EE122: Communication Networks **SP'10**

Midterm — March 5

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SOLUTIONS

Problem 1. (**Multiple Choice 50%**) *(choose the correct answer(s), if any)*

- *The* end-to-end principle *is motivated by*
  - – *trying to make connections reliable;* *(This could be done link by link.)*
  - – *improving error detection between devices;* *(This could be done link by link.)*
  - – *agreement between transmitter and receiver;(This does not specify what is implemented inside the network.)*
  - X *scalability of the Internet.*

- *Advantages of Ethernet addressing over IP addressing include*
  - – *it makes the routing tables smaller;* *(It makes them bigger.)*
  - X *it does not require changing addresses as devices move;*
  - – *it simplifies the routing algorithm;* *(Makes it harder.)*
  - – *it is compatible with optical links.* *(Irrelevant.)*

- *A router with 16 ports of 10 Gbps each, with an average delay per packet of 5ms stores, on average, the following amount of data:*
  - – *1GByte;*
  - – *16GBytes;*
  - X *100MBytes;* *($16.10^{10} \times 5.10^{-3}/8$ bytes.)*
  - – *80MBytes;*
  - – *10MBytes;*
  - – *none of the above.*

- *Ethernet with a hub is more efficient than WiFi because:*
  - *the links are faster;* *(We should not confuse efficiency and rate.)*
  - X *the transmitter can detect a collision and abort;*
  - X *wireless links are noisy;*
  - *there are fewer nodes on the network;*
  - *the nodes do not move;* *(WiFi nodes hardly move.)*
  - *none of the above: it is not more efficient.*

- *Delay jitter in an Internet connection is typically caused by:*
  - X *packet losses;* *(Cause retransmissions.)*
  - *changes in the path of the connection;*
  - *fluctuations in the link rates;* *(Not typical.)*
  - X *variability of the queue backlogs due to random traffic;*
  - *features of the MPEG3 and other compression schemes;* *(Secondary effect.)*
  - *mobility of the nodes.* *(Secondary effect.)*

- *Factors that contribute to the scalability of the Internet include:*
  - X *location-based addresses;*
  - *the spanning tree protocol;*
  - *RTS/CTS;*
  - X *two-level routing;*
  - *the control of QoS;*
  - X *hierarchical names;*
  - X *statistical multiplexing enabled by packet switching;*
  - X *standardization of layers.* *(Reduces cost.)*

- *WiFi, in the IEEE 802.11a/b/g standards, uses different interframe sequences*
  - *to separate different classes of application traffic;*
  - *to adjust the transmission rate of packets;*
  - *to identify the hidden nodes;*
  - X *to enable an ACK to be sent right after the packet;*
  - *to correct for the delay jitter.*

Problem 2. *(**25%**) Computer A in Berkeley sends 1000-byte packets to computer B in Boston. The packets go through 20 routers, each which introduces a delay of 12ms, on average, including the 8ms transmission time on the outgoing port. The propagation time from A to B corresponds to 3,000 miles. Assume that the signal takes 5μs per km. The link rates are all assumed to be 1Mbps, for simplicity.*

a) What is the average delay from A to B for each packet?

b) Approximately, how long does it take for a 1MByte file sent by A to reach B? (Ignore the overhead due to packet headers.)

a) The average delay per packet is $20 \times 12ms + PROP$ where $PROP = 3,000 \times 1.6 \times 5\mu s \approx 24ms$. Thus, the average delay is about 264ms.

b) Time $= \frac{8.10^6}{10^6} = 8$s (plus 264ms to be more accurate).

The mistake to avoid in this problem is to look at the delay of one packet, say 264ms, count the number of packets (1000), and multiply the two numbers to get 264s. This calculation assumes that one packet is sent at a time, i.e., that A waits for a packet to arrive at B before A sends the next packet. This is not how the transmission works.

Problem 3. *(25%) Two wireless nodes ($i = 1, 2$) transmit on the same radio channel and they interfere so that simultaneous transmission collide. They use a version of a slotted Aloha protocol where they independently trasmit an original packet with probability p_0 and to retransmit a packet that collided previously with probability p_1.*

a) What is the probability that no packet is successfully transmitted in the first time slot and one is transmitted successfully in the second time slot? (We start with a new packet.)

b) Draw a Markov chain state transition diagram where the state is (X_1, X_2) with $X_i = 0$ if the current packet of node i has not collided previously and $X_i = 1$ otherwise. Thus, there are four states $\{00, 01, 10, 11\}$. Draw the arrows with the possible transitions and indicate the probabilities of those transitions. For simplicity, do not write down the probabilities that the state does not change in the next step.

c) Explain how you would use this Markov chain to calculate the long-term rate of successful transmissions. Do not do the calculations, but explain what calculations one should make.

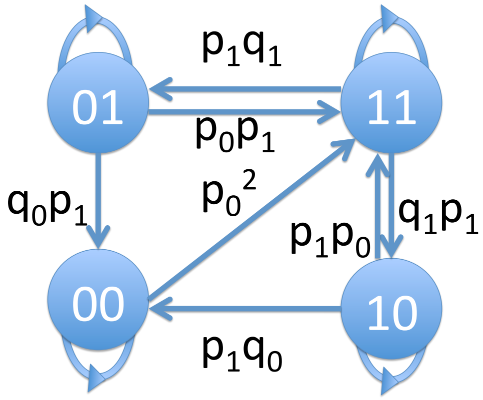
a) There are two possibilities: (idle, success) and (collision, success). Now, (with $q_i = 1 - p_i$)

$$P(\text{idle, success}) = q_0^2 \times [2p_0q_0].$$

Also,

$$P(\text{collision, success}) = p_0^2 \times [2p_1q_1].$$

b) The diagram is shown below:



For instance, the probability of a transition from (11) to (10) is the probability that 1 does not transmit and node 2 does, which is q_1p_1 because both nodes have packets that have collided previously.

c) We would compute the invariant distribution of the Markov chain by solving $\pi P = \pi$. After that, we would compute the rate of success as $\sum_{i,j} \pi(i,j)s(i,j)$ where $s(i,j)$ is the probability of success in state (i,j). Thus,

$$s(0,0) = 2p_0q_0, s(0,1) = p_0q_1 + q_0p_1 = s(1,0), s(1,1) = 2p_1q_1.$$