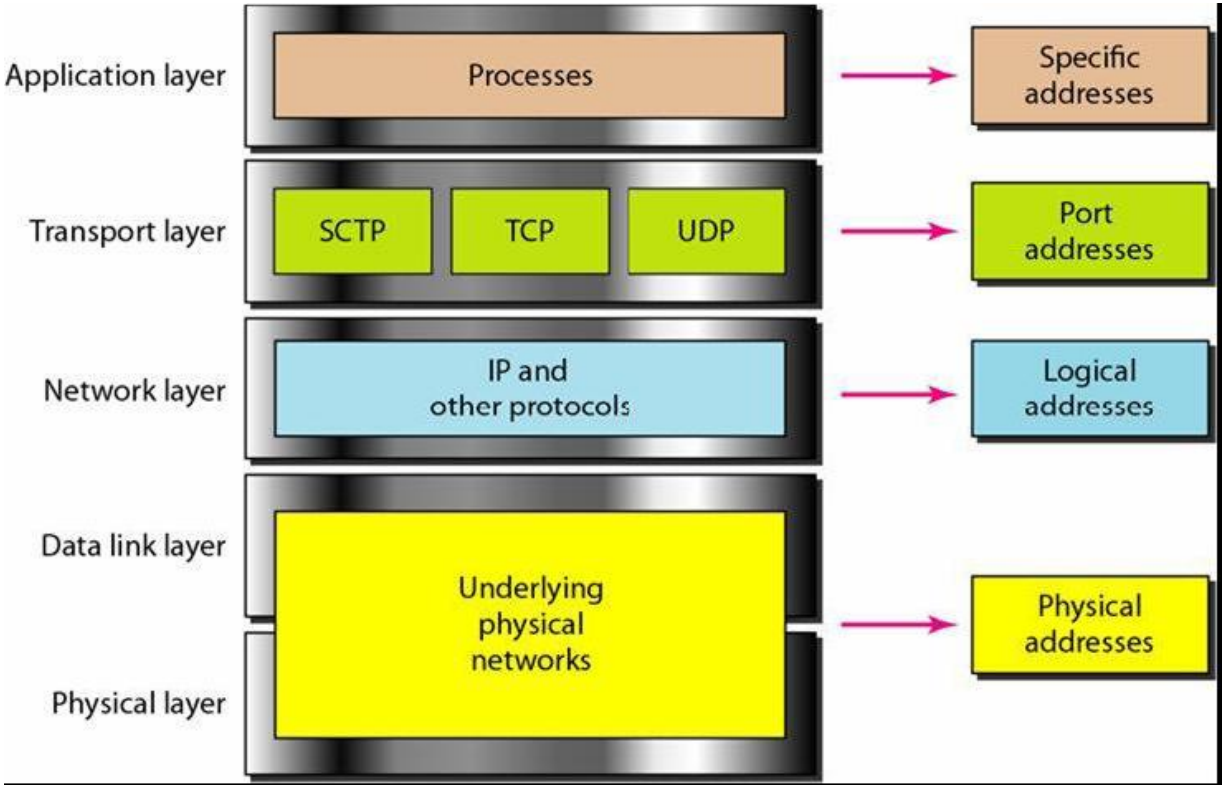
Lecture 1-3

Introduction to Computer Networks:
Addressing and Network Properties

Addressing

- Four levels of addresses in TCP/IP
  - physical
  - logical
  - port
  - specific



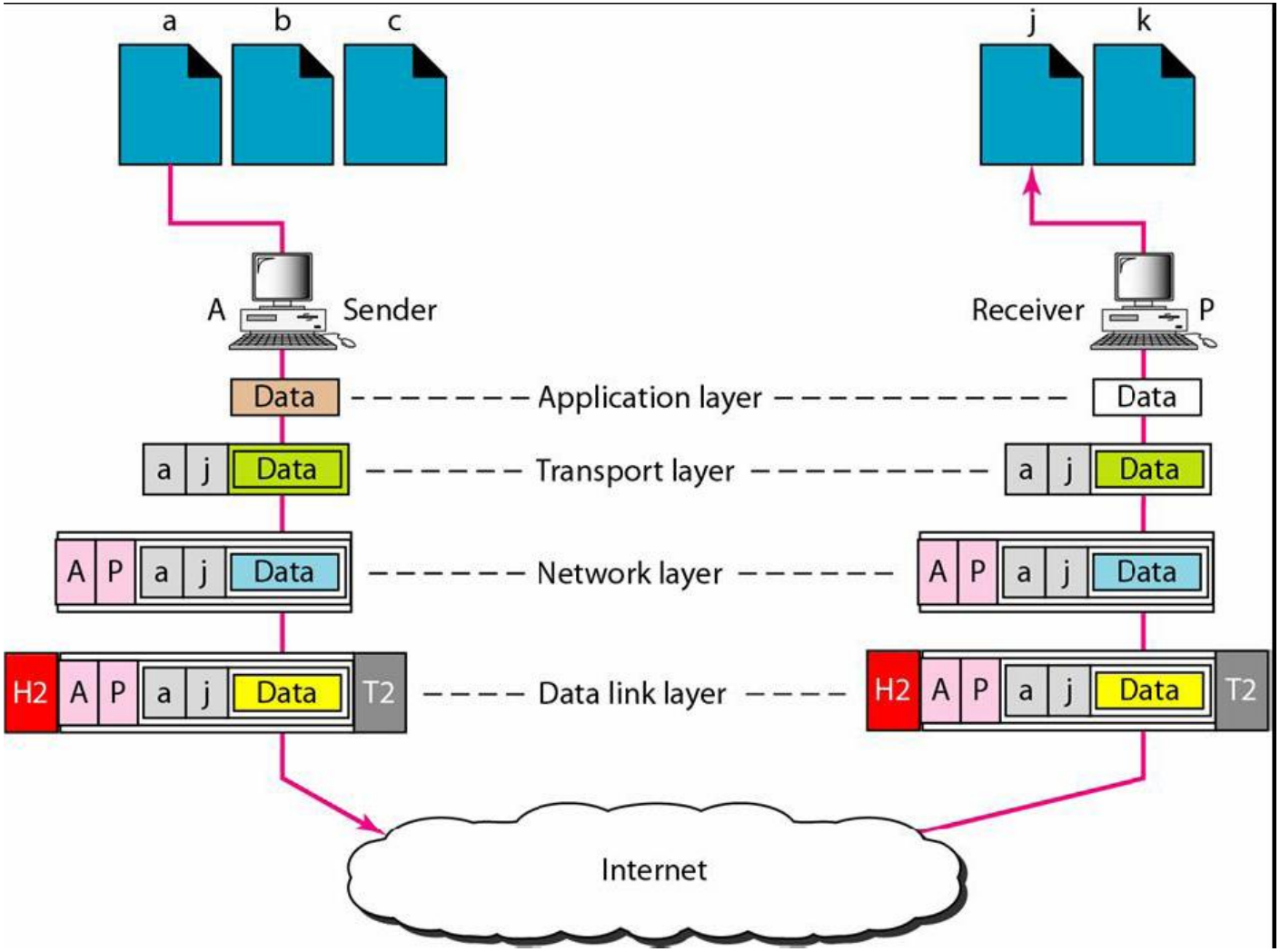
Physical Address

- Most LANs use a 48-bit (6-byte) physical address written as 12 hexadecimal digits
- Often called a MAC address
- Every MAC address of a device is unique
- Example = 07:01:02:01:2C:4B
- Data link layer addressing

IP Address (Logical Address)

- A numeric identifier assigned to each machine on an IP network
- Designates the specific location of a device on the network
- Allows hosts on one network to communicate with a host on a different network
  - Regardless of the type of LANs the hosts are participating in
- Network layer addressing

Port Address



Port Number Ranges

What are port numbers that you know?
What are they for?

Specific addresses

- User friendly address
- Examples
  - www.kku.ac.th (URL)
  - your email address

Network Properties

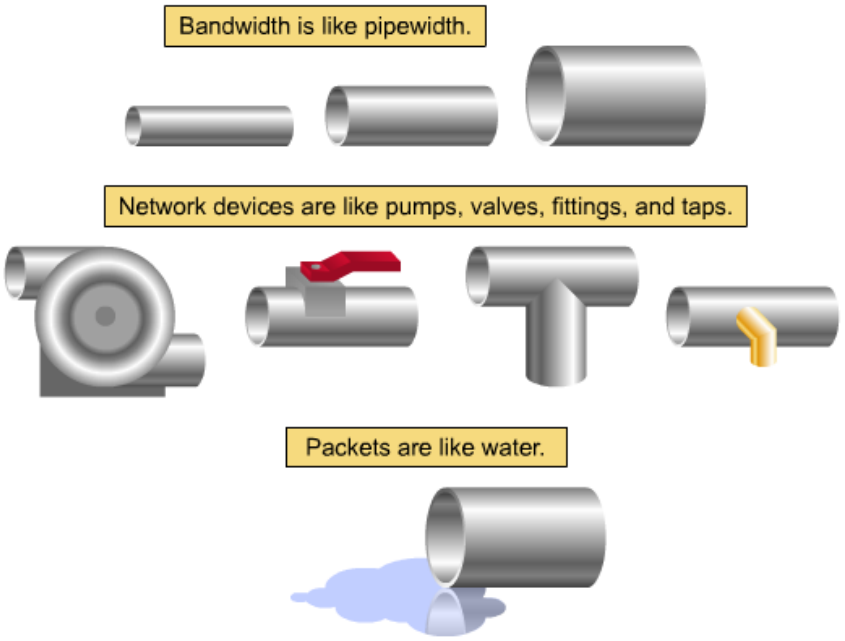
- Bandwidth
- Throughput
- Delays
  - Propagation delay
  - Transmission delay
  - Queuing delay
  - Processing delay
- Loss

Bandwidth

- In Signals:
  - The difference between the highest and the lowest frequencies contained in that signal
- In Computer Network:
  - The amount of information that *can* flow through a network in a given time
  - "Capacity" of a network
- Unit: bits per second (bps)

Why Bandwidth is Important?

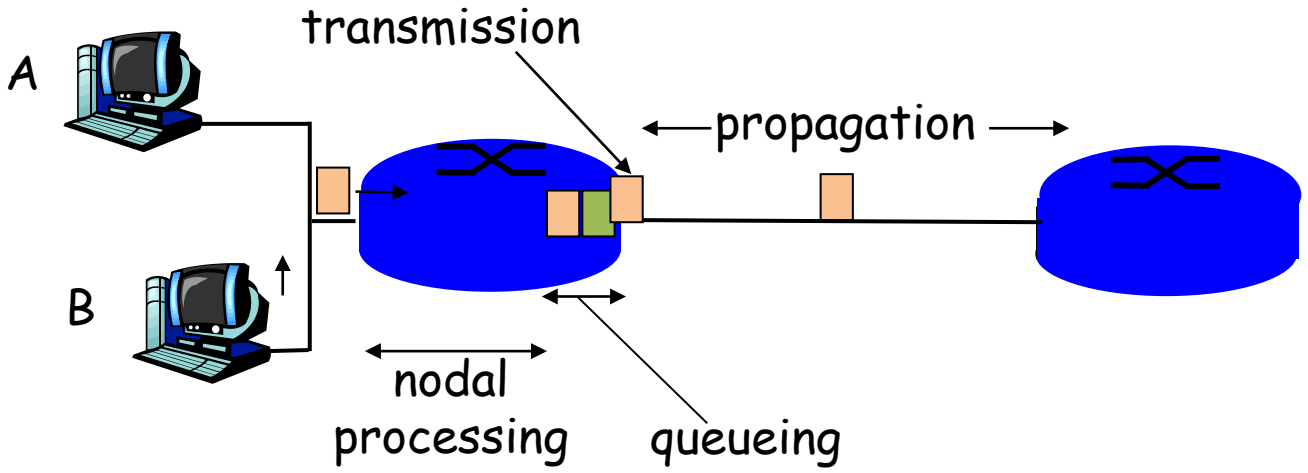
- Bandwidth is limited by physics and technology
- Bandwidth is not free
- Bandwidth requirements are growing at a rapid rate
- Bandwidth is critical to network performance
  - How?



Throughput

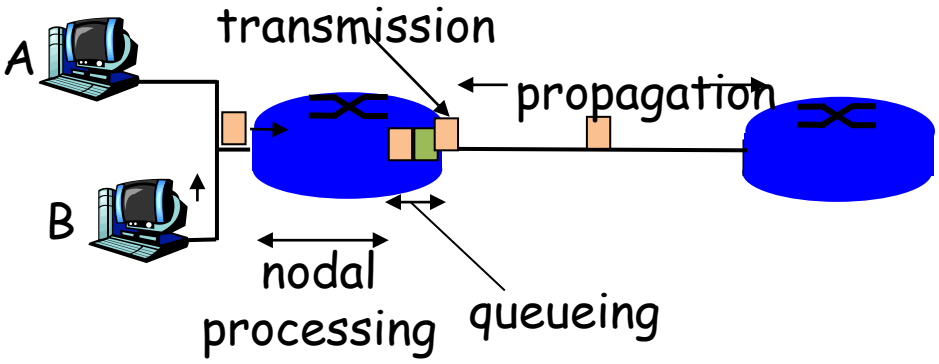
- Actual data that get through a network at a given time of a day
  - Unit: usually also bits per second (bps)
- Throughput is less than or equal to bandwidth
  - *instantaneous:* rate at given point in time
  - *average:* rate over long(er) period of time
  - Maximum throughput = bandwidth
- What's different between bandwidth and throughput again?

Packet Delays



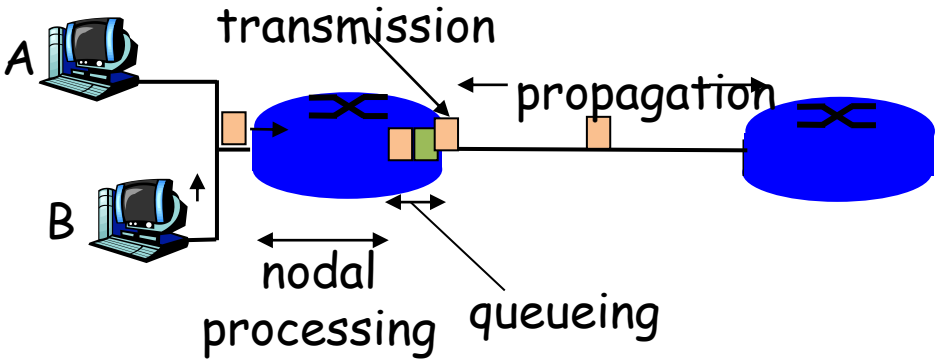
- 4 types of delays
  - Transmission
  - Processing
  - Queuing
  - Propagation

Four Sources of Packet Delay (1)



- Nodal processing delay
  - Delay in processing a packet in a node
  - Checking bit errors
  - Determining an output link (table lookup)
- Queuing delay
  - Time waiting at an output link for transmission
  - Depending on a congestion level of a router

Four Sources of Packet Delay (2)



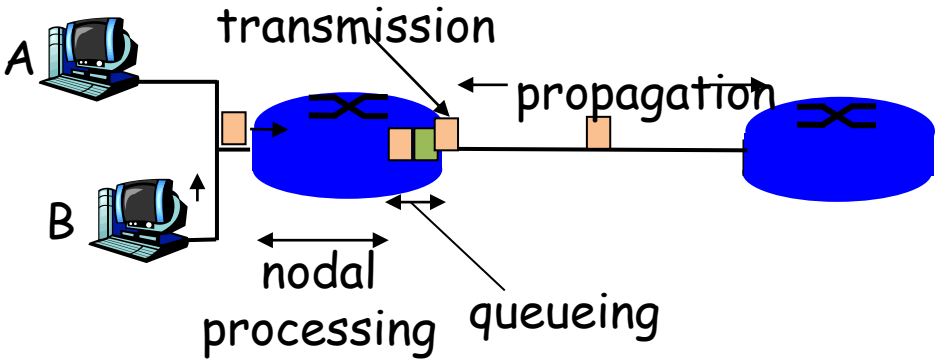
- Transmission delay
  - Time from starting to send a packet, to finishing to send a packet
  - Limited by link bandwidth

R = link bandwidth (bps)

L = packet length (bits)

Transmission delay = L/R

Four Sources of Packet Delay (3)



- Propagation delay
  - Time that data travels through a link
  - Limited by a physical distance between 2 nodes

    d = length of physical link

    s = propagation speed in medium (~2×10^8 m/sec)

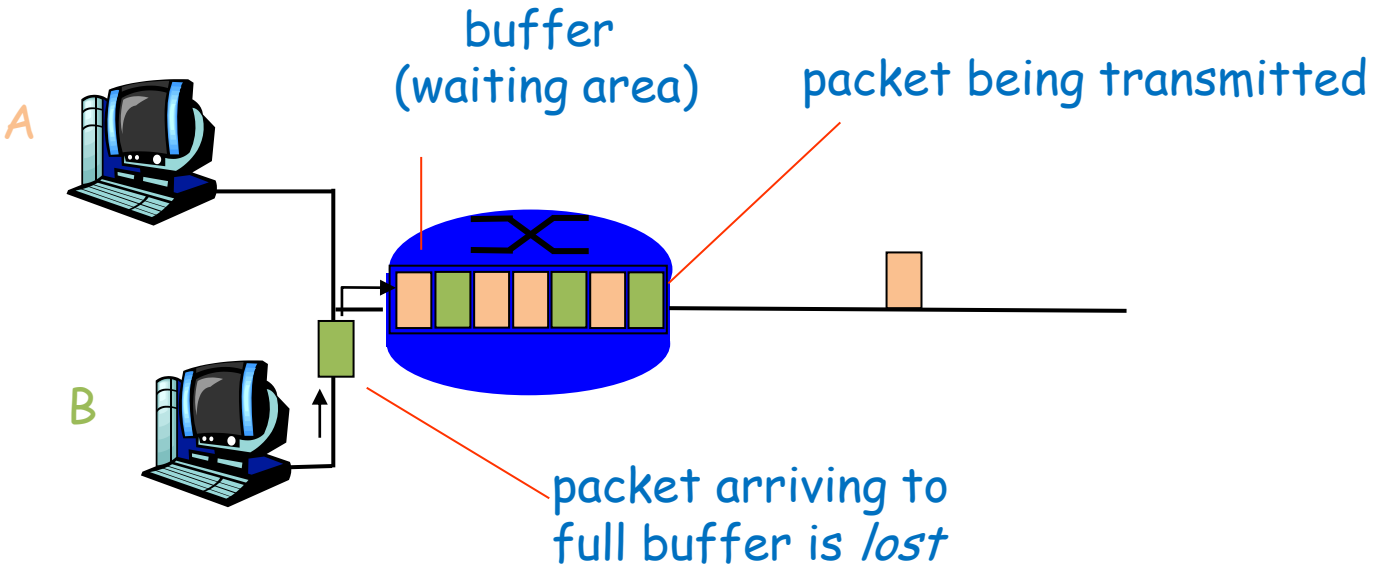
    Propagation delay = d/s

Nodal Delay

$$d_{\text{nodal}} = d_{\text{proc}} + d_{\text{queue}} + d_{\text{trans}} + d_{\text{prop}}$$

- d_{proc} = processing delay
  - typically a few μs or less
- d_{queue} = queuing delay
  - depends on congestion
- d_{trans} = transmission delay
  - = L/R, significant for low-speed links
- d_{prop} = propagation delay
  - a few μs to hundreds of ms

Packet Loss



- A queue (buffer) preceding a link has finite capacity
- Packet arriving to a full queue is dropped

Packet Retransmission

- A lost packet may be retransmitted by
  - Previous node
  - Source end system
  - No one (no resending)

Standards

- Standards Organizations
  - ISO, ITU-T, CCITT, ANSI, IEEE, EIA
- Regulatory Agencies
  - Federal Communications Commission(FCC)
- Internet Standards
  - Internet drafts = working document no official status, 6-month lifetime
  - Request for Comment (RFC) edited, assigned a number, made available to all interested parties.