EECS 122: Introduction to Communication Networks

Midterm 2 Solutions

(50 points)

Wednesday April 12, 2000

Problem 1 (10 points). Please circle the most correct choice.

1.1 (1 point) IEEE 802.11 permits wireless LANs to be organized in an ad-hoc or access point controlled mode. If the LAN hosts are to use the LAN for voice calls it would be better to

- break up the LAN into two subnetworks
- **organize the LAN in the ad-hoc mode**
- organize the LAN in the access point controlled mode
- none of the above

1.2 (1 point) The HiperLAN Medium Access Control Protocol (EY-NPMA) is designed to reduce the probability of collision. The presence of hidden terminals

- reduces the probability of collision
- **increases the probability of collision**
- has nothing to do with the probability of collision
- none of the above

1.3 (1 point) When a wireless modem senses carrier it knows that

- a collision is in progress
- a successful transmission is in progress
- three successful transmissions or collisions are in progress
- **none of the above**

1.4 (1 point) The ISM band is

- **for unlicensed operation that conforms to FCC regulations on maximum power, modulation, and channelization**
- for unlicensed operation and there are no regulations on modulation, power, or channelization
- for licensed operation
- none of the above

1.5 (1 point) If the minimum Hamming distance of an error coding scheme is 2d + 1 it can

- **detect up to 2d bit errors and correct up to d bit errors**
- detect and correct up to d bit errors
- detect and correct up to 2d bit errors
- none of the above

1.6 (1 point) Ethernet emulation over ATM is an example of emulation

- a point to point network using a broadcast network
- **a broadcast network using a point to point network**
- a broadcast network using another broadcast network
- none of the above

1.7 (1 point) Network resource allocation algorithms may be host centric or router centric.

- TCP/IP is router centric while ATM is host-centric
- **ATM is router centric while TCP/IP is host centric**
- both TCP/IP and ATM are router centric
- none of the above

1.8 (1 point) The motivation for TCP fast retransmit is

- to use information about round trip delays obtained from timeouts
- **to use information about the state of the receiver as implied by duplicate ACKs**
- to replace slow start
- none of the above

1.9 (1 point) Correct reliable transmission protocols can be designed based on one bit sequence numbers provided

- the channel connecting sender and receiver is full duplex
- the channel connecting sender and receiver id LIFO
- **the channel connecting sender and receiver is FIFO**
- none of the above

1.10 (1 point) The purpose of TCP Congestion Control is to

- **maximize the throughput of the connection while sharing resourced fairly with other connections**
- monopolize network resourced to maximize the throughput of the connection
- reduce network delay
- none of the above

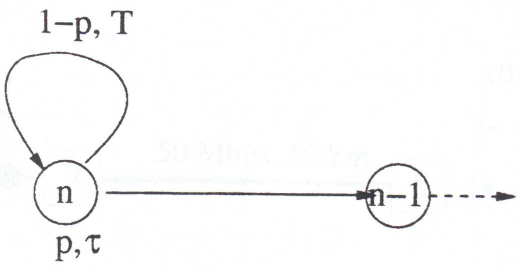

Figure 1: GBN Markov chain diagram for problem 2.1

Problem 2 (20 points)

1. (6 points) Derive the efficiency of Go-Back-N with errors. Assume that the round-trip time is constant (S), equal to the timeout value (T), and $S = T = W\tau$ where W is the window size and τ is the packet transmission time. Use the Markov chain model in figure 1 as a starting point for your derivation and show your work. p is the probability of successful transmission. Efficiency is defined as the ration of the packet transmission time to the expected amount of time spent waiting for the transmission of the packet.

From the figure $E[X] = p\tau + (1 - p)(E[x] + T)$. This implies $E[X] = \tau + (1-p) / p * T$

Now efficiency $\eta = \tau / E[X]$ which implies $\eta = \tau / (\tau + (1-p) / p * T)$

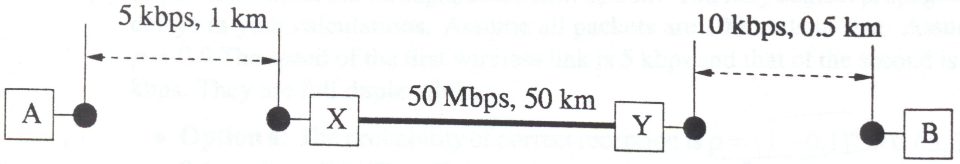

Figure 2: Network for problem 2.2

2. For the following recall that efficiency of ABP is tau / (S + (1 - p) / p * tau). Now consider the network in figure 2 and consider four reliable transmissions protocol options. In each case assume there are no bit errors in the fiber. Data flows from A to B while only ACKs flow from B to A.

(a) ABP run end to end from A to B

(b) ABP run on each wireless link

(c) GBN run end to end from A to B

(d) GBN run on each wireless link

Answer the following questions.

(a) (4 points) What would be the optimal window sizes in the two GBN options (c and d)?

Option c: The window is set to keep the pipe full assuming there are no losses. The transmission time at A is 0.2 sec and that at B is 0.1 sec for both data and ACK. Since the fiber is fast and the link lengths are small all other delays are negligible. Thus the roundtrip delay is 0.6 sec. Accordingly the best window size is

$$W = S / tau = 0.6 / 0.2 = 3$$

Option d: The transmission time at A is 0.2 sec for both data and ACK. All other delays are negligible. Thus the roundtrip delay is 0.4 sec. Accordingly the best window size is

$$W = S / tau = 0.4 / 0.2 = 2$$

(b) (8 points) What is the throughput for each option? You may neglect propagation delays in your calculations. Assume all packets are 1000 bits in size. Assume p = 0.9 The speed of the first wireless link is 5 kbps and that of the second is 10 kbps. They are full duplex links.

- **Option a:** The probability of correct reception is p = (1 - 0.1)^4 = 0.65, S = 0.6, and tau = 0.2. The efficiency is given by eta = tau / (S + (1 - p) / p * tau). The throughput is eta*c bps, where c is the link capacity, i.e., 5 kbps. Alternatively the throughput is 1 / E[X] packets per second. Substituting values in the expressions we get the throughput in 1.41 kbps.
- **Option b:** Here we set p = (1 - 0.1)^2 = 0.81, S = 0.4, tau = 0.2, c = 5 kbps and use the same formula for efficiency as in the previous part. The throughput is 2.22 kbps.
- **Option c:** Here we use the formula eta = tau / (tau + (1 - p) / p * S) derived in part 1. The parameter values are p = (1 - 0.1)^4 = 0.65, S = 0.6, tau = 0.2, c = 5 kbps. Thus the throughput is 1.91 kbps.
- **Option d:** The only parameter value different from the above here is p = (1 - 0.1)^2 = 0.81 and S = 0.4. Thus the throughput is 3.33 kbps.

(c) (2 points) Consider GBN and ABP running only on the link AX. How would the throughput of the two compare if the wireless link were half duplex?

The throughput of the two would be the same because both protocols would have to send a data packet and wait for the ACK before sending the next one.

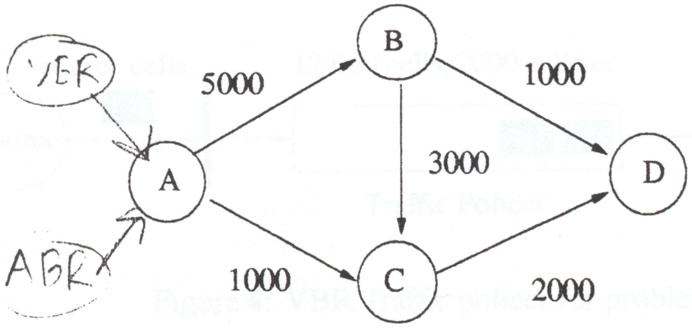

Figure 3: Network for problem 3

Problem 3 (20 points). Consider the network in figure 3. The numbers on each link are the link capacities in cells per second. Suppose the network is running ATM and receives request for two connections. First it receives a VBR connection request from A to D with traffic descriptors as shown in figure 4. Immediately after it receives an ABR connection request from A to D with a minimum rate requirement of 1000 cells/sec. There are no other traffic sources or sinks in the network.

1. (2 points) Allocate a suitable path to the VBR connection.

A - B - C - D

This path is chosen because it is the only path with the capacity to carry the sustained cell rate of the VBR source.

2. (2 points) Allocate a suitable path to the ABR connection

A - B - D

This path is chosen because, given the choice in the previous part, this is the only path with the capacity to carry the minimum cell rate of the ABR source.

3. (2 points) Assume that the VBR source has been silent before t = 0 but produces the maximum amount of data as fast as permitted thereafter. Graph the output of the source as a function of time in figure 5. Assume there are no bit errors in the network. Assume infinite buffers.

Approximate all the flows as fluids flowing continuously in time as shown in figure 5 for the ABR source output.

See the figure.

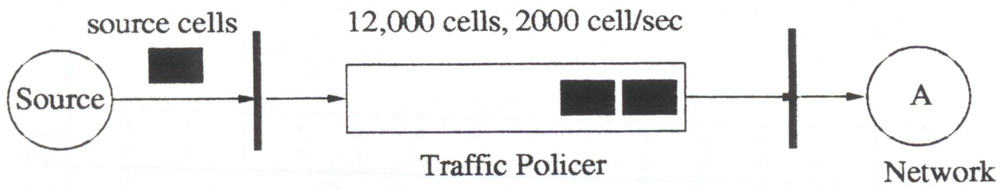

Figure 4: VBR Traffic policer for problem 3

4. (2 points) Graph the VBR output of switch A as a function of time in figure 5. Assume that the ABR source produces enough data to exceed its 1000 cells/sec minimum rate. How many seconds is the 12,000-th cell emitted by the VBR source queued by A?

Queuing delay at A = 2 seconds.

5. (2 points) Graph the VBR input to switch B as a function of time on the same figure. Neglect propagation delays here and subsequently.

The input to B is the same as the output of A.

6. (2 points) Graph the VBR output of switch B as a function of time on the same figure. How many seconds is the 12,000-th cell emitted by the VBR source queued by B?

Queuing delay at B = 1 second.

7. (2 points) How many seconds is the 12,000-th cell emitted by the VBR source queued by C?

Queuing delay at C = 2 seconds.

8. (2 points) If the VBR connection wants a maximum delay guarantee, what is the smallest

delay the network can offer to the VBR connection?

Smallest delay = 1 + 2 + 1 + 2 = 6 sec.

This is so because the figure shows that the largest queuing delay is experienced by the 12,000-th cell.

9. (4 points) What is the smallest delay the network could offer if the network switches were plain IP routers?

Plain IP routers forward traffic on a FIFO basis. The ABR source could produce unlimited amounts of traffic. This could delay the VBR source traffic by unpredictable amounts. Thus a plain IP network would not be able to guarantee

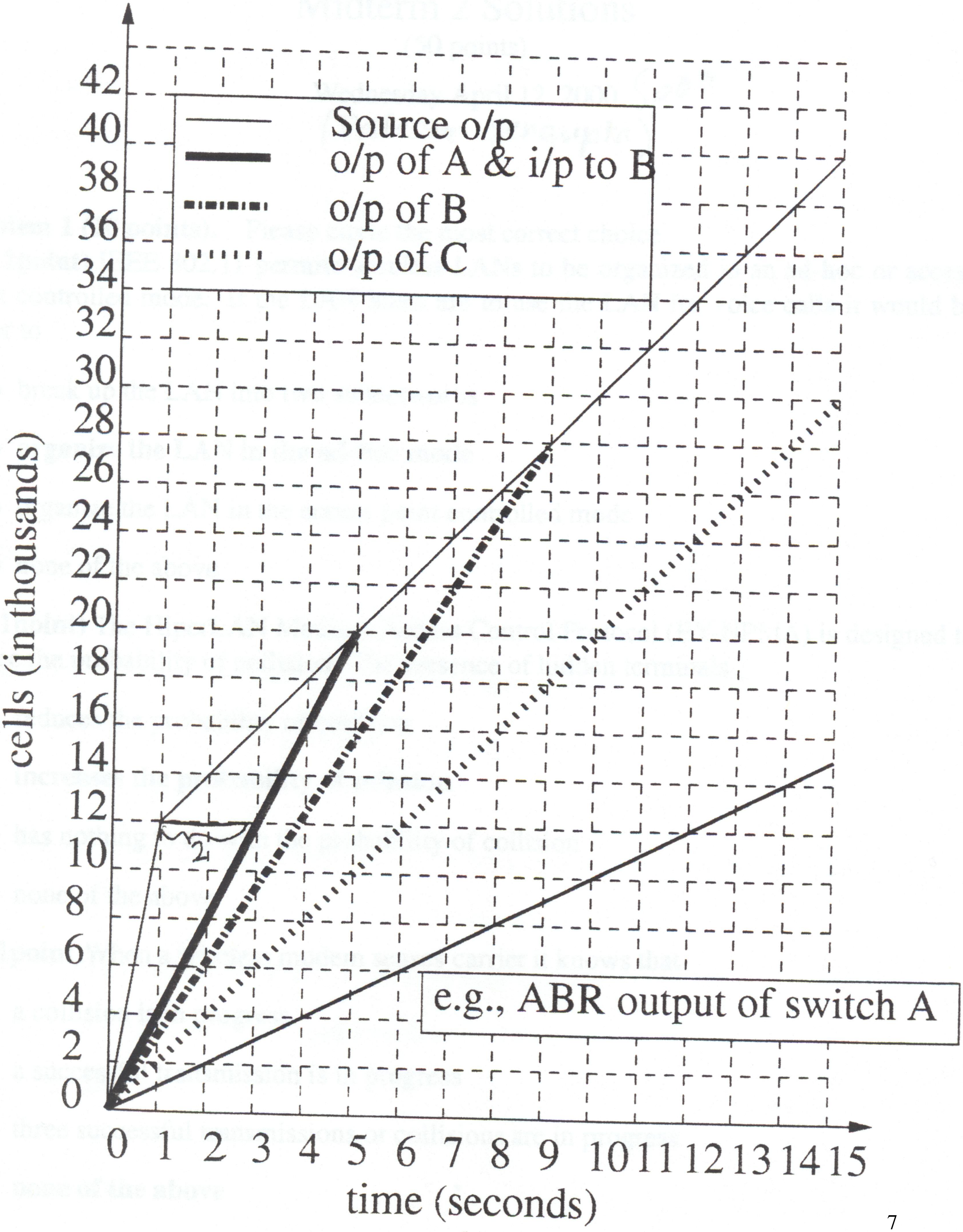

Figure 5: Graph for problem 3