Universiti Tun Hussein Onn Malaysia

UNIVERSITI TUN HUSSEIN ONN MALAYSIA

FINAL EXAMINATION
SEMESTER II
SESSION 2022/2023

COURSE NAME	:	WIRELESS SENSOR AND MOBILE AD-HOC NETWORKS
COURSE CODE	:	BEJ 41503
PROGRAMME CODE	:	BEJ
EXAMINATION DATE	:	JULY/ AUGUST 2023
DURATION	:	3 HOURS
INSTRUCTION	:	1. ANSWER ALL QUESTIONS 2.THIS FINAL EXAMINATION IS CONDUCTED VIA **CLOSED BOOK.** 3.STUDENTS ARE **PROHIBITED** TO CONSULT THEIR OWN MATERIAL OR ANY EXTERNAL RESOURCES DURING THE EXAMINATION CONDUCTED VIA CLOSED BOOK

THIS QUESTION PAPER CONSISTS OF **TEN (10)** PAGES

Q1 Consider the MAC and PHY frame of the IEEE 802.15.4 protocol is shown as in **Figure Q1(i)** and its related packet data **Table Q1**.

(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) The schematic view of the MAC Layer data frame and the Acknowledgement frame is shown **Figure Q1 (ii)**. The related packet data is given in **Table Q1**. Calculate:

(i) the data payload;
(ii) the data frame transfer time; and
(iii) the effective data rate.

(12 marks)

(c) Next, consider the system as a non-ideal and only **ONE (1)** retry is allowed with up to 20% Packet Error Rate. The related data is given in **Table Q1.** Analyze this scenario and determine,
(i) the actual data rate; and
(ii) the time taken to transfer 3 MByte of data.

(7 marks)

Q2 Consider a wireless sensor network shown in **Figure Q2**. All the nodes are stationary.

(a) Show and explain the flowchart of sensor node and clusterhead operation in one round.

(11 marks)

(b) Let the sources of energy consumption come from the following Node and CH activities as shown in **Table Q2(b)**.

Table Q2(b)

Node (n_a and n_b)	sensing, transmitting
Cluster head (CH)	sensing, receiving and transmitting

The propagation model is assumed to follow the free space fading with path loss exponent of 4. The weighting factor is given as,

$$\{h_1, h_2, h_3, h_4\} = \{1.2, 1.2, 1.1, 1.1\}.$$

(i) Analyze the energy consumption in each node and cluster head.

(5 marks)

(ii) Develop the total energy model for this sensor network in terms of variables in **Table Q2(b)(ii).**

(5 marks)

(iii) Calculate the total energy consumption using the values given in **Table Q2(b)(ii)**.

(4 marks)

Q3 Localization is one of the most important issues in wireless sensor networks.

(a) Describe the mechanism of Received Signal Strength Indicator (RSSI) to estimate the distance using the free space propagation model.

(8 marks)

(b) Consider three anchor nodes with known position,(x_1, y_1), (x_2, y_2) and (x_3, y_3). The unknown node is located at position (x_u, y_u). Assume that the distance from (x_u, y_u) to all three nodes are perfect distances.

(i) Formulate the necessary linear matrix equation to represent the solution of (x_u, y_u).

(10 marks)

(ii) **Figure Q3(b)** shows three anchors of known position and a node of unknown location. If the distances r_1, r_2 and r_3 are given as 10, 2 and 3 respectively, deduce the coordinate of the unknown node.

(7 marks)

Q4 (a) Routing protocol is one of the very important elements in the management of mobile ad hoc network. State **THREE (3)** design objectives of routing protocols with regards to wireless mobile ad hoc network. Explain briefly each of them.

(6 marks)

(b) Ad Hoc On Demand Distance Vector (AODV) is a well-known protocol for mobile ad hoc network. It consists of a number of sub-protocols namely Route Discovery and Route Reply.

(i) Explain the operation of Route Discovery Protocol at the source, intermediate and at the destination.

(7 marks)

(ii) Evaluate **FOUR (4)** optimization processes as applied to AODV protocol.

(12 marks)

-END OF QUESTIONS –

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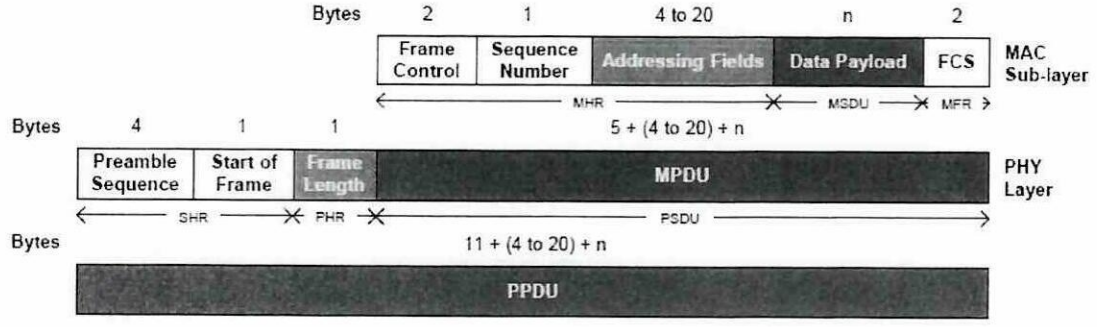
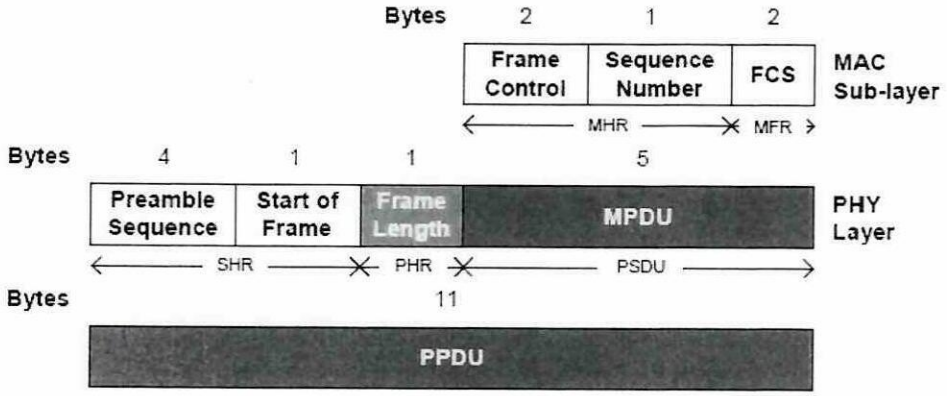


Figure Q1 (i)



FigureQ1(ii)

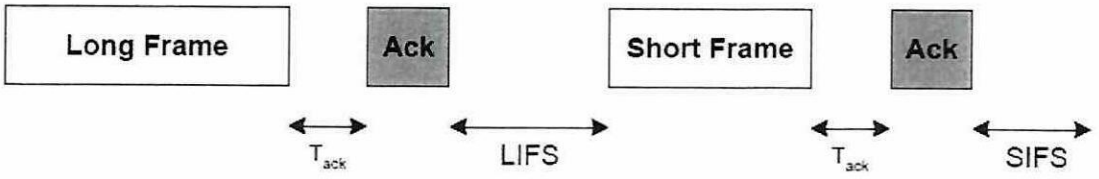


Figure Q1(iii)

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Table Q1. Data related to IEEE 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 µs
aMaxPHYPacket Size	127 bytes
Minimum Frame Overhead when using short addressing	13 bytes
SHR	5 bytes
PHR	1 byte
Turnaround Time	192 µs
ackFrameSize	11 bytes
maxACKWaitDuration	54 symbols

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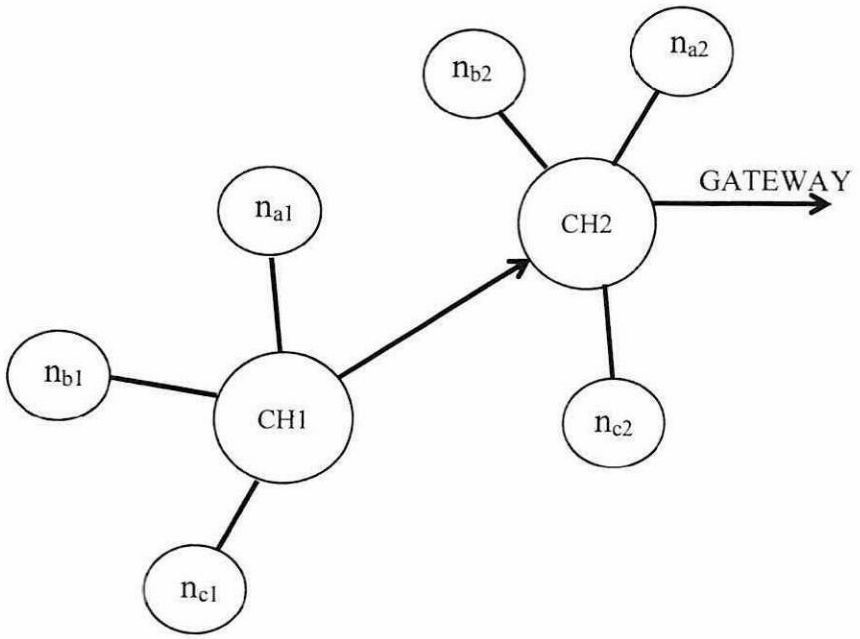

CH1 – child clusterhead CH2 – parent clusterhead

Figure Q2 Wireless sensor network

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Table Q2(b)(ii) List of of variables

SYMBOL	DESCRIPTION	VALUE
N_{cyc}	Number of clock cycles per task	0.97 x 10^6
C_{avg}	Avg. capacitance switch per cycle	22 pF
V_{sup}	Supply voltage to sensor	2.7 V
f	Sensor frequency	191.42 MHz
n_p	Constant depending on the processor	21.26
n	Path Loss Exponent	2 or 4
I_o	Leakage Current	1.196 mA
V_t	Thermal Voltage	0.2 V
b	Transmit Packet Size	2 kb
E_{elec}	Energy dissipation: electronics	50 nJ/bit
E_{amp}	Energy dissipation: power amplifier	100 pJ/bit/m2
T_{tranON}	Time duration: sleep -> idle	2450 µs
$T_{tranOFF}$	Time duration: idle -> sleep	250 µs
I_A	Current: Wakeup mode	8 mA
I_S	Current: sleeping mode	1 µA
T_A	Active time	1 ms
T_S	Sleeping time	299 ms
T_{tr}	Time between consecutive packets	300 ms
T_{sense}	Time duration: sensor node sensing	0.5 ms
I_{sense}	Current: sensing activity	25 mA
I_{write}	Current: flash writing 1 byte data	18.4 mA
I_{read}	Current: flash reading 1 byte data	6.2 mA
T_{write}	Time duration: flash writing	12.9 ms
T_{read}	Time duration: flash reading	565 µs

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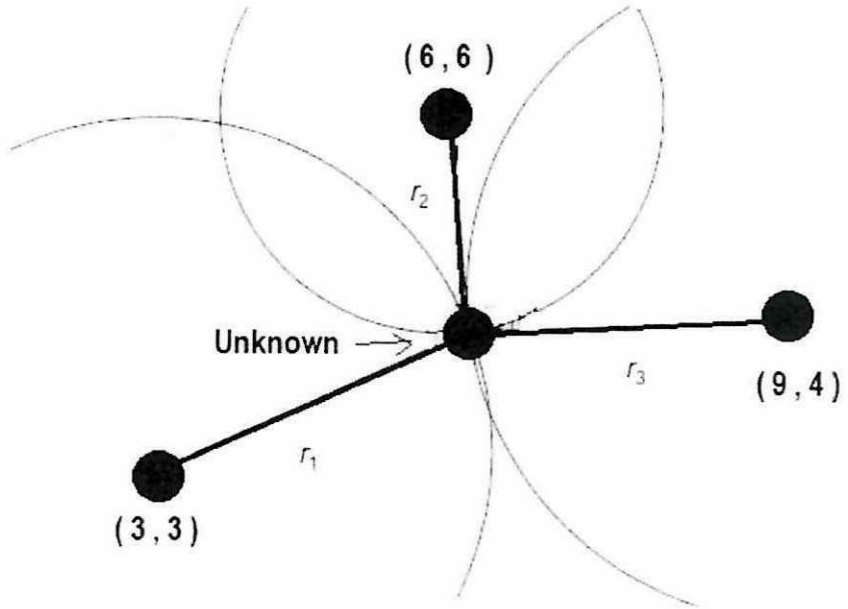

FIGURE Q3(b)

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Formula
MET11103 SWSN

h_1 =Processing, h_2 =Tx and Rx, h_3 = Sensing, and h_4 = Logging

$\boldsymbol{E_{sensN}(b)}$ = total energy dissipation at sensor node in one round,

$$E_{sensN}(b) = b.V_{sup}I_{sens}T_{sens}$$

$\boldsymbol{E_{txN}(b, d_{ij})}$ = Energy dissipation in transmitting b bit packet, in a distance dij from sensor node to CH per round

$$E_{txN}(b, d_{ij}) = b.E_{elec} + bd_{ij}^{n}E_{amp}$$

$\boldsymbol{E_{sensCH}(h_3, b)}$ = the total energy dissipation for sensing activity at the CH per round by

$$E_{sensCH}(h_3, b) = h_3.E_{sensN}(b)$$

$\boldsymbol{E_{txCH}(h_2, b_2, d_{ij})}$ = the energy dissipation, due to transmitting b_2 bit packet in a distance dj from CH1 to CH2 (i.e. parent clusterhead) per round

$$E_{txCH}(h_2, b_2, d_{ij}) = h_2.b_2.E_{elec} + b_2d_{ij}^{n}E_{amp}$$

$\boldsymbol{E_{rxCH}(b_2)}$ = The energy dissipation, due to receiving b_2 bit packet from regular sensor node and from Child CH per round

$$E_{rxCH}(b_2) = h_2.b_2.E_{elec}$$

$\boldsymbol{E_{\log(N)}(b)}$ = total energy dissipation for sensor logging activity for a sensor node per round

$$E_{\log(N)}(b) = E_{write} + E_{read} = \frac{b.V_S}{8}(I_{write}.T_{write} + I_{read}.T_{read})$$

$\boldsymbol{E_{\log(CH)}(h_4 b)}$ = total energy dissipation for sensor logging activity for a sensor node per round

$$E_{\log(CH)}(h_4, b) = h_4.E_{\log(N)}(b)$$

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Formula
MET11103 SWSN

$\boldsymbol{E_{proN}(b_1, N_{cyc})}$ = Total energy dissipation by the sensor node used for data processing/aggregation b_1 bit packet

$$E_{proN}(b_1, N_{cyc}) = b_1 . N_{cyc} . C_{avg} . V_{sup}^2 + b_1 V_{sup} \left(I_0 e^{\frac{V_{sup}}{n_p V_t}} \right) \left(\frac{N_{cyc}}{f} \right)$$

$\boldsymbol{E_{pro(CH)}(h_1, b_1, N_{cyc})}$ = Total energy dissipation by the Cluster Head (CH)

$$E_{pro(CH)}(h_1, b_1, N_{cyc}) = h_1 . E_{proN}(b_1, N_{cyc})$$