UNIVERSITY OF MORATUWA

FACULTY OF ENGINEERING

DEPARTMENT OF COMPUTER SCIENCE & ENGINEERING

MSc in Computer Science
2014 Intake Semester 1 Examination

CS5440 Wireless Access Networks

Time allowed: 2 Hours April 2014

ADDITIONAL MATERIAL: *None*

INSTRUCTIONS TO CANDIDATES:

1. This paper consists of **5** questions in **5** pages.
2. Answer any **4** questions.
3. Start answering each of the main questions on a new page.
4. The maximum attainable mark for each question is given in brackets.
5. Relevant equations and parameter values are given in Appendix (page 5).
6. This examination accounts for 40% of the module assessment.
7. This is a closed book examination.

   NB: It is an offence to be in possession of unauthorised material during the examination.
8. Only calculators approved by the Faculty of Engineering are permitted.
9. Assume reasonable values for any data not given in or with the examination paper. Clearly state such assumptions made on the script.
10. In case of any doubt as to the interpretation of the wording of a question, make suitable assumptions and clearly state them on the script.
11. This paper should be answered only in English.

Question 1 (25 marks)

A low Earth orbit satellite used for satellite telephone is positioned 200 km from the surface of the Earth. It transmits a 1.6 GHz wireless signal with a transmit power of 2 W. The transmitting antenna gain is 10 dB and receiver antenna gain is 1 dB.

(i) Briefly describe any 3 types of attenuation experienced by such wireless signals. [6]

(ii) Find the received power for the link from the satellite to a handheld satellite phone. [6]

(iii) What is the Signal to Noise Ratio (SNR), if the receiver antenna temperature is 290 K and receiver bandwidth is 31.5 KHz? [4]

(iv) Is the SNR sufficient to operate the handheld satellite phone at an acceptable voice quality? Briefly explain. [3]

(v) What type of an antenna would you recommend for the handheld satellite phone? Briefly explain. [2]

(vi) As the low Earth orbit satellites are close to the surface of the Earth, they rotate much faster than the surface of the Earth. Hence, a caller cannot be connected to the same satellite for a long time. Would you recommend soft handoff or hard handoff when transferring a connection from one satellite to another? Explain. [4]

Question 2 (25 marks)

A large department store (i.e., retail establishment with a building selling verity of items such as clothing, housewares, furniture, etc.) is interested in using electronic price tags. Each electronic price tag includes an LCD display, a microcontroller, and a radio receiver. These price tags enable the store to dynamically change the prices of products in a fraction of a second, while offering various discounts.

Suppose that a stationary transmitter is used to send the prices to respective electronic tags. The frequency of the transmitter is 914 MHz and the transmission power is 6.3 mW. Gains of both the transmitting and receiving antennas are 1.

(i) Compare and contrast (i.e., similarities and dissimilarities) Bluetooth, ZigBee, and WiFi technologies. [6]

(ii) Based on the comparison in question (i), what wireless technology would you recommend for communicating with electronic tags? Justify your recommendation. [2]

(iii) What type of a network topology would you recommend for connecting the electronic tags and stationary transmitter? Justify your recommendation. [3]

(iv) What is the received power at 10 m? [5]

(v) Can the signals be received at an acceptable quality at a distance of 75 m? Assume the sensitivity level of the proposed receiver is -90 dBmW. [5]

Hint: Based on empirical evidence, it has been found that it is more reasonable to model the received power in an indoor environment as a log-distance path-loss model. Assume the reference distance is 10 m.

(vi) List 4 wireless network related security issues that might arise in the proposed network. [4]

Question 3 (25 marks)

(i) Using a suitable diagram briefly explain how the Frequency-Hopping Spread Spectrum technology works. [5]

(ii) In a Frequency-Hopping Spread Spectrum system, a hopping bandwidth of 31.5 MHz and a frequency spacing of 41.67 KHz are used. Given *M* frequencies, the modulation scheme uses *b*-bit number to determine which of the *M* frequencies to be used to modulate at a given instance.

a) How many different frequencies (*M*) are there? [3]

b) How many bits (size of *b*) are required to determine which frequency to use? [3]

(iii) "Guaranteed Time Slots in the IEEE 802.15.4 standard allows contention free communication between devices". Do you agree or disagree with this statement? Briefly explain. [4]

(iv) Data-centric routing is an alternative routing paradigm that is popular in Wireless Sensor Networks.

a) Discuss why Data-centric routing is more useful in sensing applications than IP-based routing. [4]

b) Using a suitable example, explain the data-centric routing. [6]

Question 4 (25 marks)

(i) Mobility is important in wireless networks. Briefly discuss to what extent is the mobility supported by current Wireless LAN (i.e., WiFi) implementations. [4]

(ii) Briefly explain 5 key Wireless LAN implementation problems. [5]

(iii) Briefly explain 3 security issues in WLANs and how those can be addressed using existing techniques and best practices. [6]

(iv) What are the advantages offered by 4G wireless metropolitan area networks over 3G networks? Briefly explain. [4]

(v) "4G networks are more vulnerable to external and internal attacks than 3G networks". Do you agree or disagree with this statement? Explain in detail. [6]

Question 5 (25 marks)

Mobile social networking is a form of social networking where users with similar interests converse and connect with one another through their mobile devices (e.g., smart phones and tablets). One such application is the sharing of "hot deals" and customer feedback within a large shopping mall. Customers can use such a network to share good bargains with other potential customers, e.g., items on sale. They can also share their ratings about a particular product or a shop. Shop owners can also use the same network to advertise about the products that are on sale.

(i) Would you recommend an infrastructure-based network or infrastructure-less network to build such a mobile social network? Explain. [3]

(ii) What wireless technology (e.g., Bluetooth, ZigBee, WiFi, 3G, 4G, etc.) would you recommend for this network? Justify your recommendation. [3]

(iii) What type of a network topology would you recommend? Justify your recommendation. [3]

(iv) What type of a message routing scheme would you recommend? Justify your recommendation. [4]

(v) Design a suitable messaging format to share information about various types of messages. For example, there will be at least messages about discounts and customer ratings. [8]

(vi) List 4 security issues you may have to address while implementing the proposed solution. [4]

Appendix

Speed of light	3×10^{8} ms^{-1}
Boltzmann constant	1.3806488×10^{-23} m^2 kg s^{-2} K^{-1}
Speed equation	$v = f\lambda$
Friis free-space equation	$P_R(d) = \frac{P_T G_T G_R \lambda^2}{(4\pi)^2 d^2}$
Log-distance path-loss model	$P_R(d) = P_0(d_0) - 10n_p \log(d/d_0) + X_\sigma$
Thermal (white) noise	$P_{Thermal} = KTB$

Table 1 – Path-loss exponent and standard deviation in different buildings.

Building	Frequency (MHz)	Path-loss exponent, n	Standard deviation (dB)
Retail store	914	2.2	8.7
Grocery store	914	1.8	5.2
Office, hard partition	1500	3	7
Office, soft partition	900	2.4	9.6
Office, soft partition	1900	2.6	14.1
Factory, line of sight	1300	2	3
Suburban, indoor street	900	3	7
Factory, obstructed path	1300	3.3	6.8

Source: S. Rao, "Estimating the ZigBee transmission-range ISM band," EDN, May 2007, pp. 67-72.

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