UNIVERSITY OF MORATUWA

FACULTY OF ENGINEERING

DEPARTMENT OF COMPUTER SCIENCE & ENGINEERING

MSc in Computer Science
2018 Intake Semester 2 Examination

CS5440 WIRELESS ACCESS NETWORKS

Time allowed: 2 Hours July 2018

ADDITIONAL MATERIAL: *None*

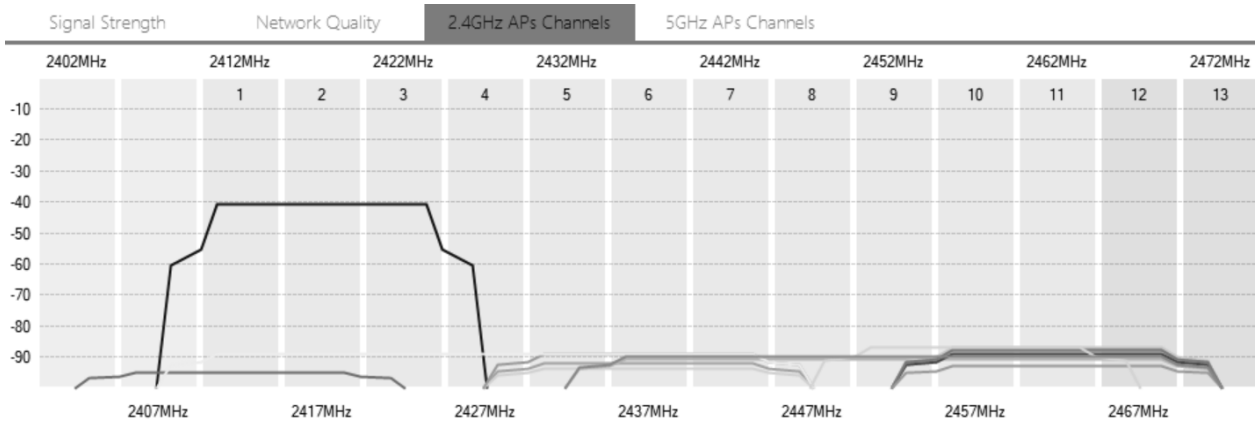
INSTRUCTIONS TO CANDIDATES:

1. This paper consists of **4** questions in **6** pages.
2. Answer **All** 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. Assume reasonable values for any data not given in or with the examination paper. Clearly state such assumptions made on the script.
9. 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.
10. This paper should be answered only in English.

Question 1 (25 marks)

(i) A wireless scanner detected the following WiFi networks around Park Street, Colombo 2.

SSID	MAC Address	RSSI	Chan	802.11	Max Speed	WEP	WPA	WPA2	WPS	Vendor
Guest_Wifi	58:97:1E:E8:33:C2	-86	11	b, g, n	144.4 Mbps	Open				Cisco Systems. Inc
[Hidden]	18:A6:F7:7E:30:10	-45	2	b, g, n	144.4 Mbps		PSK-(TKIP|CCMP)	PSK-(TKIP|CCMP)		TP-LINK TECHNOLOGIE
Mobitel_EB	54:4A:00:4B:3C:F2	-88	6	b, g, n	144.4 Mbps		PSK-CCMP	PSK-CCMP		Cisco Systems. Inc
Mobitel_Open	54:4A:00:4B:3C:F0	-95	6	b, g, n	144.4 Mbps	Open				Cisco Systems. Inc
Mobitel_EAP	54:4A:00:4B:3C:F1	-93	6	b, g, n	144.4 Mbps			MGT-(TKIP|CCMP)		Cisco Systems. Inc
Ravidu	F2:4F:7E:BA:46:E1	-91	1	b, g, n	72.2 Mbps			PSK-CCMP		
[Hidden]	FA:8F:CA:8C:AF:E3	-92	1	b, g, n	72.2 Mbps	Open				
NVR639904553	BC:AD:28:EF:22:21	-92	11+7	b, g, n	300 Mbps			PSK-CCMP	1.0	Hangzhou Hikvision Dig
WIFI_SAP	58:97:1E:E8:33:C5	-85	11	b, g, n	144.4 Mbps			PSK-CCMP		Cisco Systems. Inc
Test_AD	58:97:1E:E8:33:C3	-86	11	b, g, n	144.4 Mbps			MGT-CCMP		Cisco Systems. Inc
HEMASEXT	58:97:1E:E8:33:C1	-89	11	b, g, n	144.4 Mbps			PSK-CCMP		Cisco Systems. Inc
HEMAS	58:97:1E:E8:33:C0	-86	11	b, g, n	144.4 Mbps			PSK-CCMP		Cisco Systems. Inc
AndroidAP	94:B1:0A:87:2F:CD	-93	6	b, g, n	72.2 Mbps	Open				Samsung Electronics Co.
[Hidden]	58:97:1E:E8:33:C4	-85	11	b, g, n	144.4 Mbps			PSK-CCMP		Cisco Systems. Inc
SkyCargoCMB	90:61:0C:30:FF:75	-92	2+6	b, g, n	300 Mbps		PSK-CCMP	PSK-CCMP	1.0	Fida International (S) Pte
Harsha Mac	6C:40:08:9E:7E:16	-93	11	b, g, n	216.7 Mbps			PSK-CCMP		Apple. Inc.
20A2sam	F4:83:CD:F1:BD:C3	-94	1+5	b, g, n	450 Mbps		PSK-CCMP	PSK-CCMP		TP-LINK TECHNOLOGIE
NARAWIFI	DC:09:4C:A3:31:A0	-87	10	b, g, n	144.4 Mbps		PSK-(TKIP|CCMP)	PSK-(TKIP|CCMP)		HUAWEI TECHNOLOGIE
LTL1	98:DE:D0:65:B6:48	-93	1	b, g, n	300 Mbps		PSK-(TKIP|CCMP)	PSK-(TKIP|CCMP)		TP-LINK TECHNOLOGIE
Dialog 4G	44:6E:E5:6A:9A:5C	-95	10	b, g, n	144.4 Mbps		PSK-(TKIP|CCMP)	PSK-(TKIP|CCMP)		HUAWEI TECHNOLOGIE
Mobitel_EB	54:4A:00:4B:3C:FD	-95	36	a, n	144.4 Mbps		PSK-CCMP	PSK-CCMP		Cisco Systems. Inc
Mobitel_EAP	54:4A:00:4B:3C:FE	-94	36	a, n	144.4 Mbps			MGT-(TKIP|CCMP)		Cisco Systems. Inc
[Hidden]	42:AD:28:EF:22:21	-93	11+7	b, g, n	300 Mbps	Open				



a) What can you conclude from the observations?

Hint: Focus on the key observations that affect range, bandwidth, QoS, etc. [6]

b) How secure are these networks? [3]

c) List 3 suggestions to improve the wireless communication environment. [3]

d) It can be seen that access points operating on the same channel have different throughputs such as 72.2, 144, and 300 Mbps. How is this possible? [3]

(ii) Suppose one of the above access points has a channel width of 20 MHz and operates on channel 6 (i.e., frequency 2,437 MHz) with an output power of -28 dBm.

a) What will be the signal strength at 50 m from the access point? Assume the reference distance is 5 m and the path loss exponent is 2.2. Transmission and receiver antenna gains are 2 and 1, respectively. [7]

b) Is the signal strength sufficient, if the receiver sensitivity is -95 dBm? Discuss. [3]

Question 2 (25 marks)

Today people tend to carry multiple mobile devices such as two smartphones and/or smartwatch. Sometimes they forget those devices and leave only with one device, later to realize they have lost the other device. While sophisticated solutions exist to track lost smartphones, those are expensive and require mobile provider's support.

Suppose you are required to develop a simple device tracking App, where it generates an audible alarm (on both the devices) if the devices are not in each other's range. You may assume no infrastructure-based networks are available in the vicinity and a smart device can communicate only with other smart devices (e.g., smartphone and smartwatch) in its neighborhood. Ideally, a user should be able to connect more than 2 devices.

Answer the following questions in the context of this problem.

(i) What property in wireless communication could be used to detect that 2 smart devices are not in each other's range? [3]

(ii) From the wireless technologies such as Bluetooth, WiFi, NFC, ZigBee, and 6LowPAN, which technology would you recommend for the communication between the smart devices? Justify. [3]

(iii) Design a protocol for the communication between the smart devices. Indicate messages types, fields/attributes of a message, their sizes, and order. [6]

(iv) How would your solution support multi-device connectivity, e.g., a person with 2 smartphones and smartwatch? [4]

(v) As the proposed device tracking App is expected to be running all the time, what techniques can be used to reduce the power consumption for communication? [4]

(vi) How would you extend your solution to provide better tracking and localization features if the following constraint is relaxed?

"You may assume no infrastructure-based networks are available in the vicinity and a smart device can communicate only with other smart devices …" [5]

Question 3 (25 marks)

A wireless LAN is being designed for a large warehouse with 15 computer users. All users have web access (including webmail) and access to a cloud-based stock management system. These users also connect to a file and print server at the warehouse. Warehouse consists of 4 CCTV cameras, and the video streams from the cameras are sent to the head office for viewing and archiving. A set of wireless sensors are also used to monitor micro-climate, doors, and windows of the warehouse from the head office. The following traffic loads are given:

- Web Access – 30 Kbps/user
- CCTV – 500 Kbps per camera
- All Sensors – 15 Kbps
- Stock management system – 50 Kbps/user
- File and Print services – 1 Mbps/user

(i) Calculate the total Internet bandwidth requirement. [3]

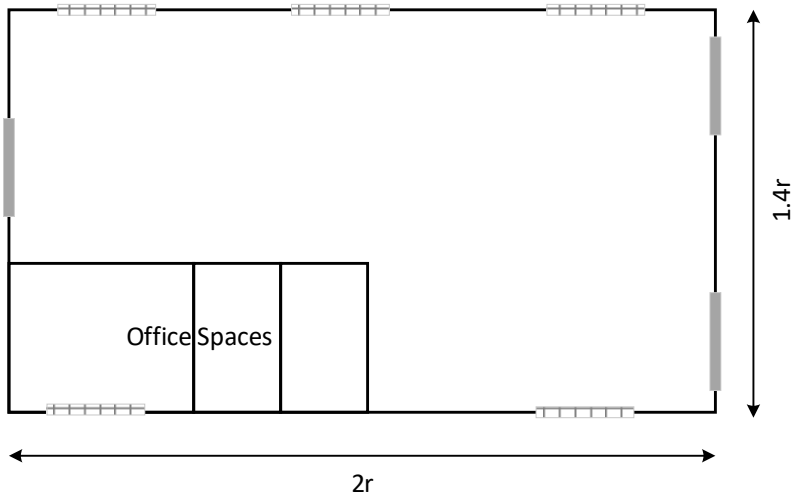
(ii) Calculate the total capacity requirement within the wireless LAN. [3]

(iii) An ISP has recommended using a "4G Wireless router based on LTE-Advanced technology" to provide the connectivity to the warehouse.

Do you agree or disagree with this recommendation? Justify. [4]

(iv) Suppose you are to place 3 Access Points (APs) based on IEEE 802.11n with a range of *r*. Where would you place the 3 APs if the warehouse has the following layout?

Sketch a rough diagram on the answer sheet and clearly mark the APs.



[4]

(v) What non-technical factors should be considered while deploying the proposed wireless LAN? Briefly discuss. [4]

(vi) Owner of the warehouse has realized that the storage facilities are not optimally utilized and items are not stored and dispatched on time. Moreover, some of the food items tend to go bad much earlier than their expiration date, as the micro-climate of the warehouse is not properly maintained. Furthermore, the owner has realized inconsistencies in the actual stock and stock management system.

Propose an IoT-based solution to overcome the issues. Your solution should consider sensors, connectivity, and people & processes in an IoT environment. [7]

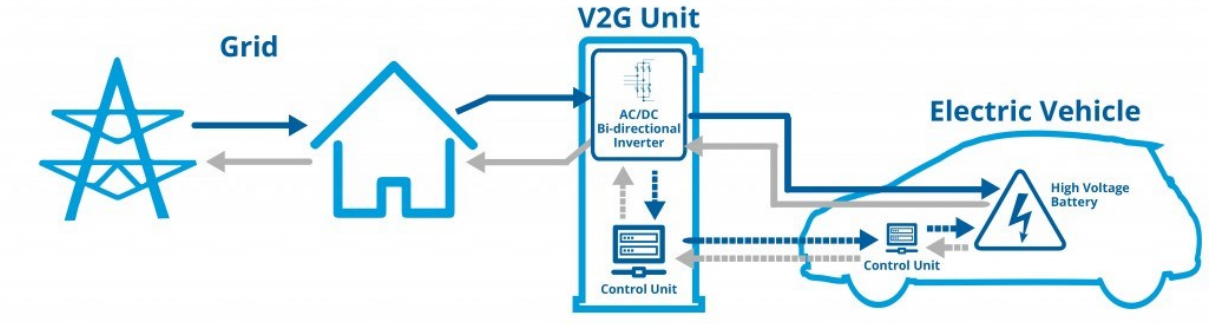
Question 4 (25 marks)

(i) Bring Your Own Device (BYOD) is becoming popular where users can use their personal devices for office work. While this brings in many advantages, it also creates several technical and security issues.

a) Using an example, describe how a user's BYOD device can be located regardless of its location (i.e., home, office, or on the go). [5]

b) Describe 2 techniques to minimize security issues while using BYOD devices. [4]

(ii) With the popularity of electric cars, one of the biggest challenges the electricity providers face is the large increase in power consumption throughout the day. For example, some cars charge at normal rate consuming ~16 A while rapid charging draw ~32 A from the power grid. Aggregation of total current drawn by multiple cars on a neighborhood introduces a significant load to the power grid. Moreover, controlling the current aggregation is difficult as cars are charged from the respective houses, and the car owners do not have any visibility on what other cars are charged at the same time.



Source: http://www.cenex.co.uk/vehicle-to-grid/

As a way of solving this problem CEB is proposing to allocate a guaranteed 100 A and 400 A for a given neighborhood to charge cars during peak and off-peak hours, respectively. To utilize this capacity, an agent-based module is to be attached to the charging (V2G) unit at a house. Agent-based modules at each V2G unit are expected to negotiate with each other to decide who will charge and when. The proposed unit will switch on the V2G units only if there is sufficient current capacity in the power grid. If not, the agent-based module will retry with a random delay. You are required to develop a solution for the communication between V2G units.

a) What wireless technology would you recommend for the communication between a V2G unit and the utility office? Justify. [4]

b) What network topology would you recommend for the communication between a V2G unit and the utility office? Justify. [4]

c) What message routing scheme(s) would you recommend for the communication between a V2G unit and the utility office, as well as between V2G units? Justify. [4]

"*I recommend having two-way communication between V2G unit and the utility office, as well as among V2G units.*"

d) Do you agree or disagree with this statement? Discuss. [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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