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Master of
Cyber Physical Systems

# INTERNATIONAL MASTER OF SCIENCE ON CYBER PHYSICAL SYSTEMS

The course content has been originally prepared by Dell-EMC

and is modified/improved by Dr. Ala' Khalifeh- German Jordanian

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# Cloud Computing and BigData

Dr. Ala'a Khalifah

# Redundant Array of Independent Disks (RAID)



**RAID**

A technology which utilizes multiple disk drives as a set to provide protection, capacity, and/or performance benefits

- Overcomes limitations of disk drives
- Improves storage system performance
  - By serving I/Os from multiple disks simultaneously
- RAID techniques are:
  - Striping, mirroring, and parity

# RAID Techniques

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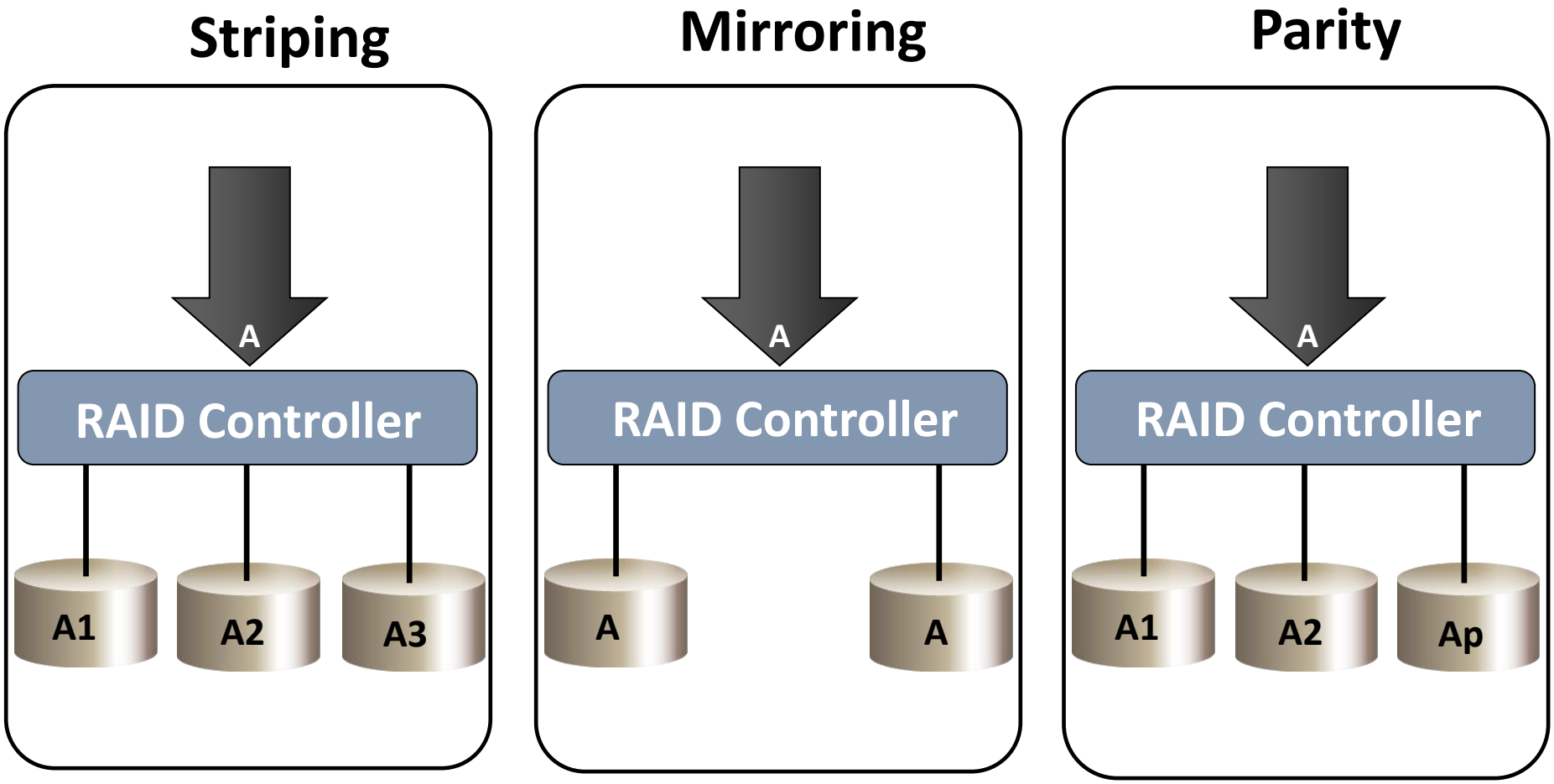


# RAID Levels

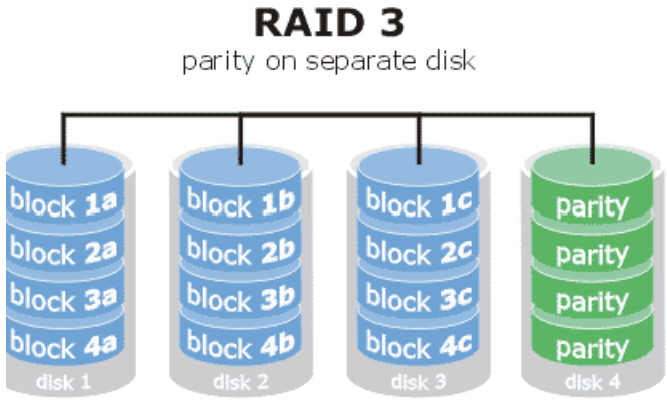


| RAID Levels | Definition |
|---|---|
| RAID 0 | Striping with no fault tolerance |
| RAID 1 | Disk mirroring |
| Nested | Combinations of RAID levels; Example: RAID 1 + RAID 0 |
| RAID 3 | Parity RAID with dedicated parity disk |
| RAID 5 | Parity RAID with distributed parity across all the disks in the set |
| RAID 6 | Distributed parity RAID with dual parity |

# Classic Data Center



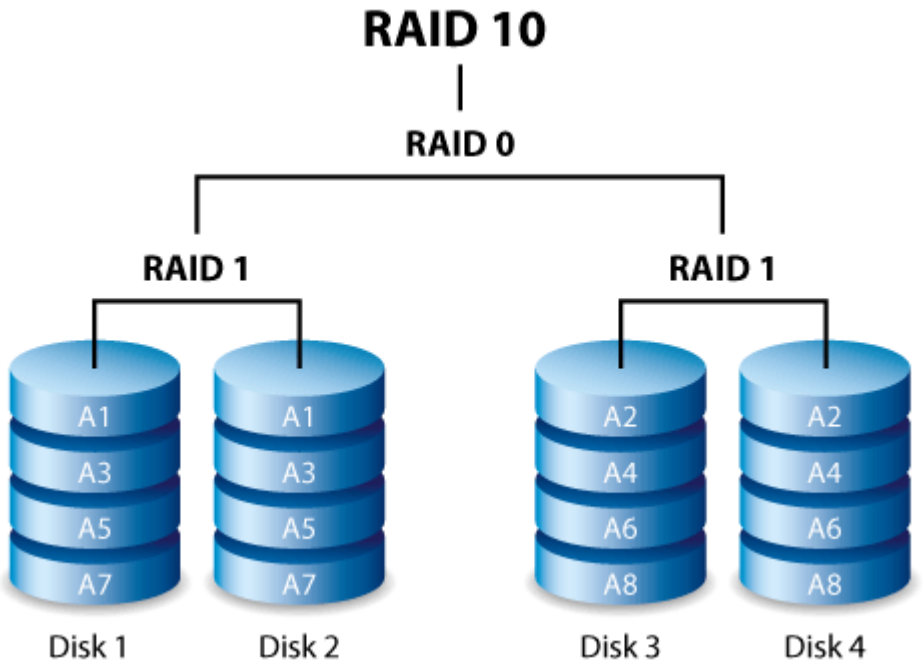
- -Raid 3 is byte level striping
- - RAID 4 uses block level striping
- - Both have dedicated parity disk




- http://fatmin.com/2010/04/30/raid-levels-explained-and-simplified/

# Classic Data Center






http://www.seagate.com/em/ar/manuals/network-storage/business-storage-nas-os/raid-modes/:

# Intelligent Storage System



- Is a RAID array highly optimized for I/O processing
- Have large amounts of cache for improving I/O performance
- Have operating environments that provide:
  - Intelligence for managing cache
  - Optimal management, allocation, and utilization of storage resources

# Components of an Intelligent Storage System

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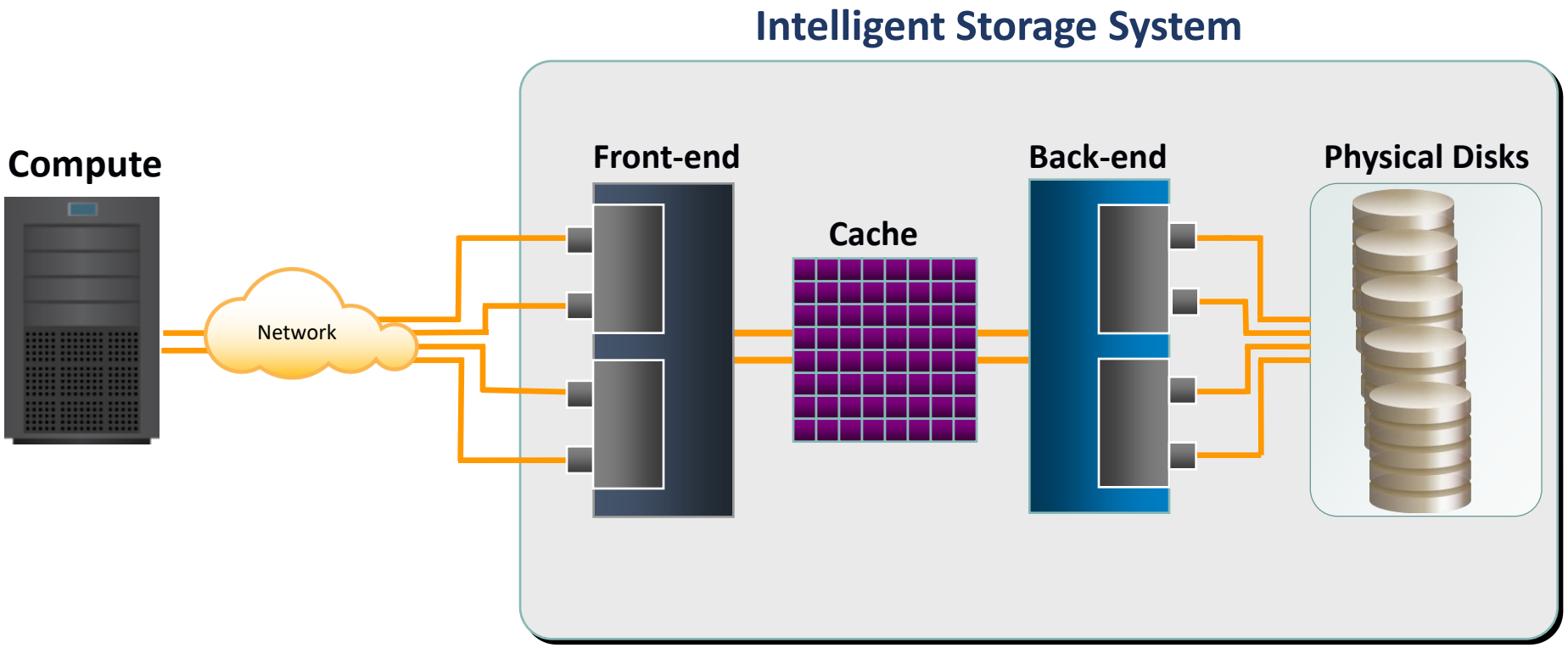

# Presenting Storage to Compute System

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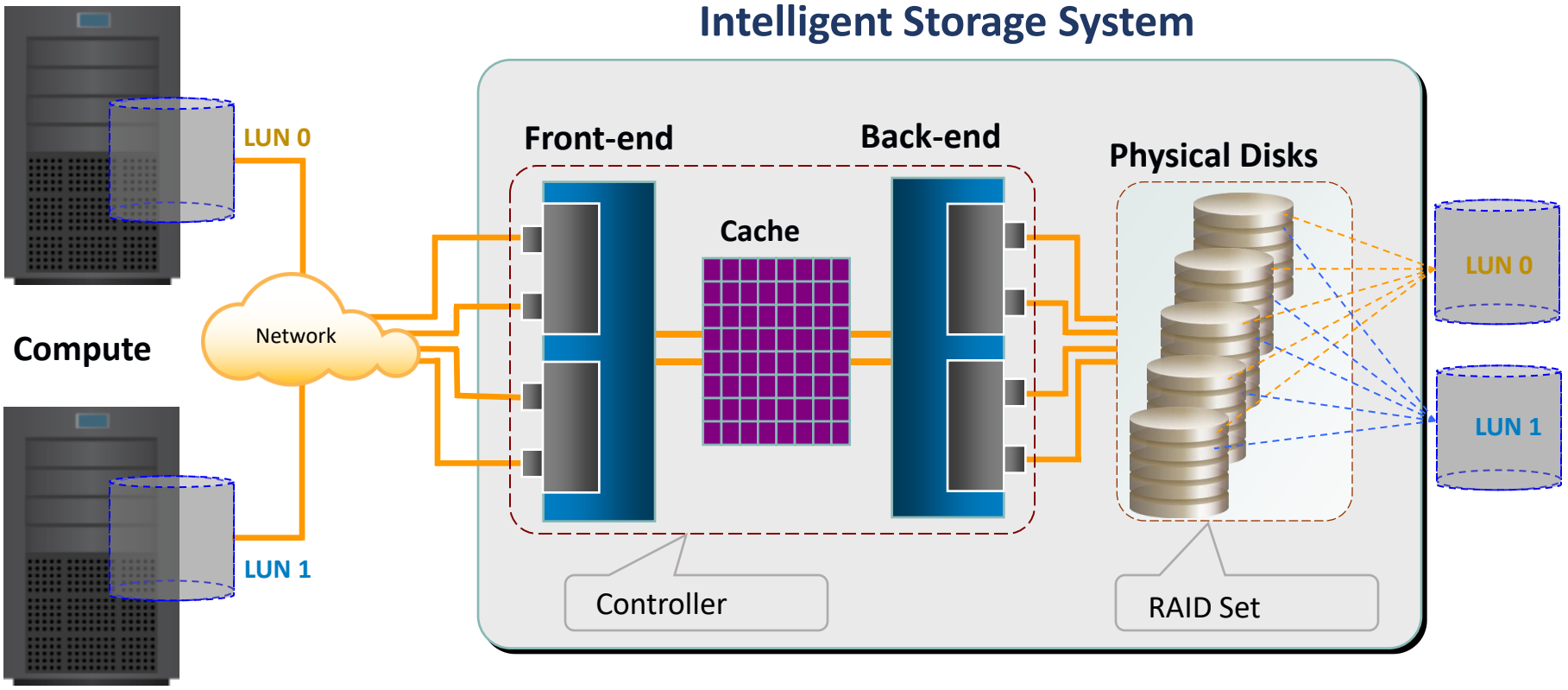

# Storage Networking Technologies -1

- Topics covered in this lesson:
  - Compute to compute communication
  - Compute to storage communication
    - Direct Attached Storage (DAS)
    - Fibre Channel SAN (FC-SAN)

# Compute to Compute Communication



- Typically uses Ethernet or TCP/IP protocol
  - LAN, MAN, and WAN
- Communication is enabled using various components:
  - Network Interface Card (NIC)
    - Has unique MAC address
  - Switches and routers
    - Switch provides scalability and interconnection between multiple compute systems
    - Routers allow different networks to communicate with each other
  - Cables
    - Twisted pair, co-axial cable, optical fiber

# Compute to Storage Communication



- Communication is enabled using various hardware components (HBA, CNA, NIC, switch, router, gateway ,and cables) and protocols
- Host bus adaptor (HBA): Is an application-specific integrated circuit (ASCI) board that performs I/O interface functions between the host and the storage, relieving the CPU from additional I/O processing workload. (like the DMA controller)
- Converged network adaptor (CNA): Is a multi function adapter which consolidates the functionality of an NIC card and a Fiber Channel Host bus adaptor (HBA) onto a single adapter.

# Compute to Storage Communication

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- Communication is enabled using various hardware components (HBA, CNA, NIC, switch, router, gateway ,and cables) and protocols
- Communication between compute and storage can be done using channel or network technologies

| Channel Technology | Network Technology |
|---|---|
| Compute system and peripheral devices are connected through channel | Compute system and peripheral devices are connected over a network |
| Provides low protocol overhead due to tight coupling | High protocol overhead due to network connection |
| Supports transmission only over short distances | Supports transmission over long distances |
| Protocol examples: PCI, IDE/ATA, SCSI, etc. -Channel technologies provide fixed connections between compute systems and their peripheral devices | Protocol examples: iSCSI( SCSI over IP), FCoE ( Fibre Channel over Ethernet), and FC |

# Communication Protocols



- Peripheral Component Interconnect (PCI)
  - Provides interconnection between CPU and attached devices
  - Latest PCI Express bus provides throughput of 133 MB/sec
- Integrated Device Electronics/Advanced Technology Attachment (IDE/ATA)
  - Popular protocol to connect to disk drives
  - Supports 16-bit parallel transmission
  - Serial version is called Serial ATA (SATA)
  - Both versions offer good performance at a relatively low cost

# Communication Protocols (contd.)



- Small Computer System Interface (SCSI)
  - Preferred storage connectivity option for high-end environments
  - Improved performance, scalability, and high cost when compared to ATA
  - Serial version is called Serial Attached SCSI (SAS)
- Transmission Control Protocol/Internet Protocol (TCP/IP)
  - Traditionally used for compute to compute communication
  - Now used for compute to storage communication also
    - iSCSI (SCSI over IP) and FCoE (Fibre Channel over Ethernet) are examples

# Direct Attached Storage (DAS)

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DAS

An internal or external storage device, which connects directly to a compute system

- DAS is classified as internal or external based on the location of the storage device with respect to the compute system
- Benefits:
  - Simple to deploy and ideal for local data provisioning
  - Low capital expense and less complexity
- Challenges:
  - Limited scalability
  - Limited ability to share resources
    - Islands of over and under utilized storage resources

# Emergence of Storage Networking Technologies

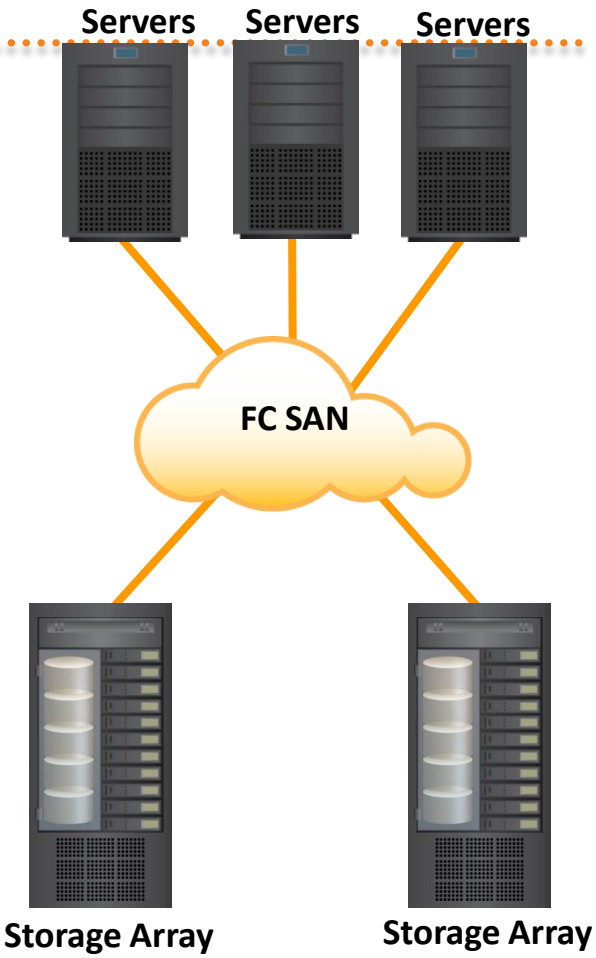


- Just-in-time information for business users
- Flexible and resilient storage architecture
- DAS is inefficient to fulfill these requirements
- Storage networking technologies emerged as a solution
  - Fibre Channel SAN (FC SAN)
  - Network Attached Storage (NAS)
  - Internet Protocol SAN (IP SAN)
  - Fibre Channel over Ethernet (FCoE)

# What is Fiber Channel SAN (FC SAN)?



- Dedicated high speed network of compute systems and shared storage devices
- Uses SCSI over FC protocol
- Provides block level data access




**Benefits**

- Enables storage consolidation and sharing
- Enables centralized Management
- Provides scalability and high performance
- Reduces storage and administration cost

# Components of FC SAN



- Node ports
- Cables
- Connectors
- Interconnecting Devices
- Storage Arrays
- SAN Management software

# Fiber Channel Fabric

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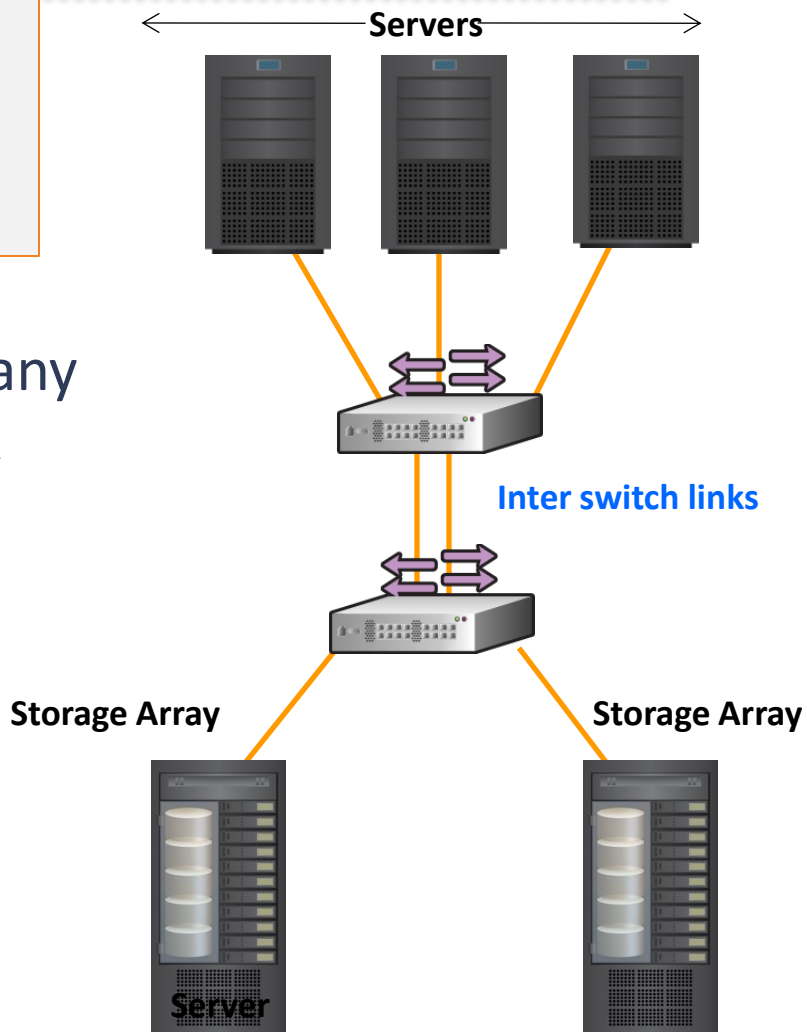
**FC Fabric**

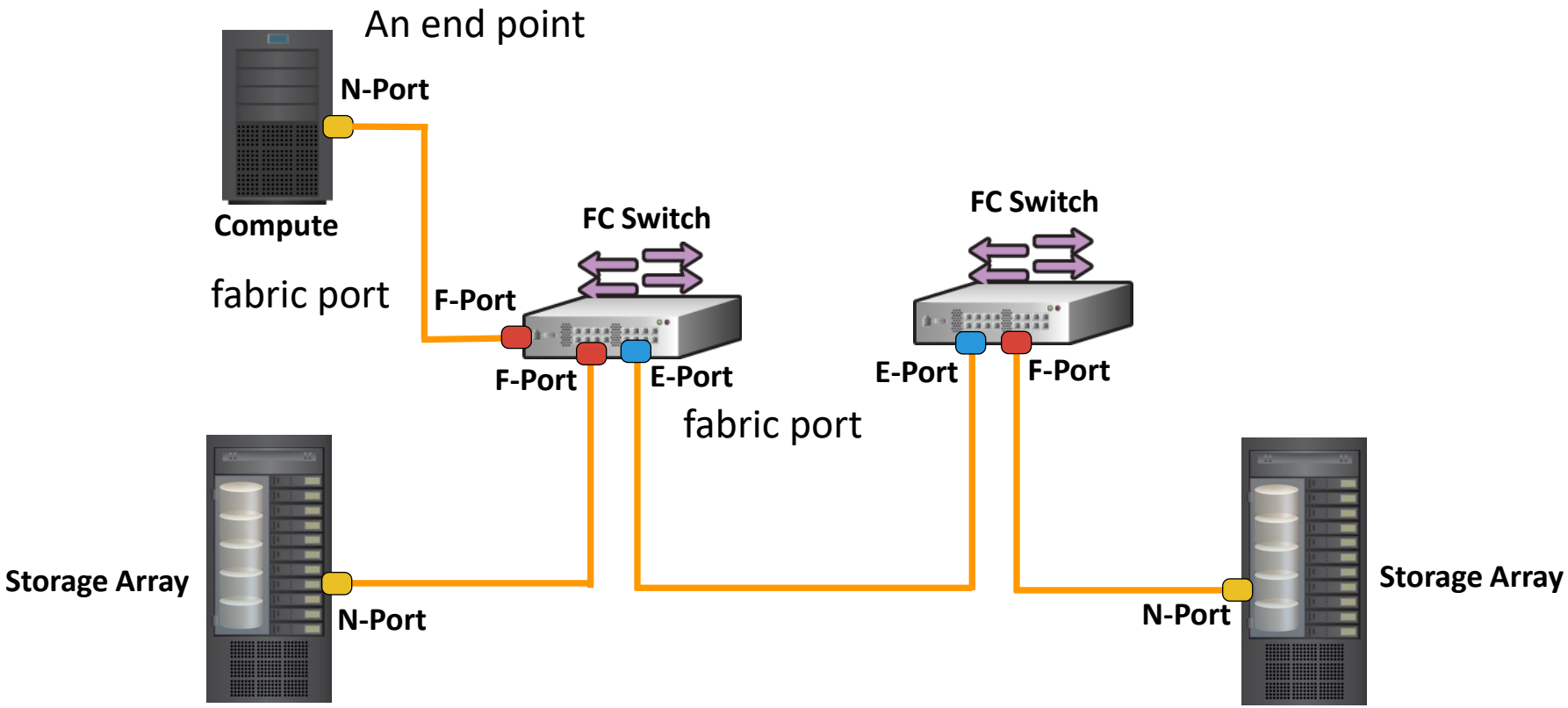
One or more interconnected FC switches through which multiple SAN nodes can communicate

- In a switched fabric, the link between any two switches is called Inter Switch Link (ISL)



# Port Types




An end point
N-Port
Compute
fabric port
F-Port
FC Switch
F-Port
E-Port
fabric port
FC Switch
E-Port
F-Port
Storage Array
N-Port
N-Port
Storage Array

- Storage Networking Technologies -2
  - Topics covered in this lesson:
    - Internet Protocol SAN (IP-SAN)
    - Fiber Channel over Ethernet (FCoE)
    - Network Attached Storage (NAS)

# IP-SAN





It is a technology that provides transfer of block level data over an IP network.

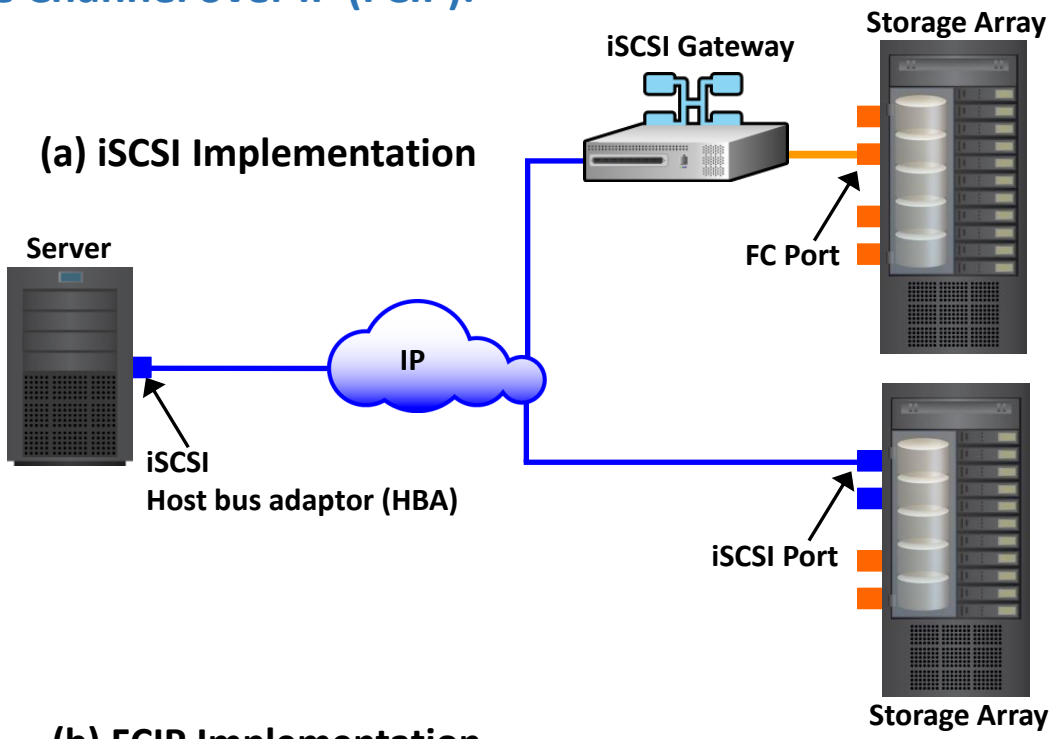
- IP is being positioned as a storage transport because:
  - Offers easier management
  - Allows existing network infrastructure to can be leveraged
  - Reduces cost compared to new SAN hardware and software
  - Supports multi-vendor interoperability
  - Many long-distance disaster recovery solutions already leverage IP-based networks
  - Many robust and mature security options are available for IP networks

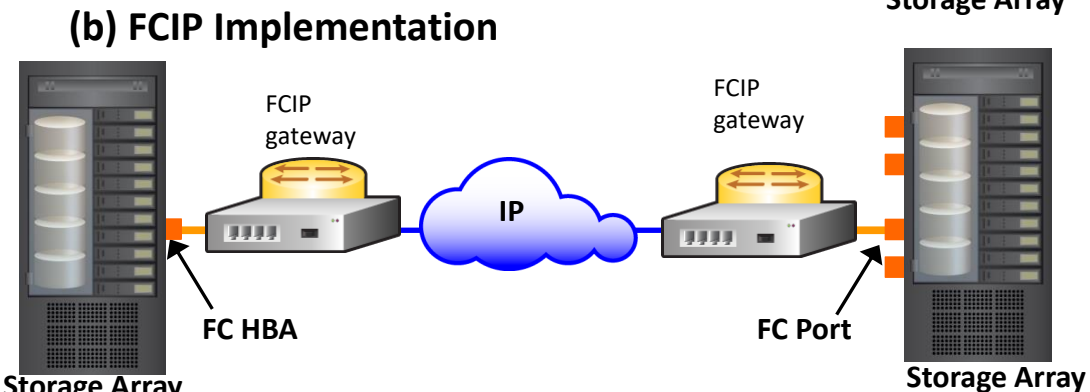
# Block Storage Over IP – Protocol Options



**Two primary protocols that leverage IP as the transport mechanism for block level data transmission are iSCSI and Fibre Channel over IP (FCIP).**

- iSCSI (SCSI over IP)
  - Encapsulation of SCSI data in IP packets
    - Ethernet NIC card
    - TCP/IP offload engine (TOE) card **or**
    - iSCSI Host bus adaptor (HBA)
  - Hardware-based gateway to Fibre Channel storage
  - Used to connect compute systems
- FCIP
  - Fibre Channel-to-IP bridge/tunnel (point-to-point)
    - Fibre Channel end points
  - Used in DR

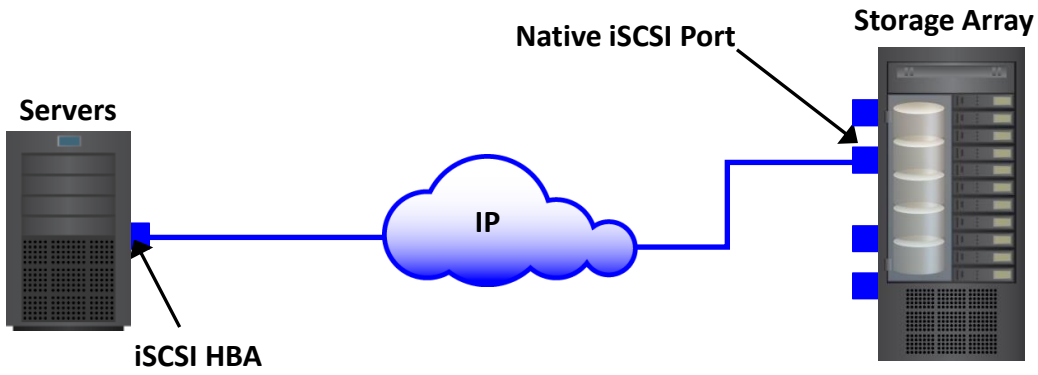


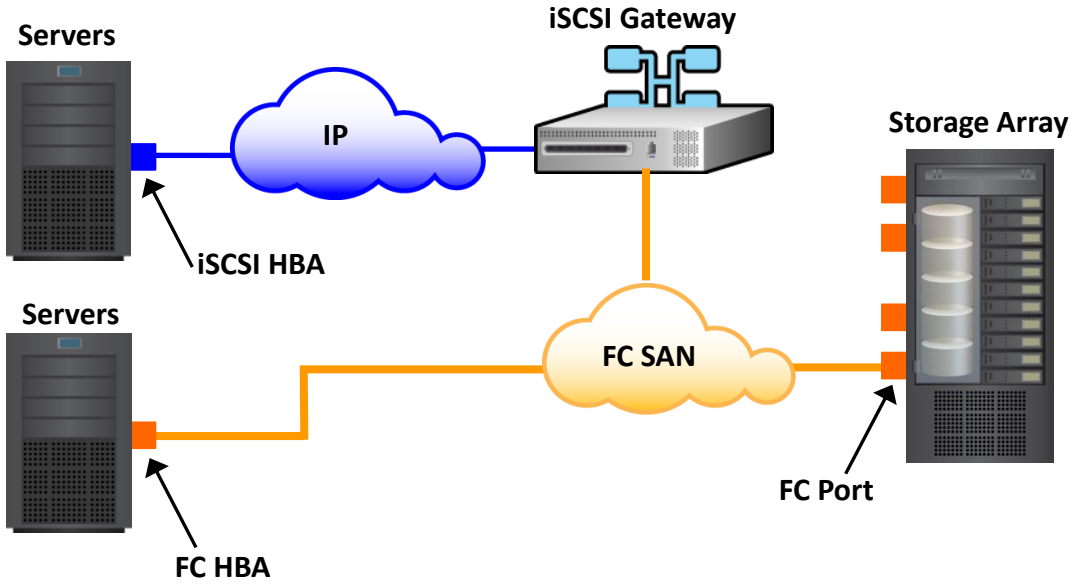
# iSCSI Topologies



- Native
  - No FC components
  - iSCSI Initiators connect directly to the Array




- Bridged
  - Translates iSCSI/IP to FC
  - iSCSI initiator configured with bridge as target
  - Bridge acts as virtual FC initiator



# Fibre Channel over IP (FCIP)

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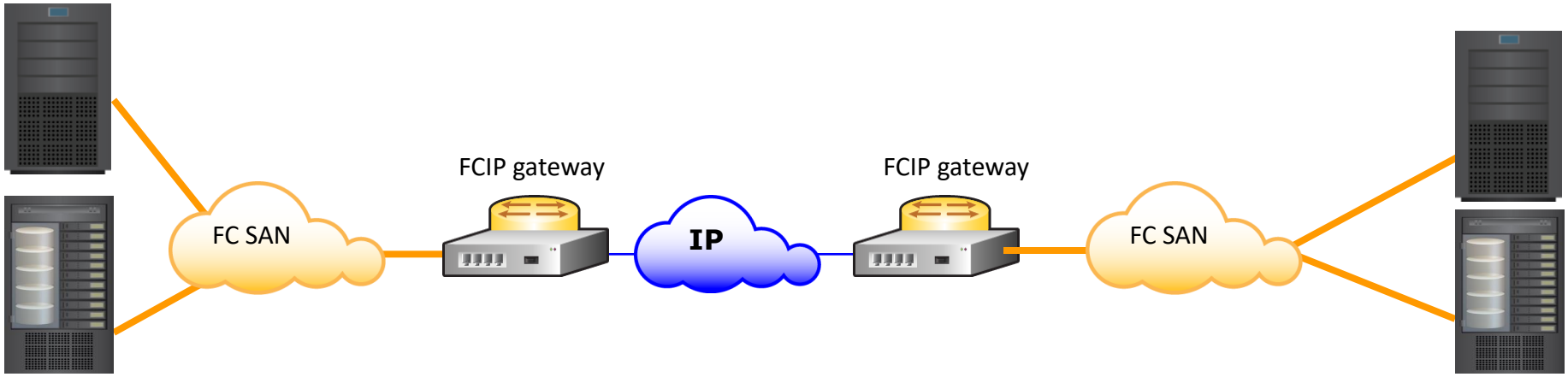
- IP-based storage networking technology
- Combines advantages of Fibre Channel and IP
- Creates virtual FC link that connects devices in a different fabric
- Distance extension solution
  - Used for data sharing over geographically dispersed SAN



# Fibre Channel over Ethernet (FCoE)



- A protocol that encapsulates Fibre Channel frames for transport over Enhanced Ethernet networks
- Enables the consolidation of SAN traffic and Ethernet traffic onto a common 10 Gigabit Ethernet infrastructure
  - Consolidates compute to compute and compute to storage communication over a single channel

**Benefits**

- Lowers capital expenditure
- Reduces power and cooling requirements
- Enables consolidation of network infrastructure
- Lowers Total Cost of Ownership (TCO)

# I/O Consolidation with FCoE

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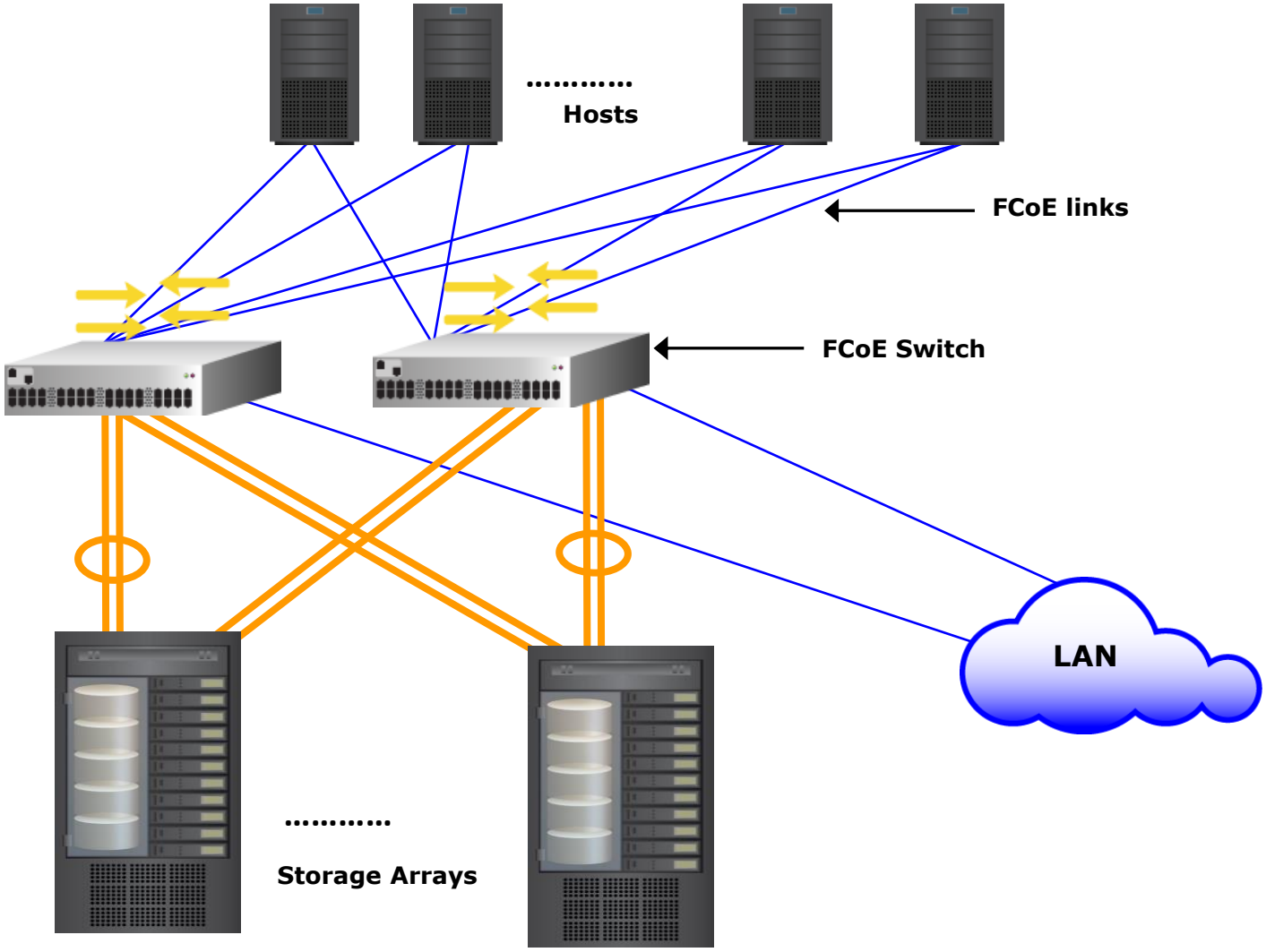

# Classic Data Center



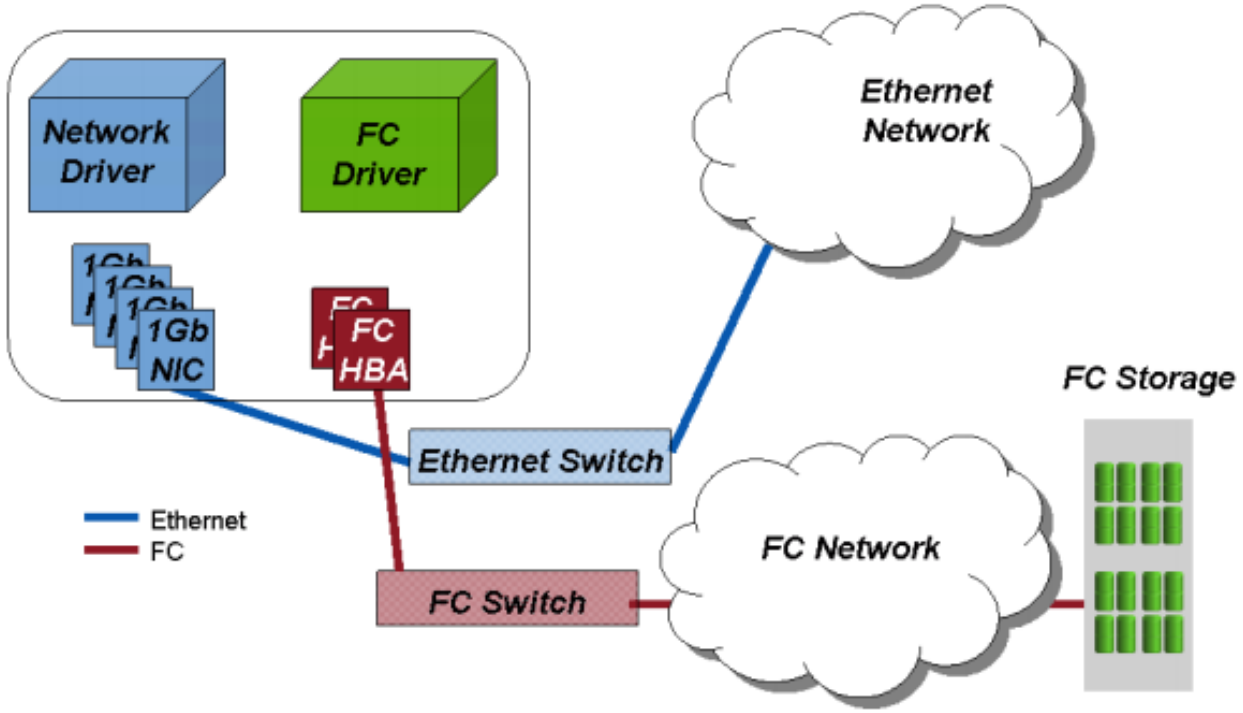


**Figure 1. Existing data center with separate Ethernet and FC networks**

https://www.emc.com/collateral/hardware/white-papers/h5916-intro-to-fcoe-wp.pdf

# Classic Data Center

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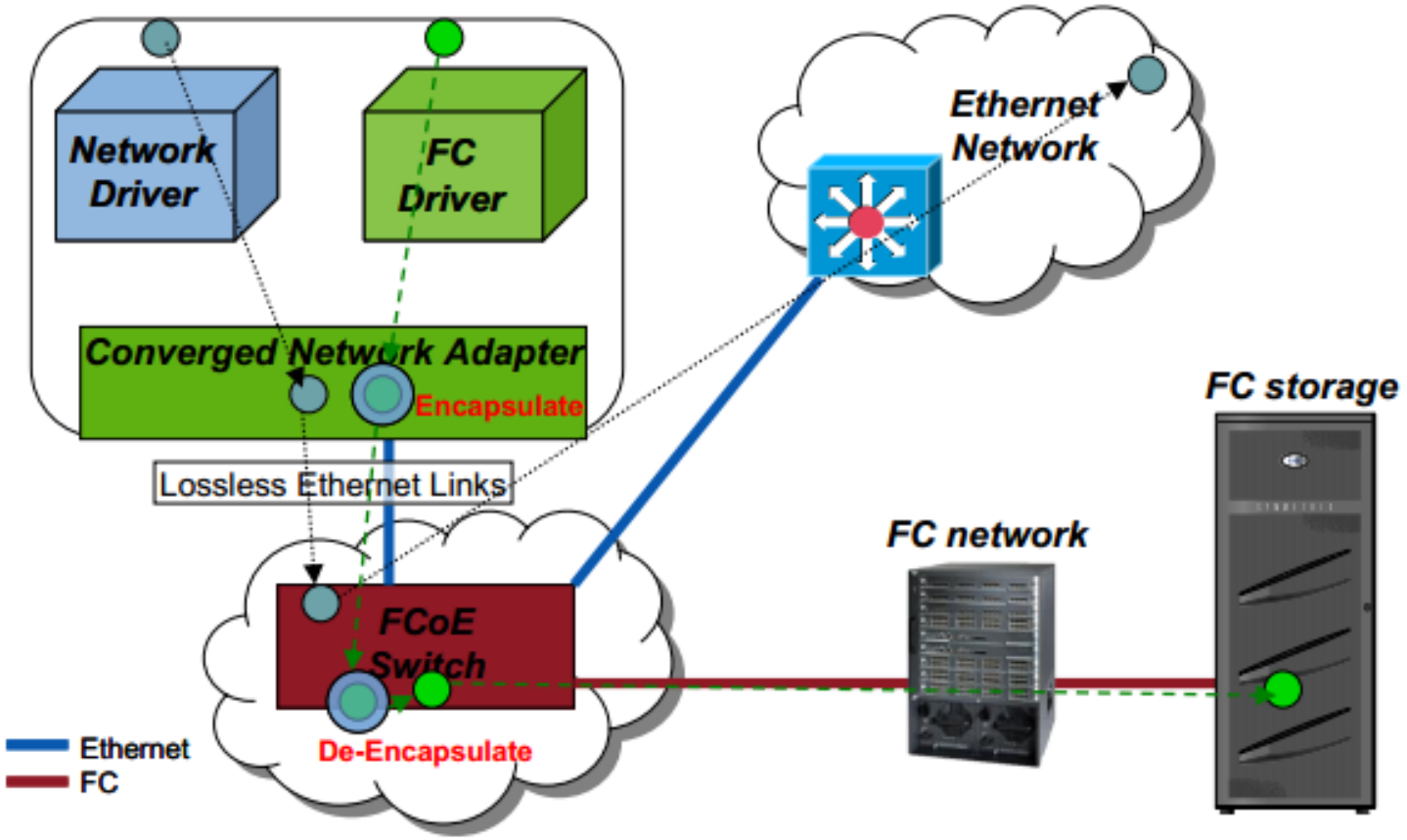


**Figure 2. FCoE environment with converged adapters at the server attached to a converged switch**

https://www.emc.com/collateral/hardware/white-papers/h5916-intro-to-fcoe-wp.pdf

# Components of FCoE



- Converged Network Adapter(CNA)
  - Multi function adapter
  - Performs the data networking of NIC and storage networking of HBA
- FCoE Switch
  - Contains Ethernet bridge and Fibre Channel Forwarder (FCF)
  - FCF encapsulates FC frames into FCoE frames and de-capsulates FCoE frames to FC frames
- Converged Enhanced Ethernet (CEE)
  - Extensions to conventional Ethernet standard to eliminate its lossy nature

## Business Continuity Overview and Backup

- Topics covered in this lesson:
  - Business Continuity (BC) Terminologies
  - Backup Granularity
  - Backup Components and Operation
  - Deduplication: Types and methods

# Business Continuity

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BC

Processes and/or procedures for ensuring continued business operations

- BC solutions address unavailability and degraded application performance
- BC is an integrated and enterprise wide process and set of activities to ensure “information availability”

# BC Terminologies

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| BC Terminologies | Description |
|---|---|
| Disaster Recovery(DR) | Coordinated process of restoring systems, data, and infrastructure required to support ongoing business operations in the event of a disaster |
| Hot Site | A site to where an enterprise's operations can be moved, in the event of a disaster.<br><br>It is a site equipped with all the required hardware, operating system, application, and network support that help perform business operations, and where the equipment is available and running at all times. |
| Cold Site | A site to where an enterprise's operations can be moved, in the event of disaster<br><br>It has minimum IT infrastructure and environmental facilities in place, but are not activated. |
| Cluster | A group of servers and other necessary resources, coupled to operate as a single system |

# Classic Data Center



- A hot site has all the equipment needed for the enterprise to continue operation,
- A cold site is less expensive, but it takes longer to get an enterprise in full operation after the disaster.

-Typically, a business has an annual contract with a company that offers hot and cold site services with a monthly service charge

## CDC Management

Topics covered in this lesson:

- Key Management activities in a CDC
- Information Lifecycle Management (ILM)

# Overview of CDC Management Activities



Key management activities in a CDC:

- Monitoring and Alerting
- Reporting
- Availability Management
- Capacity Management
- Performance Management
- Security Management

# Monitoring



- Compute systems, storage, and networks are the key components to be monitored

| Key Parameters to be Monitored | Description |
|---|---|
| Accessibility | Availability of a component to perform a desired operation |
| Capacity | Amount of resources available<br>For ex: free space available on a file system or RAID group |
| Performance | How efficiently different components are performing |
| Security | Mechanisms to track and prevent unauthorized access |

# Classic Data Center



- Monitoring CDC resources for security helps to track and prevent unauthorized access and login failures, whether accidental or malicious.
- Security monitoring also helps to tracks unauthorized configuration changes of storage infrastructure elements. For example, security monitoring tracks and reports the initial zoning configuration performed and all subsequent changes.

- Physical security of a storage infrastructure is also continuously monitored using badge readers, biometric scans, or video cameras.

# Alerting of Events

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- Alerting is an integral part of monitoring
- Monitoring tools enables administrators to assign different severity levels for different alerts

| Levels of Alerts based on Severity | Description |
|---|---|
| Information alert | Provides useful information and may not require administrator intervention<br>For ex: creation of zone or LUN |
| Warning alert | Require administrative attention<br>For ex: file systems becoming full |
| Fatal alert | Require immediate administrative attention<br>For ex: power failures/disk failures/memory failures |

# Reporting



- Reporting on CDC resources involves keeping track and gathering information from various components/processes

| Type of Report | Description |
|---|---|
| Capacity Planning | Provides current and historic information about utilization of storage, file system, database tablespace, ports, and so on |
| Chargeback | Provides information about the allocation or utilization of the CDC infrastructure components by various departments or user groups |
| Performance | Provides details about the performance of various infrastructure components in a CDC |

# Availability Management

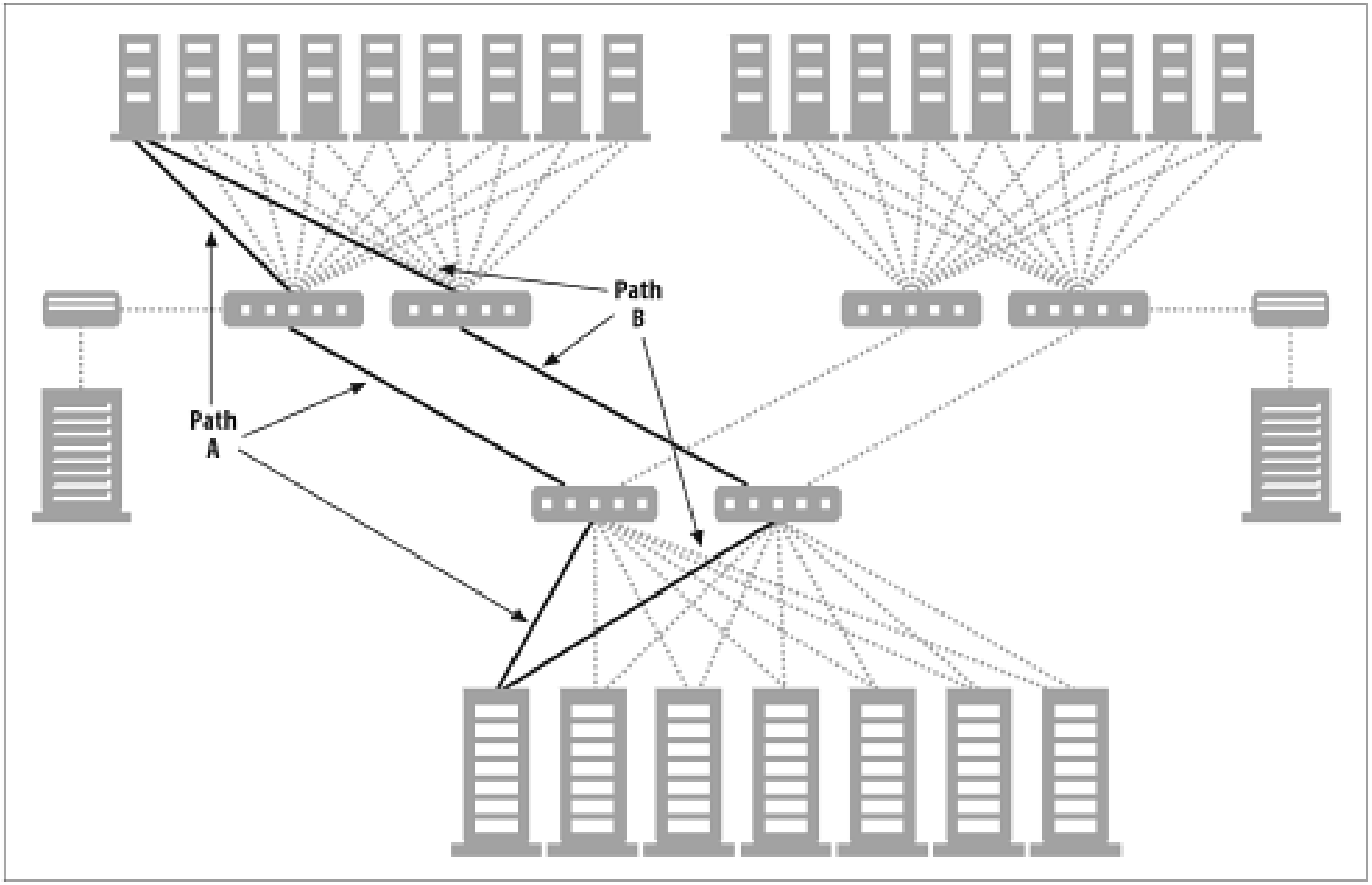


- Establishes guidelines for all configurations to achieve high availability based on service level requirements
- Ensures high availability by:
  - Eliminating single points of failure by configuring
    - Two or more host bus adapters (HBAs)/NICs
    - Multipathing software
    - RAID protection
    - Redundant Fabrics
      - Connecting the server to the storage array using at least two independent fabrics and switches that have built-in redundancy
  - Performing data backup and replication

# Availability Management



- Multipathing



# Availability Management



- Multi-pathing
- The role of multi-pathing software
- 1. Automatic failover:
- To automatically re-distribute I/O to another channel in the case of fabric
- 2. Load Balancing
- Dynamic load distribution among several network parts and nodes
- * Using SANs and NAS: Help for Storage Administrators Curtis Preston, O'Reilly

# Availability Management



- Multipathing

- Examples of multipathing software:

- EMC's power path
- Solaris 8 has native multipathing support
- Veritas Volume Manager has multipathing support
- Vicom's storage virtualization Engine

- * Using SANs and NAS: Help for Storage Administrators Curtis Preston, O'Reilly

# Managing Information in CDC – Challenges

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- Exploding digital universe
  - Multifold increase of information growth
- Increasing dependency on information
  - The strategic use of information plays an important role in determining the success of an organization
- Changing value of information
  - Information that is valuable today may become less important tomorrow