Homework 1

CS 414, Spring 2012
Instructor: Klara Nahrstedt

Note: Homework is an individual effort, i.e., no working in groups. Consider the homework as a preparation for your midterm. The deadline for HW1 is Thursday, March 1, midnight. You can upload your solutions through Compass in pdf format or you can slide the homework solutions in paper form under the door of the office 3104 Siebel Center. The homework has 100 points together.

Problem 1: Multiple-choice (10 points – 10 questions 1 points each)

1. Weakly periodic stream means that
   a. Time intervals between two consecutive packets are of the same length;
   b. Packet sizes are of the same length;
   c. Packets are transmitted without intermediate gaps;
   d. None of the above

Answer:

2. An closed LDU (Logical Data Unit) means that
   a. There is a pre-defined duration of the LDU;
   b. Duration of the LDU is not known in advance;
   c. Duration of the LDU is predictable;

Answer:

3. Nyquist theorem says
   a. For lossless digitization, the sampling rate must be in the range of human hearing frequency;
   b. For lossless digitization, the sampling rate must be at least twice the maximum frequency responses.
   c. For lossless digitization, the sampling rate must be 44100 Hz;

Answer:

4. Sampling rate of audio means
   a. Allocation of number of bits to the sampled waveform;
   b. Rate at which a continuous waveform is sampled;
   c. Frequency of voice;

Answer:
5. Flicker effect is avoided if
   a. We increase spatial resolution of video to 1080p resolution;
   b. We increase aspect ratio to 16/9;
   c. We increase viewing distance to 5 m;
   d. We increase refresh rate to 50 Hz.

   Answer:

6. Chrominance signal carries
   a. Color information;
   b. Brightness information;
   c. Compressed information;

   Answer:

7. PAL system uses
   a. RGB color encoding;
   b. YUV color encoding;
   c. YIQ color encoding;

   Answer:

8. HDTV system differs from NTSC system in
   a. Resolution, aspect ratio, viewing distance;
   b. Coding, flicker effect handling;
   c. Deployment, robustness;

   Answer:

9. Pulse Code Modulation represents
   a. Each PCM-encoded sample as a whole;
   b. First PCM-coded sample as a whole and following samples as differences from
      the first PCM-coded sample;
   c. First PCM-coded sample as a whole and following samples as differences from
      the previous PCM-coded sample;

   Answer:

10. Quantization Matrix in JPEG compression was introduced because
    a. It is computationally more efficient to work with matrix than with scalar
        quantization;
    b. It allows better entropy encoding due to DC and AC coefficient distribution in the
        8x8 block matrix;
    c. It allows better differentiation of DC and AC coefficients in the 8x8 block matrix
        than a scalar quantization;

    Answer:
Problem 2 (15 Points)

1. (5 Points) Consider the textual sequence “aaaaaaaaacccccccccddddddddfffffff”. Compress the textual sequence and compare the compression of the textual sequence when applying two following compression algorithms:
   a. (a) Run-Length Coding, and
   
   b. (b) Huffman Coding (Note: calculate the probabilities of symbol occurrence based on the occurrence of symbols in the textual sequence, e.g., P(a) = 9/33)
2. (5 Points) Explain what is minimum coded unit (MCU) and how to build MCU in JPEG compression (Image preparation step) if image has different resolution for single component. Show the MCU construction (e.g., MCU₁ and MCU₂) on an example with three components C₁, C₂, C₃ and their resolution relation is C₁ (H = 2, V = 2); C₂ (H = 2, V = 1); C₃ (H = 1, V = 2).

3. (5 Points) Provide five differences between MPEG-4 video encoding standard and the H.261.
Problem 3 (20 Points)

1. Consider that the threshold of hearing is at $10^{-12}$ W/m$^2$ and the threshold of pain for hearing is at 1 W/m$^2$. (Assume dB = 10*log(I/I$_0$), where I$_0$ is the reference level, equal to the threshold of hearing)

   a. (5 Point) Show that the threshold of pain is 120 dB.

   b. (5 Point) Derive what the intensity I is for conversation of 60 dB.

   c. (10 Points) Suppose whisper produces a sound of 30dB. How many times more intense is the sound of a conversation if it produces a sound of 60 dB?
Problem 4 (20 Points)

Consider the alphabet $A\{a,b,g\}$. Let $p(a) = 0.51$, $p(b) = 0.29$, $p(l) = 0.2$.

1. (10 Points) Compute the Huffman code for this alphabet and encode the word “ball”.
2. (10 Points) Consider Arithmetic coding with \( p(a) = 0.5 \), \( p(b) = 0.3 \), \( p(g) = 0.2 \) and consider a word that has the **encoded value** 0.64, and the length of the word is 3. What is the word? Show your work as you decode.
Problem 5 (20 Points)

Write in pseudo-code the triangular negotiation protocol. Consider (target QoS) as the input pair into the triangular negotiation. Assume that the sender initiates the negotiation.

1. (5 Points) Write in pseudo-code the functionality of the sender during the triangular negotiation.
2. (5 Points) Write in pseudo-code the functionality of the receiver during the triangular negotiation.
3. (10 Points) Write in pseudo-code the functionality of the service provider (network) during the triangular negotiation.
Problem 6 (15 Points)

Consider three flows with the following shapes:

1. Video flow $f_1$ with the frame size 640x480 pixels, 24 bits per pixel and 30 fps rate
2. Video flow $f_2$ with the characteristics of HDTV format
3. CD quality audio flow $f_3$

These three flows are to be exchanged between the sender $A$ and receiver $B$. Let us also assume that all three flows are stored at the sender $A$, the network packet size to transmit the flow information is 4 KBytes, the sender $A$ has the maximum available network bandwidth of 100 Mbps and the receiver B has the maximum available bandwidth of 60 Mbps prior to sending any of the three flows $f_1, f_2, f_3$. Also, assume that the receiver has an access to the name (e.g., movie or song name) of each flow.

Perform the following tasks to prepare the end-to-end transmission of the three multimedia flows:

a. (7 Points) Show how the receiver-driven peer-to-peer negotiation protocol would work between the sender $A$ and receiver $B$ (Note: specify the steps);
b. (5 Points) Show how the network bandwidth admission control would be conducted at the sender and at the receiver side. (Note: show your steps and also explain if all three flows can be admitted and if yes, why?)
c. (3 Points) Show how the translation between the application flows \( f_1, f_2, f_3 \) and their corresponding network flows happens, i.e., what is the application bandwidth \( B_A \) and the network bandwidth \( B_N \)?