Two hours

UNIVERSITY OF MANCHESTER
SCHOOL OF COMPUTER SCIENCE

Mobile Systems

Date: Monday 24\textsuperscript{th} May 2010
Time: 09.45 – 11.45

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

This is a CLOSED book examination

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

   Answer all of the following parts of this question (2 marks each)

   a) What three processes must be performed to convert an analogue signal from a microphone into a sequence of numbers suitable for handling by a computer?

   b) A high-quality telephone system samples its speech input at 10kHz and with a 10-bit linear accuracy. How much memory is required to store one minute of speech? (Express your answer in bytes.)

   c) Explain the difference between "hard" real-time computation and "soft" real-time computation.

   d) What is the role of a watchdog timer in a real-time system?

   e) Why does the Internet Real-time Transport Protocol (RTP) not use retransmission to recover from packets received with errors?

   f) What are the roles of compression, error correction and transmit power control in enabling a mobile system to have minimum power consumption?

   g) CD-quality sound is sampled in stereo at 44.1kHz with 16-bit linear accuracy. What is the data capacity of a CD that can store one hour of music? (Express your answer in Mbytes.)

   h) The Manchester “baby” computer used 3.5KW of electrical power whilst executing 700 instructions per second. A processor in a modern mobile system may achieve a power efficiency of 10,000 MIPS/Watt. How much more efficient than the baby is the modern processor?

   i) Why, if an image is compressed too much using the JPEG algorithm, can the result look blocky?

   j) What key psychoacoustic techniques are used in mp3 compression?
2. This question is related to the coursework undertaken in the laboratory.

You are involved in the design of a mobile system to support voicemail in an office environment. The following tasks can be identified.

a) the speech sampling system
b) the speech compression/decompression system
c) the error correction system used to recover from radio transmission errors
d) system power analysis and optimisation

Discuss the approach you would take to specifying the operation of one of the tasks (b) to (d) only.

Whichever task you choose, be sure to write down the technical issues that arise, the trade-offs you need to consider, and the way your task interacts with other members of the design team who are performing the other three tasks above (including task a) (20 marks)

3. This question is concerned with error detection and correction.

a) What is the Hamming distance between the two 8-bit binary codes 10110111 and 00101011? (2 marks)

b) In order to detect or correct errors that may arise in the transmission of such codes, additional redundant information must be added. What must the Hamming distance between the valid resulting codewords be in order to:

i) detect d-bit errors? (1 mark)
ii) correct d-bit errors? (1 mark)

Suggest coding schemes that can be used to

iii) detect a 1-bit error, and (1 mark)
iv) correct a 1-bit error (2 marks)

illustrating how the two 8-bit binary codes above would appear when encoded with each scheme. (5 marks)

c) Briefly explain (in non-technical language) the principle behind a convolution encoder such as Viterbi. What sort of errors does this encoder protect against? Give a block diagram of a simple 4-state Viterbi encoder. (8 marks)
4. This question is concerned with still and moving image and speech compression and transmission, together with high-level mobile system design issues.

a) MPEG video compression is asymmetric: the compression phase is more compute-intensive than the decompression phase. What component of the algorithm is responsible for the asymmetry? (2 marks)

b) Outline the computations required by this asymmetric component in each phase. (4 marks)

c) Digital television broadcasts employ error correction and MPEG encoding. Under what conditions might the received picture show errors, what is the characteristic appearance of those errors, and why do the errors have that characteristic appearance? (4 marks)

d) A supermarket is considering deploying a mobile stock-checking system based on a smart-phone with a built-in digital camera, using WiFi (802.11) radio communications to a central server. The idea is to use the camera to take an image of the shelf label under each stock item, and for the operator to speak the stock level into the phone. The image and voice samples are then communicated back to the stock computer for analysis and comparison with stock records based on data from the check-out tills.

Various mechanisms are under consideration for sending the image back to the server. What would you advise are the advantages and disadvantages of each of the following:

i) capture the raw image and send it to the server for analysis?

ii) compress the raw image and send a JPEG file to the server for analysis?

iii) analyze the image on the phone and send the stock identification number to the server? (2 marks each)

e) Discuss how you might send the voice sample back to the server. What are the options, and what are their relative advantages and disadvantages? (4 marks)