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Internal Assessment Test 2 Scheme and Solution – April 2024

Sub:	Internet of Things					Sub Code:	18CS81	Branch:	ISE
Date:	13/04/2024	Duration:	90 mins	Max Marks:	50	Version/ Sem / Sec:	VIII/A,B,C		OBE

Answer any FIVE FULL Questions

		MARKS	CO	RBT
1.	Explain Message Queuing Telemetry Transport	6+4= [10]	CO3	L2

At the end of the 1990s, engineers from IBM and Arcom (acquired in 2006 byEurotech) were looking for areliable, lightweight, and cost-effective protocol to monitor and control a large number of sensors and theirdata from a central server location, as typically used by the oil and gas industries.

Their research resulted in the development and implementation of the Message Queuing Telemetry Transport (MQTT) protocol that is now standardized by the Organization for the Advancement of Structured InformationStandards (OASIS).

Considering the harsh environments in the oil and gas industries, an extremely simple protocol with only afew options was designed, with considerations for constrained nodes, unreliable WAN backhaul communications, and bandwidth constraints with variable latencies. These were some of the rationales for the selection of a client/server and publish/subscribe framework based on the TCP/IP architecture, as shown in Figure

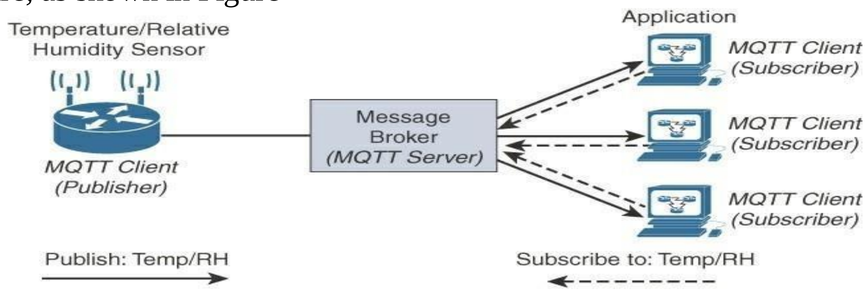


Figure 3.20 *MQTT Publish/Subscribe Framework*

An MQTT client can act as a publisher to send data (or resource information) to an MQTT server acting as an MQTT message broker. In the example illustrated in Figure 3.20, the MQTT client on the leftside is a temperature (Temp) and relative humidity (RH) sensor that publishes its Temp/RH data. The MQTT server (or message broker) accepts the network connection along with application messages, such as Temp/RH data, from the publishers. It also handles the subscription and unsubscription process and pushesthe application data to MQTT clients acting as subscribers.

The application on the right side of Figure 3.20 is an MQTT client that is a subscriber to the Temp/RHdata being generated by the publisher or sensor on the left. This model, where subscribers express a desireto receive information from publishers, is well known. A great example is the collaboration and social networking application Twitter.

With MQTT, clients can subscribe to all data (using a wildcard character) or specific data from theinformation tree of a publisher. In addition, the presence of a message broker in MQTT decouples the datatransmission between clients acting as publishers and subscribers. In fact, publishers and subscribers do noteven know (or need to know) about each other. A benefit of having this decoupling is that the MQTT message broker ensures that information can be buffered and cached in case of network failures. This also means thatpublishers and subscribers do not have to be online at the same time.

2.	Explain about IEEE 1901.2a IoT Access Technology in detail.	6+4= [10]	CO2	L2

This is a standard for Narrowband Power Line Communication (NB-PLC). NB-PLC leverages a narrowband spectrum for low power, long range, and resistance to interference over the same wires that carry electric power. NB-PLC is often found in use cases such as the following:

Smart metering: NB-PLC can be used to automate the reading of utility meters, such as electric, gas, and water meters. This is true particularly in Europe, where PLC is the preferred technology for utilities deploying smart meter solutions.

■ Distribution automation: NB-PLC can be used for distribution automation, which involves monitoringand controlling all the devices in the power grid.

■ Public lighting: A common use for NB-PLC is with public lighting—the lights found in cities andalong streets, highways, and public areas such as parks.

■ Electric vehicle charging stations: NB-PLC can be used for electric vehicle charging stations, where thebatteries of electric vehicles can be recharged.

Microgrids: NB-PLC can be used for microgrids, local energy grids that can disconnect from thetraditional grid and operate independently.

■ Renewable energy: NB-PLC can be used in renewable energy applications, such as solar, wind power,hydroelectric, and geothermal heat.

All these use cases require a direct connection to the power grid. So it makes sense to transport IoT dataacross power grid connections that are already in place.

Standardization and Alliances:

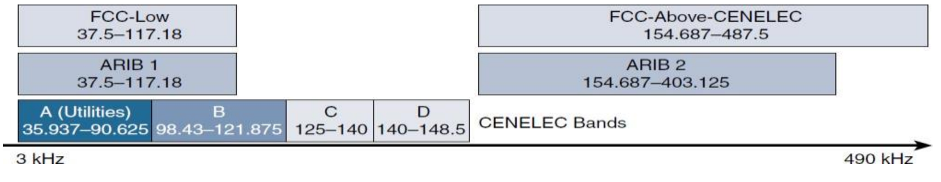
The first generations of NB-PLC implementations have generated a lot of interest from utilities in Europe but have often suffered from poor reliability, low throughput , lack of manageability, and poor interoperability.

The IEEE 1901.2a standard does have some alignment with the latest developments done in other IEEE working groups. For example, using the 802.15.4e Information Element fields eases support for IEEE 802.15.9 key management. In addition, a dual-PHY approach is possible when combined with IEEE802.15.4g/e on endpoints.

Physical Layer

NB-PLC is defined for frequency bands from 3 to 500 kHz. Much as with wireless sub-GHz frequency bands, regional regulations and definitions apply to NB-PLC. The IEEE 1901.2 working group has integrated support for all world regions in order to develop a worldwide standard.

Figure shows the various frequency bands for NB-PLC. Notice that the most well known bands are regulated by CENELEC and the FCC, but the Japan Association of Radio Industries and Businesses (ARIB) band is also present. The two ARIB frequency bands are ARIB 1, 37.5–117.1875 kHz, and ARIB2, 154.6875–403.125 kHz.



Based on OFDM, the IEEE 1901.2 specification leverages the best from other NB-PLC OFDM technologies that were developed previously. Therefore, IEEE 1901.2a supports the largest set of coding and enables both robustness and throughput. The standard includes tone maps and modulations, such as robust

<table>
<tr><td></td><td>modulation (ROBO), differential binary phase shift keying (DBPSK), differential quadrature phaseshift keying (DQPSK), differential 8-point phase shift keying (D8PSK) for all bands, and optionally 16 quadrature amplitude modulation (16QAM) for some bands.

One major difference between IEEE 802.15.4g/e and IEEE 1901.2a is the full integration of different types of modulation and tone maps by a single PHY layer in the IEEE 1901.2a specification</td><td></td><td></td><td></td></tr>
<tr><td>3.</td><td>Interpret 6Ti SCH.

To standardize IPv6 over the TSCH mode of IEEE 802.15.4e (known as 6TiSCH), the IETF formed the 6TiSCH working group. This working group works on the architecture, information model, and minimal 6TiSCH configuration, leveraging and enhancing work done by the 6LoWPAN working group, RoLL workinggroup, and CoRE working group. The RoLL working group focuses on Layer 3 routing for constrained networks.

The IEEE 802.15.4e standard defines a time slot structure, but it does not mandate a scheduling algorithm forhow the time slots are utilized. This is left to higher-level protocols like 6TiSCH. Scheduling is critical because it can affect throughput, latency, and power consumption. Figure 3.7 shows where 6top resides inrelation to IEEE 802.15.4e, 6LoWPAN HC, and IPv6. HC

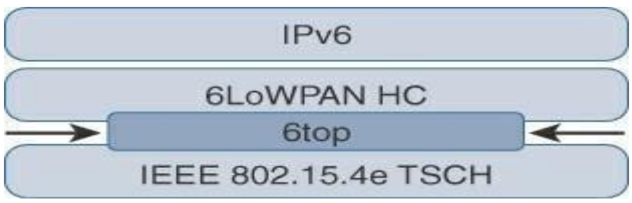


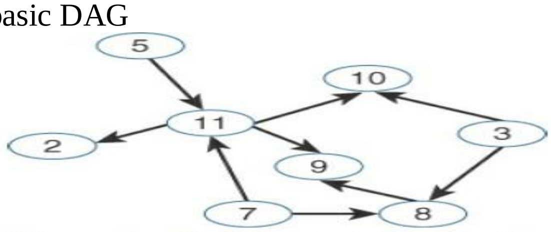
Figure 5-7 Location of 6TiSCH’s 6top Sublayer</td><td>6+4= [10]</td><td>CO3</td><td>L3</td></tr>
<tr><td>4.</td><td>Illustrate Routing Protocol for Low power and Lossy networks(RPL), with a neat diagram
In an RPL network, each node acts as a router and becomes part of a mesh network.
Routing is performed at the IP layer
Each node examines the received IPv6 packet and determines the next-hop destination based on the information contained in the IPv6 header.
RPL is based on the concept of a directed acyclic graph (DAG).
A DAG is a directed graph where no cycles exist.
All of the edges are arranged in paths oriented toward and terminating at one or more root nodes.
Figure shows a basic DAG


Figure 5-8 Example of a Directed Acyclic Graph (DAG)</td><td>6+4= [10]</td><td>CO3</td><td>L3</td></tr>
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- A basic RPL process involves building a destination-oriented directed acyclic graph (DODAG).
- A DODAG is a DAG rooted to 1 destination.
- In RPL, this destination occurs at a border router known as the DODAG root.
- Figure compares a DAG and a DODAG.
- From figure a DAG has multiple roots, whereas the DODAG has just one.

- In a DODAG, each node maintains up to three parents that provide a path to the root.
- Upward routes in RPL are discovered and configured using DAG Information Object (DIO) messages.
- Nodes establish downward routes by advertising their parent set toward the DODAG root using a Destination Advertisement Object (DAO) message.
- In the case of the *non-storing mode* of RPL, nodes sending DAO messages report their parent sets directly to the DODAG root (border router), and only the root stores the routing information.
- For *storing mode*, each node keeps track of the routing information that is advertised in the DAO messages.
- RPL messages, such as DIO and DAO, run on top of IPv6.
- As illustrated in Figure DAO and DIO messages move both up and down the DODAG, depending on the exact message type.

Objective Function (OF)

- It defines how metrics are used to select routes and establish a node's rank Whenever a node establishes its rank, it simply sets the rank to the current Minimum Expected Number of Transmissions (METX) among its parents.

Rank

- The rank is a rough approximation of how "close" a node is to the root.
- It helps avoid routing loops and the count-to-infinity problem.
- Nodes can only increase their rank when receiving a DIO message with a larger version number.

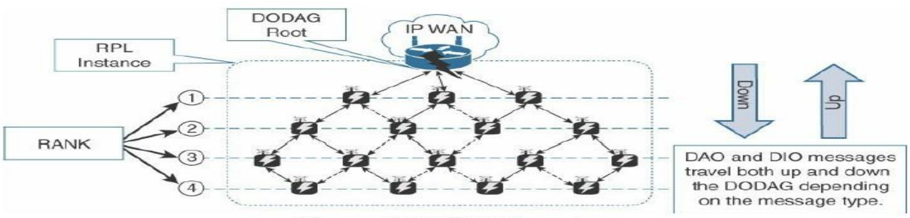


Figure 5-10 RPL Overview

RPL Headers

- RFC 6553 defines a new IPv6 option, known as the RPL option.
- The RPL option is carried in the IPv6 Hop- by-Hop header.
- The purpose of this header is to leverage data packets for loop detection in a RPL instance

RPL defines a large and flexible set of new metrics and constraints for routing in RFC 6551

1. Expected Transmission Count (ETX)
2. Hop Count
3. Latency

4. Link Quality Level
5. Link Color
6. Node State and Attribute
7. Node Energy
8. Throughput

5. Illustrate the COAP Message format usage. — 6+4= [10] | CO3 | L3

Constrained Application Protocol (CoAP) resulted from the IETF Constrained RESTful Environments (CoRE) working group's efforts to develop a generic framework for resource-oriented applications targeting constrained nodes and networks.

From a formatting perspective, a CoAP message is composed of a short fixed-length Header field (4 bytes),a variable-length but mandatory Token field (0–8 bytes), Options fields if necessary, and the Payload field.Figure 3.17 details the CoAP message format, which delivers low overhead while decreasing parsing complexity.

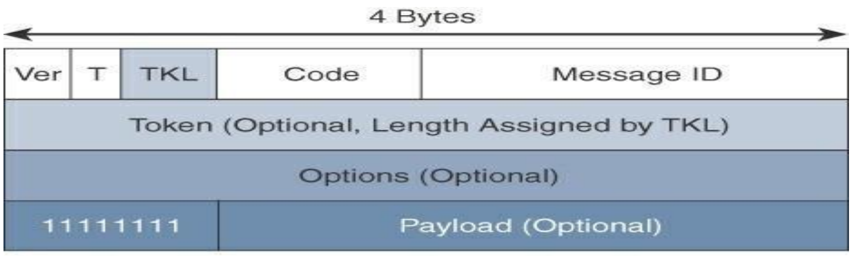


Figure 3.17 *CoAP Message Format*

As illustrated in Figure 3.18, CoAP communications across an IoT infrastructure can take various paths.

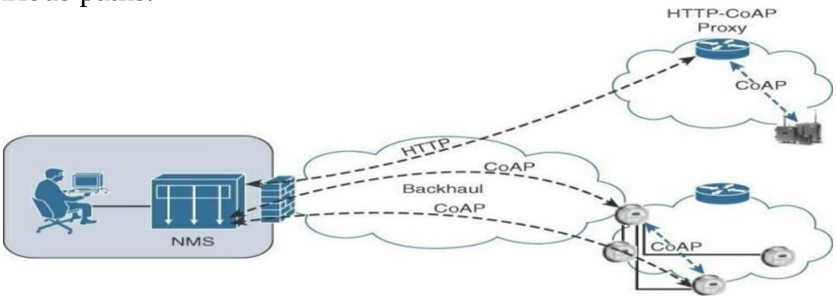


Figure 3.18 *CoAP Communications in IoT Infrastructures*

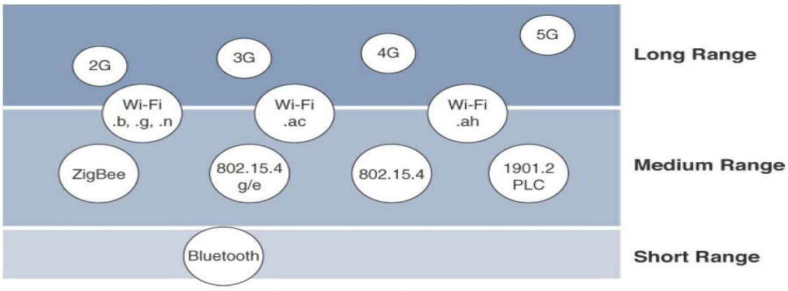
Connections can be between devices located on the same or different constrained networks or betweendevices and generic Internet or cloud servers, all operating over IP. Proxy mechanisms are also defined, and RFC 7252 details a basic HTTP mapping for CoAP. As both HTTP and CoAP are IP-based protocols, theproxy function can be located practically anywhere in the network, not necessarily at the border between constrained and non-constrained networks.

6 (a) Explain the following key factors involved in connecting smart objects to the network : i)RANGE — 4+2=[06] | CO2 | L2

- ✓ Wireless communication is prevalent in the world of smart object connectivity because it allows smart objects to be mobile.

RANGE:

- ✓ **Short range:** Are alternative to a serial cable, supporting tens of meters of maximum distance between two devices. Ex- Bluetooth, Visible Light Communications.

	 **Figure 4-1** Wireless Access Landscape ✓ **Medium range:** This range is the main category of IoT access technologies. • The maximum distance is generally less than 1 mile between two devices. • Ex-Wi-Fi, Ethernet, Narrowband Power Line Communications. ✓ **Long range:** Distances greater than 1 mile between two devices require long-range technologies. • Ex- Wi-Fi , Low-Power Wide-Area technologies. • These technologies are ideal for battery-powered IoT sensors			
6 (b)	Explain the following key factors involved in connecting smart objects to the network : ii) FREQUENCY BANDS **FREQUENCY BAND:** • Telecommunication Union and the Federal Communications Commission, groups define the regulations and transmission requirements for various frequency bands. • to utilize licensed spectrum users must subscribe to services when connecting their IoT devices. • Most well-known ISM(Industrial scientific Medical) bands are: ✓ 2.4 GHz band as used by IEEE 802.11b/g/n Wi-Fi ✓ IEEE 802.15.1 Bluetooth ✓ IEEE 802.15.4 WPAN	[04]	CO2	L2

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