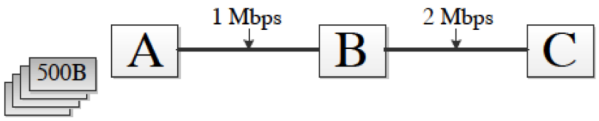
CS422 Computer Networks (Spring 2024): Homework 1

(Due Date: 23:59:59PM Friday Feb 2, 2024, Total: 30 points)

1. **(12 points)** Consider sending 4 packets from Node A to Node C via Node B (see the figure below). The packet length is 500 bytes each. The propagation delay of both Link A-B and link B-C is 1 msec (0.001 second). Link A-B's bandwidth is 1Mbps ($1x10^6$ bits per second), and link B-C's bandwidth is 2Mbps.
   (Note: 1Mbps equals to 1024 * 1024 bps but is $1x10^6$ in this question for sake of calculation simplicity).



   Assume the router's buffer is empty and there are no other packets except these four packets from A to C. A starts transmitting the first packet at time t = 0,

   (a) (3 points) When will the first packet arrive at C?
   (b) (3 points) What is the time gap between the first and second packets when they arrive at C? (i.e. the time gap between receiving the last bit of the first packet and the last bit of 2nd packet)
   (c) (3 points) When will C receive all the 4 packets?
   (d) (3 points) Now let us assume Link A-B's bandwidth is 2Mbps and link B-C's bandwidth is 1Mbps. Let us re-calculate the above question: When will C receive all the 4 packets?

2. **(13 points)** A client is fetching a base html file with $k = 10$ referenced objects from an Internet server. Assume the base html file is extremely small, <1KB and each object file is of size $L = 1MB$ (1B = 8 bit). Assume the transmission rate for each file and referenced objects is constant, if any, is $R = 100Mbps$. Further, the only transmission/reception bottleneck in the network is the access link through which the client is connected to the Internet. Let RTT be $r = 1s$.

   (a) (3 points) Compute the delay for non-persistent HTTP without parallel TCP connections.
   (b) (2 points) Compute the delay for persistent HTTP without pipelining.
   (c) (2 points) Compute the delay for non-persistent HTTP with parallel TCP connections. (no limit on the number of parallel connections)
   (d) (3 points) Compute the delay for non-persistent HTTP with parallel TCP connections, when the limit on the number of parallel connections is 5.
   (e) (3 points) Please specify the impact of factors k, L, R, r and c (the limit of parallel connections) on the delays in non-persistent HTTP with parallel connections and persistent HTTP without pipelining. (Hint: please show the formula).

3. **(5 points)** HTTP messages.

   (a) (3 points) What is the purpose the following HTTP request?
   GET /images/test.jpeg HTTP/1.1 \r\n
   Host: www-net.cs.umass.edu \r\n
   User-Agent: Firefox/3.6.10 \r\n
   Accept: ... \r\n
   Accept-Language: ... \r\n
   \r\n
   (b) (2 points) If the HTTP request can be served, what is the first line in the response message?