Exercises for Chapters 1 through 3

DT066A TCP/IP Internetworking

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Questions

(3p) 2. In rdt protocols,

- Why did we need to introduce sequence numbers?
- Why did we need to introduce timers?

(3p) 3. Draw the Finite State Machine (FSM) for the receiver side of protocol rdt3.0.

(3p) 4. What does it mean for a protocol to be stateless? Explain whether IMAP and SMTP are stateless or stateful, and justify your answer with examples of how each protocol handles client-server interactions.

(3p) 5. Is it possible for an application to enjoy reliable data transfer even when the application runs over UDP? If so, how?

(3p) 6. Answer the following questions.

- What are cookies, and how do they work in the context of web browsing?
- Why are cookies needed and important for websites and web applications?
- Please explain the process of how a cookie is created, stored, and transmitted between a web server and a client's browser.
- What are the advantages of using cookies in web development? How do they enhance the user experience?
- What are some potential weaknesses or vulnerabilities associated with cookies?
- Elaborate on benefits and drawbacks using examples and illustrations.

(3p) 7. What is congestion at the transport layer, and how does it impact network performance? What are the congestion control techniques employed by TCP, and could you explain each of them in detail?

(3p) 8. Answer the following questions.

- How does packet loss impact a transport layer protocol that aims to achieve reliable delivery over an unreliable channel? What mechanisms are employed to manage packet loss in such protocols?
- What is the effect of duplicate acknowledgments on a transport layer protocol striving for reliable delivery over an unreliable channel? How does the protocol handle duplicate acknowledgments to ensure proper management of the issue?
- Explain how congestion affects a transport layer protocol designed for reliable delivery over an unreliable channel. What mechanisms and algorithms are utilized to manage congestion in such protocols and maintain reliable communication?

(3p) 9. Explain how the following problems affect a transport layer protocol that should achieve reliable delivery over an unreliable channel. For each of the problems, explain the mechanisms used to manage the problem.

- Packet Loss.
- Duplicate Acknowledgement.
- Congestion.

(3p) 10. Consider that only a single TCP (Reno) connection uses one 54 Mbps wireless link which does not buffer any data. Suppose that this link is the only congested link between the sending and receiving hosts. Assume that the TCP sender has a huge file to send to the receiver, and the receiver's receive buffer is much larger than the congestion window.

We also make the following assumptions: each TCP segment size is 536 bytes; the two-way propagation delay of this connection is 6 msec; and this TCP connection is always in the congestion avoidance phase, that is, ignore slow start.

- What is the maximum window size (in segments) that this TCP connection can achieve?
- What is the average window size (in segments) and average throughput (in bps) of this TCP connection?
- How long would it take for this TCP connection to reach its maximum window again after recovering from a packet loss?

Hints:

$$W \cdot \frac{\text{MSS} \cdot 8}{\text{RTT}} = \text{Throughput (bits per second)}$$

- W is the window size in segments.
- MSS is the Maximum Segment Size in bytes.
- 8 is the number of bits in a byte.
- RTT is the Round-Trip Time.

Average Window Size (W) (Section 3.7 page 303)

The congestion window size varies from $\frac{W}{2}$ to W (assuming TCP congestion avoidance phase, ignoring slow start). The average window size is given as $0.75W$.

$$\text{Average Window Size} = 0.75W$$

Packet Loss

- After detecting a packet loss, TCP Reno enters a "fast recovery" phase.
- The window size W is reduced to half of its current value $W/2$.

$$W' = \frac{W}{2}$$

Time to Recover

- The time it takes to recover the window size from $W/2$ to W is determined by the number of round-trip times (RTTs).
- Each round-trip time allows the window size to increase by one MSS (Maximum Segment Size).

$$\text{Time to Recover} = (W - W') \times \text{RTT}$$

(3p) 11. At home, I noticed that in one of my rooms, I had a loss rate of $L = 40\%$ when I tested the link. The RTT I got was 0.5 ms and I use a standard maximum segment size (MSS) for an Ethernet connection.

$$\text{Avg. Throughput} = \frac{1.22 \times \text{MSS}}{\text{RTT}\sqrt{L}}$$

With the help of the above relationship, answer the following:

- What average throughput did I get from that connection? Give the answer in bits per second (b/s) and bytes per second (B/s).
- Luckily it was just because of a bad cable, and once I changed it, I got a throughput of 1 Gbps. What loss rate is tolerated to get that speed? Explain this loss rate in percentage and in terms of X packets lost per Y packets sent.