CMPUT 313 - Assignment #1 (6%)

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Due: Thursday, September 24, 2015 (in classroom)

Guidelines:

- **Start the answer of each question on a separate page.**
- **Write neatly (or use a computer to typeset and spell your answers).**

1. A file is transmitted over a path of 3 links. The relevant parameters and assumptions of the transmission are listed below:

   - L (bits): the length of the file
   - R (bps): the data rate of each link
   - d_{cs} (sec.): in case of circuit switching, the circuit setup time
   - p: in case of packet switching, the file is divided into p packets (assume equal length packets)
   - H (bits): in case of packet switching, the length of the header field that is added to each packet
   - there is no congestion, so in packet switching, a packet is transmitted onto a link as soon as a router verifies the checksum field

   (a) Give an expression for T_1 the file transmission time, assuming circuit switching is used.

   (b) Give an expression for T_2 the file transmission time, assuming packet switching, and $p = 1$ is used.

   (c) Give an expression for T_3 the file transmission time, assuming packet switching, and $p > 1$ is used.

   (d) For a given $p > 1$, give an expression for the maximum d_{cs} that will cause circuit switching to be better than packet switching.

   (e) Obtain numerical values for the above parts assuming that $L = 15$ Mbits, $d_{cs} = 5$ sec, $R = 10$ Mbits/sec, H= 40 bits, and $p = 10$. For part (d), derive the required d_{cs} value.

2. Consider Figure 1.19(a). Assume that we know the bottleneck link along the path from the server to the client is the first link with rate R_s bits/sec. Suppose we send a pair of packets back to back from the server to the client, and there is no other traffic on this path. Assume each packet of size L bits, and both links have the same propagation delay d_{prop}.

   (a) What is the packet inter-arrival time at the destination? That is, how much time elapses from when the last bit of the first packet arrives until the last bit of the second packet arrives?

(b) Now assume that the second link is the bottleneck link (i.e. $R_c < R_s$). Is it possible that the second packet queues at the input queue of the second link? Explain.

(c) Now suppose that the server sends the second packet T seconds after sending the first packet. How large must T be to ensure no queueing before the second link? Explain.

3. Problem P33, page 78, of the textbook (in the 5/E, P32, page 79; erratum: $L = 40+S$ should be $L = 80 + S$). **Show your work.**

4. Consider a server that sends packets to a client over a path of N links. Each link loses packets with probability q independent of other links. When a packet is lost, the server retransmits the packet (intermediate routers do not take any recovery action).

   (a) What is the probability that a packet transmitted by the server is successfully received by the client?

   (b) On average, how many times will the server transmit a packet until the client successfully receives the packet?

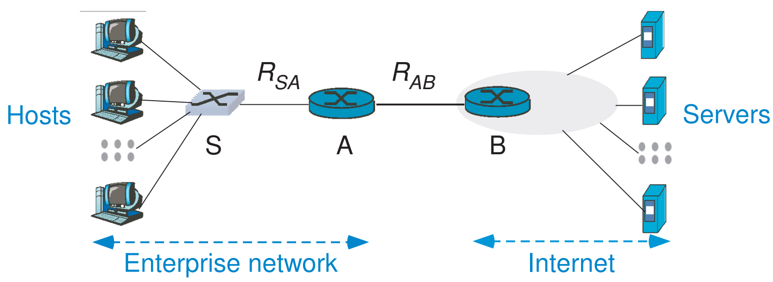
5. The *stop-and-wait* protocol is a simple protocol that ensures error-free delivery of packets over a channel that may corrupt transmissions. In stop-and-wait, when the receiver gets a packet with errors, a negative acknowledgment (NAK) message is sent back to the source, and the source retransmits the packet. On the other hand, when a packet is received error-free, the receiver sends an acknowledgment (ACK) back to the source. Assume that each packet transmission is independently successfully transmitted with probability p.

   (a) Give a probability model of X, the number of times that a packet is transmitted by the source.

   (b) Suppose that each packet takes 1 millisecond to transmit, and the source waits an additional millisecond to receive the returned ACK, or NAK, message before retransmitting. Let T equal the time required until the sender receives an ACK message. Give a probability model of T.

   (c) On the average, how long does it take until the sender receives an ACK message?

6. The following Figure illustrates an enterprise network connected to servers on the Internet by the AB link. Hosts in the enterprise network request data objects from the servers. Request packets have negligible length. We model the average response time seen by an enterprise user using the following parameters.



- L bits: the average object size requested by enterprise users
- R_{SA} bits/sec: data rate of the SA link (in each direction), and any other link in the enterprise network
- R_{AB} bits/sec: data rate of the AB link (in each direction)
- λ_{all} requests/sec: the average rate of requests for data objects generated by enterprise users
- T_{serve} sec (average Internet delay): the amount of time it takes from when router B forwards a request to the servers for a data object until it receives the object.

The average response time, denoted $T_{response}$, is approximated by the sum $T_{serve} + T_{BA} + T_{AS}$ where

- T_{BA}: the average delay (queueing + transmission) of a data object in router B before it is forwarded to router A
- T_{AS}: the average delay (queueing + transmission) of a data object in router A before it is forwarded to the requesting host (the switch S does not store data)

Using the M/M/1 model for queuing delays applied to data objects in routers A and B, answer the following questions.

(a) Give an algebraic expression for $T_{response}$ as a function of the model inputs: L, R_{SA}, R_{AB}, λ_{all}, and T_{serve}. Explain.

(b) Assume that $L = 850000$ bits, $\lambda_{all} = 16$ requests/sec, $T_{serve} = 3$ sec, $R_{SA} = 100$ Mbps, and $R_{AB} = 15$ Mbps. Find the numerical value of $T_{response}$ derived in (a). Show your work.

(c) Now suppose that one of the hosts acts as an enterprise cache server for the data objects. Suppose that the miss rate of this cache server is 0.4. Give an algebraic expression for $T_{response}$. Explain.
(**Note:** **(a)** here, $T_{response}$ has a new component corresponding to cases where data objects are served from the cache server, and **(b)** the average rate of requests served by the Internet servers is less than λ_{all} since many requests are served by the enterprise cache server.)

(d) Use the numerical values in (b) to find the value of $T_{response}$ derived in (c).