EECS 122, Spring 2001
Midterm #2 Solutions
Professor Walrand

Multiple Choice (5/20)

A. Flow control in TCP is designed to (select the correct statement(s))
(a) Limit the number of losses in routers
(b) Share the link bandwidth fairly
(c) Share the link bandwidth efficiently
(d) Avoid overwhelming the destination

B. Select the correct statements (if any):
(a) Output buffer switches use memory more efficiently than virtual output buffer switches
(b) The memory throughput of input buffer switches can be smaller than that of virtual output buffers
(c) Virtual output buffer switches have no head of line blocking

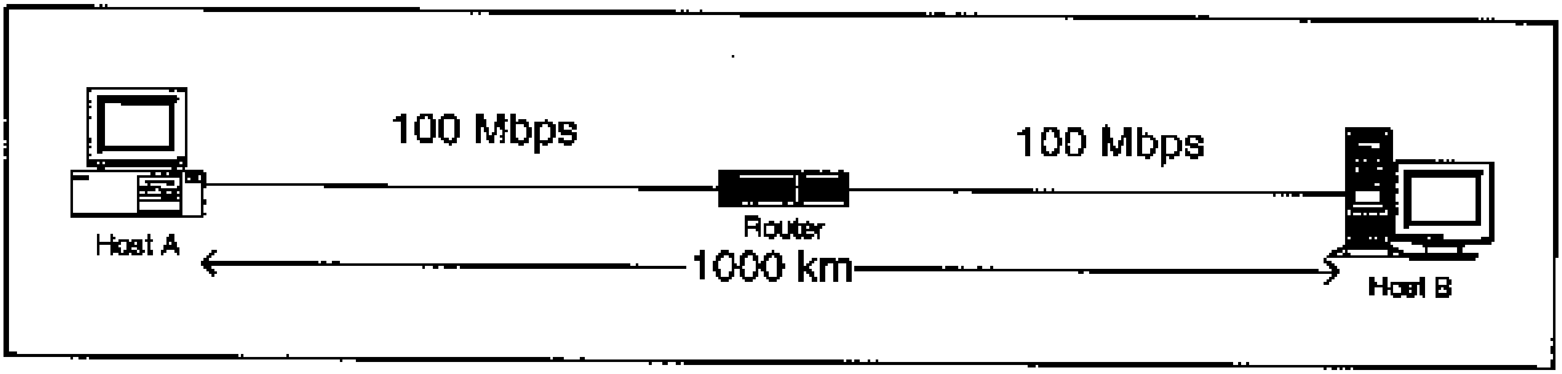
C. Reservation Aloha is more efficient than Aloha because (choose the correct statement(s))
(a) The probability of transmission automatically adapts to the load
(b) The probablily of collision is smaller with shorter reservation packets
(c) Fewer stations transmit than reserve
(d) The long packet transmissions are not subject to collisions

D. Consider an M/M/1 queue with a fixed utilization of 80%. Choose the correct statements(s):
(a) The average queue length decreases with the arrival rate
(b) The average delay per packet decreases with the arrival rate
(c) The average queue length decreases with the service rate

E. In an Ethernet network, the spanning tree algorithm guarantees that (choose the correct statement(s))
(a) Every packet follows the path with the smallest number of hops to its destination within the LAN
(b) No packet is duplicated
(c) Every packet follows the fastest path to its destination within the LAN

Problem 1. TCP (5 out of 20)

Consider the situation shown in the figure below.



Host A sends 1500-byte packets to host B using TCP. Host B sends back ACKs. We assume that the hosts are very fast and have huge memories. What is the minimum size of the memory that the router must make available to the packets from host A to be able to sustain the maximum throughput from A to B? Explain your answer carefully.
(Note: Neglect the packet processing times; the propagation speed corresponds to 5 μs/km.)

The router should be able to store (T is the propagation time)
$K := 2T \times 100$ Mbps $= 2 \times 1000$ km $\times 5$ μs/km $\times 100$ Mbps $= 1$ Mbits.

To see this, assume that the buffer can store B bits. When the window size of TCP increases beyond B, say at time t, the router drops a packet and the source learns about it at time RTT, when the window size has reached approximately B + K bits. The source then divides its window size by a factor of 2 to about (B + K)/2. For the transmitter to transmit at full throughput, this reduced window must still be equal to at least K. Thus, $(B + K)/2 \geq K$, or $B \geq K$.

Problem 2. Multiple Access (5 out of 20)

Two stations A and B share a time-slotted channel as follows. In each time slot, the stations transmit independently, station A with probability p(A) and station B with probability p(B). We want to choose p(A) and p(B) so that A gets to transmit twice as frequently as B and to maximize the average transmission rate given that constraint. Explain your answer carefully.

Let R(A) be the transmission rate of A and R(B) that of B. Then

$R(A) = p(A)(1 - p(B))$
$R(B) = p(B)(1 - p(A))$

We need to maximize $R(A) + R(B)$ subject to $R(A) = 2R(B)$.

The second constraint implies

$p(A)(1 - p(B)) = 2p(B)(1 - p(A))$
or

p(A)[1 + p(B)] = 2p(B)
or
p(A) = 2p(B)/[1 + p(B)].

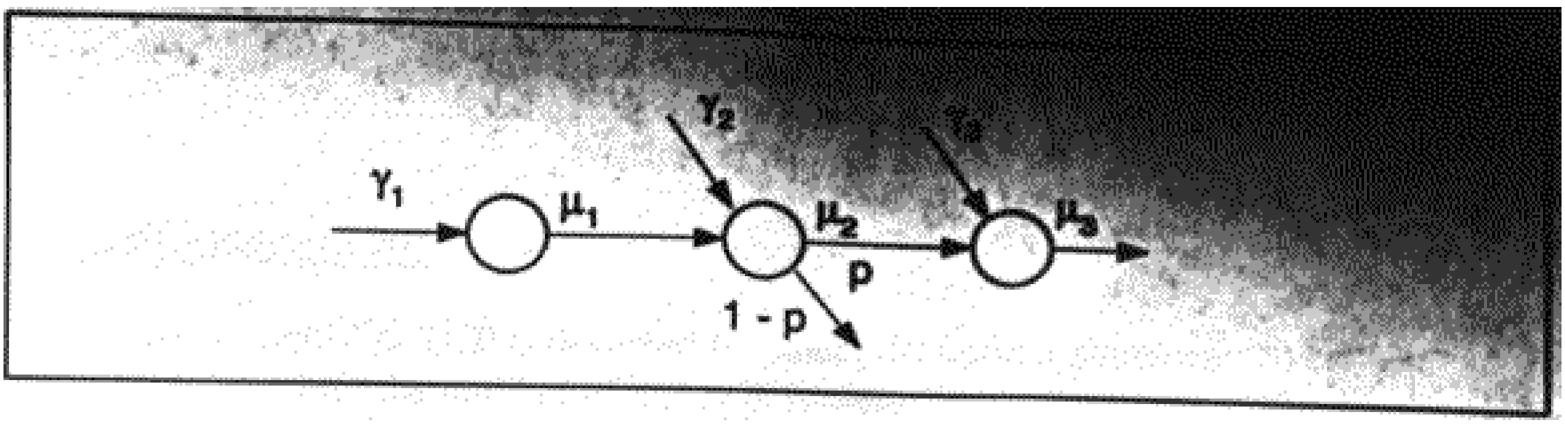
We must maximize R(A) + R(B) = 3R(B) = 3p(B)(1 - p(B))/(1 + p(B)).

That is, we must maximize x(1 - x)/(1 + x) over x = p(B).

Setting the derivative equal to zero, we find x = 2^0.5 - 1 = 0.41. Hence,

p(A) = 2 - 2^0.5 = 0.59 and p(B) = 0.41.

Problem 3. Performance Model (5 out of 20)



In the network above, find the average delay per packet in the network. The notation is as in the lectures. That is, $gamma_1$-$gamma_3$ are the average arrival rates in packets per second, μ_1-μ_3 are the average transmission rates in packets per second, and p is the fraction of packets that go to queue 3 upon leaving queue 2. Show your work.

We use the general results that we learned in class. We can calculate

$T_j = 1/(\mu_j - lambda_j)$ *for j = 1, 2, 3*

where $lambda_1 = gamma_1$, $lambda_2 = gamma_1 + gamma_2$, *and* $lambda_3 = gamma_3 + (gamma_1 + gamma_2)p$.

Now, the average delay T is given by

$T = a_1T_1 + a_2T_2 + a_3T_3$

where a_j *is the average number of times that a typical packet goes through queue j. The figure shows that*

a_1 = lambda$_1$/(gamma$_1$ + gamma$_2$ + gamma$_3$), a_2 = lambda$_2$/(gamma$_1$ + gamma$_2$ + gamma$_3$), a_3 = lambda$_3$/(gamma$_1$ + gamma$_2$ + gamma$_3$).
