EEEN3008J: Advance wireless communications

Communication Networks

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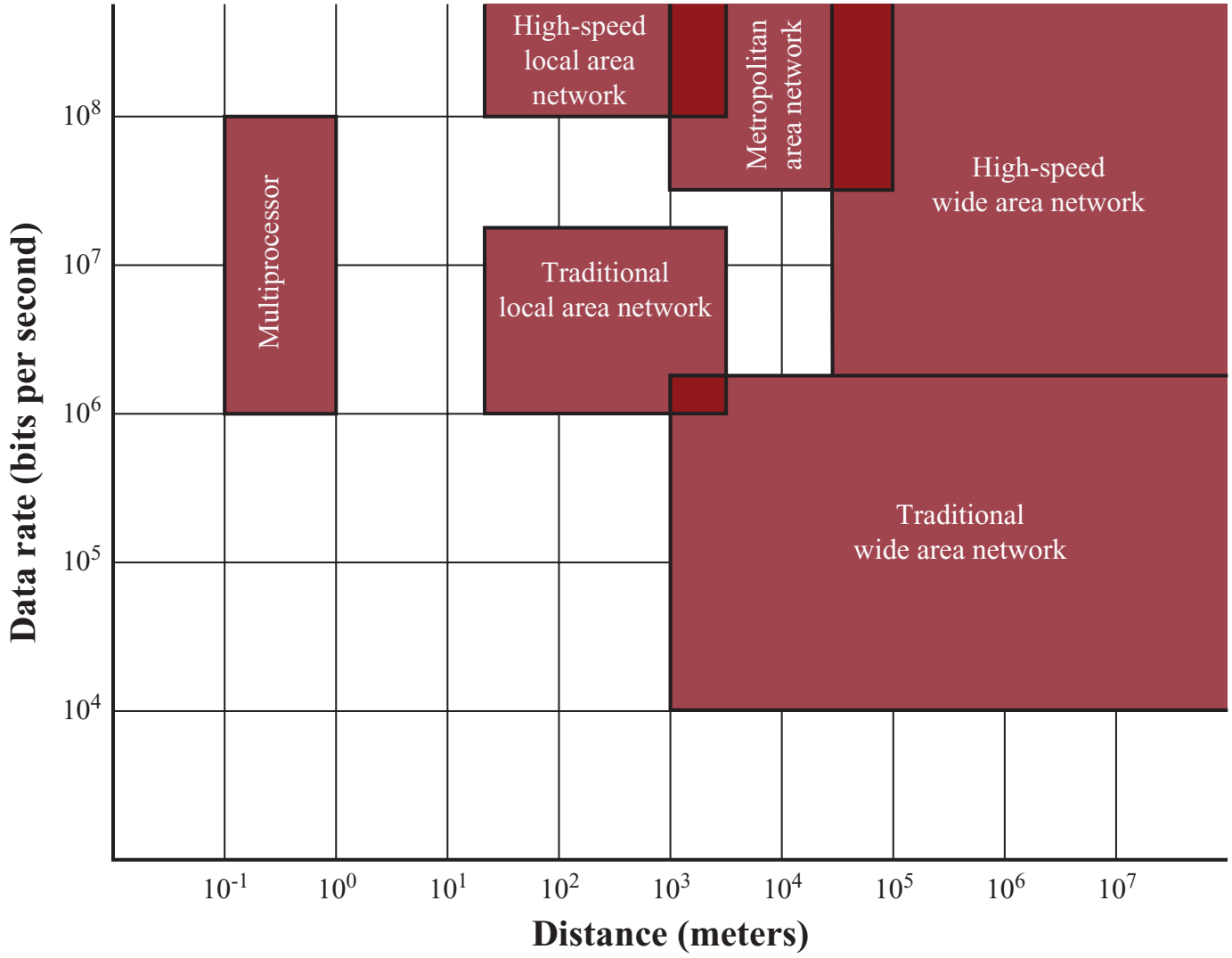
Distance and Data rate comparison of different systems

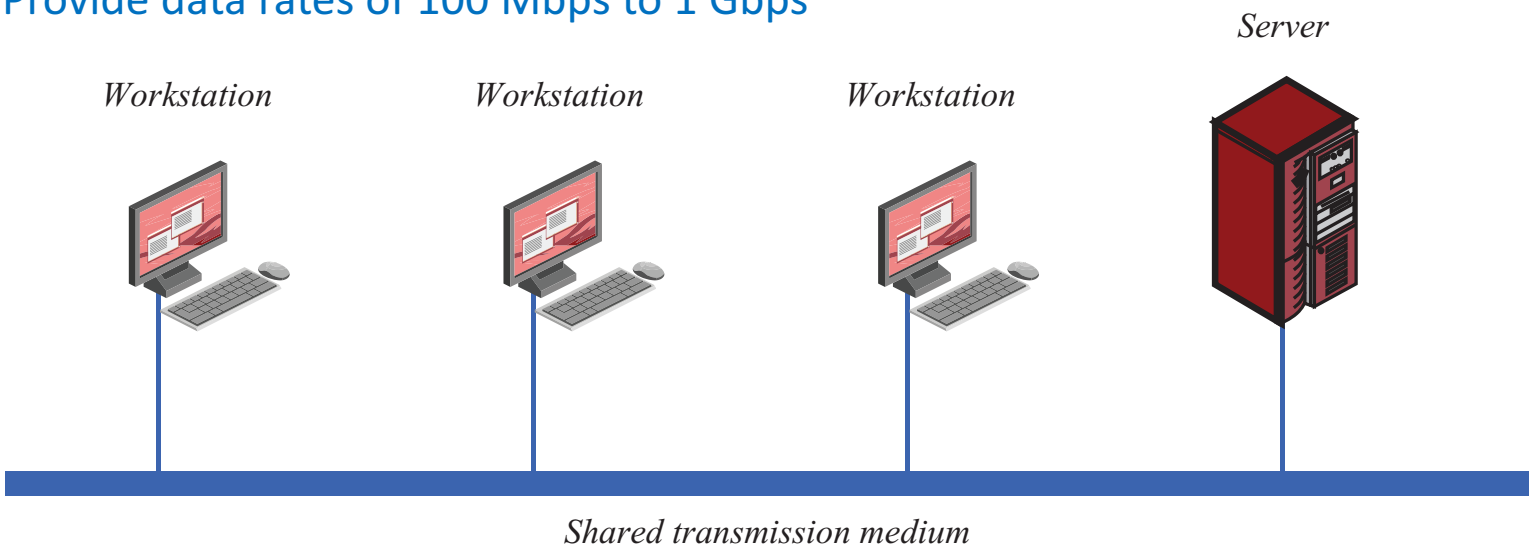


Characteristics of WANs

- Covers large geographical areas
- Circuits provided by a common carrier
- Consists of interconnected switching nodes
- Traditional WANs provided modest capacity
- Higher-speed WANs use optical fiber and transmission technique known as asynchronous transfer mode (ATM)
  - 10s and 100s of Mbps common

Characteristics of LANs

- Like WAN, LAN interconnects a variety of devices and provides a means for information exchange among them
- Traditional LANs
  - Provided data rates of 1 to 20 Mbps
- High-speed LANS
  - Provide data rates of 100 Mbps to 1 Gbps

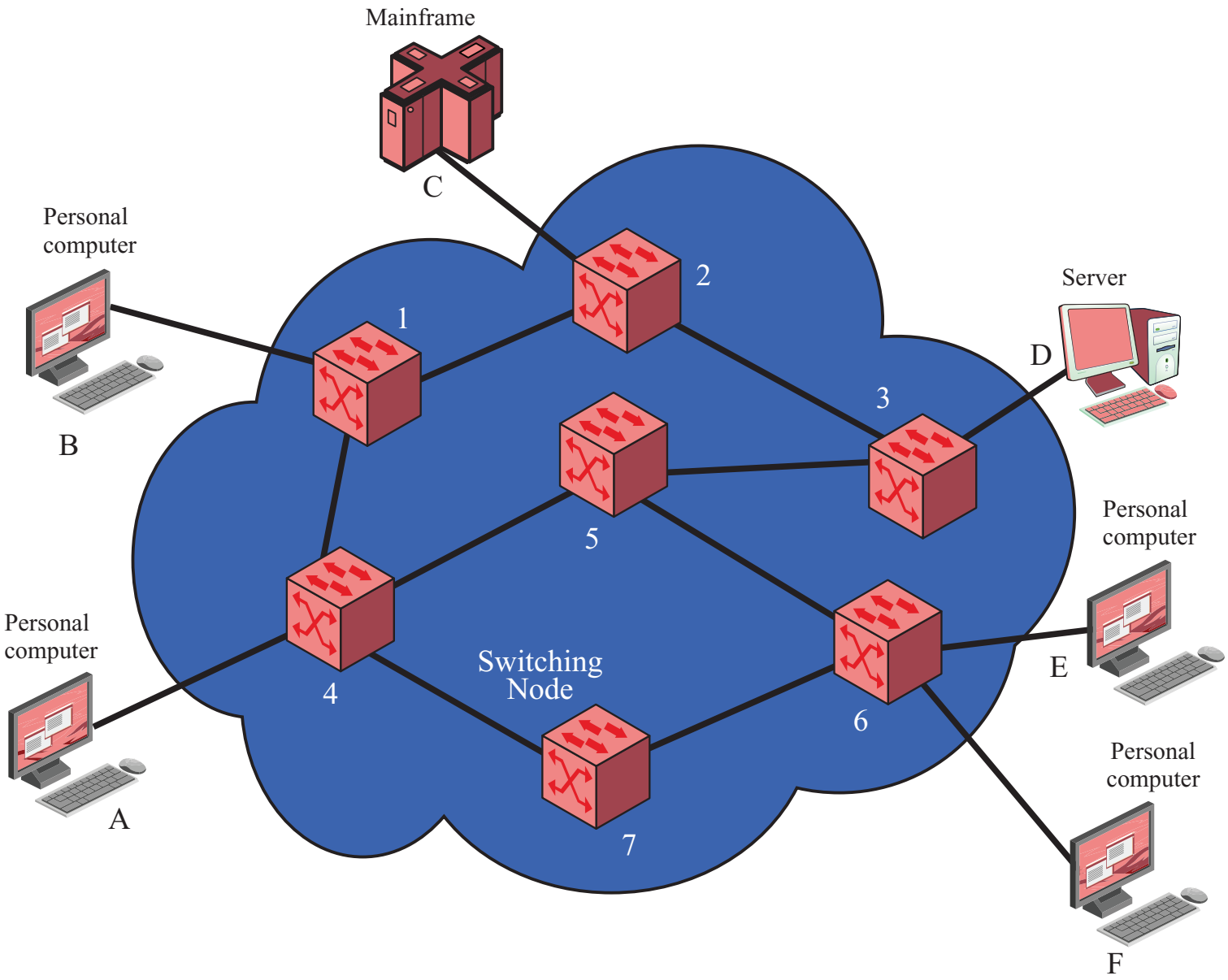


Differences between WANs and LANs

- Scope of a LAN is smaller
  - LAN interconnects devices within a single building or cluster of buildings
- LAN usually owned by the organization that owns the attached devices
  - For WANs, most of network assets are not owned by same organization
- Internal data rate of LAN is much greater

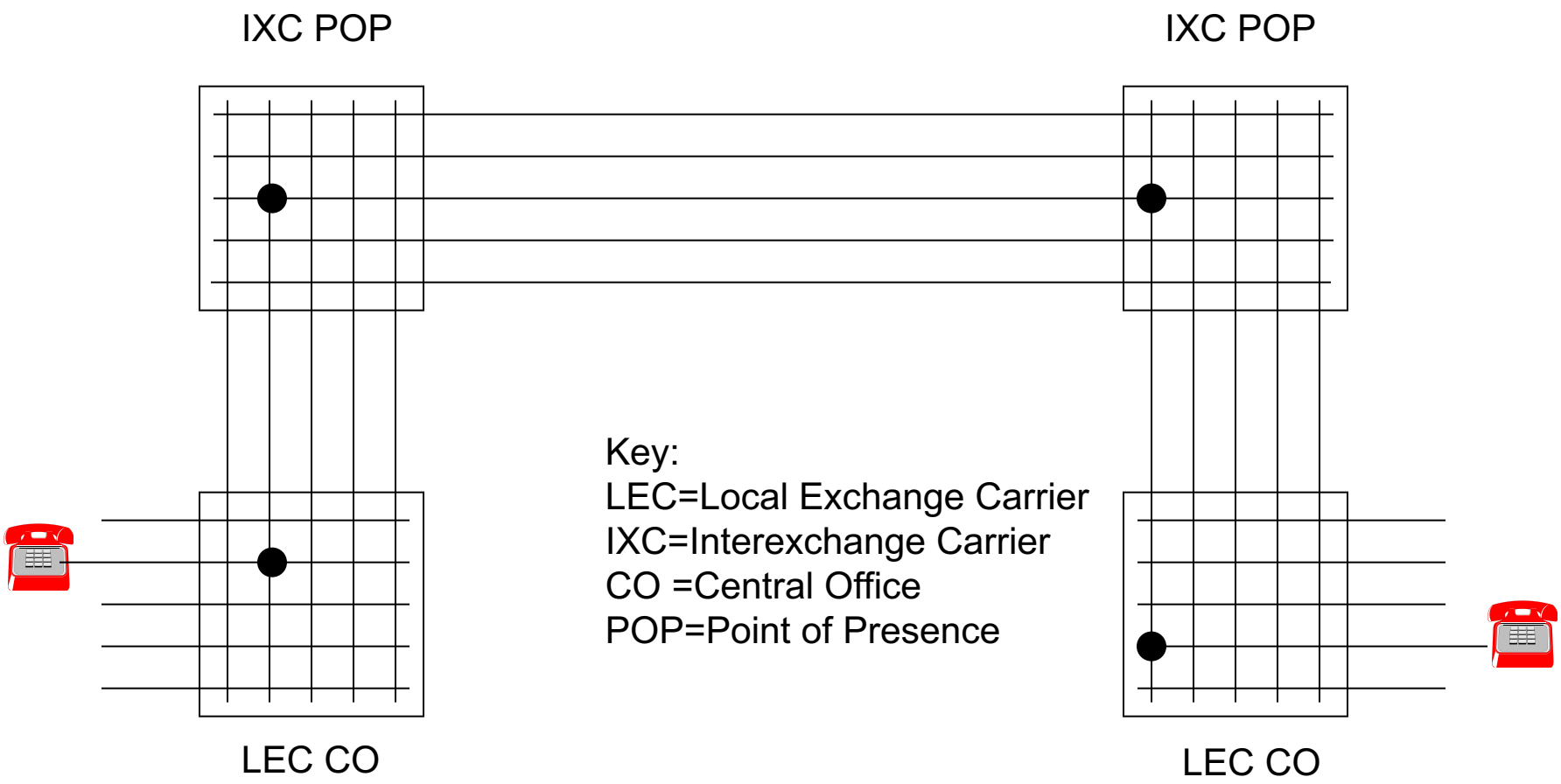
Switching Terms

- Switching Nodes:
  - Intermediate switching device that moves data
  - Not concerned with content of data
- Stations:
  - End devices that wish to communicate
  - Each station is connected to a switching node
- Communications Network:
  - A collection of switching nodes


Mainframe
C
Personal computer
B
Server
D
Personal computer
E
Personal computer
A
Personal computer
F
Switching Node
1
2
3
4
5
6
7

Techniques Used in Switched Networks

- Circuit switching
  - Dedicated communications path between two stations
  - E.g., public telephone network
- Packet switching
  - Message is broken into a series of packets
  - Each node determines next leg of transmission for each packet


IXC POP
IXC POP
Key:
LEC=Local Exchange Carrier
IXC=Interexchange Carrier
CO =Central Office
POP=Point of Presence
LEC CO
LEC CO

Phases of Circuit Switching

- Circuit establishment
  - An end to end circuit is established through switching nodes
- Information Transfer
  - Information transmitted through the network
  - Data may be analog voice, digitized voice, or binary data
- Circuit disconnect
  - Circuit is terminated
  - Each node deallocates dedicated resources

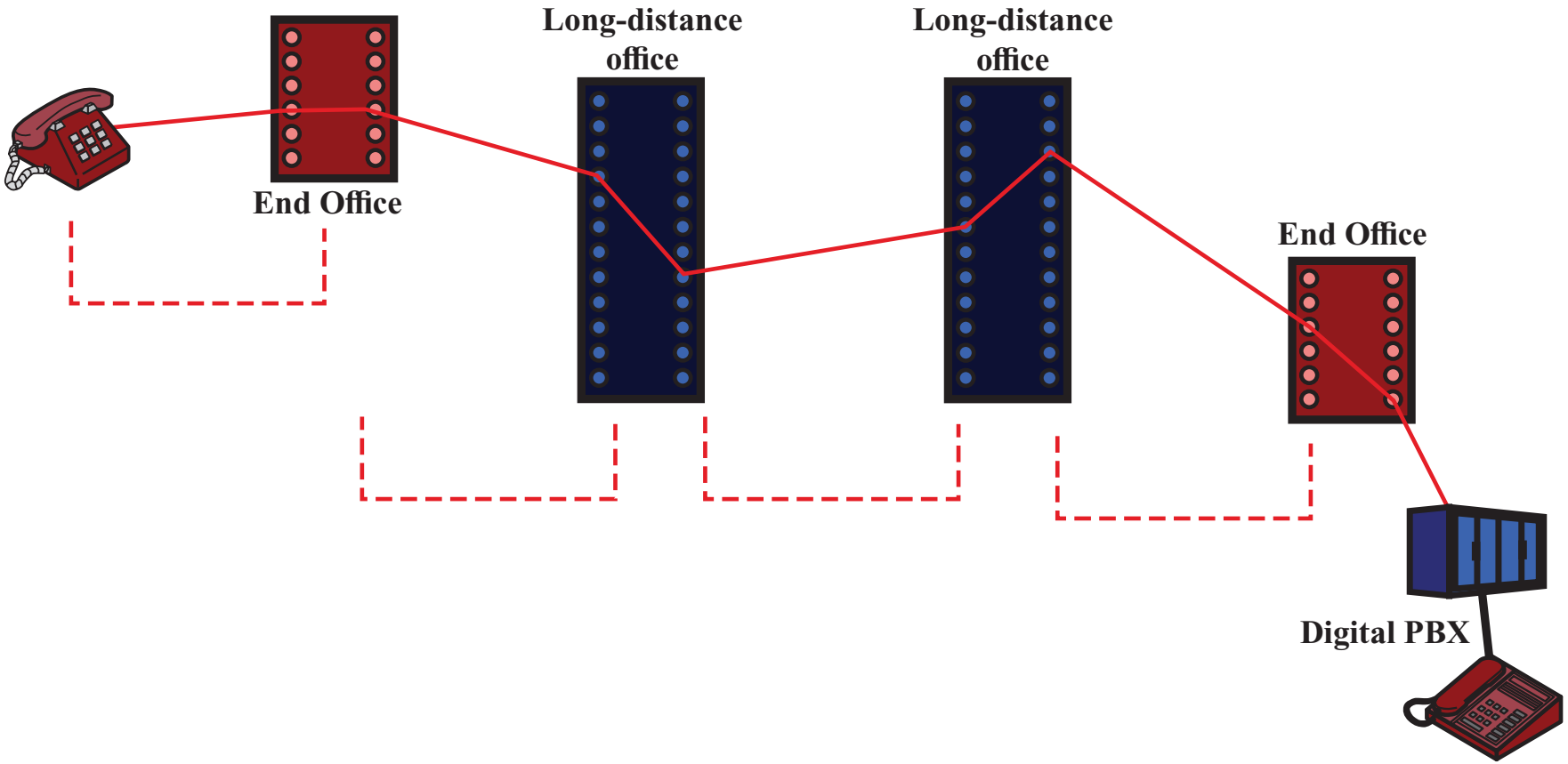
Characteristics of Circuit Switching

- Can be inefficient
  - Channel capacity dedicated for duration of connection
  - Utilization not 100%
  - Delay prior to signal transfer for establishment
- Once established, network is transparent to users
- Information transmitted at fixed data rate with only propagation delay

Components of Public Telecommunications Network

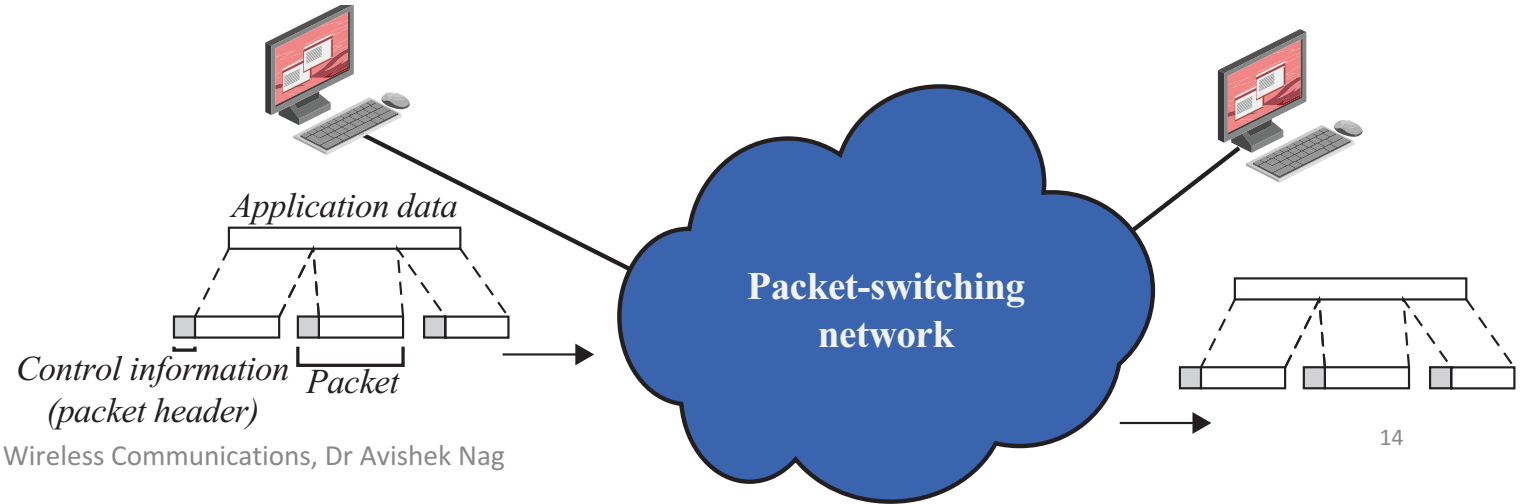
- Subscribers - devices that attach to the network; mostly telephones
- Subscriber line - link between subscriber and network
  - Also called subscriber loop or local loop
- Exchanges - switching centers in the network
  - A switching center that support subscribers is an end office
- Trunks - branches between exchanges

Example Connection Over a Public Circuit-Switching Network



How Packet Switching Works

- Data is transmitted in blocks, called packets
- Before sending, the message is broken into a series of packets
  - Typical packet length is 1000 octets (bytes)
  - Packets consists of a portion of data plus a packet header that includes control information
- At each node in route, packet is received, stored briefly and passed to the next node



Packet Switching Advantages

- Line efficiency is greater
  - Many packets over time can dynamically share the same node to node link
- Packet-switching networks can carry out data-rate conversion
  - Two stations with different data rates can exchange information
- Unlike circuit-switching networks that block calls when traffic is heavy, packet-switching still accepts packets, but with increased delivery delay
- Priorities can be used

Disadvantages of Packet Switching

- Each packet switching node introduces a delay
- Overall packet delay can vary substantially
  - This is referred to as jitter
  - Caused by differing packet sizes, routes taken and varying delay in the switches
- Each packet requires overhead information
  - Includes destination and sequencing information
  - Reduces communication capacity
- More processing required at each node

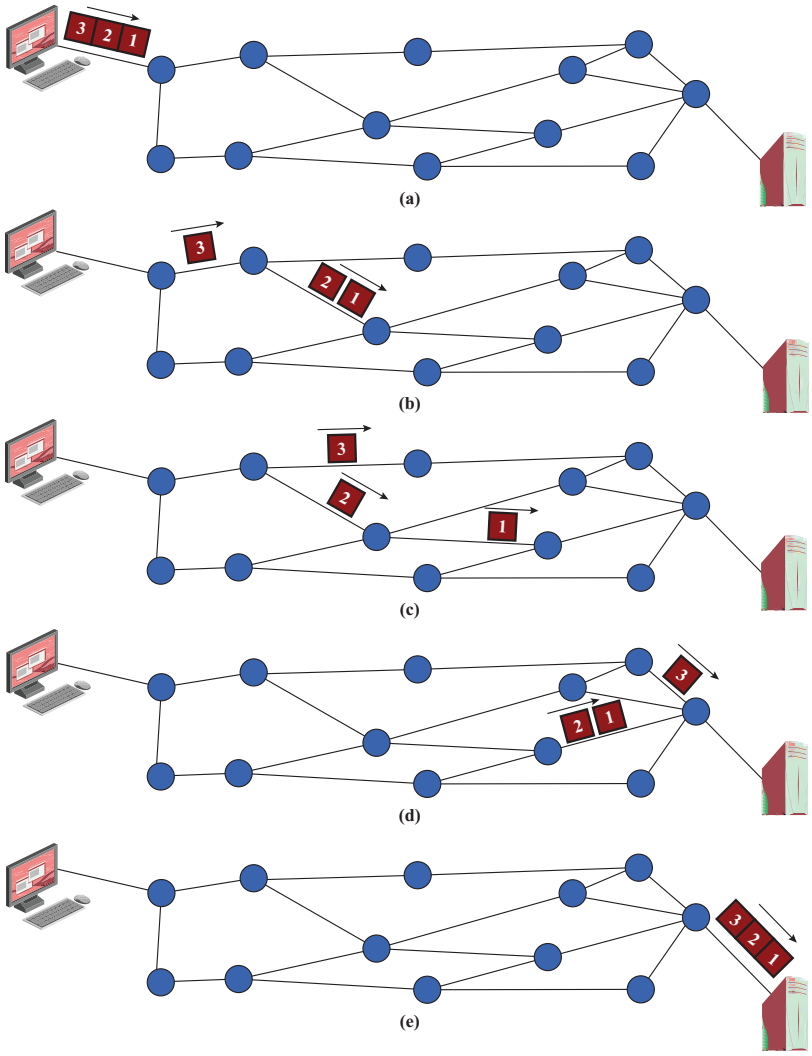
Packet Switching Networks – Datagram

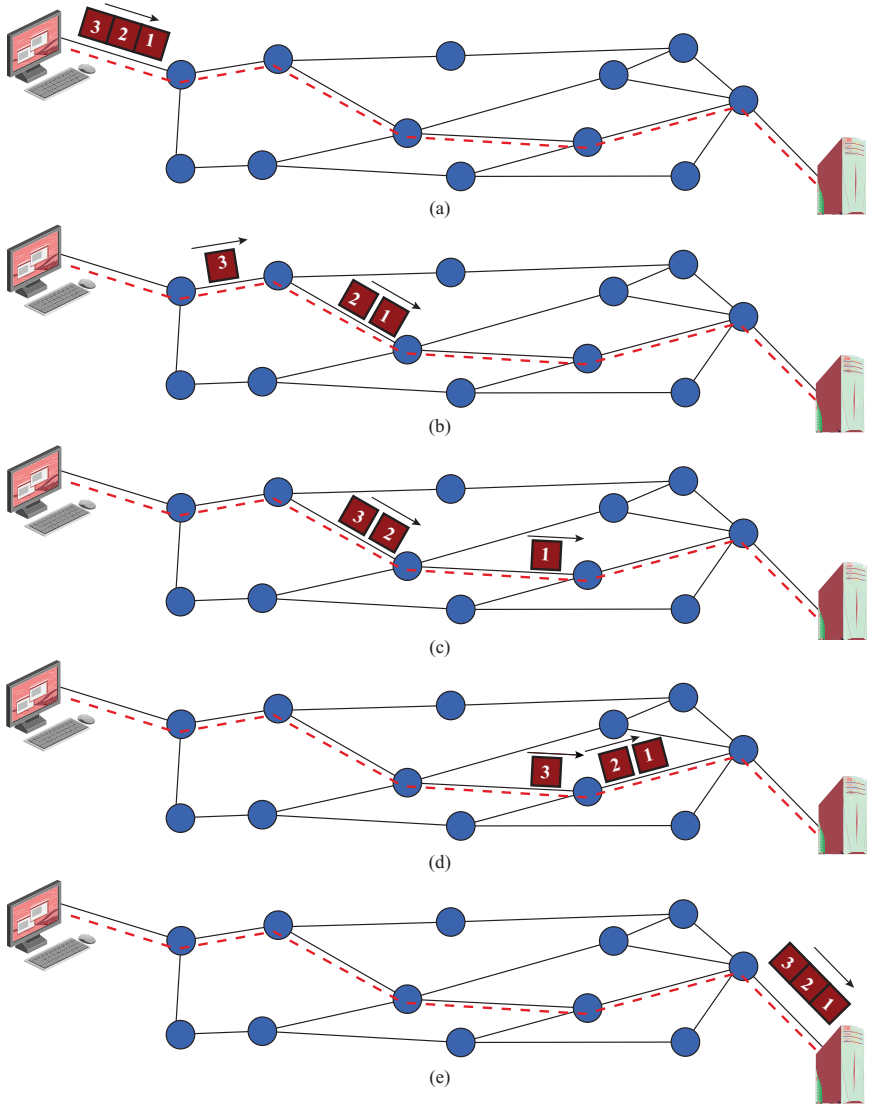
- Each packet treated independently, without reference to previous packets
- Each node chooses next node on packet's path
- Packets don't necessarily follow same route and may arrive out of sequence
- Exit node restores packets to original order
- Responsibility of exit node or destination to detect loss of packet and how to recover
- **Advantages:**
  - Call setup phase is avoided
  - Because it's more primitive, it's more flexible
  - Datagram delivery is more reliable

Packet Switching Networks – Virtual Circuit

- Preplanned route established before packets sent
- All packets between source and destination follow this route
- Routing decision not required by nodes for each packet
- Emulates a circuit in a circuit switching network but is not a dedicated path
  - Packets still buffered at each node and queued for output over a line
- **Advantages:**
  - Packets arrive in original order
  - Packets arrive correctly
  - Packets transmitted more rapidly without routing decisions made at each node

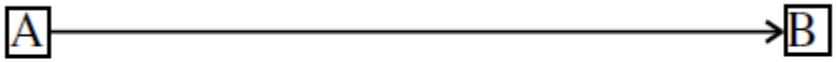
Packet switching Datagram vs Virtual circuit approach





Data transmission modes

- *Simplex*
  - ✓ communication takes place in one direction (rarely used for data communication)
  - ✓ example: TV broadcast

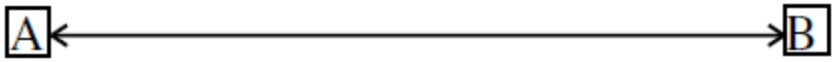


Simplex A to B only

- *Half-duplex*
  - ✓ communication takes place in both directions, but only in one direction at the time
  - ✓ such kind of line can alternately send and receive data
  - ✓ example: walkie-talkie

Half-Duplex A to B or B to A

- *Full-duplex*
  - ✓ communication takes place in both directions at the same time
  - ✓ example: telephone line



Full-Duplex A to B and B to A

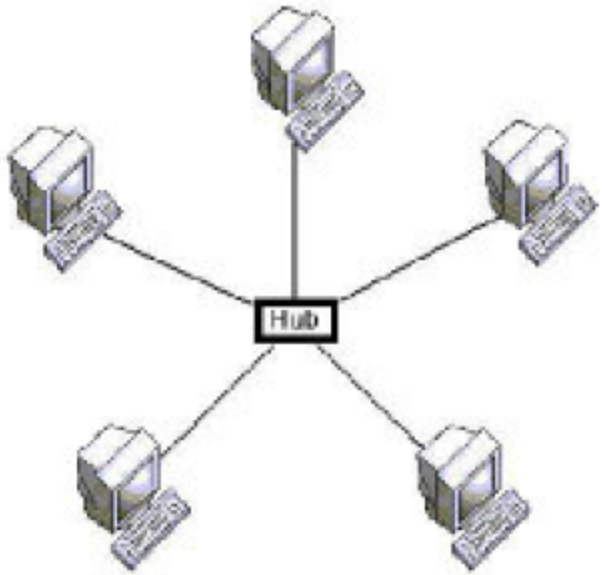
Question: Do we have real full-duplex?

Network topologies

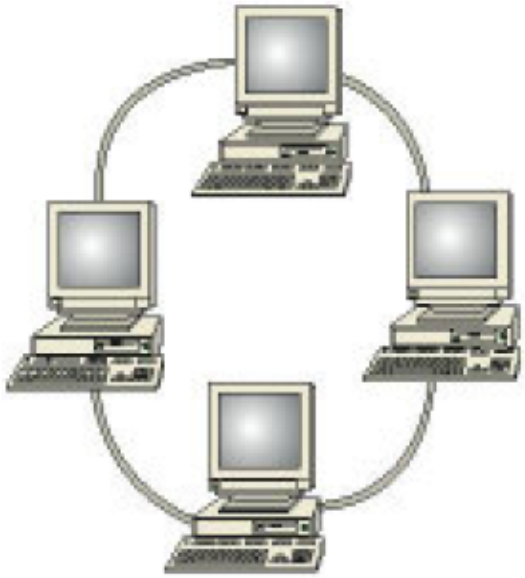
- *Topology* = geometric arrangement of network's nodes

- Common topologies include
  - ✓ star
  - ✓ ring
  - ✓ bus

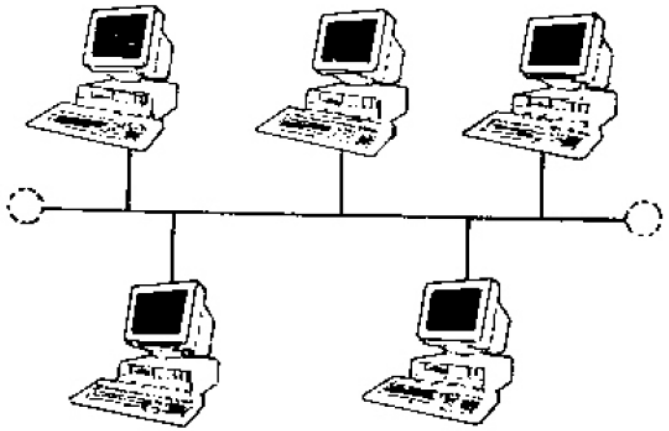
- *Star* network
  - ✓ used to connect small computers or peripheral devices to a large host computer or CPU
  - ✓ *time-sharing* so that several users can share a central processor



- *Ring* network
  - ✓ all nodes connected in a closed loop
  - ✓ nodes wait for a *token* before they transmit
  - ✓ messages travel around the ring, and each node reads those messages addressing it
  - ✓ span large distance (each node regenerates messages as they pass through it)



- *Bus* network
  - ✓ similar to ring network, but ends are not connected
  - ✓ all communications carried on a common cable/bus, and are thus available to each network's node
  - ✓ contention
    - ❖ if a line unused, device can transmit its message at will
    - ❖ if more terminals initiate messages simultaneously, they must stop and tx again at different times



Network architecture

- Architecture
  - ✓ defines the broad outlines of a system
  - ✓ Open vs. closed
    - *open* architecture
      - uses off-the-shelf components
      - conforms to approved standards
    - *closed* architecture
      - its design is proprietary (making it difficult to connect the system to other systems)
  - ✓ Peer-to-peer vs. Client/Server

❑*Peer-to-peer*

✓ each network's node has equivalent capabilities and responsibilities

✓ simple, cheap, low performance under heavy loads

❑ *Client/Server*

- ✓ each network's node is either a client or a server
- ✓ *server* = powerful computer dedicated to management (e.g., those managing network traffic are called *network servers*)
- ✓ client = less powerful computers on which users run applications
- ✓ clients rely on servers for resources, e.g., files, devices, processing power
- ✓ complex, expensive, high performance under heavy loads

Quality of Service

- Voice, Audio, and Video Traffic
  - Requirements
    - Steady delivery
    - Bounds on delay, delay variation, and minimal throughput
    - Some packet loss is acceptable
  - Types
    - Streaming live video – such as a live sporting event
    - Streaming stored video – such as Netflix, that uses buffering
    - Video conferencing – interactive and has additional requirements for round-trip delay

Quality of service

- Data Traffic
  - –Requirements
    - ➢Eventual error-free delivery
      - ❖After retransmissions
    - ➢More desirable the higher the throughput
    - ➢Elastic
      - ❖Some variation in throughput is acceptable during a transmission
  - –Types
    - ➢Interactive – such as transactions or web page interactions
    - ➢Non-interactive – background downloads of files or email

Provisioning of QoS

- Overprovisioning
  - High data rates and low congestion
  - No prioritization
  - All traffic proceeds virtually unimpeded
  - Only practical in wireless systems that have abundant bandwidth
- Prioritization without guarantees
  - Some packets marked as higher priority
  - Admission control processes are used to identify users and flows that should receive this priority
  - Various markings are used for different technologies (e.g., LTE, WiMAX)
- Prioritization with guarantees
  - Packets are tracked
  - Given numerical bounds on performance
  - Admission control also important here

Protocols

Communication protocols

- A *communications protocol* is a system of digital message formats, and rules for exchanging those messages

- Data communication protocols perform the following functions for *efficient* and *error free* transmission of data

  - ✓ *data sequencing:* a long message to be transmitted is broken into smaller packets of fixed size aiming towards error free data transmission

  - ✓ *data routing*: find the most efficient route between source and destination, before sending the data

- Data communication protocols perform the following functions for *efficient* and *error free* transmission of data

  - ✓ *flow control:* not all machines have same speed ➔ regulate process of sending data between fast sender and slow receiver

  - ✓ *error control*: error detecting and recovering ensures that data are transmitted without any error

Key Features of a Protocol

- Syntax
  - Concerns the format of the data blocks
- Semantics
  - Includes control information for coordination and error handling
- Timing
  - Includes speed matching and sequencing

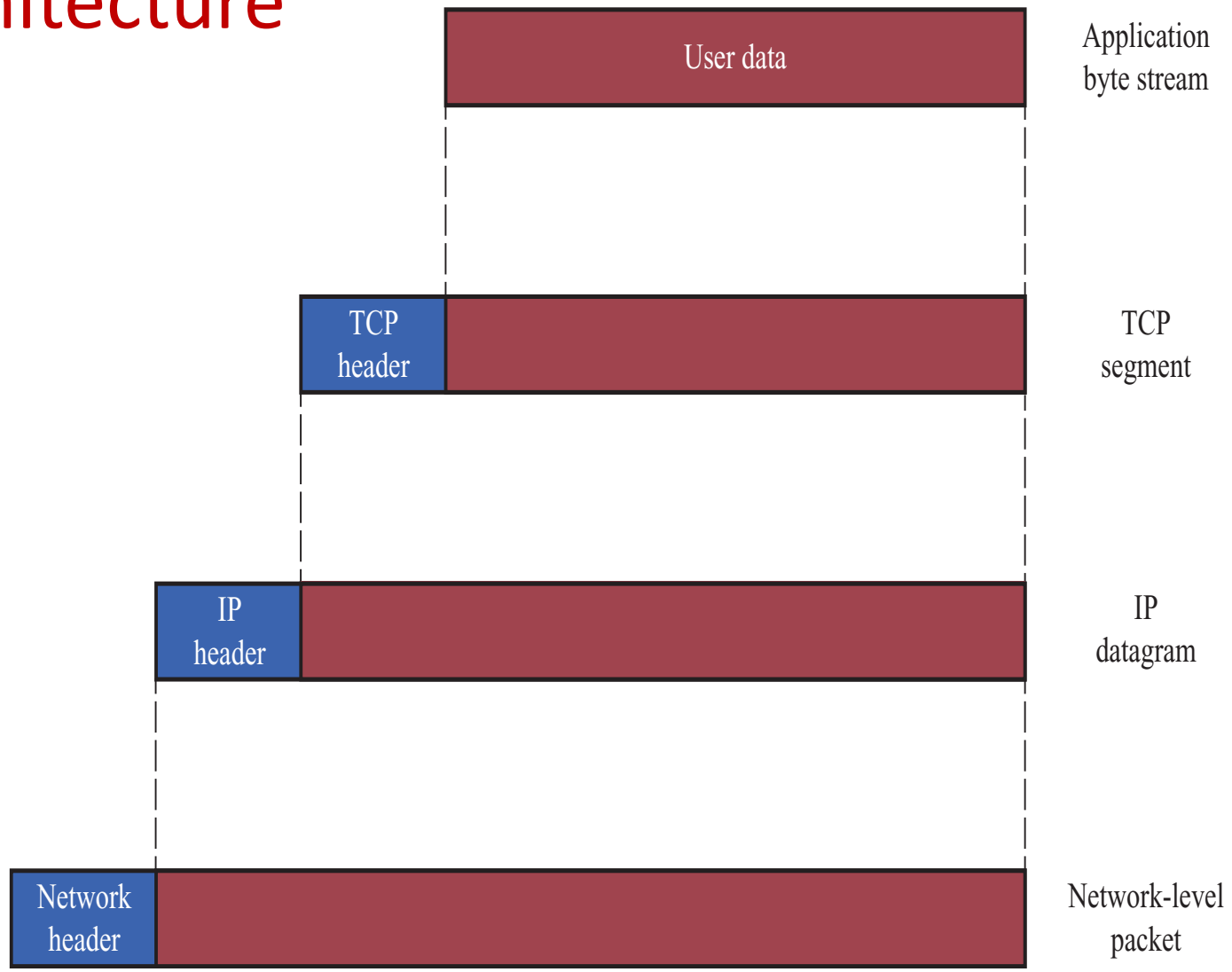
Agents Involved in Communication

- Applications
  - Exchange data between computers (e.g., electronic mail)
- Computers
  - Connected to networks
- Networks
  - Transfers data from one computer to another

TCP/IP Layers

- Physical layer
- Network access layer
- Internet layer
- Host-to-host, or transport layer
- Application layer

Protocol Data Units (PDUs) in the TCP/IP Architecture



TCP/IP Physical Layer

- Covers the physical interface between a data transmission device and a transmission medium or network
- Physical layer specifies:
  - Characteristics of the transmission medium
  - The nature of the signals
  - The data rate
  - Other related matters

TCP/IP network access layer

- Concerned with the exchange of data between an end system and the network to which it's attached
- Software used depends on type of network
  - Circuit switching
  - Packet switching (e.g., X.25)
  - LANs (e.g., Ethernet)
  - Others

TCP/IP internet layer

- Uses internet protocol (IP)
- Provides routing functions to allow data to traverse multiple interconnected networks
- Implemented in end systems *and* routers

TCP/IP Host-to-Host or Transport layer

- Commonly uses transmission control protocol (tcp)
- Provides reliability during data exchange
  - Completeness
  - Order

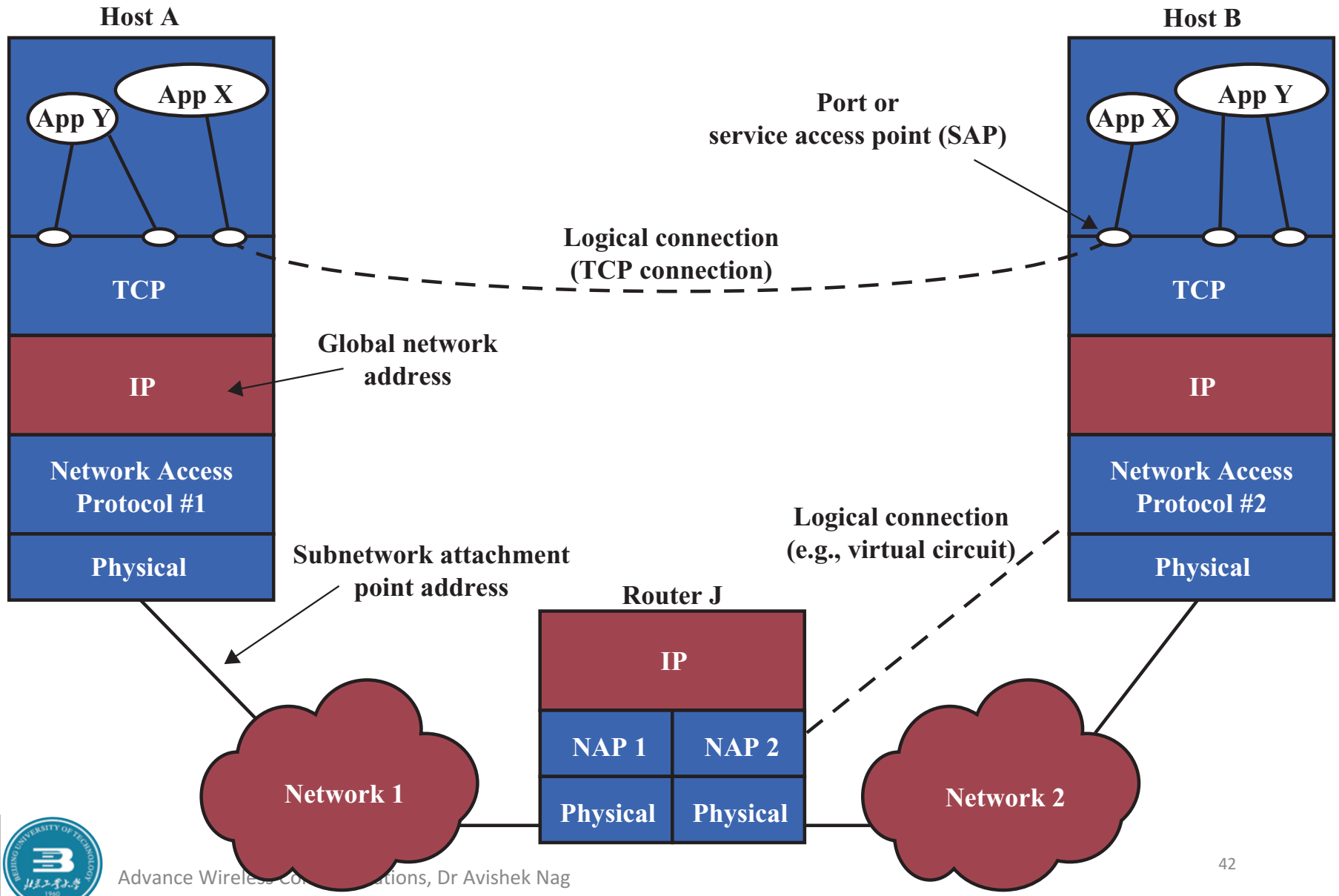
Application Layer and common applications

- Logic supports user applications
- Uses separate modules that are typical to each different type of application

Applications

- Simple mail transfer protocol (SMTP)
  - Provides a basic electronic mail facility
- File Transfer Protocol (FTP)
  - Allows files to be sent from one system to another
- Hypertext Transfer Protocol (HTTP)
  - Transfers information for the World Wide Web

TCP/IP concepts



Layers of the OSI Model

- Application
- Presentation
- Session
- Transport
- Network
- Data link
- Physical

OSI Application Layer

- Provides access to the OSI environment for users
- Provides distributed information services

OSI Presentation Layer

- Provides independence to the application processes from differences in data representation (syntax)

OSI Session Layer

- Provides the control structure for communication between applications
- Establishes, manages, and terminates connections (sessions) between cooperating applications

OSI Transport Layer

- Provides reliable, transparent transfer of data between end points
- Provides end-to-end error recovery and flow control

OSI Network Layer

- Provides upper layers with independence from the data transmission and switching technologies used to connect systems
- Responsible for establishing, maintaining, and terminating connections

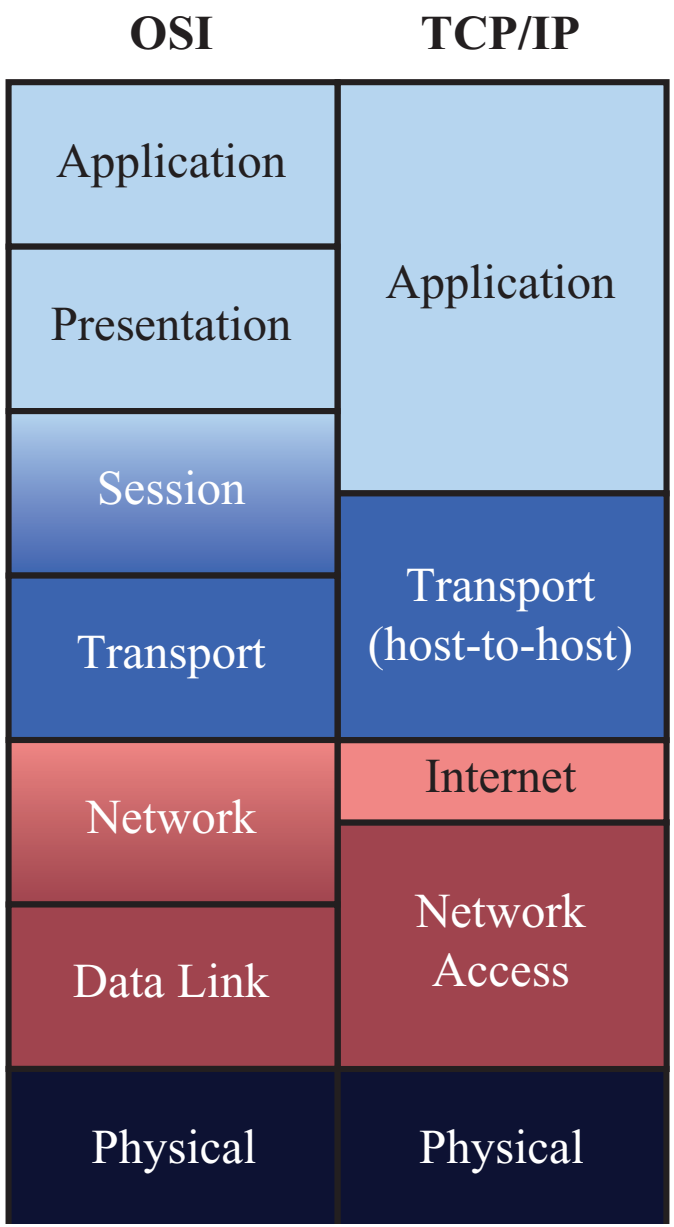
OSI Data link Layer

- Provides for the reliable transfer of information across the physical link
- Sends blocks (frames) with the necessary synchronization, error control, and flow control

OSI Physical Layer

- Concerned with transmission of unstructured bit stream over physical medium
- Deals with accessing the physical medium
  - Mechanical characteristics
  - Electrical characteristics
  - Functional characteristics
  - Procedural characteristics

A Comparison of the OSI and TCP/IP Protocol Architectures

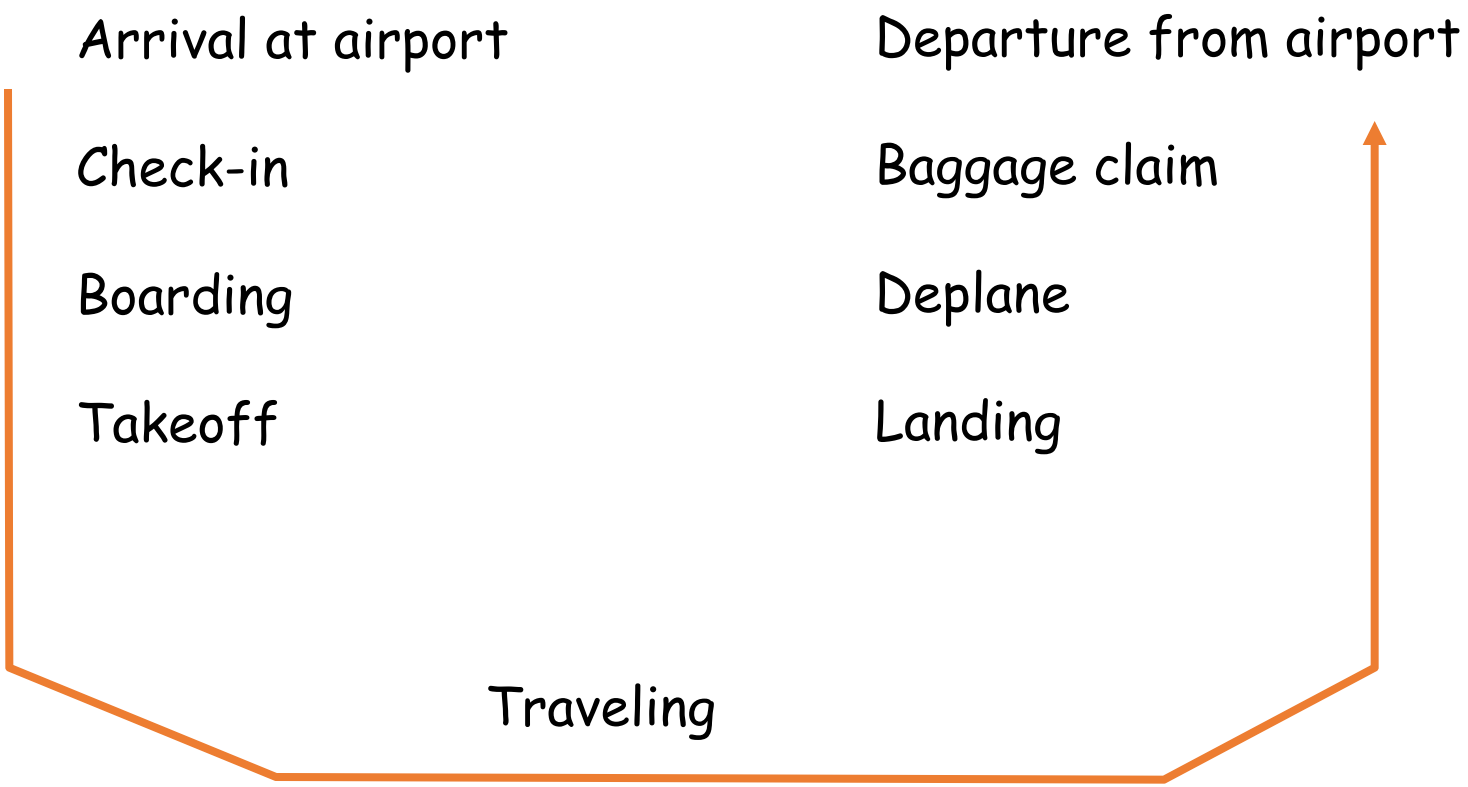


TCP/IP Architecture Dominance

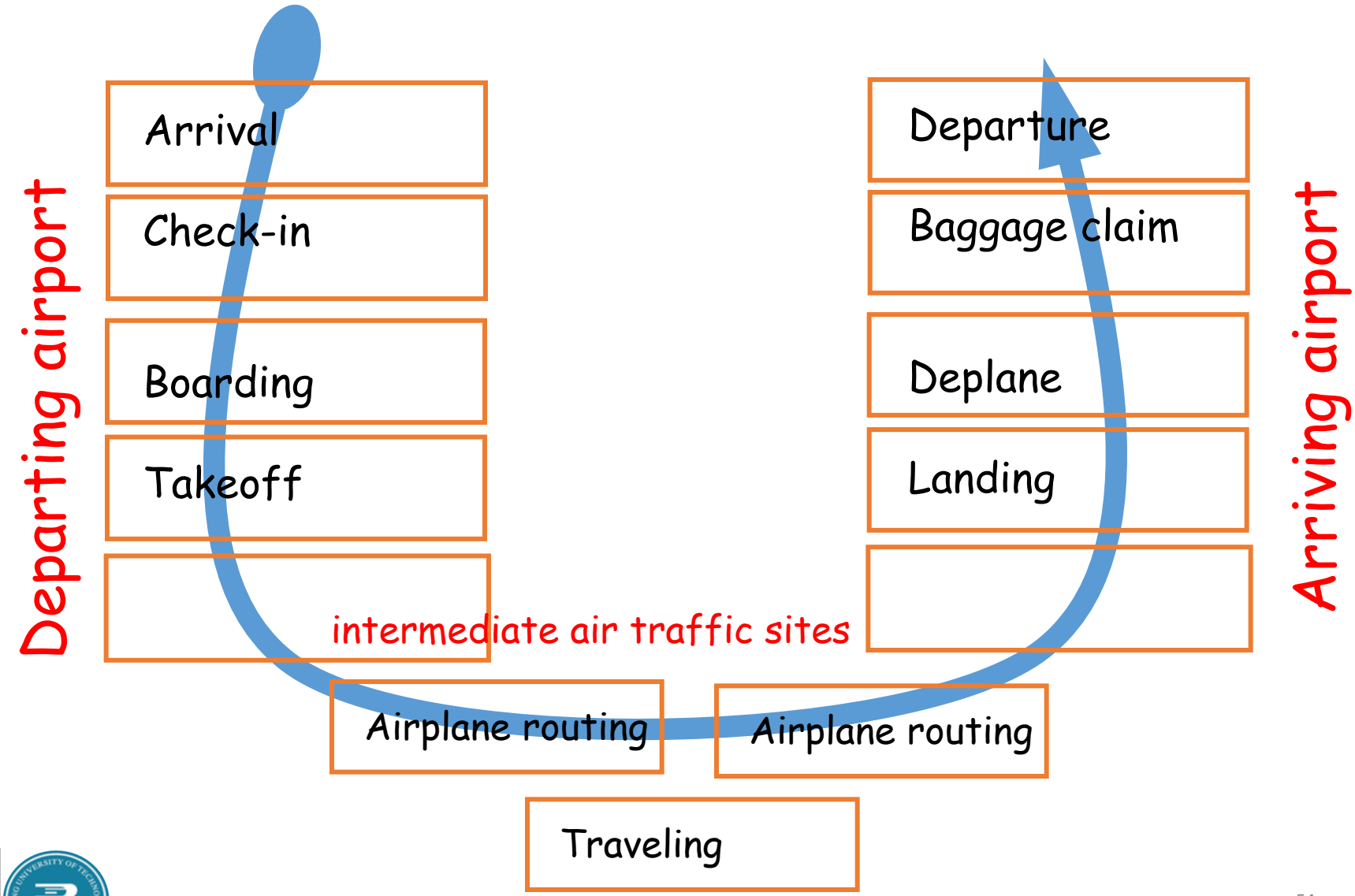
- TCP/IP protocols matured quicker than similar OSI protocols
  - When the need for interoperability across networks was recognized, only TCP/IP was available and ready to go
- OSI model is unnecessarily complex
  - Accomplishes in seven layers what TCP/IP does with fewer layers

Network Layers Analogy: Air Travel

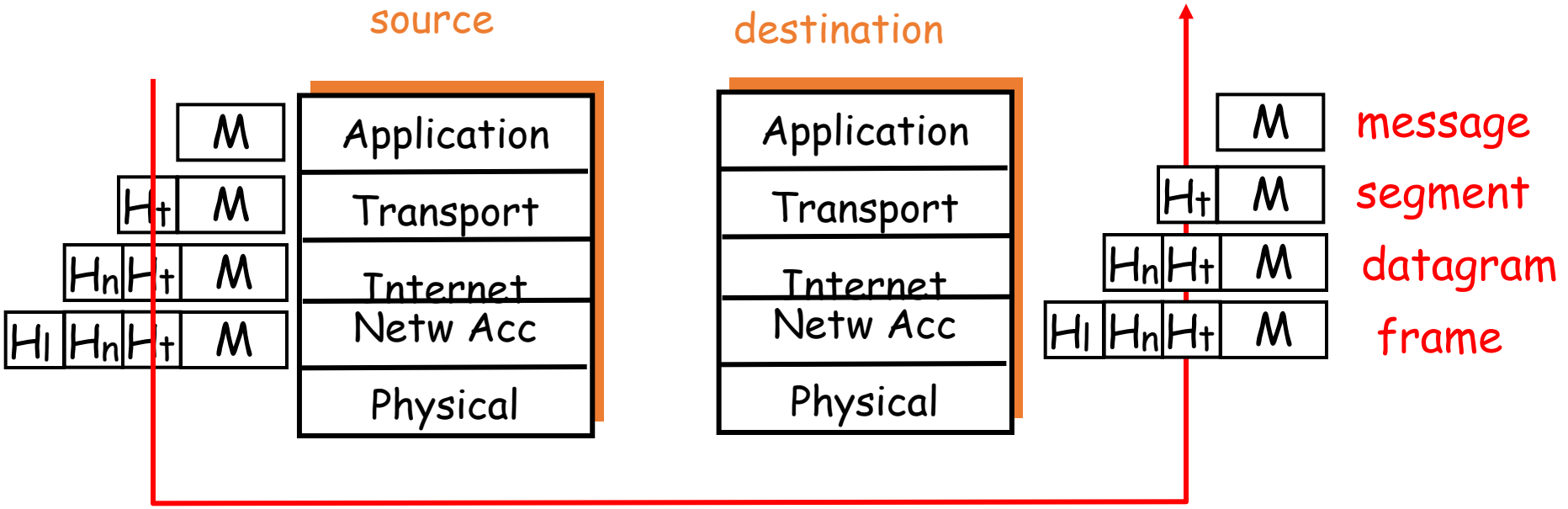
- *The problem: air travel.*
- *Decomposed into series of steps:*



More on Air Travel



Messages and Protocol Layers



Internetworking Terms

- Communication network – facility that provides a data transfer service among devices attached to the network
- Internet – collection of communication networks, interconnected by bridges/routers
- Intranet – internet used by an organization for internal purposes
  - Provides key Internet applications
  - Can exist as an isolated, self-contained internet

Internetworking Terms

- End System (ES) – device used to support end-user applications or services
- Intermediate System (IS) – device used to connect two networks
- Bridge – an IS used to connect two LANs that use similar LAN protocols
- **Router** - an IS used to connect two networks that may or may not be similar

Functions of a Router

- Provide a link between networks
- Provide for the routing and delivery of data between processes on end systems attached to different networks
- Provide these functions in such a way as not to require modifications of the networking architecture of any of the attached subnetworks

Network differences routers must accommodate:

- **Addressing schemes:** Different schemes for assigning addresses
- **Maximum packet sizes:** Different maximum packet sizes requires segmentation
- **Interfaces:** Differing hardware and software interfaces
- **Reliability:** Network may provide unreliable service