UNIVERSITY OF MORATUWA

FACULTY OF ENGINEERING

DEPARTMENT OF COMPUTER SCIENCE & ENGINEERING

B.Sc. Engineering
2011 Intake Semester 7 Examination

CS4422 WIRELESS AND BROADBAND NETWORKING

Time allowed: 2 Hours September/October 2015

ADDITIONAL MATERIAL: *None*

INSTRUCTIONS TO CANDIDATES:

1. This paper consists of **5** questions in **6** pages.
2. Answer any **4** questions (out of 5).
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. This examination accounts for **50%** of the module assessment.
6. This is an **open book** examination.
7. Key equations and design parameters are given in Appendix.
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)

(i) Wide-spread adoption of smartphones and tablets have led to many connected devices such as "Stick N Find", wireless weight scales, home automation, wireless sensors attached tennis rackets, and smart watches.

a) While considering the key characteristics of wireless communication, briefly discuss why wireless has become the preferred choice to interconnect such devices. [3]

b) Briefly discuss why Bluetooth has become the preferred wireless standard for interconnecting such devices. [3]

(ii) Suppose "Stick N Find" is to be used to locate luggage in an airport. A traveller first registers a Stick N Find tag with his/her smartphone. Then the traveller attaches the Stick N Find tag to his/her luggage. Once the Luggage is nearby, it will be indicated on his/her smart phone. Until then, the traveller can sit near the luggage counter without continuously checking whether his/her luggage arrived.

Stick N Find uses enhanced Bluetooth tags which have the following specification:

- Protocol – Bluetooth low energy
- Frequency – 2.4 GHz
- Range – 1 - 25 m
- Transmission Power – 6.3 mW
- Antenna Gain – 1

a) What is the received power at 5 m? Assume antenna gain of smartphone is 2. [5]

b) Can the signals be received at an acceptable quality at a distance of 25 m? Assume the sensitivity level of the proposed receiver is -90 dBmW.

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 5 m and path-loss exponent for an airport is 2.1. [5]

c) What challenges do you anticipate, if many travellers decided to use Stick N Find in a busy airport? [3]

d) What are your suggestions to address the challenges you identified in question (c) above? Briefly describe. [6]

Question 2 (25 marks)

(i) Satellite TV and IPTV are modern alternatives to conventional broadcast-based TV. Compare and contrast (i.e., similarities and differences) Satellite TV and IPTV delivered over broadband networks. [4]

(ii) "*IPTV over broadband is better suited to deliver Video on Demand than Satellite TV*" Do you agree or disagree with this statement? Justify. [4]

(iii) A satellite that broadcasts TV signals is positioned 60,000 km from the surface of the Earth. It transmits a 12 GHz wireless signal with a transmit power of 6 W. Transmitting antenna gain is 18 dB.

a) Find the received power for the link from the satellite to a satellite TV dish antenna mounted on a rooftop with a gain of 20 dB. [6]

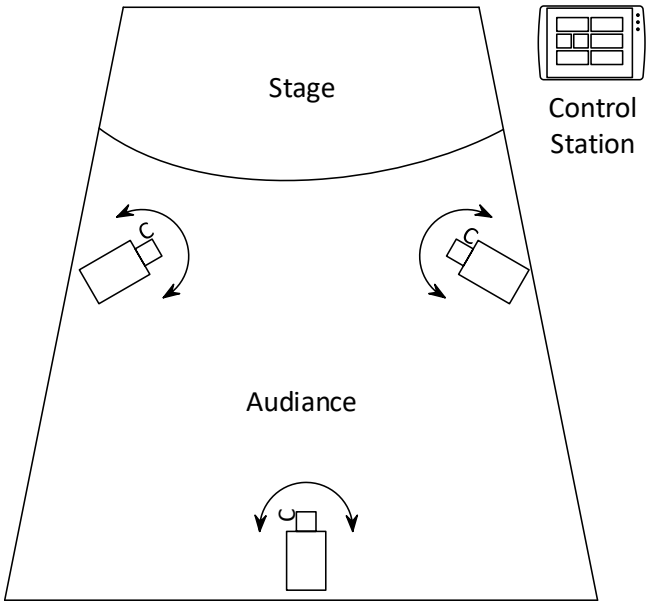
b) What is the Signal to Noise Ratio (SNR), if the receiver antenna temperature is 290 K and receiver bandwidth is 31.5 KHz? [4]

c) Is the SNR sufficient to operate the satellite TV at an acceptable video and audio quality? Briefly explain. [3]

d) How will the SNR change, if the link between the satellite and dish antenna experience heavy rain? [4]

Question 3 (25 marks)

3 cameras shown in the following figure are to be controlled via the control station on the right side of the stage.



Straight line distance to each camera from the Control Station is 5m, 17m, and 33m, respectively. Each camera supports P/T/Z (i.e., camera can pan, tilt, and zoom) and valid range of values are as follows:

- Pan – 0 - 180^0
- Tilt – 0 - 45^0
- Zoom – 0 - 10x

Suppose you were invited to design a wireless controller to remotely control each of the cameras. The camera operator at the Control Station (Windows-based PC) controls and sets P/T/Z values for each camera. Those values need to be wirelessly communicate to the respective camera with

minimum delay, as the camera operator may change the P/T/Z configuration while a recording is going on. You are also told that in the future the number of cameras may increase to 6.

(i) Would you recommend an infrastructure-based network or infrastructure-less network to control the 3 cameras? Explain. [3]

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

(iii) What wireless technology (e.g., Bluetooth, ZigBee, WiFi, 3G, 4G, etc.) would you recommend to create these wireless controllers? Justify your recommendation. [3]

(iv) What type of a message routing scheme would you recommend? Justify your recommendation. [3]

(v) What measures can you take to ensure only the authorized control station can control the cameras? [3]

(vi) Design a suitable message format to control the cameras from the Control Station. [10]

Question 4 (25 marks)

(i) "Hidden Terminal" and "Exposed Terminal" are 2 of the common issues in wireless communication.

a) Using a suitable diagram explain why Ethernet-type collision detection algorithm will not work in "Hidden Terminal" problem. [5]

b) Due to high error rate in wireless communication it is recommended to use small frame sizes. Discuss how the overall throughput/bandwidth will be affected when small frames are used in the presence of "Hidden Terminal" problem. [4]

(ii) A wireless LAN is being designed for a branch office with 23 users. All 23 users have webmail access. However, only 12 users have access to other websites inducing online productivity tools like Google Docs and Office 365 (other than webmail). 5 users access a cloud-based Enterprise Resource Planning (ERP) system. It is also important to allow LAN communication among the PCs and laptops in the branch, e.g., file and printer sharing. Following traffic loads are given:

- Webmail access – 5 Kbps/user
- Web access – 25 Kbps/user
- ERP access – 50 Kbps/user
- LAN communication – 2 Mbps/user

a) Calculate the total Internet bandwidth requirement. [3]

b) Calculate the total capacity requirement within the wireless LAN. [3]

c) Would you recommend 802.11g network or an 802.11n network? Briefly explain. [3]

d) A vender has recommended to use a "4G Wireless router" to provide the connectivity to the branch office. Do you agree or disagree with this recommendation? Justify. [3]

(iii) Using a suitable example explain the statement "*LTE-Advanced provides better QoS*". [4]

Question 5 (25 marks)

(i) Recommend with justification a suitable wired/wireless technology for each of the following cases:

a) To provide Internet access to a house in a rural village. [4]

b) To upload data from a buoy on deep sea which is positioned to detect tsunami. [4]

c) A "touch and go" application that allows you to get more information about a movie shown on a smart poster. [4]

(ii) Internet of Things (IOT) combine sensors, connectivity, and people/processes to build smart systems.

a) Outline an IOT-based solution to address one of the common problems faced in a city like traffic, air pollution, parking, and crimes.

Your solution needs to identify how sensors, connectivity, and people/processes are combined to provide a smart solution. Also, you need to identify types of sensors to use, connectivity options, processes, and interfaces to interact with humans (e.g., visualization). [9]

b) Briefly explain 2 security and privacy related challenges you may have to overcome while developing such a 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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