Homework for Chapter 6

1. In our example transport primitives of Fig. 6-2, LISTEN is a blocking call. Is this strictly necessary? If not, explain how a nonblocking primitive could be used. What advantage would this have over the scheme described in the text?

   Solution:

   Not strictly necessary.

   The LISTEN call could be a nonblocking call, just indicating a willingness to establish new connections.

   When an attempt to connect was made, the caller could be given a signal (an interrupt).

   It would then execute, say, OK or REJECT to accept or reject the connection.

   See the flow control protocol for Data link layer.

2. Suppose that the clock-driven scheme for generating initial sequence numbers is used with a 15 bit wide clock counter. The clock ticks once every 100 msec, and the maximum packet lifetime is 60 sec. How often need resynchronization take place

   a. in the worst case?

   b. when the data consumes 240 sequence numbers/min?

   Solution:

   a. At zero generation rate, the sender would enter the forbidden zone at $2^{15} \times 0.1 - 60 = 3216.8$ sec.

   b. One line is $y = \dfrac{240}{60} t = 4t$.

      The other line (the left edge of the forbidden zone) is $y = \dfrac{1}{0.1}(t - 3216.8) = 10t - 32168$.

      The intersection point: $t = 536.133$.

3. Why does the maximum packet lifetime, T, have to be large enough to ensure that not only the packet but also its acknowledgements have vanished?

   Solution:

   Look at the second duplicate packet in Fig. 6-11(b).

   When that packet arrives, it would be a disaster if acknowledgements to y were still floating around.

4. Consider a connection-oriented transport-layer protocol that uses a time-of-day clock to determine packet sequence numbers. The clock uses a 10 bit counter, and ticks once every 125 msec. The maximum packet lifetime is 64 sec. If the sender sends 4 packets per second, how long could the connection last without entering the forbidden region?

   Solution:

   The line for the sending packets:

   $$y = 4t$$

   The top line for the forbidden region

   $$y = \frac{1}{0.125}(t - (2^{10} \times 0.125 - 64)) = 8(t - 64)$$

   Then

   $$\begin{cases} y = 4t \\ y = 8(t - 64) \end{cases} \Rightarrow t = 128.$$

5. Discuss the advantages and disadvantages of credits versus sliding window protocols.

   Solution:

The sliding window is simpler, having only one set of parameters (the window edges) to manage. Furthermore, the problem of a window being increased and then decreased, with the segments arriving in the wrong order, does not occur.

The credit scheme is more flexible, allowing a dynamic management of the buffering, separate from the acknowledgements.

6. Two hosts simultaneously send data through a network with a capacity of 1 Mbps. Host *A* uses UDP and transmits a 100 bytes packet every 1 msec. Host *B* generates data with a rate of 600 kbps and uses TCP. Which host will obtain higher throughput?

   Solution:

   UDP on host A will use 800 kbps, leaving only 200 kbps for TCP on host B.

7. Why does UDP exist? Would it not have been enough to just let user processes send raw IP packets?

   Solution:

   UDP's ports are used to specify the user processes on the sending and receiving hosts.

   An IP address specifies a interface (and its host). This is not enough.

8. A client sends a 128 byte request to a server located 100 km away over a 1-gigabit optical fiber. What is the efficiency of the line during the remote procedure call?

   Solution:

$$\frac{\frac{128\times 8}{1\times 10^9}}{\frac{2\times 100\times 10^3}{2\times 10^8}} = 0.001 = 0.1\%.$$

9. Consider the situation of the previous problem again. Compute the minimum possible response time both for the given 1 Gbps line and for a 1 Mbps line. What conclusion can you draw?

   Solution:

   For 1 Gbps line:

$$\frac{128\times 8}{1\times 10^9} + \frac{2\times 100\times 10^3}{2\times 10^8} = 1\times 10^{-3} = 1 \text{ msec.}$$

   For 1 Mbps line:

$$\frac{128\times 8}{1\times 10^6} + \frac{2\times 100\times 10^3}{2\times 10^8} = 2\times 10^{-3} = 2 \text{ msec.}$$

   For the response time, 1 Gbps line is not that great!

10. Datagram fragmentation and reassembly are handled by IP and are invisible to TCP. Does this mean that TCP does not have to worry about data arriving in the wrong order?

    Solution:

    Even though each datagram arrives intact, it is possible that datagrams arrive in the wrong order, so TCP has to be prepared to reassemble the parts of a message properly.

11. In Fig. 6-36, we saw that in addition to the 32 bit acknowledgement field, there is an ACK bit in the fourth word. Does this really add anything? Why or why not?

    Solution:

    The ACK bit is helpful for normal data traffic.

    The ACK bit is crucial for connection control management.

12. Consider a connection that uses TCP Reno. The connection has an initial congestion window size of 1 KB, and an initial threshold of 64. Assume that additive increase uses a step-size of 1 KB. What is the size of the congestion window in transmission round 8, if the first transmission round is number 0?

    Solution:

Round	0	1	2	3	4	5	6	7	8
CWD (KB)	1	2	4	8	16	32	64	65	$\boxed{66}$

13. In a network whose max segment is 128 bytes, max segment lifetime is 30 sec, and has 8 bit sequence numbers, what is the maximum data rate per connection?

    Solution:

$$\frac{(2^8 - 1) \times 128 \times 8}{30} \text{ bps} = 8704 \text{ bps} = 8.704 \text{ kbps}.$$

14. To get around the problem of sequence numbers wrapping around while old packets still exist, one could use 64 bit sequence numbers. However, theoretically, an optical fiber can run at 75 Tbps. What maximum packet lifetime is required to make sure that future 75-Tbps networks do not have wraparound problems even with 64 bit sequence numbers? Assume that each byte has its own sequence number, as TCP does.

    Solution:

$$\frac{2^{64}}{\frac{75 \times 10^{12}}{8}} \approx 1.968 \times 10^6.$$

    Attractive.

15. Calculate the bandwidth-delay product for the following networks:

    (1) T1 (1.5 Mbps),

    (2) Ethernet (10 Mbps),

    (3) T3 (45 Mbps), and

    (4) STS-3 (155 Mbps).

    Assume an RTT of 100 msec. Recall that a TCP header has 16 bits reserved for Window Size. What are its implications in light of your calculations?

    Solution:

    TCP Window Size = 2^{16} = 64 KB

    (1)

$$\frac{1.5 \times 10^6 \times 0.1}{8} \text{ B} = 18.75 \text{ KB}$$

    (2)

$$\frac{10 \times 10^6 \times 0.1}{8} \text{ B} = 125 \text{ KB}$$

    (3)

$$\frac{45 \times 10^6 \times 0.1}{8} \text{ B} = 562.5 \text{ KB}$$

    (4)

$$\frac{155 \times 10^6 \times 0.1}{8} \text{ B} = 1937.5 \text{ KB}$$

    To use Ethernet, T3, STS-3 efficiently, Window size **scaling** is required.