CPSC 317 COMPUTER NETWORKING

Module 7: Link Layer – Day 4 – Physical and Link Layer Issues

1

LEARNING GOALS

The physical layer and advanced link layer issues

- Describe how bits are transmitted on a medium
- Explain the timing of sending and receiving bits and packets
- Enumerate and describe the various media that can be used at the physical layer
- Describe the purpose and mechanism of VLANs
- Describe the unique problems of data-center computing
- Describe the possible architectures of data-center networking

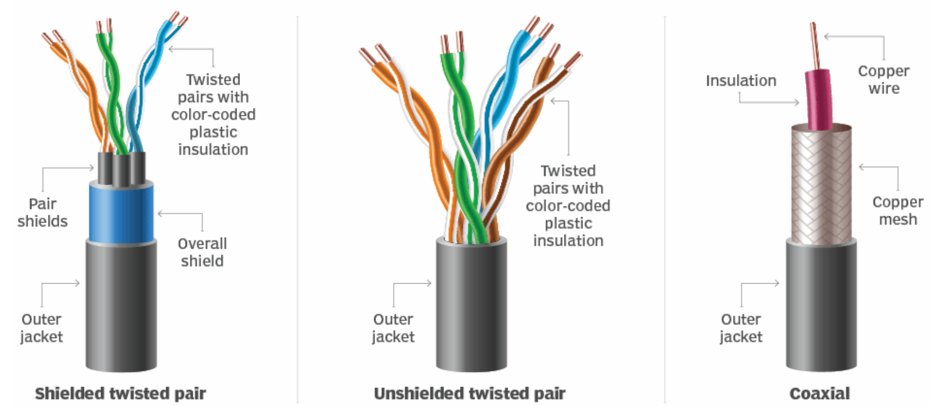
READING

- Reading: 1.2.1, 1.2.2, 6.4.4, 6.6

THE PHYSICAL LAYER

There are many different media that can support networking

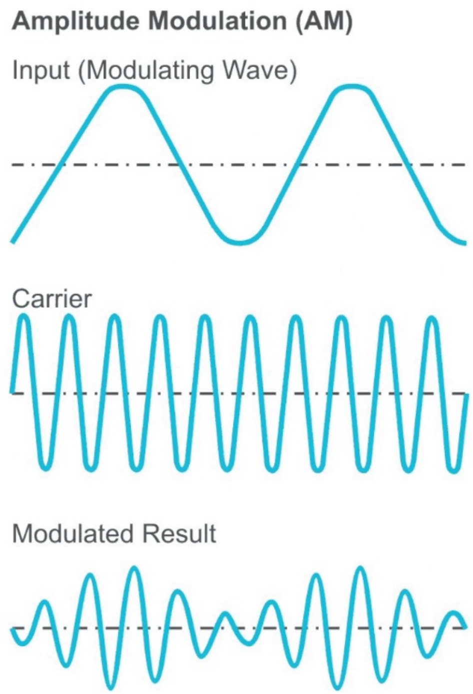
- Co-axial cable
- Twisted pair (phone cables)
- Fiber
- Radio
  - WiFi
  - Bluetooth
  - Cellular
  - Satellite



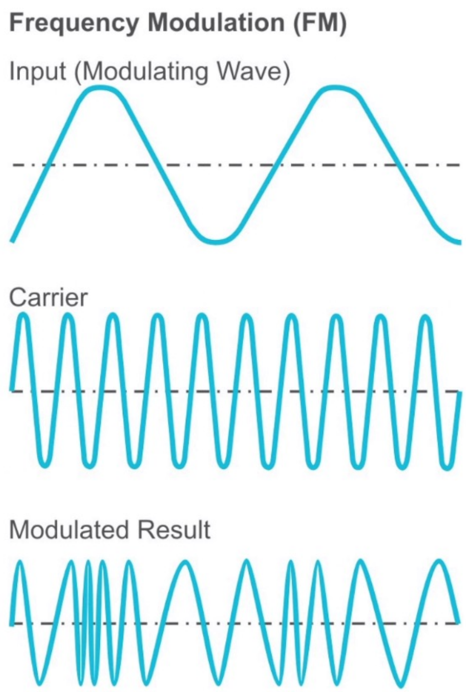
MODULATION

- How bits are put on the medium is an electrical engineering issue, but generally there is a “carrier” signal which is modulated to contain the data
- AM
  - Amplitude modulation
- FM
  - Frequency modulation
- PM
  - Phase modulation

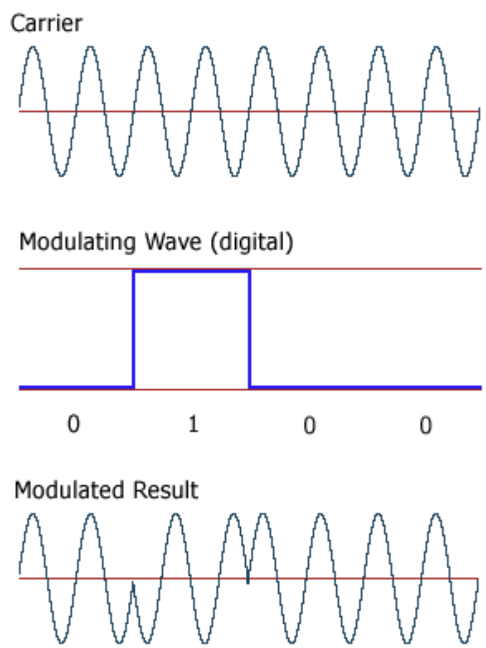
AMPLITUDE MODULATION



FREQUENCY MODULATION



PHASE MODULATION



SENDING THE BITS

- Almost all physical networks send the bits of the message one at a time on the medium
  - Code-Division multiplexing complicates this because a single code symbol generally encodes more than one bit
- The timing of when bits are sent is determined by the bandwidth of the medium
  - 10 Mbps: one bit every 100ns 100 Mbps: one bit every 10ns
  - 1 Gbps: one bit every 1ns 10 Gbps: one bit every 100ps
- The timing of when bits arrive is determined by the propagation time and the send timing

A SCENARIO

- A sender is sending 8 bits to a receiver
- Propagation time is 5 time units
- Transmission time is 1 time unit per bit
- A realistic scenario:
  - 100Mbps network
  - Distance between sender and receiver is 10 metres
  - A time unit is 10ns
  - In 50ns the signal will travel 50 * 10^-9 * 2*10^8 = 10m

ENVISIONING BITS

Sender sending 01001110

Receiver

Time 0

ENVISIONING BITS

Time 1

ENVISIONING BITS

Sender sending 01001110

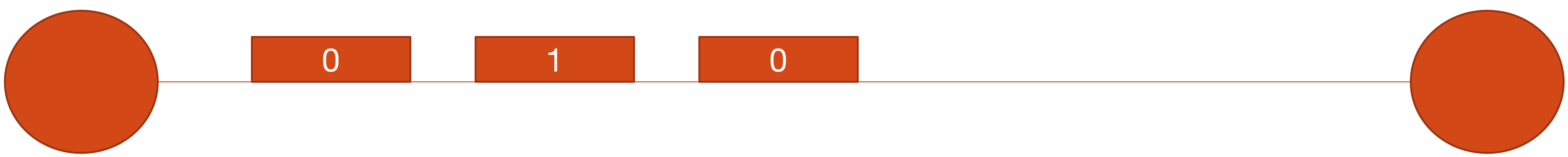
Receiver

Time 2

ENVISIONING BITS

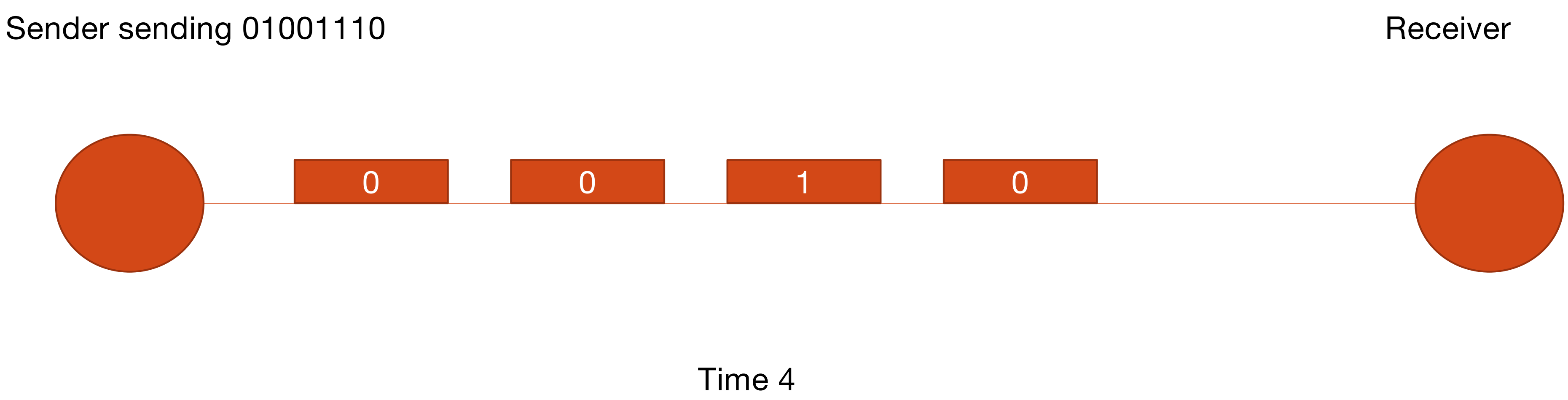
Sender sending 01001110

Receiver



Time 3

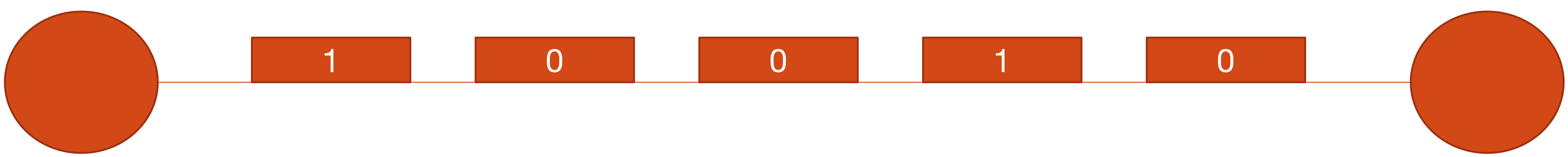
ENVISIONING BITS



ENVISIONING BITS

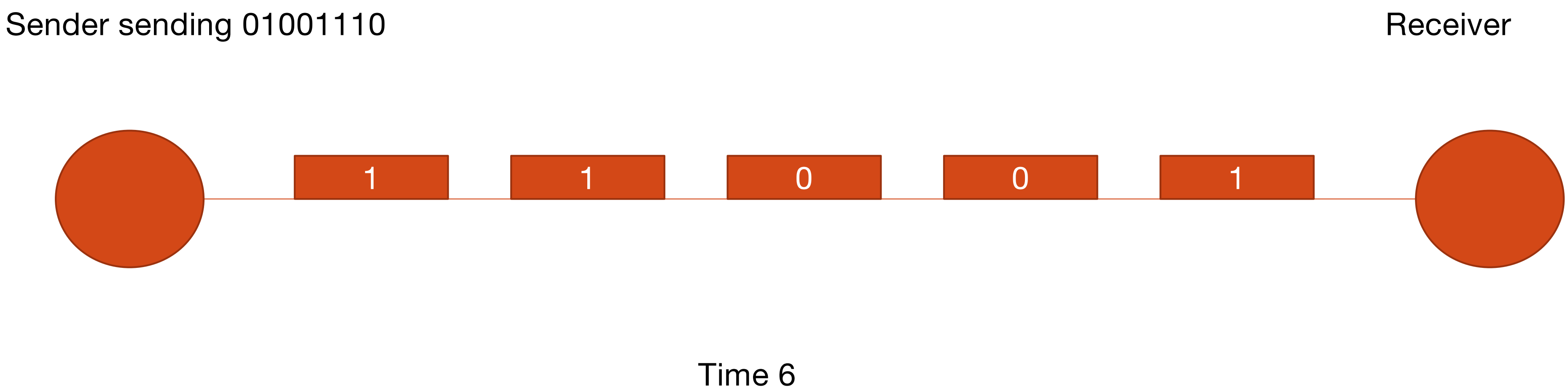
Sender sending 01001110

Receiver

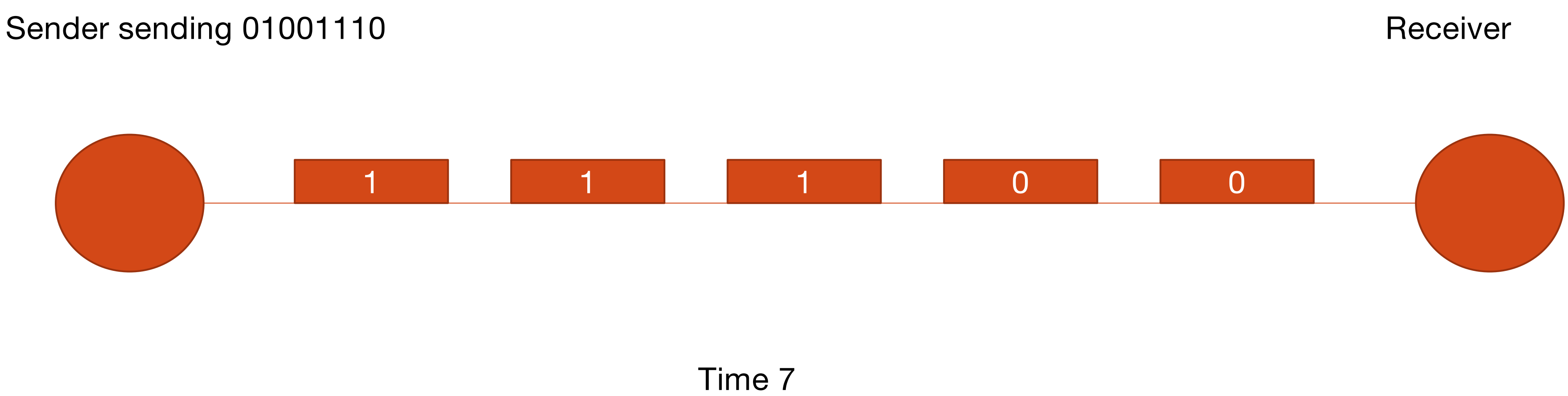


Time 5

ENVISIONING BITS



ENVISIONING BITS



ENVISIONING BITS

Sender sending 01001110

Receiver

Time 8

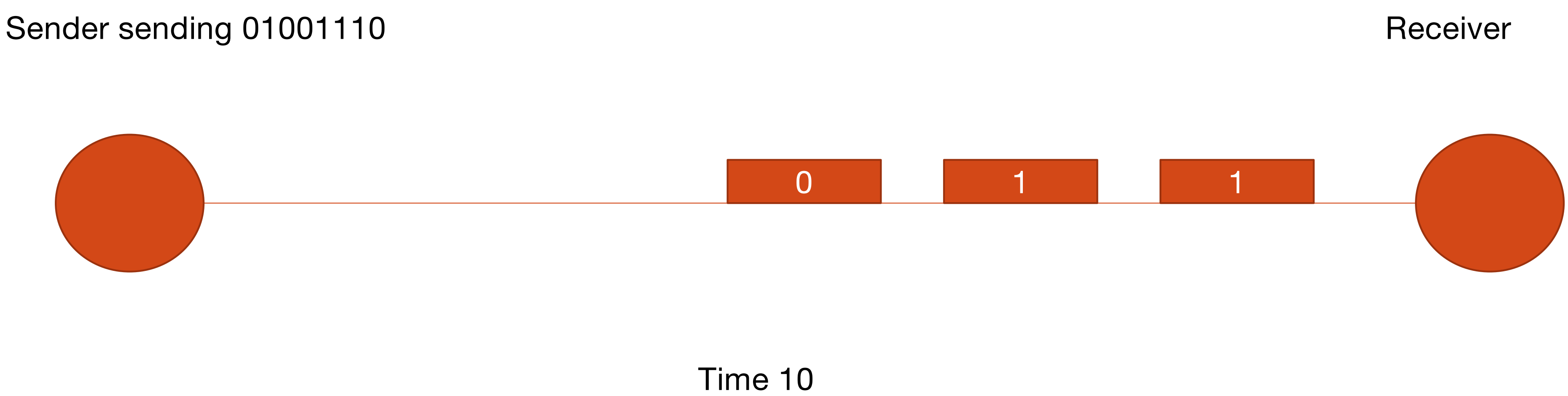
ENVISIONING BITS

Sender sending 01001110

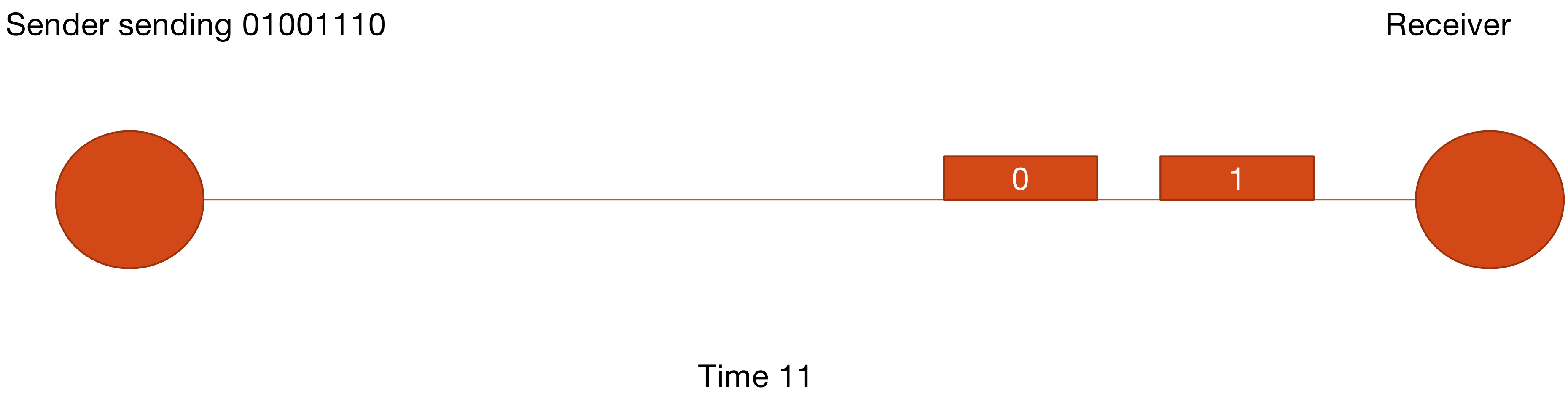
Receiver

Time 9

ENVISIONING BITS



ENVISIONING BITS



ENVISIONING BITS

Sender sending 01001110

Receiver

Time 12

ENVISIONING BITS

Sender sending 01001110

Receiver

Time 13

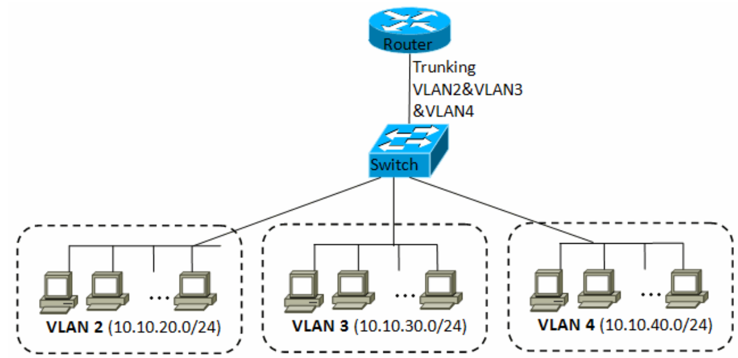
TIME TO DELIVER A MESSAGE

- Transmission time
  - 1 time unit per bit
- Propagation time (bit)
  - Only for the last bit
- Total time = Transmission time + Propagation time
  - A sender is sending 8 bits to a receiver
  - Propagation time is 5 time units
  - Transmission time is 1 time unit per bit
  - Total time = 5 * 1 + 8 = 13

A PROBLEM WITH LANS

- Having a single large LAN is sometimes less than ideal
  - All broadcast traffic goes to every adapter
  - Privacy and security
    - Anyone using Wireshark can see any frames
- Creating separate LANs would solve the problem
  - One LAN for each group in a company, for example
  - But each LAN needs a switch
  - Many small switches are more expensive than a single large switch

WHAT IF WE COULD …



- Have multiple virtual LANs using a single switch
- Enter the Virtual Local Area Network – VLAN
- Since switches contain software forwarding already, it is possible to create multiple VLANs on a single switch
  - Identified by port
  - Identified by MAC address
- With a bit more software, the switch hardware can also be the router that connects these VLANs together

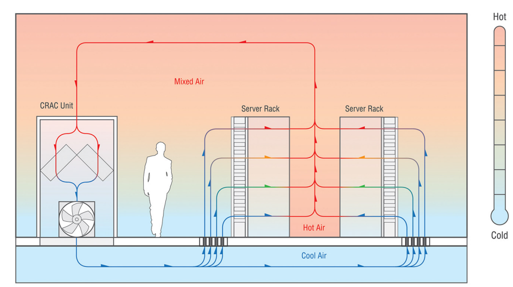
DATA CENTER NETWORKING

- The networking needs of data centers are unique
- 10,000 – 100,000 of computers in a small space
- Distributed algorithms run on these computers
  - Spark, Hadoop, TensorFlow, etc
  - Communication is a key component
- How are these things connected together?

DATA CENTER NETWORKING

DATA CENTER NETWORKING

Traditional Cooling Diagram



UNIVERSITY DATA CENTER (UDC)

DATA CENTER NETWORKING

- The networking needs of data centers are unique
- 10,000 – 100,000 of computers in a small space
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  - Spark, Hadoop, TensorFlow, etc
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A HIERARCHICAL STRUCTURE

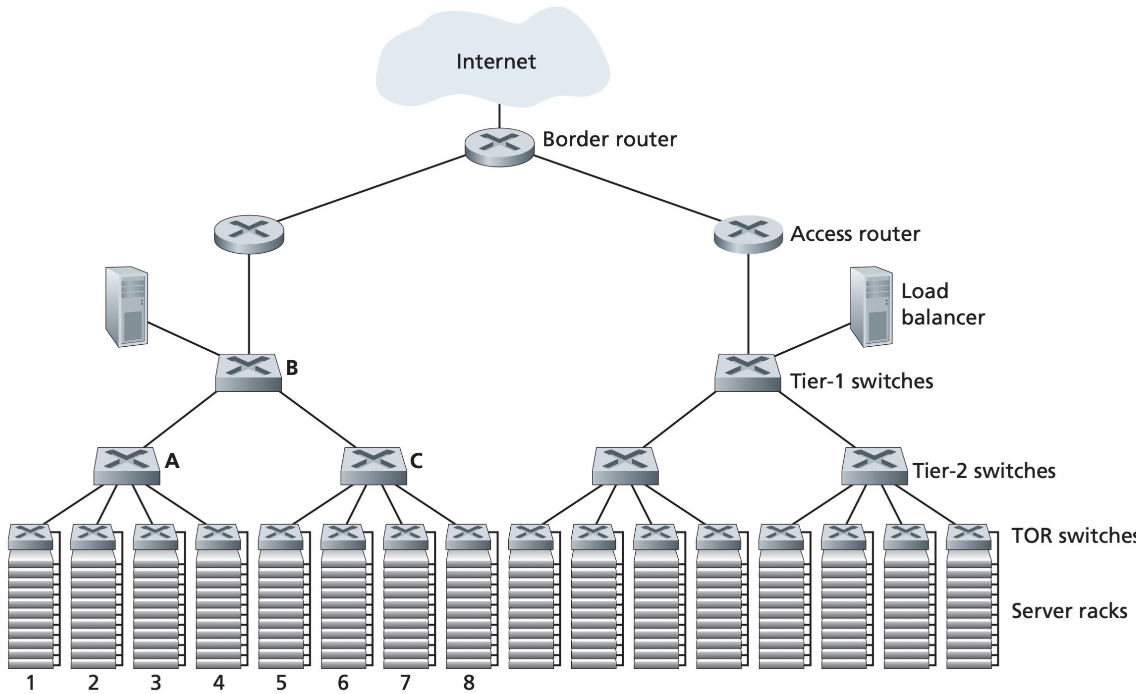
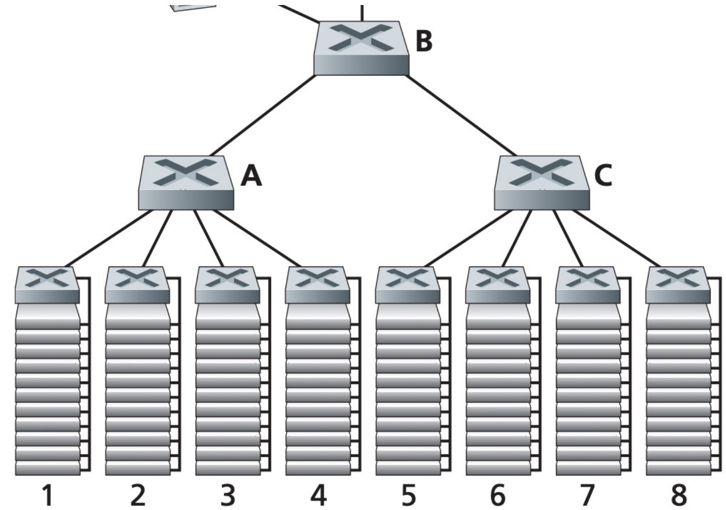


Figure 5.30 ♦ A data center network with a hierarchical topology

DATA CENTER CHARACTERISTICS

- Network speeds up to 100 Gbps
- 20-40 servers per rack
- How efficient is communication in this setting?
  - Within a rack?
  - Between racks?

CLICKER QUESTION



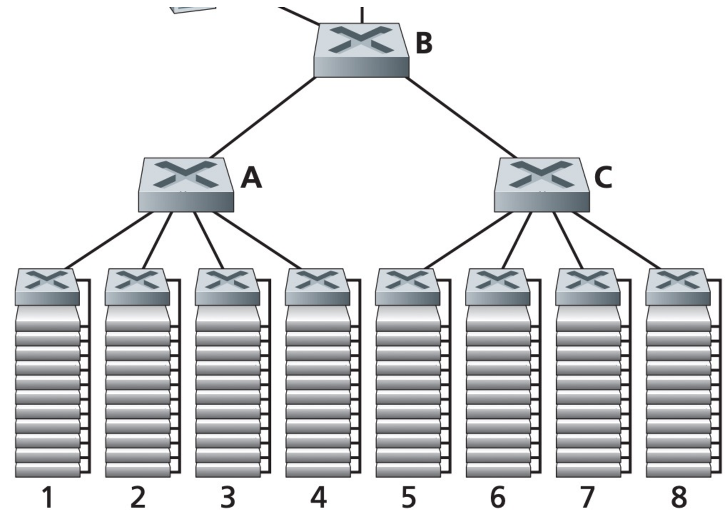
40 servers per rack
100Gbps bandwidth

Suppose all 40 servers in a rack need to talk to a different server in the same rack. What is the bandwidth of each connection?

A. 100Gbps

B. 2.5Gbps

CLICKER QUESTION



40 servers per rack
100Gbps bandwidth

Suppose all 40 servers in one rack need to talk to the corresponding server in a different rack. What is the bandwidth of each connection?

A. 100Gbps
B. 2.5Gbps
C. It depends on where the two racks are physically

A RICHER INTERCONNECTION STRUCTURE

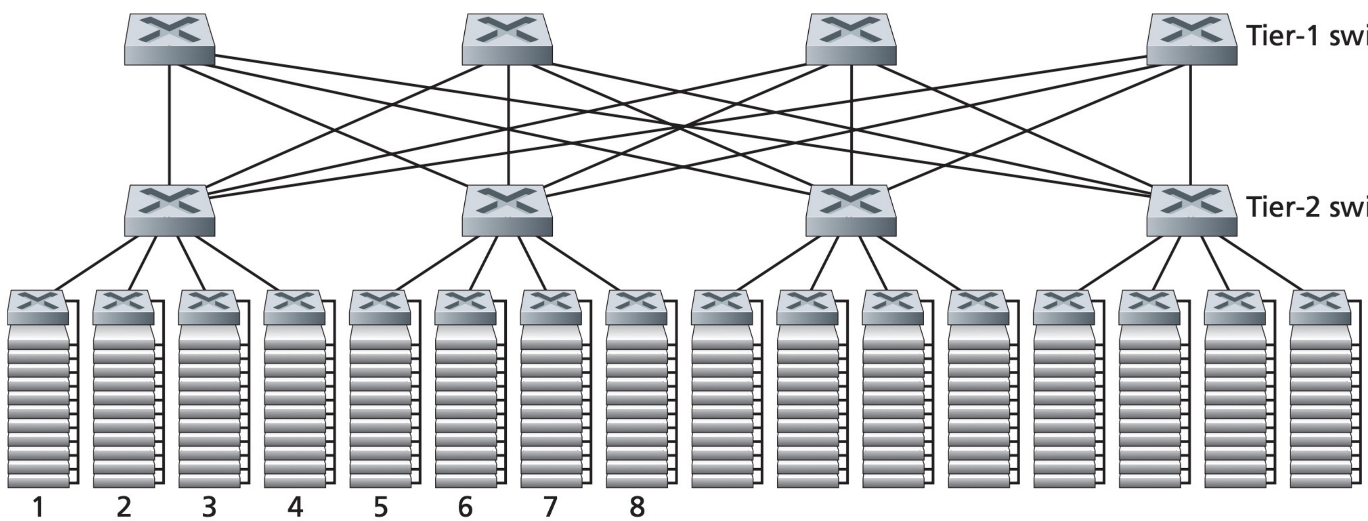


Figure 5.31 ♦ Highly-interconnected data network topology

A RICHER INTERCONNECTION STRUCTURE

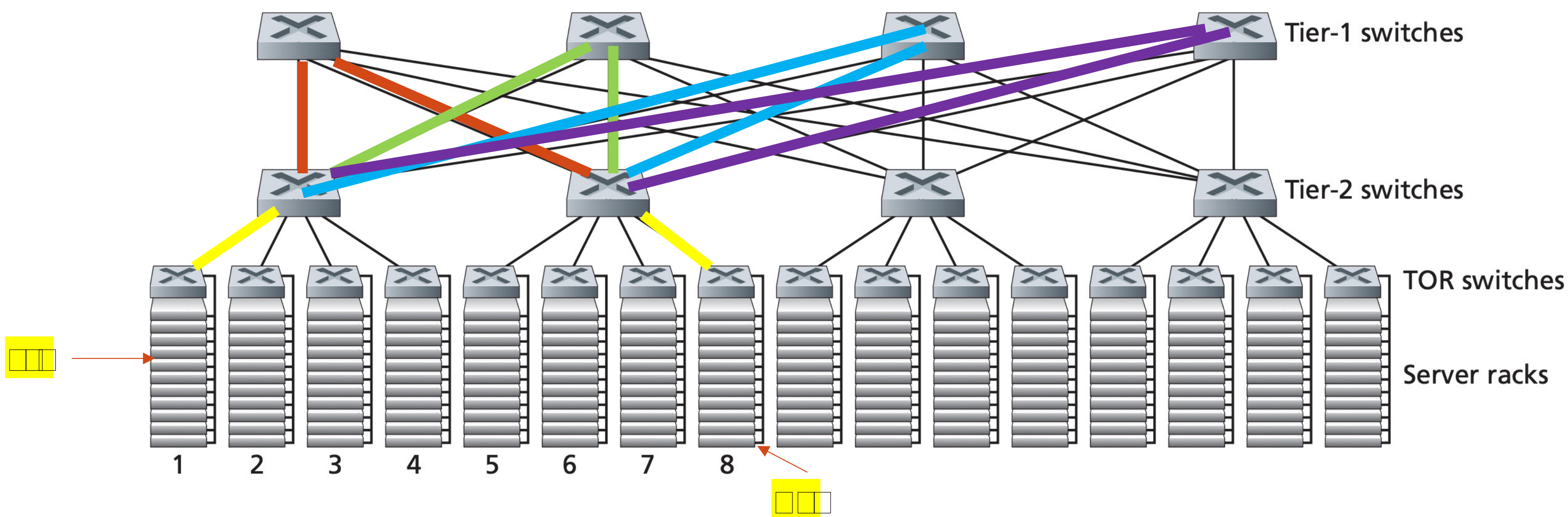


Figure 5.31 ♦ Highly-interconnected data network topology

IN-CLASS ACTIVITY

- None