CSG2132 Module 5
Storage Virtualisation and Capacity Planning

NAS

Network Attached Storage (NAS) is a storage array that acts as a discreet, independent node on the network rather than embedded with a network node such as a server. All servers on the network will see the NAS as its own local DAS, even though it's not. NAS usually reside within their own devices that contain the hardware and software (logic) to house the storage devices and act as a 'file server' of sorts.

The key advantage of NAS is that its capacity is easily scalable by simply adding more NAS nodes to the network. The disadvantage of NAS is that RW performance is highly dependent on network speed, which may well deteriorate as additional devices impact on network performance in the form of congestion. This, any plan to add NAS nodes may necessitate commensurate upgrades of the underlying network transmission hardware as well.

At the enterprise level, NAS will generally use SAS (Serial Attached SCSI) enabled drives that are faster and more reliable than SATA drives, essential in high speed and high availability data transfer I/O requirements such as banking transactions and Ecommerce.

SAN

Storage Area Network (SAN) allow attached client nodes to stored data at the block level. Block level storage places HDD/SSD assets in a remote chassis accessible via Fibre Channel or iSCSI. In effect therefore, SAN storage is seen as a locally attached disk to network servers, which they then interact with accordingly, even though they are not local to the servers at all.

Servers can even be configured to boot from SAN rather than local disk. SAN offers flexibility in data storage management because the location and configuration of physical storage devices is irrelevant to users. Since servers only have direct access only to the SAN device (remote chassis), and not to the storage that device manages, SAN expansions and reconfigurations can be done without impacting attached servers.

This is perfect for 'live' expansions. SANS usually employ one of three transmission protocols, these being Fibre Channel (FC), FC over Ethernet (FCoE) and iSCSI. Fibre Channel (FC) is a high-speed data transfer protocol that runs from 1 to 128 gigabit per second rates, providing in-order, lossless delivery of raw block data.

It usually employs optical fibre cables within and between network nodes, but can also run on copper. iSCSI (Internet Small Computer Systems Interface) is an IP-based storage networking standard that allows block-level access to SAN devices by carrying SCSI commands over a TCP/IP network and allow location-independent data storage and retrieval.

SMB stands for Server Message Block (SMB), a network communication protocol for providing shared access to files, printers, and serial ports between nodes on a network.

FTP is the File Transfer Protocol (FTP) is a standard network protocol used for the transfer of computer files between a client and server on a computer network and is built on a client-server model architecture using separate control and data connections between the client and the server.

NFS stands for the Network File System which is a distributed file system protocol that allows users on a client computer to access files over a computer network much like local storage is accessed.

SAS stands for Serial Attached Small Computer System Interface and is a point-to-point serial protocol that moves data to and from computer-storage devices such as hard drives and tape drives.

SATA stands for Serial AT Attachment and is a computer bus interface that connects host bus adapters to mass storage devices such as hard disk drives, optical drives, and solid-state drives.

SANs use Block Level Storage in a network environment. It works by establishing raw volumes of storage treated as blocks that can be controlled as if they were individual hard drives. These blocks are controlled by server based operating systems such as Windows Server and Linux Server, with each block being individually formatted with the required file system.

Block Level Storage

Block level storage can be used to store files and can work as storage for special applications like databases and Virtual machine file systems

Block level storage data transportation is highly efficient and reliable in comparison to file-based storage systems

Block level storage supports individual formatting of file systems like NFS, NTFS or SMB (Windows) or VMFS (VMware) which are required by applications using the storage systems

Each storage volume can be treated as an independent disk drive and it can be controlled by external server operating system

Block level storage uses iSCSI and FCoE protocols for data transfer as SCSI commands act as communication interface in between the initiator and the target

As you'll recall, although being more expensive and complex that file-based storage access systems, SAN has many advantages that make it a popular choice in large-scale datacentres which include:

- The elimination of bandwidth bottlenecks associated with LAN-based server storage
- A very high degree of scalability not possible with SCSI bus-based systems

- High availability, which is critical in large-scale datacentres as we discussed last week
- Greater fault tolerance
- Centralized storage management.
- Faster backups
- Rapid data migration
- Improved storage utilization
- Better data protection and Disaster Recovery (DR)

Storage virtualisation is the pooling of physical storage from multiple storage devices into what appears to be a single storage device that is managed from a central console. The technology relies on software to identify available storage capacity from physical devices and to then aggregate that capacity as a pool of storage that can be used in a virtual environment by virtual machines (VMs).

The virtual storage software intercepts I/O requests from physical or virtual machines and sends those requests to the appropriate physical location of the storage devices that are part of the overall pool of storage in the virtualised environment. To the user, virtual storage appears like a standard read or write to a physical drive.

Even a RAID array can sometimes be considered a type of storage virtualisation. Multiple physical disks in the array are presented to the user as a single storage device that, in the background, replicates data to multiple disks in case of a single disk failure.

Types of storage virtualisation

There are two basic methods of virtualizing storage: file-based or block-based. File-based storage virtualisation is used with network-attached storage (NAS) systems. Using the Server Message Block (SMB) or Network File System (NFS) protocols, file-based storage virtualisation breaks the dependency in a normal NAS array between the data being accessed and the location of physical memory. This enables the NAS system to better handle file migration in the background to improve performance.

Block-based or block access virtual storage is more widely applied in virtual storage systems than file-based storage virtualisation. Block-based systems abstract the logical storage, such as a drive partition, from the actual physical memory blocks in a storage device, such as a hard disk drive (HDD) or solid-state memory device. This enables the virtualisation management software to collect the capacity of the available blocks of memory space and pool them into a shared resource to be assigned to any number of VMs or physical servers.

Virtualisation methods

Storage virtualisation today usually refers to capacity that is accumulated from multiple physical devices and then made available to be reallocated in a virtualised environment. There are multiple ways storage can be applied to a virtualised environment:

Host Based

Host-based storage virtualisation is seen in HCI systems and cloud storage. In this case, the host, or a hyper-converged system made up of multiple hosts, presents virtual drives of a set capacity to the guest machines, whether they are VMs in an enterprise environment or PCs accessing cloud storage. Virtualisation and management are done at the host level via software, and the physical storage can be almost any device or array.

Array Based

Array-based storage virtualisation most commonly refers to the method in which a storage array presents different types of physical storage for use as storage tiers. How much of a storage tier is made up of solid-state drives (SSDs) or HDDs is handled by software in the array and is hidden at the guest machine or user level.

Network Based

Network-based storage virtualisation is the most common form used in enterprises today. A network device, such as a smart switch or purpose-built server, connects to all storage devices in a Fibre Channel (FC) storage area network (SAN) and presents the storage as a virtual pool.

Storage virtualisation disguises the actual complexity of a storage system, such as a SAN, which helps a storage administrator perform the tasks of backup, archiving and recovery more easily and in less time.

Logical Unit Number

A logical unit number (LUN) is an identifier used for labeling and designating subsystems of physical or virtual storage. Depending on the environment, a LUN may refer to a subsection of a disk or a disk in its entirety. Different areas in physical drives are assigned LUNs so data can be read, written or fetched correctly from servers on a storage area network (SAN). In both hard disk drives (HDDs) and solid state drives (SSDs), volumes of LUNs make up the physical drive.

A LUN can represent one disk, an entire redundant array of independent disks (RAID), or partitions of a disk, all of which execute I/O commands. LUNs allow users to differentiate between and manage separate shared volumes on a single SAN.

They are the identifiers for building blocks of information on a physical disk drive and in some cases, virtual drives or virtual machines (VMs). LUNs are used to label slices of disk storage that are viewable from a server. They can also function as partitions, sectioning off portions of a volume from one another. They separate portions of disks that use different operating systems or have unique application requirements.

Thin provisioning enables storage administrators to provision more storage on a LUN than is currently available on the volume. Users often do not consume all the space they request, which reduces storage efficiency if space-reserved LUNs are used.

By over-provisioning the volume, storage administrators can increase the capacity utilization of that volume. When a new thinly provisioned LUN is created, it consumes almost no space from the containing volume. As blocks are written to the LUN and space within the LUN is consumed, an equal amount of space within the containing volume is consumed.

With thin provisioning, you can present more storage space to the hosts connecting to the storage controller than is available on the storage controller. Storage provisioning with thinly provisioned LUNs enables storage administrators to provide users with the storage they need at any given time.

The advantages of thin provisioning are as follows:

- Provides better storage efficiency.
- Allows free space to be shared between LUNs.
- Enables LUNs to consume only the space they actually need.

Software-Defined Storage

Software-Defined Storage (SDS) provides abstraction of storage characteristics from the underlying hardware. This means that SDS solutions can run on x86 processor driven server hardware enabling cost savings over traditional storage area network (SAN) and network-attached storage (NAS) systems, which tightly couple software and hardware.

With SDS, storage management becomes unified and much easier as all storage resources are pooled together and managed at the OS or Hypervisor layer with the help of virtual storage controllers running on every cluster node. This allows applications to be provisioned with the resources they require such as memory, storage, and networking, via a single management interface.

By separating the storage hardware from the software layer, Software-Defined Storage allows organisations to purchase heterogeneous storage hardware assets from multiple vendors, which increases operational options and decreases costs through genuine competition. Thus, SDS allows the avoidance of vendor lock-in and eliminates such issues as under- or over-utilisation of storage resources and interoperability problems.

One of the greatest benefits of SDS is that it allows maximum utilisation of existing storage infrastructure that may not have been previously possible. These include deduplication, replication, snapshotting, server-side caching, and log-structuring across a wide range of server hardware components.

SDS also provides advantages that come with making existing IT infrastructure more flexible. System can easily scale up by simply adding more capacity to the existing storage nodes, or to scale out by adding new nodes with their own storage, RAM, and CPUs to increase both capacity and performance.

Capacity Planning

Planning how much storage capacity a datacentre requires a balance between capacity and cost. Insufficient storage will cause massive performance issues and even downtime. Too much may waste the storage budget.

Therefore, the goal of storage capacity planning is to predict how much storage is required in any given timeframe so that the right amount of capacity can be purchased and provisioned with enough emergency buffers built in of course.

On the other hand, buying too much disk space is wasteful, therefore it is critical to track the growth rate of storage utilisation with the datacentre and extrapolate sensibly into the future.

Data Archiving

Organisations accumulate a lot of data, but sometimes they need or want to store that data in an unalterable way. A common approach to this is called *write once read many*, or WORM, compliant storage.

WORM is immutable storage. Data is written to the storage device or media precisely one time. After that, no one can legitimately change the data in any way.

A simple version of WORM storage is a CD-R disc. You can write data to the blank disc once, but that's it. The disk can be damaged or destroyed to deny access to it, but the data stored on it cannot be modified.

What WORM storage does is allow multiple readings of the data, but only one (1) write operation.

WORM Records Retention

Many organisations have record keeping obligations set in law. In WA for examples, many organisations are obliged to comply with the State Records Act 2000. Depending on the type of information being kept, required storage periods can range from seven years to many decades. In this context, WORM compliant storage becomes a serious consideration.

Content Addressable Storage

Content Addressable Storage (CAS) is a storage mechanism in which fixed data is assigned a permanent location on a hard disk and addressed with a unique content name, identifier or address. CAS is also known as associative storage, content aware storage or Fixed Content Storage (FCS).

CAS is designed to facilitate more efficient storage and access of fixed data that does not generally change over time. It allows organisations to archive and retrieve large amounts of data for longer retention periods, specifically to comply with regulatory requirements.

CAS works by storing each data object on a hard disk and assigning it a unique content address/identifier. Once the data object is stored, it cannot be duplicated, modified or deleted. To access the data, a user or application must specify the data's content address or identifier.