B.Sc. Engg. CSE 6th Semester | 31 March 2022

ISLAMIC UNIVERSITY OF TECHNOLOGY (IUT)
ORGANISATION OF ISLAMIC COOPERATION (OIC)
Department of Computer Science and Engineering (CSE)

SEMESTER FINAL EXAMINATION | **SUMMER SEMESTER, 2020-2021**

DURATION: 3 HOURS | **FULL MARKS: 100**

CSE 4615: Wireless Networks

Programmable calculators are not allowed. Do not write anything on the question paper.

Answer **all 6 (six)** questions. Marks of each question and corresponding CO and PO are written in the right margin with brackets.

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1. a) How are the *Mobile Ad Hoc Networks (MANET)* different from *Cellular Networks*? 3.5 (CO1) (PO2)

   b) Consider an *Independent Basic Service Set (IBSS)* of ***IEEE 802.11e*** wireless LAN (WLAN) consists of three stations *(A, B, and C)*. Assume that all the stations operate in same frequency band and they can all hear each other transmissions. Consider the *RTS/CTS* transmission is enabled in this scenario. 14.5 (CO3) (PO1)

   Each of the stations of this WLAN maintains two *Access Categories (AC)* labeled as *AC_HP* and *AC_LP* and thus two backoff entities exist in every IEEE 802.11e compliant stations. Note here that, the *AC_HP* and *AC_LP* serve the high priority traffic and low priority traffic of the network.

   Draw a *Timeline Diagram* representing the sequence of actions for a successful retransmission from *AC_HP* of the *Station A to Station B after one data packet collision.* Note that the x-axis of the diagram shows time and y-axis shows the contending stations in *IBSS*. An action (i.e., transmission of a frame) is represented by a horizontal line where the line is placed in the same horizontal line of the station with line length representing period.

   The diagram should depict the detailed backoff procedure performed by all the stations in the *IBSS*. Minimum *Contention Window (CW) values* for two *Access Categories* are listed in Table 1. *Arbitration Interframe Space AIFS[AC]* for two *AC* are listed in Table 2.

   The size of the *CW* in backoff stage ***i***, after ***i-1*** times unsuccessful transmission is determined by the following formula.

$$CWi[AC] = min[2^i(CWmin[AC] + 1) - 1, CWmax[AC]]$$

Table 1: Minimum Contention Window *Values*

Item	***Value***
CW_{min} [*AC_HP*]	3
CW_{min} [*AC_LP*]	5

Table 2: Arbitration Interframe Space *values*

Item	***Value***
AIFS[AC_HP]	SIFS + 2 * a Slot Time
AIFS[AC_LP]	SIFS + 3 * a Slot Time

2. a) What is meant by *Routing Metric*? 2 (CO3) (PO1)

b) Consider an application that transmits data at a steady rate (for example, the sender generates an N-bit unit of data every k time units, where k is small and fixed). Also, when such an application starts, it will continue running for a relatively long period of time. Would a packet-switched network or a circuit-switched network be more appropriate for this application? Why? 4.5 (CO1) (PO2)

c) Find the path that minimizes the *Expected Transmission Time* from ***node A*** to ***node F*** in the given network topology depicted in Figure 1. Assume the default packet size in the given network is 2 *MB*. Table 3 contains the values of different link parameters. 10 (CO3) (PO1)

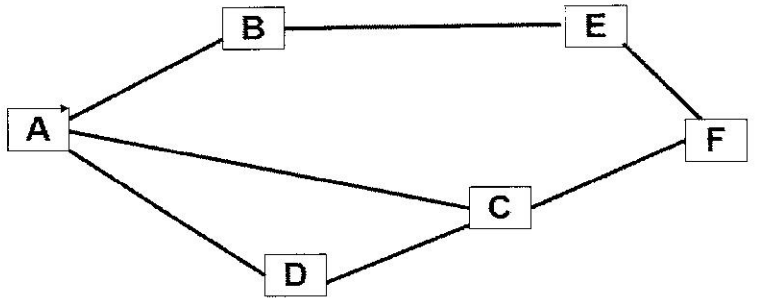

Figure 1: Network topology for question

Table 3: Network parameters for question 2.c

Link	***Forward Delivery Ratio, R_{fwd}***	***Reverse Delivery Ratio, R_{rev}***	***Link Bandidth, B MB/S***
A—B	0.85	0.92	40
A—C	0.70	0.93	42
A—D	0.92	0.87	38
B—E	0.76	0.73	30
C—F	0.88	0.90	34
D—C	0.77	0.87	36
E—F	0.88	0.66	44

3. a) Why is the ***post backoff*** used in *Distributed Coordination Function (DCF)* of the IEEE 802.11 standard? 2.5 (CO3) (PO1)

b) Clarify the fundamental concept of wastage aware routing in *Energy Harvesting Wireless Sensor Networks (EH-WSNs)*. 3.5 (CO2) (PO1)

c) Consider the sample topology for an *EH-WSN* shown in Fig. 1. Find the path that **maximizes** the **total residual network energy** for traffic generated from *node A* and destined for *node F*. Table 4 and Table 5 contain the values of different network parameters. Assume. ***B*** is the maximum battery capacity of any node and ΔT is the future period to predict the harvest and consumption. 11 (CO3) (PO1)

Table 4: Nodal energy parameters for question 3. c

Node	*Current Battery Level, E_p*	*Estimated Energy Harvest after ΔT, E_h*
A	0.90 *B*	0.15 *B*
B	0.93 *B*	0.17 *B*
C	0.77 *B*	0.21 *B*
D	0.92 *B*	0.12 *B*
E	0.89 *B*	0.20 *B*
F	0.77 *B*	0.18 *B*

Table 5: Link parameters for question 3.c

Link	*Predicted Consumption over ΔT, Ec*
A—B	0.06 *B*
A—C	0.11 *B*
A—D	0.14 *B*
B—E	0.15 *B*
C—F	0.11 *B*
D—C	0.08 *B*
E—F	0.09 *B*

4. a) Explain the necessity of Internet Standards. 2 (CO3) (PO1)

b) *Wi-Fi MultiMedia (WMM) ad hoc network* needs to maintain the priority of audio, video, and voice over other applications which are less time critical. Hence, for QoS support mechanisms in such networks, random access based *Distributed Coordination Function* at *Medium Access Control (MAC)* sublayer requires modifications. 3 (CO2) (PO2)

Mention the appropriate IEEE MAC standard as a supplement to the IEEE 802.11 standard which will support quality-of-service (QoS) in the given scenario. Justify your answer with proper arguments.

c) With the aid of a single diagram clarify the following terminologies in wireless medium. 5 (CO3) (PO1)

i. Transmission Range
ii. Detection Range
iii. Interference Range
iv. Signal to Noise Ratio (SNR)

d) Consider a packet of length L which begins at end system A and travels over three links to a destination end system. These three links are connected by two packet switches. Let d_i, s_i, and R_i denote the length, propagation speed, and the transmission rate of link i, for i = 1, 2, 3. The packet switch delays each packet by d proc. Assuming no queuing delays, in terms of d_i, s_i, R_i, $(i = 1,2,3)$, and L, formulate the necessary equations to calculate the total **end-to-end delay** for the packet? 7 (CO3) (PO1)

Suppose, the packet is 1,500 bytes, the propagation speed on all three links is 2.5 x 10^8 m/s, the transmission rates of all three links are 2 Mbps, the packet switch processing delay is 3 msec, the length of the first link is 5,000 km, the length of the second link is 4,000 km, and the length of the last link is 1,000 km. For these values, calculate the **end-to-end delay**.

5. a) With the aid of an appropriate diagram clarify the fundamental idea of Sensor MAC (S-MAC) protocol in extending the node life time in battery powered Wireless Sensor Networks (WSNs). 4 (CO3) (PO1)

b) Consider a wireless local area network (WLAN) consists of a large number of mobile nodes with fixed infrastructure. Nodes are free to move randomly as the network topology changes frequently.
The MAC sublayer does not exhibit good channel utilization and collision avoidance in such networks while Random Channel-Access Scheme is being used without any modification.

i. Now propose few modifications in Random Channel-Access Scheme to ensure better channel utilization and collision avoidance mechanism in such scenarios. 3 (CO4) (PO3)

ii. Why does the proposed solution perform better in such scenarios? Justify the claim with proper arguments. 3 (CO1) (PO2)

iii. Draw a *Timeline Diagram* representing the sequence of actions for <u>two successful transmission *and two un*successful transmissions.</u> 7 (CO3) (PO1)

The diagram should depict the detailed backoff procedure performed by all the contending nodes. Note that, the x-axis of the diagram shows time and y-axis shows the contending stations in *WLAN*. An action (i.e., transmission of a frame) is represented by a horizontal line where the line is placed in the same horizontal line of the station with line length representing period.

6. a) A *Vehicular Ad-hoc Network (VANET)* consists of groups of moving or stationary vehicles connected by a wireless network. VANET allows vehicles to communicate with the roadside equipment. Propose two promising VANET applications for developing countries. 4.5 (CO1) (PO2)

b) Consider a High data Rate Wireless Personal Area Networks (HR-WPANs) consists of fixed number of static nodes, which is used for short-range indoor and outdoor multimedia and data centric applications.
All the nodes in this network maintain synchronized clock through some synchronization function.

i. Propose one *distributed TDMA scheduling based medium access control protocol* from the state-of-the-art protocols which will be well-suited for the given network. Justify your answer with proper arguments. 2 (CO2) (PO2)

ii. With the aid of a *Timeline Diagram*, clarify the <u>schedule preparation phase</u> of the proposed protocol. 6 (CO3) (PO1)

iii. Draw a *Timeline Diagram* to demonstrate the <u>data transmission phase</u> of the proposed protocol. 2 (CO3) (PO1)

Note that the x-axis of each Timeline Diagram shows time and y-axis shows the contending stations in HR-WPANs. An action (i.e., transmission of a frame) is represented by a horizontal line where the line is placed in the same horizontal line of the station with line length representing period.