National University of Computer and Emerging Sciences, Lahore Campus

	Course Name:	**Introduction to the Internet of Things**	**Course Code:**	**IO4041**
	Degree Program:	**BS (CS)**	**Semester:**	**Spring 2023**
	Exam Duration:	**60 Minutes**	**Total Marks:**	**35**
	Paper Date:	**10-Apr-2023**	**Weight**	**15%**
	Section:	**ALL**	**Page(s):**	**4**
	Exam Type:	**Mid-II**		

Name:_____ **Roll No.**_____ **Section:**_____

Instruction/Notes: • Answer all the question on separately provided answer book.

Question 1: Answer the following multiple-choice questions by filling the following table. Cutting and overwriting is not allowed. **[1 x 6 = 6]**

Any answers outside the table will NOT be marked.

1.1	B	**1.4**	B
1.2	D	**1.5**	A
1.3	D	**1.6**	D

1.1. Suppose there are four routers between a source host and a destination host. Ignoring fragmentation, an IP datagram successfully sent from the source host to the destination host will travel over how many interfaces?

A. 6 B. 10 C. 8 D.4

1.2. Hop-by-hop options header if present in IPv6 extended headers, then it should be placed after ----------.

A. routing options header B. authentication options header

C. upper layer header D. IPv6 base header

1.3. ------- is the correct combination of true and false for following statements: (i) IEEE 802.15.4 standard defines MAC layer and network layer functionality, (ii) The header size is variable in both IPv4 and IPv6.

A. true, true B. true, false C. false, true D. false, false

1.4. ------- is the correct combination of true and false for following statements: (i) IEEE 802.15.4 network supports 3 kinds of roles for devices, (ii) 6LoWPAN implements an adoption layer to support transmission of IPv6 packets over IEEE 802.15.4 links.

A. true, false B. true, true C. false, true D. false, false

1.5. Which protocol is used to link all the devices in the IoT?

A. TCP/IP B. UDP C. HTTP D. CoAP

1.6. The optimization objectives of routing includes _____

A. Minimizing the energy B. minimizing the latency C. satisfying the constraints D. All of these

Question 2: Answer the following questions? Avoid unnecessary details. **[6 x 2 = 12]**

(A) Fragmentation field is omitted in main header of IPv6 compared to IPv4. When an IPv6 datagram of more than 300 bytes needs to be sent over an IEEE 802.15.4 link, then how this datagram can be transmitted through this link in the absence of any fragmentation related fields in IPv6 base header?

Answer: Through provision of fragmentation header option in IPv6 extended header part.

(B) What is the purpose of Route Discovery mechanism in Dynamic Source Routing (DSR)? Does DSR require periodic packets of any kind?

Answer:

Route Discovery is the mechanism by which a node S wishing to send a packet to a destination node D obtains a source route to D.

No, DSR does not require periodic packets of any kind.

(C) The corporate network of XYZ Company comprises of about 75,000 machines that simultaneously access the Internet using port-based NAT. Suppose that intensive Web surfing is done on these machines. What problem could arise if the machines are hidden behind a single IP address?
Answer: NAT box would run out of port numbers

(D) How do you correctly compress the following IPv6 address: 2001:0db8:0000:0000:b450:0000:0000:00b4
Moreover, write the compressed form of this address.
Answer: We can compress the given IPv6 address by removing any leading zeros in each block of 16-bits. Note that we can use double colons (::) to show consecutive blocks of all zeros but only once in IPv6 address.

Compressed form of the given address: 2001:db8::b450:0:0:b4

(E) What are the two major benefits of route cache in Dynamic Source Routing?

Answer: Firstly, route cache can speed up route discovery. Secondly, it can reduce the propagation of route requests.

(F) In the context of DODAG formation in RPL routing, DIO is normally broadcasted. Is there any situation when it can be sent as a unicast? Can a node be part of 2 DODAGs in the same RPL Instance?

Answer: DIO is sent as unicast in response to DIS message from a node who wants to join DODAG.
No, it cannot be part of 2 DODAGs in the same RPL instance.

Question 3: Suppose an IPv6 datagram of 1310 bytes is required to be sent over a links with MTU of 258 bytes. This transmission requires fragmentation. The datagram includes IPv6 base header, a 30-byte unfragmentable hop-by-hop option header, and two fragmentable headers of 20 bytes each. In this case, TCP is used as upper layer protocol and TCP header does not include any option header. Note that in each fragment, the unfragmentable part is followed by an 8-byte fragment header. Keeping in view this scenario, answer the following questions. **[2 x 5= 10]**

(A) How many fragments will be needed? Show necessary calculations in support of your answer:

Answer: 8 fragments

Calculations:

original datagram size= 1310 bytes

Unfragmentable part to be present in each fragment: IPv6 base header + hop-by-hop options header.

40 + 30 = 70 bytes

Fragmentable part in the datagram: 1310 – 70 = 1240 bytes (including fragmentable extended headers)

Fragment header in each fragment = 8 bytes

So, each fragment will have 78 necessary bytes and only 180 bytes are left for carrying fragmentable data of 1240 bytes. 180 is not an exact multiple of 8, so each fragment except the last one can carry at most 176 bytes of fragmentable part.

We need 8 fragments.

First fragment: 40 (BH) + 30 (EUFH) + 8 (FH)+ 40 (EFHs)+136 (upper layer) = 254 bytes

2nd to 7th fragments: 40 (BH) + 30 (EUFH) + 8 (FH)+ 176 (upper layer) = 254 bytes

Last (8th fragment): 40 (BH) + 30 (EUFH) + 8 (FH)+ 8 (upper layer) = 86 bytes

(B) How many bytes of fragmentable part will be carried by the first and last fragment?

Answer: 176 bytes, 8 bytes

(C) How many bytes of upper layer data excluding TCP header are present in the first and last fragment?

Answer: First fragment: 116 bytes, last fragment: 8 bytes

(D) How many bytes of fragmentable extended header(s) will be present in the first and last fragment?

Answer: 40 bytes, 0 bytes

(E) How many bytes of overhead will be added because of fragmentation?

Answer: Original IPv6 datagram size: 1310

Overhead: Base header + unfragmentable header in all fragments except last + fragment header in all fragments = 7* (40 + 30) + 8 * 8 = 7 * 70 + 64 = 490 + 64 = 554 bytes

Question 4: The diagram given below shows various routes from source node **T** to **sink** node. In the diagram, PL represents the available power level of the node while ER is the energy requirement to transmit a data packet and ETX is the expected transmission count of the given link. If ETX of any link is not provided in the diagram, then consider its value as 1. Moreover, assume that the link between J and G is of bad quality.
You are required to answer the following considering the various available routes as per the diagram: **[5+2 =7]**

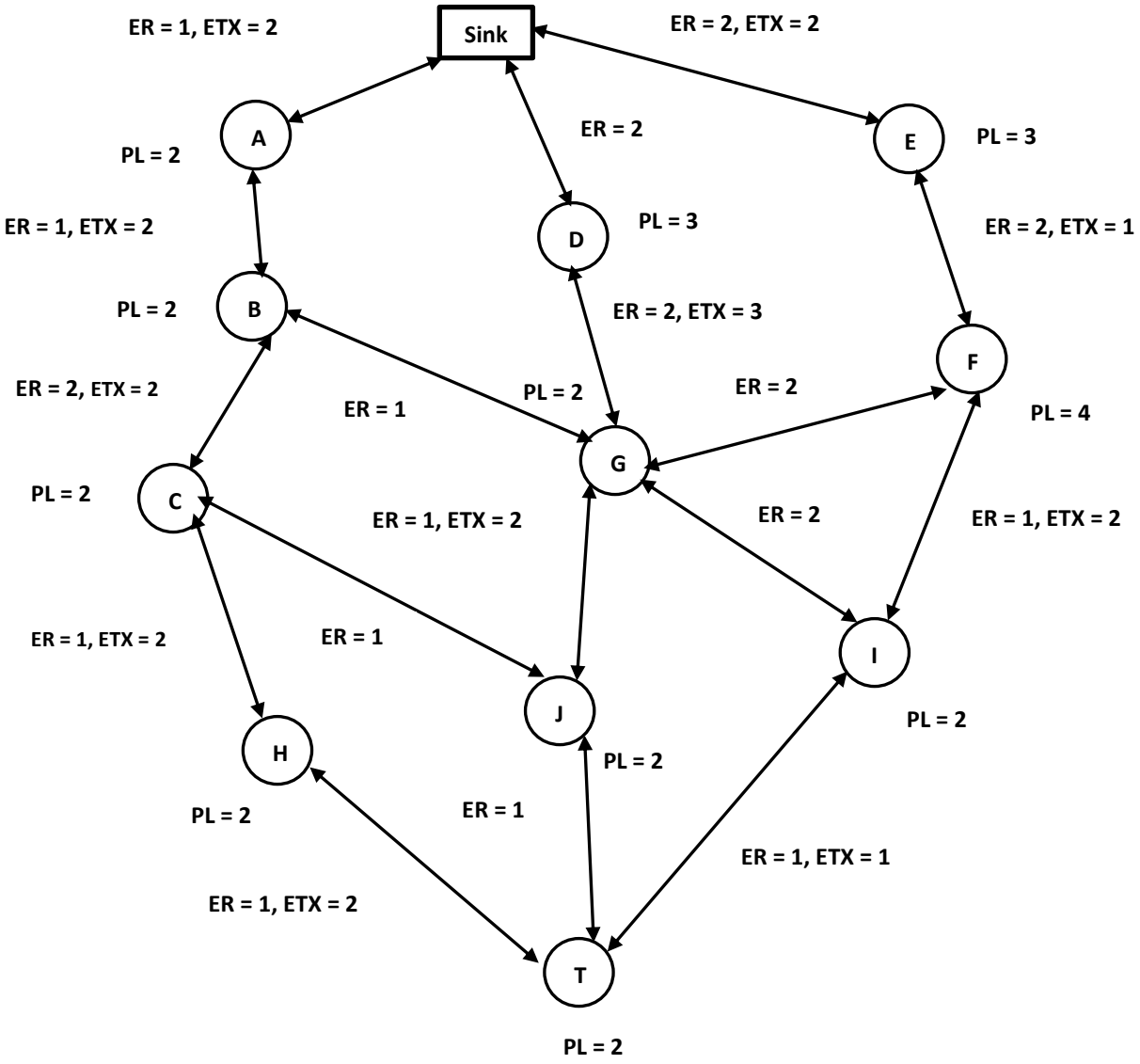
(A) Among the available paths from source node **T** to **sink** node, find and write the best path with minimum energy requirement (ER) avoiding bad quality link(s)? If multiple paths (more than one) fulfil the given objective function, then write all such paths and then select the best path with maximum available power level at the nodes. If there is still a tie, then reliability of the links will be considered to decide the best path.

Answer: The following 4 paths exist with the same amount of energy requirement: T-H-C-B-A-Sink [ER= 6], T-J-C-B-A-Sink [ER= 6], T-I-G-B-A-Sink [ER= 6], T-I-F-E-Sink [ER= 6]

Moreover, first three paths have the same power level i.e., 10 while the 4th path (T-I-F-E-A-Sink) has highest available power level i.e., 11, so this is the best path w.r.t. maximum available power level as OF.

(B) Among the available paths from source node **T** to **sink** node, find and write the best path with minimum energy requirement (ER)?

Answer: T-J-G-B-A-Sink [ER is equal to 5]


Sink
A
B
C
D
E
F
G
H
I
J
T
ER = 1, ETX = 2
ER = 2, ETX = 2
ER = 2
PL = 2
PL = 3
ER = 1, ETX = 2
PL = 3
ER = 2, ETX = 1
PL = 2
ER = 2, ETX = 3
ER = 2, ETX = 2
ER = 1
PL = 2
ER = 2
PL = 4
PL = 2
ER = 1, ETX = 2
ER = 2
ER = 1, ETX = 2
ER = 1, ETX = 2
ER = 1
PL = 2
PL = 2
ER = 1
PL = 2
ER = 1, ETX = 1
ER = 1, ETX = 2
PL = 2