Computer Networks

Lecture #1 - supplementary

What we have discussed

- Introduction to the course
- Introduction to the Internet
  - Principles
  - Terminologies
  - Trend

Today …

- Recap: stuffs discussed in the “Data Communication” course

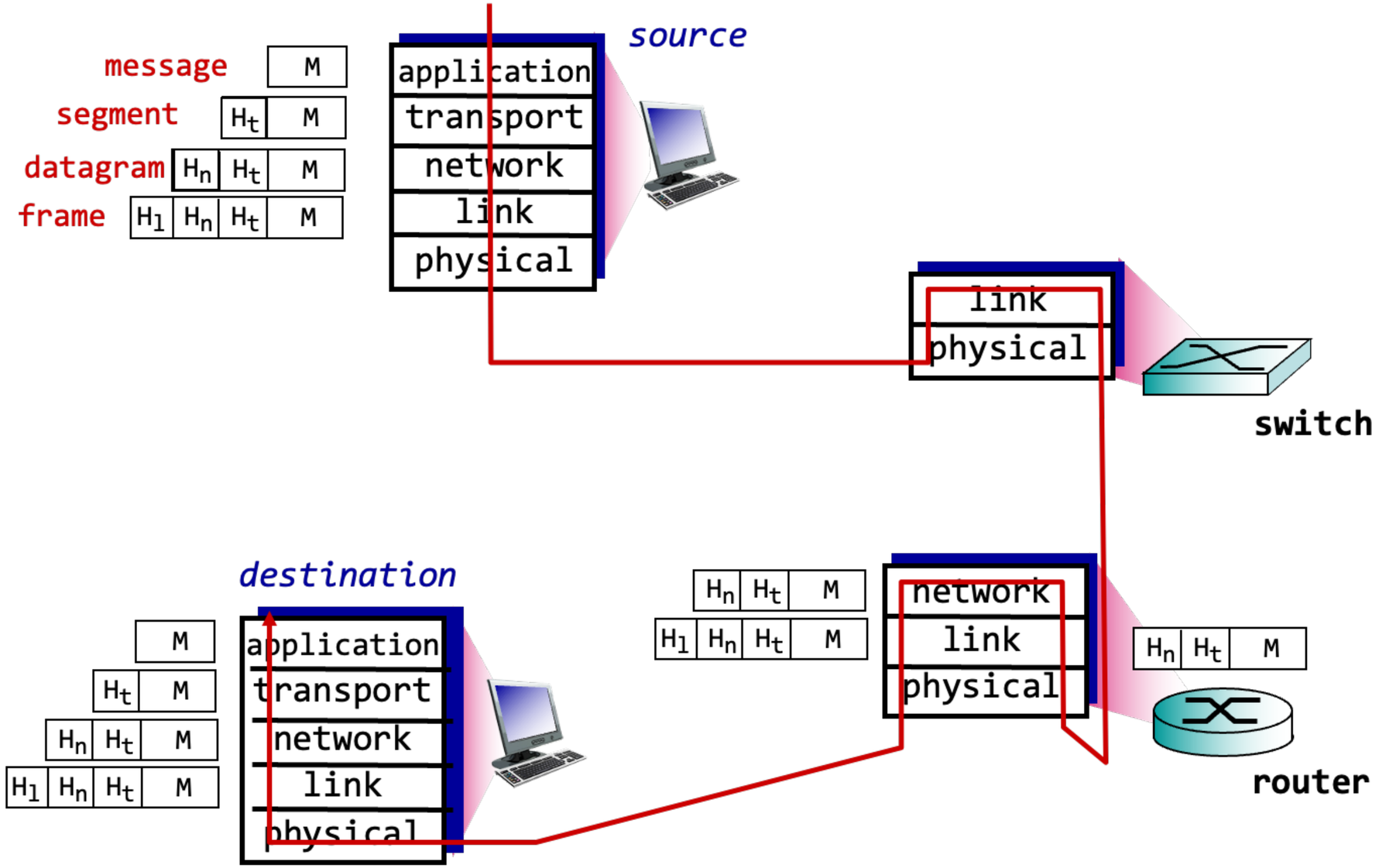
Question #1

- Typically, a packet (and also segment, frame) consists of a header and a payload. The header includes control information in the corresponding layer and the payload carries the data delivered from the above layer

- Q) What kinds of problems can you expect if the header size is quite large?

- Q) What happens if a packet does not have a header?

Encapsulation



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  → Large overhead (if the header size is equal to the payload size, 100% overhead is generated to deliver the data)

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  → Large overhead (if the header size is equal to the payload size, 100% overhead is generated to deliver the data)

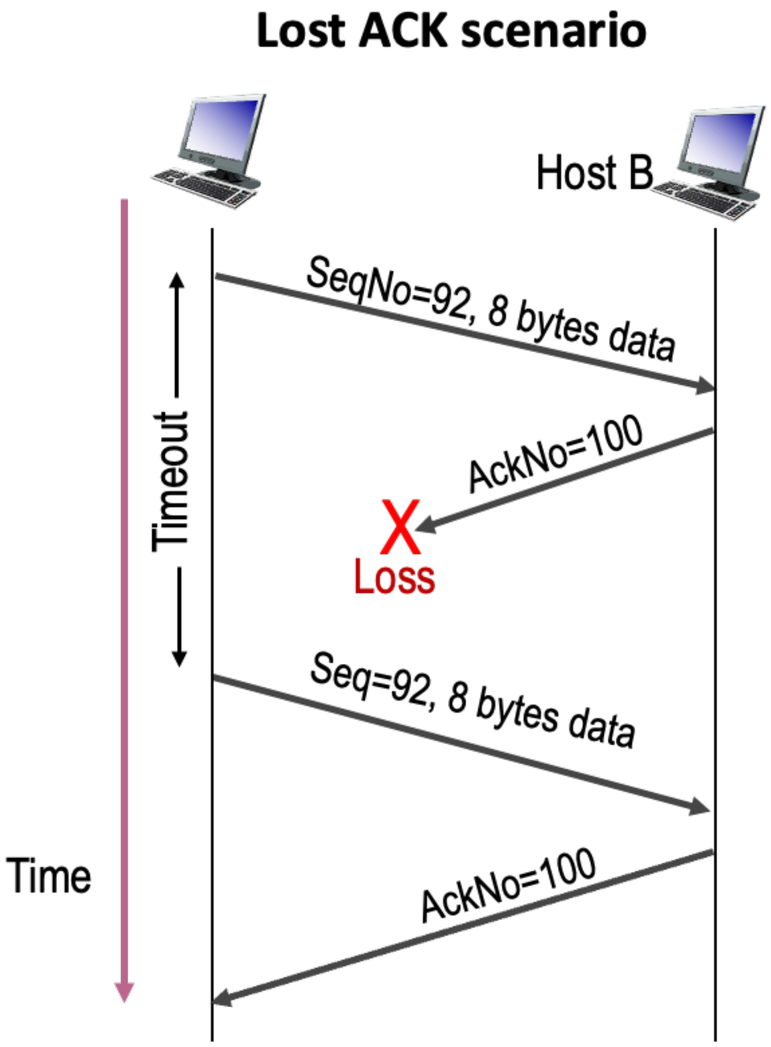
- Q) What happens if a packet does not have a header?

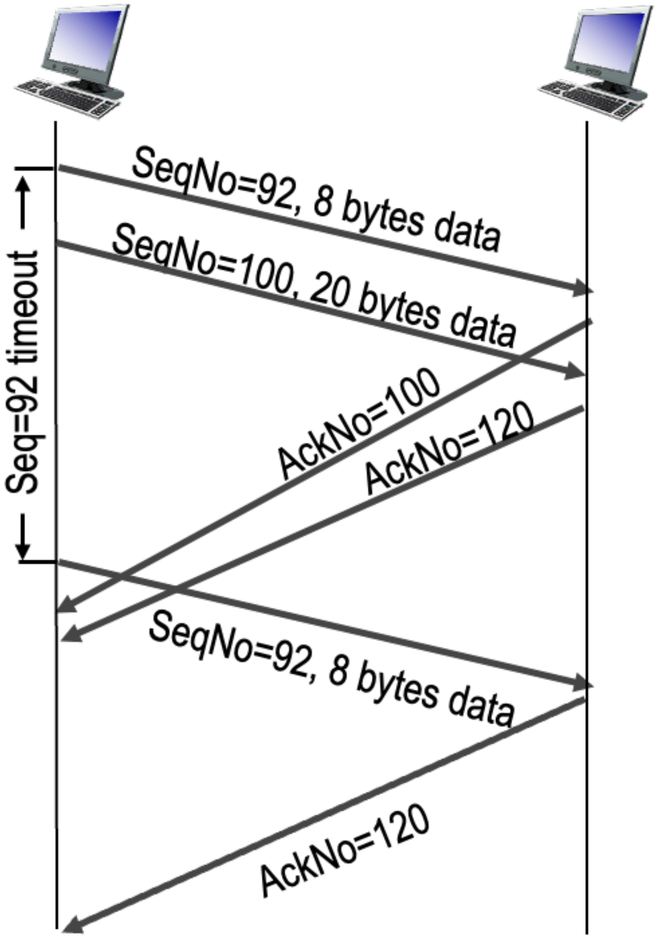
  → Protocol does not work.

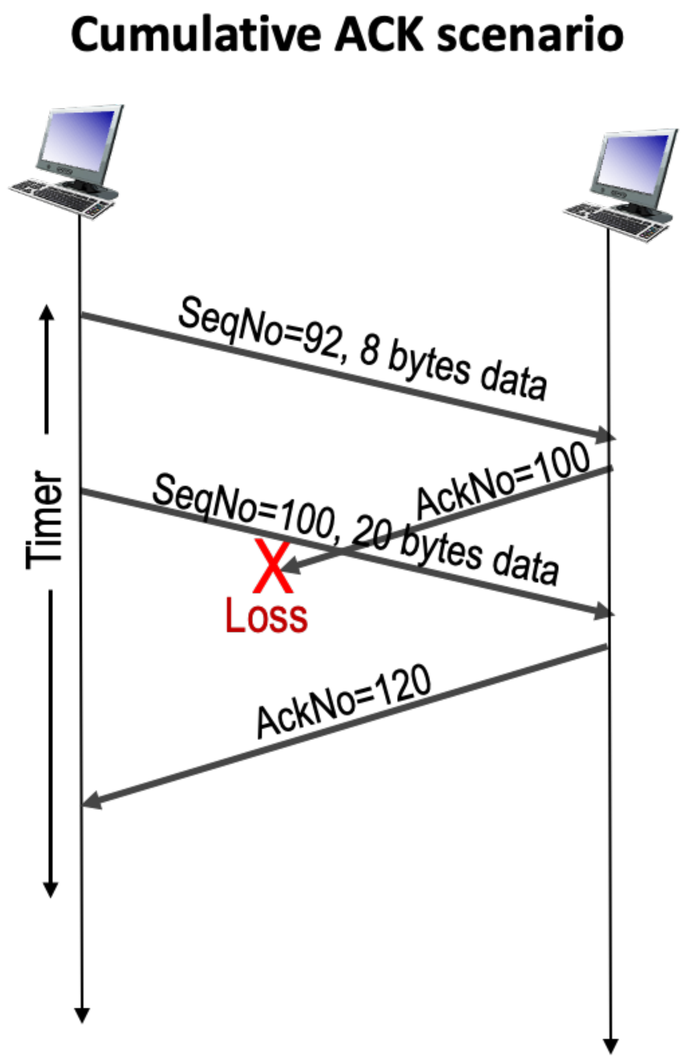
Question #2

- Q) When TCP is used, the lost packet can be retransmitted by the sender. Please refer to the documents (books or websites) and explain how such retransmission can happen for the lost packet.

Retransmission in TCP







Question #2

- Q) When TCP is used, the lost packet can be retransmitted by the sender. Please refer to the documents (books or websites) and explain how such retransmission can happen for the lost packet.

  → Sequence number, Acknowledgement number, Timer are used to detect packet loss. Go-back-N mechanism is used to retransmit packets

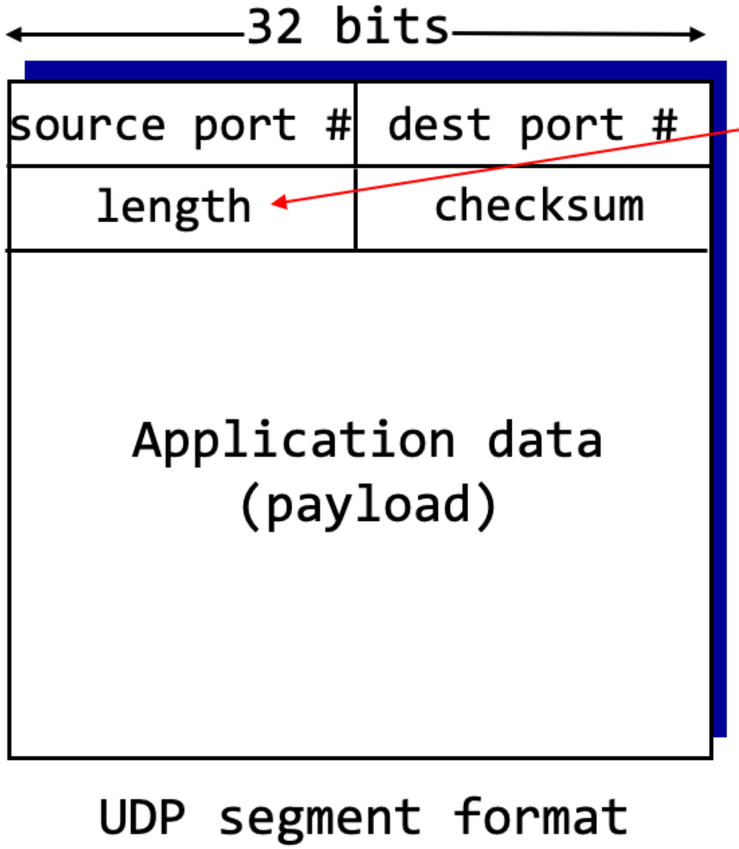
Question #3

- Unlike TCP, UDP does not provide any reliability mechanisms. Nevertheless, UDP is still used on the Internet.

- Q) Why do people use UDP?

- Q) What specific services would be better to use UDP than TCP? (Please refer to the textbook or websites)

UDP header



UDP segment format

length, in bytes of UDP segment, including header

Why is there a UDP?

No connection establishment (no additional delay)

Simple: no connection state at sender, receiver

Small header size

No congestion control: UDP can blast away as fast as desired

Question #3

- Unlike TCP, UDP does not provide any reliability mechanisms. Nevertheless, UDP is still used on the Internet.

- Q) Why do people use UDP?

  → Real-time interaction (delay-sensitive services),
  Applications involving a degree of redundancy, resilient to the loss

Question #3

- Unlike TCP, UDP does not provide any reliability mechanisms. Nevertheless, UDP is still used on the Internet.

- Q) What specific services would be better to use UDP than TCP?

  → Real-time streaming, online game, DNS service, broadcasting information, QUIC (HTTP 3.0)

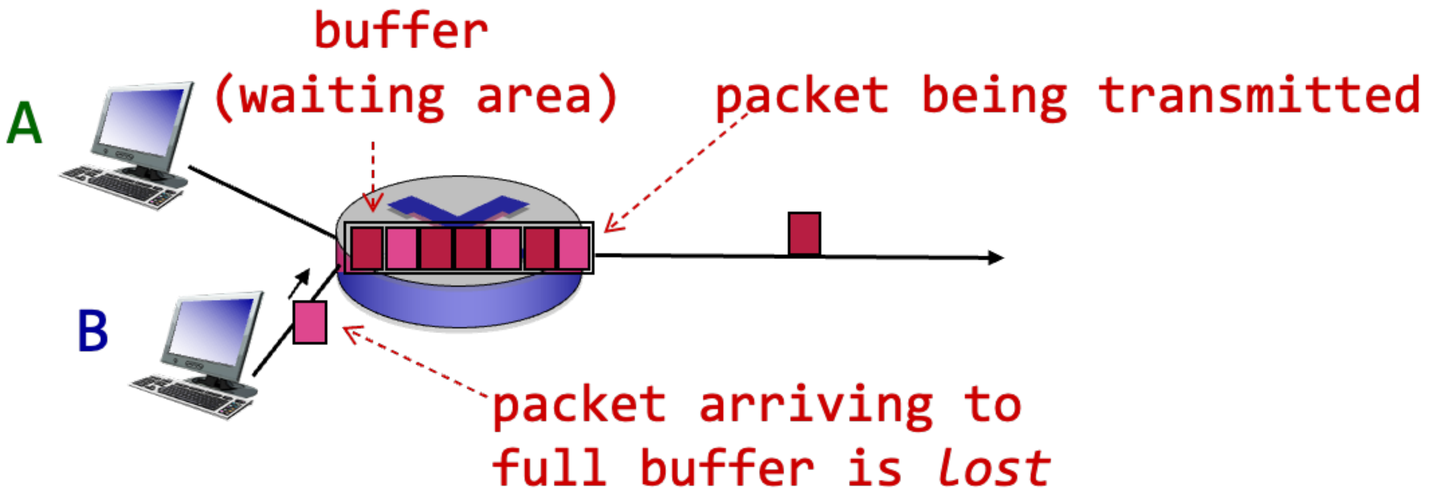
Question #4

- Sometimes, you may have experienced the frustration of your Internet service being too slow. One of the reasons behind this issue is congestion.

- Q) Explain the condition under which congestion occurs (Please refer to the textbooks or web).

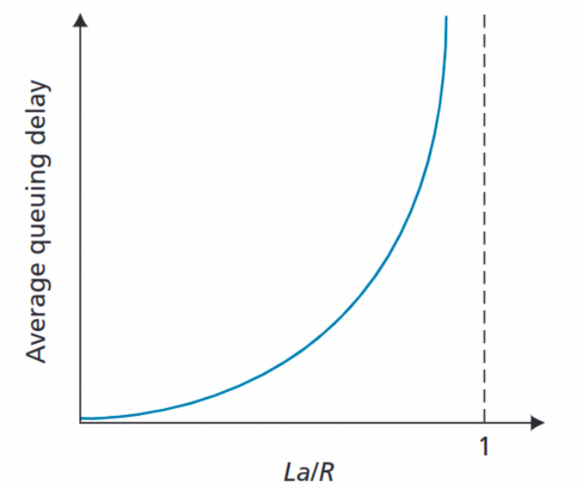
Queuing

- Preceding link in the queue (buffer) has finite capacity
- Packets arriving to full queue are dropped (aka lost)
- Lost packet may be retransmitted by previous node, by source end system, or not at all



Congestion

- R : link bandwidth (bps)
- L : packet length (bits)
- a : average packet arrival rate (packets per second)



- $\frac{L \times a}{R} \approx 0$: avg. queuing delay small
- $\frac{L \times a}{R} \rightarrow 1$: avg. queuing delay large

- $\frac{L \times a}{R} >$: more “work” arriving than can be serviced, average delay infinity

Question #4

- Sometimes, you may have experienced the frustration of your Internet service being too slow. One of the reasons behind this issue is congestion.

- Q) Explain the condition under which congestion occurs.

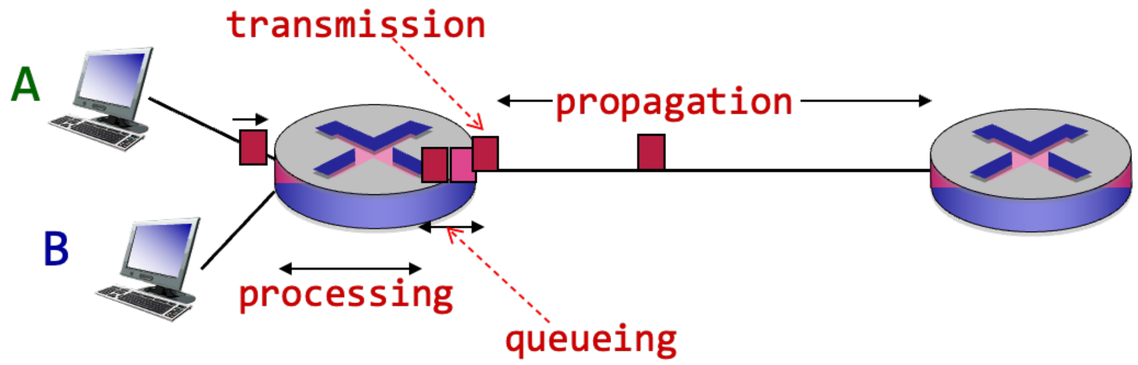
  → “too many sources sending too much data too fast for network to handle”
  More specifically, when the amount of traffic exceeds the link bandwidth, queues build up and the latency increases.

Question #5

- Q) Regarding "Delay", we can list the following four causes of delay: 1) nodal processing, 2) queuing delay, 3) transmission delay, and 4) propagation delay. Please refer to the documents (books or websites) and write down what you understand for each reason (DO NOT COPY the document).

Sources of packet delay

- d_{proc} : processing delay
  - Check bit errors
  - Determine output link
  - Typically < msec
- d_{queue} : queuing delay
  - Time waiting at output link for transmission
  - Depends on congestion level of router



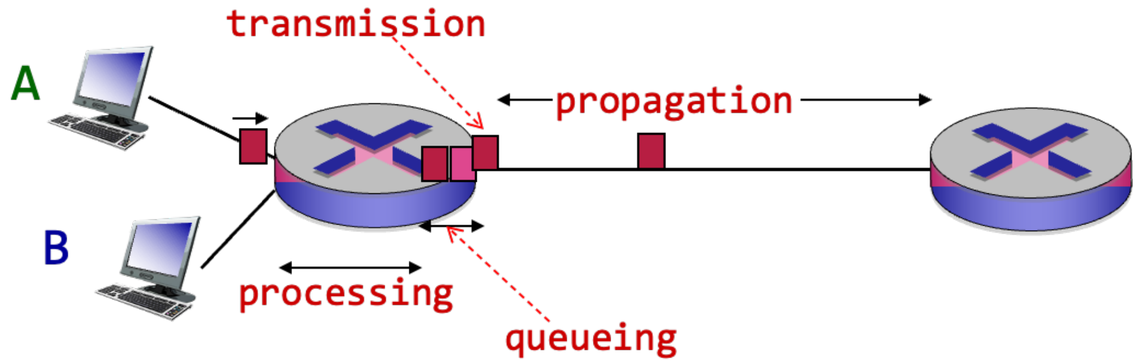
$$d_{nodal} = d_{proc} + d_{queue} + d_{trans} + d_{prop}$$

Sources of packet delay

- d_{trans} : transmission delay
  - L: packet length (bits)
  - R: link bandwidth (bps)
  - $d_{trans} = L / R$

Very different

- d_{prop} : propagation delay
  - D: length of physical link
  - S: propagation speed in medium ($2 \times 10^8 \sim 3 \times 10^8$)
  - $d_{prop} = D / S$



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

Question #6

- Q) If congestion occurs (discussed in the Question #4), what kins of delay increases among 1), 2), 3), 4) in the Question #5?

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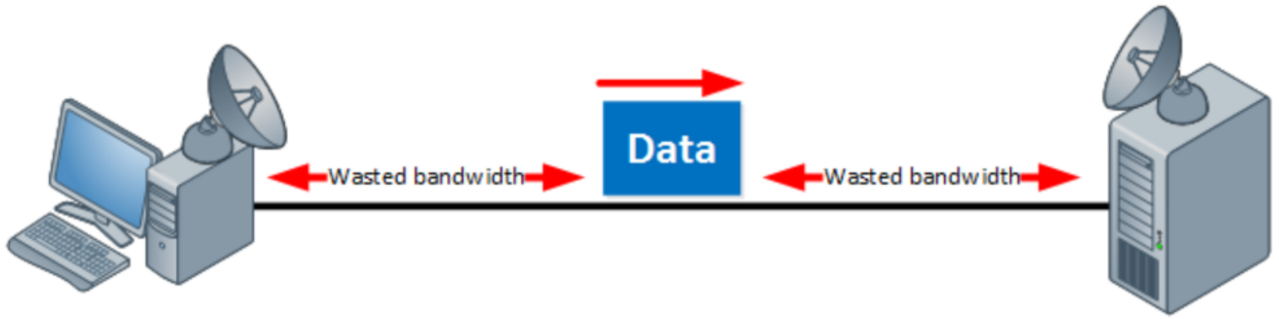
  → Queuing delay!

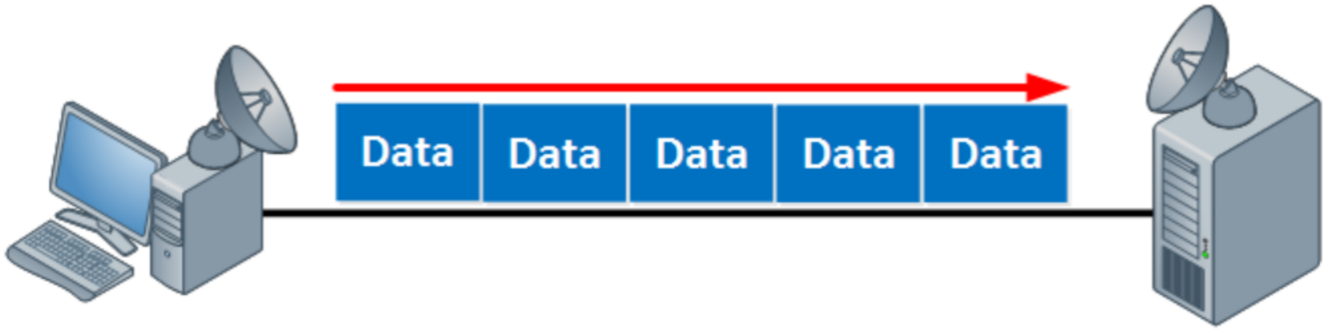
Question #7

- Q) If the link delay is 50ms and the bandwidth is 45Mbps, how much data can exist (on the move) at most on this link?

Bandwidth delay product (BDP)

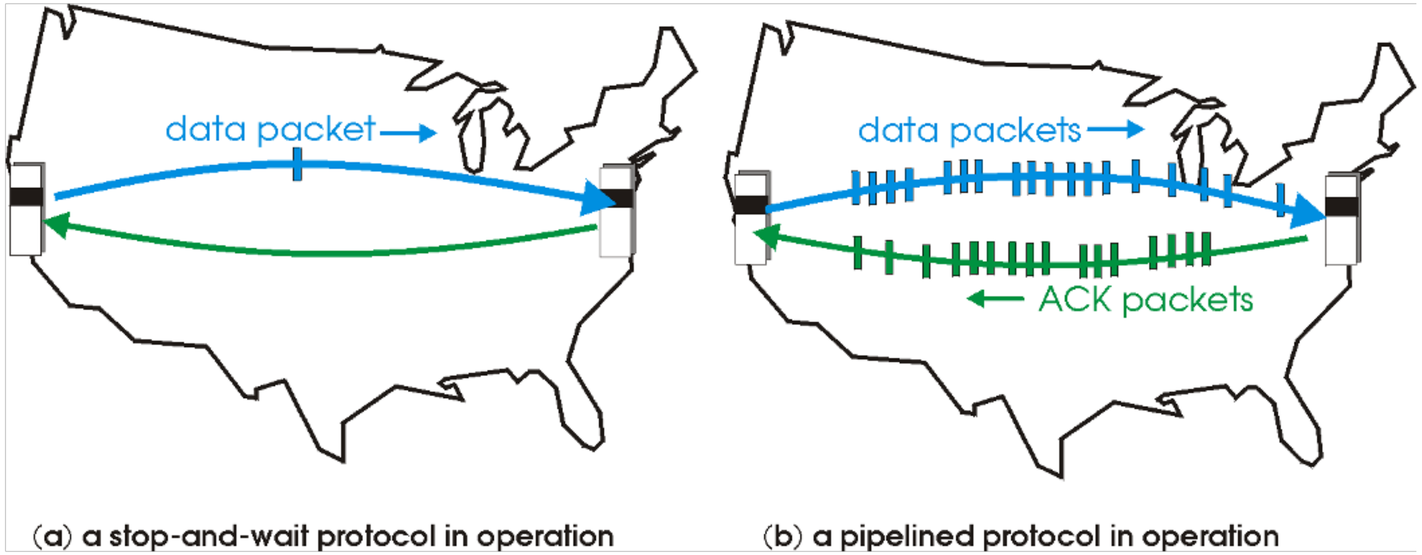
- Link BDP
  - Bandwidth (bits per second) × delay (seconds)





TCP as a pipelined protocol

- Pipelining
  - Sender allows multiple, “in-flight”, yet-to-be-acknowledged packets
  - Range of sequence numbers must be increased
  - Buffering at sender and/or receiver



Question #7

- Q) If the link delay is 50ms and the bandwidth is 45Mbps, how much data can exist (on the move) at most on this link?

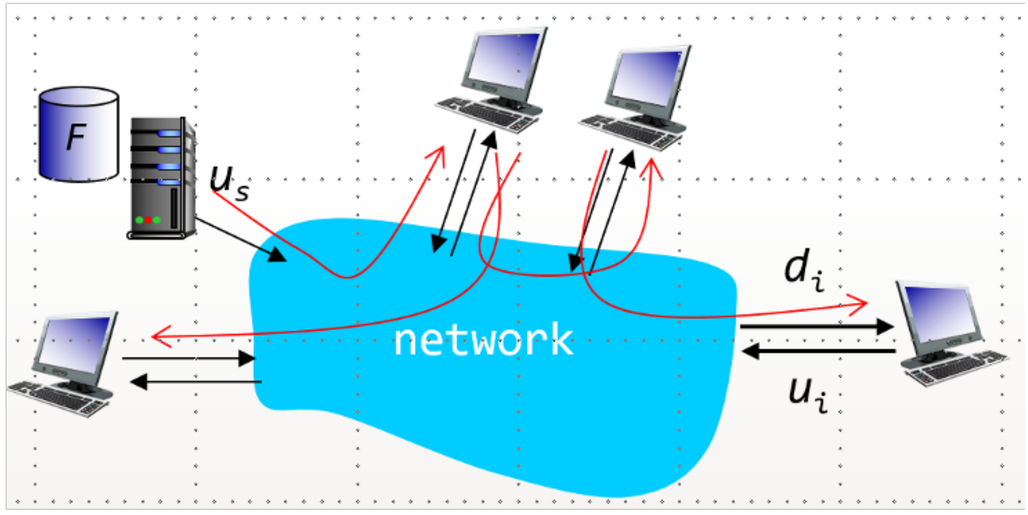
  → 45Mbps × 0.05 sec

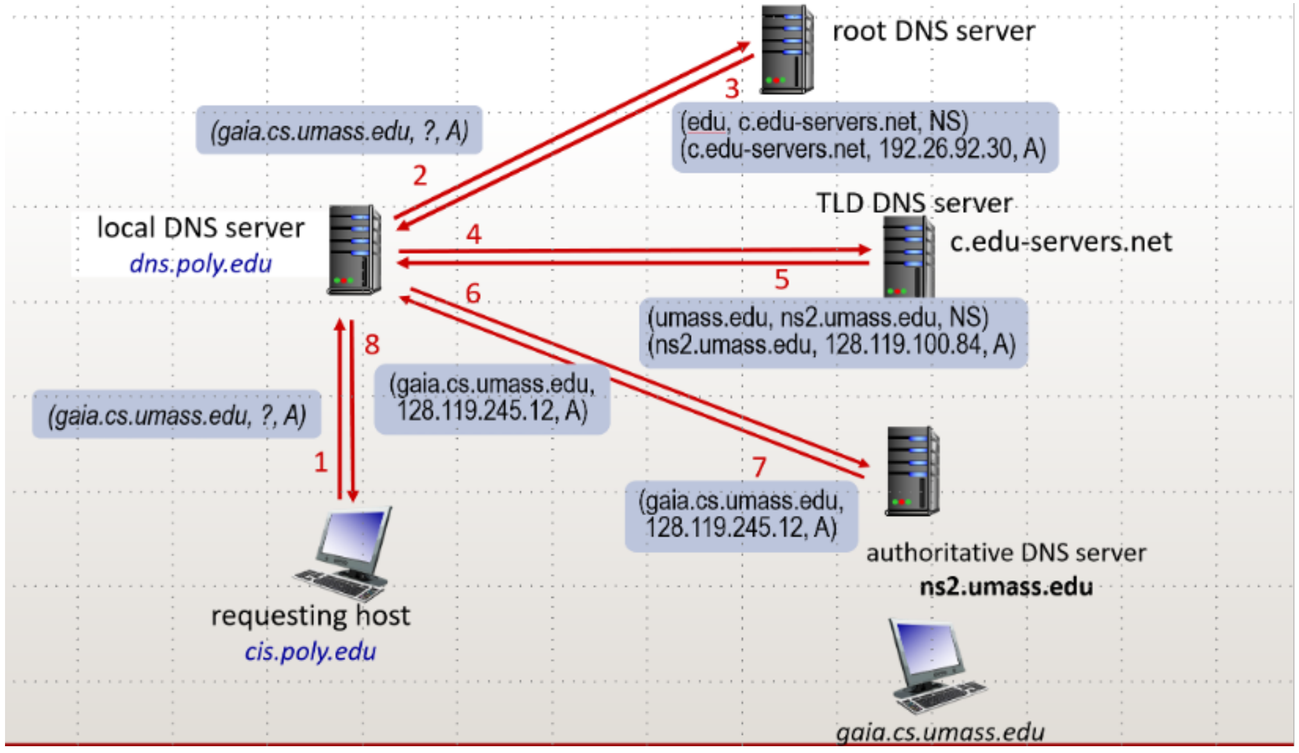
Question #8

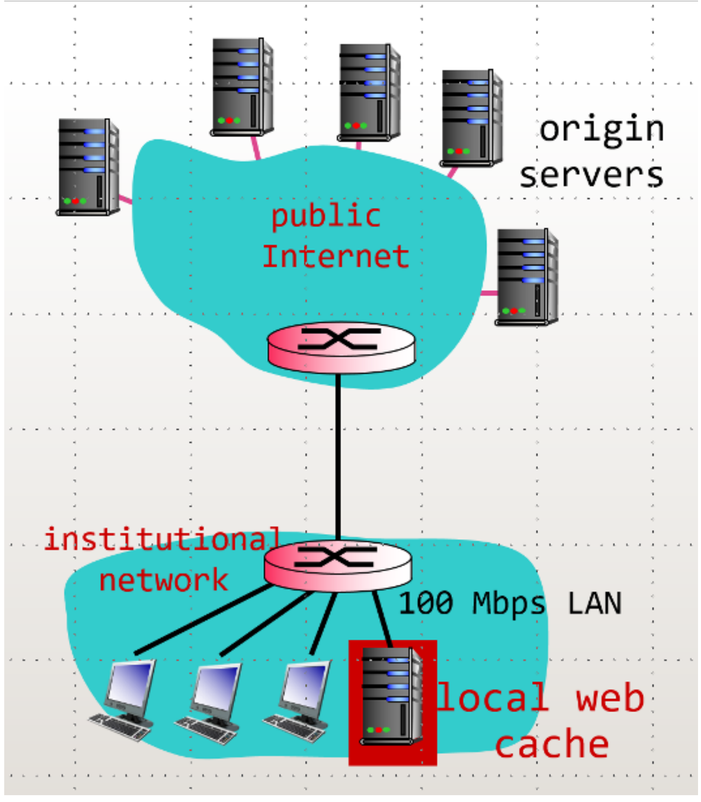
- Caching is a very popular technique used in the computer system. In general, the cache is located between the CPU and memory, and helps access latency to the data in memory reduced. The cache can be used in the network as well. Content can be placed in the cache node near users, so that user requests can be serviced by the cache node (near the users), not by the content server far away.

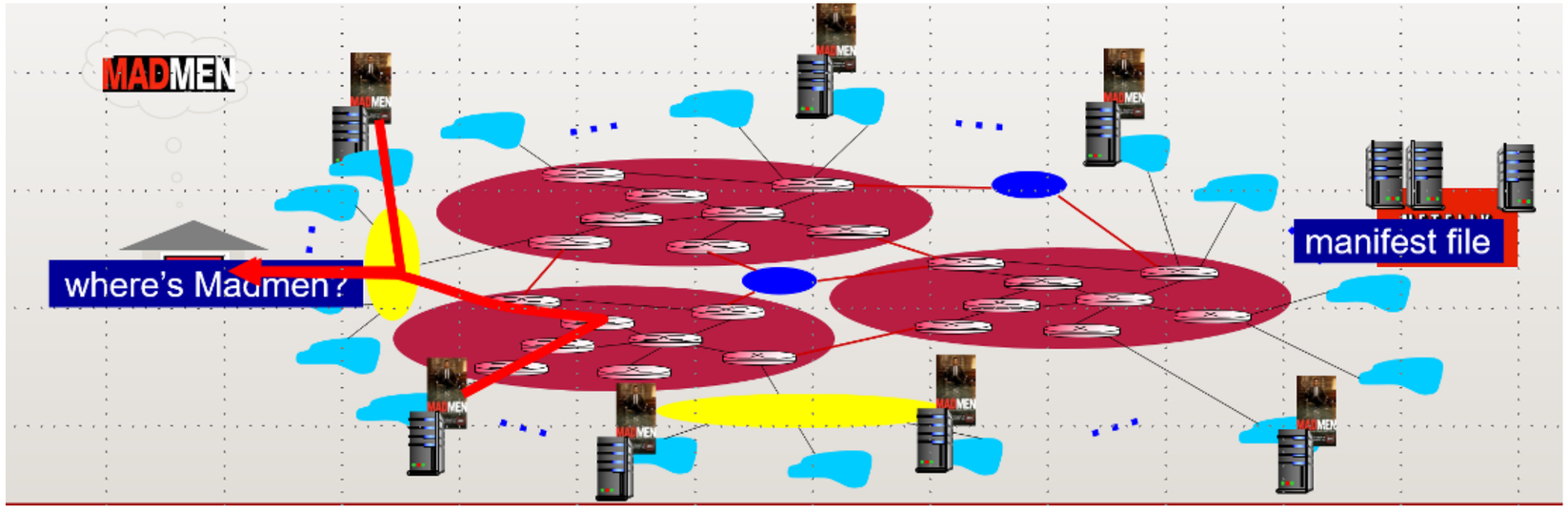
- Q) List as many examples of cache usage on the network as possible (refer to the books or websites)

- Q) Suppose that you are an administrator of the caching service company. Write down your idea to improve the performance of your caching service.


F
u_s
network
d_i
u_i


root DNS server
(gaia.cs.umass.edu, ?, A)
2
3
(edu, c.edu-servers.net, NS)
(c.edu-servers.net, 192.26.92.30, A)
TLD DNS server
local DNS server
dns.poly.edu
4
5
c.edu-servers.net
6
(umass.edu, ns2.umass.edu, NS)
(ns2.umass.edu, 128.119.100.84, A)
8
(gaia.cs.umass.edu, ?, A)
(gaia.cs.umass.edu, 128.119.245.12, A)
1
7
(gaia.cs.umass.edu, 128.119.245.12, A)
authoritative DNS server
ns2.umass.edu
requesting host
cis.poly.edu
gaia.cs.umass.edu


origin servers
public Internet
institutional network
100 Mbps LAN
local web cache


MADMEN
where's Madmen?
manifest file

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  → Web proxy, DNS, CDN, P2P, …

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- Q) Suppose that you are an administrator of the caching service company. Write down your idea to improve the performance of your caching service.
  → Selective caching for popular data, data that has traverse for a long distance, high-priority data, …

Questions?