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 2022**
	Exam Duration:	**60 Minutes**	**Total Marks:**	**35**
	Paper Date:	**7-May-2022**	**Weight**	**13%**
	Section:	**ALL**	**Page(s):**	**6 pages**
	Exam Type:	**Mid-1I**		

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

Instruction/Notes:
- Attempt all questions on the provided question paper.
- Space for rough work is provided at the end of the paper.
- Even if you do use rough sheets, they should NOT be attached with final paper.

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

Any answers outside the table will NOT be marked.

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

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

A. 6 B. 3 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) ZigBee provides the most power-efficient and the most cost-efficient solution compared to Bluetooth and IEEE 802.11b.

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 802.11b links.

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

1.5. The broadcast address for the network 10.88.0.0 with a subnet mask of 255.255.0.0 is ----------.

A. 10.88.255.254 B. 10.88.255.255
C. 10.88.0.0 D. 10.88.0.255

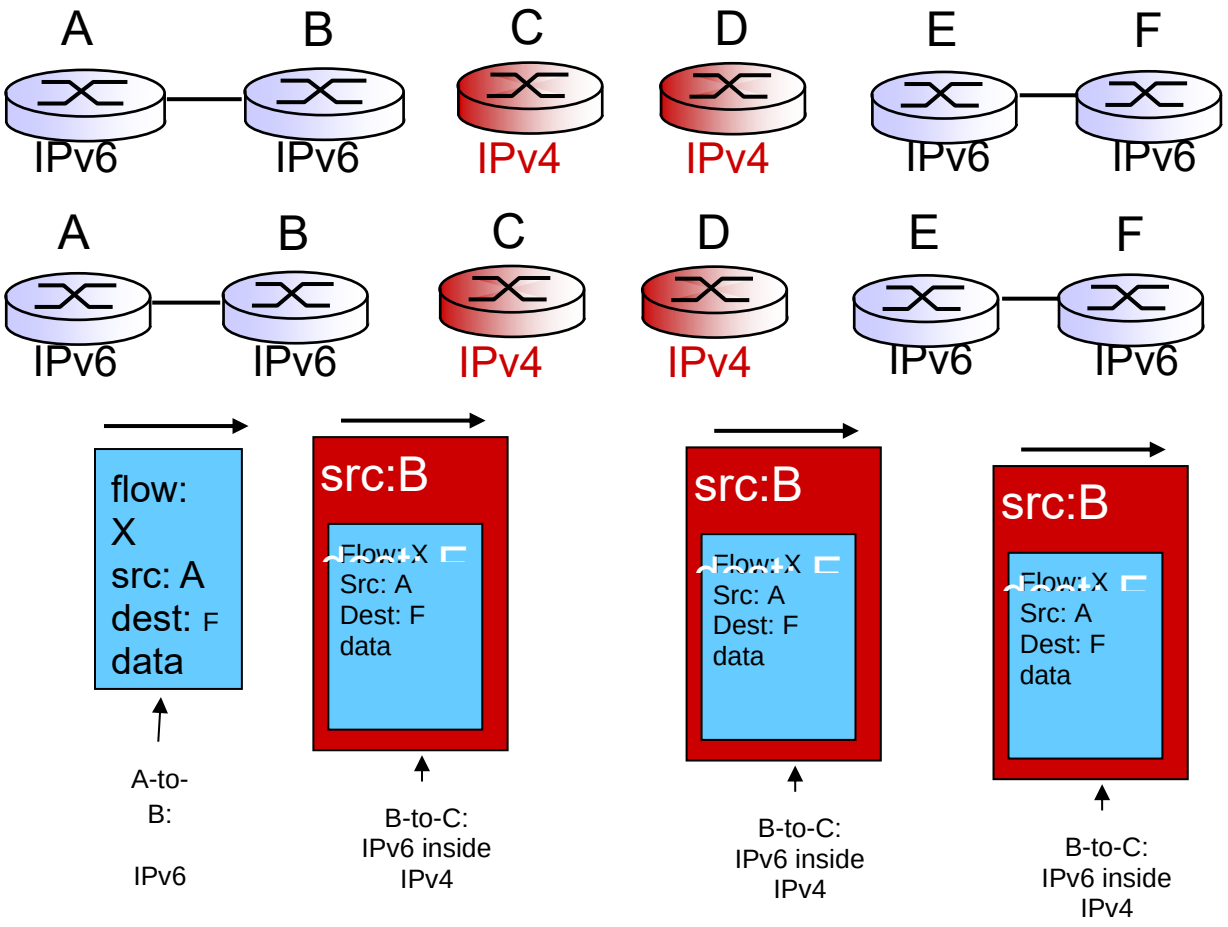
1.6 Which of the following follows request response model?

A. CoAP B. MQTT C. HTTP D. both CoAP and HTTP

Question 2: Answer the following questions: **[2+ 2+2+2+2= 10 Marks]**

(A) We know that IPv6 is the new network protocol and in future most networks will migrate to IPv6 however IPv4 will still be used in many networks. This raises the problem of integrating networks that are using different protocols. One of the solutions is tunneling mechanisms: IPv4 tunnels for IPv6 address. Explain this tunneling mechanism with the help of an example.

Answers: **Tunneling allows IPv6 datagram to be carried as *payload* in IPv4 datagram among IPv4 routers.**



In fact, IPv4 tunnel connect IPv6 routers. IPv6 routers at one end or tunnel encapsulates IPv6 packet inside IPv4 header and forwards onward through IPv4 tunnel while IPv6 router at other end of the tunnel decapsulates the same.

(B) 6LowPAN is basically an adoption layer. What does that mean? Why it is intended for Internet of Things?

Answers: 6LoWPAN implements an adaptation layer between network and data link layers to support transmission of IPv6 packets over LoWPAN. A LoWPAN is composed of devices conforming to the **IEEE 802.15.4 standard.**

Since IPv6 mandates supporting links with an MTU (of 1280 bytes, so it was necessary for IEEE 802.15.4 links that have an MTU of 127 bytes to specify an **adaptation layer below IP** which is responsible for handling packet fragmentation and reassembly

(C) Describe the concept of network congestion. What are the two major problems caused by congestion?

Answer:

Network congestion can be observed when the generated traffic load in a network gets close to the network capacity or when the queuing and storing capacities of nodes are exceeded.

Two problems caused by congestion are packet collisions and full packet buffers, both leading to packet losses and increased delays.

(D) Differentiate between conformable and non-conformable messages in the context of Constrained Application Protocol (CoAP).

Answer:

A confirmable CoAP message, indicated by setting the confirmable flag in outgoing CoAP messages, requires the destination endpoint to reply with an acknowledgment (ACK). On the other hand, if no end-to-end reliability is required by the application non-confirmable messages, which do not require an end-to-end ACK, may be used.

(E) In many ZigBee applications, the device spends most of its time in sleep mode (power saving mode). What is the rationale behind this?

Answer:

In many ZigBee applications, the device spends most of its time in a power-saving mode, also known as sleep mode because the total time the wireless device is engaged in any type of activity is very limited. Therefore, ZigBee enabled devices are capable of being operational for several years before their batteries need to be replaced.

Question 3: Answer the following questions: **[2+ 2+2+2+2+3= 13 Marks]**

(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 considering the fact that IPv6 base header does not contain any fragmentation related fields?

Answers:

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

(B) Suppose an application generates chunks of 120 bytes of data every 30 msec, and each chunk gets encapsulated in a TCP segment and then an IP datagram (without any options in both). What percentage of each datagram will be overhead, and what percentage of each datagram will be application data?

Answers:

The size of chunks generated = 120 bytes

The size of the TCP (Transmission Control Protocol) header = 20 bytes

The size of the IP header = 20 bytes

Total size of the header = TCP header + IP header = 40 bytes

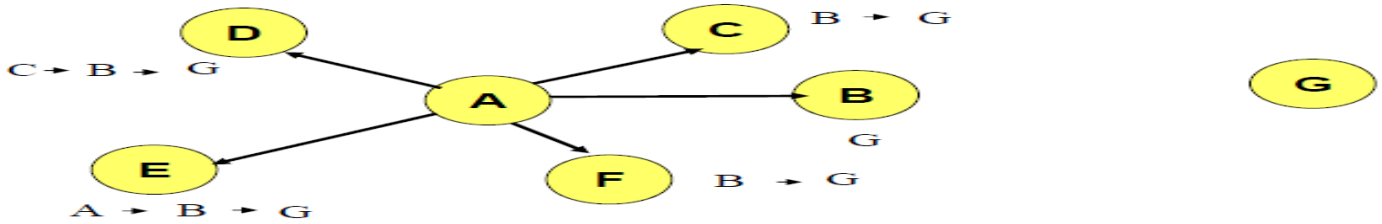
Total size of the datagram = 120 + 40 = 160 bytes

Percentage of overhead in datagram = (40/160) * 100 = 25%

Percentage of application data: (120/160) * 100 = 75%

(C) Describe the route reply storm problem with the help of an example in the context of Dynamic source routing. Moreover, what is the solution to prevent RREP storm?

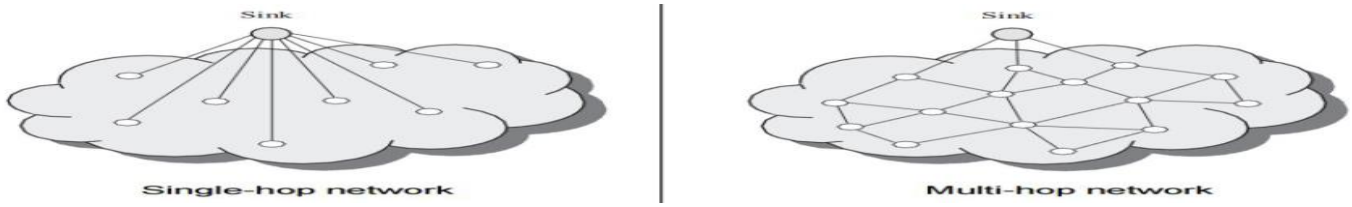
Answer: Using route cache, nodes can reply to RREQ, if they have the route. When A sends the RREQ, B, C, D, E, F (all have A's route request to destination G) can respond at the same time using their route caches because they all received the A's RREQ to destination G at the same time. Simultaneous replies from B, C, D, E, F can cause collision at A (i.e., route reply storm can occur).



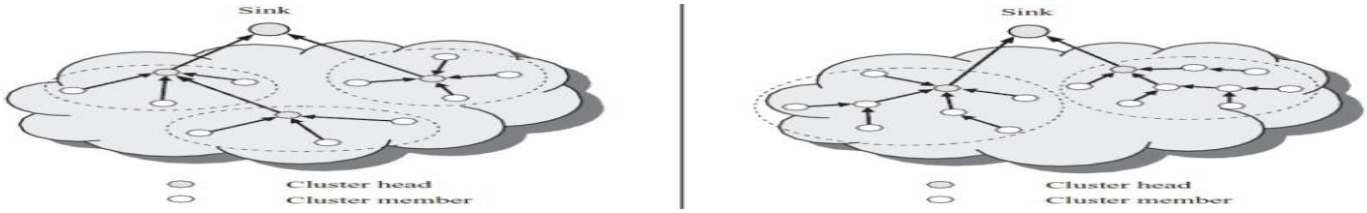
Solution to prevent Reply Storm: Each node should randomly delay the sending of RREP

(D) Differentiate between flat architecture and hierarchical architecture with the help of suitable example(s) in the context of Wireless sensor networks.

Answer: In flat architecture, each node plays the same role in performing sensing task and all sensor nodes are peers. Example



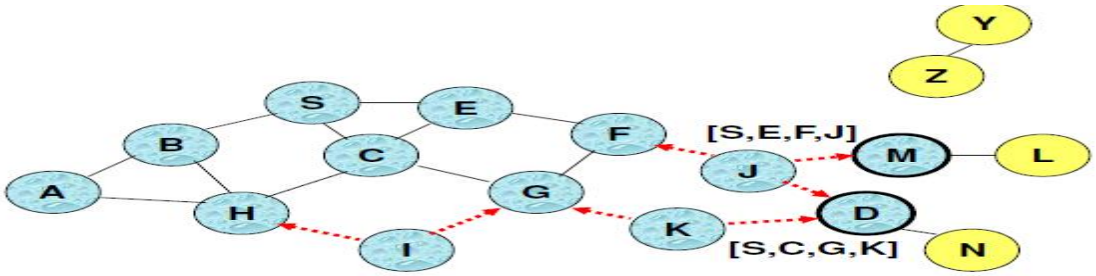
In hierarchical architecture, sensor nodes are organized in clusters, where the cluster members send their data to the sink. Example



(E) The corporate network of ABC Company comprises of about 80,000 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

(F) Consider a wireless sensor network which comprises of a source node, a destination node and multiple intermediate nodes. What possible action(s) can be taken by an intermediate node upon receipt of a RREQ message which was initiated by source node for destination node.



Answer: Upon receipt of a RREQ initiated by a source node for destination node, an intermediate node can perform the following actions:

It checks its cache whether it already has route to desired destination or not. If it has, then it replies back source (RREP message) with the route towards destination.

If no route exists in its cache and its own ID is not already included in RREQ, then it will broadcast the RREQ message. In case, its ID is present in RREQ (i.e., it has already seen the RREQ), it will discard the same.

Question 4: Suppose an IPv6 datagram is exactly 670 bytes wide which consists of IPv6 base header, 30-byte hop-by-hop option header, 30-byte authentication header, 30-byte Encapsulating security payload header and a 30-byte destination options header. All the extended headers are fragmentable except hop-by-hop option header which is unfragmentable. Suppose we need to send this over a link with an MTU of only 278 bytes and this is possible only by performing fragmentation. Note that in each fragment, unfragmentable part is followed by an 8-byte fragment header. Keeping in view this scenario, answer the following questions by showing necessary calculations in support of your answers: **[2+2+1+1 = 6 Marks]**

(A) how many bytes of data including upper layer header are present in this original IPv6 datagram?

Answer: 510 bytes

Calculations: total datagram size = 670 bytes

Size of headers = base header of 40 bytes + 4 options header of 30 bytes each = 40 + 4 * 30 = 160 bytes

So, data bytes in this datagram = 670 – 160 = 510 bytes

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

Answer: 3 fragments

Calculations:

original datagram size= 670 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: 670 – 70 = 600 bytes (including fragmentable extended headers)

Fragment header in each fragment = 8 bytes

So, each fragment will have 78 necessary bytes and only 200 bytes are left for carrying fragmentable data of 600 bytes.

We need 3 segments

(C) How many bytes of data will be carried by the last fragment?

Answer: 200 bytes

(D) How many bytes of data will be carried by the last fragment?

Answer: 200 bytes

----------**BEST OF LUCK**----------