



UTHM

Universiti Tun Hussein Onn Malaysia

UNIVERSITI TUN HUSSEIN ONN MALAYSIA

**FINAL EXAMINATION
(TAKE HOME)
SEMESTER II
SESSION 2019/2020**

COURSE NAME : WIRELESS SENSOR AND MOBILE
AD HOC NETWORKS

COURSE CODE : BEB 42003

PROGRAMME CODE : BEJ

EXAMINATION DATE : JULY 2020

DURATION : 24 HOURS

INSTRUCTION : ANSWERS ALL QUESTIONS
OPEN BOOK EXAMINATION

THIS QUESTION PAPER CONSISTS OF **EIGHT (8)** PAGES

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- Q1** (a) Differentiate between wireless sensor networks (WSN) and cellular system. (4 marks)
- (b) Discuss **THREE** (3) optimization goals in WSN. (6 marks)
- (c) **Figure Q1** shows a WSN deployment in a forest scenario. The Source Node is located at 50 m away from the Sink Node while Node A and Node B are located 90 m away from the Sink respectively. All nodes use the same type of antenna with the gain of 10 dB.

The Sink Node received a signal from the Source Node, which has a transmit power of 10 W and operate at frequency 2.4 GHz. At the same time, the Sink Node also received signals from Node A and Node B with 1 μ W and 2 μ W of received power respectively.

The forest trees produce path loss exponent, $\gamma = 2$ and shadowing variance parameter, $X_\sigma = 1$ dB. Assuming that the transmission line losses at the Source Node, $L = 1$ dB, analyze the following:

- (i) Receive power at the Sink Node, $P_{recv}(d)$ in Watt for transmitted signal from the sink node. (5 marks)
- (ii) Path Loss, $PL(d)$ from Source Node to the Sink Node (3 marks)
- (iii) Signal to Interference Noise Ratio ($SINR$) at the Sink Node. Given the ambient temperature $T = 27$ °C, bandwidth = 200 kHz and Boltzmann constant, $k = 1.38 \times 10^{-23}$ J/K. (5 marks)
- (iv) Energy bit per noise density, E_b/N_0 given the data rate, $R = 200$ kbps. (2 marks)

Q2 Consider the MAC and PHY frame of the IEEE 802.15.4 protocol is shown as in **Figure Q2** and its related parameters as in **Table Q2**.

- (a) Outline the algorithm for the Unslotted CSMA/CA channel access mechanism of the IEEE 802.15.4, operating in a non-beacon enabled mode. (6 marks)
- (b) Calculate the size of data payload in bytes, the data frame transfer time and the effective data rate. (10 marks)
- (c) Next, consider the system as a non-ideal and only one retry is allowed with up to 20% Packet Error Rate. The related data is given in **Table Q2**. Analyze this scenario and determine,
- (i) the actual data rate; and
- (ii) the time taken to transfer 3 Mbyte of data. (9 marks)

Q3 Consider a plantation with size approximately 600,000 hectares of prime agriculture land, mostly cultivated with palm oil. In order to manage the land systematically it was decided that there should be a system of wireless sensor network which is going to be installed and operate to monitor the required environmental parameters for future data gathering. A sample agriculture field of size 5 km by 5 km is being allocated for initial experimentation with installation of 100 sensor nodes and one gateway. In terms of routing protocols, the network engineer has various options, amongst them are given in **Table Q3**.

- (a) Outline the **THREE** (3) important characteristics that a routing protocol need to have for an effective implementation in a given scenario. (6 marks)
- (b) Suggests type of sensors that are useful for above application (4 marks)
- (c) Choose **ONE** (1) of the protocols in **Table Q3** that you are most familiar with.
- (i) Describe the functionality of that protocol. (5 marks)
- (ii) Outline the performance metrics and show the measurements techniques. (5 marks)
- (iii) Explain the advantages and disadvantages of the protocol. (5 marks)

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Q4 Consider the IEEE 802.15.4 protocol, which is the most viable protocol for the wireless sensor networks system. The following assumptions must be made: no collision, no packet lost, no acknowledgement, sending node always has sufficient packet to send, BER is zero, non-beacon version, only one sender and one receiver, short distance.

- (a) Describe the throughput of IEEE 802.15.4 protocol. (5 marks)
- (b) Derive the general expression for the throughput of the IEEE 802.15.4 protocol, in terms of overall delay. Defines all the terms used. (12 marks)
- (c) Find the throughput of the IEEE 802.15.4 for the operating frequencies of 915 MHz and 2.4 GHz with the following parameters: payload of 80 bytes and length of MAC address of 64 bit. You may need the information provided in the **Table Q4 (i), (ii) and (iii)**. (8 marks)

– END OF QUESTIONS –

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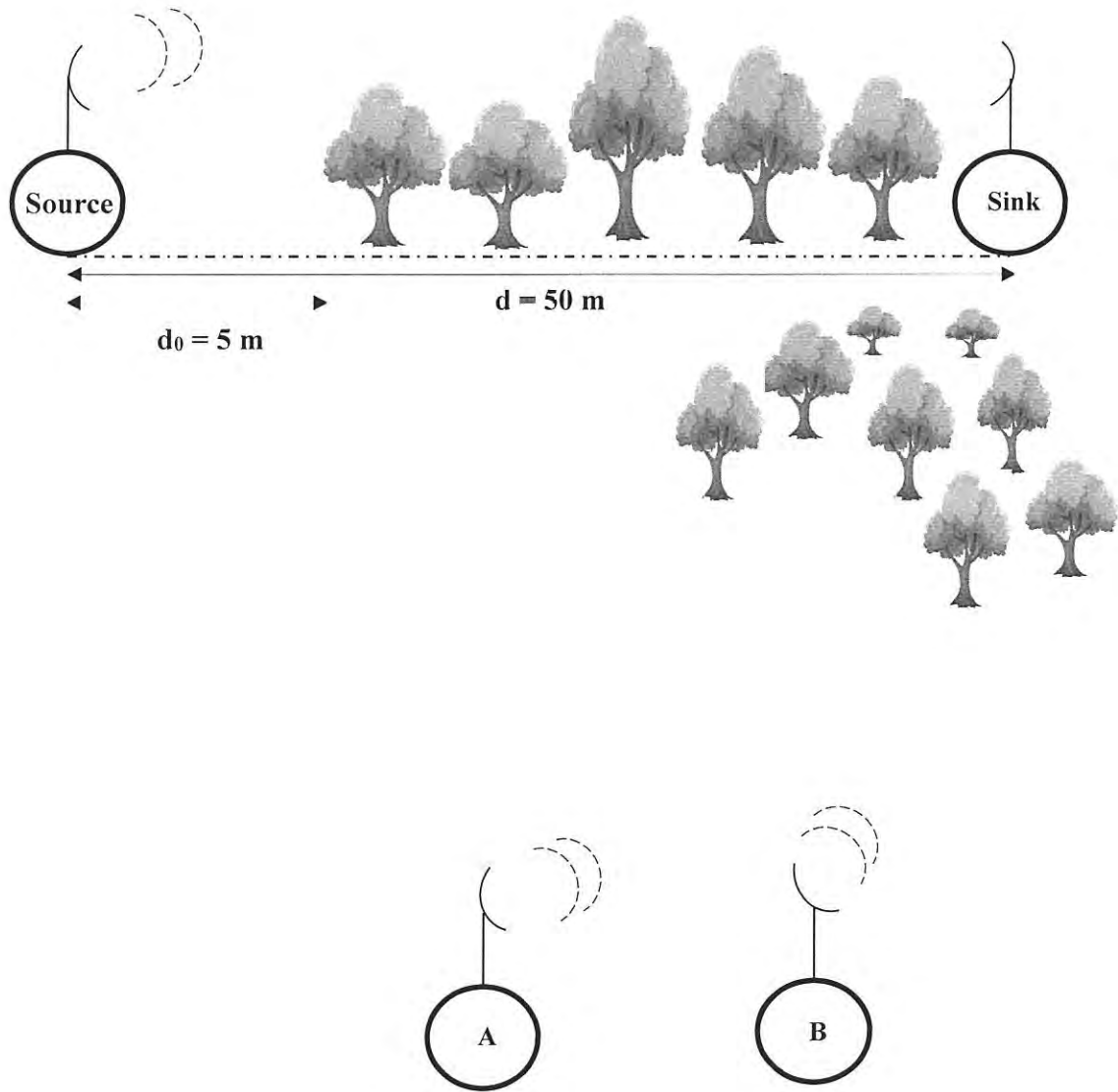


Figure Q1

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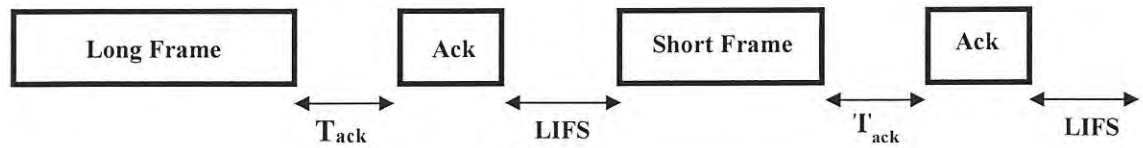
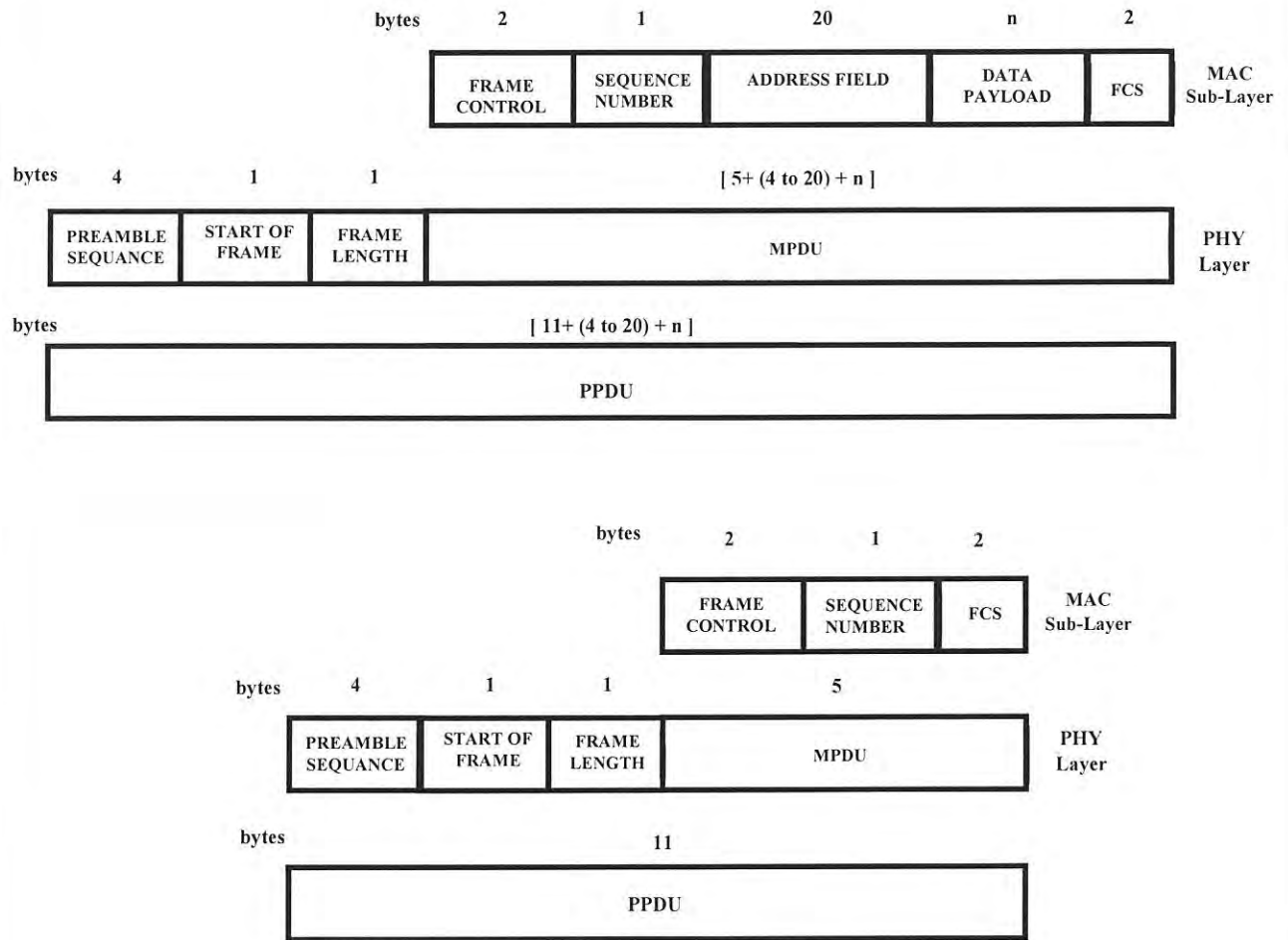


Figure Q2

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Table Q2. Data related to 802.15.4 MAC Protocol

Parameters	Values
aUnitBackOffPeriod	20 symbols
CCA detection time	8 symbols
InitialBackOffPeriod	$\{2^{BE}-1\}$
Maximum Over The Air Data Rate	250 kbps
One Symbol Period	16 μ s
aMaxPHYPacket Size	127 bytes
Minimum Frame Overhead when using short addressing	13 bytes
SHR	5 bytes
PHR	1 byte
Turnaround Time	192 μ s
ackFrameSize	11 bytes
maxACKWaitDuration	54 symbols

Table Q3. Routing Protocols

NO	PROTOCOL NAME	ACRONYM
1	Power Efficient Gathering in Sensor Information System	PEGASIS
2	Low Energy Adaptive Clustering Hierarchy	LEACH
3	Threshold Sensitive Energy Efficient	TEEN
4	Hybrid Energy Efficient Distributed	HEED



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Table Q4(i). Modulation parameters of 802.15.4

Frequency band	Symbol rate (baud/s)	Modulation	Bit rate (kbps)
868.0-868.6 MHz	20 000	BPSK	20
902-928.0 MHz	40 000	BPSK	40
2.4-2.4835 GHz	62 500	16-ary orth.	250

Table Q4(ii). Values for parameters “a” and “b”

# address bits		868 MHz		915 MHz		2.4 GHz	
		a	b	a	b	a	b
0 bits	ACK	0.0004	0.0149	0.0002	0.00745	0.000032	0.002656
	no ACK	0.0004	0.0099	0.0002	0.00495	0.000032	0.002112
16 bits	ACK	0.0004	0.0181	0.0002	0.00905	0.000032	0.002912
	no ACK	0.0004	0.0131	0.0002	0.00655	0.000032	0.002368
64 bits	ACK	0.0004	0.0229	0.0002	0.01145	0.000032	0.003296
	no ACK	0.0004	0.0179	0.0002	0.00895	0.000032	0.002752

Table Q4(iii). Minimum and maximum delay

# address bits		868 MHz		915 MHz		2.4 GHz	
		Minimum delay (ms)	Maximum delay (ms)	Minimum delay (ms)	Maximum delay (ms)	Minimum delay (ms)	Maximum delay (ms)
0 bits	ACK	13.5	63.7	6.75	31.85	2.21	6.56
	no ACK	8.5	58.7	4.25	29.35	1.66	6.02
16 bits	ACK	16.7	63.7	8.35	31.85	2.46	6.56
	no ACK	11.7	58.7	5.85	29.35	1.92	6.02
64 bits	ACK	22.9	63.7	11.45	31.82	3.30	6.56
	no ACK	17.9	58.7	8.95	29.35	2.75	6.02