Exam - Midterm

Due: 11:50am, 17 Oct 2012

Closed Book. Maximum points: 100

NAME:

1. Link Layer Design [24 pts]

You have just been tasked with designing a new shared-medium link layer using CSMA-CD, the same medium access algorithm used by Ethernet. Your design has to work at 40Mbps (4×10^7bps), and can have no repeaters. The maximum cable length has been determined for you to be 1000m. You are using copper wire, and the speed of signal propagation in this medium is $2c/3$ or $2 \times 10^8 m/s$.

a. **What is minimum frame time** required for collision detection to work on your network? **What is the minimum frame size, in bits**? [8 pts]

b. You are highly successful in your design, and now you are tasked with creating an upgraded design to make it work at 400Mbps. It turns out you need to re-tune some of the parameters, because things don't work out so great. If you want to maintain the same maximum length, 1000m, **what is the new minimum frame time and minimum frame size**? [8 pts]

c. If you want instead to maintain the minimum frame size as in a., you have to change something else. **What are the resulting values for minimum frame time and maximum network length**?[8 pts]

d. Assume you were using Manchester encoding in your second design, in which you achieved 400Mbps. **What is the baud rate of the channel**, i.e., how many chips per second were you sending? **What is the bandwidth if you maintain the same parameters and replace Manchester encoding with 4B/5B encoding**? [Bonus 7 pts]

2. Error Detection and Correction [24 pts]

As we discussed in class, recall the use of the minimum Hamming Distance between valid codewords (d) as a way to reason about the properties of error correcting and detecting codes. The Hamming distance is the minumum set of changes to turn one bit string into another. It is the number of bits that are different between the two strings, or, equivalently, the result of a bitwise XOR of the two strings.

When designing error detection/correction, you add redundant bits to your data so that not all codewords are valid; detect errors by seeing invalid codewords; and correct errors, if possible, by changing an invalid codeword to the closest valid codeword (you can't correct if there is an ambiguity, or if the error takes you closer to an incorrect, but valid, codeword).

a. You are given three codes to choose from. For each one, give (i) **the valid codewords**; (ii) **the minimum Hamming Distance** d **for the code**; (iii) the **maximum number of bit flips you can *always* detect**, if any; (iv) and the **maximum number of bit flips you can always correct, if any**. (If you say you can always correct k-bit errors, it means you can correct any error that flips k bits, no matter what the original code was). [12 pts]

   (a) Parity Code: for every 2 bits, you add a third bit that counts the number of 1's, mod 2 (e.g., 01 1).

   (b) Homer Code: for every 2 bits, you add a copy of the first bit (e.g., 00 0; 10 1).

   (c) Repeat-2 Code: for every bit, you repeat it twice (e.g., 1 11).

b. If the minimum Hamming distance between any pair of valid codes is d, **what length errors (in number of bits flipped) you can detect**? Justify your answer. [6 pts]

c. **What length errors can you always correct**? Justify your answer. [6 pts]

3. Switching [24 pts]

a. Head-of-Line Blocking is a phenomenon that happens in switches that combine input port buffering and FIFO queueing. **Explain what the problem is, and why it doesn't happen when the switch uses output port buffering**. [9 pts]

b. A switch can implement store-and-forward or cut-through switching. If t is the transmission delay for a frame, 5% of the frame is occupied by the header, and p is the processing delay (assume p is the same for both types of switching), **how long does it take for a switch under the two modes to forward this frame**, i.e., what is the time between the switch receiving the first bit of the frame, and finishing forwarding the last bit of the frame? [9 pts]

c. **Give one disadvantage of cut-through switching**. [6 pts]

4. IP Routing and Aggregation [28 pts]

Acme, Inc. finally decided to get onto the Internet. It contracted with IPSHACK, a small ISP that has AS number 64496. IPSHACK owns the prefix 128.140.0.0/20. Initially, Acme only got two things from IPSHACK: a range of IP addresses and BGP transit service. For its addresses, it got a /22 allocation from IPSHACK, 128.140.0.0/22.

a. **What IP range of IP addresses does Acme own** (list the lowest and highest numbered IP addresses it owns)? **What fraction of IPSHACK's addresses does this correspond to**?[6 pts]

b. IPSHACK does only one BGP announcement to its peers, for its entire IP address range. **What are the *path* and *destination* components of this announcement**? [6 pts]

c. As Acme grows dependent on its Internet presence, it decides it can't depend solely on IPSHACK, and decides to buy transit from IP0, another ISP. Now something interesting happens when IP0 starts announcing a route to Acme's IP addresses, i.e., to 128.140.0.0/22. If IPSHACK doesn't do anything, it suddenly sees that all traffic to Acme stops going through IPSHACK's routers (and it stops making money from that traffic!). **Why is that the case?** [10 pts]

d. **What does IPSHACK have to do to get at least some of the traffic back, and what effect does that have on the BGP routing tables of its upstream AS peers**? [6 pts]