COMP 631: Computer Networks

Assignment # 2

Due on: 10/09/14

Note:

1. You're encouraged to discuss "approaches" with each other, but remember to formulate the solution details on your own.

2. Please typeset your solutions and write clearly. Writing your arguments as points rather than as long paragraphs would make it easier to read and grade.

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1. Suppose hosts A and B are connected by a link. Host A continuously transmits the current time from a high-precision clock, at a regular rate, fast enough to consume all the available bandwidth. Host B reads these time values and writes them each paired with its own time from a local clock synchronized with A's. Give qualitative examples of B's output assuming the link has
   (a) High bandwidth, high latency, low jitter.
   (b) Low bandwidth, high latency, high jitter.
   (c) High bandwidth, low latency, low jitter, occasional lost data.
   For example, a link with zero jitter, a bandwidth high enough to write on every other clock tick, and a latency of 1 tick might yield something like (0000, 0001), (0002, 0003), (0004, 0005). *(10 points)*

2. With 1 parity bit, we can detect all 1-bit errors. Show that at least one generalization fails, as follows:
   (a) Show that if messages *m* are 8 bits long, then there is no error detection code $e = e(m)$ of size 2 bits that can detect all 2-bit errors.
   (Hint: Consider the set *M* of all 8-bit messages with a single 1 bit; note that any message from *M* can be transmuted into any other with a 2-bit error, and show that some pair of messages m_1 and m_2 must have the same error code *e*.)
   (b) Find an *N* (not necessarily minimal) such that no 32-bit error detection code applied to *N*-bit blocks can detect all errors altering up to 8 bits. (Don't rely on hit-and-trial for finding *N*! You'll be awarded points for the logic used.) *(15 points)*

3. Let A and B be two stations attempting to transmit on an Ethernet. Each has a steady queue of frames ready to send; A's frames will be numbered A_1, A_2, and so on, and B's similarly. Let T = 51.2 μs be the exponential backoff base unit. Suppose A and B simultaneously

attempt to send frame 1, collide, and happen to choose backoff times of 0 x T and 1 x T, respectively, meaning A wins the race and transmits A_1 while B waits. At the end of this transmission, B will attempt to retransmit B_1 while A will attempt to transmit A_2. These first attempts will collide, but now A backs off for either 0 x T or 1 x T, while B backs off for time equal to one of 0 x T, …, 3 x T.

(a) Give the probability that A wins this second backoff race immediately after this first collision; that is, A's first choice of backoff time k x 51.2 is less than B's.

(b) Suppose A wins this second backoff race. A transmits A_3, and when it is finished, A and B collide again as A tries to transmit A_4 and B tries once more to transmit B_1. Give the probability that A wins this third backoff race immediately after the first collision.

(c) Give a reasonable lower bound for the probability that A wins all the remaining backoff races.

(d) What then happens to the frame B_1?

This scenario is known as the Ethernet *capture effect*. *(4+6+9+1=20 points)*

4. Suppose an IP packet is fragmented into 10 fragments, each with 1% (independent) probability of loss. To a reasonable approximation, this means there is a 10% chance of losing the whole packet due to loss of a fragment. What is the probability of net loss of the whole packet if the packet is transmitted twice,
   (a) Assuming all fragments received must have been part of the same transmission?
   (b) Assuming any given fragment may have been part of either transmission?
   (c) Explain how use of the *Ident* field might be applicable here.

(4+4+2=10 points)

5. Let *A* be the number of autonomous systems on the Internet, and let *D* (for diameter) be the maximum AS path length.
   (a) Give a connectivity model for which *D* is of the order *log A* and another for which *D* is of the order $\sqrt{A}$.
   (b) Assuming each AS number is 2 bytes and each network number is 4 bytes, give an estimate for the amount of data a BGP speaker must receive to keep track of the AS path to every network. Express your answer in terms of *A*, *D*, and the number of networks, *N*. *(6+6=12 points)*

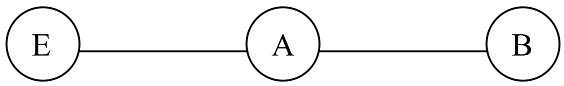
6. Suppose a network N within a larger organization A acquires its own direct connection to an Internet service provider, in addition to an existing connection via A. Let R1 be the router connecting N to its own provider, and let R2 be the router connecting N to the rest of A.
   (a) Assuming N remains a subnet of A, how should R1 and R2 be configured? What limitations would still exist with N's use of its separate connection? Would A be prevented from using N's connection? Specify your configuration in terms of what

R1 and R2 should advertise, and with what paths. Assume a BGP-like mechanism is available.

(b) Now suppose N gets its own network number; how does this change your answer in (a)?

(c) Describe a router configuration that would allow A to use N's link when its own link is down. *(6+6+6=18 points)*

7. Consider the simple network shown below, in which A and B exchange distance-vector routing information. All links have cost 1. Suppose A-E link fails.



(a) Give a sequence of routing table updates that leads to a routing loop between A and B.

(b) Estimate the probability of the scenario in (a), assuming A and B send out routing updates at random times, each at the same average rate.

(c) Estimate the probability of a loop forming if A broadcasts an updated report within 1 second of discovering the A-E failure, and B broadcasts every 60 seconds uniformly. *(2+4+4=10 points)*