

## CS 536 Homework -1

**Handed Out:** 17<sup>th</sup> September 2007

**Due Date:** 24<sup>th</sup> September 2007 (In Class)

### Q.1 [Problem 7, Chapter – 1, Kurose 4<sup>th</sup> Edition]

Suppose users share a 1 Mbps link. Also suppose each user requires 100 kbps when transmitting, but each user transmits only 10 percent of the time. (See the discussion of statistical multiplexing in section 1.3).

- When circuit switching is used, how many users can be supported ?
- For the remainder of the problem, suppose packet switching is used. Find the probability that a given user is transmitting.
- Suppose there are 40 users. Find the probability that at any given time, exactly  $n$  users are transmitting simultaneously. (Hint: Use the binomial distribution).
- Find the probability that there are 11 or more users transmitting simultaneously.

### Q.2 [Problem 13, Chapter – 1, Kurose 4<sup>th</sup> Edition]

Consider the queuing delay in a router buffer (preceding an outbound link). Suppose all packets are  $L$  bits, the transmission rate is  $R$  bps, and that  $N$  packets simultaneously arrive at the buffer every  $LN/R$  seconds. Find the average queuing delay of a packet. (Hint: The queuing delay for the first packet is zero, for the second packet  $L/R$ ; for the third packet  $2L/R$ . The  $N$ th packet has been transmitted when the second batch of packets arrives.)

### Q.3 [Problem 18, Chapter – 1, Kurose 4<sup>th</sup> Edition]

Suppose two hosts, A and B, are separated by 10,000 kilometers and are connected by a direct link of  $R = 1$  Mbps. Suppose that the propagation speed over the link is  $2.5 * 10^8$  meters/sec.

- Calculate the Bandwidth-Delay product,  $R * d_{prop}$ .
- Consider sending a file of 400,000 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 in the link at any given time ?
- Provide an interpretation of the bandwidth-delay product.
- What is the width (in meters) of a bit in the link ? Is it longer than a football field ?
- Derive a general expression for the width of a bit in terms of the propagation speed  $s$ , the transmission rate  $R$ , and the length of the link  $m$ .

**Q.4** [Problem 7, Chapter – 2, Kurose 4<sup>th</sup> Edition]

Suppose within your web browser you click on a link to obtain a Web page. The IP address for the associated URL is not cached in your local host, so a DNS lookup is necessary to obtain the IP address. Suppose that  $n$  DNS servers are visited before your host receives the IP address from DNS; the successive visits incur an RTT of  $RTT_1, \dots, RTT_n$ . Further suppose that the Web page associated with the link contains exactly one object, consisting of a small amount of HTML text. Let  $RTT_0$  denote the RTT between the local host and the server containing the object. Assuming zero transmission time of the object, how much time elapses from when the client clicks on the link until the client receives the object ?

**Q.5** [Problem 10, Chapter – 2, Kurose 4<sup>th</sup> Edition]

Consider a short, 10 meter link, over which a sender can transmit at a rate of 150 bits/sec in both directions. Suppose that packets containing data are 100,000 bits long, and packets containing only control (eg. ACK or handshaking) are 200 bits long. Assume that  $N$  parallel connections each get  $1/N$  of the link bandwidth. Now consider the HTTP protocol, and suppose that the object is 100Kbits long, and the initial downloaded object contains 10 referenced objects from the same sender. Would parallel downloads via parallel instances of non-persistent HTTP make sense in this case ? Now consider persistent HTTP. Do you expect significant gains over the non-persistent case ? Justify and explain your answer.

**Q.6** [Problem 19, Chapter – 2, Kurose 4<sup>th</sup> Edition]

Consider an overlay network with  $N$  active peers, with each pair of peers having an active TCP connection. Additionally, suppose that the TCP connections pass through a total of  $M$  routers. How many nodes and edges are there in the corresponding overlay network ?

**Q.7** [Problem 23, Chapter – 2, Kurose 4<sup>th</sup> Edition]

Consider query flooding, as discussed on Section 2.6. Suppose that each peer is connected to at most  $N$  neighbors in the overlay network. Also suppose that the node-count field is initially set to  $K$ . Suppose Alice makes a query. Find an upper bound on the number of query messages that are sent into the overlay network.