UNIVERSITY OF MORATUWA

FACULTY OF ENGINEERING

DEPARTMENT OF COMPUTER SCIENCE & ENGINEERING

MSc in Computer Science
2015 Intake Semester 1 Examination

CS5440 Wireless Access Networks

Time allowed: 2 Hours April 2015

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 **6**).
6. This examination accounts for 40% of the module assessment.
7. This is an **open book** 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)

(i) While reflection of wireless signals is usually considered as problematic, several wireless technologies consider reflection as a benefit. Using suitable examples explain how reflection can become an advantage in one wireless technology while it becomes a disadvantage in another. [6]

(ii) International Space Station (ISS) is positioned 400 km from the surface of the Earth. It uses a telephone system similar to satellite telephones. It transmits a 1.6 GHz wireless signal with a transmit power of 2.2 W. The transmitting antenna gain is 10 dB and receiver antenna gain is 3 dB.

a) Find the received power for the link from the ISS to a satellite phone on the ISS-control-station on Earth. [4]

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 phone at an acceptable voice quality? Briefly explain. [3]

d) What type of an antenna would you recommend for the satellite phone on ISS-control-station on Earth? Briefly explain. [4]

e) As the ISS is relatively close to the surface of the Earth, it rotates much faster than the surface of the Earth. Hence, a call cannot be directly connected to the same ISS-control-station for a long time. Would you recommend soft handoff or hard handoff when transferring a connection from one station to another? Briefly explain. [4]

Question 2 (25 marks)

(i) In practice IEEE 802.11b (i.e., Direct Sequence Spread Spectrum (DSSS) based Wi-Fi) technology can use only channels 1, 6, and 11 simultaneously. Using a suitable diagram explain why other channels cannot be used simultaneously. [5]

(ii) When asked about the opinion from a networking consultant about making a medium sized office entirely Wi-Fi, he gave the following answer.

"I would not recommend having only a Wi-Fi network in your office. For example, we did that in our office. But later our software development team said they experienced high latency when they SSH into servers using the Wi-Fi network, even though the servers were in our own server room. Therefore, now we have given a separate Ethernet LAN for our development team to connect to the servers. But others in our office use only the Wi-Fi network."

Do you agree or disagree with the recommendation of the consultant? Briefly explain. [5]

(iii) "Evolved High-Speed Packet Access (HSPA+) is a better alternative than 4G Long Term Evolution (LTE)".

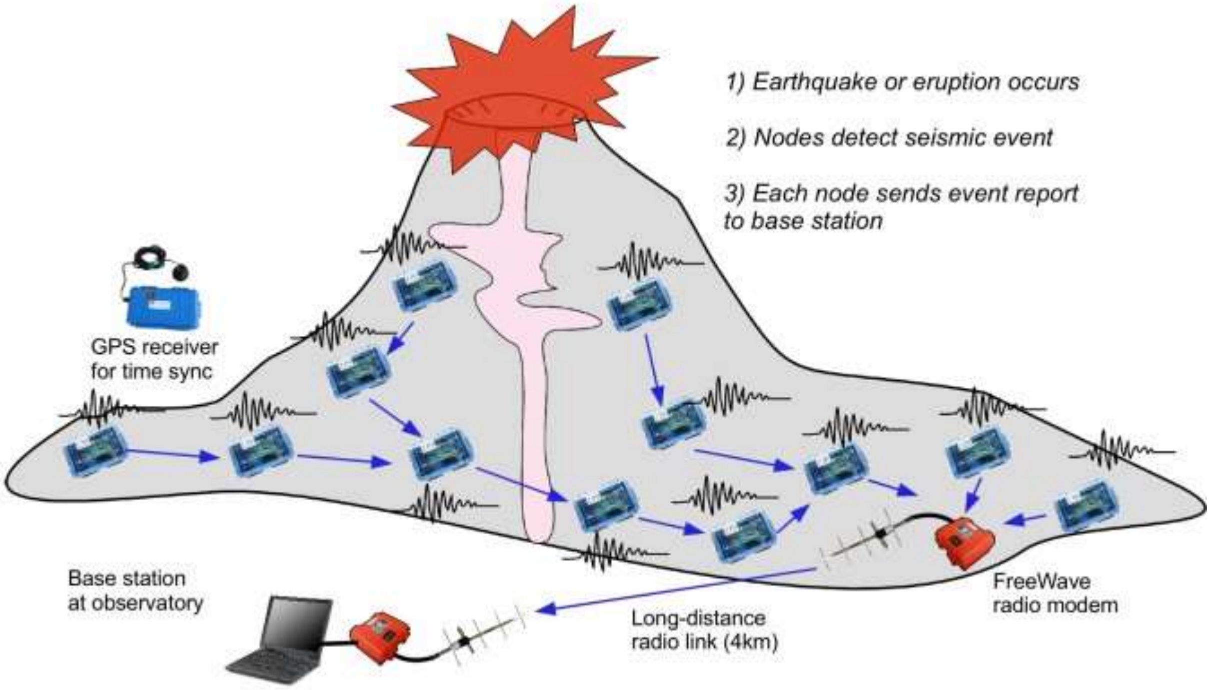
Do you agree or disagree with this statement? Briefly explain. [5]

(iv) LTE offers several deployment options such as Macro, Femto, and Pico. Discuss why such multiple deployment options are required. [5]

(v) In addition to increased bandwidth, 4G LTE technology also provides better Quality of Service (QoS). Discuss what types of applications can benefit from such QoS enhancements. [5]

Question 3 (25 marks)

Following is a diagram of a Wireless Sensor Network (WSN) deployed to monitor a volcano. It illustrates the follow of data from sensor motes to the base station.



Source: http://fiji.eecs.harvard.edu/Volcano

(i) What wireless technology would you recommend for the communication among sensor motes? Justify your recommendation. [3]

(ii) What wireless technology would you recommend for the communication between the base station and gateway (i.e., FreeWave radio modem)? Justify your recommendation. [3]

(iii) What type of a network topology would you recommend for interconnecting the sensor motes? You may assume communication is mostly unidirectional from sensor motes to base station. Justify your recommendation. [4]

(iv) Suppose the frequency of the transmitter is 2.4 GHz and the transmission power is 6.3 mW. Gains of both the transmitting and receiving antennas are 1.

a) What is the received power at 75 m? [4]

b) 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. [3]

(v) Recommend a suitable solution to address each of the following challenges faced by this WSN. Give a one sentence justification for each solution.

a) Deployment of sensor motes. [2]

b) Data dissemination from sensor motes to the gateway. [2]

c) Not missing any of the volcanic eruptions and associated Earthquakes. [2]

d) Unattended operation over a long time period. [2]

Question 4 (25 marks)

(i) Among many applications of Inter-Vehicle Communication, safety applications are the most popular. One such safety application is to inform the cars/drivers that the car in front of them is applying the brakes. This can be achieved by sending a message from the car that applies braking to all the cars behind it. This message may indicate the location of the car and intensity of breaking, e.g., slow breaking vs. rapid breaking. When such a message is received, cars behind can automatically apply brakes with a suitable force/intensity. How much of a break force to apply can be determined by the gap between the two cars, current speed, and intensity of the brake applied by the car in front of them.

a) Briefly explain 3 wireless-network-related challenges you may have to overcome while developing such a solution? [6]

b) Briefly explain how each of the challenges you mentioned in part (a) can be overcome with existing technologies. [6]

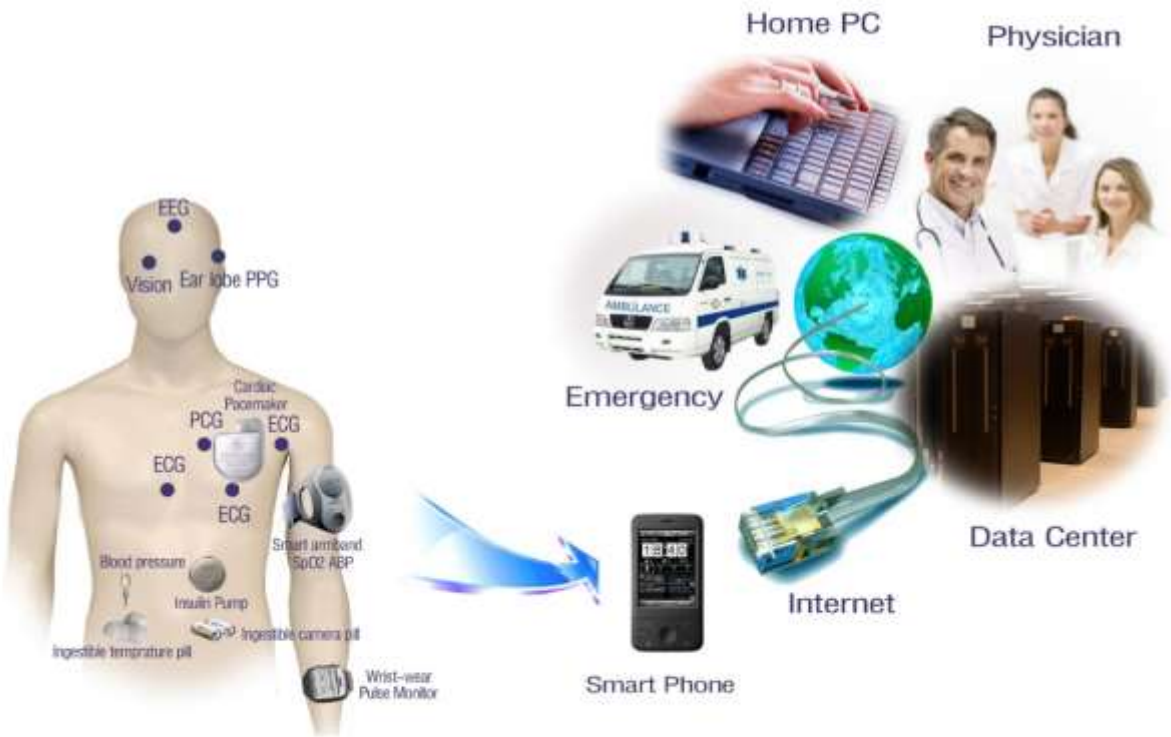
c) Explain why Data-Centric Routing is more suitable for this solution than TCP/IP. [3]

d) What kind of security issues need to be addressed by this solution. [4]

(ii) Using a suitable diagram explain what is the Triangular Routing Problem in mobile IP. Also explain a possible solution to fix the problem. [6]

Question 5 (25 marks)

Following is a diagram of a typical body sensor network and its backend.



Source: http://robotics.ece.mtu.edu

(i) "This application/system falls under the domain of Internet of Things (IoT)"
Do you agree or disagree with this statement? Briefly discuss. [3]

(ii) What type of a wireless technology would you recommend to connect the sensors attached to the body to the smart phone? Justify your recommendation. [3]

(iii) What type of a wireless technology would you recommend to connect the smart phone to the backend? Justify your recommendation. [3]

(iv) Design a suitable messaging format to transfer the data between the sensors and the backend (i.e., data center). Clearly state any assumptions. [5]

(v) Draw a suitable architecture for this application/system while illustrating key components/layers related to communication and computation. [5]

(vi) List 3 security and privacy issues of this application/system and how those issues can be addressed using existing techniques and best practices. [6]

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	$P_R(d) = P_0(d_0) - 10 n_p \log(d/d_0) + X_\sigma$
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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