EE 450

Exam 1 Solutions

October 28, 2013

Work all 18 problems. Total = 140 points.

Problem 1. [10 pts.] How long (in seconds) does it take a packet of length 10,000 bytes to propagate over a length of 1500 km if the propagation speed is 2.5×10^8 m/s and the transmission rate is 15 Mbps?

Solution.

$$t_{prop} = \frac{1500 \times 10^3 \ m}{2.5 \times 10^8 \ m/s} = 6 \ msec.$$

Problem 2. [16 pts.] Suppose 2 hosts A and B are separated by 10,000 kilometers (km) and are connected by a direct link of rate $R = 4$ Mbps. Suppose the propagation speed in the link is 2.5×10^8 m/sec.

a. The bandwidth-delay product is defined to be $R \times d_{prop}$ where d_{prop} is the propagation delay. Calculate the bandwidth-delay product.
Solution.

$$R \times d_{prop} = 4 \times 10^6 \ bps \times \frac{10,000 \times 10^3 \ m}{2.5 \times 10^8 \ m/sec} = 1.60 \times 10^5 \ bits.$$

b. Consider sending a file of 10,000,000 bits from Host A to Host B and suppose the file is sent continuously as one large message. What is the maximum number of bits that will be in the link at any give time?
Solution.

$$maximum \ number \ of \ bits = 1.60 \times 10^5 \ bits.$$

c. What is the width of a bit? That is, if you could look at the bits in the link at some moment in time what would be the distance (in meters) between the beginning of a bit and the beginning of the next bit following it.
Solution.

$$width = \frac{10,000 \times 10^3\ m}{1.60 \times 10^5\ bits} = 62.5\ m/bit.$$

d. How long does it take to send the file?
Solution.

$$\begin{aligned} t_{trans} &= \frac{10,000,000\ bits}{4 \times 10^6\ bps} = 2.5\ sec \\ t_{prop} &= \frac{10,000 \times 10^3\ m}{2.5 \times 10^8\ m/sec} = 0.04\ sec \\ t &= t_{trans} + t_{prop} = 2.54\ sec \end{aligned}$$

Problem 3. [12 pts.] A geostationary satellite is located 36,000 kilometers (km) away from the surface of the Earth. Once a minute it takes a digital picture and transmits the data to a base station on Earth. The rate of transmission is 10 Mbps and the propogation speed is 2.5×10^8 m/s.

a. What is the propagation delay of the link?
Solution.

$$t_{prop} = \frac{36,000 \times 10^3\ m}{2.5 \times 10^8\ m/s} = 0.144\ sec$$

b. The bandwidth-delay product is defined to be $R \times d_{prop}$ where d_{prop} is the propagation delay. Calculate the bandwidth-delay product $R \times d_{prop}$ where d_{prop} is the propagation delay.
Solution.

$$R \times d_{prop} = 10\ Mbps \times 0.144\ sec = 1.44\ Mbits$$

c. Let x denote the size of the picture in bits. What is the minimum value for x so that the satellite is continuously transmitting data over the link?
Solution.

$$x_{min} = R \times 60\ sec = 10\ Mbps \times 60\ sec = 600\ Mbits$$

Problem 4. [5 pts.] Suppose you wanted to perform a single transaction from a remote client to a server as fast as possible. Would you use UDP or TCP? Explain why?

Solution. UDP. With UDP transmissions can be completed in 1 RTT. With TCP we need at least 2 RTT.

Problem 5. [5 pts.] What is the main task of the Internet's domain name system (DNS)?

Solution. Translate host names to IP addresses.

Problem 6. [10 pts.] Consider the following circular DHT. Peer 1 is at the top of the circle and 1's successor peer (clockwise) is 3 and 3's successor peer is 4 and 4's successor peer is 5 and 5's successor peer is 8 and 8's successor peer is 10 and 10's successor peer is 12 and 12's successor peer is 15 and 15's successor peer is 1. So we have $1 \rightarrow 3 \rightarrow 4 \rightarrow 5 \rightarrow 8 \rightarrow 10 \rightarrow 12 \rightarrow 15 \rightarrow 1$. Suppose a new peer 6 wants to join the DHT and peer 6 initially only knows peer 15's IP address. What steps are taken to enable peer 6 to join?

Solution. Peer 6 would first send peer 15 a message, saying what will be peer 6's predecessor and successor? This message gets forwarded through the DHT until it reaches peer 5, who realizes that it will be 6's predecessor and that its current successor, peer 8, will become 6's successor. Next, peer 5 sends this predecessor and successor information back to 6. Peer 6 can now join the DHT by making peer 8 its successor and by notifying peer 5 that it should change its immediate successor to 6.

Problem 7. [10 pts.] In our rdt protocols, why did we need to utilize sequence numbers and timers?

Solution. Sequence numbers are required for a receiver to find out whether an arriving packet contains new data or is a retransmission. Timers are required to handle losses in the channel. If the ACK for a transmitted packet is not received within the duration of the timer for the packet, the packet (or its ACK or NACK) is assumed to have been lost. Hence, the packet is retransmitted.

Problem 8. [12 pts.] UDP and TCP use 1s complement for their checksums. Suppose you have the following two 8-bit bytes: 01010011, 00111010.

a. What is the 1s complement of the sum of these 8-bit bytes?
Solution. Adding these 2 numbers we get 10001101. Taking the complement of the sum we get the 1s complement as 01110010.

b. With this scheme how does the receiver detect errors?
Solution.The receiver adds the two words received to the checksum. If 0 occurs anywhere in the result we know there was a transmission error.

c. How many errors are you guaranteed to detect with this scheme?
Solution. Guaranteed to detect a single error (or an odd number of errors) but not double errors.

Problem 9. [10 pts.] Suppose we are going to send a packet (2000 bytes including header fields and data) across the country at 10^9 bits/sec using a Go-Back-N protocol. How big would the window size have to be (in unit size of packets) for the channel utilization factor to 95%?
Solution.

$$\begin{aligned}
\frac{L}{R} &= \frac{2000 \times 8 \; bits}{10^9 \; bps} = 16 \times 10^{-6} \; sec \\
U_{sender} &= \frac{L/R}{RTT + L/R} = 5.33 \times 10^{-4}, \text{ where } RTT = 30 \; msec \\
n &= \frac{0.95}{U_{sender}} = 1783
\end{aligned}$$

Problem 10. [5 pts.] What is the difference between routing and forwarding?
Solution. Routing is thru the entire network. Forwarding is thru the router or switch.

Problem 11. [5 pts.] Consider a virtual circuit that has an 8-bit field. What is the maximum number of virtual circuits that can be carried over the field?
Solution. $2 * 8 = 256$.

Problem 12. [5 pts.] Is a network connection service between two processes? If your answer is no then state what is involved in the connection service.
Solution. No. A network connection is between 2 hosts with routers possibly involved.

Problem 13. [5 pts.] What are the five layers of the Internet Protocol Stack?
Solution. Application, Transport, Network, Link, Physical.

Problem 14. [5 pts.] What is the purpose of a socket?
Solution. It is the software bridge between the Application and Transport Layers.

Problem 15. [10 pts.] Briefly discuss the difference between TCP and UDP.
Solution. TCP utilizes handshaking to establish a connection. TCP uses reliable data transfer whereas UDP is wide open.

Problem 16. [5 pts.] What is the purpose of SSL and what layer is it implemented?
Solution. It provides security at the Application Layer.

Problem 17. [5 pts.] Is HTTP an application layer or transport layer protocol? Does it use TCP or UDP?
Solution. It is at the Application Layer. Usually it is TCP but can be UDP.

Problem 18. [5 pts.] In class we discussed an equation that estimates the round trip time of a packet as follows:

$$\text{EstimatedRTT} = (1 - \alpha)\text{EstimatedRTT} + \alpha\text{SampleRTT}$$

where α is a small real number. We related this to a simple kind of averager. What kind of averager did we use and how conceptually did we relate it, that is, what statistics of the data did we use?

Solution. We related the expression above (which is an IIR filter) to a sliding window integrator (SWI) by matching the mean and variance of the output to a white Gaussian noise input.