DATA STORAGE TECHNOLOGIES & NETWORKS (CS C446 & IS C446)

LECTURE 35 – SAN, FIBRE CHANNEL

FC- SAN Components

- Components
  - Hosts
    - Client / Server computers
  - Storage Devices
  - Interfaces
    - (Fibre-Channel) Ports for communication
  - Hubs (understand only AL topology), Switches (switched fabric topology), router (route traffic based on load and find alternate path when necessary), bridges (serial data stream to parallel data stream and vice versa) and Gateways

FC - SAN Components

- **Interconnects**
  - Cables – Fiber Optic - Serial
  - Transceivers
  - Interface Converters (Optical/Electrical)
  - Host-Bus Adapters
    - Servers connect to the SAN via their host bus adaptor
    - Parallel-Serial Conversion
    - SCSI – FC conversion
  - Inter Switch Links (ISLs)
    - Connect E-ports on switches
- **Cascading**
  - Seamless extension of fabric by adding switches
  - ISLs can also provide redundant paths

FC - SAN Components

- **Devices**
  - Hubs, Switches/Directors
  - Gateways enable connection of SAN over WANs
    - SAN to SAN
    - SAN to hosts on the Internet
  - Multiprotocol Routers (FCP, FCIP, iFCP, iSCSI)

- **Latency**
  - Switch latencies are about a few microseconds
    - Switches use cut-through routing
  - Note:
    - Compare this with the latency of a long fiber link (say 10 km) and disk access latency

Storage on the Network - Pragmatics

- SAN Advantages
  - Network is designed primarily for storage
    - and hence can be tuned for high performance
      - data transfer rates, I/O rates, availability, reliability, etc.
  - Can support both
    - streaming (large files/streams accessed sequentially) and
    - transactional (small records) access.

(Separate) networks for Storage

- **Reasons to use a separate network for Storage:**
  - Increased Throughput
    - improves performance of I/O sensitive applications
  - More flexibility
    - for change in storage compared to the Direct Attached Storage model
  - Higher Scalability
    - in terms of greater numbers of servers and storage units to be interconnected
  - Data Mobility / Migration
    - is easier
  - Data / Storage Management
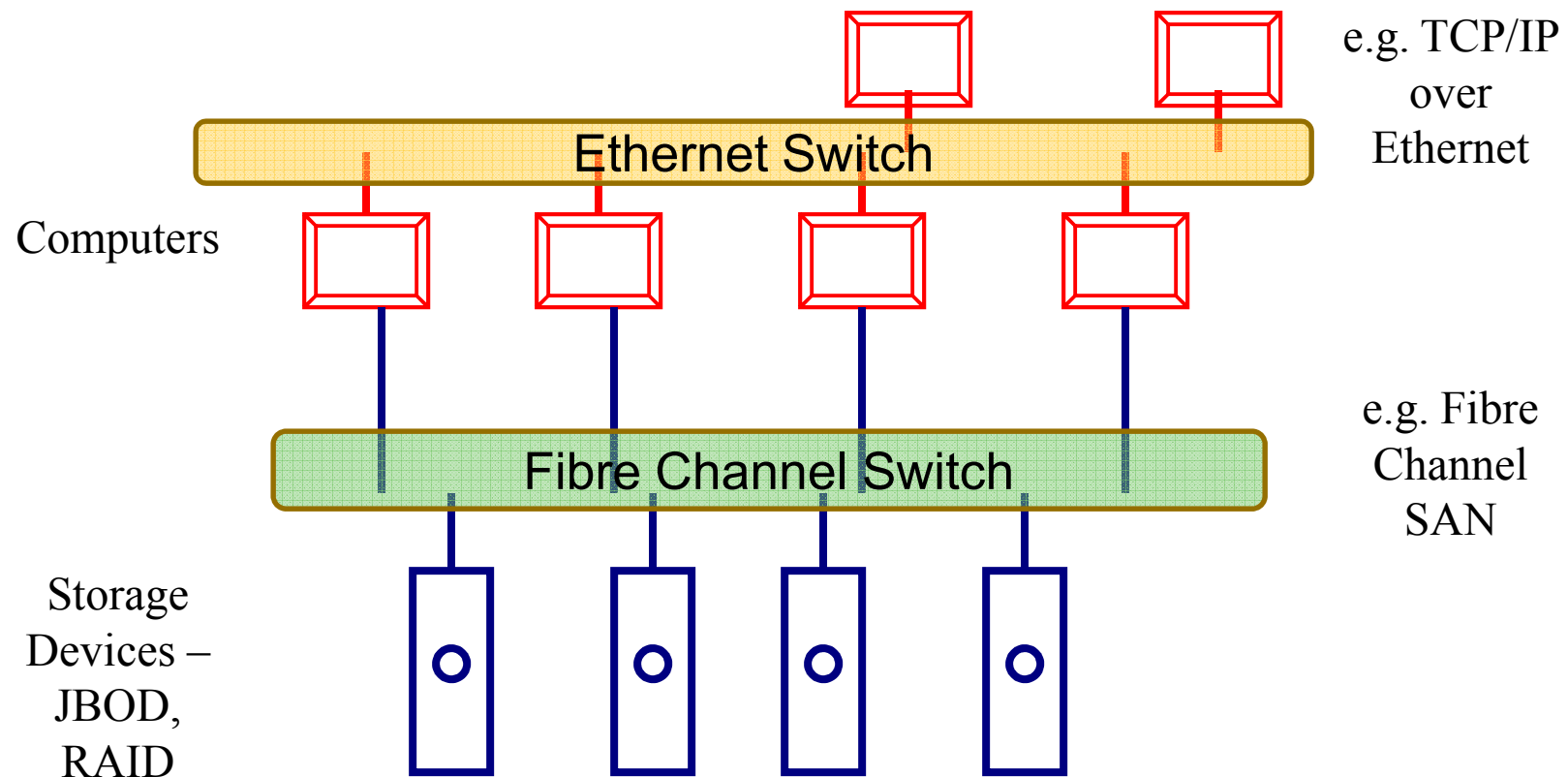   - is easier (e.g. backup is independent of LAN)

SAN Traffic

- Communication between Initiator (a computer and its controller) and target (storage device) uses SCSI
  - SCSI commands:
    - Types: Non-data, Write, Read, Bidirectional
      - E.g. Test Unit Ready, Inquiry, Start/Stop Unit, Request Sense (for error), Read Capacity, Format Unit, Read (4 variants), Write (4 variants)
    - Command Descriptor:
      - Opcode, LUN (3 bits)
      - E.g. for Read
        - Read (6): 21 bits LBA, 1 byte transfer length
        - Read(10): 32 bit LBA, 2 byte transfer length
        - Read(12): 32 bit LBA, 4 byte transfer length
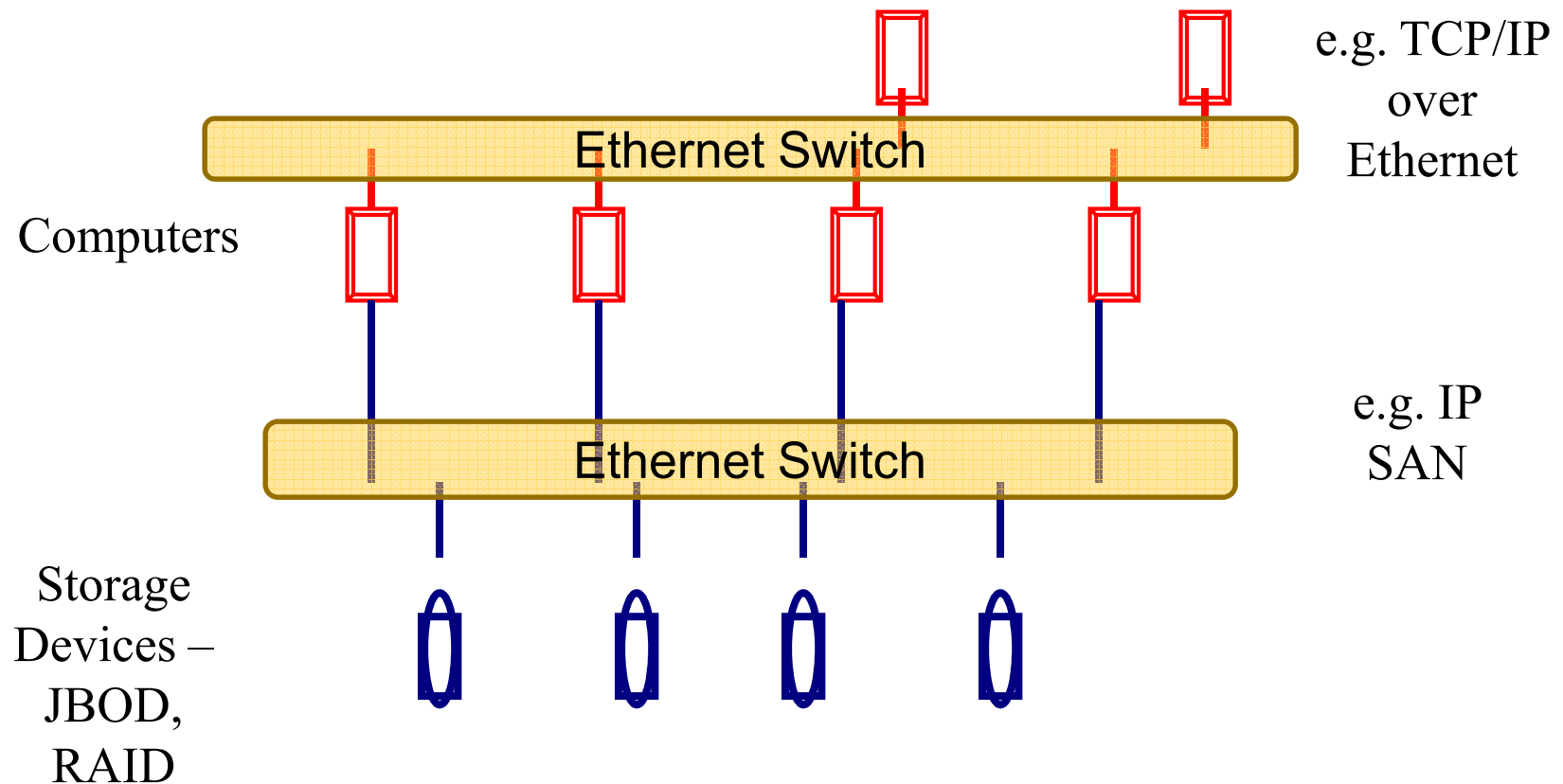   - Read Long for ECC-Compliant data

SAN Traffic

- Typical SAN Traffic is that of SCSI commands
  - The transmission protocol may vary
- The earliest SANs used Fibre Channel for transmission
  - But iSCSI (Internet SCSI) enables the use of TCP/IP for transmission
- Essentially, SCSI commands are carried as payloads (i.e. data) over SAN protocols
  - In SCSI -3 Architecture the SCSI command protocol and bus protocol are referred to as the SCSI Parallel Interface (SPI)

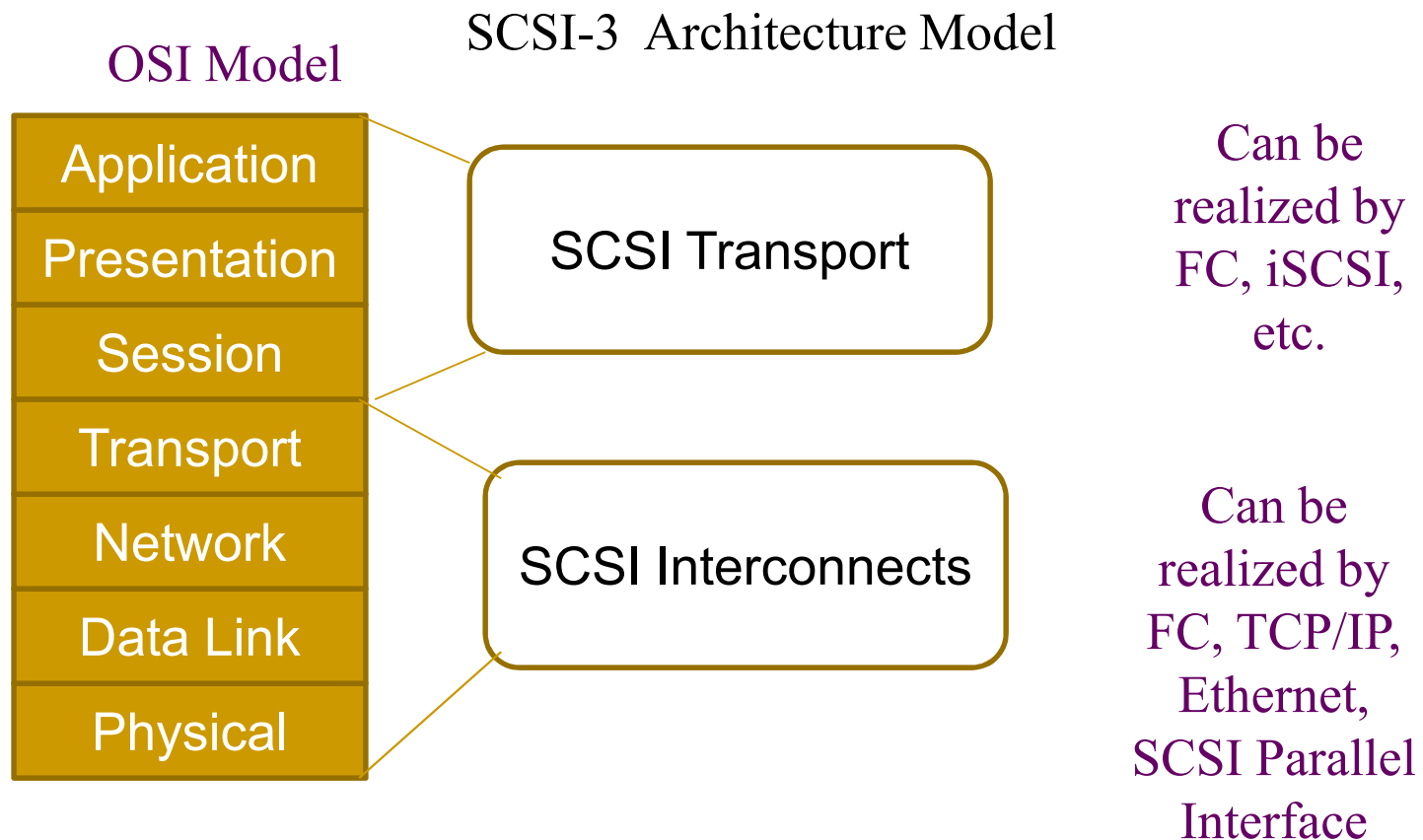# Storage Area Networks - Structure

e.g. TCP/IP over Ethernet

Ethernet Switch

Computers

e.g. Fibre Channel SAN

Fibre Channel Switch

Storage Devices – JBOD, RAID

Buses vs. Hubs vs. Switches, Topologies – Shared (Bus, Ring), Star, Mesh ...

Storage Area Networks - Structure

Computers

Ethernet Switch

e.g. TCP/IP over Ethernet

Ethernet Switch

e.g. IP SAN

Storage Devices – JBOD, RAID

Compute-Network vs. Storage Network

OSI Model

SCSI-3 Architecture Model

Application
Presentation
Session
Transport
Network
Data Link
Physical

SCSI Transport

Can be realized by FC, iSCSI, etc.

SCSI Interconnects

Can be realized by FC, TCP/IP, Ethernet, SCSI Parallel Interface

Fibre Channel Protocol

- FCP follows a layered architecture:
  - Protocol is specified via 5 functional layers
- Design goals
  - Serial tx for high speed long distance
  - Low rate of tx errors
  - Low delay (latency) of tx data
  - Implementation of FCP in hardware on host bus adapter cards will free up server CPUs
  - Latest FC implementation (16GFC) offer a throughput of 3200 MB/s (16Gb/s) whereas Ultra640 SCSI can reach 640MB/s only
  - FC architecture is very scalable – single FC network can accommodate approximately 15 million devices

Why Fibre Channel

- Supports other non-network protocols like SCSI

- Confirmed delivery – enhanced reliability

- High QoS including fractional bandwidth and connection oriented virtual circuits to guarantee bandwidth for critical backup etc

- Extremely low latency connection and connectionless service

- Support for 3 different network topologies including auto discovery of each topology and of all nodes placed in network

- Efficient, high bandwidth, low latency transfers using variable length frames (0 to 2KB). This allows efficient transfer regardless of the payload size

- Hot pluggable device support, which enables devices to be initialized or removed without impacting the host system