

Homework 5

1. Suppose an application generates chunks of 40 bytes of data every 20 msec, and each chunk gets encapsulated in a TCP segment and then an IP datagram. What percentage of each datagram will be overhead, and what percentage will be application data?

$$40 \text{ bytes for IP datagram} + 40 \text{ bytes for TCP segment} \\ \therefore 50\% \text{ overhead}$$

2. Consider that only a single TCP connection uses one 10Mbps 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 receivers receive buffer is much larger than the congestion window. We also make the following assumptions: each TCP segment size is 1,500 bytes; the two-way propagation delay of this connection is 150 msec; and this TCP connection is always in congestion avoidance phase, that is, ignore slow start.

a. What is the maximum window size (in segments) that this TCP connection can achieve?

$$W = \text{maximum window size (segments)}$$

$$\frac{W * MSS}{RTT} = 10Mbps$$

$$\frac{W(1500 \text{ bytes} * 8 \text{ bits})}{0.150 \text{ sec}} = 10,000,000 \text{ bps}$$

$$W = \frac{10000000 * 0.150}{1500 * 8} = 125 \text{ segments}$$

b. What is the average window size (in segments) and average throughput (in bps) of this TCP connection?

$$\text{Average window size from } \frac{W}{2} \text{ to } W = 0.75W$$

$$\text{Average window size} = 0.75 * 125 = 93.75 \sim 94 \text{ segments}$$

$$\text{Average throughput} = \frac{W_{avg} * MSS}{RTT} = \frac{93.75 * (1500 * 8)}{0.150} = 7.5 \text{ Mbps}$$

c. How long would it take for this TCP connection to reach its maximum window again after recovering from a packet loss?

$$\text{Number of RTTs to increase } W \text{ from } \frac{W}{2} \text{ to } W = \frac{W}{2} * RTT = \frac{125}{2} * 150 = 9375 \text{ msec} \\ = 9.375 \text{ sec}$$

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3. Consider a modification to TCPs congestion control algorithm. Instead of additive increase, we can use multiplicative increase. A TCP sender increases its window size by a small positive constant a ($0 < a < 1$) whenever it receives a valid ACK. Find the functional relationship between loss rate L and maximum congestion window W . Explain why for this modified TCP, regardless of TCPs average throughput, a TCP connection always spends the same amount of time to increase its congestion window size from $W/2$ to W .

$S = \text{total number of segments sent when TCP changes } W \text{ from } \frac{W}{2} \text{ to } W$

$$S = \frac{W}{2} + \frac{W}{2} * (1 + a) + \frac{W}{2} * (1 + a)^2 + \frac{W}{2} (1 + a)^3 + \dots + \frac{W}{2} (1 + a)^k$$

$$k = \log(1 + a) 2$$

$$S = \frac{W(2a + 1)}{2a}$$

$L = \text{loss rate}$

$$L = \frac{1}{S} = \frac{2a}{W(2a + 1)}$$

Time TCP takes to increase $\frac{W}{2}$ to W : $k * RTT = \log(1 + a) 2 * RTT$

$$\text{TCP throughput: } B = \frac{MSS * S}{RTT(k + 1)} = \frac{MSS}{L * RTT * (k + 1)}$$

The time TCP takes to increase $W/2$ to W is independent of TCP throughput.

4. Calculate the network mask, the number of bits of the network, the number of endpoint addresses in the network (excluding special addresses), the network address, and the broadcast address of the network for the following:

a. 131.179.196.0/24

Netmask: 255.255.255.0
Bits: 24
Endpoints: 254
Address: 131.179.196.0
Broadcast: 131.179.196.255

b. 169.232.34.48/30

Netmask: 255.255.255.252
Bits: 30
Endpoints: 2
Address: 169.242.34.48
Broadcast: 169.232.34.51

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c. 196.22.136.0/21

Netmask: 255.255.248.0
Bits: 21
Endpoints: 2046
Address: 196.22.136
Broadcast: 196.22.143.255

d. 93.181.192.0, netmask 255.255.224.0

Netmask: 255.255.224.0
Bits: 19
Endpoints: 8190
Address: 93.181.192.0
Broadcast: 93.181.233.255

e. 10.128.0.0, netmask 255.192.0.0

Netmask: 255.192.0.0
Bits: 10
Endpoints: 4194302
Address: 10.128.0.0
Broadcast: 10.191.255.255

5. Consider the router trying to send the following IP packet:

4	5	TOS	6123			
123098			0	0	0	0
25		6	checksum			
10.1.1.1						
80.233.250.62						
data (6103 bytes)						

Assuming that the maximum transmission unit that can be transferred over the link is 1500 bytes, show

a. Into how many fragments this IP packet is being split

5 fragments

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b. For each of the fragment show the header length, total length, identification, flags, fragment offset, TTL, protocol fields, and IP payload size.

Header length	Total length	Identification	Flags	Fragment offset	TTL	Protocol	Data size
20	1500	123098	1	0	25	6	1480
20	1500	123098	1	185	25	6	1480
20	1500	123098	1	370	25	6	1480
20	1500	123098	1	555	25	6	1480
20	203	123098	0	730	25	6	183