Net Centric Chapter 1 – Problem Set

- Chapter 1 Review Questions: R1, R4, R5, R11, R12, R13, R16, R18, R19, R23, R24, R25

Turquoise for complete

Orange for incomplete

Red: Has not been started

Section 1.1

R1. What is the difference between a host and an end system? List several different types of end systems. Is a Web server an end system?

-There is no difference between a host and an end system. They can be used interchangeably. Different types of end systems include: PCs, mainframes, cellphones, tablets, and smart watches. A web server is an end system.

Section 1.2

R4. List six access technologies. Classify each one as home access, enterprise access, or wide- area wireless access.

1. WLAN: mobile access
2. DSL over telephone line: residential/home access
3. Ethernet: Enterprise
4. Cellular: Wide-area wireless access
5. Wi-Fi: Home and enterprise
6. Dial-up modem: Home

R5. Is HFC transmission rate dedicated or shared among users? Are collisions possible in a downstream HFC channel? Why or why not?

-HFC transmission rate is shared among users. Packets come from the head end (single source) on the downstream channel so there are no collisions

Section 1.3

R11. Suppose there is exactly one packet switch between a sending host and a receiving host. The transmission rates between the sending host and the switch and between the switch and the receiving host are $R1$ and $R2$, respectively. Assuming that the switch uses store-and-forward packet switching, what is the total end-to-end delay to send a packet of length L? (Ignore queuing, propagation delay, and processing delay.)

Complete transmission and the switch gets the entire packet : t1 = L/R1

From switch to receiving host : t2 = L/R2

End-to-end delay: t1 + t2 = (L/R1) + (L/R2)

R12. What advantage does a circuit-switched network have over a packet-switched network? What advantages does TDM have over FDM in a circuit-switched network?

In packet-switched networks, there may be a wait time because a session's messages use the resources on demand (the resources were not reserved). A circuit-switched network guarantees a certain amount of bandwidth, but packet-switched networks cannot. Since FDM shifts signals into their appropriate frequency bands, it requires complex analog hardware.

R13. Suppose users share a 2 Mbps link. Also suppose each user transmits continuously at 1 Mbps when transmitting, but each user transmits only 20 percent of the time. (See the

discussion of statistical multiplexing in Section 1.3 .)

a. When circuit switching is used, how many users can be supported?

Supports two users. Each user requires half of the bandwidth.

b. For the remainder of this problem, suppose packet switching is used. Why will there be essentially no queuing delay before the link if two or fewer users transmit at the same time? Why will there be a queuing delay if three users transmit at the same time?

There will be no queuing delay with the two users since they cannot exceed the bandwidth at anytime. If there are three users, the maximum bandwidth that can be requested would be 3 Mbps and because this is greater than the 2 Mbps link, there would be a queuing delay.

c. Find the probability that a given user is transmitting.

Each user is transmitting 20% of the time, so 0.2

d. Suppose now there are three users. Find the probability that at any given time, all three users are transmitting simultaneously. Find the fraction of time during which the queue grows.

Binomial Distribution:

Pr = (n k)(p^k)[(1 - p)^(n - k)]

= (3 3)(0.2^3)[(1 - 0.2)^(3 - 3)]

= 0.008

Section 1.4

R16. Consider sending a packet from a source host to a destination host over a fixed route. List the delay components in the end-to-end delay. Which of these delays are constant and which are variable?

-There are 4 delays: propagation delays, queuing delays, processing delays, and transmission delays.

-Queuing delays are variable while the other delays are fixed.

R18. How long does it take a packet of length 1,000 bytes to propagate over a link of distance 2,500 km, propagation speed 2.5·10^8 m/s, and transmission rate 2 Mbps? More generally, how long does it take a packet of length *L* to propagate over a link of distance *d*, propagation speed *s*, and transmission rate *R* bps? Does this delay depend on packet length? Does this delay depend on transmission rate?

Convert to m : (2500 * 10^3)

(2500 * 10^3)/(2.5*10^8) = 0.01s = 10ms

d/s

No

No

R19. Suppose Host A wants to send a large file to Host B. The path from Host A to Host B has three links, of rates R1=500 kbps, R2=2 Mbps, and R3=1 Mbps.

a. Assuming no other traffic in the network, what is the throughput for the file transfer?

500 kbps (smallest rate of the three)

b. Suppose the file is 4 million bytes. Dividing the file size by the throughput, roughly how long will it take to transfer the file to Host B?

   File in bits: (4*10^6)*8

   Throughput in bits: (500*10^3)

   (4*10^6)*8 / (500*10^3) = 64s

c. Repeat (a) and (b), but now with *R*2 reduced to 100 kbps.

   (4*10^6)*8 / (100*10^3) = 320s

Section 1.5

R23. What are the five layers in the Internet protocol stack? What are the principal responsibilities of each of these layers?

-Application: Is where network applications and their application-layer protocols reside.

-Transport: Transports application-layer messages between application endpoints

-Network: Responsible for moving network-layer packets known as datagrams from one host to another.

-Link: Moves a packet from one node to another.

-Physical: Job is to move the individual bits within the frame from one node to the next.

R24. What is an application-layer message? A transport-layer segment? A network-layer datagram? A link-layer frame?

Application-layer message - The message an application sends from the host.

Transport-layer segment - The application-layer message and the transport-layer header information together constitute the transport-layer segment

Network-layer datagram - The transport layer passes a segment to the network-layer, which adds network-layer header information such as source and destination end system addresses, creating a network-layer datagram.

Link-layer frame - Encapsulates the network-layer datagram with the link-layer header

R25. Which layers in the Internet protocol stack does a router process? Which layers does a link-layer switch process? Which layers does a host process?

-Routers process layers 1-3

-Link-layer switches process layers 1-2

-Host process all 5 layers

[redacted]

[redacted]

- Chapter 1 Problems: P3, P4, P8, P10, P13, P20, P24, P29a, P31.

P3. Consider an application that transmits data at a steady rate (for example, the sender generates an *N*-bit unit of data every *k* time units, where *k* is small and fixed). Also, when such an application starts, it will continue running for a relatively long period of time. Answer the following questions, briefly justifying your answer:

e. Would a packet-switched network or a circuit-switched network be more appropriate for this application? Why?

-A circuit switched-network would be more appropriate because the application would demand steady and warranted bandwidth during long sessions.

f. Suppose that a packet-switched network is used and the only traffic in this network comes from such applications as described above. Furthermore, assume that the sum of the application data rates is less than the capacities of each and every link. Is some form of congestion control needed? Why?

-No congestion control mechanism is required. Even if all the applications simultaneously transmit over one or more network links, the links offer sufficient bandwidth to handle the sum of all the applications' data rates, so not congestion will occur.

P4. Consider the circuit-switched network in **Figure 1.13**. Recall that there are 4 circuits on each link. Label the four switches A, B, C, and D, going in the clockwise direction.

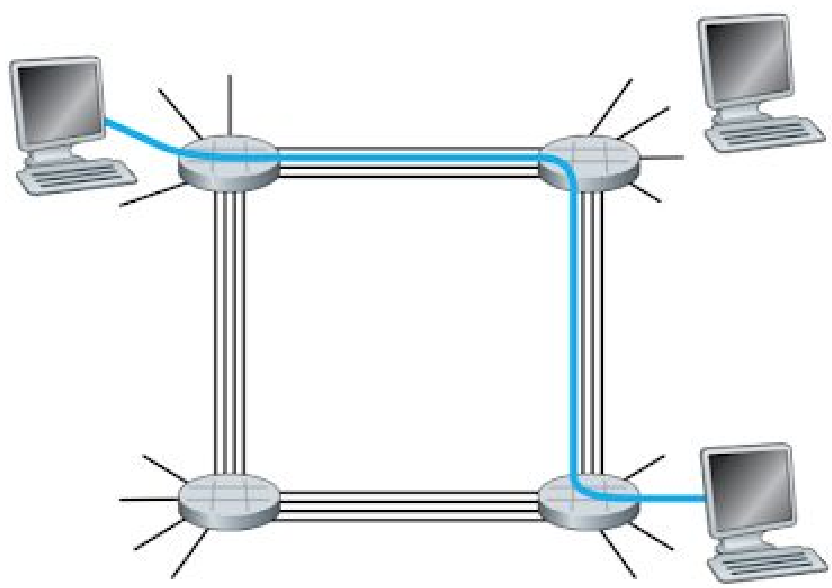

Figure 1.13 ♦ A simple circuit-switched network consisting of four switches and four links

g. What is the maximum number of simultaneous connections that can be in progress at any one time in this network?

h. Suppose that all connections are between switches A and C. What is the maximum number of simultaneous connections that can be in progress?

i. Suppose we want to make four connections between switches A and C, and another four connections between switches B and D. Can we route these calls through the four links to accommodate all eight connections?

P8. Suppose users share a 3 Mbps link. Also suppose each user requires 150 kbps when transmitting, but each user transmits only 10 percent of the time. (See the discussion of packet switching versus circuit switching in **Section 1.3** .)

j. When circuit switching is used, how many users can be supported?

k. For the remainder of this problem, suppose packet switching is used. Find the probability that a given user is transmitting.

l. Suppose there are 120 users. Find the probability that at any given time, exactly *n* users are transmitting simultaneously. (*Hint*: Use the binomial distribution.)

m. Find the probability that there are 21 or more users transmitting simultaneously.

P10. Consider a packet of length *L* that begins at end system A and travels over three links to a destination end system. These three links are connected by two packet switches. Let d_i, s_i, and R_i denote the length, propagation speed, and the transmission rate of link *i,* for $i=1,2,3$. The packet switch delays each packet by d_{proc}. Assuming no queuing delays, in terms of d_i, s_i, R_i, $(i=1,2,3)$, and *L,* what is the total end-to-end delay for the packet? Suppose now the packet is 1,500 bytes, the propagation speed on all three links is 2.5 · 108m/s, the transmission rates of all three links are 2 Mbps, the packet switch processing delay is 3 msec, the length of the first link is 5,000 km, the length of the second link is 4,000 km, and the length of the last link is 1,000 km. For these values, what is the end-to-end delay?

P13.

a.

Suppose *N* packets arrive simultaneously to a link at which no packets are currently being transmitted or queued. Each packet is of length *L* and the link has transmission rate *R*. What is the average queuing delay for the *N* packets?

b.-----

Now suppose that *N* such packets arrive to the link every *LN/R* seconds. What is the average queuing delay of a packet?

P20. Consider the throughput example corresponding to **Figure 1.20(b)** . Now suppose that there are *M* client-server pairs rather than 10. Denote R_s, R_c, and *R* for the rates of the server links, client links, and network link. Assume all other links have abundant capacity and that there is no other traffic in the network besides the traffic generated by the *M* client-server pairs. Derive a general expression for throughput in terms of R_s, R_c, *R*, and *M*.

P24. Suppose you would like to urgently deliver 40 terabytes data from Boston to Los Angeles. You have available a 100 Mbps dedicated link for data transfer. Would you prefer to transmit the data via this link or instead use FedEx over-night delivery? Explain.

P29. Suppose there is a 10 Mbps microwave link between a geostationary satellite and its base station on Earth. Every minute the satellite takes a digital photo and sends it to the base station.

Assume a propagation speed of $2.4 \cdot 108$ meters/sec.

a. What is the propagation delay of the link?

P31. In modern packet-switched networks, including the Internet, the source host segments long, application-layer messages (for example, an image or a music file) into smaller packets and sends the packets into the network. The receiver then reassembles the packets back into the original message. We refer to this process as *message segmentation*. **Figure 1.27** illustrates the end-to-end transport of a message with and without message

segmentation. Consider a message that is 8*10^6 bits long that is to be sent from source to destination in **Figure 1.27** . Suppose each link in the figure is 2 Mbps. Ignore propagation, queuing, and processing delays.

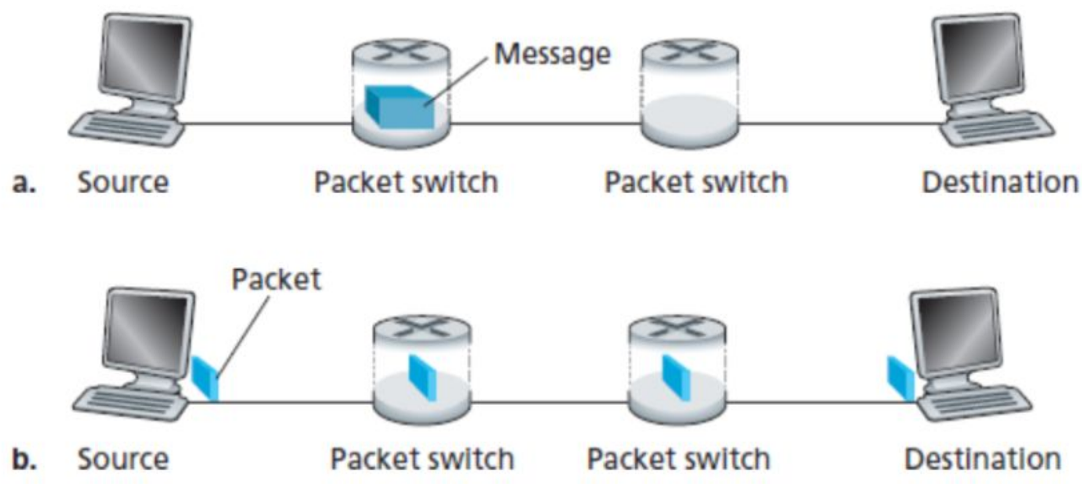

Figure 1.27 End-to-end message transport: (a) without message segmentation; (b) with message segmentation

a.

Consider sending the message from source to destination *without* message segmentation. How long does it take to move the message from the source host to the first packet switch? Keeping in mind that each switch uses store-and-forward packet switching, what is the total time to move the message from source host to destination host?

b.-

Now suppose that the message is segmented into 800 packets, with each packet being 10,000 bits long. How long does it take to move the first packet from source host to the first switch? When the first packet is being sent from the first switch to the second switch, the second packet is being sent from the source host to the first switch. At what time will the second packet be fully received at the first switch?

c.

How long does it take to move the file from source host to destination host when message segmentation is used? Compare this result with your answer in part (a) and comment.

d.-

In addition to reducing delay, what are reasons to use message segmentation?

e.

Discuss the drawbacks of message segmentation.