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Block-based storage

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Block-based Storage System

Upon completion of this module, you should be able to:

- Describe the components of block-based storage system
- Describe traditional and virtual storage provisioning
- Describe storage tiering mechanisms

Lesson 1: Components of Block-based Storage System

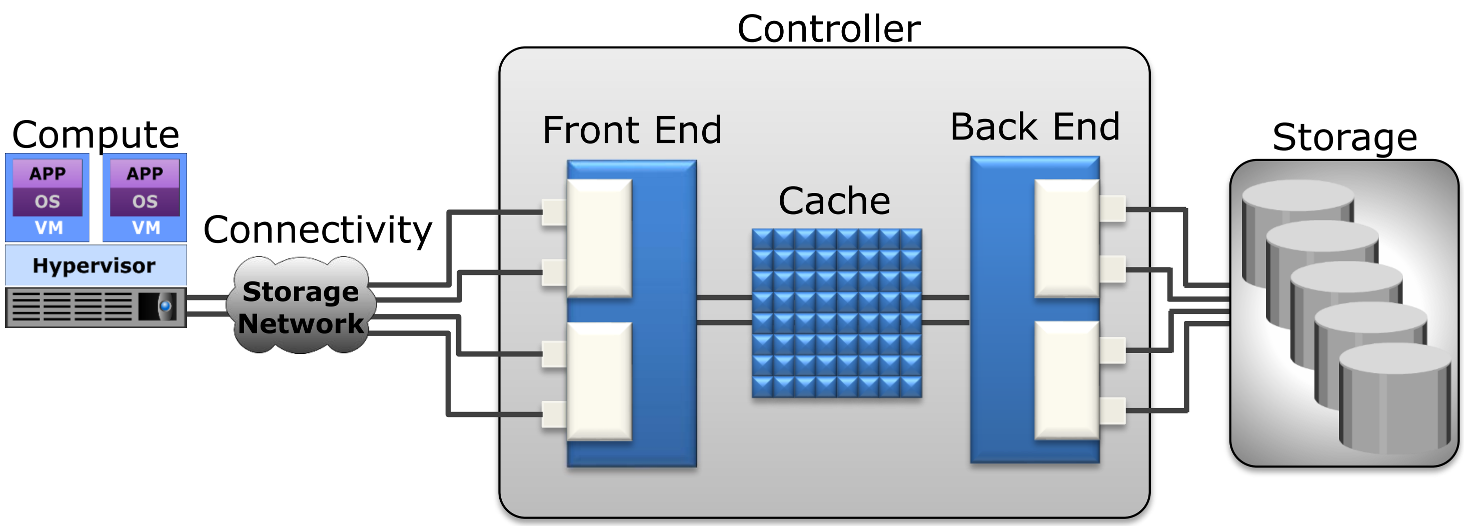
This lesson covers the following topics:

- Block-based storage system components
- **Intelligent cache algorithms**
- Cache protection mechanisms

What is a Block-based Storage System?

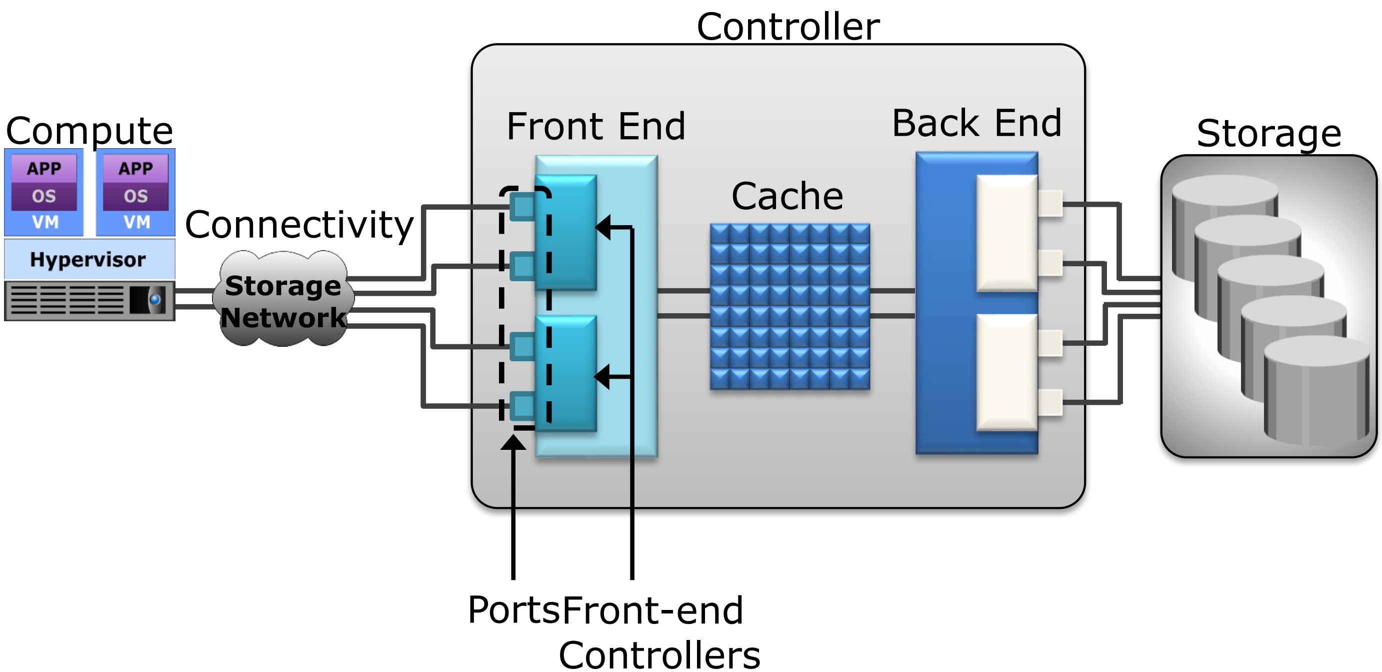
- Provides compute system with block-based access to storage
- Can be based on scale-up or scale-out architecture
- Two components:
  - Controller
  - Storage

Components of a Controller



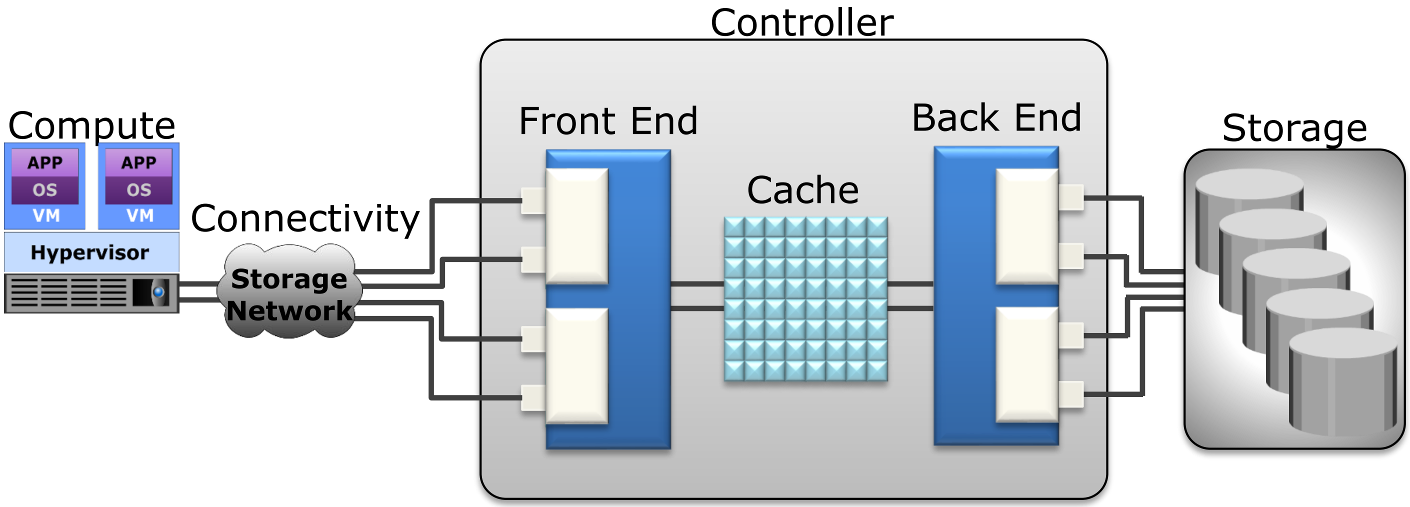
Components of a Controller

- Front End

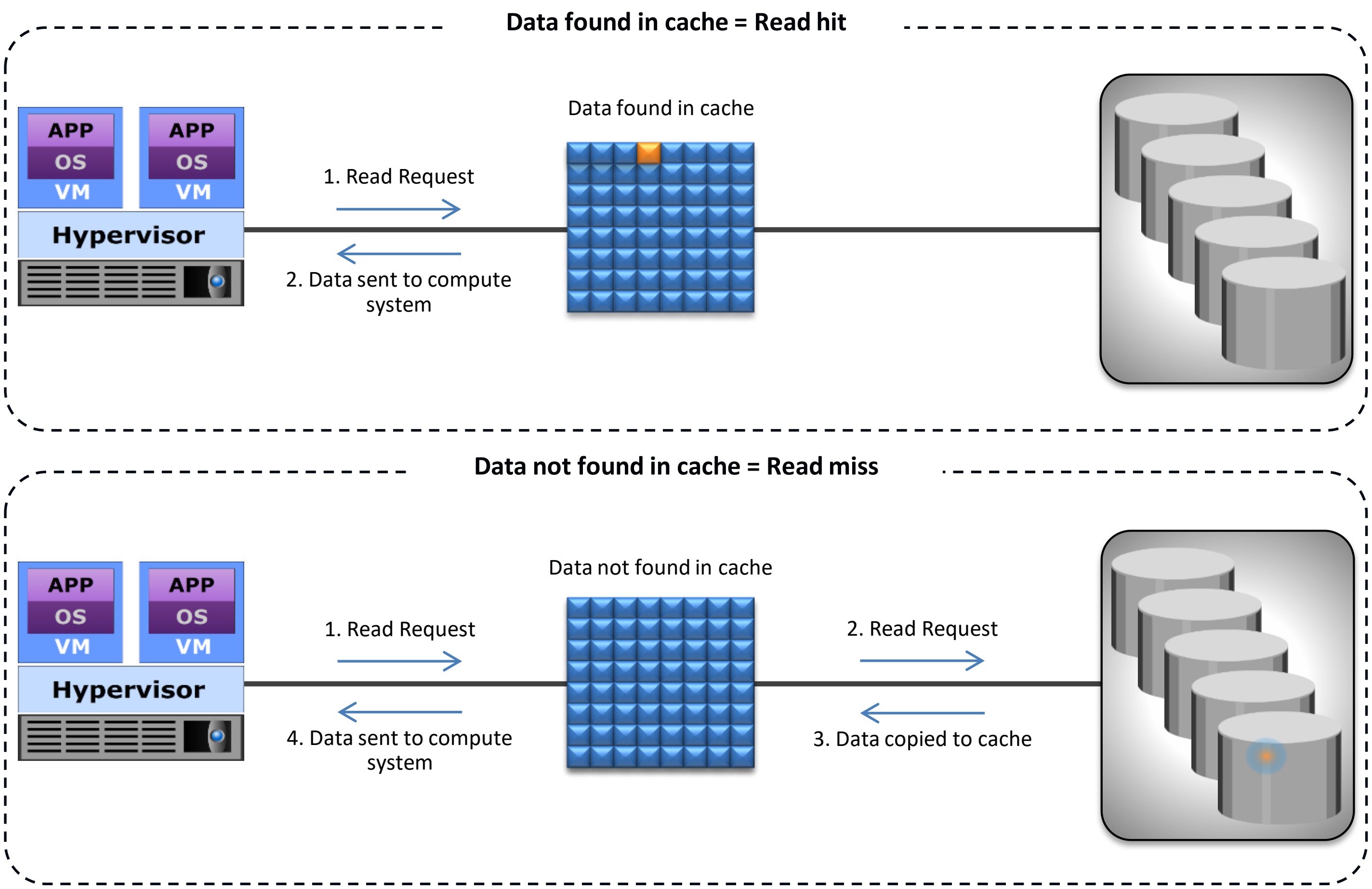


Components of a Controller

- Cache



Read Operation with Cache



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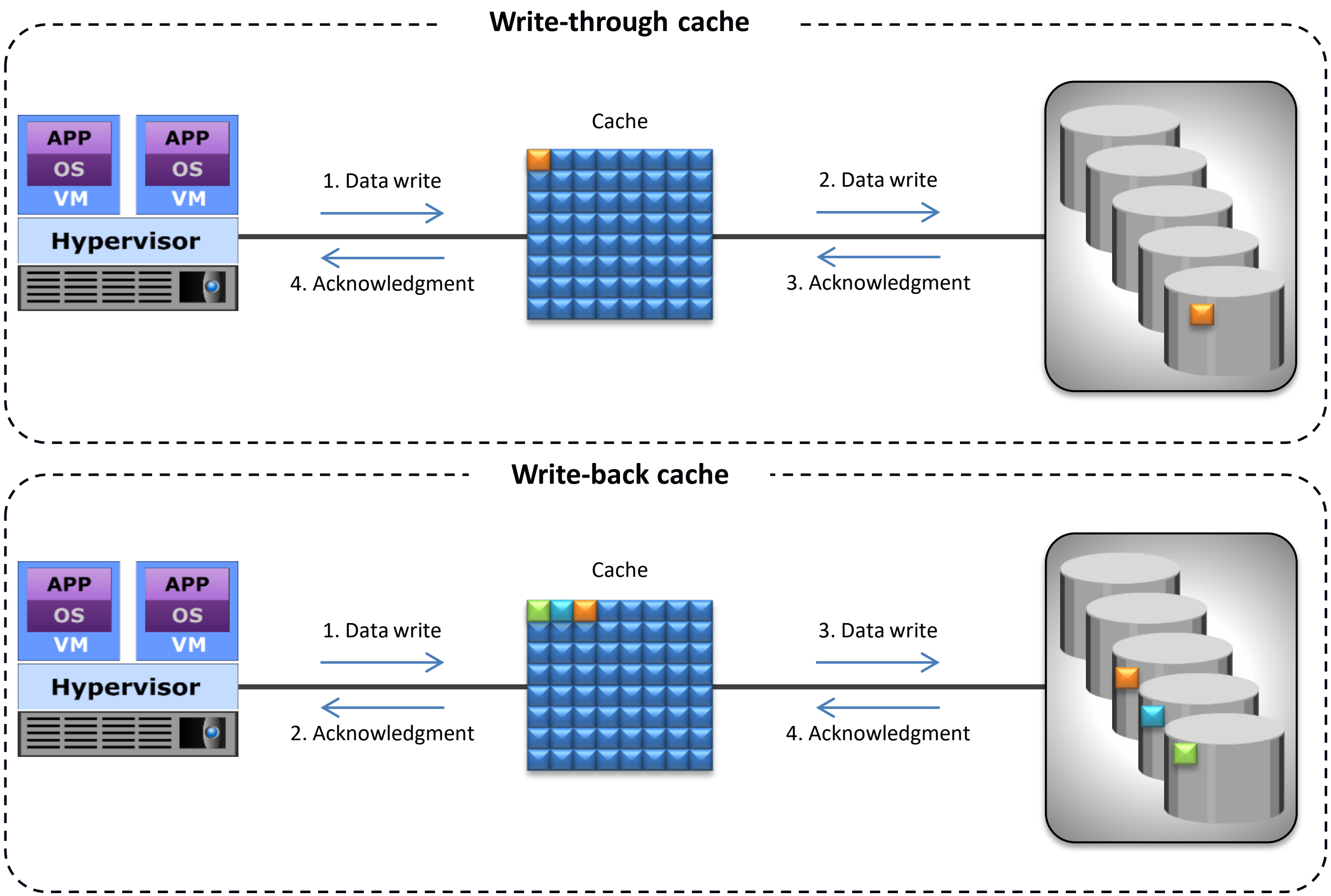
Write Operation with Cache



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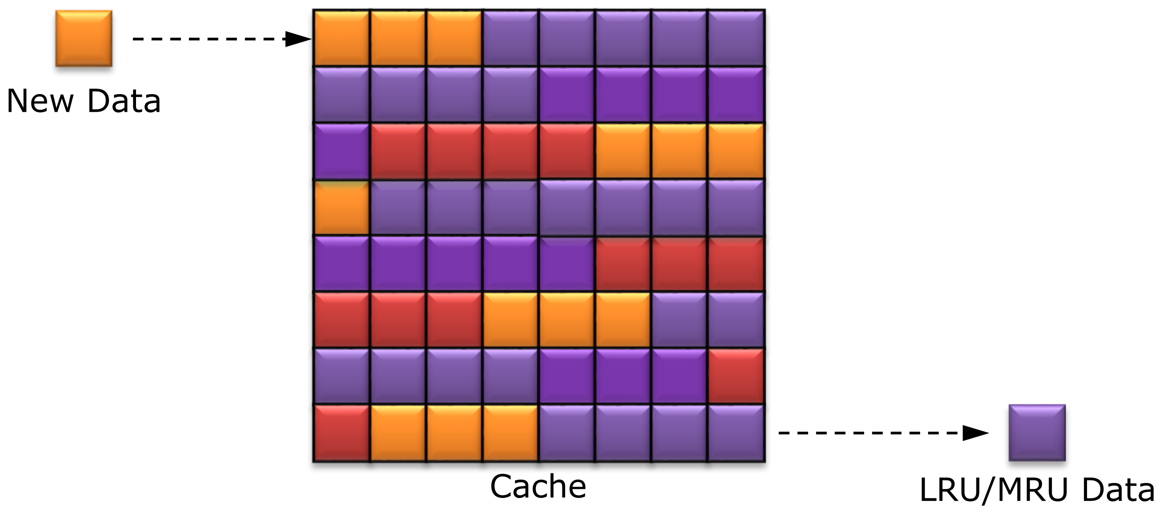
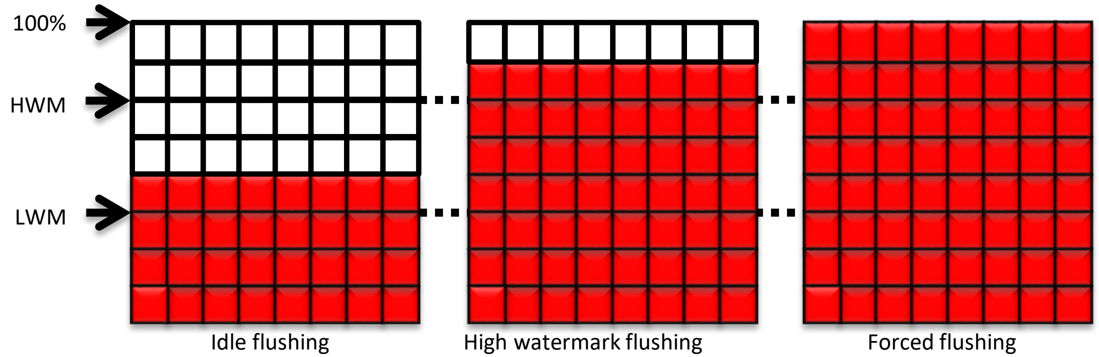
Cache Management: Algorithms

- **Least recently used (LRU)**
  - Discards data that have not been accessed for a long time
- **Most recently used (MRU)**
  - Discards data that have been most recently accessed



Cache Management: Watermarking

- **Manages I/O burst through flushing process**
  - Flushing is the process of committing data from cache to the storage drives
- **Three modes of flushing to manage cache utilization are:**
  - Idle flushing
  - High watermark flushing
  - Forced flushing



Cache Data Protection

- **Protects data in the cache against power or cache failures:**
  - Cache mirroring
    - Provides protection to data against cache failure
    - Each write to the cache is held in two different memory locations on two independent memory cards
  - Cache vaulting
    - Provides protection to data against power failure
    - In the event of power failure, uncommitted data is dumped to a dedicated set of drives called vault drives

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Lesson 1: Summary

During this lesson the following topics were covered:

- Components of block-based storage system
- Intelligent cache algorithms
- Cache protection mechanisms

Lesson 2: Storage Provisioning

This lesson covers the following topics:

- Traditional and virtual provisioning
- LUN expansion
- LUN masking

Overview of Storage Provisioning

Storage Provisioning

The process of assigning storage resources to compute system based on capacity, availability, and performance requirements.

- **Can be performed in two ways:**
  - Traditional storage provisioning
  - Virtual storage provisioning

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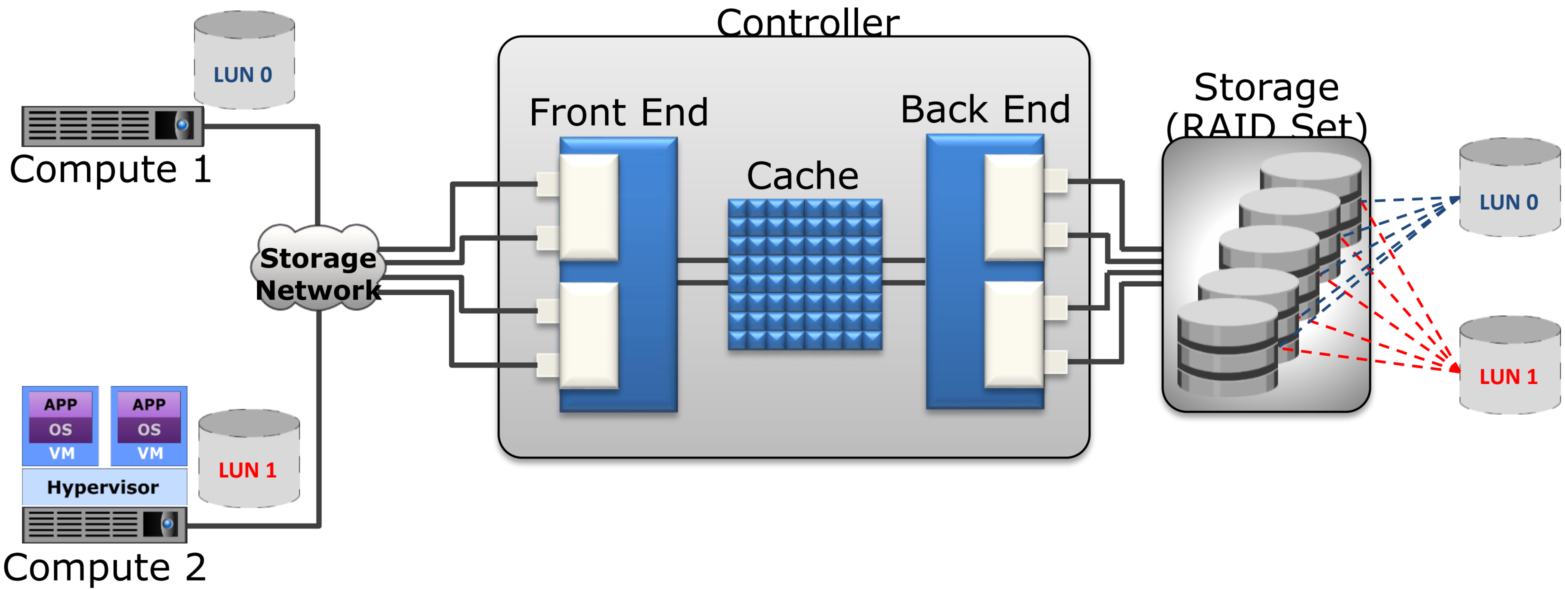
Traditional Provisioning

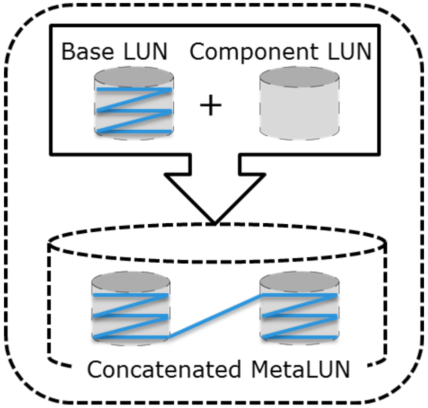


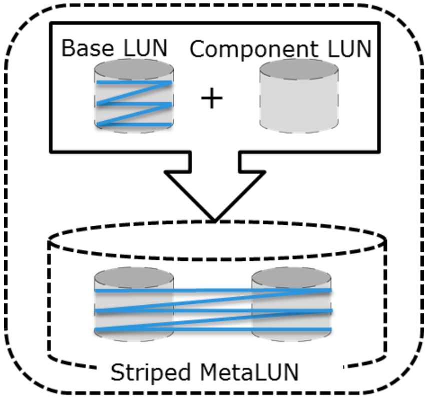
LUN Expansion

MetaLUN

A method to expand LUNs that require additional capacity or performance.

- **Created by combining two or more LUNs**
- **MetaLUNs can either be concatenated or striped**
- **Concatenated metaLUN**
  - Provides only additional capacity but no performance
  - Expansion is quick as data is not restriped
- **Striped metaLUN**
  - Provides capacity and performance
  - Expansion is slow as data is restriped





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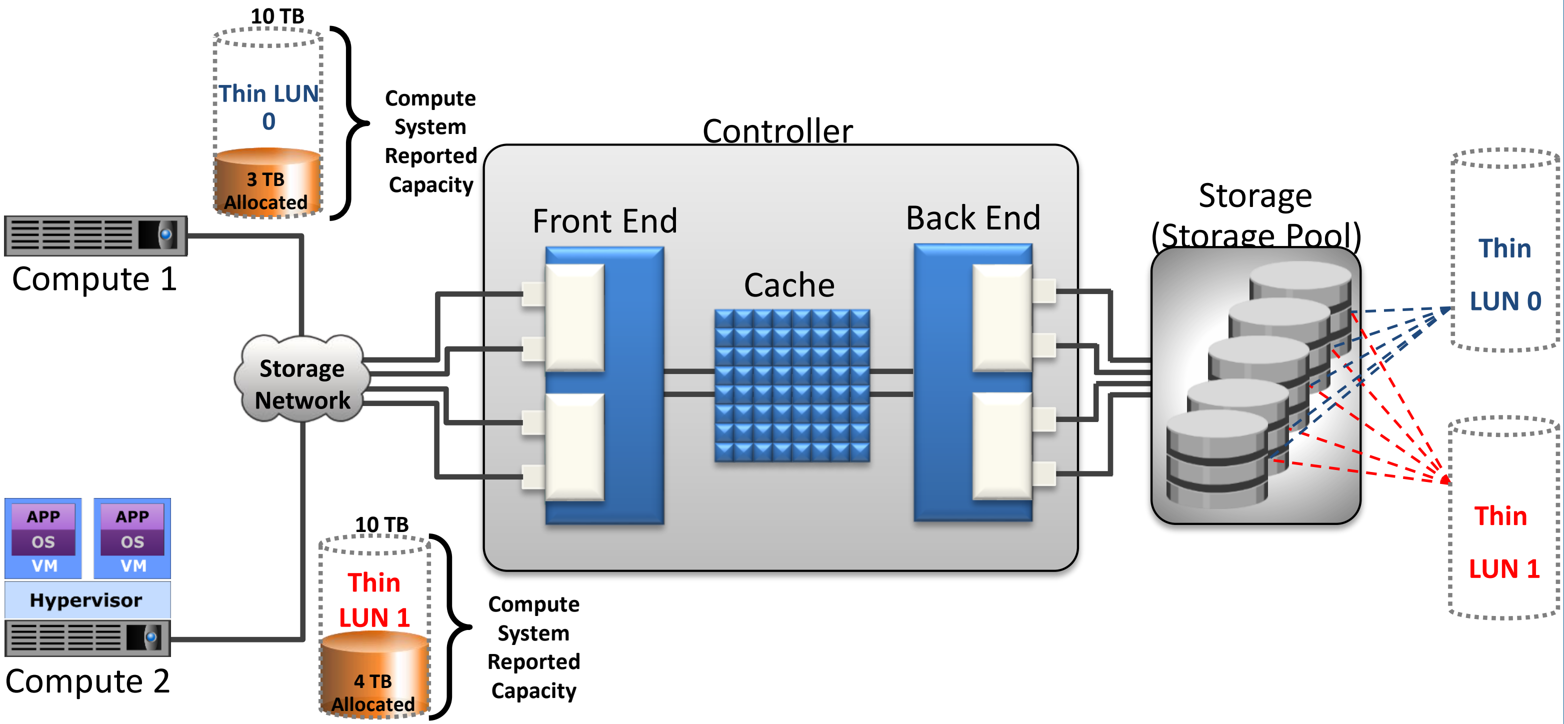
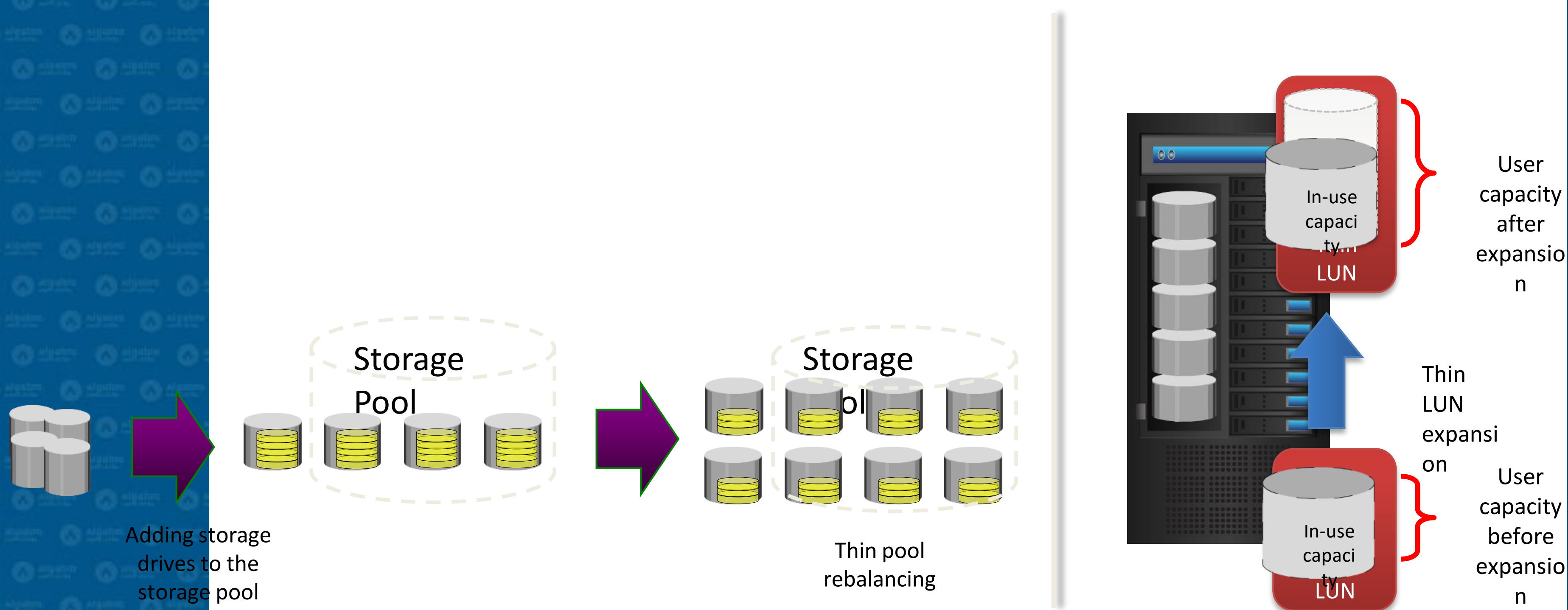
Virtual Provisioning



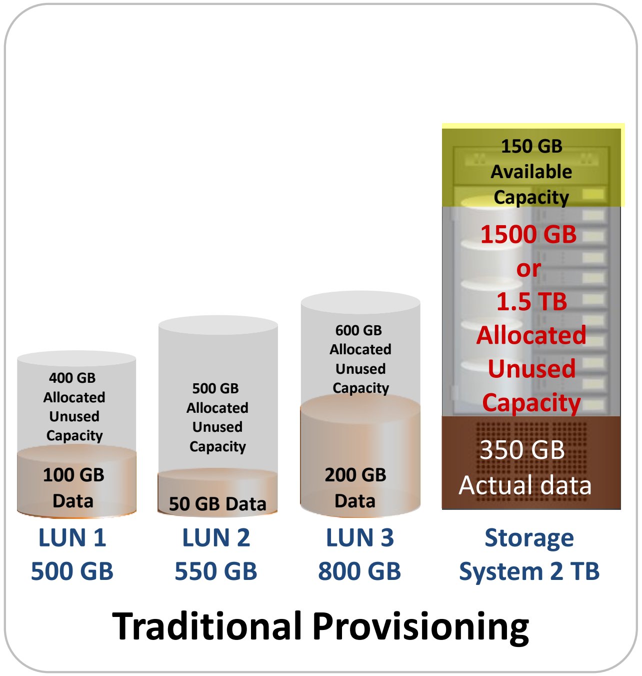
Expanding Thin LUNs

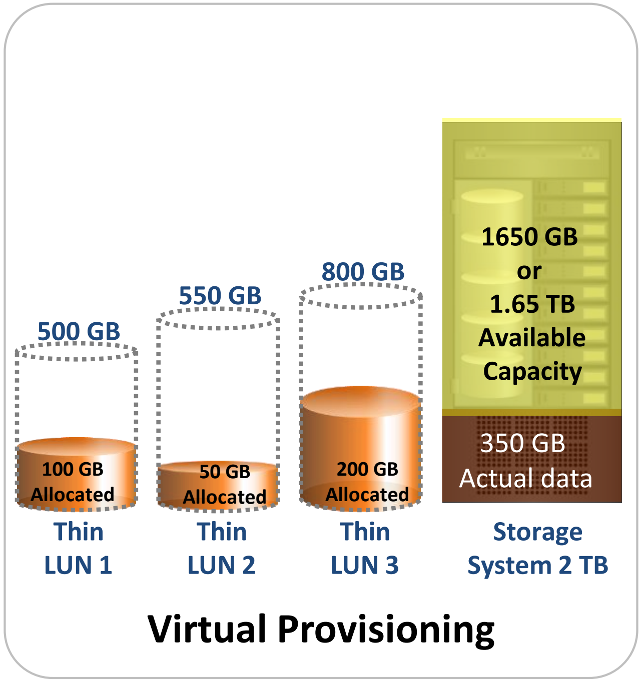


Storage Pool Expansion

Thin LUN Expansion

Traditional Provisioning Vs. Virtual Provisioning





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LUN Masking

LUN Masking

A process that provides data access control by defining which LUNs a compute system can access.

- Implemented on storage system
- Prevents unauthorized or accidental use of LUNs in a shared environment

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Lesson 2: Summary

During this lesson the following topics were covered:

- Traditional and virtual provisioning
- LUN expansion
- LUN masking

Lesson 3: Storage Tiering

This lesson covers the following topics:

- **LUN and Sub-LUN tiering**
- **Cache tiering**
- Server flash caching

Storage Tiering Overview

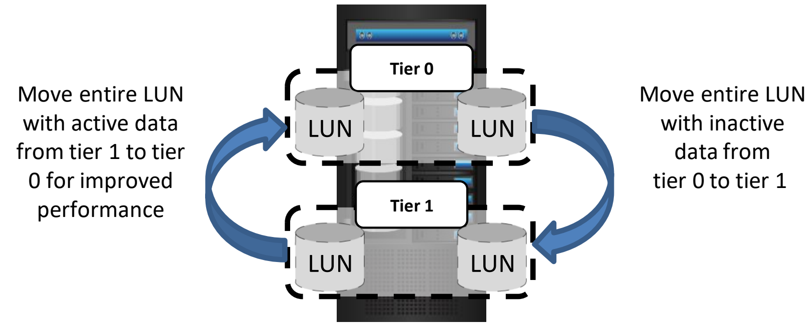
Storage Tiering

A technique of establishing a hierarchy of storage types and identifying the candidate data to relocate to the appropriate storage type to meet service level requirements at a minimal cost.

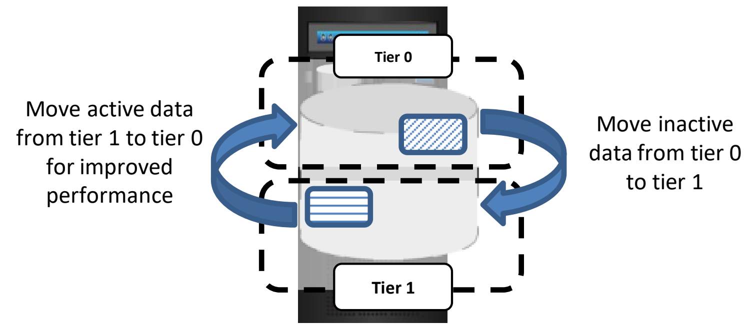
- **Each tier has different levels of protection, performance, and cost**
- **Efficient storage tiering requires defining tiering policies**
- **Tiering in block-based storage systems**
  - LUN and sub-LUN tiering
  - Cache tiering
  - Server flash-caching

LUN and Sub-LUN Tiering

- **LUN tiering**
  - Moves entire LUN from one tier to another
  - Does not give effective cost and performance benefits
- **Sub-LUN tiering**
  - A LUN is broken down into smaller segments and tiered at that level
  - Provides effective cost and performance benefits



LUN Tiering

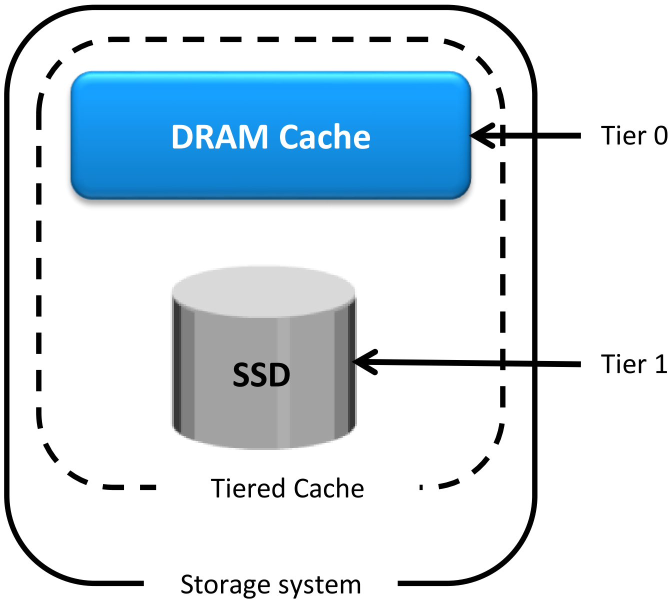


Sub-LUN Tiering

Inactive Data
Active Data

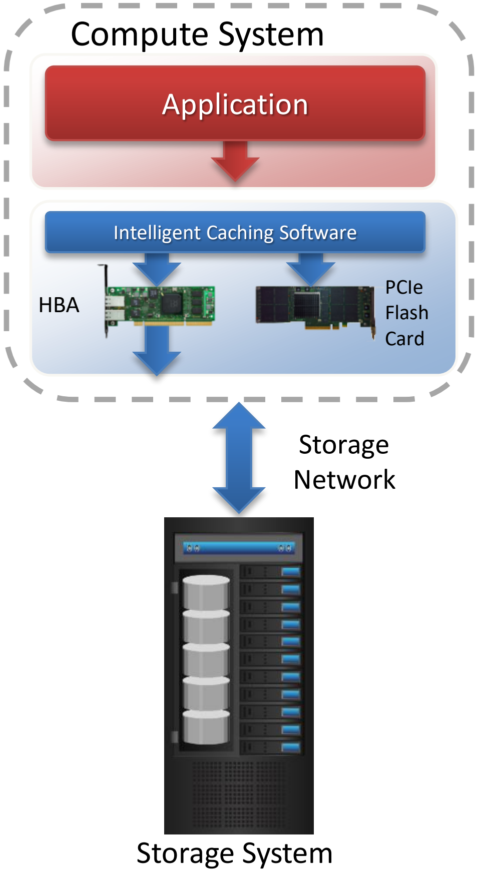
Cache Tiering

- **Enables creation of a large capacity secondary cache using SSDs**
- **Enables tiering between DRAM cache and SSDs (secondary cache)**
- **Most reads are served directly from high performance tiered cache**
- **Benefits**
  - Enhances performance during peak workload
  - Non-disruptive and transparent to applications



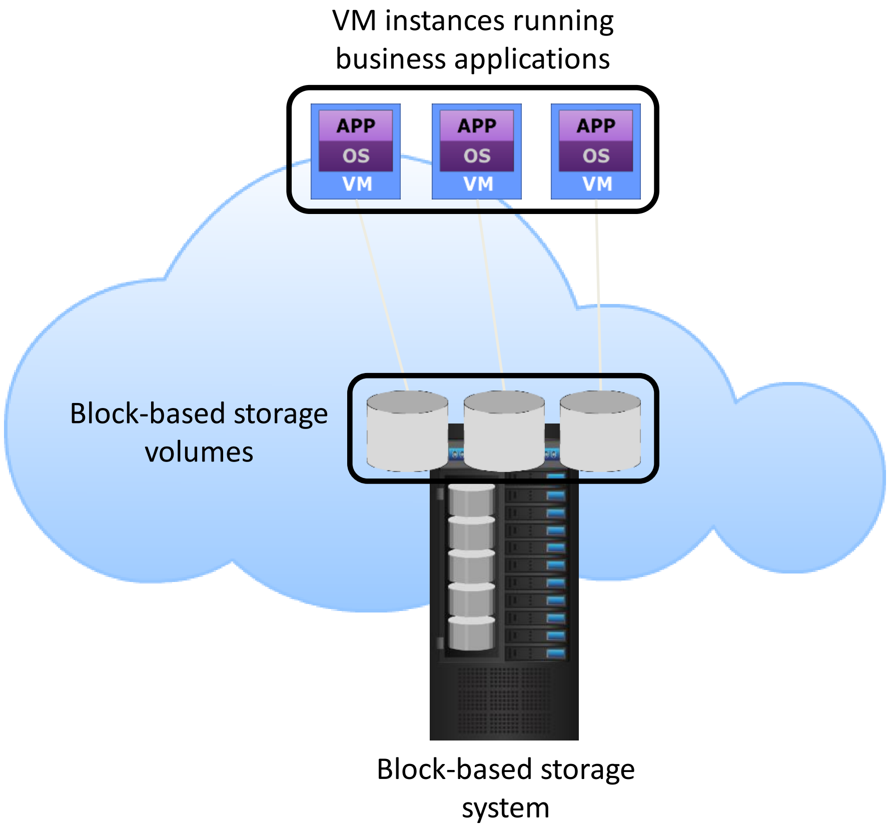
Server Flash-caching Technology

- **Uses intelligent caching software and PCIe flash card on compute system**
- **Dramatically improves application performance**
  - Provides performance acceleration for read-intensive workloads
  - Avoids network latencies associated with I/O access to the storage system
- **Intelligently determines data that would benefit by sitting in compute system on PCIe flash**
- **Uses minimal CPU and memory resources**
  - Flash management is offloaded onto PCIe card



Use Case – Block-based Storage in Cloud

- Storage as a Service



Lesson 3: Summary

During this lesson the following topics were covered:

- LUN and Sub-LUN tiering
- Cache tiering
- Server flash caching
- Block-based storage use case

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Module 3: Summary

Key points covered in this module:

- Components of block-based storage system
- Traditional and virtual storage provisioning
- Storage tiering mechanisms

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What is IP SAN?

- **A SAN that uses Internet Protocol (IP) for the transport of block-level data**
- **Uses IP-based protocols for communication, commonly:**
  - Internet SCSI (iSCSI)
  - Fibre Channel over IP (FCIP)

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Drivers for IP SAN

- **Existing IP-based network infrastructure can be leveraged**
  - Reduced cost compared to deploying new FC SAN infrastructure
- **IP network makes it possible to extend or connect SANs over long distances**
- **Many long-distance disaster recovery solutions already leverage IP-based network**
- **Many robust and mature security options are available for IP network**

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Lesson 1: iSCSI

This lesson covers the following topics:

- iSCSI network components
- iSCSI connectivity
- iSCSI protocol stack
- iSCSI address and name
- iSCSI discovery

iSCSI Overview

- IP-based protocol that enables transporting SCSI data over an IP network
- Encapsulates SCSI I/O into IP packets and transports them using TCP/IP

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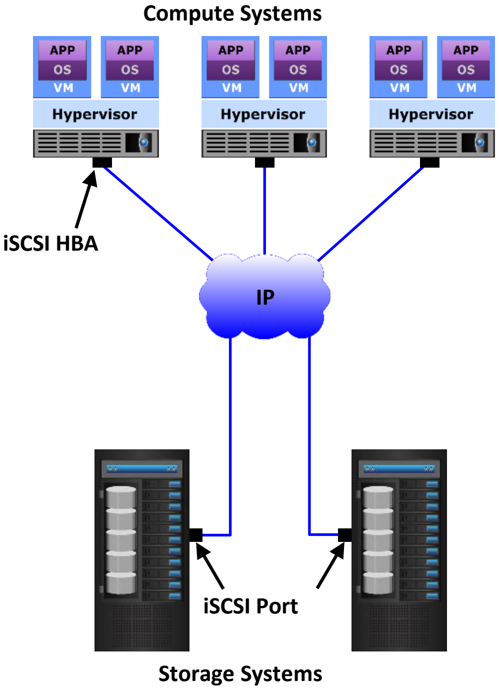
Components of iSCSI Network

- **iSCSI initiators**
  - Example: iSCSI HBA
- **iSCSI targets**
  - Example: Storage system with iSCSI port
- **IP-based network**
  - Example: Gigabit Ethernet LAN

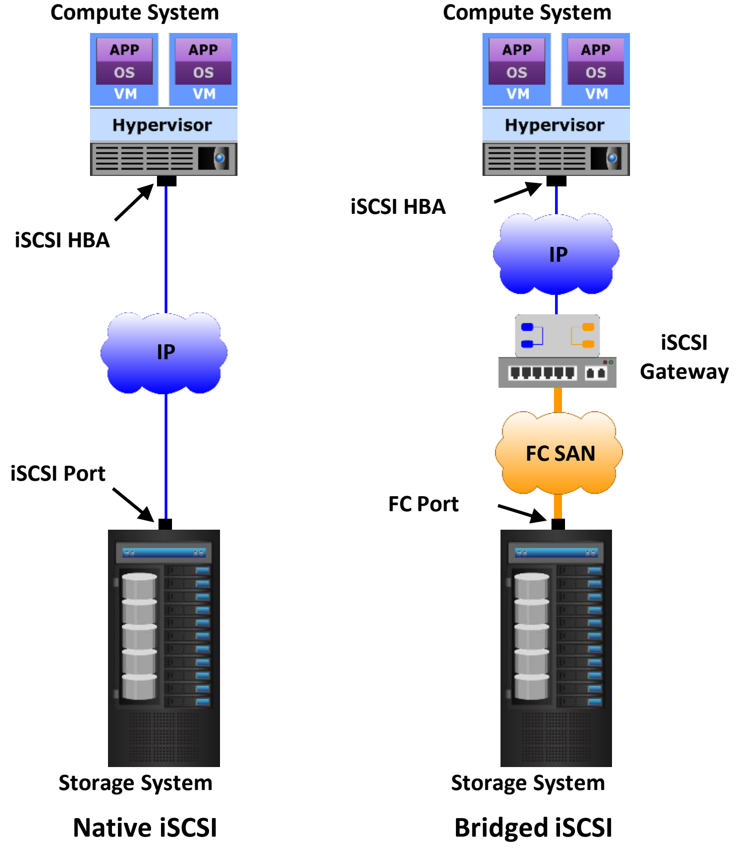


Types of iSCSI Initiator

- **Standard NIC with software iSCSI adapter**
  - NIC provides network interface
  - Software adapters provide iSCSI functionality
  - Both iSCSI and TCP/IP processing require CPU cycles of compute system
- **TCP Offload Engine (TOE) NIC with software iSCSI adapter**
  - TOE NIC performs TCP/IP processing
  - Software adapter provides iSCSI functionality
  - iSCSI processing requires CPU cycles of compute system
- **iSCSI HBA**
  - Performs both iSCSI and TCP/IP processing
  - Frees-up CPU cycles of compute system for business applications

iSCSI Connectivity

- **Native**
  - iSCSI initiators connect to iSCSI targets directly/through IP network
  - No FC component
- **Bridged**
  - iSCSI initiators are attached to IP network
  - Storage systems are attached to FC SAN
  - iSCSI gateway provides bridging functionality



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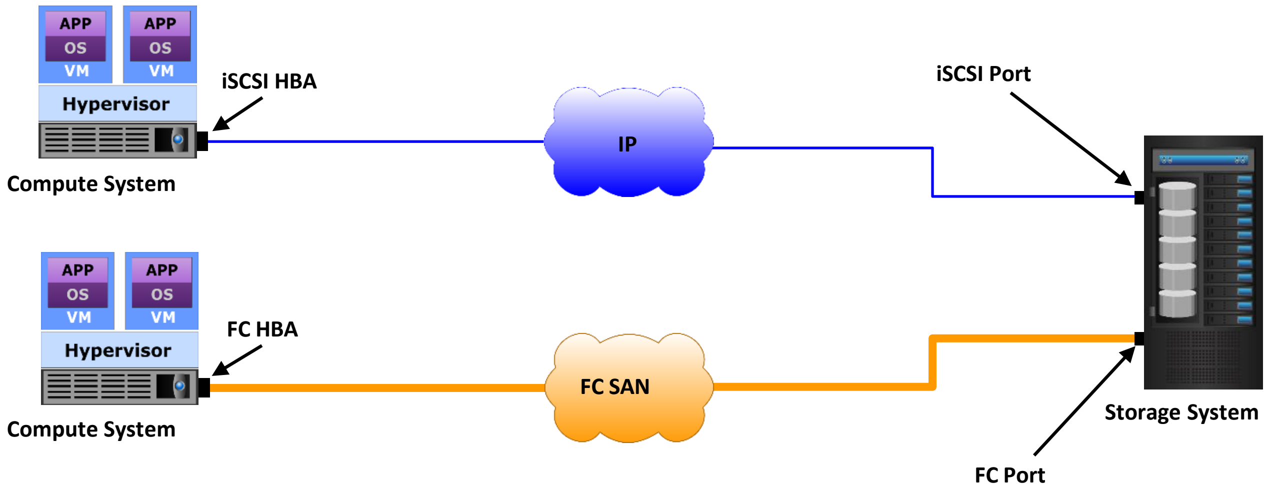
Combining FC and Native iSCSI Connectivity

- Storage system provides both FC and iSCSI ports
  - Enable iSCSI and FC connectivity in the same environment
  - No bridge device is needed



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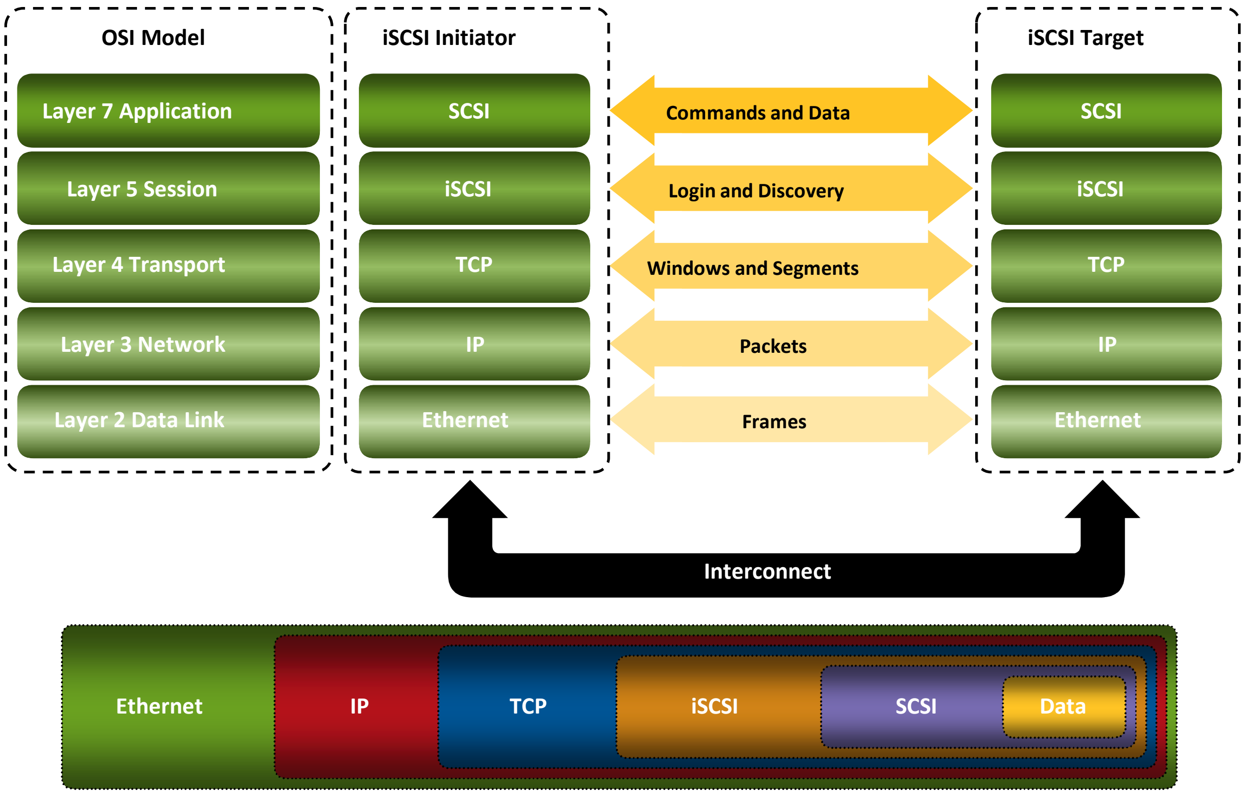
iSCSI Protocol Stack



iSCSI Address and Name

- **iSCSI address is the path to iSCSI initiator/target, which is comprised of:**
  - Location of iSCSI initiator/target
    - Combination of IP address and TCP port number
  - iSCSI name
    - Unique identifier for initiator/target in an iSCSI network

Common Types of iSCSI Name

- IQN: iSCSI Qualified Name
  - iqn.2008-02.com.example:optional_string
- EUI: Extended Unique Identifier
  - eui.0300732A32598D26
- NAA: Network Address Authority
  - naa.52004567BA64678D

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iSCSI Discovery

- **For iSCSI communication, initiator must discover location and name of targets on the network**
- **iSCSI discovery commonly takes place in two ways:**
  - SendTargets discovery
    - Initiator is manually configured with the target's network portal
    - Initiator issues SendTargets command; target responds with required parameters
  - Internet Storage Name Service (iSNS)
    - Initiators and targets register themselves with iSNS server
    - Initiator may query iSNS server for a list of available targets

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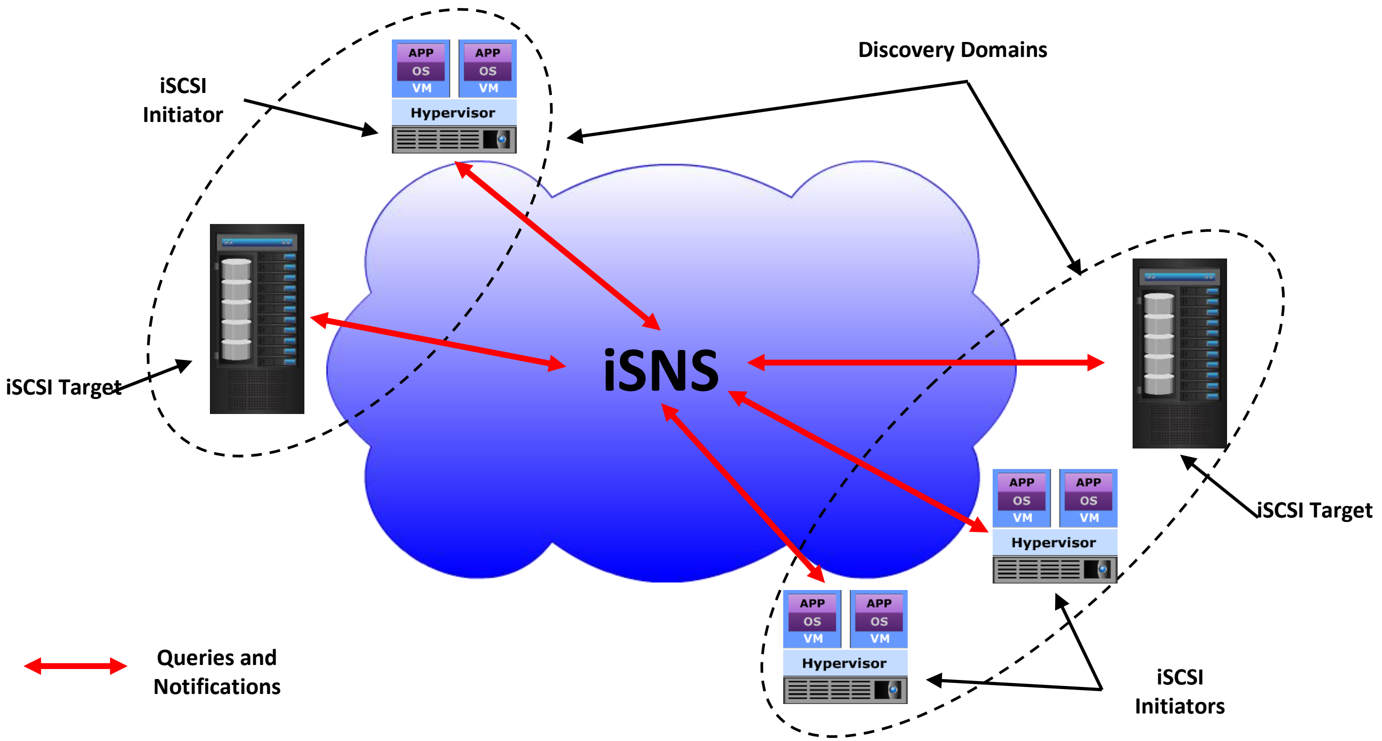
iSNS Discovery Domain



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Lesson 1: Summary

During this lesson the following topics were covered:

- iSCSI network components
- iSCSI connectivity
- iSCSI protocol stack
- iSCSI address and name
- iSCSI discovery

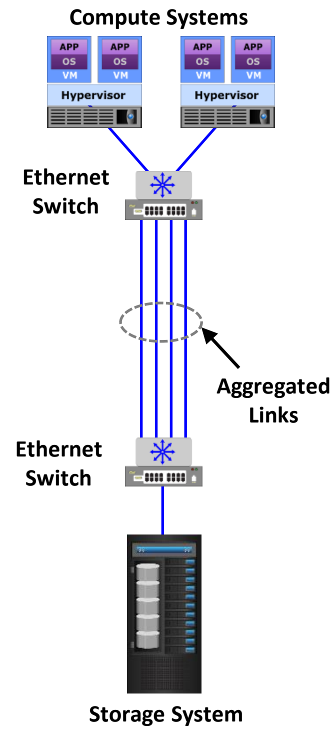
Lesson 2: Link Aggregation and VLAN

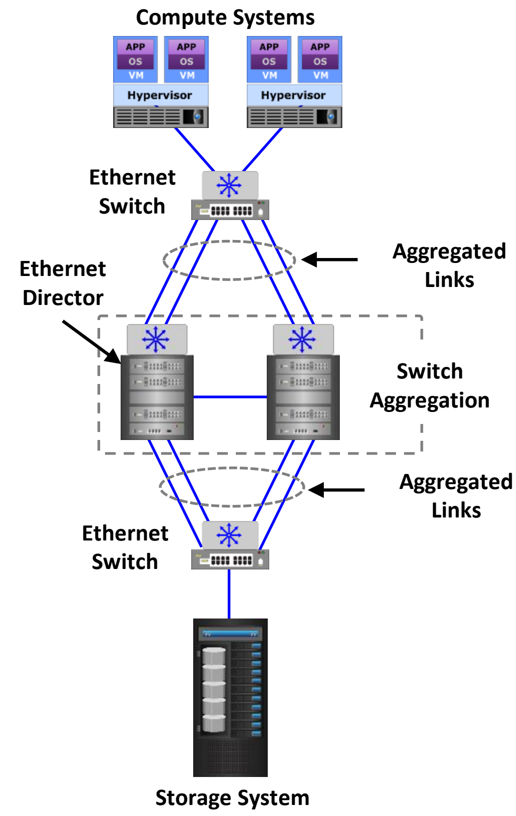
This lesson covers the following topics:

- Link aggregation
- Switch aggregation
- Self-forming network
- Virtual LAN (VLAN)
- Stretched VLAN

Link and Switch Aggregation

- **Link aggregation:**
  - Distributes network traffic across aggregated links
  - Provides higher throughput than a single link could provide
- **Switch aggregation:**
  - Aggregated physical switches appear as a single logical switch
  - Distributes traffic across all links from aggregated switches
  - Provides higher throughput than a single switch could provide





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Self-forming Network and Link Aggregation

- **Self-forming network:**
  - Allows an Ethernet switch to join an Ethernet network automatically
  - Network automatically detects new switch, discovers topology, and populate routing table to start forwarding traffic immediately
- **Self-forming link aggregation:**
  - Includes new interswitch links into a port-channel automatically and redistributes network traffic among all aggregated links

Benefits

- Simplify configuration and ongoing management operations
- Reduce manual, repetitive, and error-prone configuration tasks
- Provide agility needed to deploy, scale, and manage network infrastructure

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Virtual LAN (VLAN)

VLAN

A logical network created on a LAN enabling communication between a group of nodes with a common set of functional requirements, independent of their physical location in the network.

- **Helps isolating iSCSI traffic from other network traffic in a physical Ethernet network**
- **Configuring a VLAN:**
  - Define VLANs on switches with specific VLAN IDs
  - Configure VLAN membership based on a supported technique
    - Port-based, MAC-based, protocol-based, IP subnet address-based, or application-based

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VLAN Trunking and Tagging

- **VLAN trunking allows a single network link (trunk link) to carry multiple VLAN traffic**
- **To enable trunking, trunk ports must be configured on both sending and receiving network components**
- **Sending network component inserts a tag field containing VLAN ID into an Ethernet frame before sending through a trunk link**
- **Receiving network component reads the tag and forwards the frame to destination port(s)**
  - Tag is removed once a frame leaves trunk link to reach a node port

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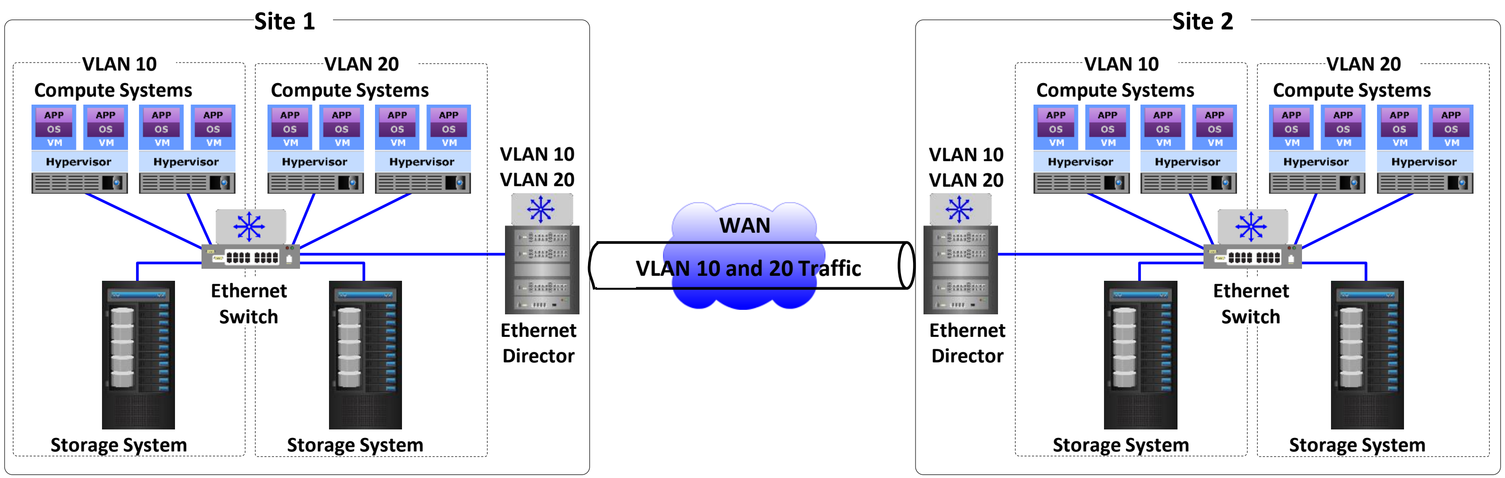
Stretched VLAN

Stretched VLAN

A VLAN that spans multiple sites and enables OSI Layer 2 communication between a group of nodes over an OSI Layer 3 WAN infrastructure, independent of their physical location.



Lesson 2: Summary

During this lesson the following topics were covered:

- Link aggregation
- Switch aggregation
- Self-forming network
- VLAN configuration, trunking, and tagging
- Stretched VLAN

Module 4: Summary

Key points covered in this module:

- iSCSI protocol, network components, and connectivity
- Link aggregation, switch aggregation, and VLAN

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Lesson 1: Overview of FCoE SAN

This lesson covers the following topics:

- Components of FCoE SAN
- FCoE SAN connectivity
- VLAN and VSAN in FCoE
- FCoE port types

What is FCoE SAN?

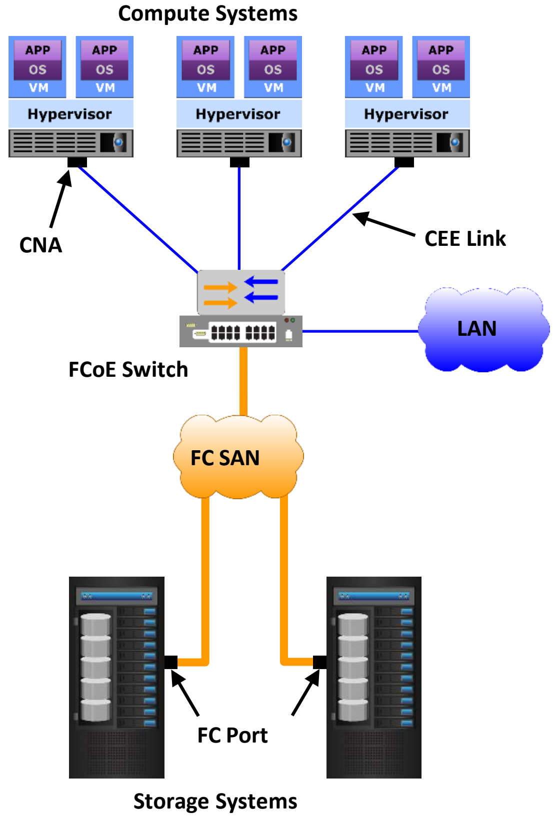
- A SAN that transports FC data along with regular Ethernet traffic over a Converged Enhanced Ethernet (CEE) network
- Uses FCoE protocol that encapsulates FC frames into Ethernet frames
- Ensures lossless transmission of FC traffic over Ethernet

Drivers for FCoE SAN

- **Multi-function network components are used to transfer both compute-to-compute and FC storage traffic**
  - Reduces the complexity of managing multiple discrete networks
  - Reduces the number of network adapters, cables, and switches required in a data center
  - Reduces power and space consumption in a data center

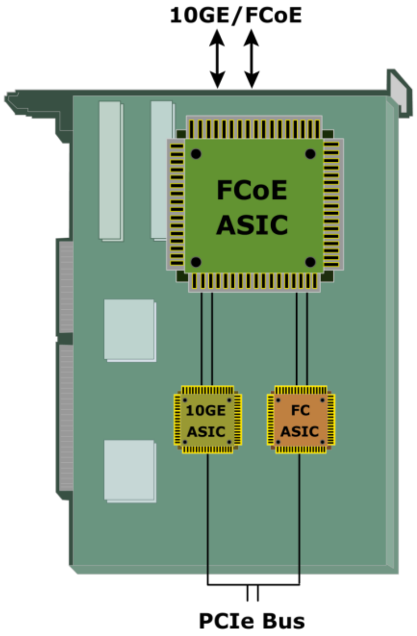
Components of FCoE SAN

- **Network adapters**
  - Example: Converged Network Adapter (CNA) and software FCoE adapter
- **Cables**
  - Example: Copper cables and fiber optical cables
- **FCoE switch**



CNA and Software FCoE Adapter

- **CNA:**
  - A physical adapter that provides functionality of both NIC and FC HBA
  - Encapsulates FC frames into Ethernet frames and forwards them over CEE links
  - Contains separate modules for 10 GE, FC, and FCoE ASICs
- **Software FCoE adapter:**
  - An OS/hypervisor-resident software that performs FCoE processing
  - Supported NICs transfer both FCoE traffic and regular Ethernet traffic



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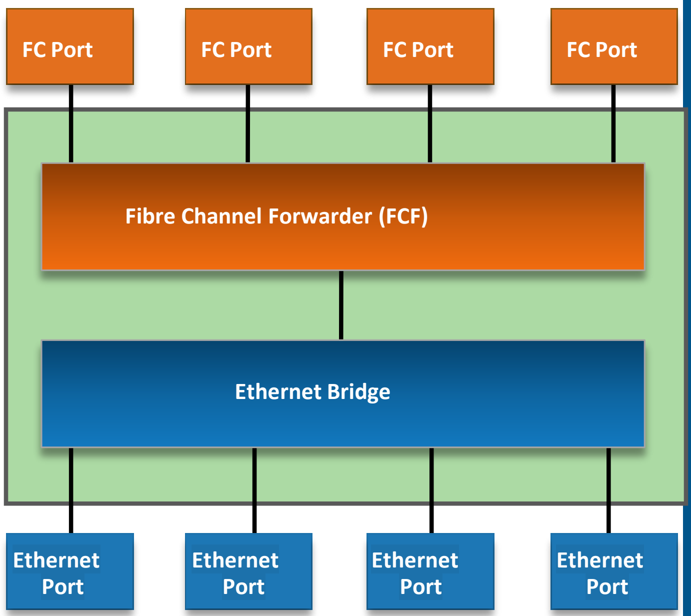
FCoE Switch

- **Provides both Ethernet switch and FC switch functionalities**
- **Consists of FCF, Ethernet bridge, and ports for FC and Ethernet connectivity**
  - FCF functions as the communication bridge between CEE and FC networks
    - Handles FCoE login requests, applies zoning, and provides fabric services
    - Encapsulates and decapsulates FC frames
- **Forwards frames based on Ethertype**



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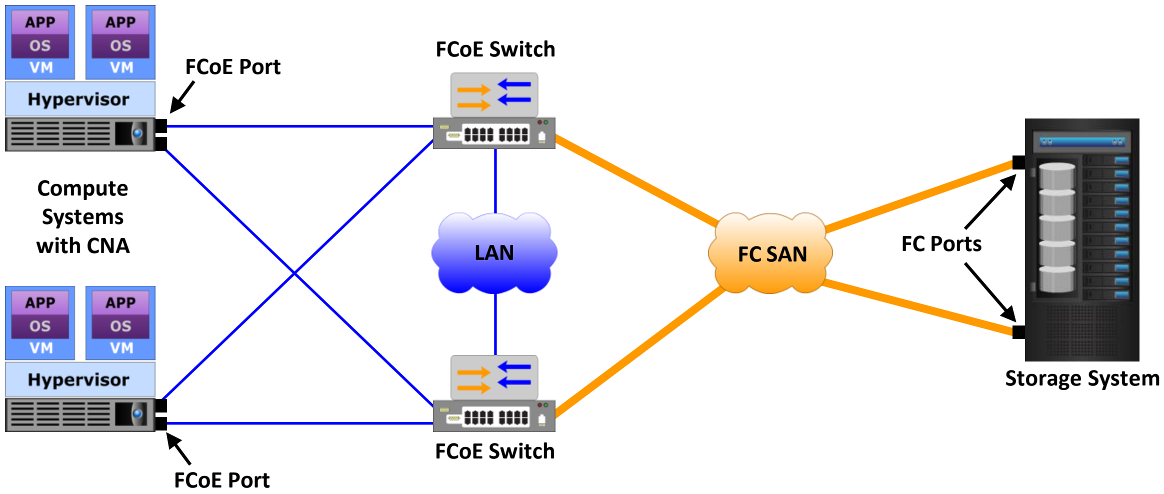
FCoE SAN Connectivity

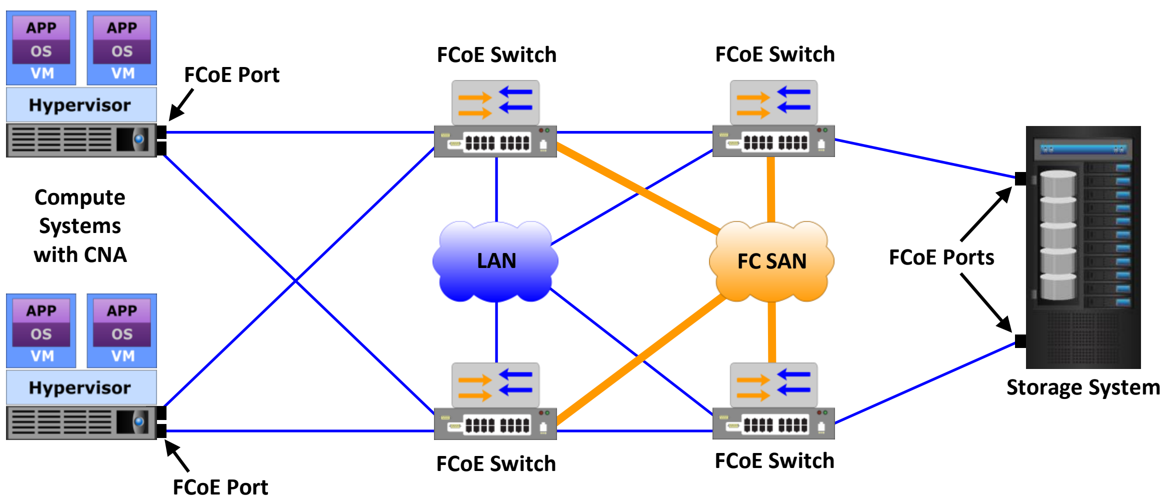
- FCoE with Existing FC SAN

- **FCoE switches interconnect a CEE network containing compute systems with an FC SAN containing storage systems**
  - Suitable for environment with existing FC SAN



FCoE SAN Connectivity

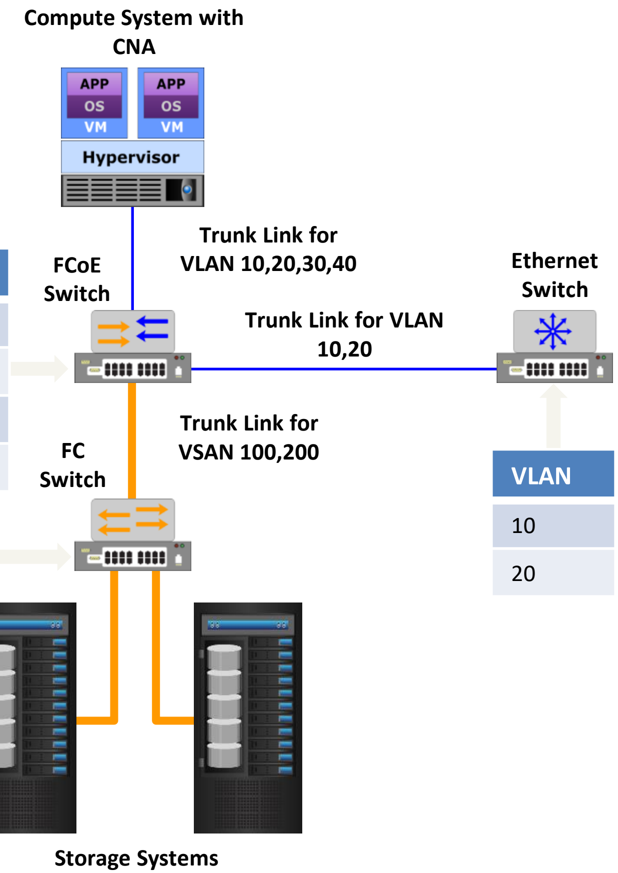
- End-to-end FCoE
- FCoE switches interconnect FCoE compute systems with FCoE storage systems
  - Suitable for new FCoE deployments



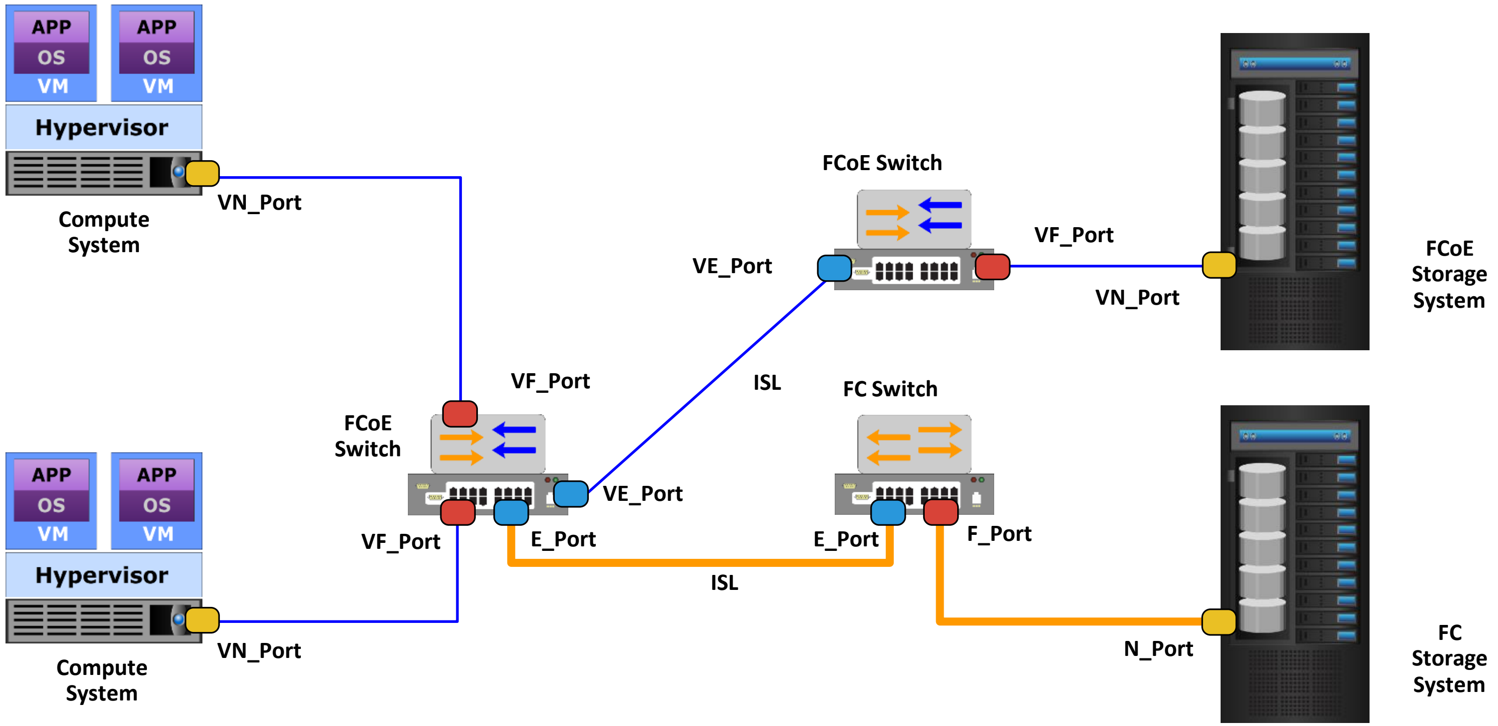
VLAN and VSAN in FCoE

- Both VLAN and VSAN may exist in the FCoE with existing FC SAN environment
- FCoE switch supports VSAN to VLAN mapping
- A dedicated VLAN is configured for each VSAN
- VLANs configured for VSANs should not carry regular LAN traffic

VLAN	VSAN	FCoE
10	N/A	No
20	N/A	No
30	100	Yes
40	200	Yes



Port Types in FCoE



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Lesson 1: Summary

During this lesson the following topics were covered:

- Components of FCoE SAN
- FCoE SAN connectivity
- VLAN and VSAN in FCoE
- FCoE port types

Lesson 2: Converged Enhanced Ethernet (CEE)

This lesson covers the following topics:

- Priority-based flow control
- Enhanced transmission selection
- Congestion notification
- Data center bridging exchange protocol

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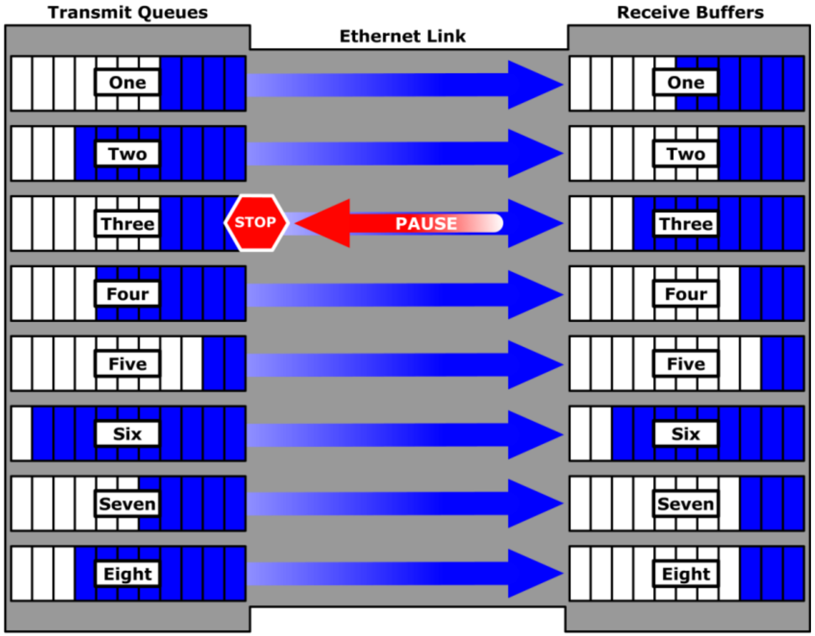
Introduction to CEE

- **CEE refers to a set of enhancements to conventional Ethernet for making it lossless and for converging various traffic types**
- **CEE ensures lossless transmission of FC data over an Ethernet network**
  - Eliminates the dropping of frames due to congestion
- **CEE requires these functionalities:**
  - Priority-based flow control (PFC)
  - Enhanced transmission selection (ETS)
  - Congestion notification (CN)
  - Data center bridging exchange protocol (DCBX)

Priority-based Flow Control (PFC)

- Creates eight virtual links on a single physical link
- Uses PAUSE capability of Ethernet for each virtual link
  - A virtual link can be paused and restarted independently
  - PAUSE mechanism is based on user priorities or classes of service



Enhanced Transmission Selection (ETS)

- Allocates bandwidth to different traffic classes such as LAN, SAN, and Inter Process Communication (IPC)
- Provides available bandwidth to other classes of traffic when a particular class of traffic does not use its allocated bandwidth

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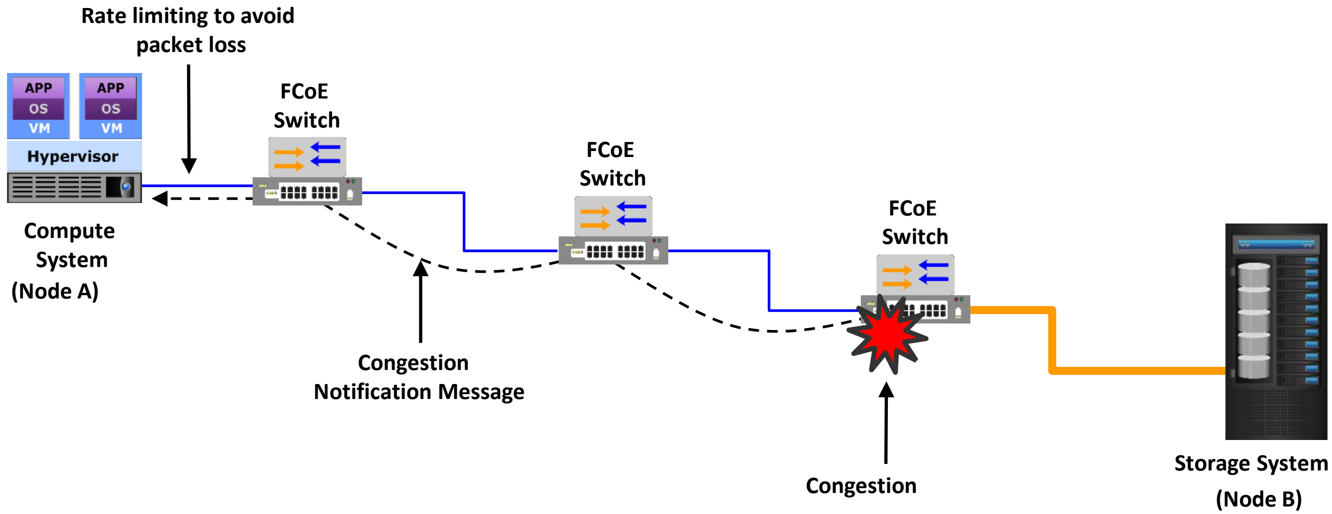
Congestion Notification (CN)

- **Provides a mechanism for detecting network congestion and notifying the source**
  - Enables a switch to send a signal to other ports that need to stop or slow down their transmissions



Data Center Bridging Exchange Protocol (DCBX)

- **Enables CEE devices to convey and configure their features with other CEE devices in the network**
  - Allows a switch to distribute configuration values to attached network adapters
- **Ensures consistent configuration across a network**

Lesson 2: Summary

During this lesson the following topics were covered:

- Priority-based flow control
- Enhanced transmission selection
- Congestion notification
- Data center bridging exchange protocol

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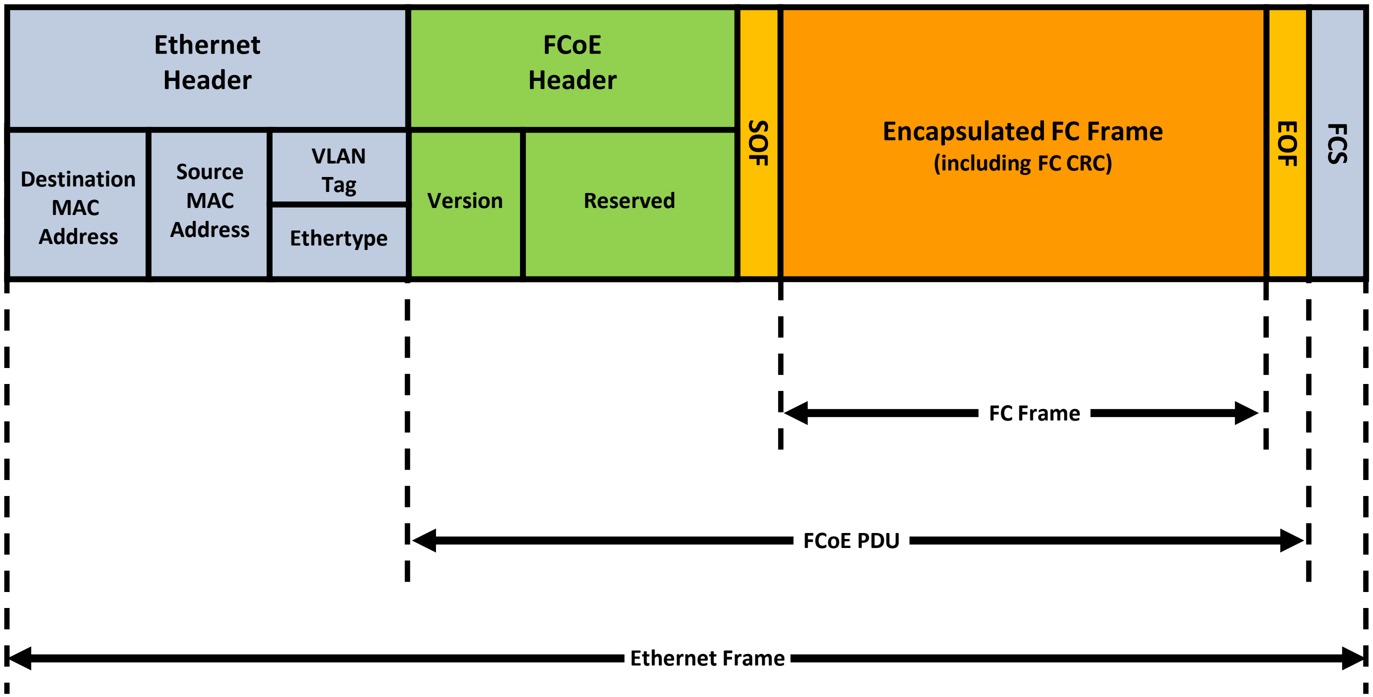
Lesson 3: FCoE Architecture

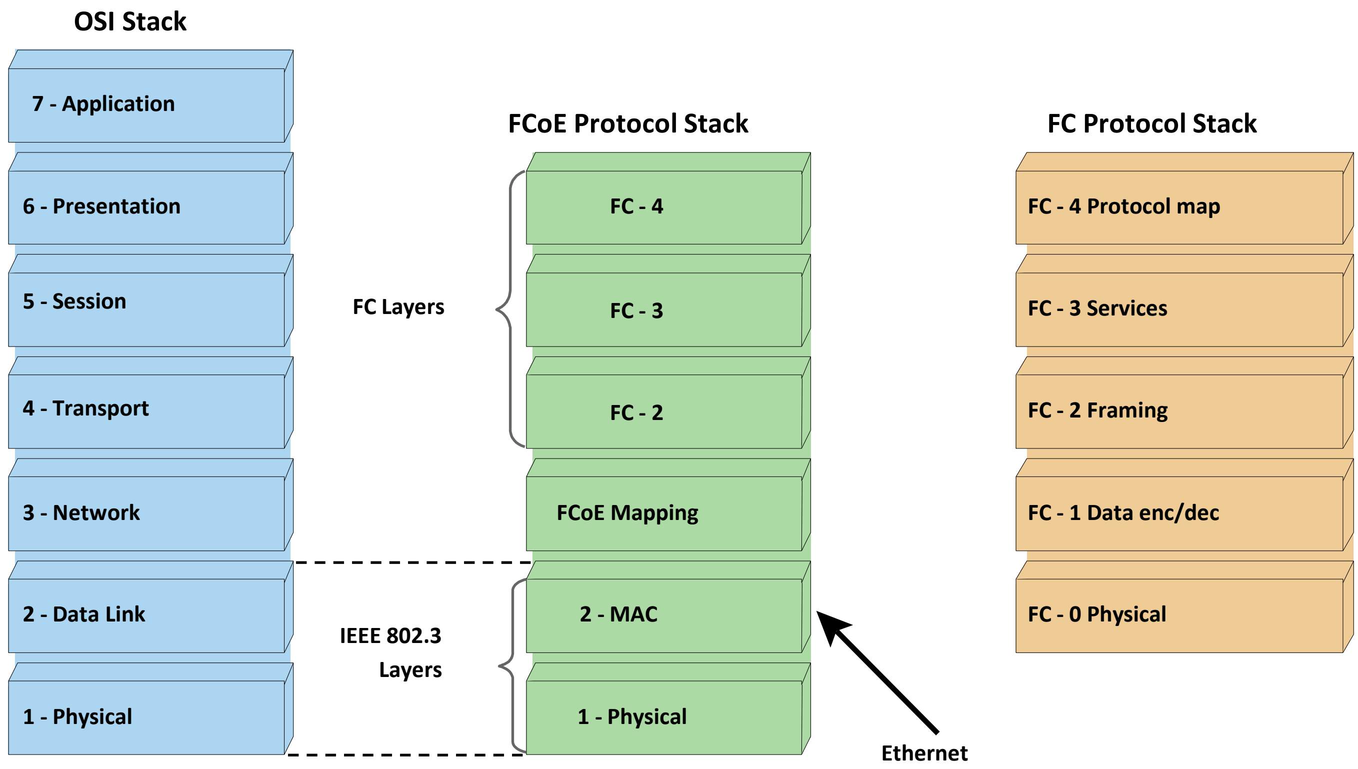
This lesson covers the following topics:

- FCoE frame structure
- FCoE frame mapping
- FCoE process
- FCoE addressing
- FCoE frame forwarding

FCoE Frame Structure



FCoE Frame Mapping



FCoE Process

- **FCoE process includes three key phases:**
  - Discovery phase:
    - FCFs discover each other and form an FCoE fabric
    - FCoE nodes find available FCFs for login
    - FCoE nodes and FCFs discover potential VN_Port to VF_Port pairing
  - Login phase:
    - Virtual FC links are created – VN_Port to VF_Port, VE_Port to VE_Port
    - VN_Port performs FC login and obtains FC address
    - VN_Port obtains a unique MAC address
  - Data transfer phase:
    - VN_Ports transfer regular FC frames (encapsulated) over CEE network

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FCoE Initialization Protocol (FIP)

- **FIP is used for discovering FCFs and establishing virtual links between FCoE nodes and FCoE switches**
- **FIP frames do not transport FC data, but contains discovery and login parameters**
- **Discovery and login use these FIP operations:**
  - FCoE node sends multicast FIP Solicitation frame to find FCFs for login
  - Each FCF replies to FCoE node by sending unicast FIP Advertisement frame
  - FCoE node sends FIP FLOGI request to an appropriate FCF
  - FCF sends FIP FLOGI Accept containing FC and MAC addresses for VN_Port

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FCoE Addressing

- **An FCoE SAN uses MAC address for frame forwarding**
  - MAC addresses are assigned to VN_Ports, VF_Ports, and VE_Ports
- **VF_Ports and VE_Ports obtain MAC addresses from FCoE switch**
- **FCoE supports two types of addressing for VN_Ports:**
  - Server-provided MAC address (SPMA) and fabric-provided MAC address (FPMA)

SPMA

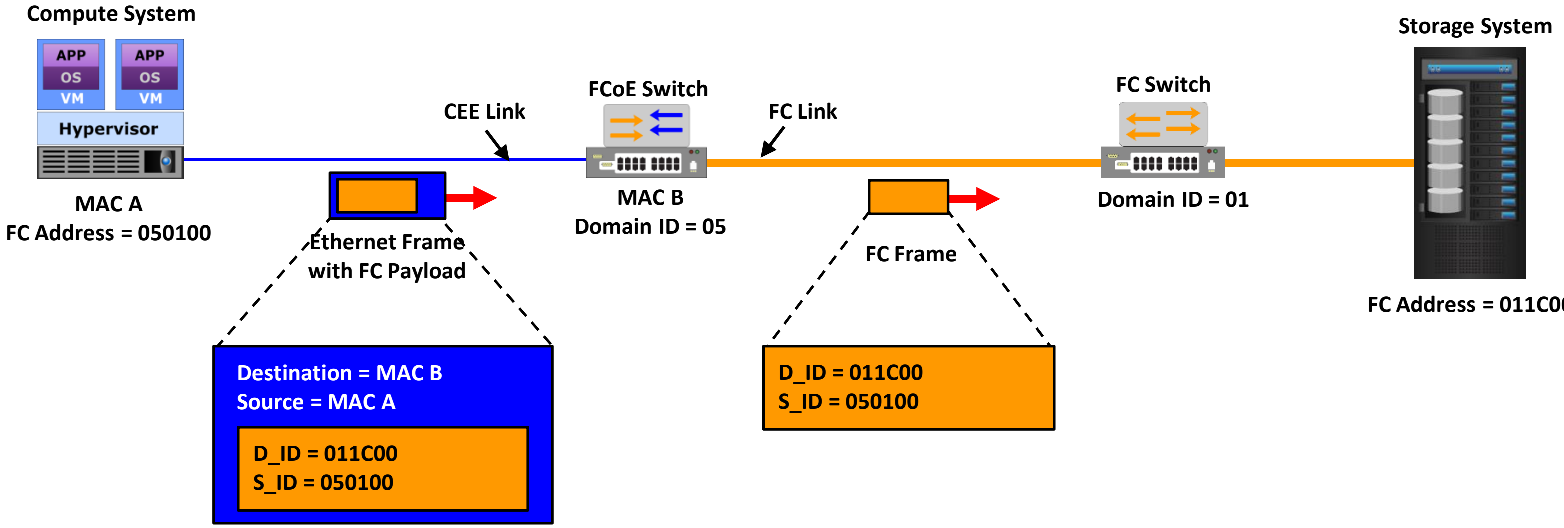
- Compute systems provide MAC addresses to associated VN_Ports as per Ethernet standards
- MAC addresses are either burned-in or are configured by administrators

FPMA

- FCoE switches provide MAC addresses to VN_Ports dynamically during node login
- MAC address has two parts: 24-bit FC-MAP and 24-bit FC address

FCoE Frame Forwarding

- To forward frame, a node must know both the MAC address of FCoE switch port and the FC address of destination node port



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Lesson 3: Summary

During this lesson the following topics were covered:

- FCoE frame structure
- FCoE frame mapping
- FCoE process
- FCoE addressing
- FCoE frame forwarding

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Module 5: Summary

Key points covered in this module:

- FCoE SAN components and connectivity
- Converged Enhanced Ethernet functionalities
- FCoE architecture

Upon completion of this module, you should be able to:

- List the third platform requirements for SAN
- Describe software-defined networking
- Describe FC SAN and its components
- Describe FC architecture
- Describe FC SAN topologies, link aggregation, and zoning
- Describe virtualization in FC SAN

Lesson 1: Introduction to SAN

This lesson covers the following topics:

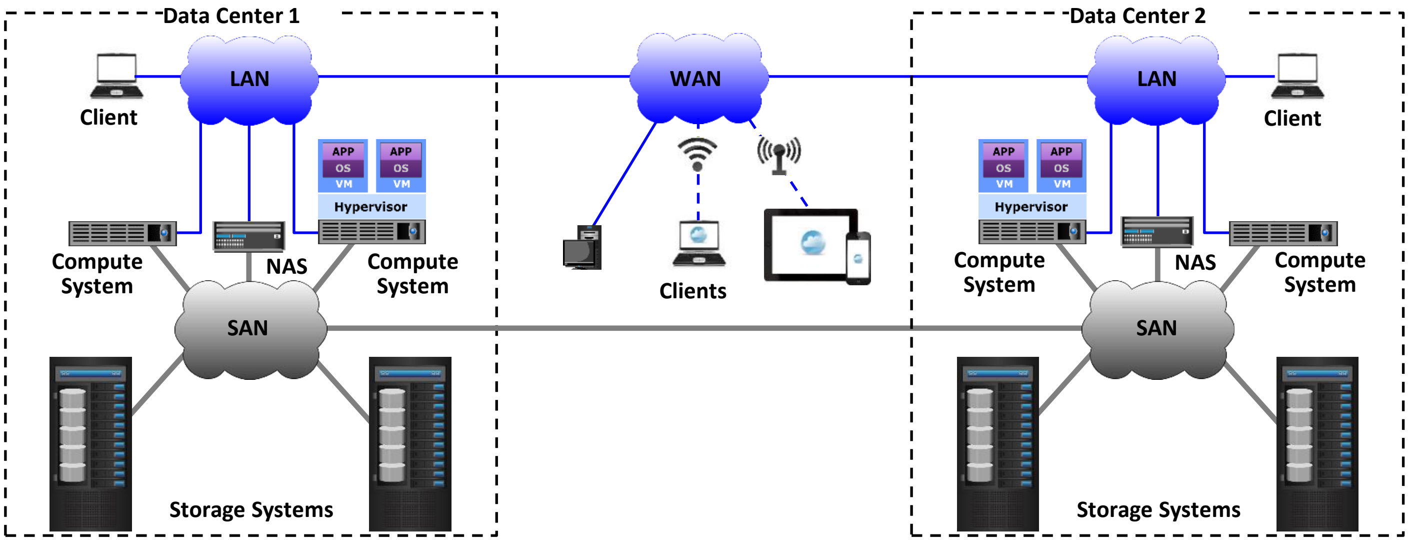
- Definition and benefits of SAN
- Third platform requirements for SAN
- Technology solutions for SAN
- Software-defined networking

What is a SAN?

SAN

A network whose primary purpose is the transfer of data between computer systems and storage devices and among storage devices.

- Storage Networking Industry Association



Benefits of SAN

- **Enables both consolidation and sharing of storage resources across multiple compute systems**
  - Improves utilization of storage resources
  - Centralizes management
- **Enables connectivity across geographically dispersed locations**
  - Enables compute systems across locations to access shared data
  - Enables replication of data between storage systems that reside in separate locations
  - Facilitates remote backup of application data

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Third Platform Requirements for SAN

- **An effective SAN infrastructure must provide:**
  - High throughput to support high performance computing
  - Interconnectivity among a large number of devices over wide locations to transfer massively distributed, high volume of data
  - Elastic and non-disruptive scaling to support applications that are horizontally scaled
  - Automated and policy-driven infrastructure configuration
  - Simplified, flexible, and agile management operations

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Technology Solutions

- **Software-defined networking**
- **SAN implementations:**
  - Fibre Channel (FC) SAN
  - Internet Protocol (IP) SAN
  - Fibre Channel over Ethernet (FCoE) SAN
- **Virtualization in SAN**

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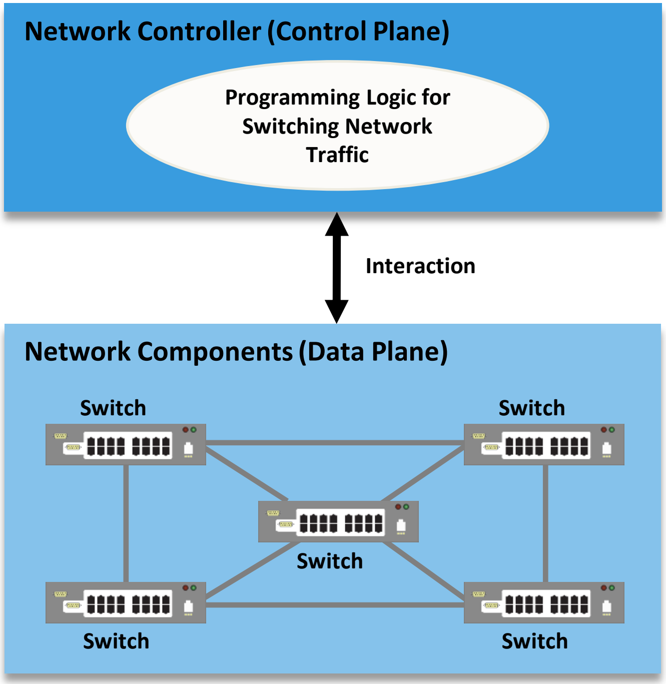
Software-Defined Networking

- Abstracts and separates control plane from data plane
- Software (controller) external to the network components takes over control functions
- Controller sends instructions for data plane at the network component to handle network traffic



Benefits of Software-Defined SAN

- **Centralized control**
  - Single point of control for SAN infrastructure
- **Policy-based automation**
  - Management operations are programmed in the network controller based on business policies
- **Simplified, agile management**
  - Management functions are simplified through abstraction of operational complexity

Lesson 1: Summary

During this lesson the following topics were covered:

- Definition and benefits of SAN
- Third platform requirements for SAN
- Technology solutions for SAN
- Software-defined networking

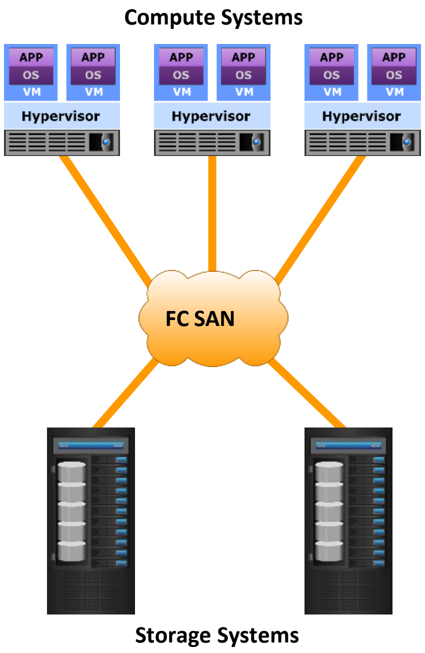
Lesson 2: FC SAN Overview

This lesson covers the following topics:

- Components of FC SAN
- FC interconnectivity options
- FC port types

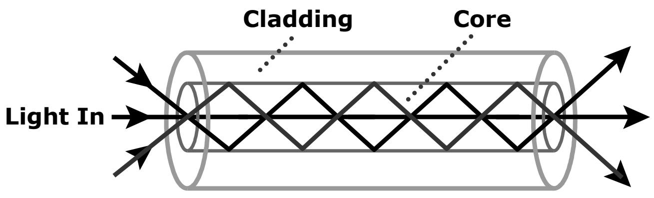
What is FC SAN?

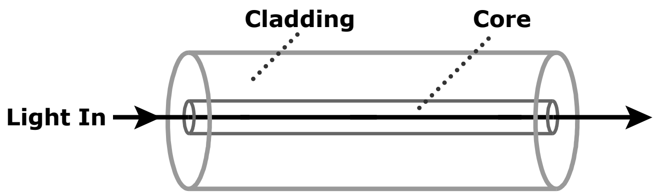
- A SAN that uses Fibre Channel (FC) protocol for communication
- Supports data transmission speed up to 16 Gb/s
- Enables data transmission without dropping frames
- Provides high scalability
  - Theoretically, accommodate approximately 15 million devices



Components of FC SAN

- **Network adapters**
  - FC HBAs in compute system
  - Front-end adapters in storage system
- **Cables**
  - Copper cables for short distance
  - Optical fiber cables for long distance
    - Two types: multimode and single-mode
- **Interconnecting devices**
  - FC hubs, FC switches, and FC directors





Hub, Switch, and Director

FC Hub	FC Switch	FC Director
• Nodes are connected in a logical loop • Nodes share loop • Provides limited connectivity and scalability	• Each node has a dedicated communication path • Provides a fixed port count – active or unused • Active ports can be scaled-up non-disruptively • Some components are redundant and hot-swappable	• High-end switches with a higher port count • Has a modular architecture • Port count is scaled-up by inserting line cards/blades • All key components are redundant and hot-swappable

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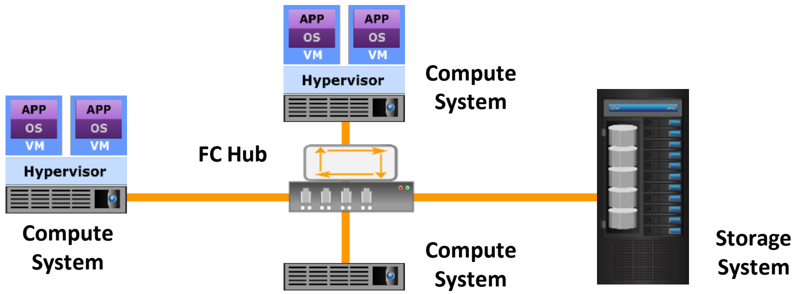
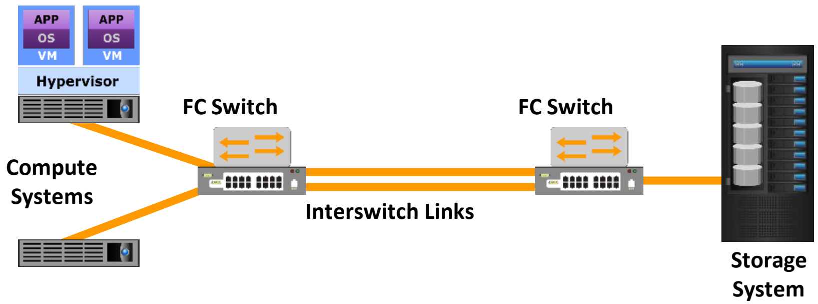
FC Interconnectivity Options

- Point-to-point: Enables direct connection between two nodes

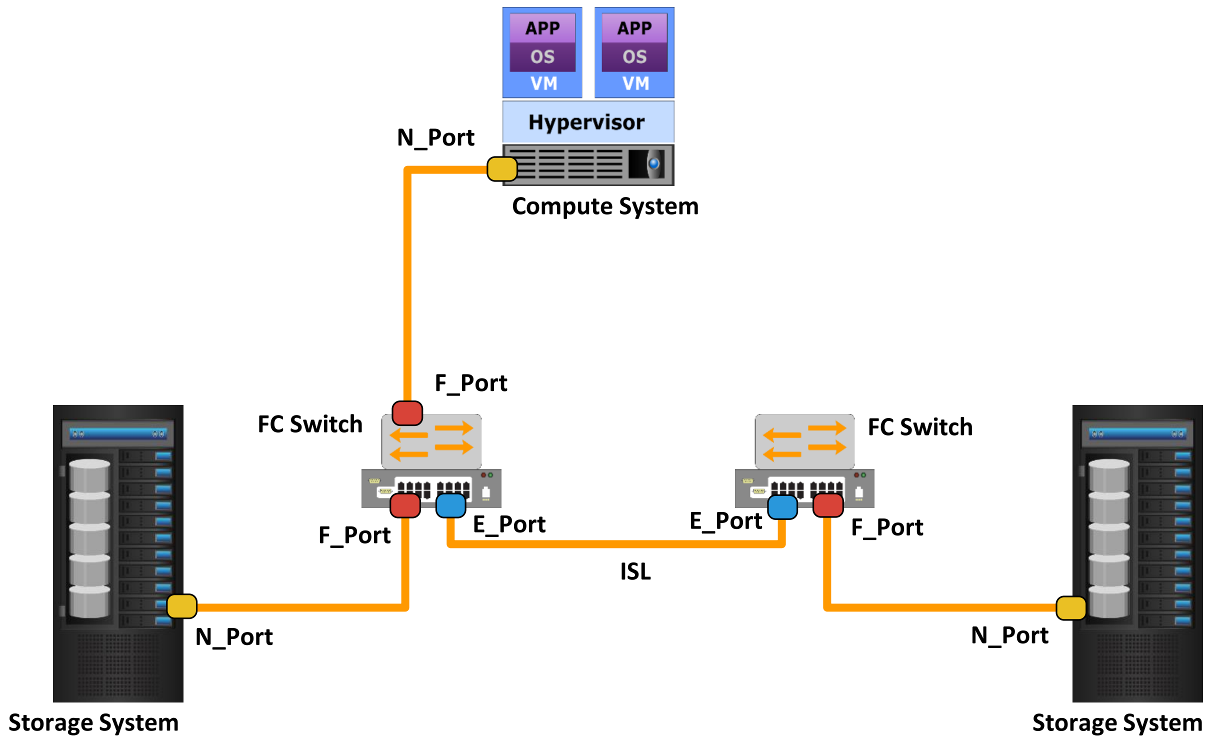
- FC arbitrated loop (FC-AL): Provides shared loop to the attached nodes



- FC switched fabric (FC-SW): Nodes communicate with one another using switches



Port Types in Switched Fabric



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Lesson 2: Summary

During this lesson the following topics were covered:

- Components of FC SAN
- FC interconnectivity options
- FC port types

Lesson 3: Fibre Channel (FC) Architecture

This lesson covers the following topics:

- FC protocol stack
- FC and WWN addressing
- Structure and organization of FC data
- Fabric services
- Fabric login types
- Flow control

FC Architecture Overview

- **Provides benefits of both channel and network technologies**
  - Provides high performance with low protocol overheads
  - Provides high scalability with long distance capability
- **Implements SCSI over FC network**
  - Transports SCSI data through FC network
- **Storage devices, attached to FC SAN, appear as locally attached to the OS or hypervisor**

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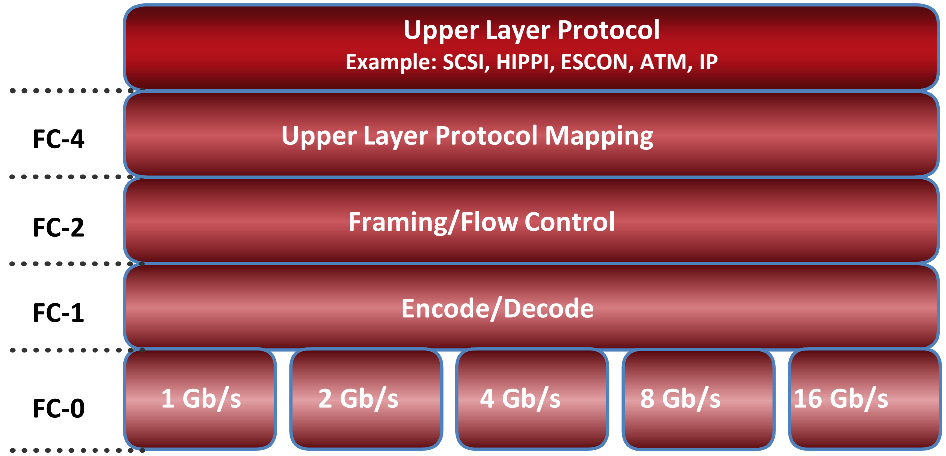
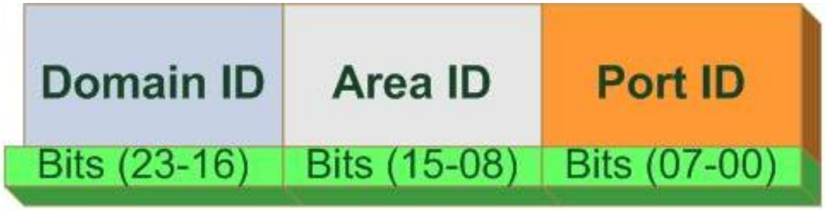
FC Protocol Stack



FC Layer	Function	Features Specified by FC Layer
FC-4	Mapping interface	Mapping upper layer protocol (e.g. SCSI) to lower FC layers
FC-3	Common services	Not implemented
FC-2	Routing, flow control	Frame structure, FC addressing, flow control
FC-1	Encode/decode	8b/10b or 64b/66b encoding, bit and frame synchronization
FC-0	Physical layer	Media, cables, connector

FC Addressing in Switched Fabric



- **FC address is assigned to node ports during fabric login**
  - Used for communication between nodes in an FC SAN
- **Address format:**
- **Domain ID is a unique number provided to each switch in the fabric**
  - 239 addresses are available for domain ID
- **Maximum possible number of node ports in a switched fabric:**
  - 239 domains X 256 areas X 256 ports = 15,663,104 ports

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World Wide Name (WWN)

- **Unique 64-bit identifier**
- **Static to node ports on an FC network**
  - Similar to MAC address of NIC
  - WWNN and WWPN are used to physically identify FC network adapters and node ports respectively

World Wide Name - Array															
5	0	0	6	0	1	6	0	0	0	6	0	0	1	B	2
0101	0000	0000	0110	0000	0001	0110	0000	0000	0000	0110	0000	0000	0001	1011	0010
Format Type	Company ID 24 bits						Port	Model Seed 32 bits							

World Wide Name - HBA															
1	0	0	0	0	0	0	0	c	9	2	0	d	c	4	0
Format Type	Reserved 12 bits			Company ID 24 bits						Company Specific 24 bits					

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Structure and Organization of FC Data

- FC data is organized as Exchange, Sequence, and Frame

FC Data Structure	Description

Exchange	• Enables two N_Ports to identify and manage a set of information units
	  • Information unit: upper layer protocol-specific information that is sent to another port to perform certain operation
	  • Each information unit maps to a sequence
	• Includes one or more sequences

Sequence	• Contiguous set of frames that correspond to an information unit
Frame	• Fundamental unit of data transfer • Each frame consists of five parts: SOF, frame header, data field, CRC, and EOF

SOF 4 Bytes	Frame Header 24 Bytes	Data Field 0 - 2112 Bytes	CRC 4 Bytes	EOF 4 Bytes

Fabric Services

- FC switches provide fabric services as defined in FC standards

Fabric Services	Description
Fabric Login Server	• Used during the initial part of the node's fabric login process • Located at pre-defined address of FFFFFE
Name Server	• Responsible for name registration and management of node ports • Located at pre-defined address FFFFFC
Fabric Controller	• Responsible for managing and distributing Registered State Change Notifications (RSCNs) to attached node ports • Responsible for distributing SW-RSCNs to every other switch • Located at pre-defined address FFFFFD
Management Server	• Enables FC SAN management using fabric management software • Located at pre-defined address FFFFFA

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Fabric Login Types

- **Fabric login (FLOGI)**
  - Occurs between an N_Port and an F_Port
  - Node sends a FLOGI frame with WWN to Fabric Login Server on switch
  - Node obtains FC address from switch
  - Immediately after FLOGI, N_Port registers with Name Server on switch
  - N_Port queries name server about all other logged in ports
- **Port login (PLOGI)**
  - Occurs between two N_Ports to establish a session
  - Exchange service parameters relevant to the session
- **Process login (PRLI)**
  - Occurs between two N_Ports to exchange ULP related parameters

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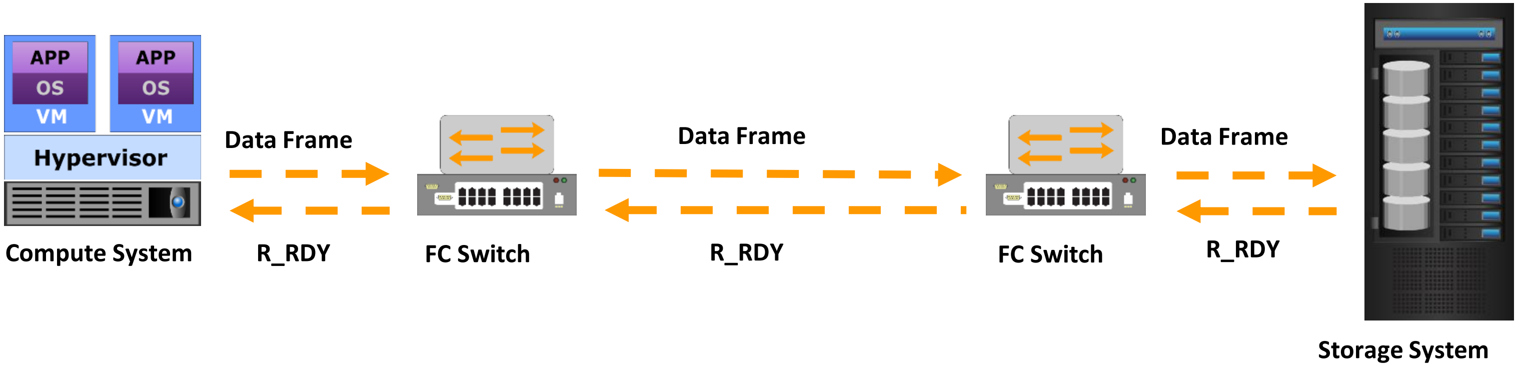
Flow Control

- **Fabric uses BB_Credit for flow control between FC port pairs**
  - Occurs between an N_Port and an F_Port, and between two E_Ports
  - Credit value is negotiated based on receiving port's capability
  - R_RDY is used for acknowledgment



Lesson 3: Summary

During this lesson the following topics were covered:

- FC protocol stack
- FC and WWN addressing
- Structure and organization of FC data
- Fabric services
- Fabric login types
- Flow control

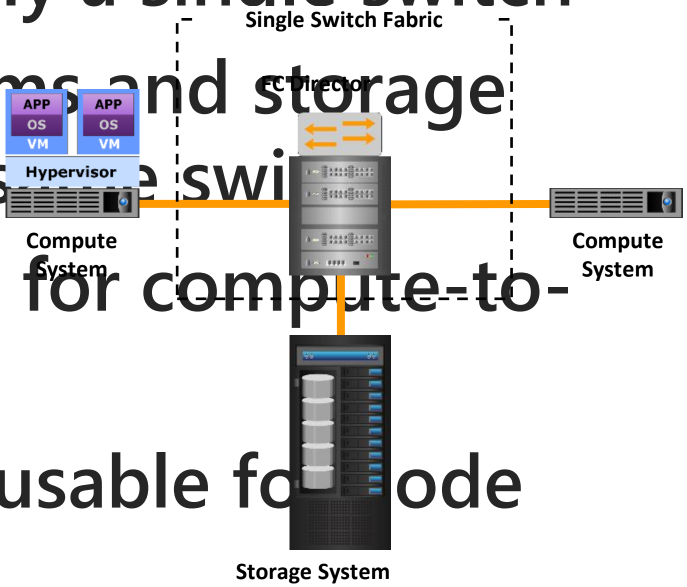
Lesson 4: Topologies, Link Aggregation, and Zoning

This lesson covers the following topics:

- Single-switch topology
- Mesh topology
- Core-edge topology
- Link aggregation
- Types of zoning

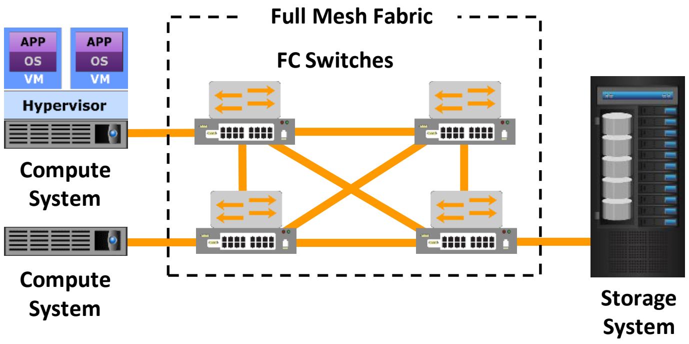
Single-switch Topology

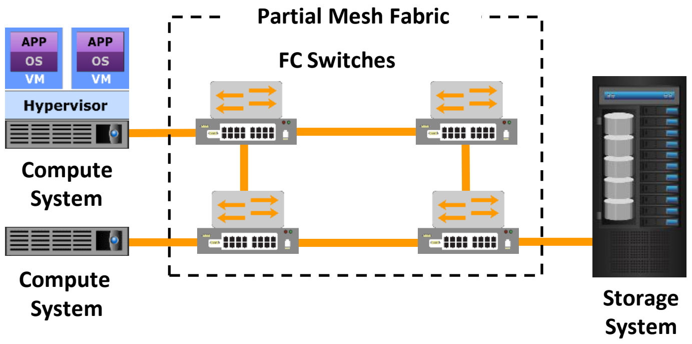
- Fabric consists of only a single switch
- Both compute systems and storage systems connect to single switch
- No ISLs are required for compute-to-storage traffic
- Every switch port is usable for node connectivity



Mesh Topology

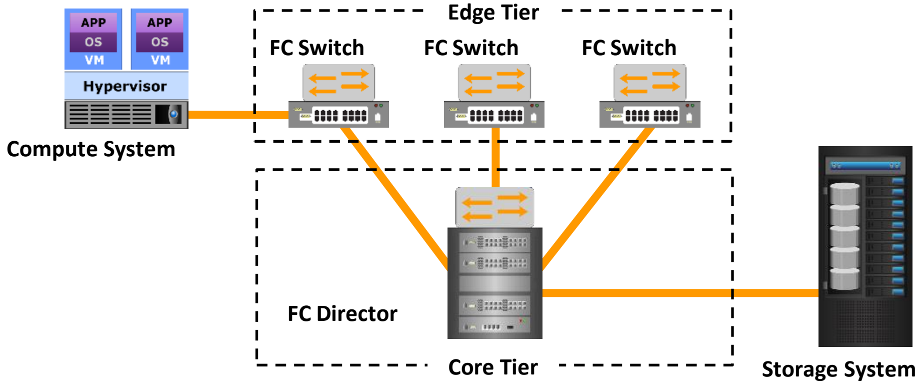
- **Full mesh**
  - Each switch is connected to every other switch
  - Maximum of one ISL is required for compute-to-storage traffic
  - Compute systems and storage systems can be connected to any switch
- **Partial mesh**
  - Not all the switches are connected to every other switch





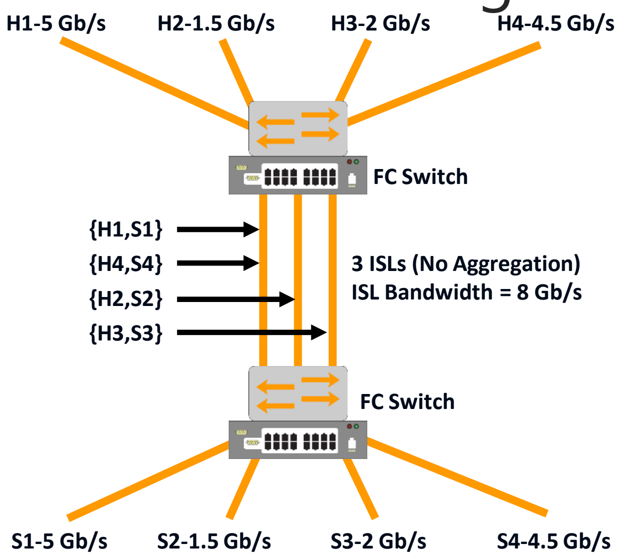
Core-edge Topology

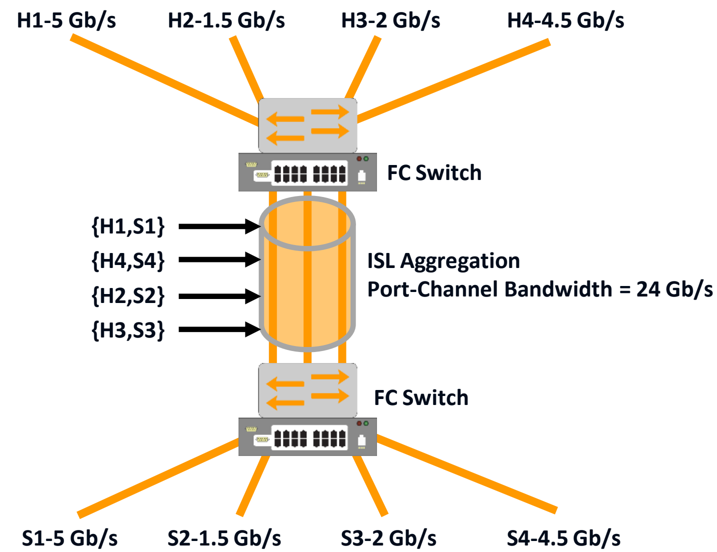
- Consists of edge and core switch tiers
- Storage systems are usually connected to the core tier
- Maximum of one ISL is required for compute-to-storage traffic
- Fabric can be scaled to a larger environment by adding more core and edge switches



Link Aggregation

- **Combines multiple ISLs into a single logical ISL (port-channel)**
  - Provides higher throughput than a single ISL could provide
  - Distributes network traffic over ISLs, ensuring even ISL utilization



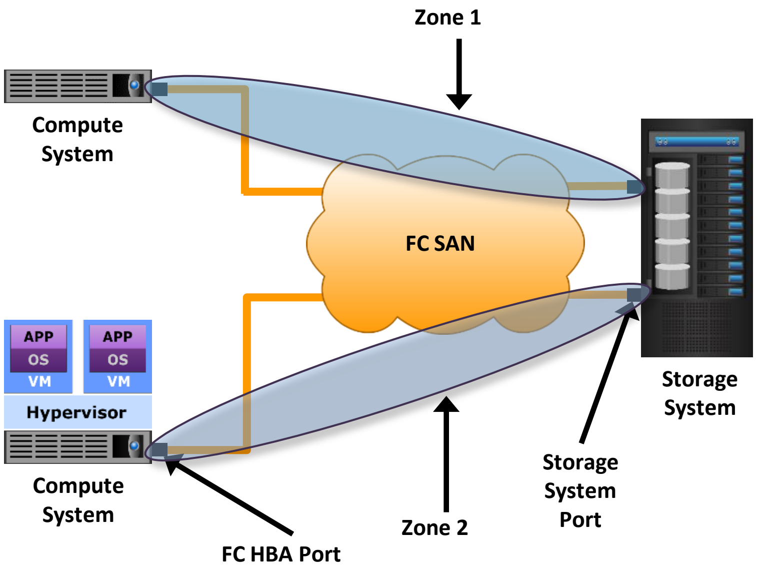


Zoning

Zoning

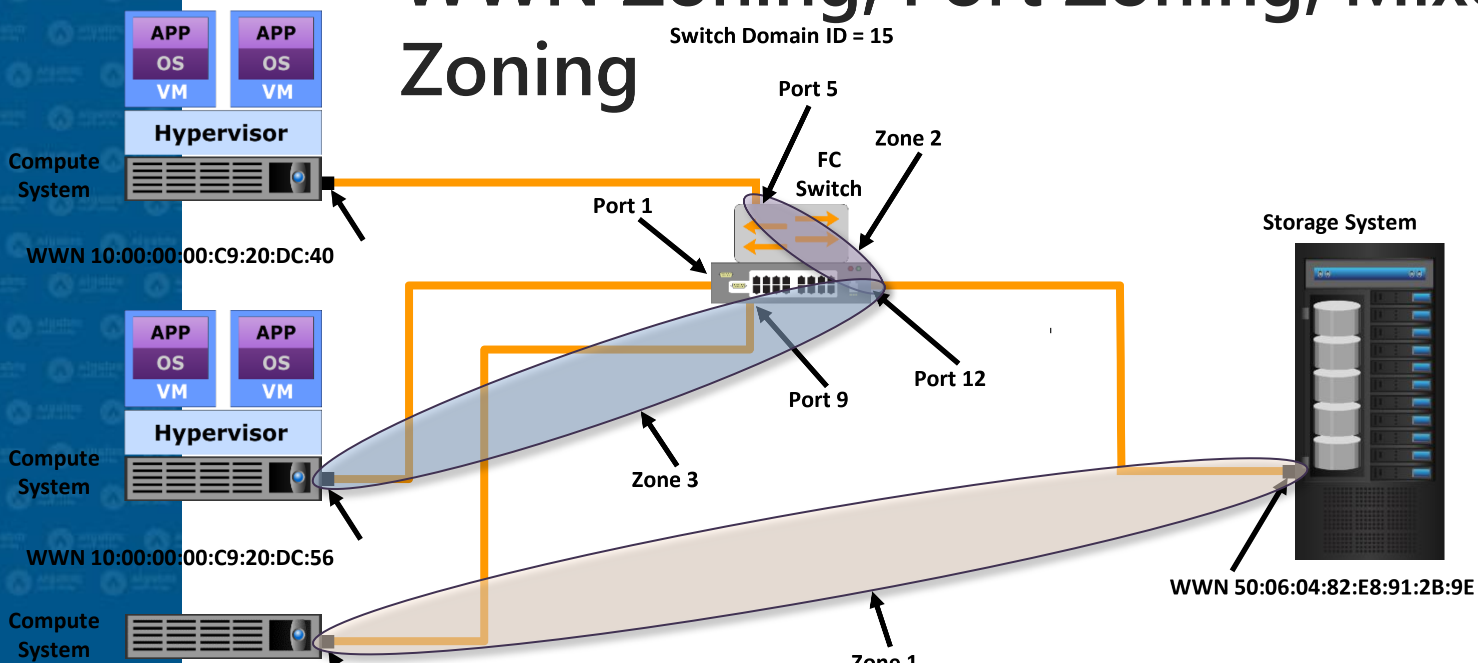
An FC switch function that enables node ports within the fabric to be logically segmented into groups, and communicate with each other within the group.

- Zone set comprises zones
- Each zone comprises zone members (FC HBA and storage system ports)
- Benefits:
  - Restricts RSCN traffic
  - Provides access control



Types of Zoning

- WWN Zoning, Port Zoning, Mixed Zoning



Zone 1 (WWN Zone) = 10:00:00:00:C9:20:DC:82 ; 50:06:04:82:E8:91:2B:9E
Zone 2 (Port Zone) = 15,5 ; 15,12
Zone 3 (Mixed Zone) = 10:00:00:00:C9:20:DC:56 ; 15,12

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Lesson 4: Summary

During this lesson the following topics were covered:

- Single-switch topology
- Mesh topology
- Core-edge topology
- Link aggregation
- Types of zoning

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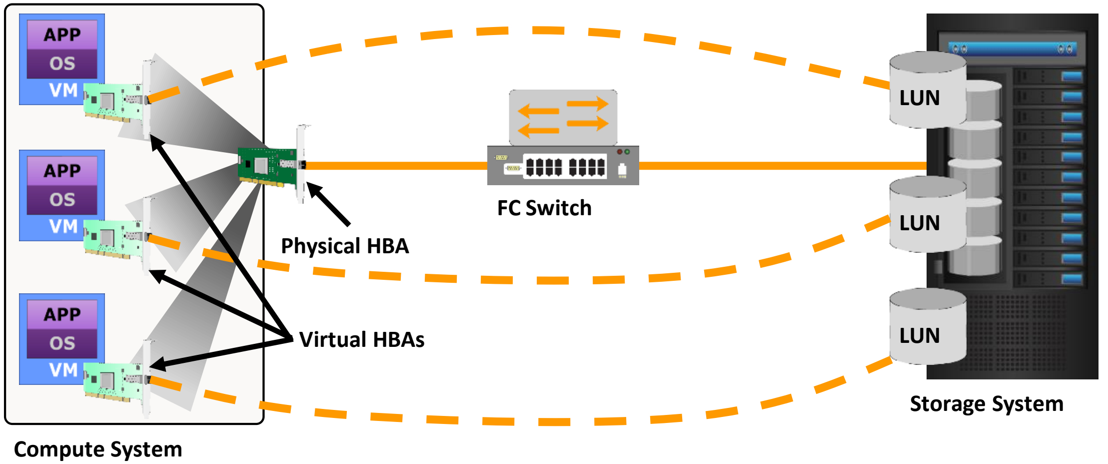
Lesson 5: Virtualization in FC SAN

This lesson covers the following topics:

- **Port virtualization**
  - N_Port ID virtualization (NPIV)
  - N_Port virtualization (NPV)
- **Block-level storage virtualization**
- **Virtual SAN**

N_Port ID Virtualization (NPIV)

- **A single N_Port functions as multiple virtual N_Ports**
  - Each virtual N_Port has a unique WWPN and FC address in FC SAN
- **Hypervisors leverage NPIV to create virtual N_Ports on HBA**
  - A virtual N_Port acts as a virtual FC HBA port that is used by a VM
  - Enables zoning and LUN masking at VM level



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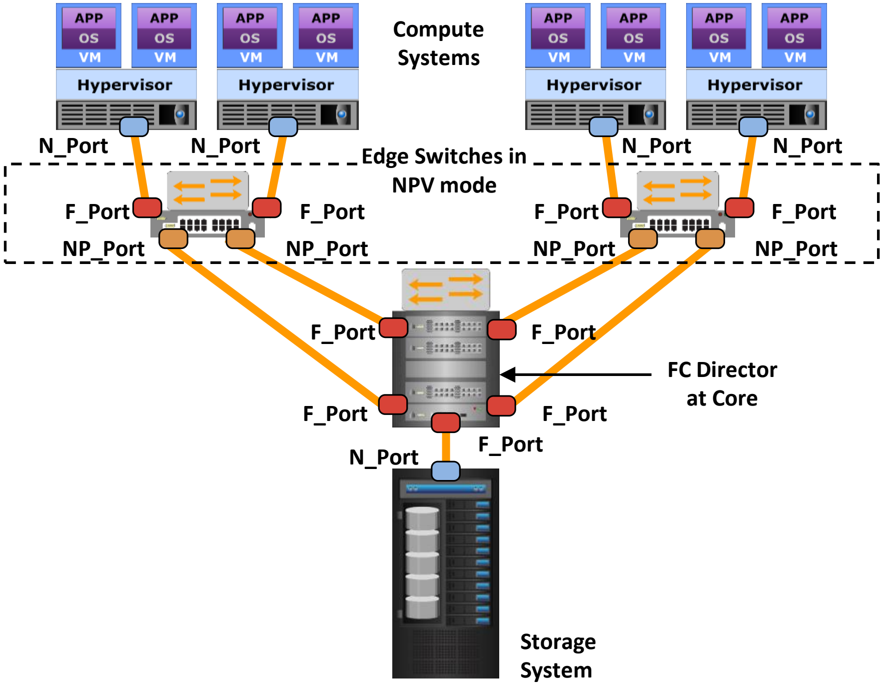
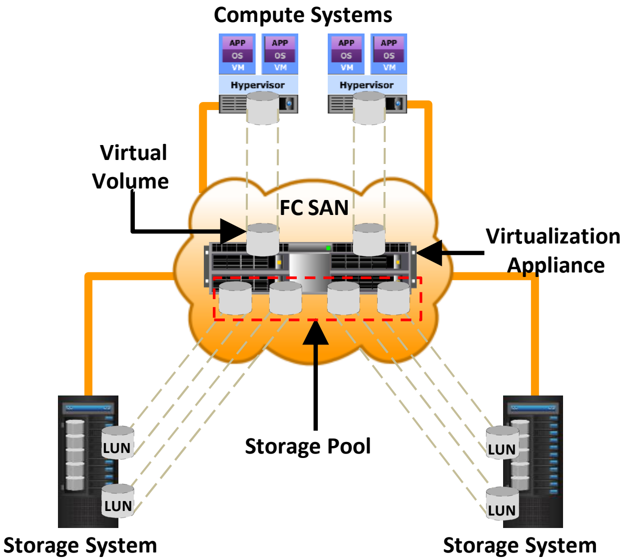
N_Port Virtualization (NPV)

- NPV supported switch functions as a pass-through device
  - Does not require domain ID
  - Does not perform fabric services
- Solves domain ID explosion problem in a fabric

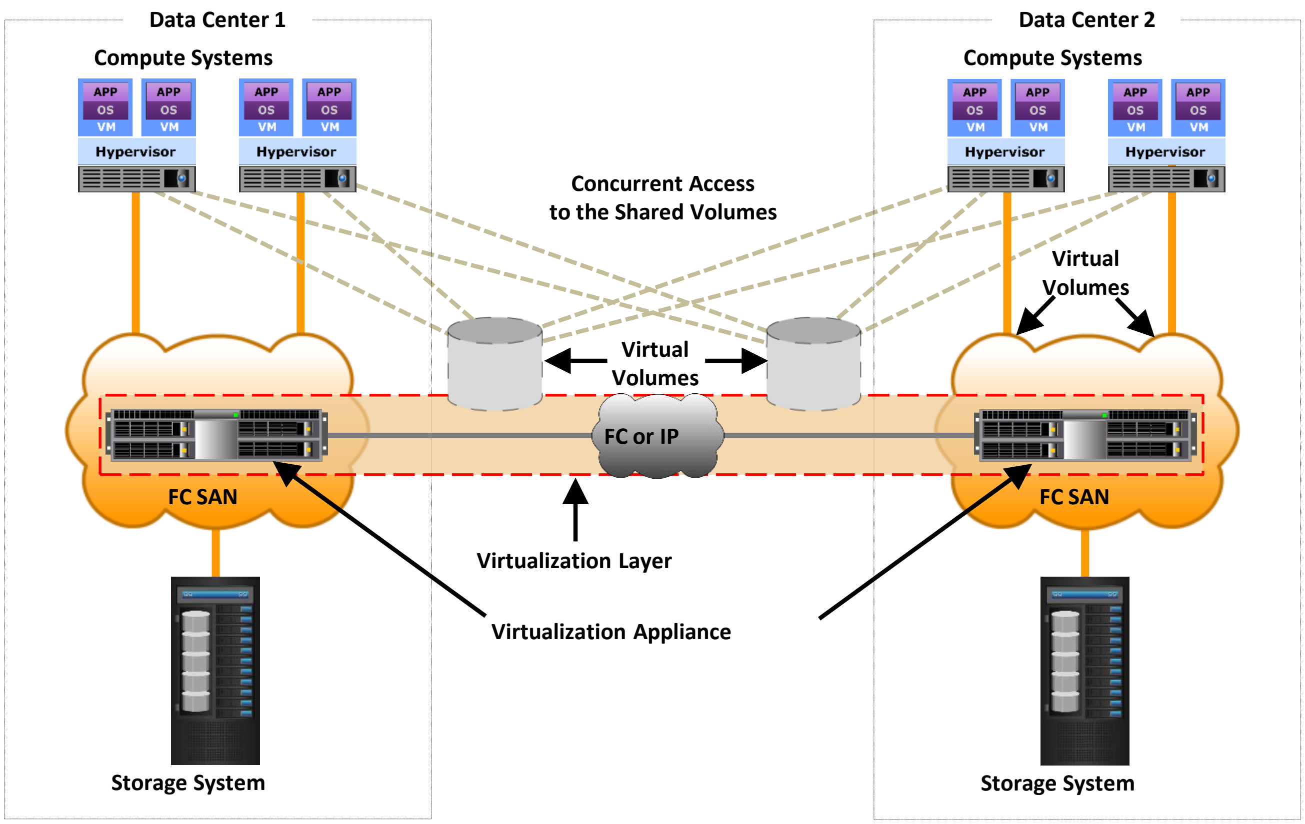


Block-level Storage Virtualization

- **Provides a virtualization layer in SAN**
  - Abstracts block-based storage systems
  - Aggregates LUNs to create storage pool
- **Virtual volumes from storage pool are assigned to compute systems**
  - Virtualization layer maps virtual volumes to LUNs
- **Benefits:**
  - Online expansion of virtual volumes
  - Non-disruptive data migration



Use Case: Storage Virtualization Across Data Centers

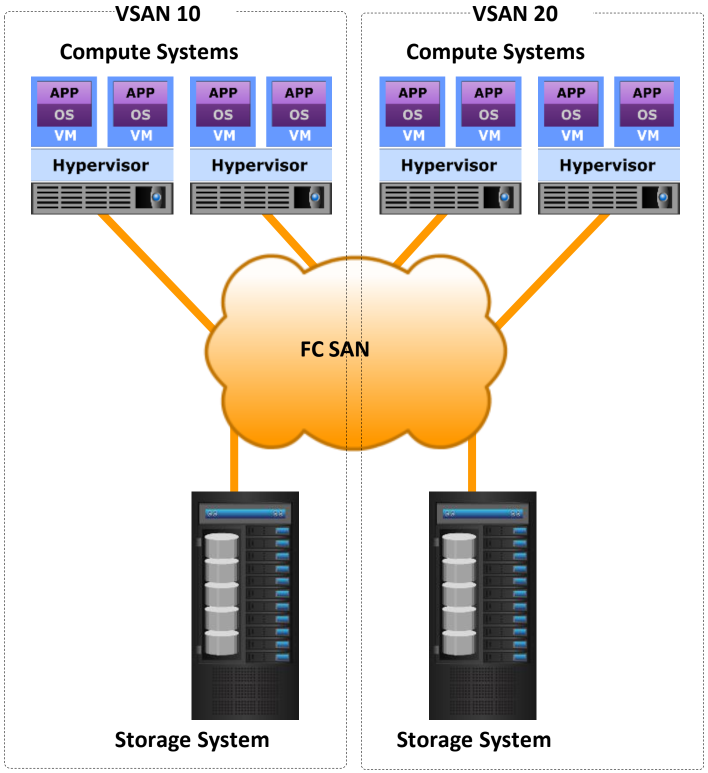


Virtual SAN (VSAN)/Virtual Fabric

VSAN

A logical fabric on an FC SAN, enabling communication among a group of nodes, regardless of their physical location in the fabric.

- Each VSAN has its own fabric services, configuration, and set of FC addresses
- VSANs improve SAN security, scalability, availability, and manageability



VSAN Configuration

- Define VSANs on fabric switch with specific VSAN IDs
- Assign VSAN IDs to F_Ports to include them in the VSANs
- An N_Port connecting to an F_Port in a VSAN becomes a member of that VSAN
- Switch forwards FC frames between F_Ports that belong to the same VSAN

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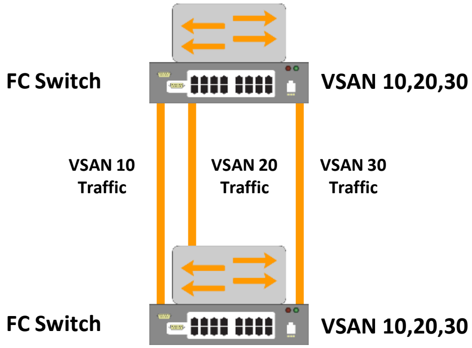
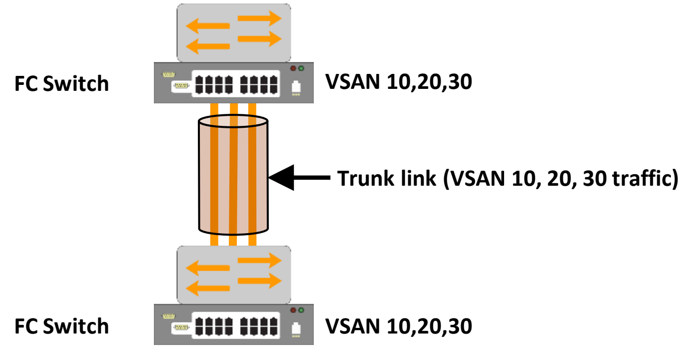
VSAN Trunking

- Allows network traffic from multiple VSANs to traverse a single ISL (trunk link)
- Enables an E_Port (trunk port) to send or receive multiple VSAN traffic over a trunk link
- Reduces the number of ISLs between switches configured with multiple VSANs



Without VSAN Trunking



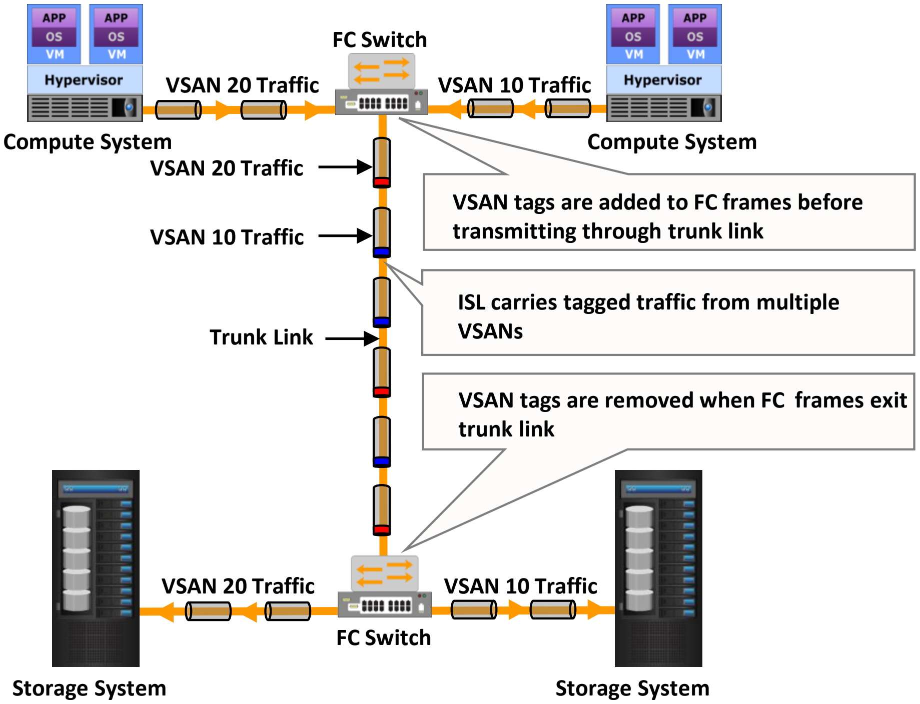
With VSAN Trunking

VSAN Tagging

VSAN Tagging

A process of adding or removing a tag to the FC frames that contains VSAN-specific information.

- Helps isolate FC frames from multiple VSANs that travel through and share a trunk link



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Lesson 5: Summary

During this lesson the following topics were covered:

- N_Port ID virtualization (NPIV)
- N_Port virtualization (NPV)
- Block-level storage virtualization
- Virtual SAN

Module 6: Summary

Key points covered in this module:

- Third platform requirements for SAN and software-defined networking
- FC SAN components and connectivity options
- FC protocol stack, FC addressing, fabric services, flow control
- Fabric topologies, link aggregation, and types of zoning
- NPIV, NPV, block-level storage virtualization, and virtual SAN