UNIVERSITI TUN HUSSEIN ONN MALAYSIA

FINAL EXAMINATION
SEMESTER II
SESSION 2016/2017

COURSE NAME	:	WIRELESS SENSOR AND MOBILE AD HOC NETWORKS
COURSE CODE	:	BEB 42003
PROGRAMME	:	BEJ
EXAMINATION DATE	:	JUNE 2017
DURATION	:	3 HOURS
INSTRUCTION	:	ANSWER **FOUR (4)** QUESTIONS ONLY

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

Q1 In the implementation of wireless sensor networks within a large geographical area, clustering is the most preferred networking architecture, due to its various benefits.

(a) State **FIVE (5)** advantages of clustering as regards to the architecture of the wireless sensor networks.

(5 marks)

(b) Consider a wireless sensor network shown in **Figure Q1(b).** Let the sources of energy consumption come from the following node and cluster head activities,

node : sensing and transmitting,
cluster head: receiving and transmitting.

Assume the free space fading as the propagation model, the sensing number of bits ia 12 bits and the weighting factor for transmitting and receiving only as $\{ h_2 \} = \{1.3\}$. Derive the total energy model for this wireless sensor networks.

(14 marks)

(c) Using the values given in **Table Q1(c)** differentiate the energy consumed in a node and in a cluster head. Show the total energy consumption of the network.

(6 marks)

Q2 Localization is one of the most important issues in wireless sensor networks.

(a) Deduce the mechanism whereby the Received Signal Strength Indicator (RSSI) is to be used 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 determine the coordinate of the unknown node (x_u, y_u).

(10 marks)

(ii) **Figure Q2(b)** shows three anchors of known positions and a node of unknown location. If the distances r_1, r_2 and r_3 are given as $\sqrt{10}$, 2 and 3 units respectively, deduce the coordinate of the unknown node.

(7 marks)

Q3 (a) Explain why time synchronization needed in a WSN by stating **THREE(3)** good examples.

(9 marks)

(b) Differentiate between external and internal time synchronization and discuss **ONE(1)** good example for each type of synchronization.

(6 marks)

(c) Node X sends a synchronization request to node Y at 3250 ticks (on node X's clock). At 3350 ticks, node X receives the reply from node Y with a timestamp of 3220 ticks.

(i) Calculate the node X's clock offset with respect to the time at node Y (you can ignore any processing delays at either node).

(4 marks)

(ii) Determine whether node X's clock is too slow or too fast.

(3 marks)

(iii) Explain, one approach how node X adjust the clock.

(3 marks)

Q4 AODV is a well known protocol for mobile ad hoc network. It consists of a number of sub-protocols namely, route discovery, route maintenance and packet transmission.

(a) Explain the function of RREQ (Route Request Packet) and Route Reply Packet (RREP) with regard to the AODV protocol at the source node, intermediate node and at the destination node.

(6 marks)

(b) Produce the flowchart related to the route discovery protocol of the AODV. Elaborate briefly on all the elements of the flowchart.

(6 marks)

(c) Consider a network of mobile nodes arranged in a grid formation as shown in **Figure Q4(c)**, running on AODV protocol. Assume that the nodes are

static. The networking area is given as 800 m by 600 m. The transmission range is set as 200 m. Two nodes in the vertical and horizontal location are within the communication range, but not the nodes that are in diagonal to each other. Calculate the total number of overhead packets that are generated for the successful of route discovery. You may consider additional coverage $C_1 = 0.41$, $C_2 = 0.19$, $C_3 = 0.09$ and $C_4 = 0.05$.

(13 marks)

Q5 (a) Consider the system of mobile ad hoc network of **Figure Q5(a)** which consists of two nodes, n_1 and n_2. Node n_1 is stationary and node n_2 is mobile. The concentric circle around n_1 is the maximum transmission range of node n_1. Discuss the following scenarios in terms of the node connectivity time between n_1 and n_2.

(i) increasing the angle of arrival.

(ii) increasing the velocity of node n_2.

(6 marks)

(b) Consider two nodes, one stationary and the other moves at a certain velocity into the transmission range of the stationary node. The node transmission range is 150 m. The mean node connectivity time ($\overline{T}_{NCT}$) is defined as the average time a node is within the transmission range of the other node, where during this period they are fully connected. The mean node connectivity time depends on its probability density function (pdf), which is given as,

$$f_{NCT}(t) = \frac{4R}{\pi . V_m} \cdot \frac{1}{t^2} \cdot \left[1 - \sqrt{1 - \left(\frac{V_m t}{2R} \right)^2} \right] \quad \text{where} \quad 0 \le t \le \frac{2R}{V_m}.$$

(i) Derive the expected mean node connectivity time for the two nodes operation.

(11 marks)

(ii) For a given average velocity of 8 m/s, 12 m/s, 18 m/s and 24 m/s, calculate the corresponding mean node connectivity time.

(8 marks)

- END OF QUESTIONS -

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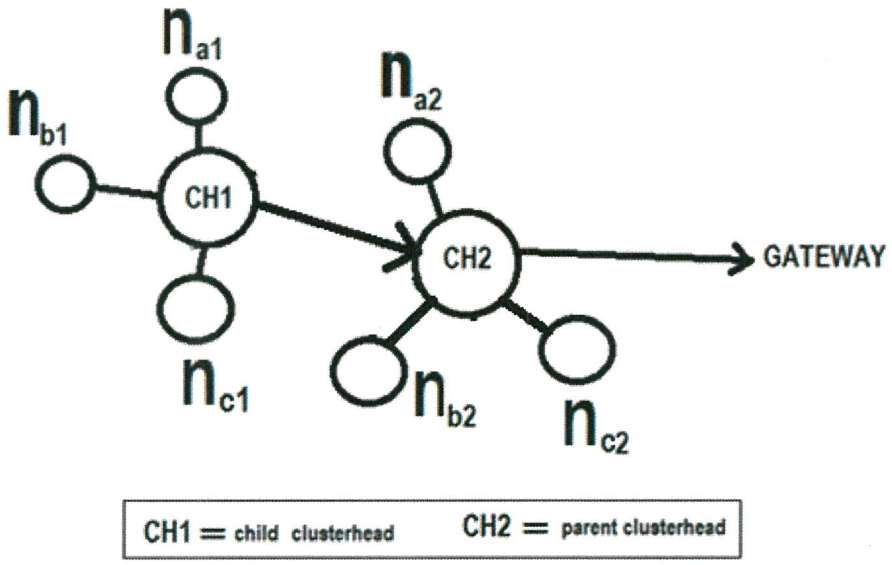

Figure Q1(b)

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Table Q1(c)

SYMBOL	DESCRIPTION	VALUE
N_{cyc}	Number of clock cycles per task	0.97 x 10^6.
C_{avg}	Average capacitance switch per cycle	22pF
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/m^2
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_{sens}	Time duration: sensor node sensing	0.5 mS
I_{sens}	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
E_{actu}	Energy dissipation: actuation	0.02 mJ

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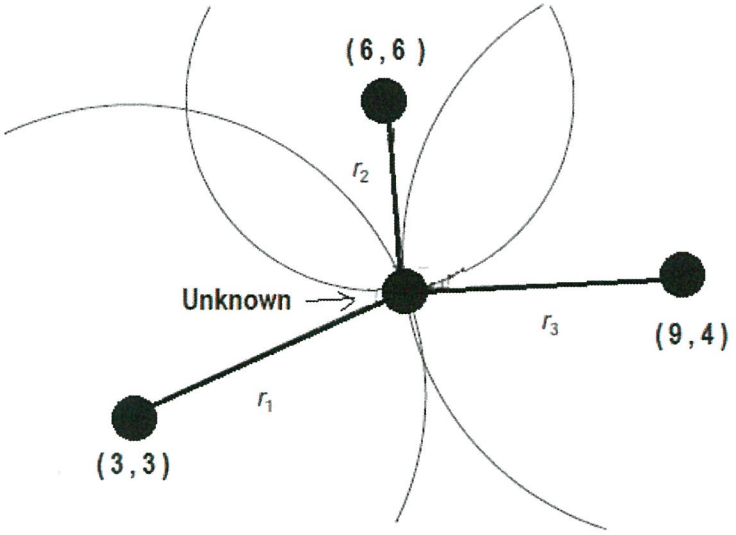

Figure Q2(b)

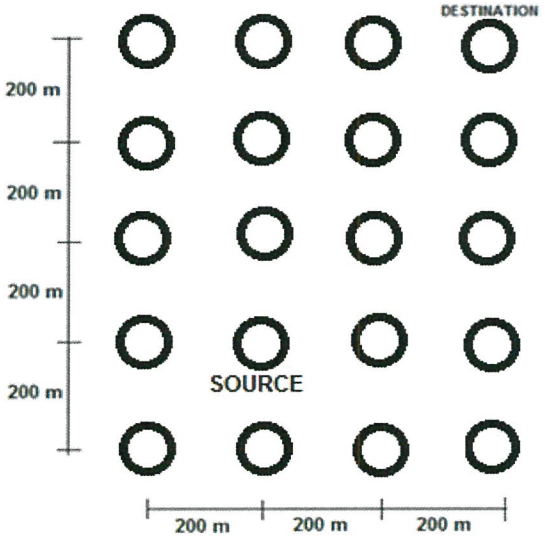

Figure Q4(c)

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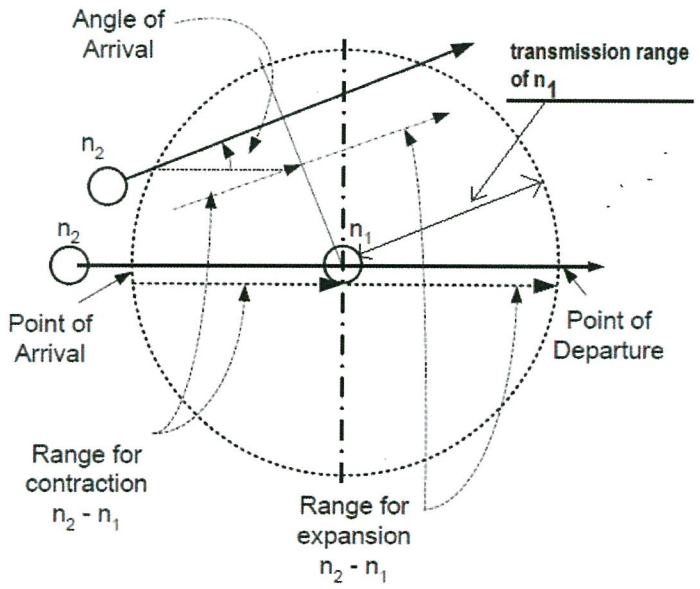

Figure Q5(a)