# ISLAMIC UNIVERSITY OF TECHNOLOGY (IUT)

**ORGANISATION OF ISLAMIC COOPERATION (OIC)**

## Department of Computer Science and Engineering (CSE)

**SEMESTER FINAL EXAMINATION** **SUMMER SEMESTER, 2021-2022**

**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. Figures in the right margin indicate full marks of questions whereas corresponding CO and PO are written within parentheses.

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1. a) Conduct a comparative analysis of *Bluetooth, WiMedia, ZigBee*, and *Wi-Fi* networks in brief. 4

   b) How do flow control and congestion control differ from each other? Provide appropriate example for clarification. 3

   c) Figure 1 depicts the network topology of a multi hop wireless ad hoc network. The scenario involves multiple stations (A, B, C, D, and E), each with a distinct circular transmission range surrounding it. It is assumed that all stations operate in the same frequency band, and the *RTS/CTS* transmission mechanism is disabled. The transmission interference only occurs if two stations transmit simultaneously, and their transmission areas overlap.

      i. Identify four potential cases of the *Hidden Terminal* problems in the given scenario. 2 (CO3) (PO2)

      ii. Mention 3 effective approaches to resolve the issue of *Hidden Terminal* problems. 4

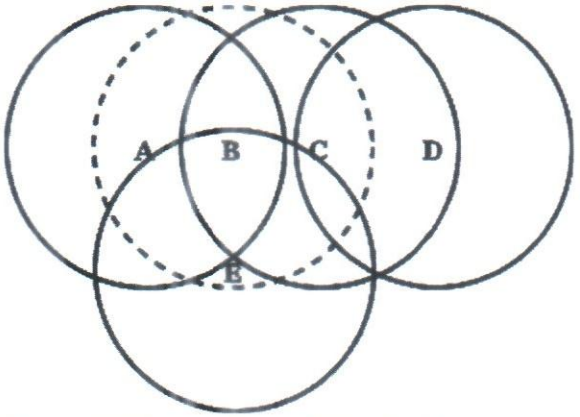


**Figure 1:** Network topology for Question 1.c)

2. a) State the reason for not using the CSMA/CA based MAC protocol for wireless sensor networks. Justify your answer with proper argument and diagram. (CO1) (PO1)

   b) The remote forests situated in the Grampians region of eastern Victoria in Australia are affected by recurring forest fires each year, resulting in the destruction of millions of acres of land. To tackle this issue, a wireless sensor network prototype based on IEEE 802.15.4 / ZigBee was developed to detect forest fires in real-time. The lack of a continuous power source for the sensor nodes is a fundamental hindrance, posing a significant challenge to prolong the network's lifetime.

i. Suggest essential guidelines for the following layers in the WSN protocol stack, the incorporation of which could significantly enhance the network's lifetime: 6 (CO3) (PO2)

- Application layer
- Network layer
- MAC sub layer
- Physical layer

ii. Explain the detailed operation of Medium Access Control from an existing research work which could significantly enhance the network's lifetime in the given scenario. Justify your answer with proper argument. 7

iii. Address the limitations and challenges associated with this proposed protocol. 2

3. a) Using the sample topology for an *Energy Harvesting Wireless Sensor Networks (EH-WSN)* as shown in Figure 2 and the values for various network parameters listed in Table 1 and Table 2, determine the route that would maximize the overall remaining energy of the network for traffic originating from node *A* and destined for node *E*. It should be assumed that the maximum battery capacity of any node is *B* and the future period for predicting harvest and consumption is $\Delta T$. 9

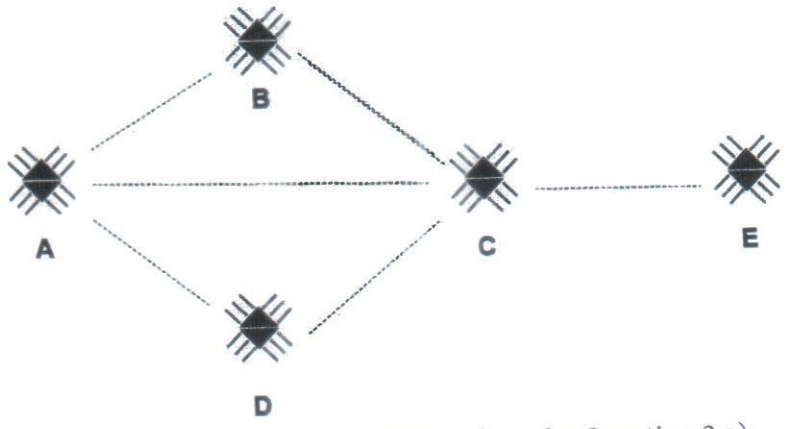


**Figure 2:** Network Topology for Question 3.a)

**Table 1:** Network Parameters of Nodes for Question 3.a)

| ***Node*** | ***Current Battery Level, $E_p$*** | ***Expected Energy Harvest over $\Delta T$, $E_h$*** |
|---|---|---|
| A | 0.90 *B* | 0.10 *B* |
| B | 0.95 *B* | 0.25 *B* |
| C | 0.80 *B* | 0.20 *B* |
| D | 0.90 *B* | 0.20 *B* |
| E | 0.79 *B* | 0.07 *B* |

**Table 2:** Network Parameters of Links for Question 3.a)

| ***Link*** | ***Expected Energy Consumption over $\Delta T$, Ec*** |
|---|---|
| A—B | 0.10 *B* |
| A—C | 0.15 *B* |
| A—D | 0.20 *B* |
| B—C | 0.15 *B* |
| C—E | 0.10 *B* |
| D—C | 0.10 *B* |

b) To transmit a high volume of data packets from a router located at IUT to a router at the University of Dhaka (DU) via a *Wireless Metropolitan Area Network* (*WMAN*), there are several potential routes to choose from. 8

Identify the path that is anticipated to have the shortest transmission time in the network topology depicted in Figure 3. Table 3 contains the values for different link parameters. The default packet size within the network is 2 MB.

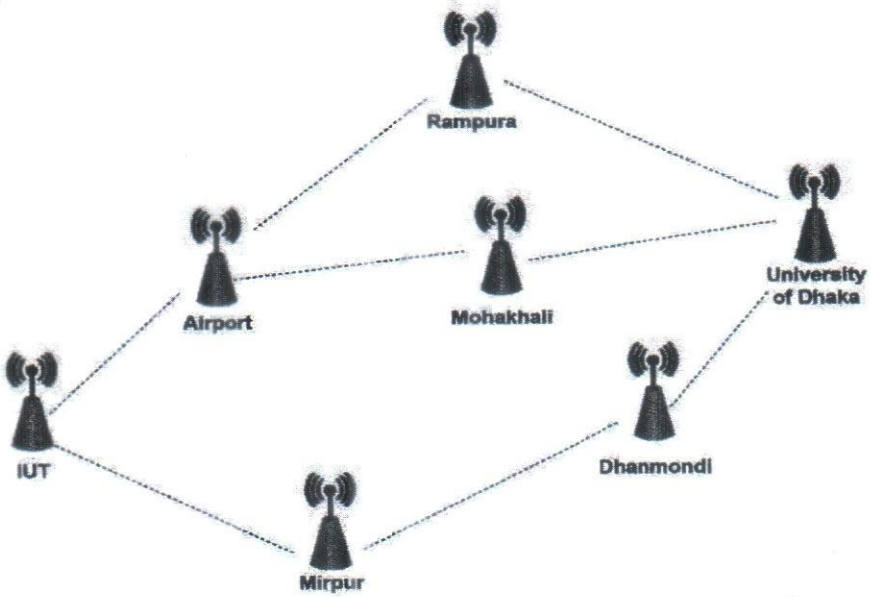


**Figure 3:** Network Topology for Question 3.b)

**Table 3:** Link Parameters for Question 3.b)

| *Link* | *Forward Delivery Ratio,* $R_{fwd}$ | *Reverse Delivery Ratio,* $R_{rev}$ | *Link Bandidth, B MB/S* |
|---|---|---|---|
| IUT—Airport | 0.85 | 0.92 | 40 |
| IUT—Mirpur | 0.70 | 0.93 | 42 |
| Airport—Rampura | 0.92 | 0.87 | 38 |
| Airport—Mohakhali | 0.76 | 0.73 | 30 |
| Mirpur—Dhanmondi | 0.88 | 0.90 | 34 |
| Rampura—DU | 0.77 | 0.87 | 36 |
| Mohakhali—DU | 0.88 | 0.66 | 44 |
| Dhanmondi—DU | 0.79 | 0.92 | 42 |

4. a) What is the reason for the poor performance of traditional *TCP* in a *wireless ad-hoc network*? 6

b) What role does a *Cognitive Radio Network* serve? 3

c) Does migrating the *Backoff* operation to the *Frequency Domain* offer any advantages?

i. Justify your answer with appropriate argument. 7 (CO2) (PO1)

ii. Enumerate the costs and benefits of implementing Frequency Domain backoff. 4

5. a) In what ways does *Orthogonal Frequency-Division Multiplexing (OFDM)* enhance capacity when contrasted with traditional *FDM*? 4

b) Consider a Basic Service Set (BSS) wireless LAN (WLAN) consisting of three stations *A*, *B*, and *C*. Assume that all the stations can all hear each other's transmission and employ

*Perfect Coordination (PC)* protocol to prepare *TDMA* schedules in a completely distributed way.

i. Draw a Timeline Diagram representing the sequence of actions for two successful transmissions of MSDU (MAC Service Data Unit) from Station *B* to Station *C*. The diagram should depict the detailed backoff procedure conducted by all the stations. Note that, the x-axis of the diagram should show time and y-axis should show one horizontal line for each of the contending stations. 8

ii. Outline the advantages and disadvantages of this protocol. 2

6. a) State the core research goal in Energy Harvesting Wireless Sensor Networks (EH-WSN). 2

b) The degradation of throughput in Wireless Ad-hoc Networks is primarily caused by collisions. The existing contention mechanism employed in IEEE 802.11 networks called CSMA/CA depends on a fully decentralized random backoff, which is incapable of eradicating collisions. Consequently, network throughput is degraded as more contenders seek to access the channel.

To resolve these situations, the current contention mechanism must be modified to produce a collision-free schedule that is fully decentralized, simple, and cost-effective.

i. Identify an existing contention mechanism from state-of-the-art research works that satisfies our requirements. 2

ii. What is the key idea by which a collision-free schedule is generated in fully decentralized and cost-effective way? 6

iii. What are the constraints associated with this mechanism? 2

iv. Propose any required adjustments that could be made to incorporate the Quality of Service (QoS) characteristic in this context. 4 (CO4) (PO1)