CSCI5221: Advanced Computer Networks
Homework Assignment 1 Due 6:30pm Feb 20, 2007

Important Notes:
Please submit your homework using the on-line electronic submission system on the class website.

In case you could not use the on-line electronic submission system, please hand in to the instructor (or TA) in class on the due day. Please use the on-line electronic submission to register first.

1. Virtual Circuit and Multicast

Consider a data network that employs the virtual circuit service model at the network layer. (Please refer to your csci5211/csci4211 textbook to refresh your memory on virtual circuit!) Suppose we want to support one-to-many source-specific multicast. In other words, each multicast group is identified by and associated with a single source.

a. Extend the unicast virtual circuit set-up process to implement one-to-many source-specific multicast. In particular, pay attention to the state maintained at each router.

b. Based on **a.**, please describe the operations by routers in forwarding data sent by the source to each member of the multicast group.

c. Briefly discuss the pros and cons of your implementation.

2. Multimedia Networking

Consider two FEC (forward error correction) schemes for VoIP (see Slides 55 and 56 of the Lecture Notes on Multimedia Networking). In the first scheme, we generates a redundant chunk for every four original chunks, where the redundant chuck is obtained by XOR-ing the bits in the four original chunks, and the redundant is sent out immediately after the four original chunks, namely, before next round of four original chunks. Here we assume that all chunks are of the same size, and each chunk including the redundant chunks is sent out as a single packet. In the second scheme, we use a low-bit rate encoding whose transmission rate is 25 percent of the transmission rate of the nominal stream. More specifically, for each original chunk, we generate a low-bit rate chunk (encoding) of the chunk, the size of which is 25% of the original one. This low-bit rate chunk is then sent out together with the next original chunk in a single packet (in other words, comparing with the first scheme, the packet is now 25% bigger, but 25% few packets are transmitted). Answer the following questions.

a. How do the two schemes perform if the first packet is lost in every group of five packets? Which scheme will have better quality?

b. How do the two schemes perform if the first packet is lost in every group of two packets? Which scheme will have better audio quality?

3. Internet Indirection Infrastructure

a. Using your own words, briefly describe the notions of public and private triggers in i3, and what are advantages of introducing the notion of private triggers.

b. Briefly describe – use an example if needed – how private triggers can be used to address the "triangle inequality" problem, which for example arises when a sender S and a receiver R are close-by, however, the servers responsible for their id's id_S and id_R may be far away from them.

4. Implementation of Weighted Fair Queueing using Virtual Time/Clock

Please provide a detailed description (e.g., using "psuedocode") of an algorithm for implementing the weighted fair queueing scheduling policy using the notion of virtual time/clock discussed in class. You can assume that there are a total of N queues (one for each possible flow or class), each is assigned with a weight w_i, $\sum w_i = 1$. In your description, pay particular attention to both the states you need to maintain about each queue and any "global" states you need to maintain. (In general, the fewer states you need to maintain, the better the implementation!)

5. Basic QoS Theory

a. Given a flow $x(t)$ that is bounded by an arrival curve $\alpha(t)$, suppose it is offered a service curve $\beta(t)$. Please write down the condition under which the backlog and (virtual) delay of the flow at any time will be bounded (i.e., will not become infinity, as $t \to \infty$!).

b. In **a.**, let $\alpha(t) = \min\{rt + b, pt + M\}$, where the parameters r, p, b and M are as defined in the Lecture Notes (note that $p > r$ and $b > M$), and $\beta = [R - T]^+$, where $T > 0$ and $r < R < p$. Please provide a detailed derivation for the maximum backlog and delay bounds given in the Lecture Notes:

$$w_{max} := b + r \max\left(\frac{b-M}{p-r}, T\right)$$

and

$$d_{max} := \frac{M + \frac{b-M}{p-r}(p-R)^+}{R} + T.$$