COMP28512

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