NCSA-HC

**Cloud Fundamentals**

**Storage Fundamentals**

* **Disk** – uses rapidly rotating disks coated with magnetic material for storing and retrieving digital information.
  + **RAID 4 –** provides a parity disk to protect the data in the event of a single-disk failure. Requires a minimum of 3 disks
  + **RAID-DP –** provides two parity disks to protect the data in the event of a double-disk failure. Requires a minimum of 5 disks
  + **RAID-TEC –** provides three parity disks to protect the data in the event of a triple-disk failure. Requires a minimum of 7 disks.
* **Disk Array** – collection of disks that form a redundant storage system that is controlled by firmware. Has cache memory and advanced functionality such as RAID and virtualization. Increases availability, resiliency, and maintainability.
* **JBOD (Just a bunch of disks)** – collection of disks that are not in a RAID configuration. Disks are presented to a server with no amalgamation, pooling, or structure applied.
* **Intelligent Storage Systems** – capability of fully or partially realizing functions that are usually implemented on host computers. Front end, cache, backend, and physical disks
* Reasons to Invest in Storage:
  + Applications
  + Data Protection
  + Data Availability
  + Data Security
  + Scalability
  + Performance
  + Cost

Storage Technologies

* **DAS (Direct attached Server)** – attached disk without any network in between.
* Can be individual disks, group of disks, attached to disk
* Application sharing and file sharing
* Used mainly for server or group of servers. Most cost-effective solution
* Protocols
  + ATA
  + SATA
  + eSATA
  + SCSI
  + SAS
  + FC
* **NAS (Network Attached Storage) –** appears as a file server with an IP address. Accessed over a network connection.
  + Takes the filer portion which handles file transfers solution. Acts like its own container computer.
  + Cost Effective
  + Utilization rate is high
  + Protocols
    - CIFS
    - NFS
* **SAN (Storage Area Network)** – block based storage system available over the system.
  + Can move large amounts of data.
  + Protocols
    - iSCSI – IP based storage access protocol. iSCSI initiator is a server that initiates iSCSI command. iSCSI targets are storage devices that are iSCSI enabled.
    - FC – HBA (host bus adapter) installed on each server. HBA’s connect the server directly to the storage system in a small environment. Can also be connected with a FC switch. Accelerate backup and restore, improve business continuanace, boost HA, and storage conslidation
    - FCoE – FC protocol with 10 GB Ethernet. Eliminates the need for two different data centers.
* **Storage virtualization** – consists of taking several physical storage devices and joining them to appear as one logical unit to manage.
* **Flash Storage**
  + Memory unit – stores data
  + Access Controller – manages and controls access to the storage space on the memory unit
* **Cloud Computing** – resources used in the cloud.
  + Public Cloud
  + Private Cloud
  + Hybrid Cloud

**Virtualization Fundamentals**

* **Virtualization** – breaks the bond between hardware and applications, allowing customers to realize higher utilization levels of their physical resources.
* **Server virtualization** – server can run multiple applications and OS’s. Greater utilization
  + Benefits: low server spend, decreased OS costs, lower management costs, increased flexibility, higher availability
  + Could have complete failure for 10 systems if data is not backuped.
  + Server sprawl doesn’t remedy storage sprawl
* **Storage virtualization:**
  + RAID 0 strips data across 2-3 disks with no parity for redundancy.
  + RAID 1 mirrors data across 2-3 disks. Fault tolerance
  + RAID 5 uses block level stripping with parity data distributed across all member disks and only needs 1 drive to be present to operate
  + RAID 10 is a strip of mirrors. Multiple raid 1 mirrors and a raid 0 strip is created over these.
  + Snapshots are incremental
  + Benefits:
    - Utilization – flexvault allows better utilization
    - Deduplication – contains a copy of 1 OS across multiple VM’s
    - Multiprotocol in a single storage pool, lower TCO, investment protection, DR more accessible.

**Flash Fundamentals**

* **SSD Basics**
  + SSD provide higher performance than HDD
    - Measuring endurance is different
    - Flash accelerates I/O
      * Server
      * Hybrid
      * All Flash array (Flash appliances) contains controllers and DRAM
      * Traditional arrays
    - Flash Devices
      * USB Drives
      * SD Cards
      * PCIe Cards (Perferral Component Interface)
      * SSD
    - Components
      * DRAM memory
      * Flash controller – manages data placement and access, transfers data to DRAM
      * Flash memory chips
* NAND - Container that stores a charge
  + Surrounds a permeable barrier to hold the charge
  + NAND is NVMEM
    - Data is maintained across power cycles
    - Barrier remains closed until power is supplied to open it
    - Barrier requires power to release its charge
    - NAND used to use SLC (Single-Layer cell) and then MLC (multilayer cell) and then TLC (Triple-layer cell)
    - 2D NAND
      * Shrinking planar cell holds less charge
      * Fewer electrons
      * Fewer program/erase (P/E) cycles
      * Small loss
    - 3D NAND
      * Use larger cells
      * More differentiation between bit states
      * Less interference
      * Better P/E cycles, better endurance
      * Increased scalability
      * Benefits
        + Endurance
        + Density
        + Power
        + Performance
* SSD Endurance
  + SLC
  + **eMLC (enterprise)** – slower programming speeds but high P/E
  + **cMLC (consumer)** – high programming speeds but low P/E
  + **P/E cycles (Program/Erase)** – finite lifetime. Bit errors occur when charged can be recognized.
  + DWPD (Drive writes per day) – Evaluation = TBD + DWPD.
    - P/E cycle rating
    - Expected lifetime of the drive
    - Average write amplification
    - Percentage of overprovisioned capacity
  + Warranty
  + Workload
  + Voltage – improves i/o but wears on it.
  + **Write amplification** – aggregate measure of PE cycles. Caused by rewrite activity to a used block. Reduces endurance
    - Voltage can’t be added incrementally to a cell. All the voltage must be taken out before a new value can be put in.
    - NAND flash must be erased before a rewrite
      * Erase block are much larger than write block
      * Rewriting a block forces a rewrite of the full erase block
    - FTL (Flash Translation Layer) part of the controller
      * FTL can move the on-disk data location as needed
      * Abstraction layer between host address and on-disk data
      * Logs overwrite as they occur.
        + New data is written to a new location
        + Dirty data is marked for deletion
        + Erased blocks are logged as dirty blocks as well
      * Attempts to use all NAND erase blocks equally which is known as wear leveling
      * Write amplification is reduced by deferring the P/E cycle.
      * Garbage collection
        + Dirty blocks accumulate
        + FTL can reclaim fragmented space
        + Increases free space on your SSD
        + Runs transparently in the background
        + Has potential for latency
        + Some systems with internal write-back cache in the controller maintain low latency.
        + Needs swap space to operate efficiently.
        + Overprovisioning (OP) is a dedicated capacity that can’t be accessed.
  + **MSW(Multi-stream Write)** – data management feature
    - Enables greater control and efficiency for data placement
    - Reduces overprovisioning requirements
    - Enables multiple data streams to be grouped or segregated
    - Enables writes to be tagged so the FTL can work better.
  + TBW (Total Bytes Written)
    - Provides data around the life of the SSD compared to it’s P/E. Compares data relative to the warranty agreement.
  + Storage disk show – shows current usage life of the SSD.

**Data Network Fundamentals**

* Data Network is data over distance
* Data Storage is data over time.
* **DAS (Direct-Attached Storage)** – Application, File System, and Storage are all connected together. Like an external hard drive.
* **NAS (Network-Attached Storage)** – Device is attached to the network but appears on the network. Accessed by other machines.
  + Looked at by one device connected through the network. Appears as a file server
  + File access
  + Management simplified
* **SAN (Storage Area Network)** – Storage appears to the network as another drive.
  + On it’s own network. Mounted as a disk drive
  + Dedicated to storage
  + Block access and stored as data blocks
  + Performance High, configuration flexible.
* SAS (Serial Attached Scusi)
  + Network is created via aerial cables.
  + Can’t be longer than 8 meters and has limited range. Inexpensive
* FC (Fibre Channel)
  + SAN environment to signal to the FC
  + Reliable, Scalable, Flexible
  + Can be used with most cable types
  + FC-P2P (point-to-point)
    - Host server connected to the storage appliance
  + FC-AL (arbitrated loop)
    - All devices are in a loop
    - More connects
    - Failures can cause a break in the loop
  + FC-SW (Switched Fabric) single or dual
    - Interconnected via switches
    - Each host either connected to a single or dual
  + Zoning
    - Group of fibre channel ports
    - Only located in one or multiple zones.
    - Hard is defined by a switch
    - Soft cables can be moved without reconfiguring.
  + Block storage
    - Handles data in chucks
    - Provides greater flexiblity
  + File storage
    - Handles data in terms of files.
    - Easier to deploy
  + HA – data available at all times
    - Redundancy
    - 99% or 99.99%
  + HPC – exceptionally large system
    - Small configuration changes produce large benefits
    - Performance is measured in FLOPS (Floating point operations per second)

**Intro into NetApp products**

* **ONTAP 9** – runs on traditional FAS and AFF with some converged systems/3rd party/near cloud
  + Consolidates data management
  + Reduces costs of flash with inline storage efficiencies
  + Increases performance up to 60% with flash optimizations
  + Shrink storage footprints with 15 TB.
* **ONTAP Select** – Software defined that is run on-premise on commodity server hardware
  + Deployed in a DC or remote office
  + Uses a flexible capacity-based license
  + Capitalizes on SDS
  + Data protection
* **ONTAP Cloud** – run in the cloud on AWS/Azure. (E, EF, and SolidFire uses other software
  + Quick deployment for DevOps
  + Enables easy data movement between onpremises.
* OnCommand Management Protfolio
  + System Manager
    - Included with ONTAP software.
    - Works with all FAS systems and flex software
  + Unified Manager/Performanced Manager
    - Provides storage health
  + OnCommand Workflow Automation (OnCommand WFA)
    - automated operations
  + API Services
  + OnCommand Insight
    - Single interface with multivendor environments
* SnapCenter Software
  + Unified solution for data protection. Powered by SnapCenter Server
  + Plug-ins replace Snapmanager and Snapdrive
  + Includes a plugin creator
  + Benefits
    - Centralized UI
    - Increases performance and reduces testings
    - RBAC
    - Offers load balancing
  + **Snapshot** – low impact. POT
  + **SnapVault** – Disk to disk backup with RPO < 1 hour and incremental transfers.
  + **SnapMirror** – Regional Dataprotection with asynchronous and fail back
  + **Metro Cluster** – array base clustering
  + **SnapLock** – retain data to maintain data compliance.

**FAS Systems**

* FAS2600 – Small enterprises, midsize businesses
* FAS8200 – Enterprise workloads
* FAS9000 – Business-critical workloads
* FAS support SAS, SATA, SSD, and NSE (Netapp Storage Encyrption) with HA

**All FLASH FAS**

* AFF8000 – Entry Level
* AFFA200
* AFF8040 – Midrange
* AFFA300
* AFF8080/AFF8080EX – High End
* AFFA700s
* AFFA700

**Unified Storage Architecture**

* Nondisruptive operations
* Seemless scalability
* Proven efficiency

**E Series**

* E2800 – small/medium workgroups
  + 12 disks
  + 24 disks
  + 60 disks
* E5700 – DC, HP environments
  + 24 disks
  + 60 disks
* EF570
  + 24 disks
* DE212C
  + 2U, 12 disks
* DE224C
  + 2U, 24 disks
* DE460C
  + 4U, 60 disks
  + System shelves contain controllers
  + Disk shelves contain input/output modules (IOM’s)
    - IOM monitor disk shelves and give a way to cascade disk shelves
* SANtricity System Manager
  + Administer E-Series or EF series
  + Maximizes storage use and promotes uninterrupted data availability
  + Highly configurable to optimize performance
  + Keeps data always available, protected, and secure

**SolidFire Systems**

* EF-Series
  + Standalone applications
  + Streamlined architecture optimized for low-latency workloads
* All Flash FAS
  + Performance plus robust data management optimized for shared general IT
  + General-purpose virtual infrastructure
* SolidFire
  + Seamless scaling, service-oriented flash storage for next-gen DC
  + Cloud infrastructure, on-premises or off-premises
  + Scale out to 100 nodes and PB of data
  + Compatible with existing customer hardware
  + QOS and system automation. HA/inline data reduction technologies
  + Add new nodes to expand
* Active IQ
  + Holistic system monitoring
  + Enable customers to prevent storage issues
  + Simplifies data management

**Converged Infrastructure Solutions**

* FlexPod
  + Combine a UCS and Nexus Switches + NetApp storage
  + Supports any cloud strategy
  + Supported by NetApp/Ciscio support desk
  + Accelerates DC transformation
  + **FlexPod Express** – remote office or branch office
  + **FlexPod Datacenter** – enterprise applications/Vdi
  + **FlexPod Select** – Big Data and Analytics
  + **FlexPod SF** – Next gen DC

**NetApp HCI**

* **HCI (Hyper Converged Infrastructure)** – relies on software to integrate compute, server, storage, virtualization, and virtualized internal networking
  + Conveniently and neatly encapsulated
  + Data Fabric Ready. Easy to scale/Guaranteed Performance/Automated Infrastructure
  + SolidFire is the pick for HCI.
    - Integrated Data Services
    - Data Fabric Services
    - Third-Party Services

**FlexArray Storage Virtualization Software**

* Enables E-Series or third-party vendor storage arrayed to be used for ONTAP aggregates
* Can be purchased and activated any time on FAS8000
* Works with FAS disk and storage arrays
* Support multiple array vendors
* Benefits
  + Converts silos into Unified

**Near-Cloud and Cloud Solutions**

* ONTAP Cloud
  + Manage elastic workloads
  + Enable customers to control and govern data in the cloud
  + OnCommand Insight
  + OnCommand Cloud Manager
  + Multiprotocol support, snapshot, provisioning, deduplication, etc
* NPS (NetApp Private Storage)
  + Manage elastic workloads
  + Can connect to multiple clouds
  + Retain control
  + Hybrid approach
* AltaVault
  + Low cost backup workloads
  + Caches backups locally vaults to public or private cloud
  + Perserve investments in existing infrastructure
* StorageGRID Webscale
  + Active archival workloads that are accessed regularly
  + Manages massive unstructured datasets
  + Spans geographic distributed locations
  + Manages data based on cost, security, etc
  + Encryption with secure multisite dispersion
* Cloud Sync
  + SaaS enables seamless secure data sync
  + Moves and syncs data between on-premise or with S3
* NetApp Cloud Control for Office 365
  + Manages data for Office 365
  + Simplified backups and advanced granular recovery

**NetApp Business Consulting and Professional Services**

* NetApp Business Consulting
  + Define strategic direction to drive innovation and evolve business
  + Supply data-drive insights and identify opportunities
  + Accelerate digital transformation
* Professional Services
  + Smooth deployment and transition with end-to-end expertise
  + Business expectations
* End-to-End Services
  + Plan/Strategy-Design
  + Build/Deploy – Transition
  + Run/Operate - Optimize

**ONTAP Cluster Fundamentals**

**Clusters**

* **Cluster** is one or more FAS controllers or ALL Flash. Controller running ONTAP is a **node**. Clusters with more node a **cluster interconnect** is needed.
* **Node contains:**
  + Network ports, expansion slots, nonvolatile memory (NVRAM/NVMEM)
  + Disks needed
* **HA pair** - contains 2 connected nodes that form a partnership. Connections are made to the same disk shelves. Ability of surviving node to take control of failed partners disks.
  + NDO applicable. Can take over partners storage and give it back later.
  + Validate HA configuration with Hardware universe.
  + Components:
    - HA interconnect which can be internal or external.
      * Must connect to the disk shelves and the partner shelves and vice versa
    - Nodes must be connected to the same shelves with redundant paths
* Networks:
  + 2 node cluster can be switchless
  + More than 2 nodes requires a switch
  + **Management network** – used for cluster administration. May be on a shared ethernet network
  + **Data network** – can be composed on one or more networks for data access. Ethernet, FC or converged with more than one switches.
  + Ports:
    - Ethernet port which then can be split into an **interface group**
    - (Virtual**) Interface groups** can be split apart into **VLAN’s.**
    - **Logical interface (LIFS)** network access point to a node in the cluster. Can be associated with a physical port. Wwpn (Worldwide port name)
* Storage Architecture
  + **Dynamic Virtualization Engine** – data volumes are mapped to physical space
    - Physical Layer:
      * **Disks** are grouped into RAID groups. Ownership can be assigned to a controller. Can change assignment. Show up as spare disks or hot spares. Disks should also be the same type an speed in a raid group
        + **SATA –** used for capacity
        + **SAS –** used for performance
        + **SSD –** for ultra performance
        + **VMDISK –** used in software versions like ONTAP select
        + **LUN –** appears when flexArray presents an array LUN to ONTAP

Array LUNS can be used in Aggregate

Array LUNS are presented to ONTAP using FlexArray storage virtualization

Created on the enterprise storage array. Can function as hot spares

Uses RAID 0 in an aggregate. Can contain only other Array LUNS in the arregrate

* + - * **Aggregates** is a collection of physical disk space that contains one or more raid groups. An aggregate is owned by a one controller. RAID type must be the same. Aggregates can be relocated in the HA partner for performance reasons.
        + **Plex –** single copy of data. Assigned a pool of hot spare disks.
        + Root aggregate (aggr0) created during system initialization. ONTAP prevents you from creating other volumes in the root aggregate. 3 disks.
        + Data aggregate does RAID-DP with five disks.
        + **ADP (Advanced Disk Partitioning) –** reserves a small slice from each disk to create the root partition and the rest for the data partitions.

**Root-data partition**

**Root-data-data**

FAS2xxx and All Flash FAS systems.

* + - * + **Hybrid Aggregate** – **Flash Pool** contains SAS or SATA disks/SSD. Good for OLTP

Offloads random read operations/Offload repetitive random write operations.

**Fabric Pool** – has a performance tier for frequently accessed data on SSD. Capacity tier for infrequently accessed data which is located on object store.

* + - Logical Layer
      * **FlexVol Volumes** – is an allocation of disk space which is a portion of the available space in the aggregate. Represents a file system in a NAS environment.
        + **Qtree –** partitions of FlexVol volumes into smaller segments.

Provides management of quotas, security style, and CIFS opportunistic lock.

* + - * Files/LUNS (SAN)
        + **LUN** is created in a FlexVol volume to provide host access through the LIF. Host controls the reads and writes of the system.

Represents a SCSI disk.

* + - * **SVM (Storage virtual machine)** – container for data volumes. Data is accessed through a LIF.
      * F**lexGroup** – scale-out NAS container constructed from a group of FlexVol volumes which are called **constituents.** 
        + Constituents are placed evenly across the cluster to automatically share traffic load.
        + Max size is 20 PB.
      * **Infinite Volumes** – appears as one scalable volume which can store up to 10 PB. Contains dozens of consitutents
        + **Data constituents** store data. Client doesn’t know about this.
        + **Namespace constituent** tracks file names, etc. Client doesn’t know about this.
        + **Namespace mirror constituent** is a data protection mirror copy of the name space constituent.
* Cluster Configurations
  + **Single-Node** – cluster that runs on a standalone node. Good for data protection for a remote office. Can’t used HA, storage failover or multimode operations
  + **Two-node switchless** – ports are connected between nodes.
  + Multinode Switched
    - Requires 2 switches which are connected to each HA pair.
    - ISL (Inter-Switch Links) – are links connected between each switch
  + MetroCluster
    - Uses mirroring between each HA pair
    - Two-Node – single node cluster at each site. Protects data at a cluster level
    - Four-Node – two-node cluster at each site
    - Eight-Node – four-node cluster at each site.
* Create and Configure a cluster
  + Can use CLI or OnCommand System Manager. Use a setup worksheet to remember what you configurated
  + Use CLI on first node and then setup wizard on the others after that.
  + OnCommand System Manager – visual representation of available resources
* **WAFL (Write Anywhere File Layout**) – organizes blocks of data on disks into files. FlexVol volumes represent the file system.
  + Stores metadata in inodes. **Inodes** – are pointers to the blocks on disks that hold the data.
  + Writes to system memory and NVRAM logs the data. Write operations are sent to disk from system memory at a **CP (consistency point).** Once complete, logs are flushed from NVRAM.
  + **Consistency point** – process for writing system memory to disk. Occurs when a snapshot is created.
    - 10 second timer. NVRAM buffer fills up and it is time to flush the writes to disk.
    - Write request goes through the NIC or HBA. Also indirect write operation
    - Direct Cache read stores the write request on the system memory and serves it back to the client.
    - Direct Read Request pulls the data from disk and the stores the cache in system memory

**Management**

* **Cluster admin** – admin the entire cluster. Can setup SVM
  + **SVM admin’s** only admin their own data SVM. Can setup LIFS, etc. Only 1 SVM admin created in cluster creation process.
    - Can’t login to System Manager
  + Cluster management LIF is configured to failover to any node in the cluster. SVM’s are displayed as vservers in the CLI
  + SSH is enabled by default. Can connect to the LIF IP
  + RSH and Telnet are disabled by default
  + Node root aggregate and node root volume are created. Node root volume (Vol0) contains log files for the node and configuration database information. User data shouldn’t be stored in the node’s root volume.
* **Replicated Database (RDB)** – is the basis of clustering. **Replication rings** are sets of identical processes that run on all nodes.
* **Clustershell** – shell in ONTAP. Supports queries.
  + ? or top command
  + Admin or Advanced privileges, Diagnostic commands. Set command to switch privileges.
* User accounts have to be specified how they can be accessed – HTTP, ONTAPI, SSH, Console, Service Processor.
* RBAC roles
  + Admin – create roles and has access to everything
  + Autosupport
  + Backup
  + Ready-only – used for auditing
  + None – used for auditing
  + SVM’s can have their own roles: vsadmin (super user), vsadmin-volume, vsadmin-protocol, vsadmin-backup, vsadmin-read-only. User accounts have to be done for each application.
  + After you add an NTP server, require time to synchronize
* **License** is a record of software entitlements
* **Basic** schedules are recurring. Jobs are asyncronous
* **Interval** schedules are run at intervals
* **Advanced** schedules are run at a specific instance.
* **Autosupport** – integrated monitoring and reporting technology. Checks health of netapp systems
* **Unified Manager** – manage cluster resources at scale
* **Insight** – storage resource management of Enterprises and SP.

**Networking**

* Can use a management network for redundancy
* Converged network – uses a UTA (Unified Target Adapter) port which supports NFS, CIFS, iSCSI, and FCoE
  + UTA2 port – e<location><letter>/<location><letter>
* FC/Ethernet
  + Ethernet
    - E<location><letter>
  + FC port
    - <location><letter>
* Interface group modes – a<number><letter>
  + Single-mode (active-standby)
  + Static multimode (active-active)
  + **Dynamic multimode using Link Aggregation Control Protocol (LACP)** – dynamically routes data if there is a potential failure.
* **Vlan’s** allow for segmentation with different broadcast domains. Can’t be created on cluster interconnect ports
* **IPspace** is a logical container for SVM, Broadcast domain, and Subnet. Separates client traffic. Each SVM has their own routing tables. Cluster IPspace is not shown.
* **Broadcast Domain** are setup to group specific ports to clients. Cluster broadcast is not shown. Contain ports, vlans, interface
* LIF Properties – SVM, Role, Protocol, Home node and port, Address, Firewall policy, Load balancing options, failover policy and group. SVM admin can only view the LIF’s.
  + Roles
    - **Cluster** – scoped to a specific node. Interface to the cluster interconnect.
    - **Cluster management** – single management interface for the entire cluster. Cluster wide (any node)
    - **Data** – interface for communication with clients or hosts. Scoped to a specific SVM.
      * **NAS LIFS’ –** multiprotocol, manually assign IP addresses. Failover or migration. NFS, CIFS, or both
      * **SAN LIF’s –** FC or iSCSI. No failover but can be migrated with restrictions
        + FC LIFE is assigned a WWPN
      * **NDO/NDU**
      * **LIF Failover Groups –**  contains network ports in a node. Cluster, Default, User-Defined.
      * **Firewall Policies** 
        + **Broadcast Domain-Wide:** all ports from all nodes in the failover group. Default for cluster management LIF
        + **System-Defined** – only ports in the failover group that are on the LIF’s home node and on a non-HA partner node. Default for NAS data LIFS
        + **Local Only** – only ports in the failover group that are on the LIF’s home node. Default and node management LIF’s
        + **Storage Failover Partner Only** – only ports in the failover group that are on the LIF’s home node and it’s HA partner node.
        + **Disabled** – not configured for failover. SAN data LIF’s
    - **Intercluster** – cross-cluster communication. Scoped to a specific node.
    - **Node Management** – dedicated interface for managing a particular node

**Storage Virtual Machines (SVM)**

* Data SVM = SVM
* Benefits:
  + Multitenancy
  + NDO
  + Scalability
  + Unified Storage
    - NAS protocols: CIFS and NFS
    - SAN protocols: iSCSI and FC
  + Delegation of management
* Use Cases
  + Configuring secure multitenancy
  + Separating resources and workloads
  + Can’t move LIFs and volumes between SVM nondisruptively
* Aggregate: 4KB blocks/WAFL reserves 10%
* Volume:
  + Thick – volume guarantee = volume
  + Thin – volume guarantee – none
    - Could potentially overcommit space
  + Dynamic mapping to physical space
  + Volume Footprint is user data that is written to the volume
  + FlexVol can be moved to another aggregate in the same SVM
* Snapshot
  + Creates pointers in time that are copied. No data is moved. iNode’s are repositioned.
  + 255 snapshots allowed. Incremental
  + **SnapRestore** – moves pointers from the good snapshot to the file system
* Deduplication – elimination of duplicate data blocks. Inline or postprocess
  + Aggregate-level inline deduplication
    - Performs cross-volume sharing for volumes belonging to the same aggregate. Doesn’t support FlashPool or HDD
    - ADS – automatically schedules background jobs.
    - Cross-volume shared block is owned by the FlexVol volume that first wrote the block
* Data Compression – Compression of redundant data blocks. Inline or post process
  + Secondary: 32KB compression groups
  + Adaptive: 8KB compression groups
* Data Compaction – stores more data in less space. Inline
  + Policy can be setup for Flashpool or HDD
* Inline Zero-block Deduplication -> inline adaptive compression -> inline deduplication -> inline data compaction
* **FlexClone** - can take copies of FlexVol volumes. FlexClone can be split up from the primary.
* NIS (Network Information Service)

**Maintenance**

* **Upgrade Advisor** – Within Insight, helps to plan the upgrade of your cluster.
* **Rolling Upgrade** – happens in two nodes or more of an HA pair. Partner takes over data of the first node.
* **Batch Upgrade** – can be performed on a cluster of eight or more nodes.
* Upgrade: Select -> Validate -> Update
* IO operation types – **IOPS** (How many requests can be managed)
  + Random
  + Sequential
* **Throughput** – measurement of how much data can be managed in one second.
* **Latency** is measurement of how long data processing takes.
* **Flash Cache –** expansion slots of a node. Cache for all volumes on the controller
* Flash Pool – hybrid aggregate of HDD and SSD.
* Issues
  + Observe LED, inspect cables, CLI
  + ONTAP monitors and take disks offline. Rapid RAID recovery.
    - Prefail->HotSpare->Copy->Fix or Fail
    - Don’t run a RAID group in degraded mode for more than 24 hours.
  + Config Advisor
    - Checks for cabling, firmware, network switches.

**NAS Fundamentals**

* SAN blocks are 512 Mb
* **Clients** – utilize server resources
* Communicate with NIS, LDAP or AD for authentication
* **Security Styles**
  + **Unix –** unix clients that use NFS
    - Support NFSv3 (mode bits)
    - NFSv4 ACL
  + **NTFS –** typically for windows clients that use SMB
    - Support NTFS ACL
  + **Mixed-** can be used when clients are allowed to change permissions
* Namespace – uses junctions to join volumes together enabling the volumes to appear in the namespace
  + / - root
  + /
  + Stand-alone volumes
  + Brand-trees
  + Qtrees
  + Load sharing mirror copy is used to protect the SVM root and to do it to each node.