**COMP38512**

Two hours

**UNIVERSITY OF MANCHESTER**
**SCHOOL OF COMPUTER SCIENCE**

Digital Wireless Communication and Networks

Date: Monday 23rd May 2016

Time: 09:45 - 11:45

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**Please answer any THREE Questions from the FOUR 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]**

If needed, you should assume the speed of light is $3x10^8$m $s^{-1}$ or $3x10^5$km $s^{-1}$.

1.

a) How does wireless propagation in a terrestrial environment differ from propagation in outer space? [5 marks]

b) A wireless receiver hears background thermal noise at -128dBW and an unwanted signal at -95dBm. Showing your reasoning and calculations, explain how powerful in dBW a wanted received signal needs to be if it needs to be 10dB stronger than everything else heard at the receiver in order to be understood? [8 marks]

c) Explain what the term EIRP means when referring to a wireless system specification? Which main components of the wireless system are affected by the maximum EIRP permitted? [4 marks]

d) Transceiver A has a shared transmit and receive antenna with a maximum gain of 9dBi which is pointed at a similar transceiver B using a dipole antenna with a gain of 2.15dBi. Showing your reasoning and calculations, what is the maximum transmitting power in the UK that can legally be sent to the antennas at A and B? [3 marks]

2.

a) How does the performance of CSMA/CA vary with data rate? Does RTS/CTS help resolve this variation? Explain your answers. [7 marks]

b) The original IEEE 802.11 and 11b, 11g and 11a all supported MAC layer frame fragmentation.

How does the fragmentation scheme work? How is it controlled?

How are retransmissions of incorrectly received fragments achieved? [4 marks]

c) The designers of IEEE 802.11n wanted to improve the efficiency of its medium usage (not QoS) alongside massively increasing the data rates available. How could they achieve this compared to the original Distributed Coordination Function (DCF)? [9 marks]

3.

a) A 3G User Equipment (UE) needs to contact a nearby Node B having been idle for some time.

i. Give some reasons why the UE needs to contact the Node B?

ii. What does the UE do to make contact?

iii. What does the UE do if initially the Node B does not respond?

iv. What can the UE do if it cannot establish a connection to the nearby Node B? [7 marks]

b) Why did 2G (GSM) mobile phone systems typically operate with cell clusters of 7 or larger, whereas 3G systems almost always had a cell cluster size of 1? [3 marks]

c) In a city which is surrounded by a large area of flat countryside there is a 2G (GSM) cell structure. The whole city is covered by one large cell which completely overlaps with a single cluster of micro cells which is sufficient to manage the user demand for mobile phone service using just 1 full-duplex frequency channel per cell.

What is the minimum number of different frequencies needed to service the city and its nearest countryside neighbours with no co-channel interference? Using a diagram, explain why your answer is correct. [5 marks]

d) In a centrally controlled and scheduled single channel half-duplex wireless system, a single TDMA time-slot transmission is on air for 546.5μs and there is a gap of 30.5μs between each time-slot transmission.

i. How long before the base station expects to receive the start of a transmitted frame must two mobile devices, one 8km and one 35km away from the base station transmit? [2 marks]

ii. Explain what implications this large propagation distance has for the base station and the mobile device that is 35km away so that they can successfully communicate using TDMA with accurate timing at each other's location? [3 marks]

4.

*In order to answer this question well you may wish to step outside networking norms you learned for infrastructure wired and wireless solutions. You may find it easier to provide a listed answer and reasons rather than write an essay.*

A battery powered wireless Personal Area Network (PAN) is to be used to send 10 uniformly distributed readings per sensor mote per heartbeat of blood pressure from all external parts of the body to a central control, data storage and forwarding mote labelled 'MASTER'. The MASTER is attached to a belt worn around the waist of a hospital patient. The transmission range of each wireless sensor mote is about 20cm, meaning that quite a lot of sensor motes are required so that all extremes (fingers, toes) of the body can communicate easily with the MASTER mote. The sensors each have a unique ID but are attached in random order. The PAN should be able to be used for long periods of time without any intervention or replacement parts.

a) Choose suitable features and behaviours that the data-link, routing and transport protocols should have during different periods of operation (which you should identify) if almost no data losses are permitted on download from the MASTER mote but a few upload losses are permissible.

b) Describe how the motes:

   i. Find one another and,

   ii. Work out how to route their readings to the MASTER mote. Ideally, the motes should do this very soon after they are attached to the patient's body.

   Specify which of the protocols provided in part (i) above are used for each of these functions and why.

c) How should the motes and their protocols be configured to collect the sensor data so that all sensor readings are available at the MASTER mote within 1 minute of being initially collected?

d) If the control system is told to change so the motes collect 1 hour's worth of data prior to uploading it to the MASTER mote, explain how this change can be implemented almost simultaneously by all the motes?

   After such a change, are any other changes or adaptations to the protocol stack or its configuration sensible?

[20 marks]

**END OF EXAMINATION**