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Subject : Principles of Virtualization

Module Number : 3.0

Module Name: Storage Features in vSphere

Storage Features in vSphere

AIM:

To understand all the Storage types in Vmware and find out its importance.

Objective:

The Objectives of this module is to:

- Understand Fundamentals of virtual Storage

Storage Features in vSphere

Outcomes:

At the end of this module, you are expected to:

- Define Shared ,Virtual Volume and SAN and networking features in vsphere

Table of Contents

VMware vSphere Components and its Features

- **VMware ESXi-** A virtualization layer run on physical servers that abstracts processor, memory, storage, and resources into multiple virtual machines.
- **VMware vCenter Server-**The central point for configuring, provisioning, and managing virtualized IT environments. It provides essential datacenter services such as access control, performance monitoring, and alarm management.
- **VMware vSphere Client-** An interface that enables users to connect remotely to vCenter Server or ESXi from any Windows PC.
- **VMware vSphere Web Client-** A Web interface that enables users to connect remotely to vCenter Server from a variety of Web browsers and operating systems.
- **VMware vSphereSDKs-** Feature that provides standard interfaces for VMware and third-party solutions to access VMware vSphere.

VMware vSphere Components and its Features

- **vSphere Virtual Machine File System (VMFS)-**A high performance cluster file system for ESXi virtual machines.
- **vSphere Virtual SMP-**Enables a single virtual machine to use multiple physical processors simultaneously.
- **vSphere vMotion-** Enables the migration of powered-on virtual machines from one physical server to another with zero down time, continuous service availability, and complete transaction integrity.
- Migration with vMotion cannot be used to move virtual machines from one datacenter to another.

VMware vSphere Components and its Features

- **vSphere Storage vMotion**

  Enables the migration of virtual machine files from one datastore to another without service interruption. You can place the virtual machine and all its disks in a single location, or select separate locations for the virtual machine configuration file and each virtual disk. The virtual machine remains on the same host during Storage vMotion.

  Migration with Storage vMotion lets you move the virtual disks or configuration file of a virtual machine to a new datastore while the virtual machine is running. Migration with Storage vMotion enables you to move a virtual machine's storage without any interruption in the availability of the virtual machine.

VMware vSphere Components and its Features

- **vSphere High Availability (HA)**

  A feature that provides high availability for virtual machines. If a server fails, affected virtual machines are restarted on other available servers that have spare capacity.

- **vSphere Distributed Resource Scheduler (DRS)**

  Allocates and balances computing capacity dynamically across collections of hardware resources for virtual machines. This feature includes distributed power management (DPM) capabilities that enable a datacenter to significantly reduce its power consumption.

VMware vSphere Components and its Features

- **vSphere Storage DRS**

Allocates and balances storage capacity and I/O dynamically across collections of datastores. This feature includes management capabilities that minimize the risk of running out of space and the risk of I/O bottlenecks slowing the performance of virtual machines.

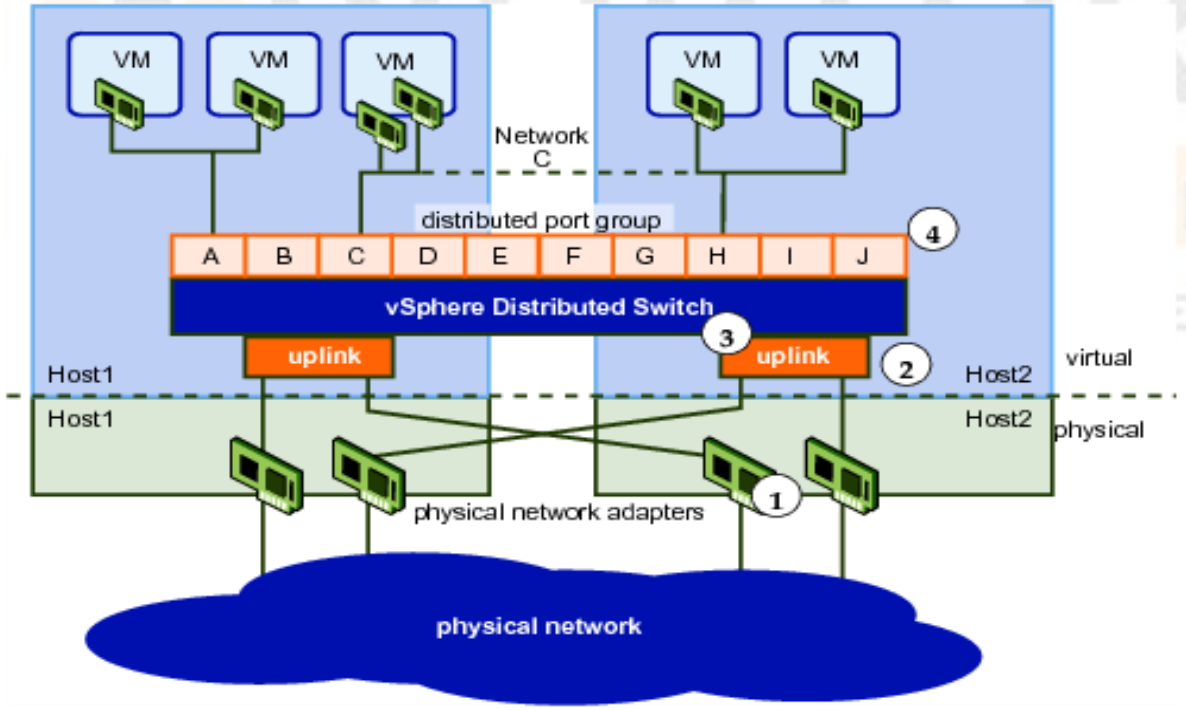
- **vSphere Fault Tolerance**

Provides continuous availability by protecting a virtual machine with a copy. When this feature is enabled for a virtual machine, a secondary copy of the original, or primary, virtual machine is created. All actions completed on the primary virtual machine are also applied to the secondary virtual machine. If the primary virtual machine becomes unavailable, the secondary machine becomes immediately active.

VMware vSphere Components and its Features

➢ vSphere Distributed Switch (VDS)

A virtual switch that can span multiple ESXi hosts, enabling significant reduction of on-going network maintenance activities and increasing network capacity. This increased efficiency enables virtual machines to maintain consistent network configuration as they migrate across multiple hosts.



VMware vSphere Components and its Features

- **Host Profiles**

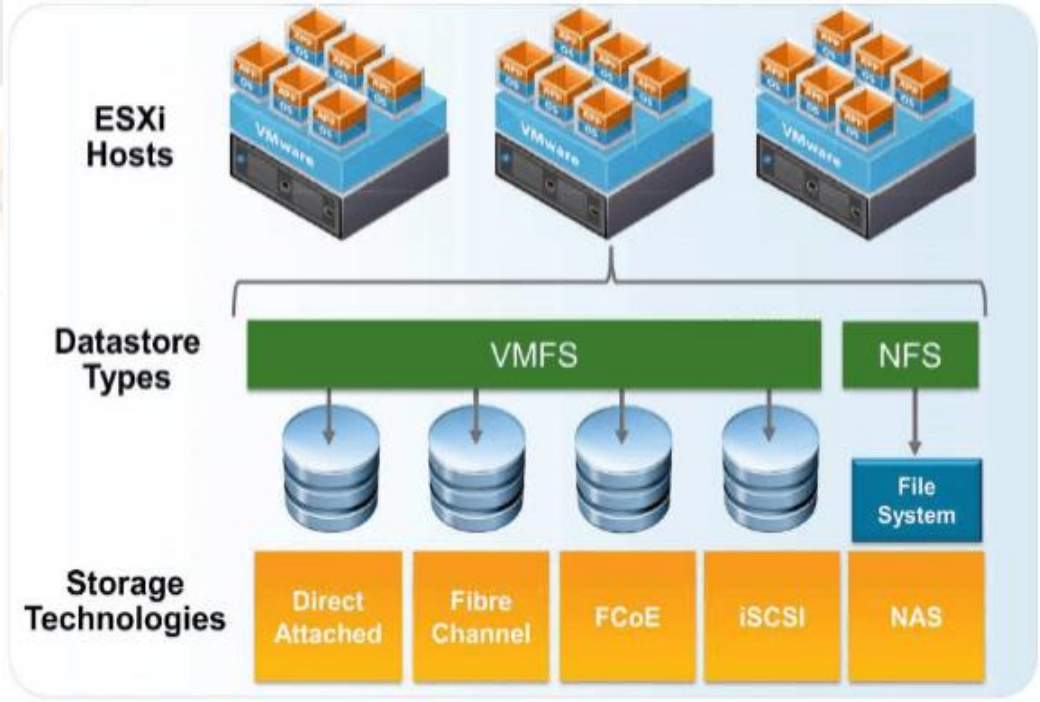
  A feature that simplifies host configuration management through user-defined configuration policies. The host profile policies capture the blueprint of a known, validated host configuration and use this configuration to configure networking, storage, security, and other settings across multiple hosts. The host profile policies also monitor compliance to standard host configuration settings across the datacenter. Host profiles reduce the manual steps that are involved in configuring a host and can help maintain consistency and correctness across the datacenter.

  Host profiles are also a component of vSphere Auto Deploy. The concept of an autodeployed host means that vCenter Server owns the entire host configuration and it is captured within a host profile. Certain policies require user input to provide host-specific values. To support Auto Deploy for host profiles, an answer file is created that contains the definitions for those policies.

Shared Storage

The common technique for increasing redundancy, high availability, and load efficiency for a vSphere environment is to arrange ESXi hosts into vCenter cluster. One of the most important requirements for clusters is creating a VMware shared storage. There are several ways to do this:

- SAS interfaces on storage servers and an ESXi host
- Fibre Channel
- iSCSI
- Virtual SAN (vSAN)



Shared Storage

SAS Interface

- SAS Interface is an approach which requires hardware SAS interfaces on both server and client sides. The indicated technology provides speeds of up to 12 Gbit/s (which is true for SAS-3, and we're expecting SAS-4 in 2017 with up to 22.5 Gbit/s), but it has several limitations. First of all, SAS infrastructure is not scalable because of the finite number of SAS ports on the storage server. However, if you need more storage, you must replace disks with larger ones or install an additional storage server. Second, a storage server and disks must be mounted in the same rack because of the cable length. Thus, this approach works well for small-to-medium environments with high data transfer speed demands.

Shared Storage

Fibre Channel Technology

- The Fibre Channel Technology requires additional hardware as well: an FC-controller on a storage server and host-based adapters (HBAs) for each ESXi host in the vCenter cluster. In addition, you will need FC-switches if the number of ESXi hosts is greater than the number of FC ports in the storage. Such layout is common for large server infrastructures.
- The biggest advantage of Fibre Channel is speed. FC ‘Gen 6’ networks provide 12,800 MB/s throughoutput per direction. Given that, you can build a fully-functional high-speed network. But the price of equipment is really sky-high. Such infrastructure suits large banks and corporations, where data transfer speed and security are the highest priorities.

Shared Storage

iSCSI

- Unlike SAS or FC, iSCSI technology does not require any specific hardware. It works within existing Ethernet network infrastructure and uses software-emulated iSCSI adapters. This makes the technology easier to scale than the previous two since you don't need any additional equipment.
- On another hand, iSCSI requires a dedicated server with a specific OS and software configuration to make it work.
- iSCSI might be a solution for small environments with small IT budgets, as it doesn't require additional equipment.

Shared Storage

vSAN

- As of vSphere v5.5 launch, VMware promotes its own approach for creating shared VMFS storages. They recommend using local server resources and existing Gigabit Ethernet networking without additional storage server hardware.
- This option looks attractive since it does not need any specific hardware and can be configured via a GUI. Moreover, it does not rely on the physical location of your hosts and storage disks.
- The drawback is that vSAN requires an additional license, which can be pricey depending on the number of hosts.
- vSAN is a good choice for the infrastructure of any size and is especially handy if you are not able to install a dedicated storage server, but it may become a costly solution for larger datacenters.
- VMware Shared Storage Approach Comparison for VMware vCenter Cluster

Shared Storage

- To make the long story short, here's a brief comparison table of the approaches for creating a VMware shared storage.

Approach	Additional Hardware	Additional Software	Dedicated Server	Management Complexity
SAS	SAS interfaces	Yes	Yes	Medium
Fiber Channel	FC-controller, HBA, FC-switchess	Yes	Yes	Dedicated admin needed
iSCSI	No	Yes	Yes	Specific server configuration needed
vSAN	No	No	No	Configured via vSphere Web-Client

Shared Protocols

- iSCSI (Internet Small Computer System Interface)
- NFS (Network File System)
- Fibre Channel
- FCoe (Fibre Channel over Ethernet)

- **iSCSI (Internet Small Computer System Interface):-** iSCSI stands for Internet Small Computer Systems Interface. iSCSI is a transport layer protocol that works on top of the Transport Control Protocol (TCP). It enables block-level SCSI data transport between the iSCSI initiator and the storage target over TCP/IP networks. iSCSI supports encrypting the network packets, and decrypts upon arrival at the target.
- SCSI is a block-based set of commands that connects computing devices to networked storage, including spinning up storage media and data reads/writes.
- The protocol uses initiators to send SCSI commands to storage device targets on remote servers. Storage targets may be SAN, NAS, tape, general-purpose servers – both SSD and HDD – LUNs, or others. The protocol allows admins to better utilize shared storage by allowing hosts to store data to remote networked storage, and virtualizes remote storage for applications that require direct attached storage.

Shared Protocols

- **NFS (Network File System):-** NFS, or Network File System, was designed in 1984 by Sun Microsystems. This distributed file system protocol allows a user on a client computer to access files over a network in the same way they would access a local storage file. Because it is an open standard, anyone can implement the protocol. NFS started in-system as an experiment but the second version was publicly released after the initial success.

How does NFS work?

- To access data stored on another machine (i.e. a server) the server would implement NFS daemon processes to make data available to clients. The server administrator determines what to make available and ensures it can recognize validated clients.
- From the client's side, the machine requests access to exported data, typically by issuing a mount command. If successful, the client machine can then view and interact with the file systems within the decided parameters.

Shared Protocols

Fibre Channel Protocol (FCP):-

- Fibre Channel Protocol (FCP) is the SCSI interface protocol utilising an underlying Fibre Channelconnection. The Fibre Channel standards define a high-speed data transfer mechanism that can be used to connect workstations, mainframes, supercomputers, storage devices and displays.

There are three major FC topologies:

- **Point-to-point (FC-P2P)** – two devices connected directly to each other. Rarely used today.
- **Arbitrated loop (FC-AL)** – all devices are in a loop or ring. Rarely used today.
- **Switched fabric (FC-SW)** – all devices are connected to FC switches, devices similar to Ethernet switches, but compatible with the Fibre Channel (FC) protocol. Most array designs today use this topology.

  FC storage can be used in a vSphere environment to hold VMFS datastores. VMFS datastores store virtual machine files, templates, and ISO images and can be shared across multiple ESXi hosts, enabling advanced vSphere features such as vMotion, HA, and DRS.

Shared Protocols

FCoe (Fibre Channel over Ethernet):-

- FCoE (Fibre Channel over Ethernet) is a storage protocol that enable Fibre Channel communications to run directly over Ethernet. FCoE makes it possible to move Fibre Channel traffic across existing high-speed Ethernet infrastructure and converges storage and IP protocols onto a single cable transport and interface.
- The goal of FCoE is to consolidate input/output (I/O) and reduce switch complexity as well as to cut back on cable and interface card counts. Adoption of FCoE been slow, however, due to a scarcity of end-to-end FCoE devices and a reluctance on the part of many organizations to change the way they implement and manage their networks.
- Traditionally, organizations have used Ethernet for TCP/IP networks and Fibre Channel for storage networks. Fibre Channel supports high-speed data connections between computing devices that interconnect servers with shared storage devices and between storage controllers and drives. FCoE shares Fibre Channel and Ethernet traffic on the same physical cable or lets organizations separate Fibre Channel and Ethernet traffic on the same hardware.

Shared Protocols

- FCoE uses a lossless Ethernet fabric and its own frame format. It retains Fibre Channel's device communications but substitutes high-speed Ethernet links for Fibre Channel links between devices.
- FCoE works with standard Ethernet cards, cables and switches to handle Fibre Channel traffic at the data link layer, using Ethernet frames to encapsulate, route, and transport FC frames across an Ethernet network from one switch with Fibre Channel ports and attached devices to another, similarly equipped switch.
- FCoE is often compared to iSCSI, an Internet Protocol(IP)-based storage networking standard.

Datastores

- Datastores in VMware vSphere are storage containers for files. They could be located on a local server hard drive or across the network on a SAN.Datastores hide the specifics of each storage device and provide a uniform model for storing virtual machine files.

VMware vSphere 6.x has the following four main types of datastore:-

- **VMware FileSystem (VMFS) datastores**: All block-based storage must be first formatted with VMFS to transform a block service to a file and folder oriented services
- **Network FileSystem (NFS) datastores**: This is for NAS storage
- **VVol**: This is introduced in vSphere 6.0 and is a new paradigm to access SAN and NAS storage in a common way and by better integrating and consuming storage array capabilities
- **vSAN datastore**: If you are using vSAN solution, all your local storage devices could be polled together in a single shared vSAN datastore

Datastores

vSAN:-

- VMWare vSAN is the VMware's software-defined storage platform which delivers flash-optimized, secure storage. vSAN pools together server-attached storage to provide a highly resilient shared datastore suitable for any virtualized workload.
- Disks are very important for the vSAN implementation. It is not so difficult to scale up your vSAN cluster by adding disks or disk groups to the existing VSAN nodes. This can be done online, and new disks/disk groups will be immediately available for provisioning, rebuild, and rebalance operations.

Datastores

How to Add Capacity Disk to VSAN Disk Group

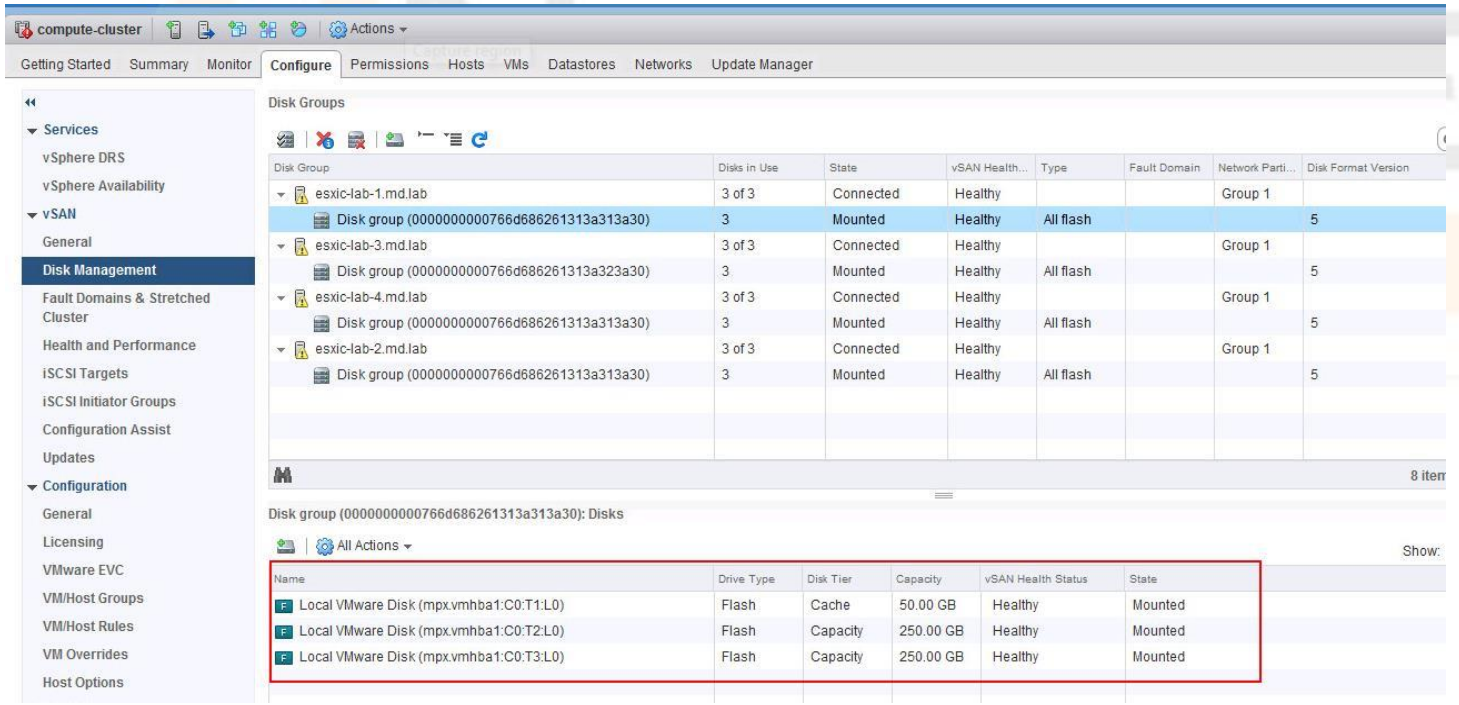
- This step is only necessary if the VSAN cluster disk claim mode is in manual mode. If vSAN is configured in automatic mode, it will automatically claim any local, empty storage devices presented to the ESXi host. If we are adding multiple disks to the server, I always recommend to Change the VSAN mode to “Manual” to better handle the disk addition to the VSAN Disk group.

Prerequisites to Add capacity disk to VSAN Disk Group

- ESXi physical server should have free slots to add the new disks
- vSAN cluster disk claiming is manual.
- The new disk must be the same as existing devices, such as SSD or magnetic disks. Capacity disk for Hybrid VSAN is Magnetic disk and Flash Disk is the capacity disk for All Flash VSAN. Take a look at my article to understand the difference between Hybrid VSAN and All-Flash VSAN
- The new disk can NOT contain any partitions. If it has existing partition such as VMFS, etc. We have the option to erase the partition from the vSphere Web Client.

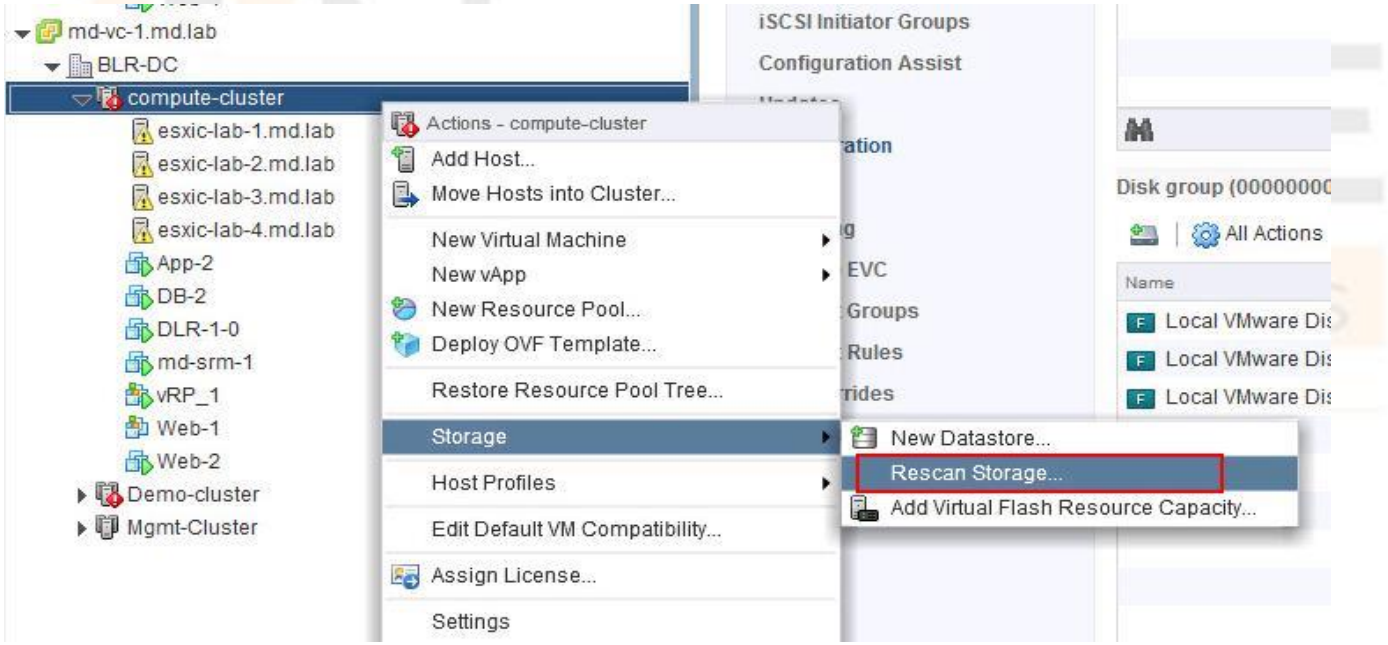
Datastores

- Maximum of 7 capacity disk is allowed per disk group. With 5 maximum disk group per host, we can add up to 35 Magnetic disks per hosts. To understand the detailed configuration maximum, Take a look at my article limitation and configuration maximums of VSAN 6.6



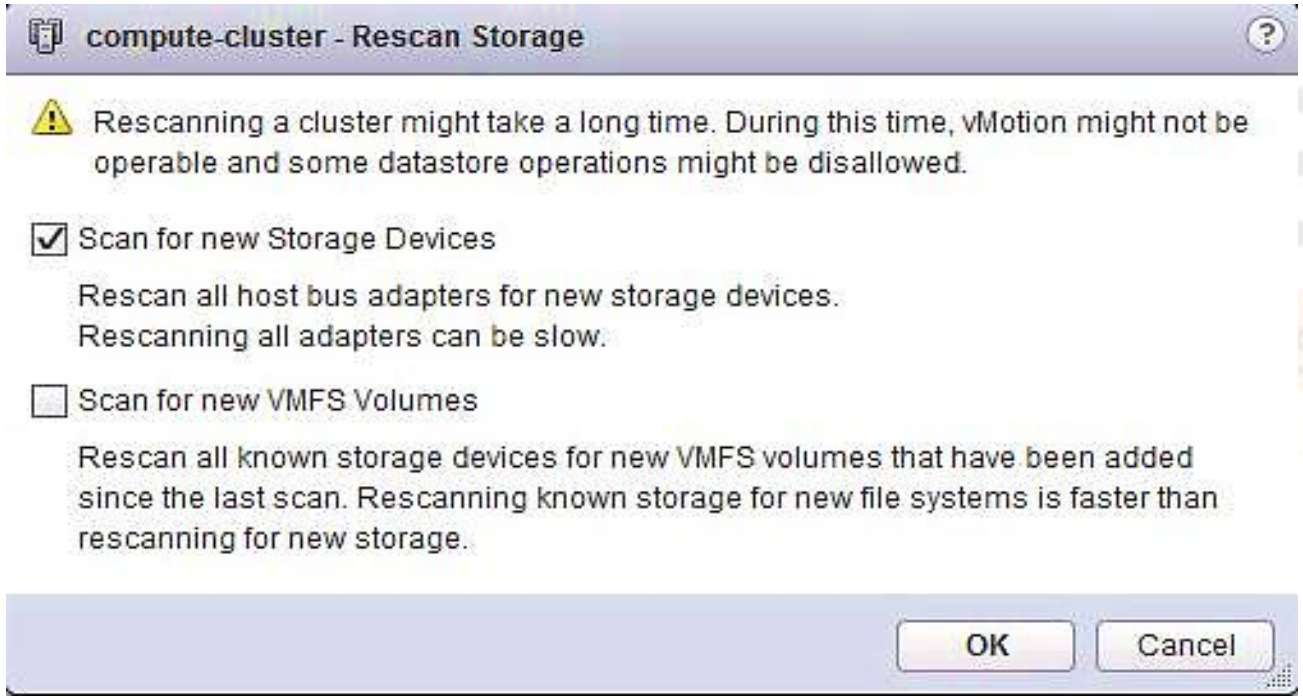
Datastores

- Once the physical disk is added to the server disk slot, you can scan for the disks in the ESXi host. To rescan the adapters to detect the newly added disks, **Right the VSAN cluster -> Storage -> Rescan Storage**



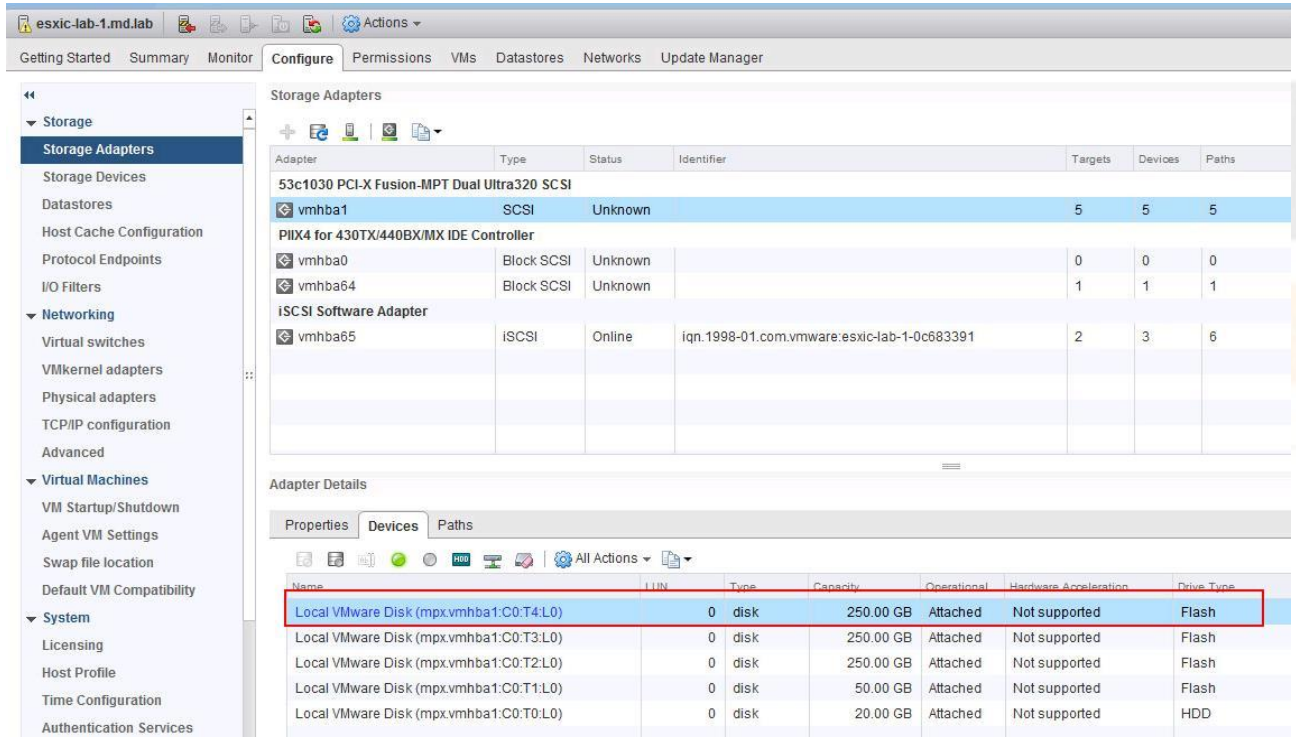
Datastores

- Select the checkbox **“Scan for new storage devices”** and click ok



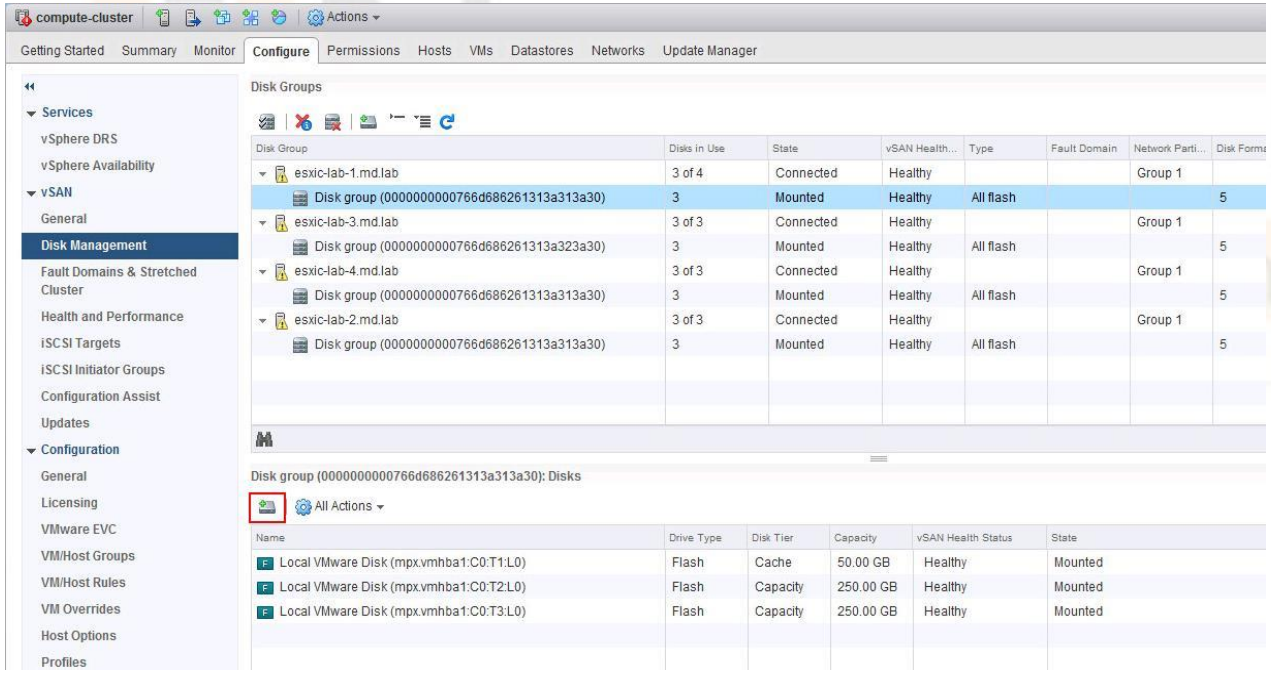
Datastores

- Once rescan is completed, I can see the newly added disk (mpx.vmhba1:C0:T4: L0) is detected under the storage adapters in the ESXi host.



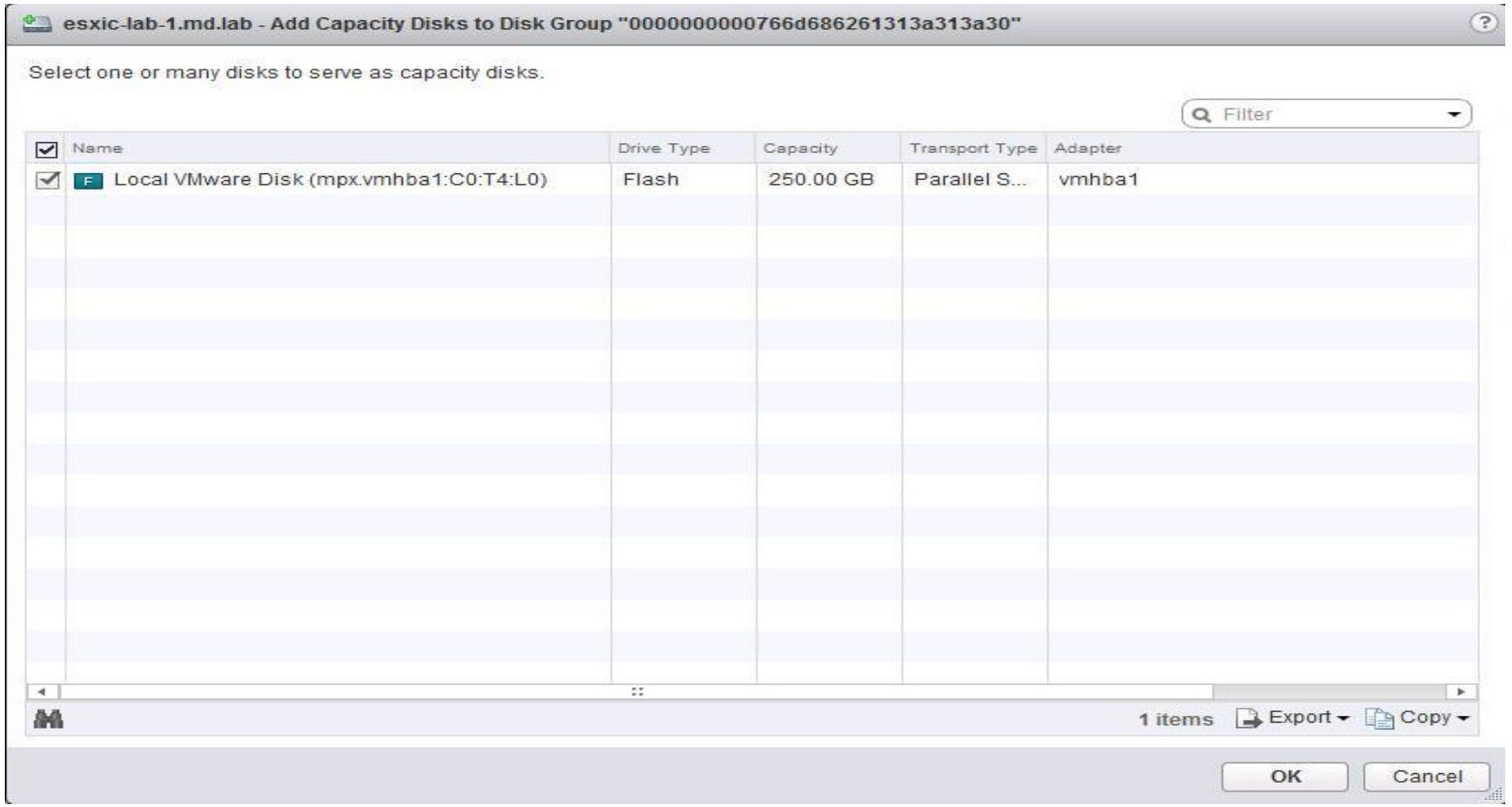
Datastores

- To add the newly added disk into disk group, Browse towards **VSAN Cluster -> Configure -> VSAN -> Disk Management.** Select the disk group under ESXi hosts where you want to add the new disk into, Click + symbol under the disk group to add the disk into the VSAN disk group.



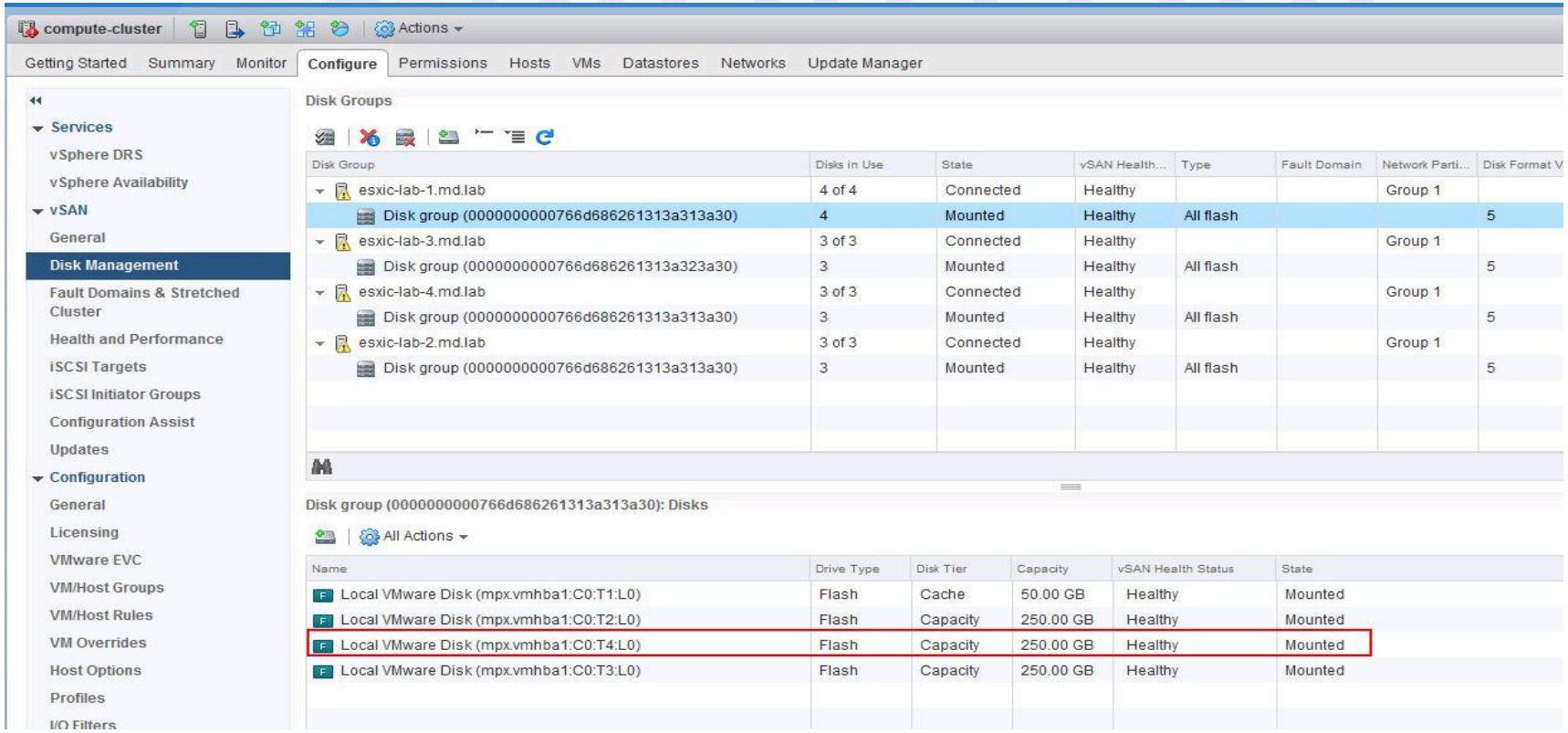
Datastores

- Select one or more disks to add it as capacity disks in the VSAN disk group. Click Ok.



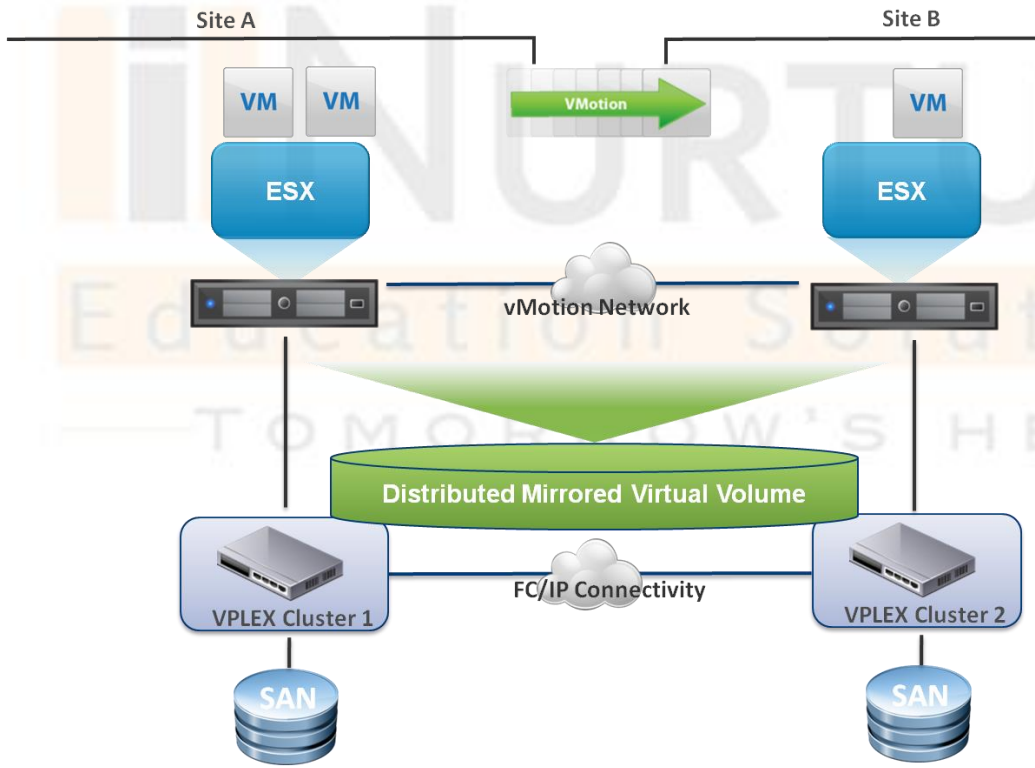
Datastores

- Once you have added the disk into VSAN disk group, you can notice the few tasks are running related to disk addition in the vSphere Web client.
- Once the disk is added to the disk group, It will start to appear under the disk group now. The new disks/disk groups will be immediately available for provisioning, rebuild, and rebalance operations. VSAN datastore capacity will also be increased automatically without any manual efforts.



Virtual Volumes

- A Virtual Volumes (VVol) datastore represents a storage container in vCenter Server and the vSphere Web Client.the vSphere Web Client.



Virtual Volumes

- After vCenter Server discovers storage containers exported by storage systems, you must mount them as Virtual Volumes datastores. The Virtual Volumes datastores are not formatted in a traditional way like, for example, VMFS datastores. You must still create them because all vSphere functionalities, including FT, HA, DRS, and so on, require the datastore construct to function properly.
- You use the datastore creation wizard in the vSphere Web Client to map a storage container to a Virtual Volumes datastore. The Virtual Volumes datastore that you create corresponds directly to the specific storage container. The datastore represents the container in vCenter Server and

Virtual Volumes

- From a vSphere administrator prospective, the Virtual Volumes datastore is similar to any other datastore and is used to hold virtual machines. Like other datastores, the Virtual Volumes datastore can be browsed and lists virtual volumes by virtual machine name. Like traditional datastores, the Virtual Volumes datastore supports unmounting and mounting. However, such operations as upgrade and resize are not applicable to the Virtual Volumes datastore. The Virtual Volumes datastore capacity is configurable by the storage administrator outside of vSphere.
- You can use the Virtual Volumes datastores with traditional VMFS and NFS datastores and with vSAN.

Virtual Volumes

Virtual Volumes, Step by Step

Each storage provider will have its own idiosyncrasies around the way it incorporates VVOLs, but they all follow these basic steps:

- Create storage container on storage array. This will vary depending on the vendor.
- Select the attributes to be surfaced from the array. This will vary depending on the vendor.
- Register the storage provider with vSphere. Accomplished through vCenter.
- Create datastores from storage container. Done through vCenter.
- Create Storage Policies. Done through vCenter.
- Deploy VMs to VVOLs. Done through vCenter.
- Manage storage lifecycle of the VM. Done through vCenter and the underlying storage.

Virtual Volumes

Virtual Volumes Benefits

- **Finer Control**

  With Virtual Volumes, it is much simpler to deliver and enable the right storage service levels according to the specific requirements of individual VMs. By having finer control over storage resources and data services down to the VM level, the VI administrator can create exact combinations and precisely deliver storage service levels. Over-provisioning is eliminated because each VM will consume the exact resources needed – nothing less, nothing more.

- **Flexibility of Choice**

  Virtual Volumes is an industry-wide initiative that will allow IT organizations to leverage the unique capabilities of their current storage investments and transition without disruption to a simpler and more efficient operational model. IT organizations can also manage heterogeneous storage using a common control plane.

Virtual Volumes

Streamlined Storage Operations

- For both the VI Admin and the Storage Admin, Virtual Volumes greatly simplifies management over the existing operational model. Virtual Volumes allows separating the presentation from consumption of storage for VMs. In the VMware SDS model with Virtual Volumes, the Storage Admin sets up the Virtual Volumes datastore, which defines the capacity and data services. The VI Admin then uses the capabilities available in the datastore to compose policies. Any service level changes are reflected by simply changing policies. The Storage Admin is responsible for upfront setup, but the VI Admin is self-sufficient after that.

Networking Features in vSphere

- Network I/O Control enhancements. With more virtual machines (VMs) consolidated onto fewer physical servers using fewer network interface cards (NICs), there is more opportunity for network congestion.
- ESXi firewall.
- VSphere Distributed Switch PowerCLI cmdlets.
- New virtual NIC driver.
- Port mirroring and NetFlow.

Networking Features in vSphere

Virtual Networking

- At the core of vSphere Networking are virtual switches. vSphere supports standard switches (VSS) and distributed switches (VDS). Each virtual switch has a preset number of ports and one or more port groups.
- Virtual switches allow your virtual machines to connect to each other and to connect to the outside world.
- When two or more virtual machines are connected to the same virtual switch, network traffic between them is routed locally.

Networking Features in vSphere

- When virtual machines are connected to a virtual switch that is connected to an uplink adapter, each virtual machine can access the external network through that uplink. The adapter can be an uplink connected to a standard switch or a distributed uplink port connected to a distributed switch.
- Virtual switches allow your ESXi host to migrate virtual machines with VMware vMotion and to use IP storage through VMkernel network interfaces.
- Using vMotion, you can migrate running virtual machines with no downtime. You can enable vMotion with vicfg-vmknic --enable-vmotion. You cannot enable vMotion with ESXCLI.

Networking Features in vSphere

- IP storage refers to any form of storage that uses TCP/IP network communication as its foundation and includes iSCSI and NFS for ESXi. Because these storage types are network based, they can use the same VMkernel interface and port group.
- The network services that the VMkernel provides (iSCSI, NFS, and vMotion) use a TCP/IP stack in the VMkernel. The VMkernel TCP/IP stack is also separate from the guest operating system's network stack. Each of these stacks accesses various networks by attaching to one or more port groups on one or more virtual switches.

Virtual Switches

VMware has designed the vSphere suite to mimic the functions of a physical network, so a lot of the network hardware you'll find in the real world, you will also find virtualized in vSphere. Virtual switches work very much like their physical counterparts, Ethernet switches, but lack some of their advanced functionality. They are used to establish a connection between the virtual and the physical network. A virtual switch can detect which virtual machines are logically connected to each of its virtual ports and use that information to forward traffic to the correct virtual machines. A virtual switch is connected to physical switches by using physical Ethernet adapters to join virtual networks with physical networks.

Virtual Switches

Two connection types are possible on a virtual switch in vSphere:

1. **virtual machine port groups** – ports used to connect virtual machines to other VMs or the physical network.
2. **VNkernel ports** – ports configured with their own IP address, subnet mask and default gateway to allow hypervisor management traffic, vMotion, iSCSI storage access, network attached storage (NAS) access, and vSphere Fault Tolerance (FT) logging.

Virtual Switches

Types of virtual switches are available in vSphere:

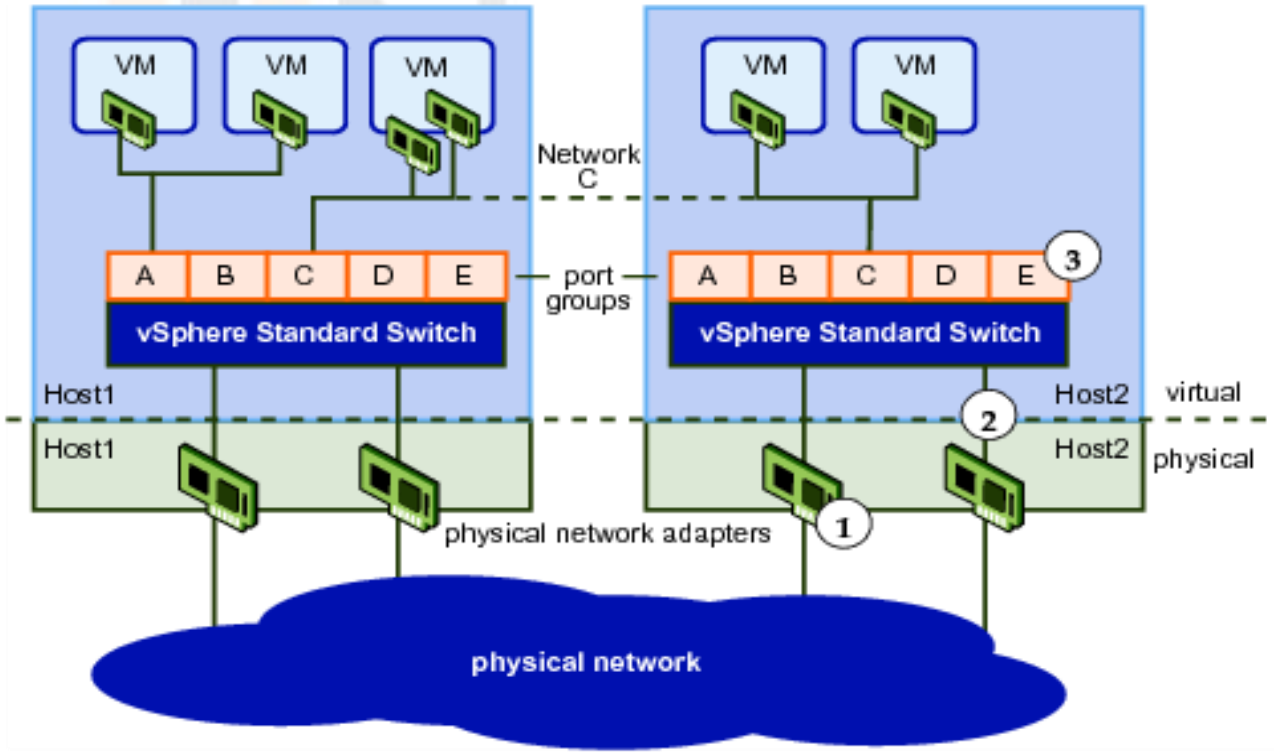
1. **vNetwork standard switches** – vNetwork Standard Switch Environment. A vNetwork Standard Switch (vSS) can route traffic internally between virtual machines and can link virtual machines to external networks. vSS Environment shows the elements of a vSS environment. At the center of networking with vSS is the virtual switch itself.

2. **vNetwork distributed switches** :- A vNetwork Distributed Switch is an aggregation of per-host virtual switchespresented and controlled as a single distributed switch through vCenter Server at the Datacenter level. The vDS abstracts configuration of individual virtual switchesand enables centralized provisioning, administration, and monitoring.

Virtual Switches

Networking Using vSphere Standard Switches

- vSphere standard switches allow you to connect virtual machines to the outside world.



Virtual Switches

Networking with vSphere Standard Switches shows the relationship between the physical and virtual network elements. The numbers match those in the figure.

- Associated with each ESXi host are one or more uplink adapters

  Uplink adapters represent the physical switches the ESXi host uses to connect to the network. You can manage uplink adapters using the esxcli network nic or vicfg-nics vCLI command. See Managing Uplink Adapters.

- Each uplink adapter is connected to a standard switch

  You can manage a standard switch and associate it with uplink adapters by using the esxcli network vswitch or vicfg-vswitch vCLI command.

- See Setting Up Virtual Switches and Associating a Switch with a Network Interface.

Virtual Switches

- Associated with the standard switch are port groups

  Port group is a unique concept in the virtual environment. You an configure port groups to enforce policies that provide enhanced networking security, network segmentation, better performance, high availability, and traffic management. You can use the esxcli network vswitch standard portgroup or vicfg-vswitch command to associate a standard switch with a port group, and the esxcli network ip interface or vicfg-vmknic command to associate a port group with a VMkernel network interface

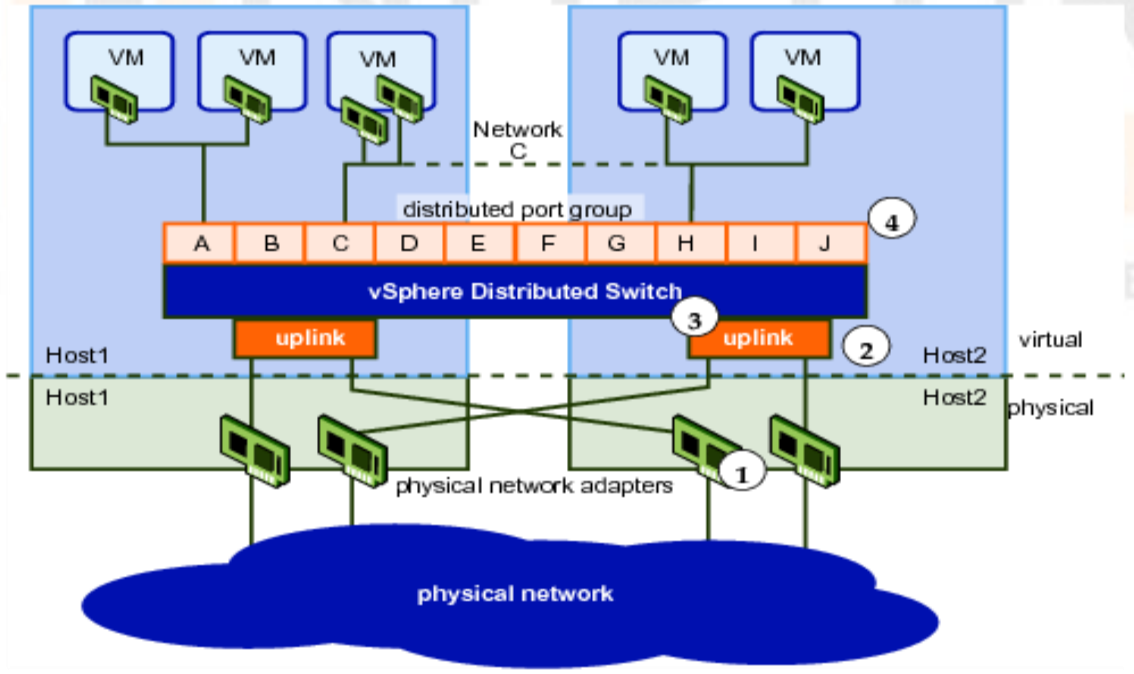
Virtual Switches

- The VMkernel TCP/IP networking stack supports iSCSI, NFS, and vMotion and has an associated VMkernel network interface. You configure VMkernel network interfaces with esxcli network ip interface or vicfg-vmknic. See Adding and Modifying VMkernel Network Interfaces. Separate VMkernel network interfaces are often used for separate tasks, for example, you might devote one VMkernel Network interface card to vMotion only. Virtual machines run their own systems' TCP/IP stacks and connect to the VMkernel at the Ethernet level through virtual switches

Virtual Switches

Networking Using vSphere Distributed Switches

- When you want to connect a virtual machine to the outside world, you can use a standard switch or a distributed switch. With a distributed switch, the virtual machine can maintain its network settings even if the virtual machine is migrated to a different host.



Virtual Switches

- Each physical network adapter on the host is paired with a distributed uplink port , which represents the uplink to the virtual machine. With distributed switches, the virtual machine no longer depends on the host's physical uplink but on the (virtual) uplink port. You manage a uplink ports primarily using the vSphere Client or vSphere APIs
- The distributed switch itself functions as a single virtual switch across all associated hosts. Because the switch is not associated with a single host, virtual machines can maintain consistent network configuration as they migrate from one host to another.

Summary

In this module we have learnt Shared storage and shared protocols.VMware Workstation is a hosted hypervisor that runs on x64 versions of Windows and Linux operating systems (an x86 version of earlier releases was available); it enables users to set up virtual machines (VMs) on a single physical machine, and use them simultaneously along with the actual machine. A Virtual Volumes (VVol) datastore represents a storage container in vCenter Server and the vSphere Web Client. ... The Virtual Volumes datastores are not formatted in a traditional way like, for example, VMFS datastores.

Document link

Topic	URL	Notes
Availability Challenges	https://www.computerweekly.com/feature/VMware-five-biggest-challenges-of-server-virtualisation	Discuss challenges of vmware availability
Scalability Challenges	http://pages.cs.wisc.edu/~remzi/Classes/838/Spring2013/Papers/p95-soundararajan.pdf	Why scalable environment is vulnerable and need focus
Management Challenges	https://www.eginnovations.com/blog/top-5-monitoring-challenges-vmware-environments/	Top-5 Performance Monitoring Challenges in VMware Environments

Ebook link

Ebook name	Chapter	Page No.	URL
vSphere Virtual Machine Administration	2-5	23-78	http://www.tu-varna.bg/tu-varnaknt/images/tutorials/vt/ve.pdf
Vmware vsphere 6.0 with vcentre server	1-5	45-90	https://ssl.www8.hp.com/de/de/pdf/virtuallisation_tcm_144_1147500.pdf

Video link

Topic	URL	Notes
Vmware Virtualization	https://youtu.be/6LDY9BatAQc	Basic of vmware
Container and VM	https://youtu.be/L1ie8negCjc	Practical approach to create VM
Why use open stack for developer	https://youtu.be/Bk4NoUsikVA	Part of Networking