CIS 375
CHAPTER 1

Introduction to Data Communications

Outline

- Why Networks are Important
- Basic Network Components
- Network Types
- Network Layers
- Network Standards
- Trends
- Implications for Management

Why Networks are Important

- Data, data, data!
- Modern organizations rely on the efficient transmission of data
- Enables distributed systems, real-time communication, electronic commerce, social media, and the Web

Three Fundamental Questions

1) How does the Internet work?

2) How do I design a network?

3) How do I manage my network to make sure it is secure and provides good performance?

Why Networks are Important

- By 2016, Cisco estimates that over 3,000 Petabytes of information will be transferred over the Internet **DAILY**!
- Netflix accounts for around **1/3** of primetime downstream traffic
- During the holiday 2013 season, Amazon sold an average of 426 items per **SECOND**!
- As of 2012, every **DAY** on Facebook there are:
  - 2.7 Billion Likes
  - 300 Million Photos uploaded
  - >500 Terabytes of data transmitted

Data Communications

- **Data Communications** is the movement of computer information from one point to another by means of electrical or optical transmission systems

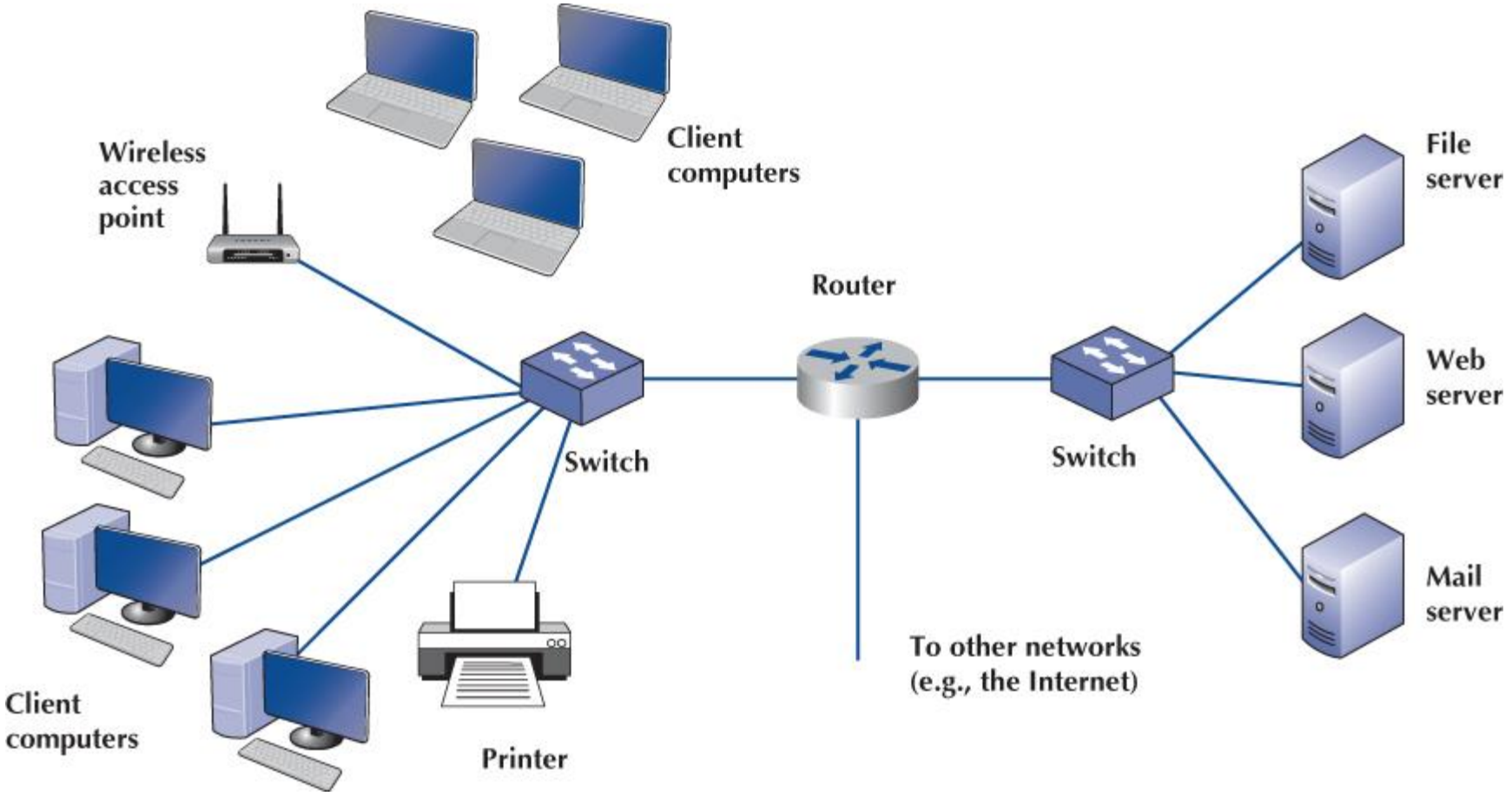
- **Telecommunications** is a broader term and includes the transmission of voice and video (images and graphics) as well as data and usually implies longer distances

Basic Network Components

- **Client** is a user device to access network and receive data from server
  - e.g., desktops, laptops, tablets, cell phones, etc.
- **Server** is a device that stores and transmits data to a client
  - e.g., Web server, mail server, file server
- **Circuit** is a pathway or connection between client and server
  - e.g., copper wire, fiber optic cable, wireless

Basic Network Components

FIGURE 1-1
Example of a local area network (LAN)

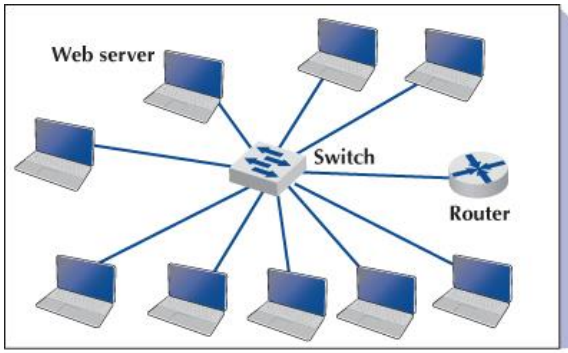


Types of Networks

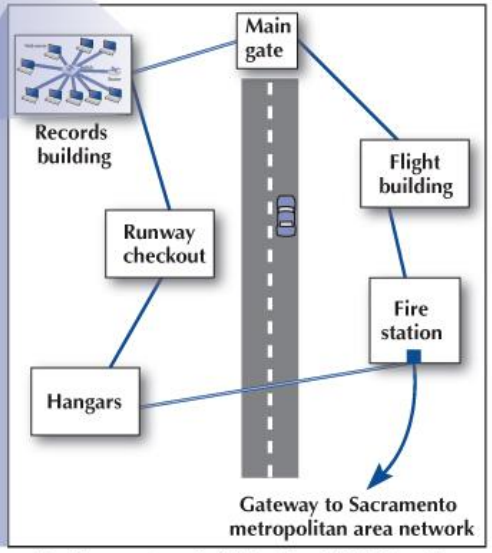
One way to categorize networks is in terms of geographic scope:

- **Local Area Networks (LANs)**
  - Covers a small, clearly defined area
  - Might contain a single floor or work area or single building
  - When LANs use wireless circuits, they are called Wireless Local Area Networks (WLAN)
- **Backbone Networks (BNs)**
  - High-speed networks connecting other networks together
  - May span hundreds of feet to several miles
- **Wide Area Networks (WANs)**
  - Largest geographic scope
  - Often composed of leased circuits
  - May spans hundreds or thousands of miles

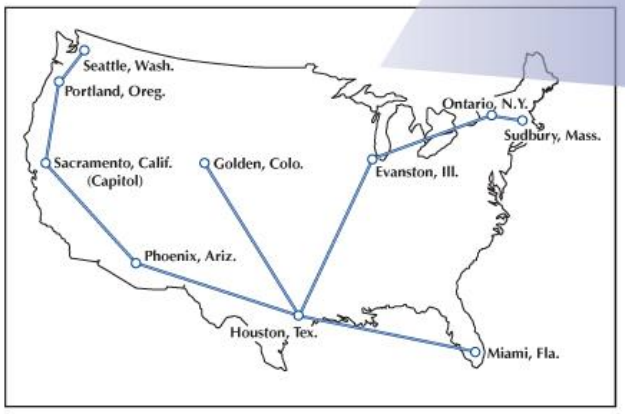
Types of Networks



Local area network (LAN) at the Records Building—one node of the McClellan Air Force Base backbone network (BN).



Backbone network (BN) at the McClellan Air Force Base—one node of the Sacramento metropolitan area network (MAN).



Wide area network (WAN) showing Sacramento connected to nine other cities throughout the United States.

FIGURE 1-2 The hierarchical relationship of a local area network (LAN) to a backbone network (BN) to a wide area network (WAN)

Types of Networks

Another way to categorize networks is in terms of access:

- **Intranet**
  - A network (often a LAN) that uses the Internet technologies to share information within an organization
  - Open only those inside the organization
  - e.g., employees accessing budgets, calendars, and payroll information available through the organization's intranet

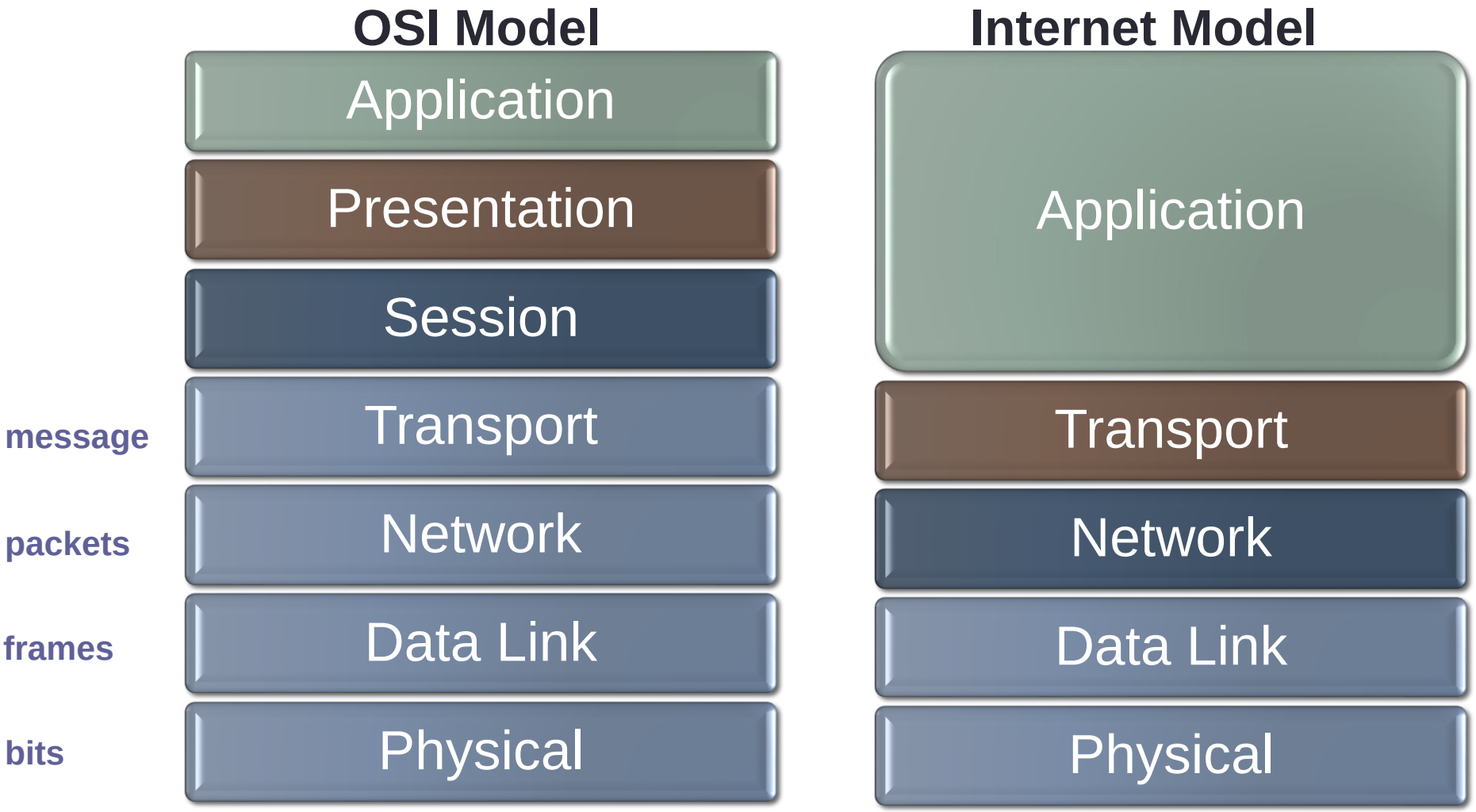
- **Extranet**
  - A network that uses the Internet technologies to share information between organizations
  - Open only those invited users outside the organization
  - Accessible through the Internet
  - e.g., suppliers and customers accessing the inventory information of a company over an extranet

Network Models

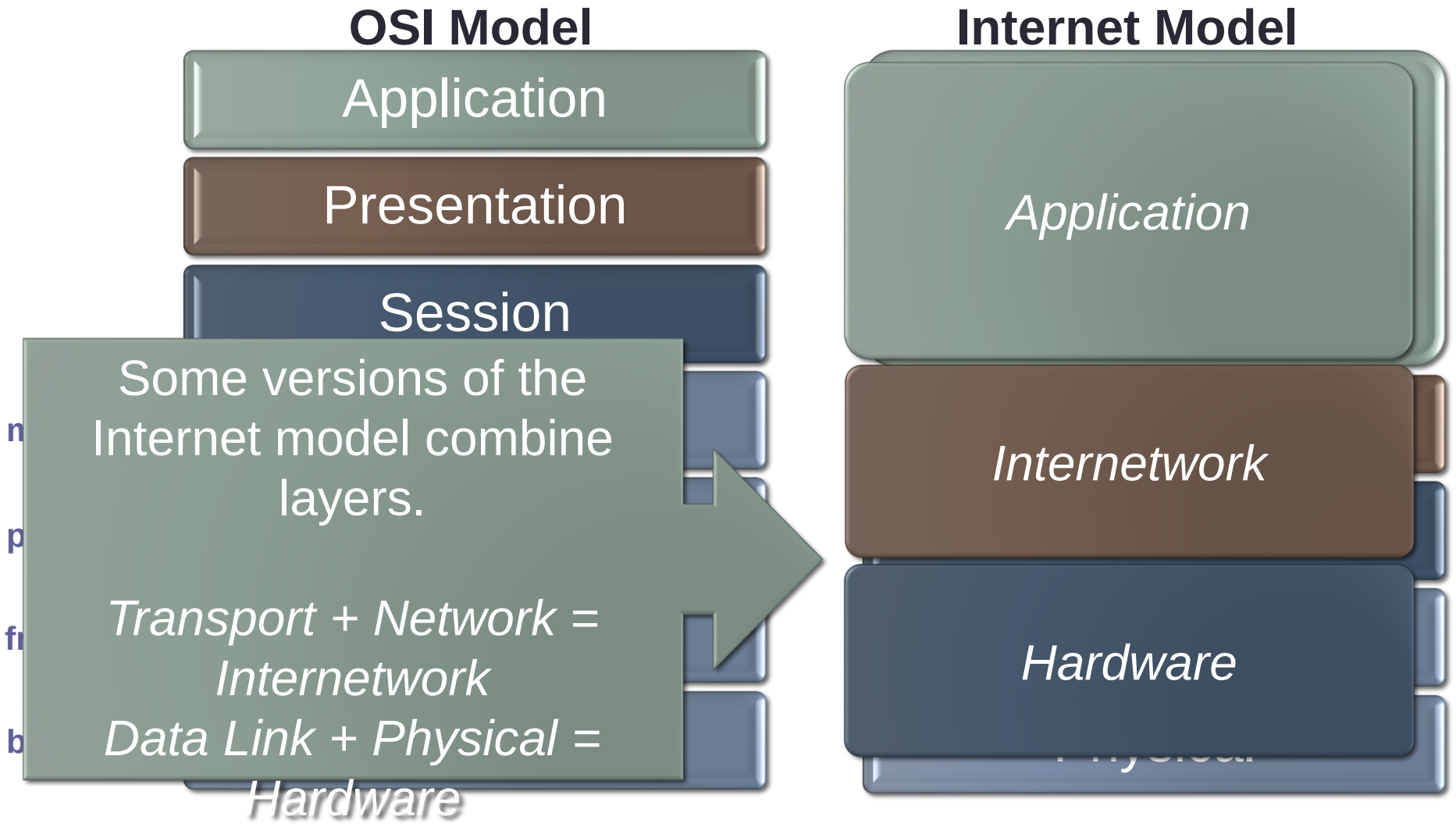
- **Network Models** divide communication functions into **layers**
  - Open Systems Interconnection Reference Model (OSI model)
  - Internet Model (or TCP/IP model)

- In practice, the Internet Model “won”

Network Models



Network Models

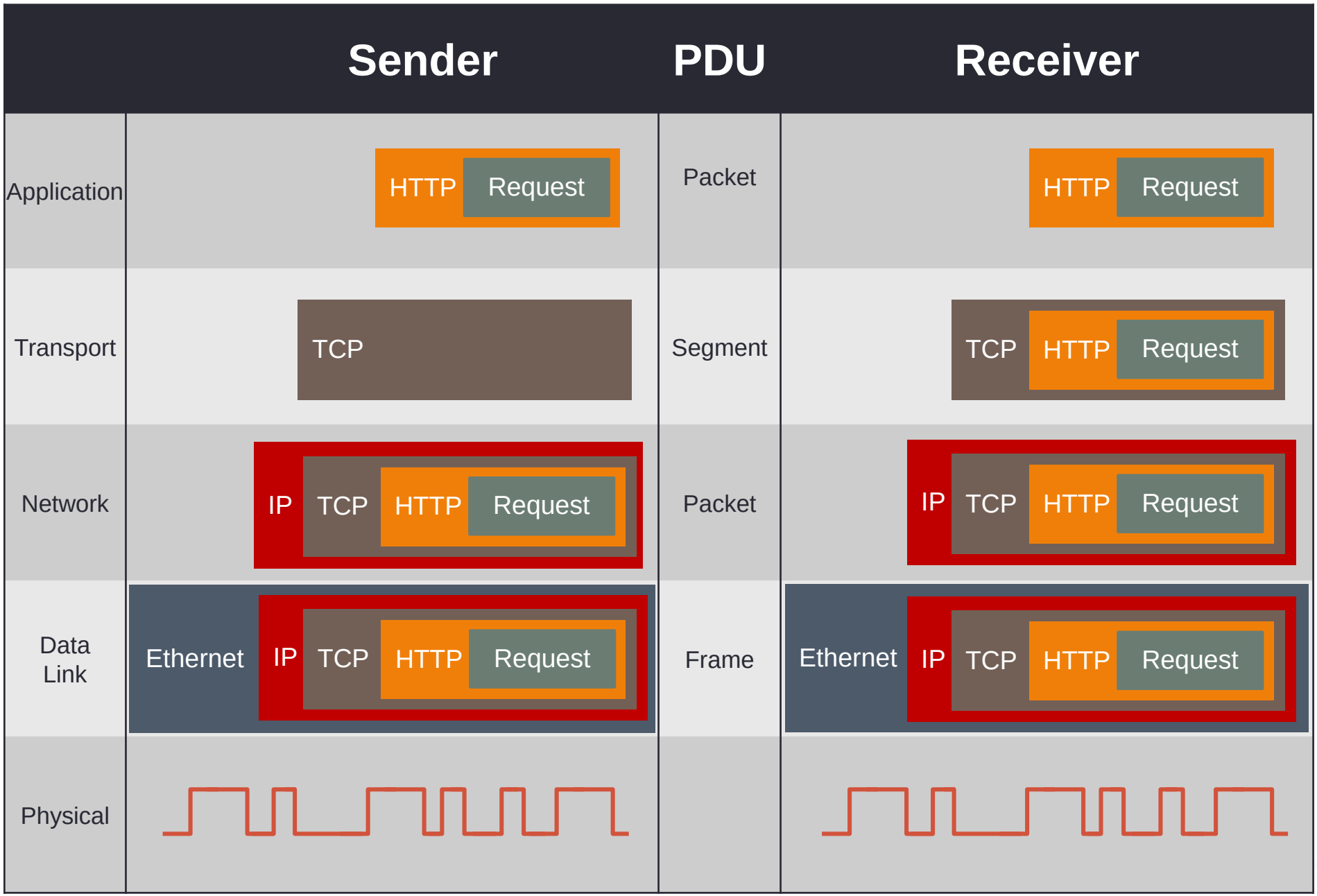


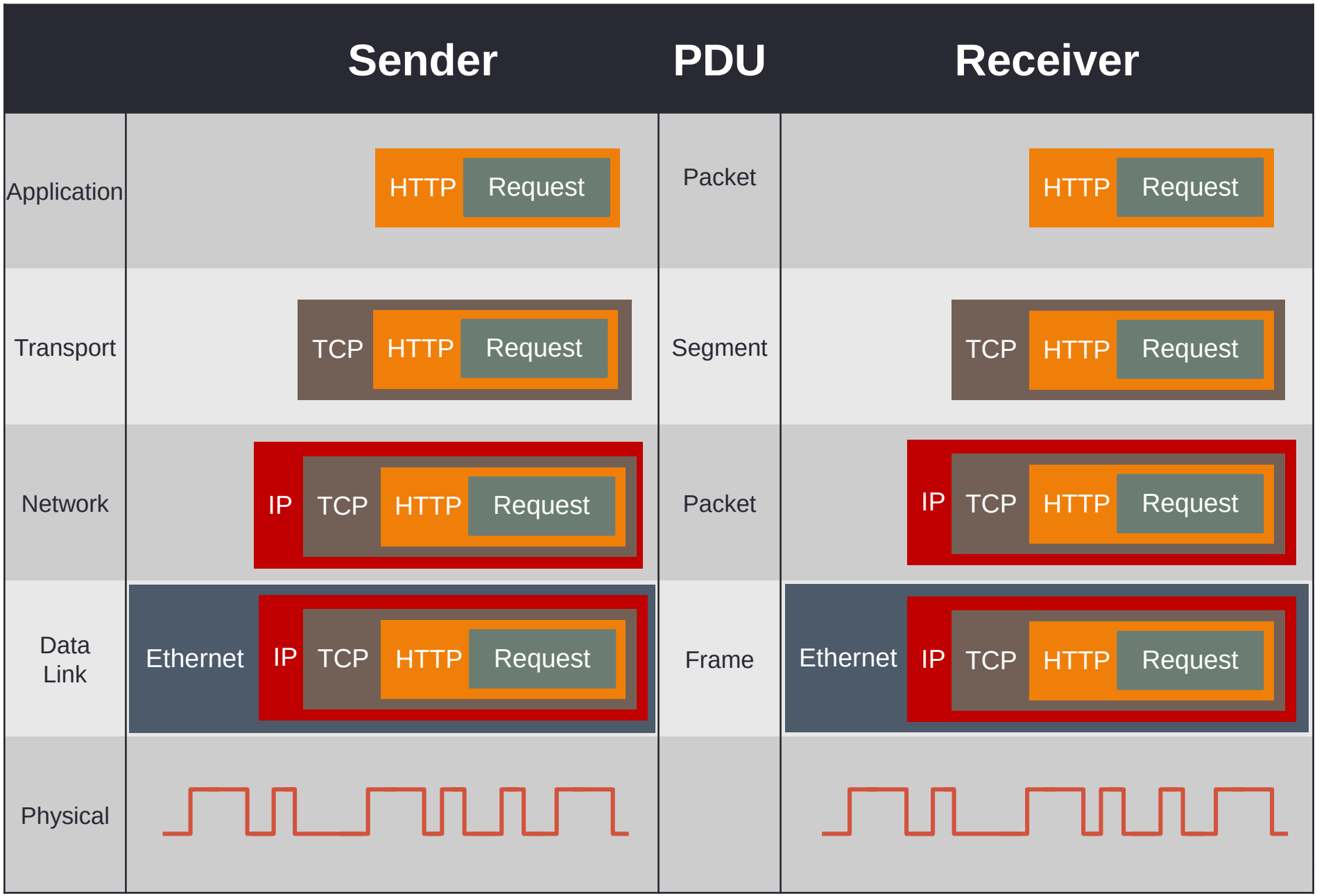
Network Models

- **Protocol** defines the language of transmission
  - It specifies the rules, functionality, and messages for communication at the layer
- **Protocol Data Unit (PDU)** contains layer-specific information necessary for a message to be transmitted through a network
  - Each layer adds a PDU
  - PDUs act like nested envelopes
  - **Encapsulation** occurs when a higher level PDU is placed inside of a lower level PDU

Network Models

Layer	Purpose	Example Protocols / Standards	PDU
5. Application	User's access to network, software to perform work	HTTP, SMTP, DNS, FTP, DHCP, IMAP, POP, SSL	Packet (or Data)
4. Transport	End-to-End Management 1. Link application layer to network 2. Segmenting and tracking 3. Flow control	TCP, UDP	Segment
3. Network	Deciding where the message goes 1. Addressing 2. Routing	IP, ICMP	Packet
2. Data Link	Move a message from one device to the next 1. Controls hardware 2. Formats the message 3. Error checking	Ethernet	Frame
1. Physical	Transmits the message	100BASE-T, 802.11n	


Sender
PDU
Receiver
Application
HTTP
Request
Packet
HTTP
Request
Transport
TCP
Segment
TCP
HTTP
Request
Network
IP
TCP
HTTP
Request
Packet
IP
TCP
HTTP
Request
Data Link
Ethernet
IP
TCP
HTTP
Request
Frame
Ethernet
IP
TCP
HTTP
Request
Physical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Request
Packet
IP
TCP
HTTP
Request
Data Link
Ethernet
IP
TCP
HTTP
Request
Frame
Ethernet
IP
TCP
HTTP
Request
Physical

Network Models

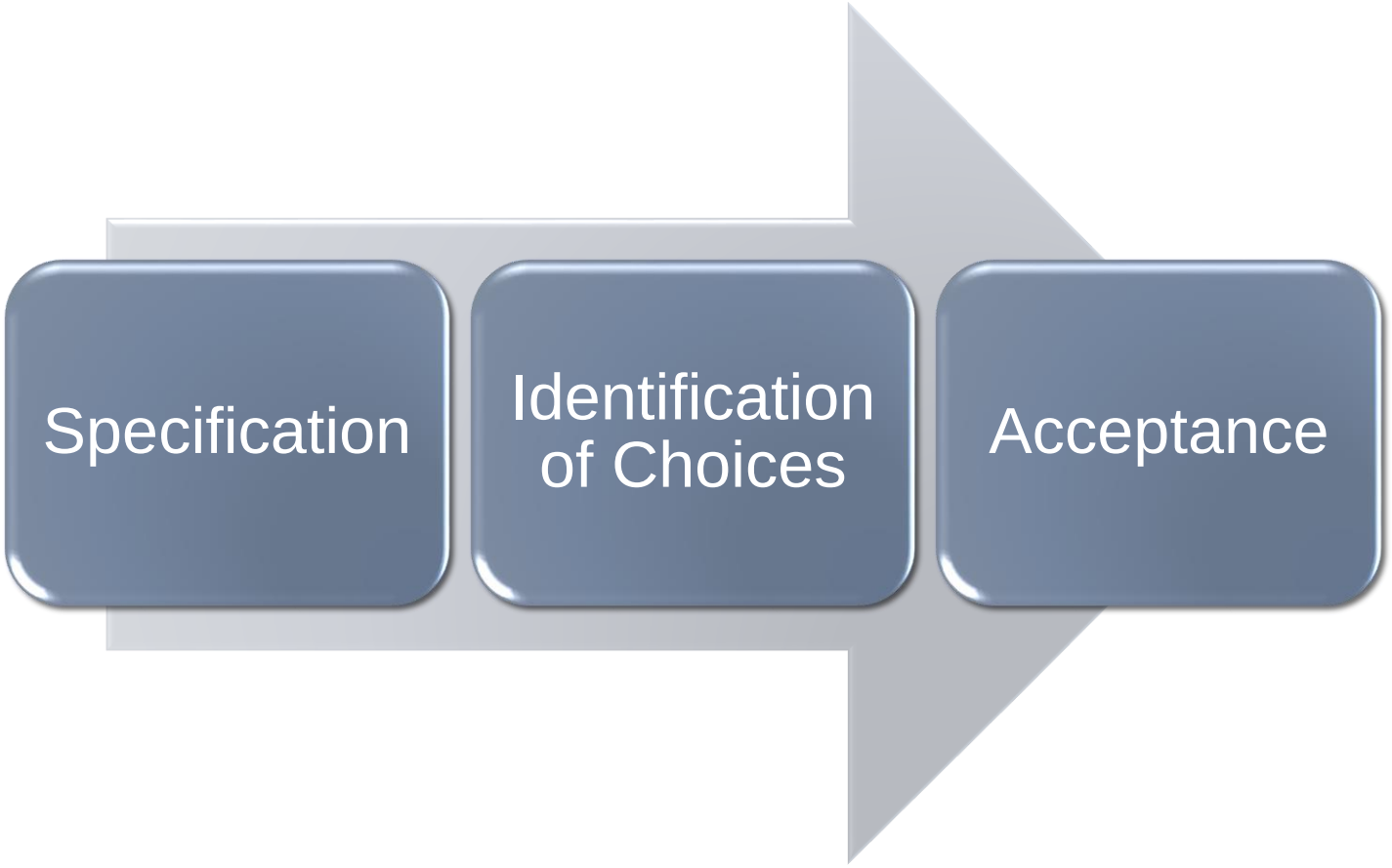
- Advantages of Layers
  - Networking functionality is modular and the software/hardware at any layer can be more easily substituted
    - E.g., substitute wired for wireless at the physical layer
  - Easier to troubleshoot or make changes to one layer at a time
  - Application developers only need to worry about the application layer in their programs
- Disadvantages of Layers
  - Inefficient because the encapsulation/de-encapsulation at each layer requires processing
  - Inefficient because encapsulation in a PDU increases overhead at each layer

Network Standards

- Standards ensure that hardware and software from different vendors work together and “speak the same language”
- De jure standards
  - Formalized by an industry or government body
  - e.g. HTTP, IEEE 802.3, 802.11n
- De facto standards
  - Widely accepted, but not formalized
  - e.g. Microsoft Windows
  - Often become de jure standards eventually

Network Standards

- De jure standardization process



Network Standards

- Common Network Standards

FIGURE 1-5

Some common data communications standards. HTML = Hypertext Markup Language; HTTP = Hypertext Transfer Protocol; IMAP = Internet Message Access Protocol; IP = Internet Protocol; LAN = local area network; MPEG = Motion Picture Experts Group; POP = Post Office Protocol; TCP = Transmission Control Protocol

Layer	Common Standards
5. Application layer	HTTP, HTML (Web) MPEG, H.323 (audio/video) SMTP, IMAP, POP (email)
4. Transport layer	TCP (Internet and LANs)
3. Network layer	IP (Internet and LANs)
2. Data link layer	Ethernet (LAN) Frame relay (WAN) T1 (MAN and WAN)
1. Physical layer	RS-232C cable (LAN) Category 5 cable (LAN) V.92 (56 Kbps modem)

Trends

- Bring your own device (BYOD)
  - Huge demand for employees to connect their personal smartphones, tablets, and other devices to organizational networks
  - Security challenges
  - Who is responsible for support?

Trends

- The Web of Things (or the Internet of Things – IOT)
  - Everything connects to the network!
    - e.g., cars, refrigerators, thermostats, shoes, doors, etc.
  - Self-driving cars
  - Networks need to support the increased demands of these devices

Trends

- Massively Online
  - Not just multiplayer online games
  - Massive open online courses (MOOC)
    - Khan Academy
    - Lynda.com
    - Code Academy
  - Millions online participating is social media and other activities
    - Coursera, EdX
  - Will require greater network infrastructure

Implications for Management

- Networks and the Internet change (almost) everything
- Today's networking is driven by standards
- As network demand increases, so will storage demands
  - "Cloud Computing"

Hands-on Activity 1B

- Page 23-25
- Use Wireshark to capture and analyze packets
- Deliverables:

  1) List the PDU at layers 2, 3, and 4 that were used to transmit your HTTP GET packet

  2) How many different HTTP GET packets were sent by your browser?

  3) List at least five other protocols that Wirehark displayed in the Packet List window.