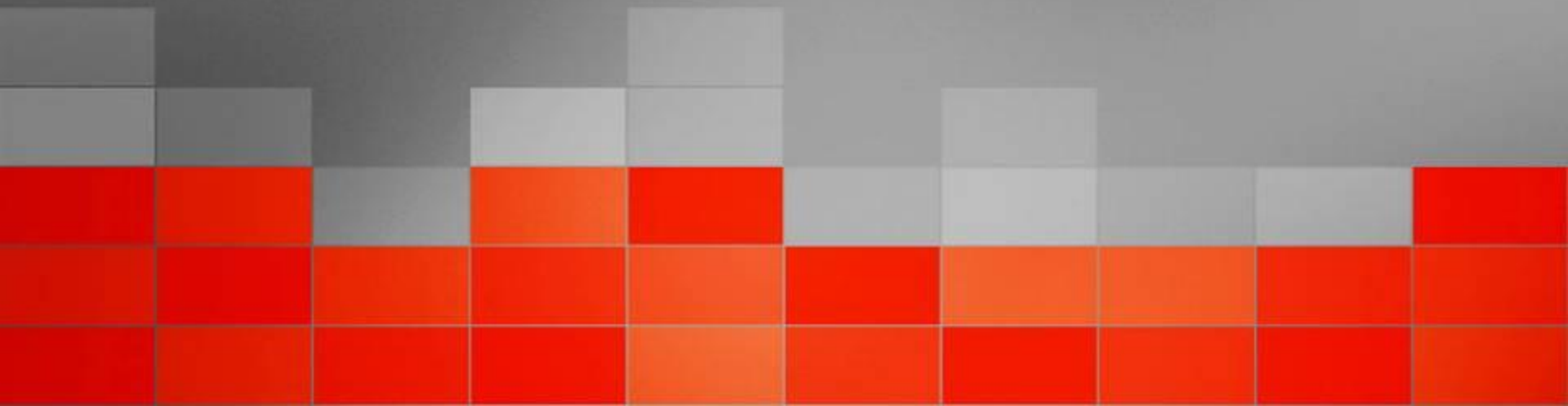# Introduction To Storage

Overview of the storage subsystem

Objectives for this Unit

- Understand Storage Basics
- Introduce Direct Attached Storage
- Differentiate between types of storage
  - DAS
  - NAS
  - ISCSI
  - SAN
- Introduce Network Attached Storage
- Introduce Fibre Channel SAN

A Few Storage Basics....

- Where will data finally end up?
- How will it get there?
- What will it pass through?

Direct Attached Storage (Internal)

Computer System

CPU

Memory

Bus

I/O - RAID Controller

Disk Drives

Direct Attached Storage (Internal)

1424 Main Street
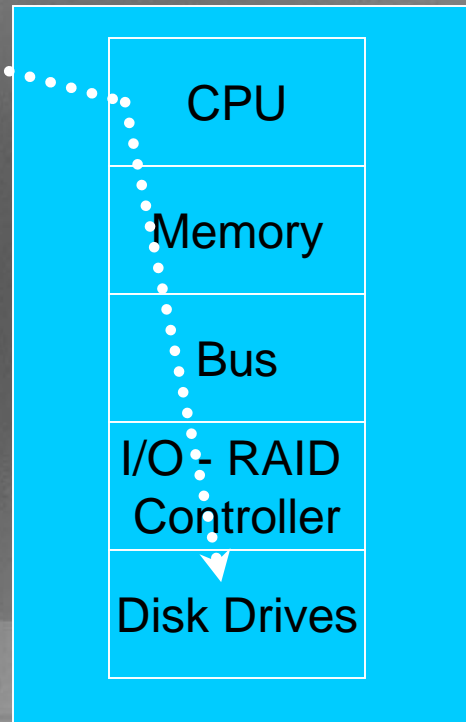512-555-12345
John Smith

Data

Computer System

CPU

Memory

Bus

I/O - RAID Controller

Disk Drives

Direct Attached Storage (Internal)

1424 Main Street
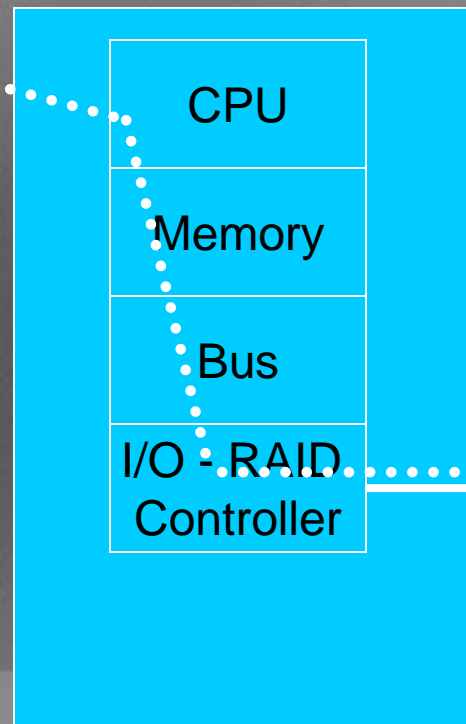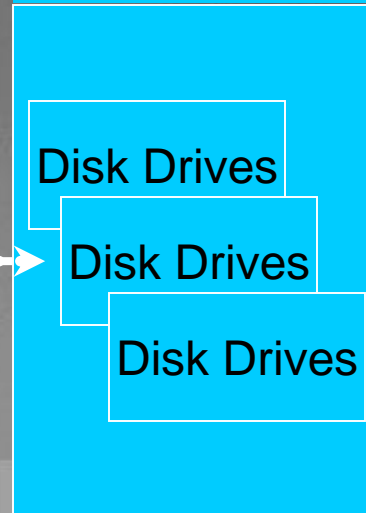512-555-1212
12345
John Smith

Computer System

CPU

Memory

Bus

I/O - RAID Controller

Disk Drives

DAS w/ internal controller and external storage

Comparing Internal and External Storage

Server

Storage

Disk Drives

RAID Controller

Internal Storage

RAID controllers and disk drives are internal to the server

SCSI, ATA, or SATA protocol between controller and disks

RAID controller is internal

SCSI or SATA protocol between controller and disks

Disk drives are external

Server

RAID Controller

Storage

Disk Drives

SCSI Bus w/ external storage
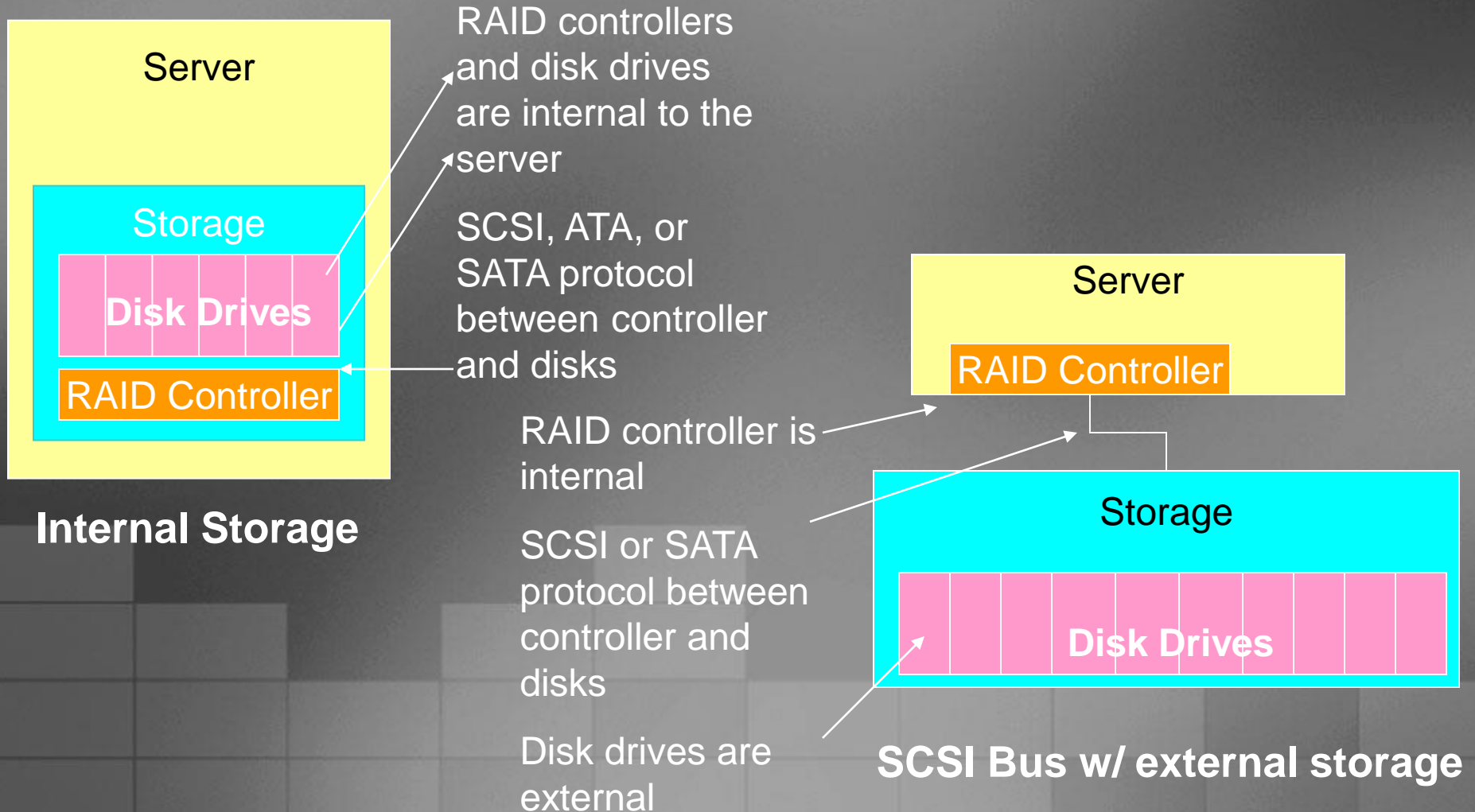
DAS w/ external controller and external storage

Storage System

Computer System
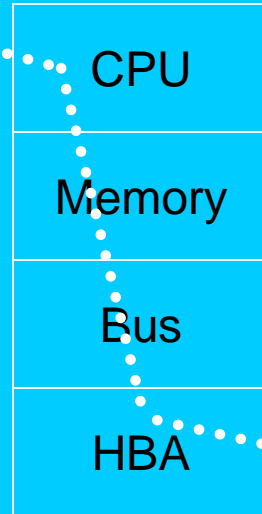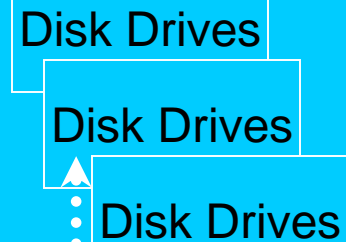
1424 Main Street
512-555-12345
John Smith

CPU

Memory

Bus

HBA

Disk Enclosure

Disk Drives

Disk Drives

Disk Drives

RAID Controller

DAS over Fibre Channel

Server

HBA

HBA is internal

Fibre Channel protocol between HBAs and external RAID controller

Disk drives and

RAID controller are external

Storage

Disk Drives
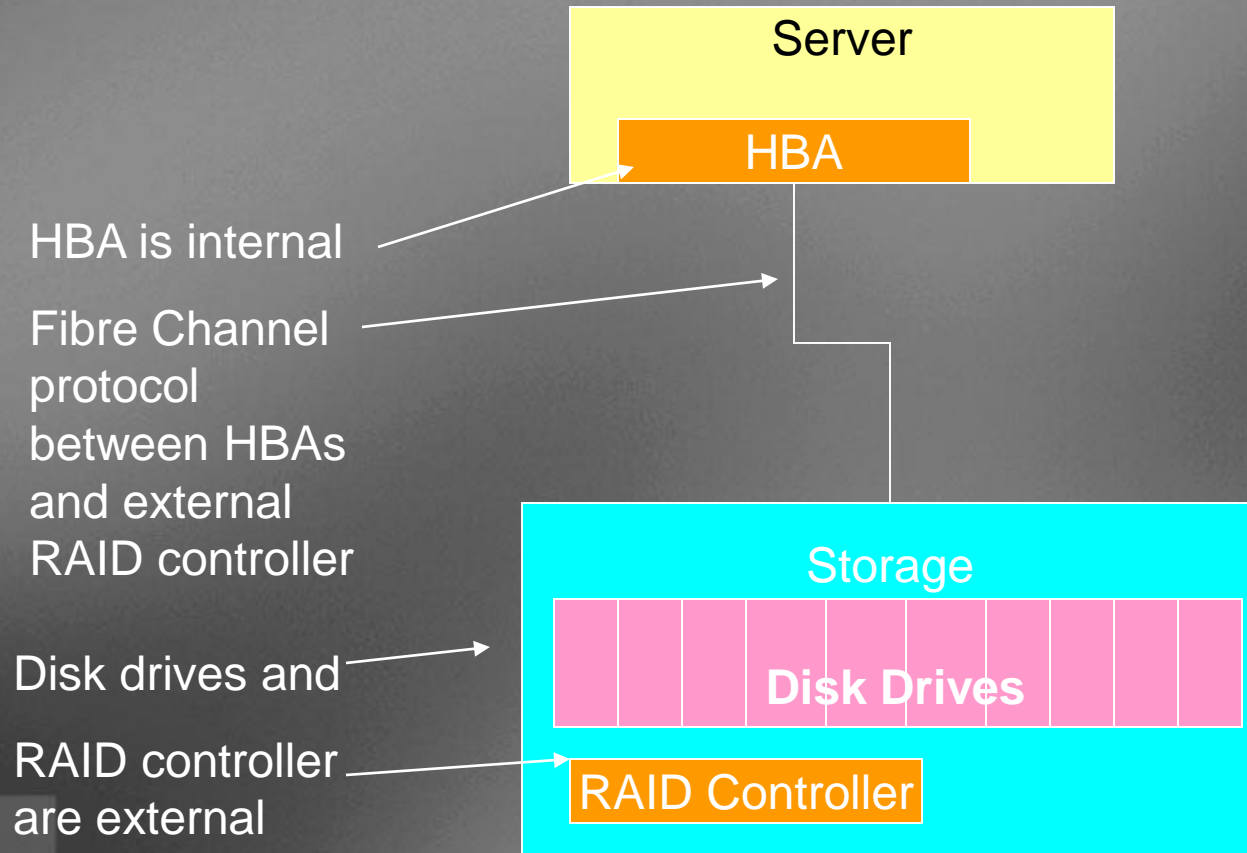
RAID Controller

External SAN Array

I/O Transfer

- RAID Controller
  - Contains the "smarts"
  - Determines how the data will be written (striping, mirroring, RAID 10, RAID 5, etc.)

- Host Bus Adapter (HBA)
  - Simply transfers the data to the RAID controller.
  - Doesn't do any RAID or striping calculations.
  - "Dumb" for speed.
  - Required for external storage.

Storage types

- Single Disk Drive
- JBOD
- Volume
- Storage Array
- SCSI device
- DAS
- NAS
- SAN
- iSCSI

NAS: What is it?

- Network Attached Storage
- Utilizes a TCP/IP network to "share" data
- Uses file sharing protocols like Unix NFS and Windows CIFS
- Storage "Appliances" utilize a stripped-down OS that optimizes file protocol performance

Networked Attached Storage

Public or Private Ethernet network

Server

NIC

NAS Server

NIC

Storage

Disk Drives

RAID Controller

All data converted to file protocol for transmission (may slow down database transactions)

Server has a Network Interface Card

No RAID Controller or HBA in the server
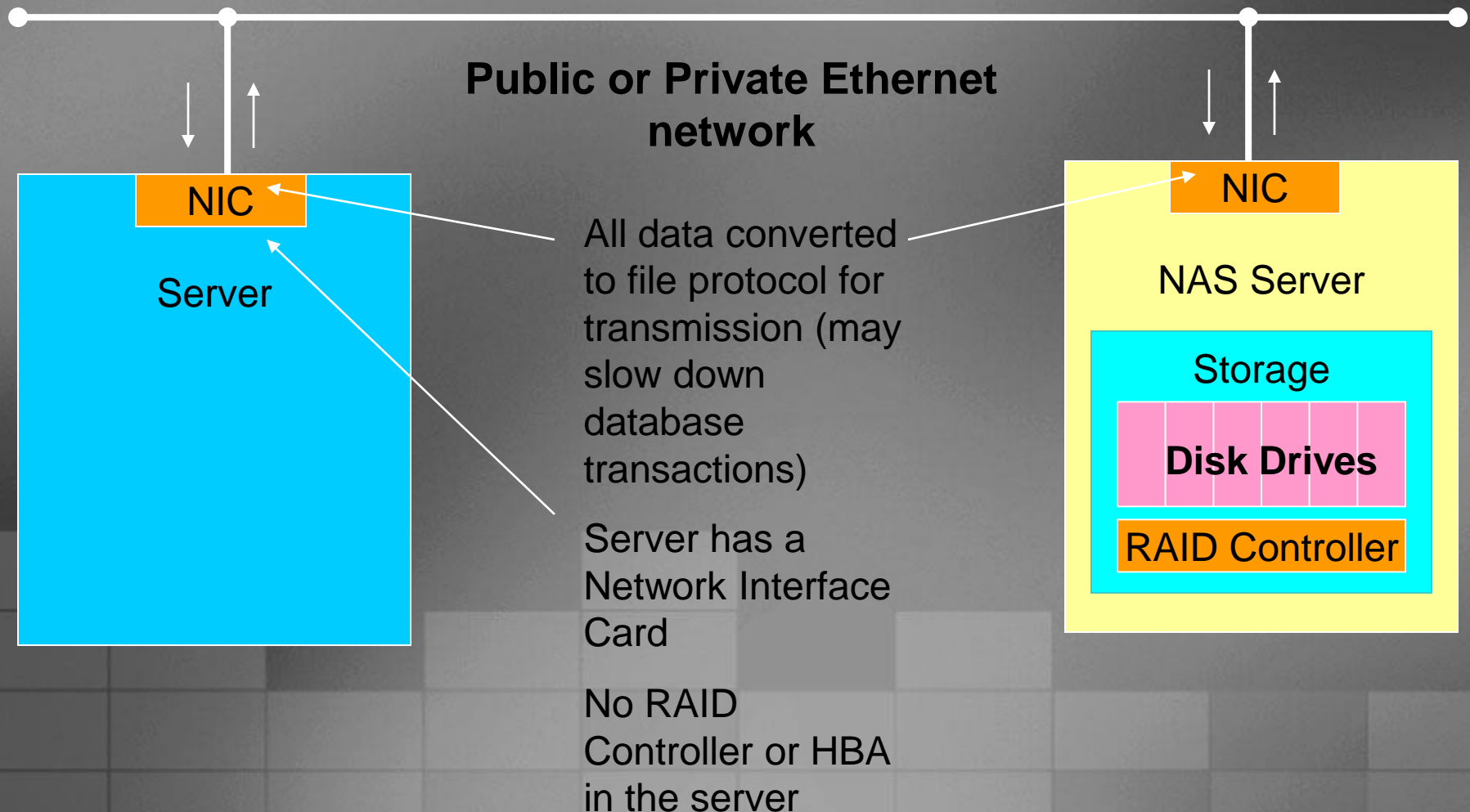
iSCSI: What is it?

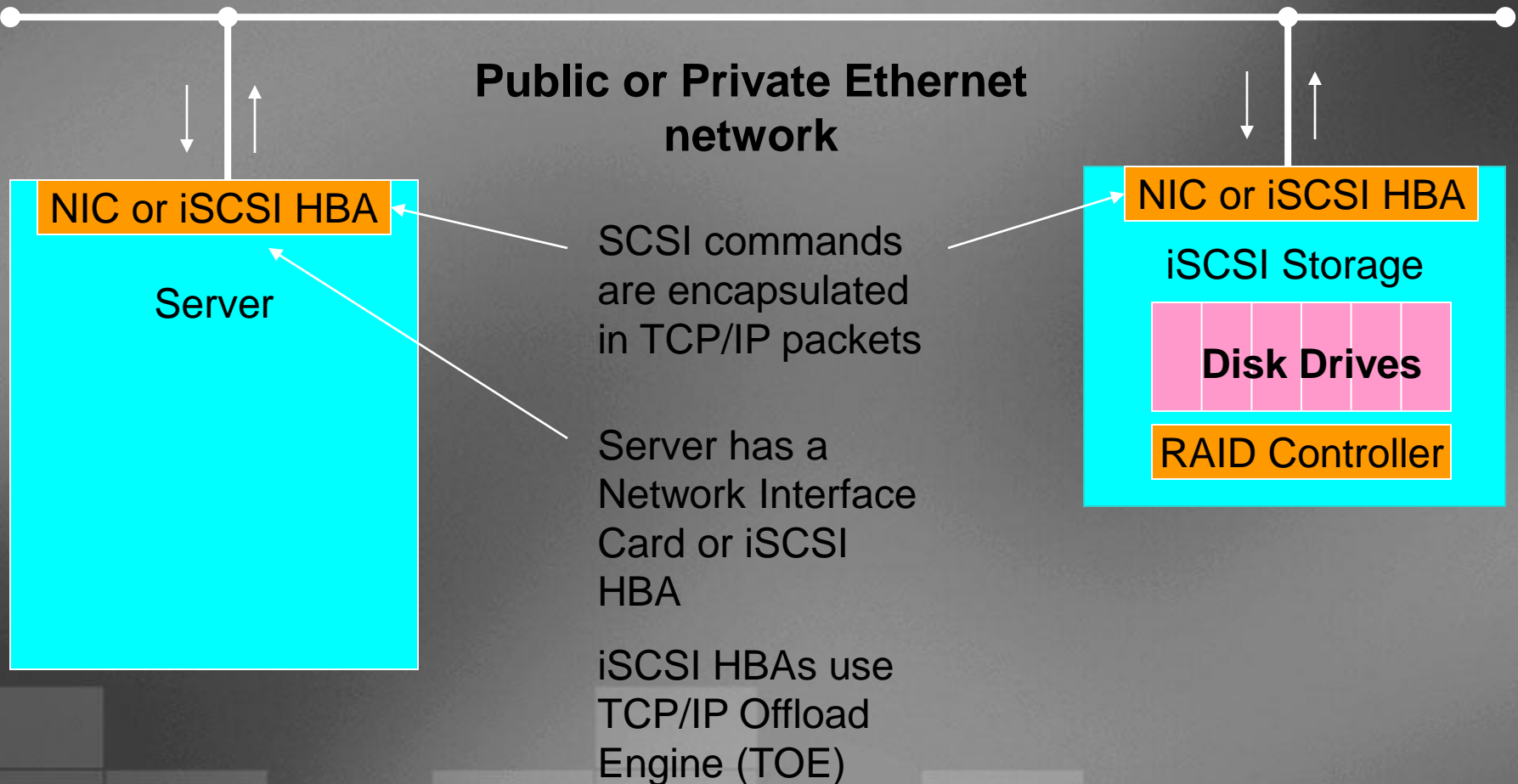- An alternate form of networked storage
- Like NAS, also utilizes a TCP/IP network
- Encapsulates native SCSI commands in TCP/IP packets
- Supported in Windows 2003 Server and Linux
- TCP/IP Offload Engines (TOEs) on NICs speed up packet encapsulation

iSCSI Storage

Public or Private Ethernet network

NIC or iSCSI HBA

Server

NIC or iSCSI HBA

iSCSI Storage

Disk Drives

RAID Controller

SCSI commands are encapsulated in TCP/IP packets

Server has a Network Interface Card or iSCSI HBA

iSCSI HBAs use TCP/IP Offload Engine (TOE)
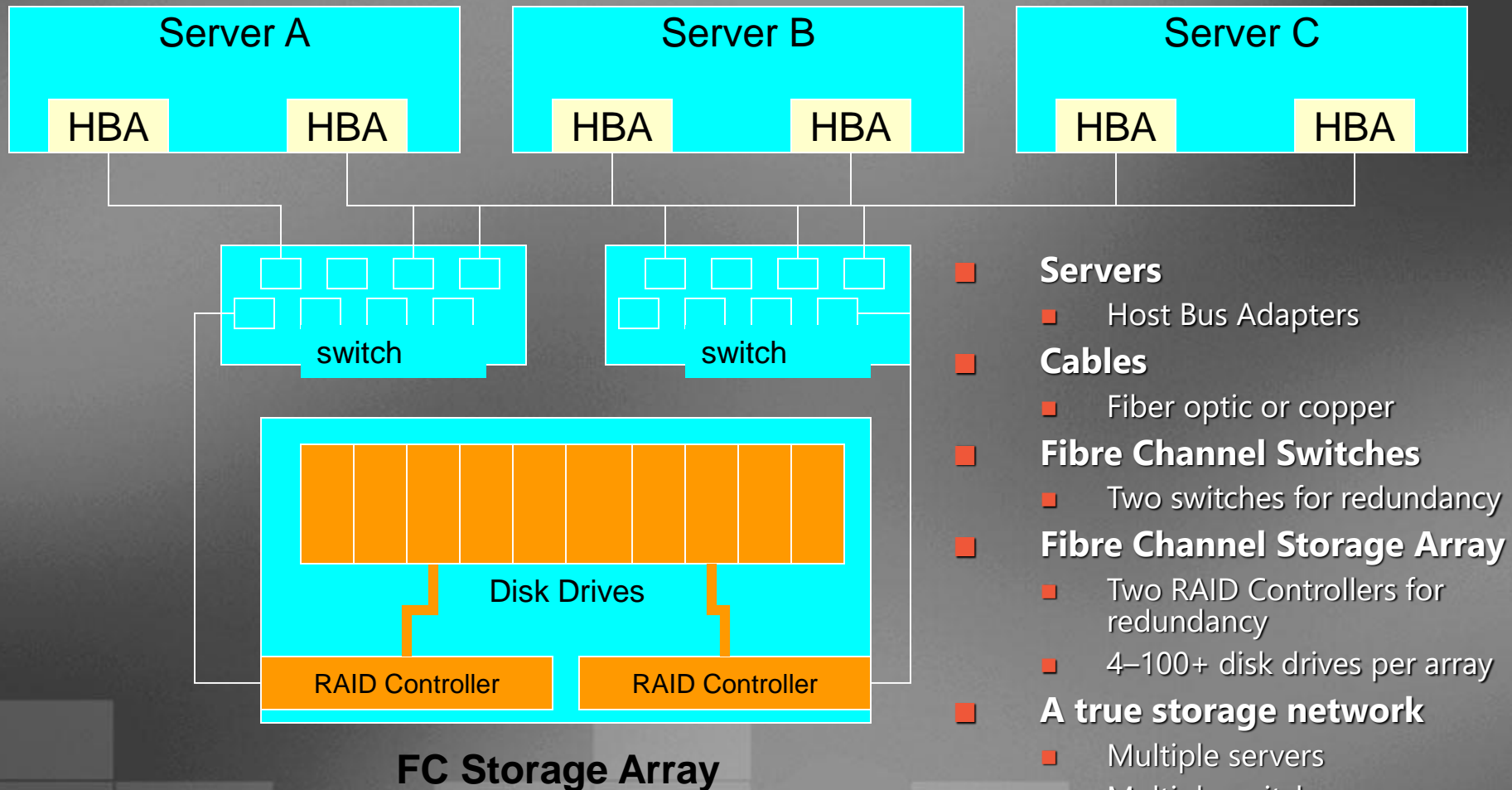
Fibre Channel: What is it?

- Fibre Channel is a network protocol implemented specifically for dedicated storage networks

- Fibre Channel utilizes specialized
    - Switches
    - Host Bus Adapters
    - RAID controllers
    - Cables

Fibre Channel Components

Server A	Server B	Server C
HBA HBA	HBA HBA	HBA HBA

switch

switch

Disk Drives

RAID Controller   RAID Controller

FC Storage Array

- **Servers**
  - Host Bus Adapters
- **Cables**
  - Fiber optic or copper
- **Fibre Channel Switches**
  - Two switches for redundancy
- **Fibre Channel Storage Array**
  - Two RAID Controllers for redundancy
  - 4–100+ disk drives per array
- **A true storage network**
  - Multiple servers
  - Multiple switches
  - Multiple Storage Arrays

SAN: What is it?

- Storage Area Network

- A network whose primary purpose is the transfer of data between storage systems and computer systems

- Fibre Channel is the primary technology utilized for SANs

- Recently, SANs have been implemented with dedicated iSCSI networks

Benefits of SAN/Consolidated Storage

- Reduce cost of external storage
- Increase performance
- Centralized and improved tape backup
- LAN-less backup
- High-speed, no single-point-of-failure clustering solutions
- Consolidation with > 70TB of storage

Fibre Channel Technology

- Provides concurrent communications between servers, storage devices, and other peripherals
- A gigabit interconnect technology
- FC1: Over 1,000,000,000 bits per second
- FC2: Over 2,000,000,000 bits per second
- A highly reliable interconnect
- Up to 127 devices (SCSI: 15)
- Up to 10 km of cabling (3-15 ft. for SCSI)
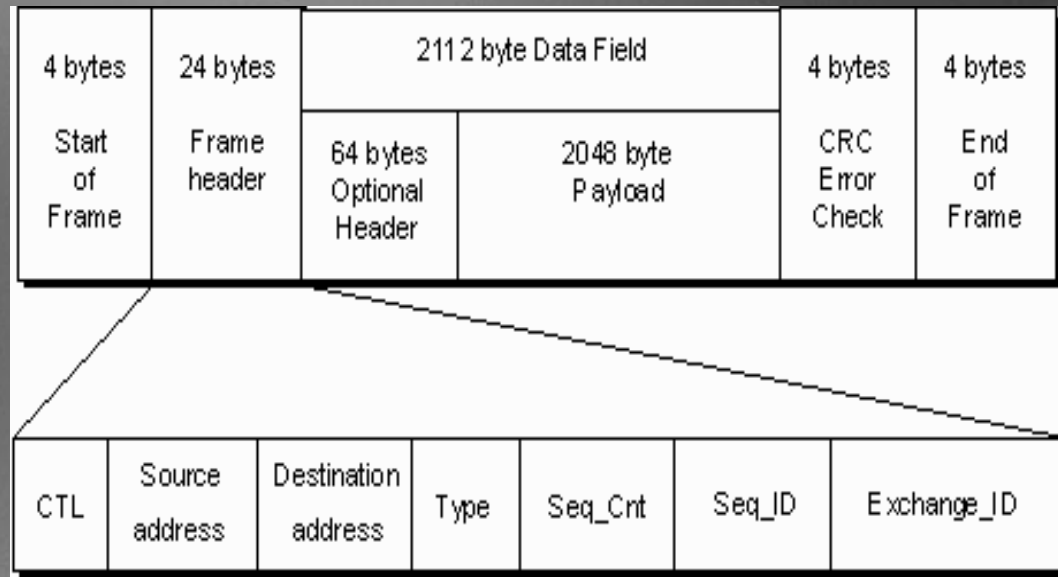- Physical interconnect can be copper or fiber optic

Fibre Channel – (continued)

- Hot-pluggable - Devices can be removed or added at will with no ill effects to data communications

- Provides a data link layer above the physical interconnect, analogous to Ethernet

- Sophisticated error detection at the frame level

- Data is checked and resent if necessary

Fibre Channel – Frame Dissection

- Up to 2048 byte payload
- 4 byte checksum for each frame

4 bytes	24 bytes	2112 byte Data Field		4 bytes	4 bytes
Start of Frame	Frame header	64 bytes Optional Header	2048 byte Payload	CRC Error Check	End of Frame

| CTL	Source address	Destination address	Type	Seq_Cnt	Seq_ID	Exchange_ID

Fibre Channel

- What's with the funny name?
  - Some background history required
  - Originally developed to only support fiber optic cabling
  - When copper cabling support was added, ISO decided not to rename the technology
  - ISO changed to the French spelling to reduce association with fiber optics only medium

Fibre Channel

- How does it work?
  - Serial interface
  - Data is transferred across a single piece of medium at the fastest speed supported
 - No complex signaling required

Fibre Channel Interface Layers

Device Driver

SCSI Protocol

Fibre Channel

Fiber Optic or Copper Cabling
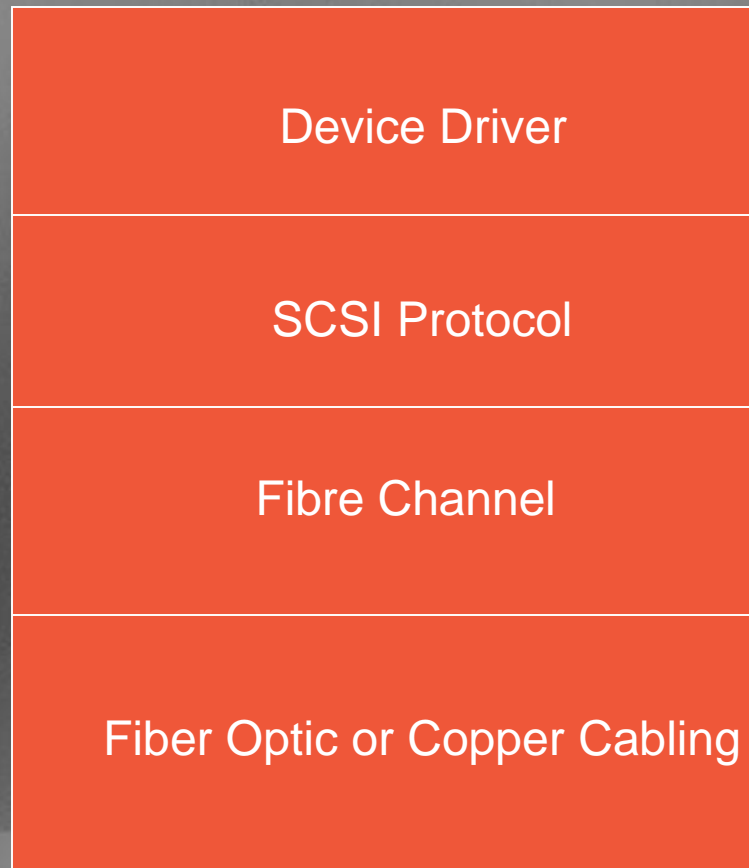
SCSI vs. Fibre Channel *Protocol*

- SCSI
  - SCSI protocol vs. SCSI device
  - SCSI is an established, tried and true protocol
  - Provides services analogous to TCP/IP
  - Supported in every major OS on market
- Fibre Channel
  - Fibre Channel runs on top of SCSI
  - No re-inventing the wheel
  - Immediate OS support

SCSI vs. FC Transmission

RAID Controller

Disk Drive

Fibre Channel

RAID Controller

Disk Drive
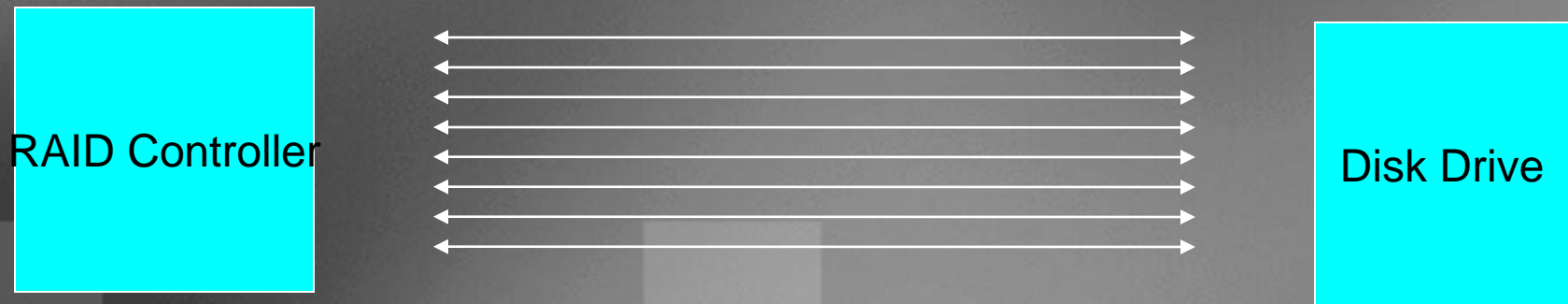
SCSI

SCSI   vs.   Fibre Channel

- Interface for internal storage to external disks
- Potential down time w/ SCSI
- Single bus
- RAID controller is SCSI hardware
- Standards:
  - Ultra2 (80 MB/sec)
  - Ultra 160 (160 MB/sec)
  - Ultra 320 (320 MB/sec)
- Media specific (copper only)
- SCSI Limitations:
  - Cables can't be any longer than 3 feet for single ended; 15 feet for LVD (low voltage differential)
  - No more than 15 devices on a SCSI bus
  - # of disk drives

- Used with SAN
- Lots of built-in redundancy with connections
- Redundant network
- HBA is fibre channel hardware
- Standards:
  - FC1: 100 MB/sec
  - FC2: 200 MB/sec
- Provides a data link layer above the physical interconnect
  - Analogous to Ethernet
  - FC is a network of devices
  - It can be media independent- copper or fibre optic
- Fibre Channel limitations:
  - Cable length: Up to 10 kilometers (more a limitation of cable than FC itself)
  - Up to 127 devices
  - # of disk drives

Fibre Channel vs. iSCSI

- Fibre Channel
    - The current market leader for shared storage technologies
    - Provides the highest performance levels
    - Designed for mission-critical applications
    - Cost of components is relatively high, particularly per server HBA costs
    - Relatively difficult to implement and manage
- iSCSI
    - Relatively new, but usage is increasing rapidly
    - Performance can approach Fibre Channel speeds
    - A better fit for databases than NAS
    - A good fit for Small to Medium Size Businesses
    - Relatively inexpensive, compared to Fibre Channel
    - Relatively easy to implement and manage

Microsoft Simple SAN Initiative

- Make operating system aware of SAN and SAN capabilities
- Shift integration burden from IT staff or services back to VENDORS products:
    - Microsoft
    - Storage hardware and software
    - Application developers
- Key storage technologies:
    - Volume Shadow Copy Service (VSS)
    - Virtual Disk Service (VDS)
    - Microsoft Multipath Input/Output (MPIO)
    - Microsoft iSCSI driver
        - Software Initiator (client)
        - Software Target (attached to disk subsystem)

Review

- What is the difference between a RAID Controller and an HBA?

- How many protocols may be used for DAS?

- Name two types of storage that rely on ethernet cables

- Name two benefits of SANs

- Describe the four interface layers of the Fibre Channel protocol

- Describe a scenario where an iSCSI SAN may be preferred over a Fibre Channel SAN

Summary

- How data is routed through a server to I/O
- Types of storage
    - DAS
    - NAS
    - iSCSI
    - SAN
- Benefits of SAN technology
    - Storage consolidation
    - Reduced costs
    - Centralized, LAN-free backup and restore
- The Fibre Channel protocol
    - How it works
    - Fibre Channel protocol vs. SCSI protocol
- Comparing Fibre Channel SANs and iSCSI SANs
    - Fibre Channel SANs offer mission-critical performance, with relatively high costs and high complexity
    - iSCSI SANs offer moderate to high performance at an attractive price/performance ration and are relatively easy to administer