CMPSCI 754: Multimedia Systems

Take home Final - May 17, 2001

Due: Friday, May 18, 2001; 5pm

General instructions:

- Please work out your solutions separately, and only submit the final answers. Explain your answers clearly and be concise. Do not write long essays.
- You are free to use any reference material to answer the questions. Please *do not discuss your solutions with anyone else.*
- If possible, please typeset your answers. If not, please write them clearly and legibly. Do not forget to write your name and student id number on your answer book.
- Your answer book should be handed in by the deadline either to the CS Main office or by email to me.
- State your assumptions clearly.

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1. **Network Video Transmission**: (20 points)

   Consider a video server that streams a single video file to multiple users. Assume that the file consists of a 1 hour long movie and has a bit rate of 1.5 Mb/s. Assume that a user request for this file arrives every 5 minutes.

   (a) If the server were to unicast the file to each user, what is the total network bandwidth requirement at the server in the steady state?

   (b) Next assume that the video is split into 5 segments and the server uses periodic broadcast to transmit this video to users. What is the total bandwidth requirement now?

   (c) What is the total bandwidth requirement if the server were to use patching? Assume that each client has sufficient buffer space to store 10 minutes of the video and that the server starts a new multicast stream for any request that arrives 15 minutes after the previous multicast stream was started.

   (d) Which of these three techniques would you implement in a server if the clients were constrained by a buffer that can store 5 minutes of the video and a cable modem connection (10Mb/s connection)? How would your answer change if the clients had a DSL connection of 2Mb/s?

2. **Processor Scheduling**: (20 points)

   (a) The MMNIX operating system uses the Virtual Clock scheduling algorithm discussed in class to schedule processes in the system. Consider a 100 MIPS machine that runs MMNIX and uses a time quantum of 10ms to schedule processes. User Joe starts a long running compilation job and requests a rate of 10 MIPS for his process. Let us assume that this process actually receives service at the rate of 50 MIPS for the first 10 minutes. At this point, Jane starts compute-intensive simulations on the machine and reserves a rate of 40 MIPS for it. What behavior does Joe observe for his process at this point?

(b) Suppose that Joe increases the requested rate to 50 MIPS at $t = 10$ minutes. What behavior would he observe?

(c) How does the observed performance change if the Virtual Clock scheduling algorithm is replaced by SFQ?

3. **End-to-end Delay Bounds**: (25 points)

A flow is said to be constrained by a leaky bucket with burstiness σ and rate ρ if the number of bits that arrive from it at a network switch in any interval Δ, denoted by $AP(\Delta)$, is given as:

$$AP(\Delta) = \sigma + \rho * \Delta \tag{1}$$

In this model, σ bits can arrive instantaneously at infinite rate. However, in reality, the arrival rate is at most the link transmission rate. To take this finite maximum arrival rate into account, let us redefine the function $AP(\Delta)$ as:

$$AP(\Delta) = \min\{\sigma + \rho * \Delta, P * \Delta\} \tag{2}$$

where P is the peak rate. Let rate $R \geq \rho$ be reserved for a flow conforming to the traffic specification defined in Equation (2). Derive an end-to-end delay bound for such a flow in a network of K GR servers, and construct an example to show that your bound is tight (i.e., show that the end-to-end delay bound cannot be smaller than your bound).

4. **Integrated Services Networks**: (20 points)

The Amherst Telephone and Telegraph (AT&T) company has announced that it will merge with the Internet service provider Amherst Online (AOL). As a Network Engineer working for AT&T, you are responsible for technical aspects of the merger. Specifically you need to decide if merging the AT&T's voice network and AOL's data network into an integrated services network is a feasible proposition. Assume that the utility function of a user who downloads files over the world wide web is $U_1(t) = S - \alpha t$, where t is the time to transfer a file, S is the utility derived when the file transfer is infinitely fast and α is the rate at which the utility decreases with time. The utility function of a user who participates in an audio conference (or a telephone call) is

$$U_2(t) = \begin{cases} S & \text{if } t < D \\ 0 & \text{otherwise} \end{cases}$$

where t is the end-to-end delay experienced by an audio packet and D is the deadline of the packet. Consider a single Internet user using AOL's data network and a single telephone user using AT&T's voice network. Assume that each user generates packets at a rate of r bytes/s and that packet arrivals are Poisson. What is the total utility of the two users when they use two separate networks of capacity μ each? What is the total utility when they use a single integrated services network of capacity 2μ? Assume that the FIFO service discipline is used in all networks. How will your answer change if the integrated services network gives strict priority to audio packets?

5. **Short answer questions** (15 points)

(a) Consider an image database used by the NASA to store satellite images of weather information. Suppose that you need to retrieve images of all hurricanes that hit Florida in the past 5 years. While storing images in the database, what information should the database extract and store to answer this query?

(b) Go to the Microsoft Terraserver image database at http://www.terraserver.microsoft.com and list a few different types of queries you can perform on the database. Locate an image of Amherst in the database and list the query used to locate this image?

(c) Consider a web proxy that supports active networking. Will such a proxy make it easier to implement a device-specific transcoding scheme as compared to a proxy that does not support active networking? Justify your answer with a brief explanation.