NANYANG TECHNOLOGICAL UNIVERSITY

SEMESTER 2 EXAMINATION 2018-2019

EE6403 – DISTRIBUTED MULTIMEDIA SYSTEMS

April / May 2019 Time Allowed: 3 hours

INSTRUCTIONS

1. This paper contains 5 questions and comprises 4 pages.
2. Answer ALL questions.
3. All questions carry equal marks.
4. This is a closed book examination.
5. Unless specifically stated, all symbols have their usual meanings.

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1. In an image compression scheme, Singular Value Decomposition (SVD) is used to compress an image block **A** given by:

$$\mathbf{A} = \begin{bmatrix} 5 & 3 & 1 \\ 2 & 2 & 1 \end{bmatrix}.$$

The SVD of **A** is given as:

$$\mathbf{A} = \mathbf{U}\boldsymbol{\Sigma}\mathbf{V}^{\mathrm{T}}.$$

(a) Show that one of the singular values in SVD of **A** is $\sigma = 6.588$. Hence, find the matrix $\boldsymbol{\Sigma}$.

(6 Marks)

(b) Find the matrix **U** in the SVD of **A**.

(6 Marks)

(c) Discuss whether SVD is effective in compressing image block **A** using rank-1 representation.

(3 Marks)

Note: Question No. 1 continues on page 2.

(d) SVD is used to compress image block **B** below using low-rank representation.

$$\mathbf{B} = \begin{bmatrix} 20 & 10 & 20 \\ 20 & 10 & 10 \\ 20 & 10 & 5 \\ 20 & 10 & 0 \end{bmatrix}$$

Sketch and explain the graph of total squared error for the reconstructed image against the number of ranks used in low-rank representation of image block **B**.

(5 Marks)

2. (a) In a video application, a user would like to encode an MPEG-2 video with a maximum bitrate of 5×10^6 bits/s and a small error propagation / drift in the Group-of-Pictures (GOP) structure.

The video is to be displayed using the following format:

Resolution of the luminance plane: 720 × 480 pixels
Color depth in each luminance and chrominance plane: 8 bits/pixel
Frame rate: 30 frames per second

The average compression ratios for the I-frames, P-frames, and B-frames are assumed to be 10:1, 20:1, and 50:1, respectively.

The user considers the following three settings to encode the video:

Setting	GOP structure	Chroma subsampling format
1	IBBPBBPBB	4:2:2
2	IBBPBBPBB	4:2:0
3	IBBBPBBBPBBB	4:2:0

Determine which of the three settings above is most suitable to encode the video. Your answer should include proper justifications and calculations.

(10 Marks)

(b) List three different types of redundancies that exist in video, and discuss how they can be reduced in the MPEG-1 video compression.

(6 Marks)

Note: Question No. 2 continues on page 3.

(c) Discuss the key consideration(s) in choosing a motion estimation method for video compression in a video-conferencing application. Suggest a suitable motion estimation method for this application.

(4 Marks)

3. (a) Describe the properties of energy compaction and redundancy reduction rendered by 2D-DCT in transform-based image compression. Explain how 2D-DCT manages to achieve energy compaction in the baseline JPEG compression.

(5 Marks)

(b) Discuss the main similarity and difference(s) between transform-based coding and vector quantization in image compression.

(5 Marks)

(c) A CRC error detection scheme uses the generator polynomial $X^4 + X^2 + X + 1$. Given a dataword 10100111, apply polynomial division to obtain the generated codeword at the sender and the decoded dataword (assume no error) at the receiver.

(8 Marks)

(d) Link layer provides error detection/correction function during data transmission over the network. Assume transmission at the physical layer is error-free, discuss whether the data link layer is still needed to support point-to-point communications.

(2 Marks)

4. (a) What are the three properties of flooding technique? With reference to the network connectivity diagram in Figure 1, explain how a packet from Node 1 delivers to Node 6 using flooding technique.

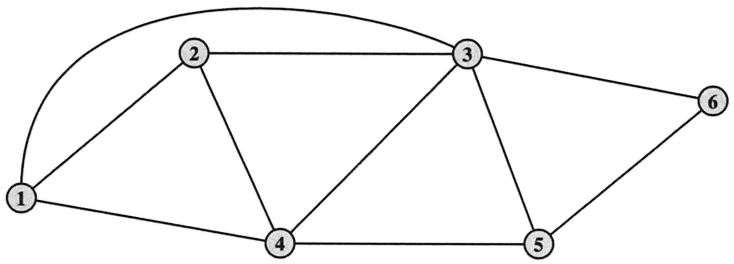

Figure 1

(10 Marks)

Note: Question No. 4 continues on page 4.

(b) Explain what is jitter in computer network? Could jitter be eliminated if packets are delivered using the same path between two end hosts?

(4 Marks)

(c) List and briefly describe 3 categories of services offered by Integrated Service Architecture.

(6 Marks)

5. (a) Discuss the differences between flow control and congestion control in network communications.

(6 Marks)

(b) Low latency and low jitter are two desirable properties for real-time communications. List and discuss 3 other desirable properties for real-time communications.

(6 Marks)

(c) Give an example of real-time distributed applications. Explain why TCP is not able to support real-time distributed applications.

(8 Marks)

END OF PAPER

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Please read the following instructions carefully:

1. **Please do not turn over the question paper until you are told to do so. Disciplinary action may be taken against you if you do so.**

2. You are not allowed to leave the examination hall unless accompanied by an invigilator. You may raise your hand if you need to communicate with the invigilator.

3. Please write your Matriculation Number on the front of the answer book.

4. Please indicate clearly in the answer book (at the appropriate place) if you are continuing the answer to a question elsewhere in the book.