

Computer Network HW1

1. $4 \times 5 = 20$ points

- R13. Suppose users share a 2 Mbps link. Also suppose each user transmits continuously at 1 Mbps when transmitting, but each user transmits only 20 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 this problem, suppose packet switching is used. Why will there be essentially no queuing delay before the link if two or fewer users transmit at the same time? Why will there be a queuing delay if three users transmit at the same time?
 - Find the probability that a given user is transmitting.
 - Suppose now there are three users. Find the probability that at any given time, all three users are transmitting simultaneously. Find the fraction of time during which the queue grows.

2. $4 \times 5 = 20$ points

- P8. Suppose users share a 10 Mbps link. Also suppose each user requires 200 kbps when transmitting, but each user transmits only 10 percent of the time. (See the discussion of packet switching versus circuit switching in Section 1.3.)
- When circuit switching is used, how many users can be supported?
 - For the remainder of this problem, suppose packet switching is used. Find the probability that a given user is transmitting.
 - Suppose there are 120 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 51 or more users transmitting simultaneously.

3. $2 \times 5 = 10$ points

- P13. (a) Suppose N packets arrive simultaneously to a link at which no packets are currently being transmitted or queued. Each packet is of length L and the link has transmission rate R . What is the average queuing delay for the N packets?
- (b) Now suppose that N such packets arrive to the link every LN/R seconds. What is the average queuing delay of a packet?

4. 1*5=5points

- P16. Consider a router buffer preceding an outbound link. In this problem, you will use Little's formula, a famous formula from queuing theory. Let N denote the average number of packets in the buffer plus the packet being transmitted. Let a denote the rate of packets arriving at the link. Let d denote the average total delay (i.e., the queuing delay plus the transmission delay) experienced by a packet. Little's formula is $N = a \cdot d$. Suppose that on average, the buffer contains 100 packets, and the average packet queuing delay is 20 msec. The link's transmission rate is 100 packets/sec. Using Little's formula, what is the average packet arrival rate, assuming there is no packet loss?

5. 2*5=10points

- P1. True or false?
- A user requests a Web page that consists of some text and three images. For this page, the client will send one request message and receive four response messages.
 - Two distinct Web pages (for example, `www.mit.edu/research.html` and `www.mit.edu/students.html`) can be sent over the same persistent connection.
 - With nonpersistent connections between browser and origin server, it is possible for a single TCP segment to carry two distinct HTTP request messages.
 - The `Date:` header in the HTTP response message indicates when the object in the response was last modified.
 - HTTP response messages never have an empty message body.

6. 1*5 = 5 points

- P7. 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?

7. $3 \times 5 = 15$ points

- P8. Referring to Problem P7, suppose the HTML file references eight very small objects on the same server. Neglecting transmission times, how much time elapses with
- Non-persistent HTTP with no parallel TCP connections?
 - Non-persistent HTTP with the browser configured for 6 parallel connections?
 - Persistent HTTP?

8. $3 \times 5 = 15$ points

- P23. Consider distributing a file of F bits to N peers using a client-server architecture. Assume a fluid model where the server can simultaneously transmit to multiple peers, transmitting to each peer at different rates, as long as the combined rate does not exceed u_s .
- Suppose that $u_s/N \leq d_{\min}$. Specify a distribution scheme that has a distribution time of NF/u_s .
 - Suppose that $u_s/N \geq d_{\min}$. Specify a distribution scheme that has a distribution time of F/d_{\min} .
 - Conclude that the minimum distribution time is in general given by $\max \{ NF/u_s, F/d_{\min} \}$.