

Two hours

Question ONE is COMPULSORY

**UNIVERSITY OF MANCHESTER
SCHOOL OF COMPUTER SCIENCE**

Mobile Systems

Date: Tuesday 27th May 2014

Time: 09:45 - 11:45

**Please answer Question ONE and also 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

[PTO]

1. **Compulsory**

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

- a) When looking at the magnitude spectrum obtained from the Fast Fourier Transform (FFT) of N samples of a real valued signal, why do we only need to plot about half of the magnitudes?
- b) What is meant by non-uniform quantisation and how is it implemented?
- c) What is meant by periodicity and pseudo-periodicity?
- d) What is meant by 'frequency-domain processing'? Give a simple example of what it can achieve.
- e) Why is run-length coding used in MP3 music coders? How could the following sequence of integers be run-length coded?

0 0 8 0 0 0 0 0 4 5 0 0 0 0 1
- f) Explain the mechanism of '1-persistent carrier sensing multiple access'.
- g) What are the main goals of the '4G MT-Advanced' standard as proposed by the International Telecommunications Union (ITU)?
- h) A 2 minute video-clip encoded using MPEG-1 at 1.2 Mbit/s is being downloaded to your mobile phone at 1 Mbit/s. What length of buffer would allow you to watch it in real time without interruptions (frame freezing)? How much delay would this cause before the video-clip starts to play?
- i) What is the 'cellular' concept of spatial multiplexing?
- j) A mobile communication system uses a radio channel of bandwidth 6000 Hz. The reception is affected by 'additive white Gaussian noise' (AWGN) whose constant level is such that the signal-to-noise ratio is 40 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? What is the maximum bit-rate that could be achieved over this channel with binary frequency shift keying (FSK) as used by 2G-GSM telephony?

2. This question is about speech digitisation, coding and multiple access for mobile telephony

- a) What is the bandwidth of 'narrowband' telephone quality speech, and at what frequency is it normally sampled? What bit-rate did 2G-GSM mobile telephony originally use for speech, and why is it not possible to digitise narrowband speech with reasonable quality at this bit-rate using waveform coding? (2 marks)
- b) What is 'voiced speech' and 'unvoiced speech'? (2 marks)
- c) With the aid of a diagram, explain how the early version of linear predictive coding known as LPC-10 models the human speech production mechanism to achieve bit-rate reduction on a mobile telephone, (8 marks)
- d) What is meant by 'vector-quantisation' as used by 'code-excited LPC' (CELP) coding? (3 marks)
- e) By what mechanism is the available spectrum within each cell shared by multiple users in 2G-GSM technology and how has this changed with the introduction of third generation (3G) mobile phones? What is the main advantage and disadvantage of the '3G' mechanism? (5 marks)

[PTO]

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

- a) Explain the mechanism of a 'cyclic redundancy check' (CRC) as used for bit-error detection in a mobile system. If a CRC has generator polynomial $G(x) = x^4 + x + 1$, calculate the CRC of the short bit-stream which has already been augmented with '0000': 1 0 1 0 0 1 0 0 0 0. (6 marks)
- b) What are the essential differences between block codes and convolutional codes for forward error correction (FEC)? If a convolutional coder has two generator functions expressed in octal as (13) and (15), what is the 'rate' of the coder and what is its 'constraint length'? Draw a diagram for the coder and calculate the first 8 bits of its output when the first 4 bits of the input are '1 0 0 1', and the coder starts in zero memory state. What is a 'systematic' coder, and could this particular convolutional coder be described as systematic? (6 marks)
- c) In principle, how is a convolutionally coded transmission decoded at the receiver, assuming that it may have been affected by bit-errors. (2 marks)
- d) 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)
- e) 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)

4. **This question is about image compression for mobile transmission, the need for Huffman coding and the derivation of a Huffman code.**

- a) How is bit-rate compression achieved for images according to the JPEG standard? (7 marks)
- b) Why is run-length coding and Huffman coding required by JPEG? (4 marks)
- c) Symbols A,B,C,D E,F have probabilities:
0.05, 0.2, 0.2, 0.15, 0.05, 0.35
Devise a Huffman code & consider how it would be decoded. (7 marks)
- d) Why would you expect a JPEG compressed image to be more sensitive to the effect of bit-errors than an uncompressed image such as a bit-map? (2 marks)

END OF EXAMINATION