Department of Computer Science and Engg, IIT Bombay

CS 716: Introduction to Communication Networks — Midsem: 17 Sept 2011; 08:30–10:30

Handwritten notes permitted. No photocopies. — Weightage: 30%, Max Marks – 60

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1. Answer in 2-3 lines each: **18 Marks**

   (a) State two advantages and two disadvantages of using a layered architecture for network protocol design.

   (b) Your friend claims that the bandwidth of a link is always a more important factor than the delay of the link, for application throughput calculations. Do you agree? Justify.

   (c) State two differences between p-persistent and non-persistent CSMA.

   (d) Consider the use of RTS_Threshold in IEEE 802.11 (WiFi). It has been observed that as the RTS_Threshold increases from zero, the network throughput initially increases. The network throughput reaches a peak for a certain value of RTS_Threshold and then starts to drop. Explain.

   (e) Suppose we have to modify the IEEE 802.11 standard to include priorities for packets, such that higher priority packets have shorter average delays. We decide to implement this as: Depending on the priority of the packet, the sender node will use a different value of CW_{min} for selecting the random backoff interval. Your friend says that we should use larger value of CW_{min} for higher priority packet. Is this correct? Justify your answer.

   (f) In Go-back-N ARQ, if the sender has packet numbers 10-15 outstanding (ack not received) and the timeout for packet 12 occurs, which packet(s) would be re-sent?

2. Consider packet sizes are 1000 bits, transmission rate is 1 Mbps, and propagation delay from source to destination is 15 milliseconds. Assume that acks are very small, processing time for packets and acks is negligible, and there are no errors in transmission. What will be the throughput if we use:

   (a) Stop-and-Wait ARQ (send one packet and wait for ack before sending next packet). (**4 marks**)

   (b) Go-back-N ARQ, with a window size of 20 frames. (**3 marks**)

3. Consider two hosts A and B connected via n links, $A \rightarrow R_1 \rightarrow R_2 \rightarrow \ldots \rightarrow R_{n-1} \rightarrow B$, where $R_1 \ldots R_{n-1}$ are routers. Suppose that all links are point-to-point and have the same capacity C (in bps). Assume that the propagation delay of the links to be negligible and that no packets from other hosts exist on the path from A to B. Consider a packet of size $S + H$ (in bits) to be transmitted from A to B. S is the amount of actual data, while H is the size of the header.

   (a) How much time does it take to transmit the packet from A to B? (**5 marks**)

   (b) Suppose the packet is split into k equal fragments. How much time would it take to transmit the packet from A to B? (**5 marks**)

   (Hint: Splitting the packet allows parallel transmissions. For example, R_1 forwarding a fragment to R_2 and A sending the next fragment to R_1, can be in parallel. Keep in mind that each fragment will need a header (of size H)).

4. Consider an 802.11 (CSMA/CA) network, in a string topology, N1-N2-N3-N4-N5-N6, with symmetric links; a link between two nodes denotes that those nodes can hear other. For example, N1 and N2 can hear each other but N1 and N3 cannot hear each other, and so on.

   (a) Node N_k has data for node N_{k+1}, k=[1..5]. Suppose RTS,CTS and ACK packets take 1 unit of time and DATA packets take 10 units of time. Calculate the minimum time required to complete all the data transfers.
   Assume that the time required for all other operations is 0. Also assume that data packets arrive at the MAC layer such that no backoff is required. (**5 marks**)

   (b) Suppose all the data packets arrive simultaneously at the MAC layers for transmission. Choose suitable values of backoff for each N_k and re-calculate the minimum time required to complete all the data transfers now.
   Assume that one backoff time-slot is 1 unit of time. (**5 marks**)

   (c) Suppose N1 is sending a data packet to N2, using RTS-CTS. Assume that packet collisions are the only cause of errors. Construct a scenario in which N2 will fail to receive the data packet, even if the RTS/CTS packets never collide with each other. (**5 marks**)

5. A company has an Ethernet LAN, having nodes N_1 to N_k. The nodes use CSMA/CD protocol for medium-access, so a node having data to send may have to wait for the medium to become free, and perform backoff in case of collision. The company is using the LAN for a real-time application, which requires the following guarantees: (i) Nodes should get medium-access in the round-robin order N_1 to N_k, and (ii) There should be no collisions.
   The company tried implementing a TDMA-based mechanism but it failed because the nodes could not maintain time synchronization. So they have hired you to design another protocol that the nodes can implement to ensure that the above guarantees are met. (**10 marks**)

   Show the details of your solution, including:

   (a) What are your assumptions regarding the nodes, regarding the packets?

   (b) What actions happen during the initialization phase (start of your protocol)?

   (c) How does your protocol ensure that nodes transmit only in the round-robin order N_1 to N_k?

   (d) How does your protocol ensure that there are no collisions when any N_i is accessing the medium?

   (e) Assuming that your protocol is correct, what do you think is a main advantage of your protocol? What is the main disadvantage of your protocol?
