Principles of Computer Networks

Tutorial 6

Part 1

Discussion on Problem 1 of Assignment 3

- **(up to 10 minutes)** Depending on students' participation in the discussion.

Part 2

Problem 1: Two peer processes A (sender) and B (receiver) use stop-and-wait ARQ to send packets over a computer network. All data packets have the same length of N_p bytes, and all acknowledgment packets have the length of N_a bytes. Assume that the communication channel between A and B is modelled as a single link of length d_{AB} meters with a channel capacity of R bytes/second. Further, the propagation speed over this link is C meter/second. For a single packet transmission, assume that A starts transmitting a data packet at time t_0, A finishes the transmission process at time t_1, the packet is completely received at B at time t_2, B finishes sending the ACK at time t_3, and the ACK is completely received at A at time t_4. Ignore processing and queueing delays. Draw a time-diagram to depict t_0, t_1, t_2, t_3, and t_4.

a) Find t_1.

b) Find t_2.

c) Find t_3.

d) Find t_4.

e) Find total communication time (time from A sends the packet until A receives an acknowledgment for the sent packet).

f) Find the average (transmission) rate (in bytes per seconds) with which process A sends data to process B?

g) What is the link utilization (the portion of the time that the link is used for transmitting a packet)?

h) Now consider the performance of pipelining schemes: Assume that A and B do not implement stop-and-wait ARQ, but that A sends up to n unacknowledged packets until it has to stop and wait for a single ACK that confirms that the n sent packets were correctly received (i.e., cumulative acknowledgment is used). For this case, express the average (transmission) rate with which process A sends data to process B as a function of n.

i) Find the link utilization as a function *n*.

j) Assume that *M* processes (each generating packets of length N_p bytes) share the single link. How should we choose *n* to avoid link congestion?

k) What happens if B acknowledges every received packet separately?

Problem 2: Consider the `rdt 3.0` protocol. Draw a diagram showing that if the network connection between the sender and receiver can reorder messages (that is, that two messages propagating in the medium between the sender and receiver can be reordered), then the alternating-bit protocol will not work correctly (make sure you clearly identify the sense in which it will not work correctly). Your diagram should have the sender on the left and the receiver on the right, with the time axis running down the page, showing data (D) and acknowledgment (A) message exchange. Make sure you indicate the sequence number associated with any data or acknowledgment segment.

Problem 3: Suppose we have two network entities, A and B. B has a supply of data messages that will be sent to A according to the following conventions. When A gets a request from the layer above to get the next data (D) message from B, A must send a request (R) message to B on the A-to-B channel. Only when B receives an R message can it send a data (D) message back to A on the B-to- A channel. A should deliver exactly one copy of each D message to the layer above. R messages can be lost (but not corrupted) in the A-to-B channel; D messages, once sent, are always delivered correctly. The delay along both channels is unknown and variable. Design (give an FSM description of) a protocol that incorporates the appropriate mechanisms to compensate for the loss-prone A-to-B channel and implements message passing to the layer above at entity A, as discussed above. Use only those mechanisms that are absolutely necessary.