CSci551 Spring 2006 Thursday Section Homework 3

Assigned: March 23, 2006. Due: noon, April 12, 2006.

You are welcome to discuss your homework with other students, but each student is expected write his or her final answer independently.

Answers should be *short* and *to the point*. Complete sentences are not required. It is possible answer the homework in one page of text, and if your answers are much more than that you should ask yourself if you're answering clearly and succinctly. We reserve the right to deduct points on answers that are too long or that miss the point.

This homework must be submitted electronically. Choice of formats is:

- Simple text (ASCII). This format is *strongly* preferred since it can be most easily marked up and returned to you.
- PDF. Please use PDF *only* if you have figures in your text.
- Postscript or HTML. Use these only if you have figures and cannot generate PDF.

Note that MS-Word or other proprietary formats are *not* accepted. See the course web page for details about how to generate postscript or PDF if you start with these formats. (See the course web site for information about how to generate PDF.)

To submit your homework, upload it to aludra.usc.edu or nunki.usc.edu, then use the submit comment as you did for the project:

```
% submit -user csci551 -tag hw3 file1 [ file2 ... ]
```

You should have one file for the body of your homework. You may have additional files if you generate html. If you have multiple files, please list them all on the command line separately (do *not* combine them ahead of time in a tar or zip file). Just a reminder: your name and student id should appear at the top of the first page of your response.

1: We saw two papers that described how self-similarity appears in network traffic.

One way to detect self-similarity is to look for long-range dependence in the data by examining the autocorrelation at different timescales. a) What is the mathematical relationship that describes how self-similar traffic behaves as a function of time-scale for autocorrelation? b) What is the mathematical relationship that describes how *Poisson* traffic behaves as a function of time-scale for this autocorrelation? c) How would you *interpret* this change autocorrelation, for both for self-similar traffic and Poisson (and how they compare)? (I.e., in English, what does the math mean?)

(For part c, you may quote from the paper, but also try and put it into your own words. If you do quote from a paper, you must put that part in quote marks.)

Answer: **Either** (for autocorrelation):

a) $r^{(m)}(k) \sim k^{-\beta}L(t)$ as $k \to \infty$, where m is timescale

b) $r(k) \sim 0$ as $m \to \infty$

c) Self-similar traffic has "long-range dependence" while Poisson does not. In my words, for self-similar traffic there are sometimes events that affect things for a long time, while with Poisson traffic, at some timescale (i.e., if you look look over some interval that is large enough), events from the past are forgotten.

2: We studied two protocols involving wireless routing: DSR and directed diffusion. Both are designed for a large network of homogeneous sensor nodes.

Recently researchers have begun exploring *tiered* sensor networks, where some nodes are smaller and less capable, while others are larger and more powerful.

Assume you have a tiered sensor network and that the small nodes are battery powered while the larger nodes have line-power (i.e., they're plugged in). a) how would you modify directed diffusion to take advantage of the larger nodes to operate the network longer?

(This is a fairly open ended question, but please keep your answer to a few sentences, not a doctoral dissertation.)

Answer: a) Many answers are possible.

The basic idea should be to shift the traffic to the larger nodes as quickly as possible, since they have effectively infinite power.

One way to do this would be to modify diffusion so that rather than reinforcing paths based on lowest latency, you reinforce paths based on fewest number of hops over the small nodes. To implement this idea you might add a counter on exploratory data ("low-rate data" in the paper) that is incremented each time the interest travels between small nodes. Each node on the path would then reinforce its upstream neighbor with the smallest counter.

Scoring: a) 4 points: does the scheme actually reduce load on little nodes? b) 3 points: is it specific enough about HOW it does that? c) 3 points: does it say WHY it actually succeeds in reducing load?

3: In class I showed several plots of wireless network performance over time that showed great variation in the reliability of communication between given nodes.

The Aguayo et al paper "Link-level Measurements from an 802.11b Mesh Network" looks at a number of possible *causes* of variation in the quality of wireless links.

a and b) What are two different ways it quantifies link variation as a function of time? For each way, point to a specific figure in the paper and describe in your own words what that figure says about link variation, and how that figure shows what you claim. (Label your two different ways a and b, don't run them together. A complete answer will be something like Figure X shows Y, and you can see this behavior in the figure because of feature Z.)

Answer: a) Figures 7 and 8 look at delivery over time, averaged over one-second intervals. They show that there some links are pretty steady and other links vary a lot over time. The figures show this explicitly by showing four different pairs of nodes with the same mean reception rate, but with high variance at the top, and low variance at the bottom.

b) Figures 9 and 10 looks at *Allan deviation* across these links. That value measures variance as a function of timescale. It shows that some links become steady at longer timescales, while others done. Specifically, links that become more consistent at larger timescales show a flat line to the right of the log-log graph of Allan deviation vs. timescale, while links that tend to be bursty at all timescales show a diagonal line across the whole range of timescales in these figures.