Universiti Tun Hussein Onn Malaysia

UNIVERSITI TUN HUSSEIN ONN MALAYSIA

FINAL EXAMINATION
SEMESTER I
SESSION 2018/2019

COURSE NAME	:	WIRELESS SENSOR AND MOBILE AD HOC NETWORKS
COURSE CODE	:	BEB 42003
PROGRAMME	:	BEJ
EXAMINATION DATE	:	DECEMBER 2018/ JANUARY 2019
DURATION	:	3 HOURS
INSTRUCTION	:	ANSWER **TWO (2)** QUESTIONS FROM **SECTION A** AND **TWO (2)** QUESTIONS FROM **SECTION B** ONLY

THIS PAPER CONSISTS OF **NINE (9)** PAGES

SECTION A : ANSWER TWO(2) QUESTIONS ONLY

Q1 Clustering is the most preferred networking technique to manage large number of sensor nodes in a monitoring environment.

(a) (i) Describe **THREE** (3) advantages of clustering techniques.

(6 marks)

(ii) Differentiate between cluster head and ordinary node in a clustering networking environment.

(4 marks)

(b) Consider a system of wireless sensor network operating as clusters utilizing LEACH protocol. Describe in detail the operation of LEACH protocol.

(15 marks)

Q2 Consider the IEEE 802.15.4 protocol, where its frame sequence is shown in **Figure Q2**. The following assumptions are made: that is no collision, no packet lost, sending node has always sufficient packet to send, BER is zero, non-beacon enabled, only one sender and one receiver operating within a short distance.

(a) Describe the following term as regards to the IEEE802.15.4 protocol.

(i) Throughput

(3 marks)

(ii) Bandwidth efficiency

(3 marks)

(iii) Delay

(3 marks)

(b) Show the mathematical expression for the throughput of the IEEE802.15.4 protocol in terms of overall delay. Define all the terms used.

(4 marks)

(c) Analyze the throughput of the IEEE802.15.4 for the operating frequencies of 868 MHz and 2.4 GHz with the following parameters: payload of 100 bytes with the length of MAC address as 32 bit. You may need all the information from **Table Q2(c)(i)**, **Table Q2(c)(ii)** and **Table Q2(c)(iii)**. Assume that no acknowledgement is included.

(12 marks)

Q3 Power consumption is the main concern in the sensor node and thus the whole setup of wireless sensor network.

(a) State **FIVE** (5) sources of power consumption in the sensor node

(5 marks)

(b) Determine the efficiency criteria of switching between operating modes of the sensor so as to reduce energy consumption.

(5 marks)

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

Types of Node	Sources of Energy Consumption
Ordinary Node	Sensing and Transmitting
Cluster Head	Receiving and Transmitting

Assume the free space fading as the propagation model with exponent 2, the number of sensing bit is 10 and the weighting factor for transmitting and receiving only is $\{ h_2 \} = \{1.4\}$. Derive the total energy model for the cluster C2 only in terms of the variables concerned. The variables are shown in **Table Q3(c).**

(15 marks)

SECTION B: ANSWER TWO(2) QUESTIONS ONLY

Q4 Ad Hoc On Demand Routing (AODV) is well known protocol for mobile ad hoc network consisting of path discovery, forward path setup, reverse path setup, path table management and path maintenance.

(a) Explain the operation of path discovery for AODV protocol with regard to source node, intermediate node and destination node. Suitable flowchart may be used to describe the operation.

(16 marks)

(b) Apply the protocol to the following events and explain the outcome.

(i) the destination node moves.

(3 marks)

(ii) a node need to determine its neighbour.

(3 marks)

(iii) link failures occur

(3 marks)

Q5 Consider the IEEE 802.11 Wireless Local Area Network (WLAN) protocol, which is the most viable MAC protocol for the mobile ad hoc network.

(a) Define the Theoretical Maximum Throughput (TMT) as applied to IEEE 802.11 and state the assumptions for it to be true.

(9 marks)

(b) Consider the IEEE 802.11, with HR-DSSS MAC schemes operating at 5.5 Mbps and 11 Mbps. Evaluate the performance of CSMA/CA and RTS/CTS for a range of MSDU given as 300 bytes and 1500 bytes. The evaluations are to be done by calculating the total delay and TMT. For all the calculations, **Table Q5(b)(i)** and **Table Q5(b)(ii)** are required.

(16 marks)

Q6 Bandwidth is one of the important factors when ensuring the connectivity among the neighboring nodes in mobile ad hoc networks.

(a) Explain the term residual capacity and show its relation to maximum achievable channel capacity.

(8 marks)

(b) Consider the network as shown in **Figure Q6**. The data can flow through the node if the node offered enough bandwidth. Estimate the bandwidth available ($B_{available(I)}$) at node I and the bandwidth consumed at node I due to flow j ($B_{consumed(I,j)}$).

(17 marks)

- END OF QUESTIONS -

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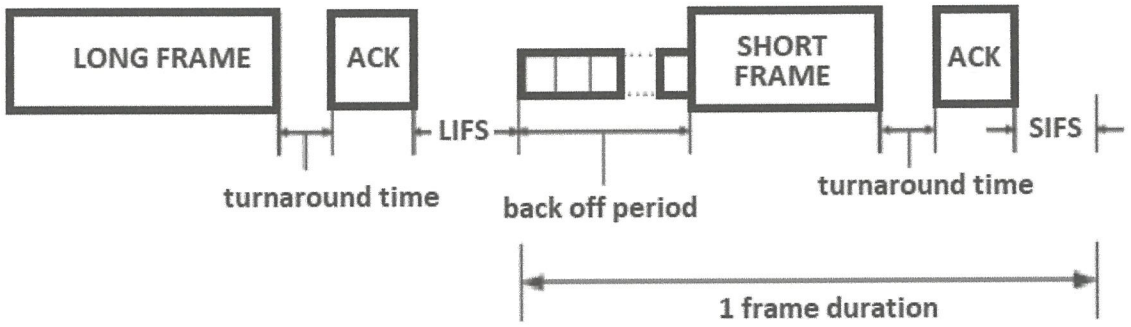

Figure Q2

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Table Q2(c)(i)
MODULATION PARAMETERS OF 802.15.4

FREQUENCY BAND	SYMBOL RATE (baud/s)	MODULATION	BIT RATE (kbps)
868.0 – 868.6 MHz	20000	BPSK	20
902 – 928.0 MHz	40000	BPSK	40
2.4 – 2.4835 GHz	62500	16-th ary Orth	250

Table Q2(c)(ii)
VALUES FOR PARAMETERS a AND b

#address bits		868 Mhz		915 MHz		2.4 GHz	
		a	b	a	b	a	b
0 bit	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 Q2(c)(iii)
MINIMUM AND MAXIMUM DELAY

#address bits		868 Mhz		915 MHz		2.4 GHz	
		Maximum bitrate (bps)	Maximum efficiency (%)	Maximum bitrate (bps)	Maximum efficiency (%)	Maximum bitrate (bps)	Maximum efficiency (%)
0 bit	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

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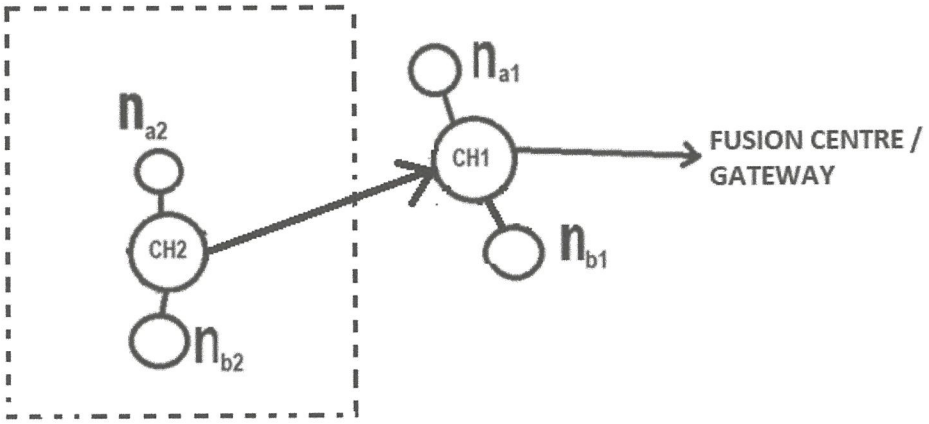

CH1 = parent cluster head
CH2 = child cluster head
n_{a1}, n_{b1} ordinary nodes connected to CH1
n_{a2}, n_{b2} ordinary nodes connected to CH2

Figure Q3

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Table Q3(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
h_1	CH weighting factor, for processing	1.2
h_2	CH weighting factor, for transmission and receiving.	1.4
h_3	CH weighting factor, for sensing	1.6
h_4	CH weighting factor, for sensor logging	1.8

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Table Q5(b)(i)

Delay components for different MAC schemes and spread spectrum techniques

Scheme	Constant and varying delay components (10^{-6} s)						
	T_{DIFS}	T_{SIFS}	T_{BO}	T_{RTS}	T_{CTS}	T_{ACK}	T_{DATA}
CSMA/CA							
HR-DSSS-5.5	50	10	310	NA	NA	304	192+8×(34+MSDU)/5.5
HR-DSSS-11	50	10	310	NA	NA	304	192+8×(34+MSDU)/11
RTS/CTS							
HR-DSSS-5.5	50	10×3	310	352	304	304	192+8×(34+MSDU)/5.5
HR-DSSS-11	50	10×3	310	352	304	304	192+8×(34+MSDU)/11

Table Q5(b)(ii)

TMT parameters for MAC schemes and spread spectrum

Scheme	Data Rate	a	b
CSMA/CA			
HR-DSSS	5.5 Mbps	1.45455	915.45
HR-DSSS	11 Mbps	0.72727	890.73
RTS/CTS			
HR-DSSS	5.5 Mbps	1.4545	1591.45
HR-DSSS	11 Mbps	0.72727	1566.73

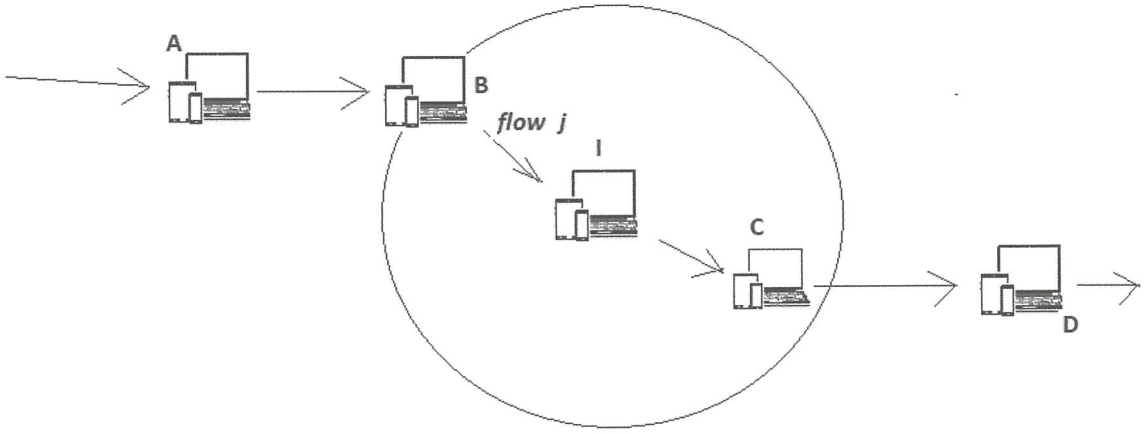

Figure Q6