Universiti Tun Hussein Onn Malaysia

UNIVERSITI TUN HUSSEIN ONN MALAYSIA

FINAL EXAMINATION
SEMESTER II
SESSION 2023/2024

COURSE NAME	:	WIRELESS SENSOR AND MOBILE AD HOC NETWORK
COURSE CODE	:	BEJ41503
PROGRAMME CODE	:	BEJ
EXAMINATION DATE	:	JULY 2024
DURATION	:	3 HOURS
INSTRUCTIONS	:	1. ANSWER ALL QUESTIONS 2. THIS FINAL EXAMINATION IS CONDUCTED VIA ☐ Open book ☒ 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 **EIGHT (8)** PAGES

Q1 Consider the superframe structure of IEEE 802.15.4 protocol, shown in **Figure Q1.1**.

(a) State the differences between Full Function Device (FFD) and Reduce Function Device (RFD).

(4 marks)

(b) Differentiate between beacon enabled and non-beacon enabled operation.

(4 marks)

(c) Describe the operation in the Contention Access Period (CAP) and Contention Free Period (CFP)

(4 marks)

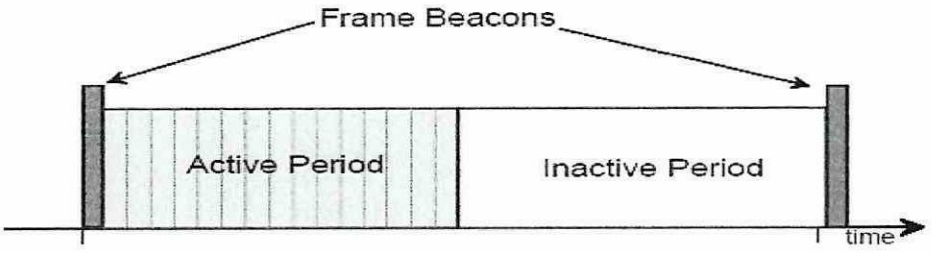


Figure Q1.1 Superframe of IEEE802.15.4

Q2 The main design goals of WSNs is to carry out data communication while trying to prolong the lifetime of the network and prevent connectivity degradation. Designing routing protocols for Wireless Sensor Networks (WSNs) presents several challenges due to the unique characteristics and constraints of these networks.

(a) State **THREE (3)** design issues related to routing protocol in WSN.

(3 marks)

(b) Differentiate between flat routing protocol and hierarchical routing protocol.

(4 marks)

(c) Explain operation of Low-energy Adaptive Clustering Hierarchy (LEACH) and Threshold-Sensitive Energy Efficient Protocols (TEEN).

(6 marks)

Q3 Clustering is the most preferred networking technique to manage large number of sensor nodes in a hierarchical system of wireless sensor network. It has various benefits and consists of two types of nodes; ordinary nodes and cluster head.

(a) Describe how cluster heads are chosen.

(2 marks)

(b) State **TWO (2)** advantages of clustering as regards to the architecture of the wireless sensor network.

(2 marks)

(c) Consider a wireless sensor network shown in **Figure Q3.1**. The sources of energy consumption come from the nodes and cluster heads activities given in **Table Q3.1.**

Table Q3.1 Source of energy consumption

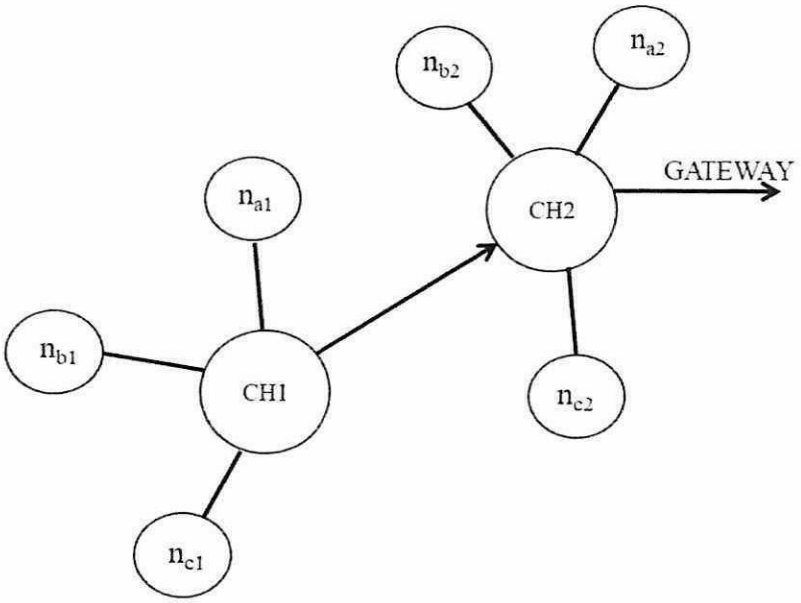
Ordinary Nodes	Cluster Heads
1. Sensing	1. Receiving
2. Transmitting	2. Transmitting

Assume the free space fading as the propagation model with exponent 2, the sensing number of bits is 10 bits and the weighting factor for transmitting and receiving only as $\{h_2\} = \{1.2\}$. Derive the total energy model for this wireless sensor network.

(18 marks)

(d) Using the values given in **Table Q3.2 in Appendix A,** differentiate the energy consumed in an ordinary node and in a cluster head

(3 marks)



CH1- child clusterhead CH2- parent clusterhead

Figure Q3.1 Clustered WSN

Q4 Routing 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 Q4.1** 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)

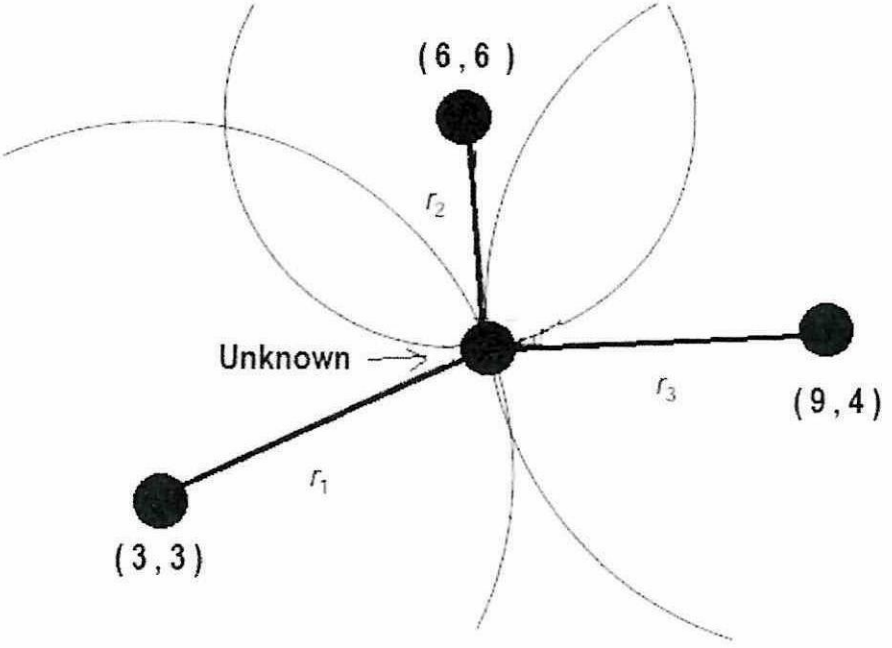


Figure Q4.1 Position of anchor nodes and an unknown node.

Q5 (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 -

APPENDIX A

Table Q3.2 Variables of WSN

SYMBOL	DESCRIPTION	VALUE
N_{cyc}	Number of clock cycles per task	0.97×10^6
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

APPENDIX B

Formula

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

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

$\boldsymbol{E_{proN}(b_1, N_{cyc})}$ = 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)

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