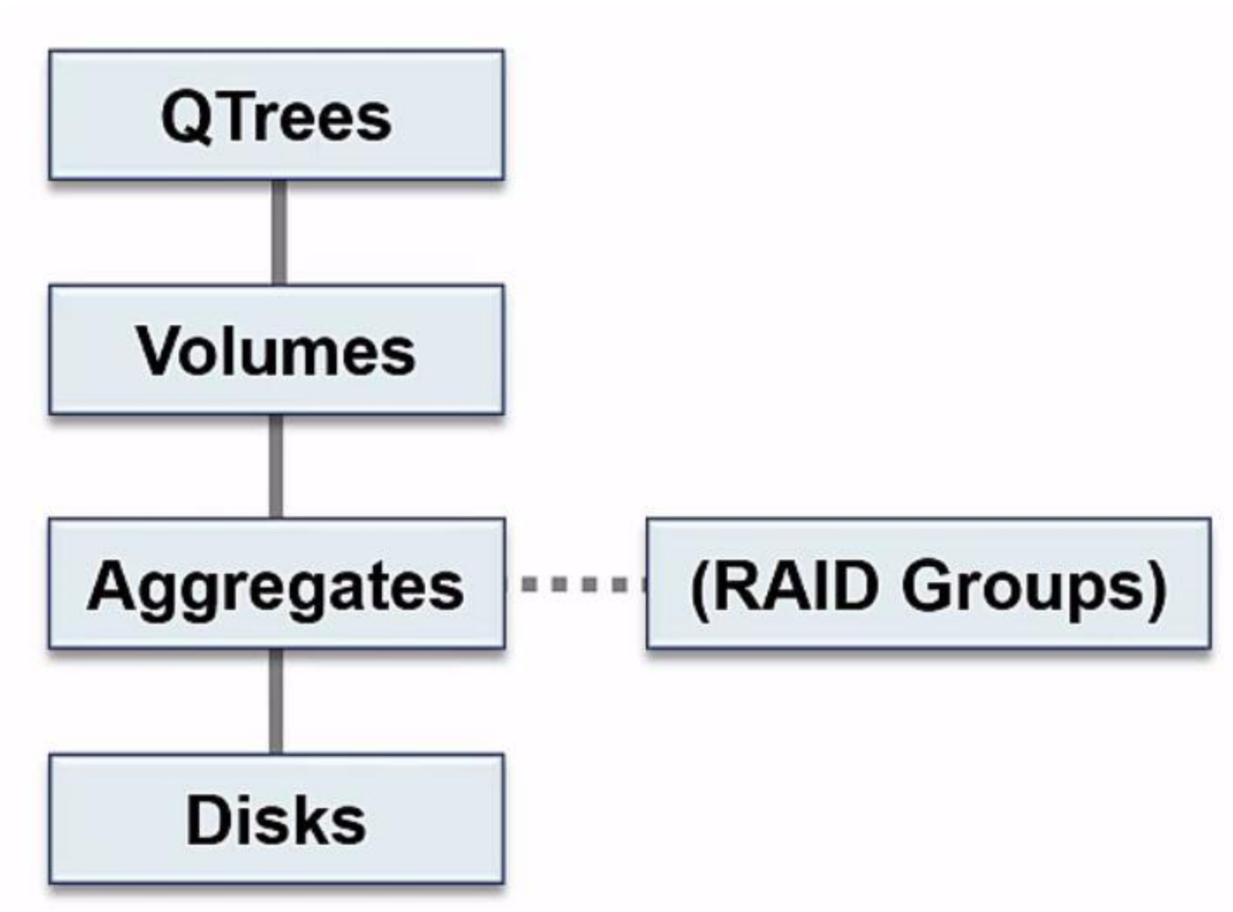
- A *node root volume* (typically "vol0") contains node configuration information and logs.
- An *SVM root volume* serves as the entry point to the namespace provided by the SVM and contains namespace directory information.
- *System volumes* contain special metadata such as service audit logs.

You cannot use these volumes to store data.



Qtrees:

Moving up the next level above volumes, we have our Qtrees which go in volumes. Qtrees are an optional component. If the containing volume is being accessed by a NAS client, it will see the Qtree as a directory in the volume. Qtrees can also be shared or exported directly themselves.



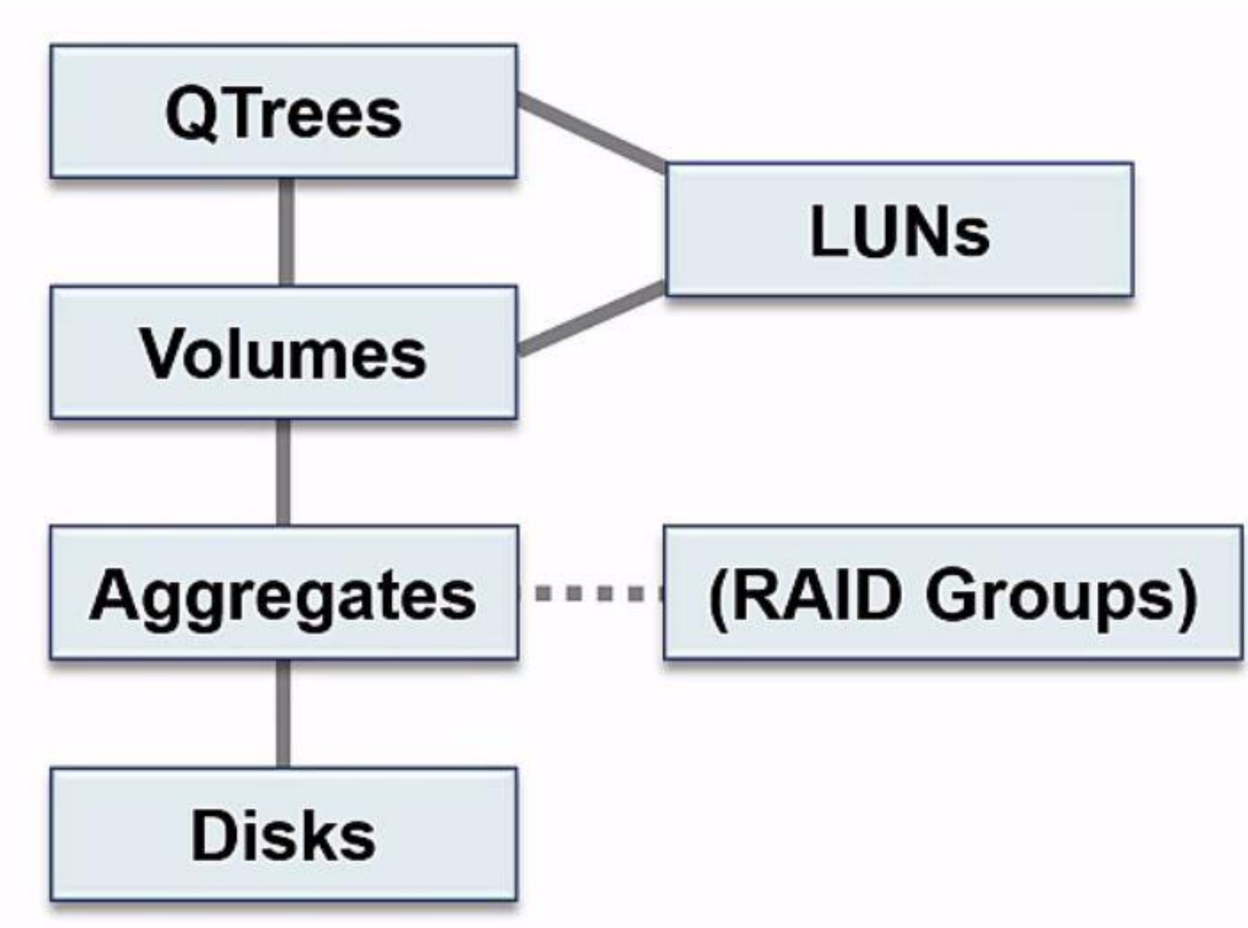
They're called Qtrees because one of their main functions is for quotas. You can limit the total size that the Qtree itself can grow to, or limit the amount of space that a user or group can use in the Qtree.

LUNs – Logical Unit Numbers

A LUN is specific to SAN protocols, and is the storage container that SAN clients use for their storage. The LUNs can either go in a Qtree or a volume. Best practice is to have a dedicated volume or Qtree for each LUN (do not put multiple LUNs in the same volume or Qtree).

Volumes contain file systems in a NAS environment and LUNs in a SAN environment. A LUN (logical unit number) is an identifier for a device called a *logical unit* addressed by a SAN protocol.

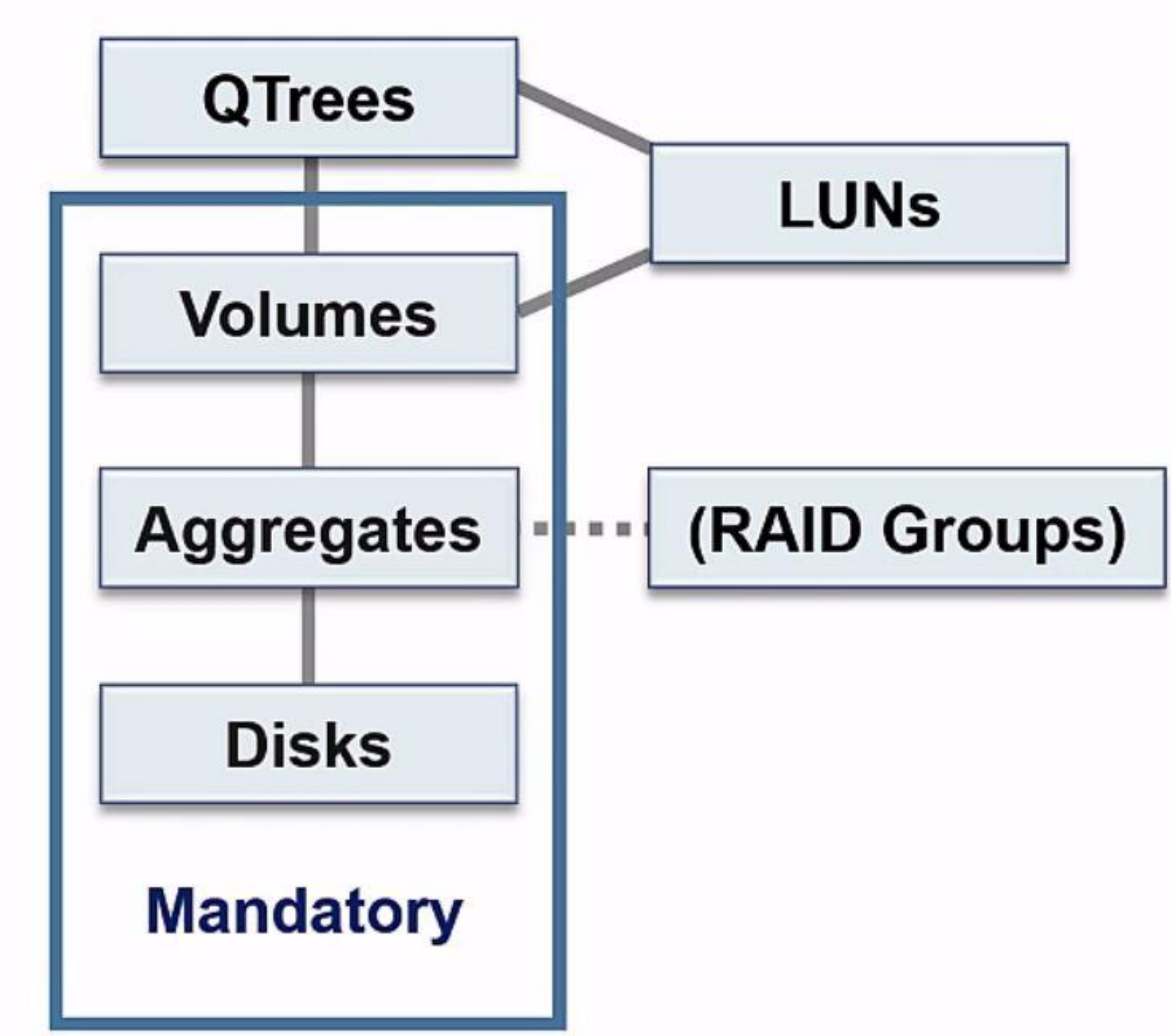
LUNs are the basic unit of storage in a SAN configuration. The Windows host sees LUNs on your storage system as virtual disks. You can nondisruptively move LUNs to different volumes as needed.



NetApp Storage Architecture *Organization*:

You can see the different components build on top of each other. We need to have our physical disks. Our disks get grouped in to aggregates. For our clients to be able to access data we configure our volumes, which go in our aggregates, and optionally we can configure Qtrees which go in our volumes and appear as a directory to NAS clients. Lastly, if we're using SAN protocols we'll need to configure LUNs. Our LUNs either go into a Qtree or into a volume.

The mandatory components are the disks, aggregates and volumes. Qtrees are optional, and LUNs are for SAN Protocols only - you wouldn't have LUNs if you were using only NAS protocols.



SVM Storage Virtual Machines:

The other storage architecture component to tell you about is Storage Virtual Machines (SVMs). These used to be known as Vservers, but they were renamed to SVMs in a more recent version of ONTAP. 'Storage Virtual Machine' and 'Vserver' both mean exactly the same thing.

If you're working in the System Manager GUI, you'll see they're listed under Storage Virtual Machines. If you're doing your configuration in the CLI the commands still use the 'vserver' syntax.

SMV Use Cases - Multitenancy

Say that you've got two different departments - Department A and Department B. They want to have their own separate secure storage. In the old days, what you would have to do is buy two completely separate storage systems, and you would require separate supporting network infrastructure for them as well. This would be pretty expensive.

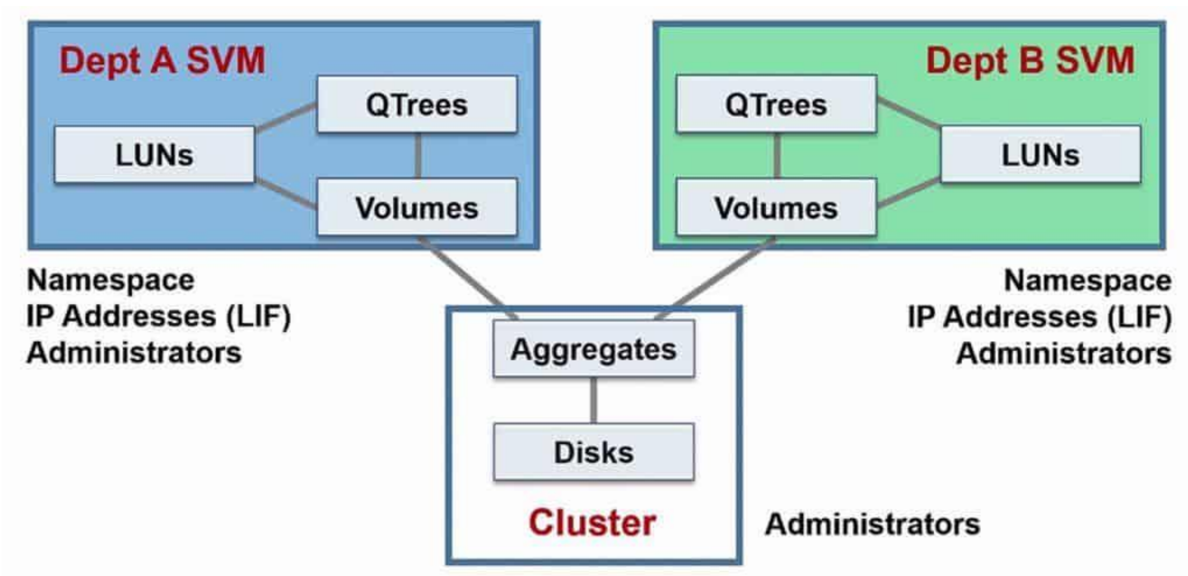
What you can do with NetApp ONTAP and Storage Virtual Machines now, is you can have one physical storage system, but you can virtualize it into separate logical storage systems, which are kept secure and separate from each other. Each SVM appears as a separate storage system to clients.

The physical resources of our disks and our aggregates are shared throughout the entire cluster, they're not dedicated to individual SVMs. The reason for this is if we had dedicated aggregates, maybe the aggregate for department A is pretty empty, and the aggregate for department B is getting really full. If the aggregates were dedicated at the SVM level, you would have to go and buy more disks for department B, even though you've got spare disks on Department A. Aggregates are a shared resource to ensure we get the most efficient use of our capacity.

Volumes are dedicated to and belong to a particular SVM. If department A has got volume A, it's owned by department A, and department B cannot see it. Other resources that are dedicated to and owned by particular SVMs are its name space (the directory structure of the SVM), its Logical Interfaces (LIFs, which are where our IP addresses live).

The SVMs can have their own separate SVM level dedicated administrators with different usernames and passwords. SVM level administrators have no visibility of the other SVM, they can't even see it exists. Global cluster level administrators can administer both SVMs.

In our example the Department A SVM will have its namespace, volumes, Logical Interfaces and administrators, and the Department B SVM will have its own separate namespace, volumes, Logical Interfaces and administrators.



SMV Use Cases – Multiple Client Access Protocols and Cloud Environments:

Another common reason for configuring separate SVMs is for ease of administration of multiple client access protocols. You could run NFS, CIFS and iSCSI for example all in the same SVM. In this case it will appear to all clients that they are accessing the same storage system. Or you could configure separate SVMs for each protocol, in which case they will appear as separate storage systems. Both configurations are supported.

SVMs are also very useful in a cloud environment, where we can have separate SVMs for different customers.

If you don't need to configure separate logical Storage Virtual Machines in your enterprise, you'll still have at least one SVM. SVMs are an integral part of the NetApp storage architecture, they house our volumes and LIFs so they are a mandatory component for client data access.

What is the difference between volume and logical unit number (LUN)? (In general , Not Netapp Specific)

A volume normally refers to a "disk" created via a "volume manager" such as Veritas or a volume created by an operating system such as Windows NT. A LUN refers to a "logical unit number" presented to a host as a SCSI ID. (i.e., LUN number 1 specifies SCSI ID 1 on that port. Therefore, the term volume can be considered software based and LUN considered hardware based.

Understanding Aggregate And Lun, Qtree, Volume:

An aggregate is the physical storage. It is made up of one or more raid groups of disks. You can see the Data ONTAP 'Storage Management Guide' for documentation.
A LUN is a logical representation of storage. It looks like a hard disk to the client. It looks like a file inside of a volume.
Aggregates are collections of raid groups. consist of one or more Raid Groups. Raid groups are protected sets of disks. consisting of 1 or 2 parity, and 1 or more data disks. We don't build raid groups; they are built behind the scene when you build an aggregate. An aggregate is just raw space.

A volume is analogous to a partition. Its where you can put data. An aggregate is the raw space (hard drive), the volume is the partition, its where you put the file system and data. We can have multiple volumes per aggregate, just like you can have multiple partitions per hard drive. and you can grow and shrink volumes, just like you can grow and shrink partitions.

A qtree is analogous to a subdirectory.

Aggregate is hard drive, volume is partition, and qtree is subdirectory. why use them? to store data. the same reason you use them on your personal PC.

Some applications need local storage;
They just can't seem to write data into a NAS (think CIFS or NFS) share. Microsoft Exchange and SQL are this way. they require local hard drives. So the question is, how do we take this network storage and make it look like an internal hard drive. the answer is a LUN. it takes a bit of logical space out of the aggregate (actually just a big file sitting in a volume or qtree) and it gets mounted up on the windows box, looking like an internal hard drive. the file system makes normal SCSI commands against it. the SCSI commands get encapsulated in FCP or iSCSI and are sent across the network to the SAN hardware where its converted back into SCSI commands then reinterpreted as WAFL read/writes.

Some applications know how to use a NAS for storage (think Oracle over NFS, or ESX with NFS data stores) and they don't need LUNs. they just need access to shared space and they can store their data in it.

So Aggregates are the raw space in your storage system. you take a bunch of individual disks and aggregate them together into aggregates. But, an aggregate can't actually hold data, it's just raw space. you then layer on partitions, which in NetApp land are called volumes. the volumes hold the data.

Volumes are access via NAS protocols, CIFS/NFS
LUNS are accessed via SAN protocols, iSCSI/FCP/FCoE.

Flex Vols are logical, Aggregates are physical. you layer one or more flex vols on top (in side) of an aggregate.

luns are logical. they go inside a volume, or in a qtree.
from a netapp perspective they are really just one big file sitting inside of a volume or qtree.

From a host perspective, they are like a volume, but use a different protocol to access them (purists will argue with that but i'm simplifying). LUNs provide a file system, like Volumes provide a file system, the major difference is who controls the files system. with a LUN the storage system can't see the file system, all it sees is one big file. the host mounts the file system via one of the previously mentioned protocols and lays a file system down inside. the host then controls that file system.

It is normally determined LUN/Volume usage by looking at the Application. Some apps won't work across a network, Microsoft SQL and Exchange are two examples of this. They require local disks. LUNs look like local disks. Some applications work just fine across the network, using NFS, like Oracle. In the end its normally the application that will determine whether you get your file system access through a LUN or a Volume. some things like Oracle or VMware can use either LUNs or NFS volumes, so with them its whatever you find easier or cheaper.

The underlying file system is always WAFL in the volume.
when you share out a volume it looks like NTFS to a windows box, or it looks like a UNIX file system to a Unix box but in the end its just WAFL in the volume.

with a LUN it's a bit different.
You first make a volume, then you put a LUN in the volume. the volume has WAFL as the file system, the LUN looks like one big file in the volume.

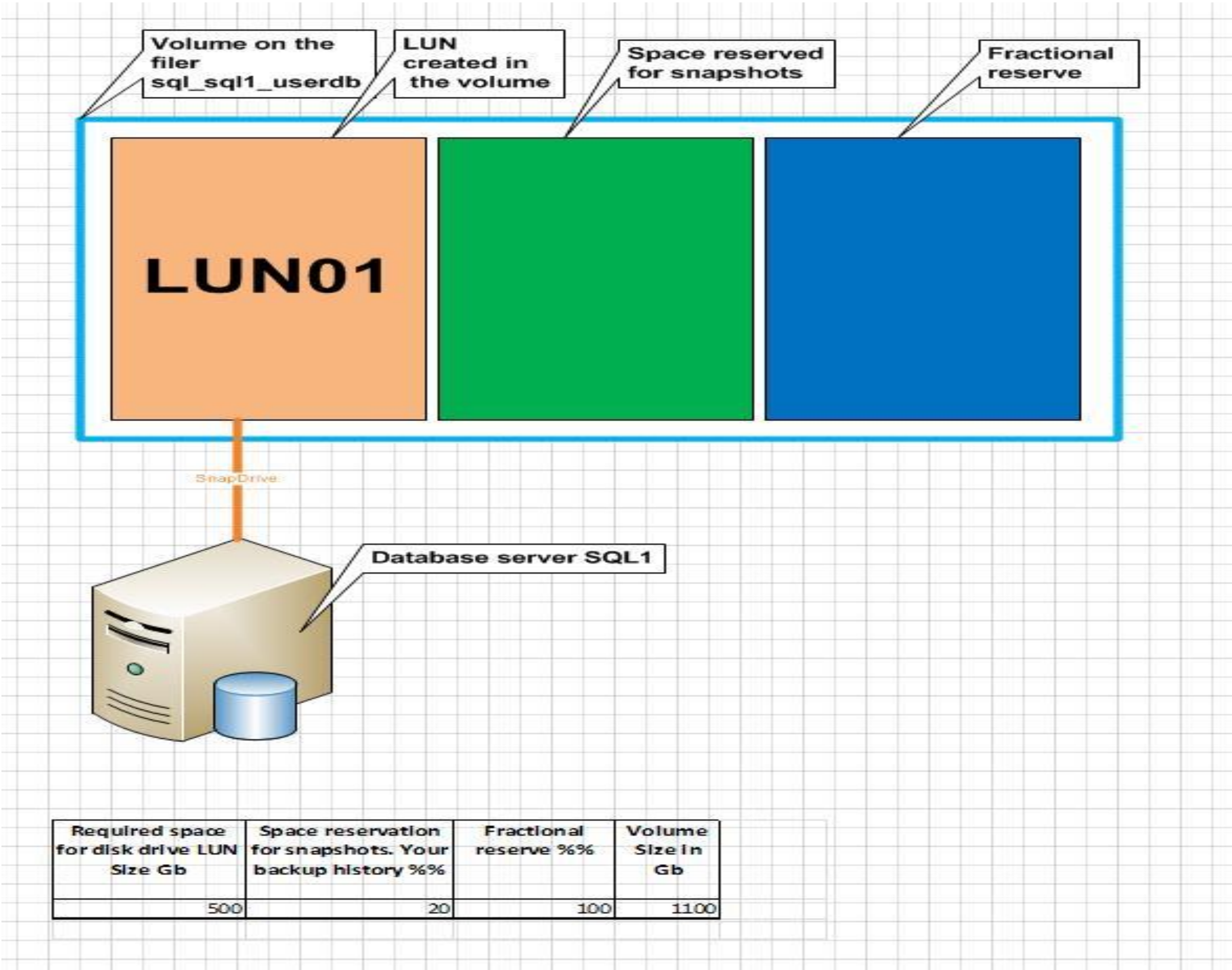
You then connect to the storage system using a SAN protocol. the big file we call a LUN is attached to the host via the SAN protocol and looks like a big hard drive. the host then formats the hard drive with NTFS or whatever File system the Unix box is using. That file system is actually NTFS, or whatever. its inside the LUN, which is big file inside of a Volume, which has WAFL as its file system.

Question: 1

Given this scenario; the volume and LUN size gives different results from each other. Volume reaches it's 100% size but on LUN it is only using 30% with same results from the virtual machine.

Answer:
So the LUN is contained within the volume. The LUN will reserve the space from the volume and can in turn use 100% of the volume's available size. Given that, the LUN itself is only using 30% of its provisioned size.
Example:

Volume is 50GB in size. LUN within the volume is 50GB in size which causes volume to be 100% full. LUN is only using 15GB of its available 50GB.



What is difference between SnapMirror and SnapVault?

SnapMirror is disaster recovery technology, designed for failover from primary storage to secondary storage at a geographically remote site. **SnapVault** is archiving technology, designed for disk-to-disk Snapshot copy replication for standards compliance and other governance-related purposes.

What is SnapCenter?

SnapCenter is a unified, scalable platform for application-consistent data protection. **SnapCenter** provides centralized control and oversight, while delegating the ability for users to manage application-specific backup, restore, and clone jobs.

What is a LUN NetApp?

A **LUN** (logical unit number) is an identifier for a device called a logical unit addressed by a SAN protocol. **LUNs** are the basic unit of storage in a SAN configuration. The Windows host sees **LUNs** on your storage system as virtual disks. You can nondisruptively move **LUNs** to different volumes as needed.

What is Flex volume in NetApp?

A FlexVol **volume** is a **volume** that is loosely coupled to its containing aggregate. ... When a FlexVol **volume** is created, it reserves a small amount of extra space (approximately 0.5 percent of its nominal size) from the free space of its containing aggregate. This space is used to store **volume** metadata.

What is a Qtree in NetApp?

A **qtree** is a logically defined file system that can exist as a special subdirectory of the root directory within an internal volume. You can create up to 4,995 **qtrees** per internal volume. There is no maximum for the storage system as a whole. In general, **qtrees**

What is NetApp snapshot?

NetApp® **Snapshot**™ software, the original and most functional point-in-time copy technology, enables you to protect your data with no performance impact and minimal consumption of storage space. ... Make up to 255 **Snapshot** copies per volume, instantly, to create online backups for user-driven recovery

What is LIFs in NetApp?

A **LIF** (logical interface) is an IP address with associated characteristics, such as a role, a home port, a home node, a routing group, a list of ports to fail over to, and a firewall policy. You can configure **LIFs** on ports over which the cluster sends and receives communications over the network.

What is RAID DP in NetApp?

NetApp® **RAID**-**DP**® technology, a standard feature of the Data ONTAP® operating system, is a double-parity **RAID** 6 implementation that prevents data loss when two drives fail. **RAID**-**DP** makes SATA disks an option for your enterprise storage.

How does SnapMirror work?

SnapMirror replicates data from a source volume or qtree to a partner destination volume or qtree, respectively, by using Snapshot copies. Before using **SnapMirror** to copy data, you need to establish a relationship between the source and the destination.

What is a NetApp SVM?

Storage Virtual Machines (**SVMs**, formerly known as Vservers) contain data volumes and one or more LIFs through which they serve data to the clients. ... **SVMs** securely isolate the shared virtualized data storage and network, and each **SVM** appears as a single dedicated server to the clients.

What is SnapManager in NetApp?

NetApp SnapManager software is a suite of data protection tools that provides an industry-leading level of data protection for enterprise applications—including Exchange, SQL Server, SharePoint, Oracle, and SAP—as well as VMware and Hyper-V virtual machines

What is aggregate and volume?

An **aggregate** is the raw space (hard drive), the **volume** is the partition, its where you put the file system and data. some other similarities include the ability to have multiple **volumes** per **aggregate**, just like you can have multiple partitions per hard drive.

What is root aggregate in NetApp?

The **root aggregate** contains the **root** volume, which contains special directories and configuration files that help you administer the storage system. The following facts apply to the **root aggregate**: ... By default, the storage system is set up to use a hard disk drive (HDD) **aggregate** for the **root aggregate**.

What is a LUN storage?

A logical unit number (**LUN**) is a unique identifier for designating an individual or collection of physical or virtual **storage** devices that execute input/output (I/O) commands with a host computer, as defined by the Small System Computer Interface (SCSI) standard.

What is the difference between LUN and volume? → In general

A **volume** normally refers to a "disk" created via a "**volume** manager" such as Veritas or a **volume** created by an operating system such as Windows NT. A **LUN** refers to a "logical unit number" presented to a host as a SCSI ID

What is infinite volume in NetApp?

NetApp Infinite Volumes. ... **Infinite Volumes** allow us to have **volumes** with a larger size because they can span multiple aggregates and nodes. An **Infinite Volume** is a single scalable **volume** that can store up to two billion files and up to 20 petabytes of data. **Infinite Volumes** can span between two and 10 nodes.

What is a Vserver NetApp?

A **Vserver** is a secure virtual storage server, which contains data volumes and one or more LIFs through which it serves data to the clients. ... In Data ONTAP 8.1. 1, a **Vserver** can either contain one or more FlexVol volumes, or a single Infinite Volume

What is NetApp cluster mode?

A **cluster** consists of one or more nodes grouped together as (HA pairs) to form a scalable **cluster**. Creating a **cluster** enables the nodes to pool their resources and distribute work across the **cluster**, while presenting administrators with a single entity to manage.

What is Qtree in Unix?

DESCRIPTION. The **qtree** command creates **qtrees** and specifies attributes for **qtrees**. A **qtree** is similar in concept to a partition. It creates a subset of a volume to which a quota can be applied to limit its size. As a special case, a **qtree** can be the entire volume

What is the difference between 7 mode and cluster mode NetApp?

A **7 mode** vfiler is called as a vserver in **Clustered mode** . ... The main **difference between** a vfiler in **7 mode** and SVM in **cluster mode** is that in **7 mode** a volumes , qtrees , shares and LUN's can work directly physical controller without vfiler,but with **cluster mode** it cannot work without SVM.

in 7-mode cluster support only two nodes, in cmode it supports 24 nodes(san-8,nas-24)
—-7mode haveing flat commnad line interface
—cmode haveing hierarical command line interface.
—-7 mode vfiler is a cmode vserver.
——junction path is a new concept in cluster mode, and it is used for mounting.
—-in c mode volume can’t be exported(nfs), and share can’t be created until the volume mounted to junction path in a name space.
1) Vserver is defined as logical container which holds the volumes. 7 mode vfiler is called as a vserver in Clustered mode.
2)Junction Path is a new term in cluster mode and this is used for mounting.
3)In Cluster mode he volume cannot be exported (NFS) and a share cannot be created (CIFS) until the volume is mounted to a junction point in the namespace.

Understanding HA pairs:

- An HA pair is two storage systems (nodes) whose controllers are connected to each other directly. In this configuration, one node can take over its partner's storage to provide continued data service if the partner goes down.
- HA pairs provide hardware redundancy that is required for non-disruptive operations and fault tolerance and give each node in the pair the software functionality to *take over* its partner's storage and subsequently *give back* the storage
- HA pairs provide fault tolerance and let you perform no disruptive operations, including hardware and software upgrades, relocation of aggregate ownership, and hardware maintenance.
- Each node in an HA pair requires a network connection, an HA interconnect between the controllers, and connections both to its own disk shelves as well as its partner node's shelves.
- HA pairs are components of the cluster, and both nodes in the HA pair are connected to other nodes in the cluster through the data and cluster networks. But only the nodes in the HA pair can take over each other's storage.

What an HA pair is?

- An HA pair is two storage systems (nodes) whose controllers are connected to each other directly. In this configuration, one node can take over its partner's storage to provide continued data service if the partner goes down.
- You can configure the HA pair so that each node in the pair shares access to a common set of storage, subnets, and tape drives, or each node can own its own distinct set of storage.
- The controllers are connected to each other through an HA interconnect. This allows one node to serve data that resides on the disks of its failed partner node. Each node continually monitors its partner, mirroring the data for each other’s nonvolatile memory (NVRAM or NVMEM). The interconnect is internal and requires no external cabling if both controllers are in the same chassis.
- *Takeover* is the process in which a node takes over the storage of its partner. *Giveback* is the process in which that storage is returned to the partner. Both processes can be initiated manually or configured for automatic initiation.

What is NetApp data fabric?

NetApp's Data Fabric is a software-defined approach to **data** management that enables businesses to connect disparate **data** management and storage resources and streamline **data** management between on-premises and cloud storage

Which is faster NAS or SAN?

SANs are the higher performers for environments that need high-speed traffic such as high transaction databases and ecommerce websites. **NAS** generally has lower throughput and higher latency because of its slower file system layer, but high-speed networks can make up for performance losses within **NAS**

What's the difference between a NAS and a SAN?

But a typical **difference between SAN** and **NAS** is that, a **NAS** is a single storage device which operates on data files, whereas **SAN** is a local network of multiple devices which operate on disk blocks . ... But in order to get connected to a **SAN**, the server class devices with the SCSI Fibre Channel is required

what is diff between SCSI and iSCSI?

The **SCSI** standards define commands, protocols, electrical, optical and logical interfaces. **SCSI** is most commonly used for hard disk drives and tape drives, but it can connect a wide range of other devices, including scanners and CD drives, although not all controllers can handle all devices

Small Computer System Interface (SCSI) is a set of standards for physically connecting and transferring data between computers and peripheral devices. The SCSI standards define commands, protocols, electrical, optical and logical interfaces. SCSI is most commonly used for hard disk drives and tape drives, but it can connect a wide range of other devices, including scanners and CD drives, although not all controllers can handle all devices. The SCSI standard defines command sets for specific peripheral device types; the presence of "unknown" as one of these types means that in theory it can be used as an interface to almost any device, but the standard is highly pragmatic and addressed toward commercial requirements.

iSCSI is the SCSI protocol mapped to TCP/IP and run over standard Ethernet technologies. This allows Ethernet networks to be deployed as SANs at a much lower TCO than Fibre Channel (FC).
Parallel SCSI and serial attached SCSI (SAS) are technologies designed to be inside a box such as DAS or within a storage array. They are not viable SAN technologies at this time.

The iSCSI on Ethernet (10/100/1000/10000) is a good viable external interconnect between application server initiators and storage targets. Parallel SCSI and SAS are good internal interconnects between the server and its internal storage or between the array controller and its drawers of hard disk drives (HDDs).

iSCSI is Internet SCSI (Small Computer System Interface), an Internet Protocol (IP)-based storage networking standard for linking data storage facilities, developed by the Internet Engineering Task Force (IETF). By carrying SCSI commands over IP networks, iSCSI is used to facilitate data transfers over intranets and to manage storage over long distances. The iSCSI protocol is among the key technologies expected to help bring about rapid development of the storage area network (SAN) market, by increasing the capabilities and performance of storage data transmission. Because of the ubiquity of IP networks, iSCSI can be used to transmit data over local area networks (LANs), wide area networks (WANs), or the Internet and can enable location-independent data storage and retrieval.

In essence, iSCSI allows two hosts to negotiate and then exchange SCSI commands using Internet Protocol (IP) networks. By doing this, iSCSI takes a popular high-performance local storage bus and emulates it over a wide range of networks, creating a storage area network (SAN). Unlike some SAN protocols, iSCSI requires no dedicated cabling; it can be run over existing IP infrastructure. As a result, iSCSI is often seen as a low-cost alternative to Fibre Channel, which requires dedicated infrastructure except in its FCoE (Fibre Channel over Ethernet) form. However, the performance of an iSCSI SAN deployment can be severely degraded if not operated on a dedicated network or subnet (LAN or VLAN), due to competition for a fixed amount of bandwidth.

NAS vs. SAN: 7 Big Differences

1) Fabric. NAS uses TCP/IP networks, most commonly Ethernet. Traditional SANs typically run on high speed Fibre Channel networks, although more SANs are adopting IP-based fabric because of FC's expense and complexity. High performance remains a SAN requirement and flash-based fabric protocols are helping to close the gap between FC speeds and slower IP.

2) Data processing. The two storage architectures process data differently: NAS processes file-based data and SAN processes block data. The story is not quite as straightforward as that of course: NAS may operate with a global namespace, and SANs have access to a specialized SAN file system. A global namespace aggregates multiple NAS file systems to present a consolidated view. SAN file systems enable servers to share files. Within the SAN architecture, each server maintains a dedicated, non-shared LUN. SAN file systems allow servers to safely share data by providing file-level access to servers on the same LUN.

3) Protocols. NAS connects directly to an Ethernet network via a cable into an Ethernet switch. NAS can use several protocols to connect with servers including NFS, SMB/CIFS, and HTTP. On the SAN side, servers communicate with SAN disk drive devices using the SCSI protocol. The network is formed using SAS/SATA fabrics, or mapping layers to other protocols such as Fibre Channel Protocol (FCP) that maps SCSI over Fibre Channel, or iSCSI that maps SCSI over TCP/IP.

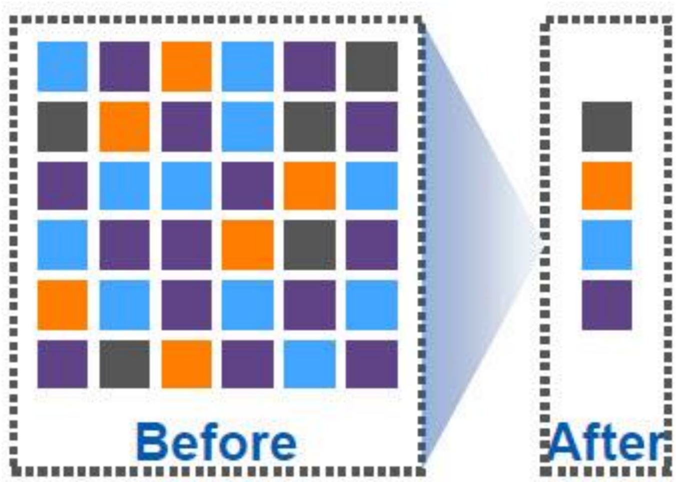
4) Performance. SANs are the higher performers for environments that need high-speed traffic such as high transaction databases and ecommerce websites. NAS generally has lower throughput and higher latency because of its slower file system layer, but high-speed networks can make up for performance losses within NAS.

5) Scalability. Entry level and NAS devices are not highly scalable, but high-end NAS systems scale to petabytes using clusters or scale-out nodes. In contrast, scalability is a major driver for purchasing a SAN. Its network architecture enables admins to scale performance and capacity in scale-up or scale-out configurations.

6) Price. Although a high-end NAS will cost more than an entry-level SAN, in general NAS is less expensive to purchase and maintain. NAS devices are considered appliances and have fewer hardware and software management components than a storage area network. Administrative costs also figure into the equation. SANs are more complex to manage with FC SANs on top of the complexity heap. A rule of thumb is to figure 10 to 20 times the purchase cost as an annual maintenance calculation.

7) Ease of management. In a one-to-one comparison, NAS wins the ease of management contest. The device easily plugs into the LAN and offers a simplified management interface. SANs require more administration time than the NAS device. Deployment often requires making physical changes to the data center, and ongoing management typically requires specialized admins. The exception to the SAN-is-harder argument is multiple NAS devices that do not share a common management console.

NetApp Deduplication:



NetApp® data deduplication and data compression are fundamental components of our core Data ONTAP® operating architecture. These innovative data reduction features can be used across multiple applications and storage tiers–including primary data, backup data, and archival data–to help you manage your data resources with greater efficiency.

NetApp data deduplication combines the benefits of granularity, performance, and resiliency to give you a significant advantage in the race to meet ever-increasing storage capacity demands.

Benefits of A-SIS FAS Deduplication

- Reduces storage use by sharing identical data blocks
- Ideal for Business Processes / Applications
  - Archiving
  - Enterprise Content Management
  - Information Lifecycle Management
  - VM binaries
- Eliminates redundancy within and across files
  - Between multiple backups of same source data set
  - Between multiple backups of different source sets
  - Within one backup (duplicate files and blocks)

NetApp data compression is a new feature that compresses data as it is written to NetApp FAS and V-Series storage systems. Like deduplication, NetApp data compression works in both SAN and NAS environments, and it is agnostic to both application and storage tier.

FAQ Question:

Question #1

A special-purpose high speed network used to interconnect storage devices with computer systems is the definition for:

a. Network attached storage (NAS)
b. A storage service provider
c. A storage area network (SAN)
d. A storage array

The correct answer is
c. A storage area network (SAN)

Learn more:
A storage area network (SAN) is a high-speed special-purpose network (or subnetwork) that interconnects different kinds of data storage devices with associated data servers on behalf of a larger network of users. Typically, a storage area network is part of the overall network of computing resources for an enterprise. A storage area network is usually clustered in close proximity to other computing resources such as IBM S/390 mainframes but may also extend to remote locations for backup and archival storage, using wide area network carrier technologies such as asynchronous transfer mode or Synchronous Optical Networks.

Question #2

Which as the killer application for a SAN:
a. Storage management
b. Backup
c. Capacity planning
d. File sharing
The correct answer is:
b. Backup
Learn more:
The vision for SANs is to have multiple applications and multiple systems used in one network. With a SAN, you can have many different data centers all managed in one place which enables your operation to be global in scope. A SAN is a suitable application for mail servers, file server resources, voice and video servers, database servers, and other high-performance application servers used for crm or data warehousing.

Question #3

Which of the following is NOT a benefit of a SAN?
a. A SAN takes all the data on all our servers and ties it together outside of the servers, which makes it easier to back up.
b. You can not move your data out horizontally in case of a disaster.
c. You can have many different data centers managed in one place, so your operation can be global in scope.
d. Placing data external to the server makes the server less important in case anything happens to it.

The correct answer is:
b. You can not move your data out horizontally in case of a disaster.
One of the critical design tasks in a disaster recovery plan is making sure that your data is being duplicated so that it can be replaced if necessary. And, as many of our experts can attest to, centralizing your backups can not only help ensure that your data is safe should anything happen to your work site, it can also help reduce costs.

Question #4

A SAN is a good solution for all but the following:
a. database operations
b. file-sharing
c. application migration
d. voice or video transmission

Question #5

Cables are what ties everything together in a SAN. When choosing your cables and setting them up, you should do all of the following except:
a. Keep in mind that the smaller the core of the cable the farther the light can pass through it.
b. Choose a large cable since it has a greater probability of signal loss than a smaller cable.
c. Try to make sure the cables are straight for the least amount of signal loss.
d. Select a cable with a minimum radius of between 1 1/4 and 1 1/2.

Question #6

This is a way of storing the same data in different places (redundantly) on multiple hard disks.
a. data mining
b. disk duplexing
c. RAID
d. data splitting
e. virtualization

Question #7

The best price-performance ratio that you can get from a RAID subsystem is available from
a. RAID 0
b. RAID 1
c. RAID 5
d. RAID 0+1 (or RAID 10)
The correct answer is:
d. RAID 0+1 (or RAID 10)

Question #8

This is a unique identifier used on a SCSI bus that enables it to differentiate between up to eight separate devices, which may be an end user, a file, or an application program.
a. Driver
b. Partition
c. LUN
d. virtual memory
The correct answer is:
c. LUN
Learn more:
A logical unit number (LUN) is a unique identifier used on a SCSI bus that enables it to differentiate between up to eight separate devices (each of which is a logical unit). Each LUN is a unique number that identifies a specific logical unit, which may be an end user, a file, or an application program.
A SCSI (Small System Computer Interface) is a parallel interface, that can have up to eight devices all attached through a single cable; the cable and the host (computer) adapter make up the SCSI bus. The bus allows the interchange of information between devices independently of the host. In the SCSI program, each device is assigned a unique number, which is either a number between 0 and 7 for an 8-bit (narrow) bus, or between 8 and 16 for a 16-bit (wide) bus. The devices that request input/output (I/O) operations are initiators and the devices that perform these operations are targets. Each target has the capacity to connect up to eight additional devices through its own controller; these devices are the logical units, each of which is assigned a unique number for identification to the SCSI controller for command processing.

Question #9

This is the function of using port zoning and worldwide name zoning in the same zone set.
a. load balancing
b. mixed zoning
c. mirroring
d. virtualization

Question #10

In order to avoid poor SAN design, you should do all of the following EXCEPT:
a. Use worldwide name zoning for flexibility and port zoning for security.
b. Use a maximum of 16 switches per fabric.
c. Minimize hops and the use of ISL links.
d. Use multiple HBA vendors and drivers, if possible.
Question #11
What does a SAN do?
SANs create connectivity. SANs offer a method of attaching storage that improves data reliability, availability and performance
SAN overcomes traditional network bottlenecks by connecting in three ways:

Server-to-storage (direct attached storage)
Server-to-server (network attached storage)
Storage-to-storage (SAN Attached Storage)

Question #11

Name some of the SAN topologies and Explain each of them ?

Point-to-point, arbitrated loop, and switched fabric topologies

a) Point-to-Point

A point-to-point connection is the simplest topology. It is used when there are exactly two nodes and future expansion is not predicted. There is no sharing of the media, which allows the devices to use the total bandwidth of the link. A simple link initialization is needed before communications can begin.

b) Arbitrary Loop
Our second topology is Fiber Channel Arbitrated Loop (FC-AL). FC-AL is more useful for storage applications. It is a loop of up to 126 nodes (NL_Ports) that is managed as a shared bus. Traffic flows in one direction, carrying data frames and primitives around the loop with a total bandwidth of 400 MBps (or 200 MBps for a loop based on 2 Gbps technology).

c) Switched Fabric Loop
It applies to switches and directors that support the FC-SW standard, that is, it is not limited to switches as its name suggests. A Fibre Channel fabric is one or more fabric switches in a single, sometimes extended, configuration. Switched fabrics provide full bandwidth per port compared to the shared bandwidth per port in arbitrated loop Implementations

Question #12

What's the need for separate network for storage why LAN cannot be used?

LAN hardware and operating systems are geared to user traffic, and LANs are tuned for a fast user response to messaging requests. With a SAN, the storage units can be secured separately from the servers and totally apart from the user network enhancing storage access in data blocks (bulk data transfers), advantageous for server-less backups.

Question #13

What is FCP?

The Fibre Channel Protocol (FCP) is the interface protocol of SCSI on Fibre Channel. It is a gigabit speed network technology primarily used for Storage Networking. Fibre Channel is standardized in the T11 Technical Committee of the InterNational Committee for Information Technology Standards (INCITS), an American National Standard Institute (ANSI) accredited standards committee. It started for use primarily in the supercomputer field, but has become the standard connection type for storage area networks in enterprise storage. Despite its name, Fibre Channel signaling can run on both twisted-pair copper wire and fiber optic cables.

Question #14

What is iSCSI ?

Internet SCSI (iSCSI) is a transport protocol that carries SCSI commands from an initiator to a target. It is a data storage networking protocol that transports standard Small Computer System Interface (SCSI) requests over the standard Transmission Control Protocol/Internet Protocol (TCP/IP) networking technology.

iSCSI enables the implementation of IP-based storage area networks (SANs), enabling customers to use the same networking technologies — for both storage and data networks. As it uses TCP/IP, iSCSI is also well suited to run over almost any physical network. By eliminating the need for a second network technology just for storage, iSCSI has the potential to lower the costs of deploying networked storage.

Question #15

What is FCIP ?

Fibre Channel over IP (FCIP) is also known as Fibre Channel tunneling or storage tunneling. It is a method to allow the transmission of Fibre Channel
information to be tunnelled through the IP network. FCIP encapsulates Fibre Channel block data and subsequently transports it over a TCP socket. TCP/IP services are utilized to establish connectivity between remote SANs. Any congestion control and management, as well as data error and data loss recovery, is handled by TCP/IP services, and does not affect FC fabric services. The major point with FCIP is that is does not replace FC with IP, it simply allows deployments of FC fabrics using IP tunneling

Question #16

What is iFCP

Internet Fibre Channel Protocol (iFCP) is a mechanism for transmitting data to and from Fibre Channel storage devices in a SAN, or on the Internet using TCP/IP. iFCP gives the ability to incorporate already existing SCSI and Fibre Channel networks into the Internet. iFCP is able to be used in tandem with existing Fibre Channel protocols, such as FCIP, or it can replace them. Whereas FCIP is a tunneled solution, iFCP is an FCP routed solution.iFCP is a gateway-to-gateway protocol, and does not simply encapsulate FC block data. Gateway devices are used as the medium between the FC initiators and targets. As these gateways can either replace or be used in tandem with existing FC fabrics, iFCP could be used to help migration from a Fibre Channel SAN to an IP SAN, or allow a combination of both

Question #17

What is FICON address ?

FICON generates the 24-bit FC port address field in yet another way. When communication is required from the FICON channel port to the FICON CU port,
the FICON channel (using FC-SB-2 and FC-FS protocol information) will provide both the address of its port, the source port address identifier (S_ID), and the address of the CU port, the destination port address identifier (D_ID) when the communication is from the channel N_Port to the CU N_Port.

Question #18

What are the two major classification of zoning?

Two types of zoning are
a) Software Zoning
b) Hardware Zoning

Question #19

What are different levels of zoning?

a) Port Level zoning
b) WWN Level zoning
c) Device Level zoning
d) Protocol Level zoning
e) LUN Level zoning

Question #20

What is FICON ?

FICON is a protocol that uses Fibre Channel as its physical medium. FICON channels are capable of data rates up to 200 MBps full duplex, they extend the channel distance (up to 100 km), increase the number of control unit images per link, increase the number of device addresses per control unit link, and retain the topology and switch management characteristics of ESCON.

Question #21

What is FSPF ?

FSPF keeps track of the links on all switches in the fabric and associates a cost with each link. The cost is always calculated as being directly proportional to the number of hops. The protocol computes paths from a switch to all other switches in the fabric by adding the cost of all links traversed by the path, and choosing the path that minimizes the cost.

Question #22

How FSPF works

The collection of link states (including cost) of all switches in a fabric constitutes the topology database (or link state database). The topology database is kept in all switches in the fabric, and they are maintained and synchronized to each other. There is an initial database synchronization, and an update mechanism.
82 Introduction to Storage Area Networks .The initial database synchronization is used when a switch is initialized, or when an ISL comes up. The update mechanism is used when there is a link state change. This ensures consistency among all switches in the fabric.

Question #23

What is Network Attached Storage (NAS) ?

Network Attached Storage (NAS) is basically a LAN-attached file server that serves files using a network protocol such as Network File System (NFS). NAS is a term used to refer to storage elements that connect to a network and provide file access services to computer systems. A NAS storage element consists of an engine that implements the file services (using access protocols such as NFS or CIFS), and one or more devices, on which data is stored. NAS elements may be attached to any type of network. From a SAN perspective, a SAN-attached NAS engine is treated just like any other server, but a NAS does not provide any of the activities that a server in a server-centric system typically provides, such as e-mail, authentication, or file management.

Question #24

How is Fiber Channel Different from iSCSI?

Fibre Channel and iSCSI each have a distinct place in the IT infrastructure as SAN alternatives to DAS. Fibre Channel generally provides high performance and high availability for business-critical applications, usually in the corporate data center. In contrast, iSCSI is generally used to provide SANs for business applications in smaller regional or departmental data centers.

Question #25

What is Frames?

Fibre Channel places a restriction on the length of the data field of a frame at 528 transmission words, which is 2112 bytes. (See Table 3-2 on page 52.) Larger amounts of data must be transmitted in several frames. This larger unit that consists of multiple frames is called a sequence. An entire transaction between two ports is made up of sequences administered by an even larger unit called an exchange.
A frame consists of the following elements:
_ SOF delimiter

_ Frame header
_ Optional headers and payload (data field)
_ CRC field
_ EOF delimiter

Question #26

What is Loop address ?
An NL_Port, like an N_Port, has a 24-bit port address. If no switch connection exists, the two upper bytes of this port address are zeroes (x'00 00') and referred to as a private loop. The devices on the loop have no connection with the outside world. If the loop is attached to a fabric and an NL_Port supports a fabric login, the upper two bytes are assigned a positive value by the switch. We call this mode a public loop.

Question #27

What is LUN?
LUN unique number that is assigned to each storage device or partition of the storage that the storage can support

Question #28

What is LUN Masking?
A method used to create an exclusive storage area and access control. And this can be achieved by storage device control program.

Question #29

What is WWN?
WWN is a 64bit address that is hard coded into a fiber channel HBA and this is used to identify individual port (N_Port or F_Port) in the fabric.

Question #30

What is a HBA?
Host bus adapters (HBAs) are needed to connect the server (host) to the storage.

Question #31

What is storage virtualization?
Storage virtualization is amalgamation of multiple n/w storage devices into single storage unit.

Question #32

What is virtualization?
A technique of hiding the physical characteristics of computer resources from the way in which other system application or end user interact with those resources. Aggregation, spanning or concatenation of the combined multiple resources into larger resource pools.

Question #33

What is Multipath I/O?
Fault tolerant technique where, there is more than one physical path between the CPU in the computer systems and its main storage devices through the buses, controllers, switches and other bridge devices connecting them.

Question #34

What are the 3 prominent characteristics of SAS Protocol?
a) Native Command Queuing (NCQ)
b) Port Multiplier
c) Port Selector

Question #35

What is the purpose of disk array?
Probability of unavailability of data stored on the disk array due to single point failure is totally eliminated.

Question #36.

What is disk array?
Set of high performance storage disks that can store several terabytes of data. Single disk array can support multiple points of connection to the network.

Question #37.

What are the advantages of RAID?
“Redundant Array of Inexpensive Disks”
Depending on how we configure the array, we can have the
- data mirrored [RAID 1] (duplicate copies on separate drives)
- striped [RAID 0] (interleaved across several drives), or
- parity protected [RAID 5](extra data written to identify errors).

These can be used in combination to deliver the balance of performance and reliability that the user requires.

Question #38.

How is a SAN managed?
There are many management software’s used for managing SAN's to name a few Santricity
- IBM Tivoli Storage Manager.
- CA Unicenter.
- Veritas Volumemanger.

Question #39.

Which one is the Default ID for SCSI HBA?
Generally the default ID for SCSI HBA is 7.
SCSI- Small Computer System Interface
HBA - Host Bus Adaptor

Question #40.

What is the highest and lowest priority of SCSI?
There are 16 different ID’s which can be assigned to SCSI device 7, 6, 5, 4, 3, 2, 1, 0, 15, 14, 13, 12, 11, 10, 9, 8.
Highest priority of SCSI is ID 7 and lowest ID is 8.

Question #41

Define RAID? Which one you feel is good choice?
RAID (Redundant array of Independent Disks) is a technology to achieve redundancy with faster I/O.

There are Many Levels of RAID to meet different needs of the customer which are: R0, R1, R3, R4, R5, R10, R6. Generally customer chooses R5 to achieve better redundancy and speed and it is cost effective.

R0 – Striped set without parity/[Non-Redundant Array].
Provides improved performance and additional storage but no fault tolerance. Any disk failure destroys the array, which becomes more likely with more disks in the array. A single disk failure destroys the entire array because when data is written to a RAID 0 drive, the data is broken into fragments. The number of fragments is dictated by the number of disks in the drive. The fragments are written to their respective disks simultaneously on the same sector. This allows smaller sections of the entire chunk of data to be read off the drive in parallel, giving this type of arrangement huge bandwidth.
RAID 0 does not implement error checking so any error is unrecoverable. More disks in the array means higher bandwidth, but greater risk of data loss

R1 - Mirrored set without parity.
Provides fault tolerance from disk errors and failure of all but one of the drives. Increased read performance occurs when using a multi-threaded operating system that supports split seeks, very small performance reduction when writing. Array continues to operate so long as at least one drive is functioning. Using RAID 1 with a separate controller for each disk is sometimes called duplexing.

R3 - Striped set with dedicated parity/Bit interleaved parity.
This mechanism provides an improved performance and fault tolerance similar to RAID 5, but with a dedicated parity disk rather than rotated parity stripes. The single parity disk is a bottle-neck for writing since every write requires updating the parity data. One minor benefit is the dedicated parity disk allows the parity drive to fail and operation will continue without parity or performance penalty.

R4 - Block level parity.
Identical to RAID 3, but does block-level striping instead of byte-level striping. In this setup, files can be distributed between multiple disks. Each disk operates independently which allows I/O requests to be performed in parallel, though data transfer speeds can suffer due to the type of parity. The error detection is achieved through dedicated parity and is stored in a separate, single disk unit.

R5 - Striped set with distributed parity.
Distributed parity requires all drives but one to be present to operate; drive failure requires replacement, but the array is not destroyed by a single drive failure. Upon drive failure, any subsequent reads can be calculated from the distributed parity such that the drive failure is masked from the end user. The array will have data loss in the event of a second drive failure and is vulnerable until the data that was on the failed drive is rebuilt onto a replacement drive.

R6 - Striped set with dual distributed Parity.
Provides fault tolerance from two drive failures; array continues to operate with up to two failed drives. This makes larger RAID groups more practical, especially for high availability systems. This becomes increasingly important because large-capacity drives lengthen the time needed to recover from the failure of a single drive. Single parity RAID levels are vulnerable to data loss until the failed drive is rebuilt: the larger the drive, the longer the rebuild will take. Dual parity gives time to rebuild the array without the data being at risk if one drive, but no more, fails before the rebuild is complete.

Question #42

What is the different between mirroring, Routing and multipathing?
Redundancy Functions Relationships Role Mirroring Generates 2 ios to 2 storage targets Creates 2 copies of data Routing Determined by switches independent of SCSI Recreates n/w route after a Failure Multipathing Two initiator to one target Selects the LUN initiator pair to use.

Question #43

Briefly list the advantages of SAN?
SANs fully exploit high-performance, high connectivity network technologies
SANs expand easily to keep pace with fast growing storage needs
SANs allow any server to access any data
SANs help centralize management of storage resources
SANs reduce total cost of ownership (TCO).

iSCSI fundamentals:-

iSCSI is a protocol defined by the Internet Engineering Task Force (IETF) which enables SCSI commands to be encapsulated in TCP/IP traffic, thus allowing access to remote storage over low cost IP networks.

Question #44

What advantages would using an iSCSI Storage Area Network (SAN) give to your organization over using Direct Attached Storage (DAS) or a Fibre Channel SAN?

iSCSI is cost effective, allowing use of low cost Ethernet rather than expensive Fibre architecture.
· Traditionally expensive SCSI controllers and SCSI disks no longer need to be used in each server, reducing overall cost.
· Many iSCSI arrays enable the use of cheaper SATA disks without losing hardware RAID functionality.
· The iSCSI storage protocol is endorsed by Microsoft, IBM and Cisco, therefore it is an industry standard.
· Administrative/Maintenance costs are reduced.
· Increased utilisation of storage resources.
· Expansion of storage space without downtime.
· Easy server upgrades without the need for data migration.
· Improved data backup/redundancy.

Question #45

How many minimum drives are required to create R5 (RAID 5) ?

You need to have at least 3 disk drives to create R5.

Question #46

What are the advantages of SAN?

Massively extended scalability
Greatly enhanced device connectivity
Storage consolidation
LAN-free backup
Server-less (active-fabric) backup
Server clustering
Heterogeneous data sharing
Disaster recovery - Remote mirroring
While answering people do NOT portray clearly what they mean & what advantages each of them have, which are cost effective & which are to be used for the client's requirements.

Question #47

What is the difference b/w SAN and NAS?

The basic difference between SAN and NAS, SAN is Fabric based and NAS is Ethernet based.
SAN - Storage Area Network
It accesses data on block level and produces space to host in form of disk.
NAS - Network attached Storage
It accesses data on file level and produces space to host in form of shared network folder.

Question #48

What is a typical storage area network consists of - if we consider it for implementation in a small business setup?

If we consider any small business following are essentials components of SAN
- Fabric Switch
- FC Controllers
- JBOD's

Question #49

Can you briefly explain each of these Storage area components?

Fabric Switch: It's a device which interconnects multiple network devices .There are switches starting from 16 port to 32 ports which connect 16 or 32 machine nodes etc. vendors who manufacture these kind

of switches are Brocade, McData.
FC Controllers: These are Data transfer media they will sit on PCI slots of Server; you can configure Arrays and volumes on it.
JBOD: Just Bunch of Disks is Storage Box, it consists of Enclosure where set of hard-drives are hosted in many combinations such SCSI drives, SAS, FC, SATA.

Question #50

What are the benefits of NAS for SMBs?

The key benefit is the ability to consolidate structured and unstructured data into a file-sharing environment that utilizes the existing IP infrastructure. Since NAS clients rarely require any additional hardware to access data, the initial investment is contained to the NAS array itself.

Question #51

Is NAS a better storage option for SMBs than a SAN or a mixed solution?

Absolutely, it is a much better option. NAS can leverage your existing IP infrastructure and very rarely requires any additional hardware or software for access. It easily integrates with corporate security and authentication domains such as Radius, Active Directory and LDAP, making it a very attractive option for SMBs.

Question #52

What is clustered NAS and what are its benefits?

Clustered NAS is typically defined as a concurrent multi-node access to and servicing of data. This is usually accomplished by implementing some kind of distributed or clustered file system that allows any node to serve data regardless of where it's located or who actually owns it. In a traditional NAS environment, the filer head actually owns that data and that is typically what serves it — very much like a server-based file-serving environment. If the server or head goes down, you can typically have a passive or a standby node pick it up and serve that same storage. Traditionally, NAS has suffered from a scalability issue at the higher end and the inability to service multiple concurrent connections. Clustered NAS overcomes these limitations by dynamically distributing client connections to multiple heads. The key thing with clustered NAS is again cost, which will need to be considered in the SMB space.

Question #53

HOW IS FIBRE CHANNEL DIFFERENT FROM ISCSI?

Fibre Channel and iSCSI each have a distinct place in the IT infrastructure as SAN alternatives to DAS. Fibre Channel generally provides high performance and high availability for business-critical applications, usually in the corporate data center. In contrast, iSCSI is generally used to provide SANs for business applications in smaller regional or departmental data centers.

SAN Objective type Questions and Answers:

1. This is a repository for the storage, management, and dissemination of data in which the mechanical, lighting, electrical and computer systems are designed for maximum energy efficiency and minimum environmental impact.
   a. Storage lab
   b. Data Center
   c. Data warehouse
   d. Fabric

Answer:b

2. This is the process of assigning storage, usually in the form of server disk drive space, in order to optimize the performance of a storage area network.
a. Storage Provisioning
b. Data mining
c. Storage assignment
d. Data Warehousing

Answer:a

3. Simply stated, these are large boxes that hold lots of hard disks.
a. Host
b. Tape library
c. Switch
d. Disk Array

Answer:d

4. This consists of the precautions taken so that the effects of a disaster will be minimized.
a. Data retrieval
b. Disaster recovery
c. Archive
d. Replication

Answer:b

5. This is the practice of collecting computer files that have been packaged together for backup, to transport to some other location, for saving away from the computer so that more hard disks can be made available, or for some other purpose.
a. Backup
b. Archive
c. Migration
d. Compression

Answer:b

6. Pick the false statement
a. RAID Level 1 provides disk mirroring
b. RAID Level 2 provides bit level striping with Hamming code ECC
c. RAID Level 4 provides block level striping
d. RAID Level 5 provides block level striping and error correction information

Answer:d

7. Which of the following provides byte level striping?
a. RAID 6
b. RAID 4
c. RAID 2
d. RAID 5

Answer:d

8. State true or false
a. Nested RAID provides better performance characteristics than the RAID levels that comprise them (true/false) – True
b. RAID Level 6 has dual parity whereas RAID Level 5 has single parity and both does block level striping(true/false) – False
c. RAID Level 7 does Asynchronous cached striping with dedicated parity(true/false) – True

Answer:d

9. Which of the following is false about tape devices?
a. A tape drive is a data storage device that reads and writes data stored on a Magnetic tape
b. Tape drives are used for archival storage of data
c. Tape media has low unit cost and long archival stability
d. Tape drives allow random access of data

Answer:d

10. Select the correct option regarding tape drive
a. Tape drives have fast average seek times
b. Tape drives can stream data at a very fast rate
c. Archival life of data stored on tape is around 5 years
d. Tape drives can be used t store data on optical disks

Answer:b

11. A tape library does not contain
a. Tape Drive
b. Bar Code Reader
c. Robotic Arm
d. RAID Array

Answer:d

12. Which of the following is not true about a tape silo?
a. Libraries provide large storage capacity at a very cheap rate
b. They have slow access time
c. Tape libraries are primarily used for backups and as the final stage of digital archiving

Answer:b

13. For long term storage (archival) of data which of the following storage devices is generally used
a. Hard Disk
b. CD Rom
c. Floppy Disk
d. Tape Cartridges

Answer:d

14. Which of the following Company manufactures Tape Library?
a. Quantum

b. Brocade
c. NetApps
d. Cisco

Answer:a

15. Which of the following Company manufactures RAID devices?
a. Qlogic
b. LSI
c. Falconstor
d. Quantum

Answer:b

16. What is the most basic level of storage
a. SAN
b. DAS
c. NAS
d. ISCSI

Answer:b

17. A NAS solution is most appropriate for what type of data environment
a. Secured Access
b. Shared access
c. Remote access
d. Parallel access

Answer:b

18. Which three statements describe differences between Storage Area Network (SAN) and Network Attached Storage (NAS) solutions? Choose three.
a. SAN is generally more expensive but provides higher performance
b. NAS uses TCP/IP for communication between hosts and the NAS server
c. NAS requires additional hardware on a host: a host bus adapter for connectivity
d. SAN uses proprietary protocols for communication between hosts and the SAN fabric

Answer:a, b, d

19. I/O requests to disk storage on a SAN are called
a. File I/Os
b. SAN I/Os
c. Block I/Os
d. Disk I/Os

Answer:c

20. Demerits of DAS are. Choose two.
a. Interconnect limited to 10km
b. Excessive network traffic
c. Distance limitations
d. Inability to share data with other servers

Answer:c, d

21Which topology is best suited for medium sized enterprise.

a. NAS
b. SAN
c. DAS

Answer:a

22. Disk controller driver in DAS architecture is replaced in SAN either with ——
a. FC Protocol
b. iSCSI
c. TCP/IP stack
d. Any one of the above

Answer:d

23. Which storage technology requires downtime to add new hard disk capacity
a. DAS
b. SAN
c. NAS
d. None of the above

Answer:a

24. In SAN storage model, the operating system view storage resources as —— devices
a. FC
b. SCSI
c. SAN
d. None of the above

Answer:b

25. Identify a network file protocol in the below mentioned set.
a. FC
b. CIFS
c. SCSI
d. NAS

Answer:b

26. What will be used by SAN to provide connectivity between hosts and storage?
a. FC
b. iSCSI
c. FC or iSCSI
d. SCSI

Answer:c

27. In FC structure which layer maps block I/O SCSI commands into FC frames?
a. FC-4

b. FC-1
c. FC-0
d. None of the above

Answer:a

28. What are the major benefits of SAN?
a. Centralized backup
b. Storage consolidation
c. LAN-less backup
d. Share resources
e. All of the above

Answer:e

29. Which data storage technology offers the best performance?
a. SAN
b. NAS
c. DAS
d. None of the above

Answer:a

30. Identify the data storage technology used in the below data center?
a. NAS
b. SAN
c. DAS
d. None of the above

Answer:b

31. Which of the following is not a non volatile storage device?
a. Memory Stick
b. Hard Disk
c. Random Access Memory
d. NVRAM

Answer:c

32. Which of the following is sequential access storage device?
a. Hard Disk
b. CD-ROM
c. Tape Cartridge
d. Main Memory

Answer:c

33. Which of the Following is not an off-line storage device?
a. Tape Cartridge
b. Flash Memory
c. Tape Library
d. CD-ROM

Answer:c

34. Pick the wrong statement about the hard disk?
a. Hard disk has multiple platters and each platter has two read/write heads one on each side
b. It’s a non-volatile & random access storage device

c. Hard disk can only have IDE or USB interface
d. Data Transfer rate is over 80 MBPS

Answer:c

35. Which of the following statements about various hard disks is wrong?
a. SATA Disks support faster transfer rates and have support for hot swapping
b. USB Hard disks store data on flash memory
c. ATA hard disks cannot be connected externally to computer

Answer:b

36. Which of the following is false?
a. NVRAM has built in battery which keeps power applied to it even after the power is switched off.
b. Flash memory can be electrically erased and reprogrammed
c. Flash memory is used in memory sticks
d. Flash disk can only have USB interface.

Answer:d

37. Which of the following is not true about JBOD?
a. JBOD can combine hard disks of different sizes into a single unit without loss of any capacity.
b. If a drive in a JBOD set dies then it may be easier to recover the files on the other Drives
c. JBOD supports data redundancy
d. JBOD doesn't has any storage controller intelligence

Answer:c

38. Pick odd one out
a. Mirroring
b. Striping
c. Error-correction
d. fault tolerance

Answer:d

39. Which one of the following is not an advantage of RAID?
a. Data Security
b. Increased & integrated capacity
c. Improved performance
d. Effective data capacity increases

Answer:d

40. Pick the false statement about RAID 0
a. Provides no redundancy
b. Provides data striping
c. improves performance
d. Provides fault tolerance

Answer:d