National University of Singapore
School of Computing
CS2105: Introduction to Computer Networks
Semester 1, 2018/2019

Tutorial 1

These questions will be discussed during the next week's discussion group meetings. Please be prepared to answer these questions during the session in class. Some of the questions are taken from the textbook, so please bring it along for reference.

1. **[KR, Chapter 1, P6]** Consider two hosts, A and B, connected by a single link of rate $\boldsymbol{R}\,bps$. Suppose that the two hosts are separated by $\boldsymbol{m}\,metres$, and suppose the propagation speed along the link is $\boldsymbol{s}\,m/s$. Host A is to send a packet of size $\boldsymbol{L}\,bits$ to Host B.
   (a) Express the propagation delay, $\boldsymbol{d}_{prop}$, in terms of $\boldsymbol{m}$ and $\boldsymbol{s}$.
   (b) Determine the transmission time of the packet, $\boldsymbol{d}_{trans}$, in terms of $\boldsymbol{L}$ and $\boldsymbol{R}$.
   (c) Ignoring processing and queuing delays, obtain an expression for the end-to-end delay $\boldsymbol{d}_{end-to-end}$.
   (d) Suppose Host A begins to transmit the packet at time $t = 0$. At time $t = \boldsymbol{d}_{trans}$, where is the last bit of the packet?
   (e) Suppose $\boldsymbol{d}_{prop}$ is greater than $\boldsymbol{d}_{trans}$. At time $t = \boldsymbol{d}_{trans}$, where is the first bit of the packet?
   (f) Suppose $\boldsymbol{d}_{prop}$ is less than $\boldsymbol{d}_{trans}$. At time $t = \boldsymbol{d}_{trans}$, where is the first bit of the packet?
   (g) Suppose $\boldsymbol{s} = 2.5 \times 10^8$, $\boldsymbol{L} = 120\,bits$, and $\boldsymbol{R} = 56\,kbps$. Find the distance $\boldsymbol{m}$ so that $\boldsymbol{d}_{prop}$ equals $\boldsymbol{d}_{trans}$.

2. **[KR, Chapter 1, 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.

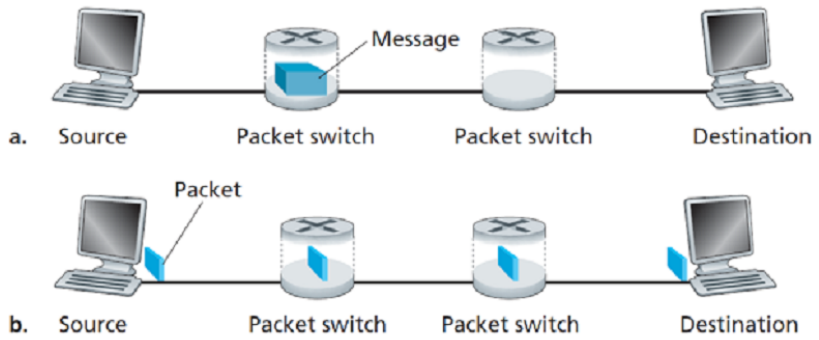

Figure 1.27 ♦ End-to-end message transport: (a) without message segmentation; (b) with message segmentation

Consider a message that is 8×10^6 bits long that is to be sent from a source to destination, through two packet switches. Suppose each link is $\boldsymbol{2}\,Mbps$. Ignore propagation, queuing and processing delays.

(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) Following a), what is the total time to move the message from source host to destination host? Keeping in mind that each switch uses store-and-forward packet switching.

(c) 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?

(d) 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.

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

(f) Discuss the drawbacks of message segmentation.

3. There are $\boldsymbol{N}$ devices that need to be connected. There can either be 0 or 1 link between 2 devices.

(a) What is the minimum number of links needed to connect all nodes? Discuss the property of the network topologies that can be formed.

(b) What is the maximum number of links that can be used to connect all nodes?

(c) What are the pros and cons of the solutions in part (a) and (b)?

4. **[KR, Chapter 1, P25]** Suppose two hosts, A and B, are separated by 20,000 kilometers and are connected by a direct link of $\boldsymbol{R} = 2\,Mbps$. Suppose the propagation speed over the link is $2.5 \times 10^8\,m/s$.

(a) Calculate the bandwidth-delay product, $\boldsymbol{R} \times \boldsymbol{d}_{prop}$.

(b) Consider sending a file of 800,000 bits from Host A to Host B. Suppose the file is sent continuously as one large message. What is the maximum number of bits that will be flowing in the link at any given time?

(c) Provide an interpretation of the bandwidth-delay product.