COMP 28512

Two hours

UNIVERSITY OF MANCHESTER
SCHOOL OF COMPUTER SCIENCE

Mobile Systems

Date: Tuesday 29th May 2018

Time: 14:00 - 16:00

Please answer all Questions.

This is a CLOSED book examination

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

[PTO]

<u>All three questions are compulsory</u>

1. **This question refers to most sections of the course. Each part is worth 2 marks.**

   a) Manufacturers of smartphone batteries often quote their capacity in mAh (milli-Ampere-hours). Expressed in joules, what is the capacity of a 2000 mAh battery of voltage 3.7 volts?

   b) What are the similarities and differences between mu-law companding as applied to telephone speech and dynamic range compression (DRC) as applied to compact disc recordings?

   c) What is meant if a signal is described as (i) periodic or (ii) pseudo-periodic?

   d) A mobile communication system uses a radio channel of bandwidth 5000 Hz. The reception is affected by 'additive white Gaussian noise' (AWGN) whose constant level is such that the signal-to-noise ratio is 30 dB. State the Shannon-Hartley Law, and calculate from it the maximum bit-rate that can be conveyed with arbitrarily low bit-error probability over this radio channel?

   e) What is space-division multiple access (spatial multiplexing) and how is it currently achieved in cellular mobile communications?

   f) What is the essential difference between ALOHA and carrier sense multiple access (CSMA) as the means of sharing a radio channel among many users? Why do both ALOHA and CSMA wait for a random time after any collision?

   g) What are the mechanisms of (i) polling and (ii) interrupts as may be used for receiving and transmitting real-time data streams, such as sampled speech, in a mobile phone application?

   h) How do the interactive real time requirements of voice telephony differ from the requirements of streaming media applications involving voice, music and video?

   i) How do the power consumption and energy-efficiency of a CMOS mobile system depend on the clock frequency, if leakage is ignored and all other parameters do not change?

   j) What is meant by the main thread in an Android application and why do we often need to use multi-threading?

2. This question is about sound digitisation, MP3 compression and Huffman coding

a) What is the normal range of sound frequencies that a human is assumed to be able to hear? How does this assumption determine the sampling frequency used for audio compact discs (CDs)? (2 marks)

b) 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 disk recordings. 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 (7 marks)

c) Why is run-length coding and Huffman coding used by MP3 coders for music and JPEG coders for images? (2 marks)

d) Symbols A, B, C, D, E, F, representing quantisation levels for non-zero DCT coefficients, have probabilities: 0.05, 0.1, 0.08, 0.07, 0.05 and 0.65 respectively. Devise a Huffman code for these symbols. (5 marks)

Estimate the percentage bit-saving that may be expected over a large number of DCT samples with the given probabilities, by using this Huffman code rather than equal length coding, (4 marks)

3. This question is about bit-error control for Wi-Fi and cellular networks.

a) How are cyclic redundancy checks (CRCs) and retransmissions used for bit-error control in mobile systems? (2 marks)

If a CRC has generator polynomial $G(x) = x^3 + x + 1$, calculate the CRC of the short bit-stream 101011, augmented with 000 to produce:

1 0 1 0 1 1 0 0 0 (4 marks)

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

If a convolutional coder has two 5-bit generator functions expressed in octal as (33) and (25), what is the 'rate' of the coder and what is its 'constraint length'? Draw a diagram for the coder and calculate the first 10 bits of its interleaved output when the first 5 bits of the input are '1 0 1 0 1', and the coder starts in zero memory state. (6 marks)

c) Explain why bit-error detection and forward error correction (FEC) are used simultaneously at the data-link layer on IEEE802.11 WLAN networks, whereas only error detection is generally used on wired networks**.** (4 marks)

d) 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? (2 marks)

END OF EXAMINATION