COMP28512

Two hours

Question ONE is COMPULSORY

UNIVERSITY OF MANCHESTER
SCHOOL OF COMPUTER SCIENCE

Mobile Systems

Date: Thursday 2nd June 2016

Time: 09:45 - 11:45

Please answer Question ONE and also TWO other Questions from the remaining THREE Questions provided

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This is a CLOSED book examination

The use of electronic calculators is permitted provided they are not programmable and do not store text

[PTO]

1. <u>Compulsory</u>

Answer all ten of the following short questions (worth 2 marks each)

a) What are the possible undesirable side-effects that can arise when converting an analogue signal that is continuous in time and amplitude into digital form that are a consequence of i) discretizing time, and ii) discretizing amplitude?

b) How might a protocol for sending a real-time data stream over a wired or wireless network differ from a non-real-time reliable data transfer protocol?

c) Describe the standard Carrier Sense Multiple Access (CSMA) protocol used on wired Ethernets. Why is this protocol not suitable for wireless networks?

d) What are the roles of compression, forward error correction and power modulation in mobile multimedia communications, and what are the key trade-offs between them?

e) How should memory be organised in an energy-efficient mobile system?

f) What is meant by non-uniform quantisation and how is it normally applied to sampled speech?

g) What are the essential similarities and differences between the Discrete Fourier Transform (DFT), the Fast Fourier Transform (FFT) and the Discrete Cosine transform (DCT)?

h) What is the ‘cellular’ concept of spatial multiplexing in mobile telephony?

i) Why are ‘RGB’ encoded images converted to luminance and chrominance form when representing them as JPEG files? In principle how is the conversion to luminance and chrominance achieved.

j) Why is it considered good practice to use XML code rather than Java code to implement graphical user interface (GUI) related functionality in Android?

2. This question is about the design of energy-efficient mobile systems.

   a) Why is CMOS a good technology for mobile systems? (2 marks)

   b) How do the power and energy-efficiency of a CMOS mobile system depend on the clock frequency, ignoring leakage and holding all other parameters constant? (3 marks)

   c) Why do both power and energy-efficiency matter in the design of a mobile system? (2 marks)

   d) What is the primary technique used to improve the energy-efficiency of a CMOS mobile system that is operating below its maximum clock frequency? (2 marks)

   e) A mobile system has two identical processor cores each with independently controllable clock frequency and supply voltage, and it is running a single real-time application load that can be divided arbitrarily between the two cores. Assuming that the maximum frequency a core can operate at is proportional to its supply voltage, what is the most efficient division of the load between the two cores? How much more efficient is this than the least efficient configuration? (8 marks)

   f) What factors are likely to limit the extent to which the optimal solution in e) can be used in practice? (3 marks)

3. This question is concerned with bit-error control.

a) What are the essential differences between block codes and convolutional codes for forward error correction? (2 marks)

b) A convolutional coder has two generator functions expressed in octal as (13) and (17), What is the 'rate' of the coder? Draw a diagram for the coder and calculate the first ten bits of its output when the first 5 bits of the input are '1 0 1 0 1', and the coder starts in zero memory state. (5 marks)

c) In principle, how is a convolutionally encoded transmission decoded at the receiver, assuming that it may have been affected by bit-errors. In IEEE802.11 Wi-Fi packetised communication, how does the receiver decide when to request an 'ARQ' retransmission? (4 marks)

d) Why is the use of forward error correction (FEC) much more important with packetized systems using radio than with systems that use wired connections? How does the use of forward error correction (FEC) in cellular mobile telephone systems increase their energy efficiency and also the effectiveness of spatial multiplexing by frequency re-use? (5 marks)

e) A mobile communication system uses a radio channel of bandwidth 3000 Hz. The reception is affected by 'additive white Gaussian noise' (AWGN) whose constant level is such that the signal-to-noise ratio is 50 dB. According to the Shannon-Hartley Law, what is the maximum bit-rate that can be conveyed with arbitrary low bit-error probability over this radio channel?

To what extent could this maximum bit-rate be increased by employing FEC. What is the maximum bit-rate that could be achieved over this channel using binary signalling as used by 2G-GSM telephony? (4 marks)

4. This question is about the digitisation of high quality speech and music

a) With the aid of a block-diagram, explain how the psycho-acoustical properties of **hearing are exploited by MP3 encoders to allow high quality music to be recorded (or transmitted**) at bit-rates considerably lower than is used for compact disc recording. In giving your answer explain what is meant by

(i) A person's masking contour 'in quiet'
(ii) Frequency (or simultaneous) masking
(iii) Temporal masking

You do not need to remember or quote any of the formulae for masking functions when answering this part of the question. (7 marks)

b) Explain what is meant by

(i) 'run-length coding'
(ii) Huffman coding

as used by MP3 encoders. Why are these coding techniques required? (6 marks)

c) Symbols A,B,C,D E and F represent six possible quantised DCT coefficients and have, respectively, the following probabilities of occurrence:

0.05, 0.05, 0.2, 0.3, 0.05, 0.35

Devise a Huffman code for these six symbols and explain how it would be decoded. (5 marks)

d) Why would you expect an mp3 recording to be more sensitive to the effect of bit-errors than an uncompressed recording? (2 marks)

END OF EXAMINATION