Homework 2

CS414, Multimedia Systems (Instructor: Klara Nahrstedt)

Posted: April 18, 2008

Due: April 25, 2008 at 11:59pm CST

Important Instructions

This homework assignment should be done individually. Penalties for cheating as described in the grading policy on the course website apply. Solutions should be done with a document preparation system, such as LaTeX or Microsoft Word (figures may be drawn by hand). In the homework solutions, you should show all of your work that you used to arrive at each answer to the problems. If possible, a hard copy of the assignment should be turned into the instructor at the beginning of class on Friday, April 25. Otherwise, a hard copy of the assignment should be slid under the door to the instructor's office (3104 SC) by the specified deadline.

1. Problem – Buffering (20 Points)

- **(5 Points)** Consider the Felini multimedia file system. In this system, data for client requests are retrieved in cycles P (P refers to the common time period of the whole system, e.g., data for client are retrieved every P=100 ms). If a client `*i*' has the consumption rate f_i (in bits per second) and there are *k* bits in the buffer at the start of a cycle, then the admission controller checks at the start of each cycle if $k \geq P \times f_i$. With this admission test, what does the admission controller ensures? Explain.

- **(5 Points)** Consider the **Maxbuf** buffering strategy with the maximal buffer size of B_{max}. Let us consider that the multimedia frame size at time t is *M(t)* , and the number of bits received at the receiver side at time t is *C(t).* What are the two buffer states that a receiver needs to check for and try to avoid? What are the exact conditions that the receiver could check for both buffer states?

- **(5 Points)** Explain the two buffer management schemes used for multimedia protocol processing, the *Offset buffer management* and *Scatter/Gather buffer management*, and compare them with respect to CPU bandwidth and memory bandwidth requirements and reason why.

- **(5 Points)** Let us assume Video-on-Demand (VOD) service with one client and one server. Let us assume that the server sends the Motion JPEG video at 20 frames per second and the client receives 20 frames per second. Let us assume that the end-to-end delay between client and server is 50 ms (in both directions) including the computational overheads

on client and server side. Let us assume that the movie in fast forward (FF) mode uses step-skipping method and step is equal to 5 (e.g. if FF mode is triggered from the beginning, only frames will be played: 1st, 6th, 11th, 16th, etc). Under the above assumption, consider the following scenario:

- **The client receives streaming video and plays it on the screen. Suddenly somewhere in the middle of the movie, the client switches to fast forward operation.**

What is the minimal buffer size (in number of frames) at the client side for this scenario, so that the movie in fast forward mode will continue to play the FF frames at the rate of 20 frames per second?

2. Problem – Networking

Assume Token Ring network with negligible ring latency (you can assume to be zero) and maximal token holding time of 10 ms.

- **(5 Points)** If we assume only one station transmitting video stream as the high-priority traffic and other stations transmitting best effort traffic, then can we guarantee that this video will play at 60 frames per second? Note that there is no buffering at the receiver side of the video stream and assume that one video frame fits into one Token Ring packet, and can be processed within the maximum token holding time. Explain your answer in detail (not just yes or no).
- **(5 Points)** Assume four stations (A,B,C,D) transmitting video streams as high-priority traffic. Assume the order A,B,C,D in terms of movement of the token, i.e., A gets the token first, then B, C, and D. Can we guarantee that video sent from station A can play at 30 frames per second? Can video sent from station D be played at 10 frames per second? Explain your answers. Note that there is no buffering at receiving stations and assume that one video frame fits into one Token Ring packet. Explain your answer in detail.
- **(5 Points)** Explain the Time Token Rotation Protocol in Token Ring, how it provides support for multimedia traffic. Specify conditions and constraints under which the support works.
- **(5 Points)** Consider transmitting MPEG-2 video over ATM networks. Which class of service would you consider to use for MPEG-2 video and why? Explain clearly.

3. Problem – Scheduling (20 Points)

Let us assume retrieval of three MPEG-2 videos with the following Group of Pictures (GOP) IPBBP… Note that each movie is stored with the same GOP pattern at the media server. The processing time `*e*' of the individual frames fluctuates as follows: e(I) = 10ms +/- 2 ms, e(P) = 5 ms +/- 1ms, e(B) = 2ms +/- 2ms (the same execution time of I, P, B frames for each video). Let us assume that `video 1' has the recorded frame rate 25 frames per second, `video 2' has the recorded frame rate of 20 frames per second and `video 3' has the recorded frame rate of 10 frames per second. Design the CPU soft-real-time scheduling framework for this workload to guarantee that the streams are schedulable at the media server. Specify admission control, reservation, scheduling policy, schedule how the tasks are scheduled and possibly adaptation policy in your scheduling framework if needed.

4. Problem – Synchronization (20 Points)

Assume multimedia presentation where a speaker uses pointer, audio and 5 visual clips (image, graphics, video, animation). The presentation takes 2 minutes long. The viewer sees the visual clips one after another. The media are used in the presentation as follows:

- The first clip – graphics of a map – occurs and the speaker starts to talk (audio) in sync with the graphics clip. The pointer moves to the upper left corner of the graphics clip. Audio is ahead of pointer by 100 ms. The speaker talks for 1 second. After this audio segment, the speaker starts to talk about the object in the lower right corner of the graphics clip and the pointer moves to the lower right corner with skew delay of 100 ms behind audio.

- 3 seconds after the start of the presentation, the speaker changes the graphics clip (clip 1) to video (clip 2) of length 20 seconds. With skew of 80 ms behind the video, the speaker starts talking. After 5 seconds of the video run time, the speaker starts to use the pointer. At this point video should be ahead of audio with 80 ms and audio should be ahead of pointer by 180ms.

- At 23 second from the start of the presentation, the speaker changes clip 2 to clip 3 which is an image. The speaker starts to talk in sync with the action of displaying the image. The speaker talks for 20 seconds.

- After that, clip4 – animation- is shown for 17 seconds. Audio and pointer are used by the speaker to explain the animation. Audio and pointer are in sync with the animation.

- The 5th visual clip – video – runs at the end for 1 minute with comments from the speaker. Audio and video are in sync.

1. **(10 Points)** Specify synchronization relations using time-axis specification.

2. **(7 Points)** Specify synchronization relations using interval-based specification.

3. **(3 Points)** Which synchronization specification out of the above is optimal for description of the multimedia presentation? Why is the other specification not suitable? What kind of information gets lost by the less optimal synchronization?

5. Problem – Internet Protocols (20 Points)

1. **(5 Points)** Specify two techniques that would be useful to speed up the current TCP or IP protocols and explain why they would speed up the process of current protocols. Provide one example for each technique in either the TCP or the IP protocol.

2. **(10 Points)** Consider the following set of protocols (SIP, RTSP, RSVP, RTCP, RTP on top of UDP. If you want to design a protocol stack (control and data plane) for Video-On-Demand (VOD) service between client and server, (a) which protocols would you use and why, and (b) in which order would you apply your selected protocols? Explain how the protocol stack of selected protocols would be used.

3. **(5 Points**) What are the differences between SIP and RTSP protocols at the session layer of a multimedia protocol stack? Give 5 differences.