**TCN 5271 Advanced IoT Communications and Networking Exam**

**Take-Home – Summer 2022**

**Question 1:** Explain the concept of M2M and IoT and explain what their differences are?

**Answer:** The phrase "machine-to-machine communication," or M2M, refers to message exchange across several devices (usually) over the Internet without human participation. It is developed from sensor technology. Even though the majority of people, along with a few IT specialists, consider such expressions as interchangeable and use these interchangeably, it doesn't take a genius to distinguish one essential difference between two. Long before the entire Internet was developed, M2M, the predecessor of IoT, was utilised as the fundamental telemetry approach since it involved an interface between two or maybe numerous machines without the participation of a client. The Internet of Things idea, on the other hand, has grown from the M2M foundation and aims to offer far more capabilities. It takes benefit of Web availability to connect various products and equipment in an effort to merge various technical architectures and build flexible and fully integrated routes across a variety of situations, as well as to ease communications among a group of comparable gadgets.

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| **M2M vs IoT** | | |
| **Ser** | **M2M** | **IoT** |
|  | Systems | Instruments |
|  | Based on hardware | Based on software |
|  | Applications are vertical | Applications are horizontal |
|  | Closed system deployment | Links with bigger network |
|  | Communication is among machines | Communication between devices, human-machine interaction, and machine-human interaction |
|  | Utilizes techniques not over IP | IP protocol is used |
|  | Could utilize the internet, but it isn't necessary | Utilizes the internet |
|  | Point-to-point connectivity is used by devices, and is typically incorporated in circuitry | IP connections are used by gadgets to interact |
|  | One-way conversations are common | Two-way communication |
|  | The primary goal is to observe and manage | Numerous uses and various levels of communication |
|  | Uses triggered reactions depending on activity to operate | Can, but need not, function through triggering reactions |
|  | Fewer possibilities for interoperability, and gadgets need to use complimentary communication protocols | There are countless integrating possibilities, but they need software to control connections and standards. |
|  | Data is structured | Data is both structured and unstructured |

**Question 2:** Explain at least three different modulation mechanisms used in the physical layers of IoT protocols?

**Answer:**

**Binary Phase Shift Keying**: The most fundamental PSK form is binary phase shift keying (BPSK), where "binary" refers to employing two-phase shifts (one for logic high, one for logic low).

It may be difficult for a recipient to distinguish between a signal with a phase deviation of 90 degrees and a signal with a stage deviation of 91 degrees, but it is instantly clear that the network may become more dependable if there is a greater difference between those two cycles. Given that we have just been presented with 360° of phase, the difference between the logic-high and logic-low stages is most significantly 180°. But since we know that rotating a sine wave output by 180 degrees is identical to reversing it, we can think of BPSK as simply reversing the signal in response to one logic level and leaving it unaltered in response to another.

**Time division multiple access (TDMA)**

Although TDMA employs streams, it somehow allows several clients to use the same streams at what appears to be the same time. The static image frame rates in theatres, which, at about 30 frames per second, provide the impression of steady flow but are really only a temporal changing activity, may serve as an analogy.

Using a 2-time slot TDMA architecture, many clients can exploit the very same frequencies in diverse ways: For about 50 milliseconds, User 1 is given access to the frequencies for a very small period of time. After that, the connection is handed over to user 2 for 50 milliseconds. After giving client each other 50 milliseconds, it cycles back around to client one.

Each customer thinks they have complete access to the wavelength band since the operation is so short. Additional frequency band is necessary to use 2-time interval TDMA with more than two conversations occurring simultaneously. Two wavelengths are said to be able to support four conversations simultaneously if there are additional 2-time period TDMA channels, owing to this transporting activity.

**Amplitude Shift Keying (ASK)**

ASK is a sort of Amplitude Modulation that expresses binary information as amplitude fluctuations in a stream.

A higher bandwidth component is present in any modulation transmission. When ASK modulates, the binary signals produces a value of 0 for lower entry and the pulse retu ASK is a kind of amplitude modulation that uses stream amplitude variations to represent binary information.

Any modulation transmission has a greater bandwidth component. A value of 0 is produced by the binary signals during ASK modulation for lower entry and a pulse return is produced for high voltage gain.rn for high voltage gain.

**Question 3:** Explain the concept of Wireless Sensor Network and its difference with an IoT network?

**Answer:**

**Wireless Sensor Network (WSN)**

WSNs are networks of regionally dispersed, specific sensors that monitor and record atmospheric related factors before transmitting the collected data to a centralised location. WSNs can assess air quality, noise levels, pollution levels, moisture, and temperature.

A WSN consists of "nodes," which can number from a few to hundreds or even thousands, each of which is connected to other devices. A transceiver module with an inside transmitter or a link to an outside transmitter, a micro-controller, an electrical circuit for integrating with devices, and a source of energy, which is typically a battery or an integrated form of power harvesting, make up the majority of such entities. Although microstructure ratios have yet to be realised, a sensing unit's size may range from a shoebox to (perhaps) a sand particle. Depending on the intricacy of the device, sensing unit prices range from a few dollars to hundreds of dollars. Design and financial constraints place restrictions on the availability of power, storage, computing power, and transmission capacity. The design of a WSN might be anything from a simple star topology to a complex multi-hop wireless mesh network. Transmission might happen by overflowing or forwarding.

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| **Ser** | **WSN** | **IoT** |
|  | A network of just devices makes up a WSN. | The Internet of Things has a bridge that may be utilized to communicate with networks (having routers, switches, APs etc). |
|  | WSN has a sink (but no gateway) and utilises IPv4. | IOT uses IPv4 for the inter network component and IPv6 for the sensor network (802.15.4 MAC/PHY). |
|  | The NetSim WSN supports the following routing protocols: AODV, DSR, ZRP, and OLSR. | The AODV and RPL routing protocols are available in NetSim IoT. |

**Question 4:** Explain the physical and link layers of the following protocol: IEEE 802.3?

**Answer:**

**Physical Layer**

The Ethernet rules' physical level requirements outline the different connections that may be used to build a network, define its design, and provide other crucial specifications including the ideal wire separation distance, speed cap, and encoding method. Physical Level Standards are essential for building a reliable Ethernet connection because they lessen the effects of problems like distortion and interference. The MAC procedure is significantly impacted by physical layer needs.

**Data Link Layer**

The main responsibility of the Ethernet framework is to structure the data that it receives from networking level standards before transferring it across the channel. The header, footer (or trailer), and data packets make up the frame. The header and footer are divided into portions which use the specific information needed to send each item to its intended recipient.

**Question 5:** Explain the physical and link layers of the following protocol: IEEE 802.11?

**Answer:**

**Physical Layer**

The initial 802.11 regulation offers two methods of spread spectrum modulation for the physical level: direct sequence modulation (802.11 FHSS) and frequency hopping (802.11 FHSS) (802.11 DSSS). Both standards call for connection speeds of 1 and 2Mbps at a working bandwidth of 2.4GHz. A second basic physical layer uses passive infrared reflection techniques to transport data at 1 and 2 Mbps, however devices have not yet started to use this protocol.

In late 1999, the IEEE released 802.11a and 802.11b, two modifications to the 802.11 standard. In the 5.8GHz band, the 802.11a protocol calls for transmission speeds of up to 54 Mbps using orthogonal frequency-division multiplexing (OFDM). The IEEE 802.11b protocol, which offers 2.4GHz operation along with additional bandwidths of 5.5 and 11 Mbps, is an improvement over the original 802.11 DSSS in terms of data transfer.

Most organisations that employ wireless LANs nowadays rely on 802.11b-based systems. The 802.11 FHSS radios are unable to interact with 802.11b access points, whereas 802.11 DSSS transmitters can.

**Data Link Layer**

Logical Link Control (LLC) and Media Access Control (MAC) are the two sub-layers that make up the data link layer of 802.11 technology (MAC). The 802.11 standard uses the same 48-bit addresses and 802.2 LLC as earlier 802 LANs, making the transition from wireless LANs to IEEE wired connections relatively straightforward. The MAC, however, is unique to wireless LANs.

The 802.11 MAC and 802.3 are essentially equivalent in that they both aim to support several clients on a single medium by allowing the transmitter to identify the channel before utilising it. In 802.3 Ethernet LANs, the Carrier Sense Multiple Access with Collision Detection (CSMA/CD) standard controls how Ethernet terminals acquire the line and recognises and handles conflicts that arise anytime two or more devices attempt to connect over the LAN at the same time.

**Question 6:** Explain the physical and link layers of the following protocol: IEEE 802.15.4?

**Answer:**

**Physical Layer**

This protocol supports a wide range of PHY options on ISM channels with frequencies between 2.4 GHz and sub-GHz. IEEE 802.15.4 allows for data transfer speeds of 20 kbps, 40 kbps, 100 kbps, and 250 kbps. The fundamental design is based on a 10 m length and a 250 kbps transmission speed. It is possible to dramatically minimise energy usage by using much lower data rates. The hardware level RF transceiver and band allocation, as well as numerous power and channel management features, are governed by IEEE 802.15.4. Depending on the needed information capacity and frequency band, there are now six PHYs specified. Four of them employ frequency hopping techniques for Direct Sequence Spread Spectrum (DSSS). To maintain a straightforward contact with the MAC, each physical information service and the administrative sector have their own specific package format.

**Data Link Layer**

The bridge between the physical and application levels is provided by the IEEE 802.15.4 MAC level. Due to the lack of an application level defined by IEEE 802.15.4, it's often an application platform like Zigbee, MiWi, RF4CE, and so on.

Two components make up the interaction between the application layer and the IEEE 802.15.4 MAC:

* **MAC Management Service:** The MAC Layer Management Entity, or MLME, is what is used for this. It enables the application protocols necessary for performing or retrieving layer administrative tasks. It is true that the IEEE 802.15.4 MAC MLME is in charge of overseeing a MAC level item library. This repository is known as the PIB, or PAN information base, for the MAC protocol. The MLME also has access to MCPS technology for databases transfer activities.
* **MAC Data Service:** The MAC Common Port Layer, or MCPS, is responsible for this. This object provides data transit functionalities between nearby MACs when used with the IEEE 802.15.4 MAC.

**Question 7:** Explain the physical and link layers of the following protocol: BLE 4.0+?

**Answer:**

**Physical Layer**

The Bluetooth® Low Energy (BLE) physical layer houses the analogue transmission technology required to effectively translate digital messages across radios (PHY). It serves as the link layer's operations layer in the network stack.

The 2.4 GHz Commercial, Technical, and Healthcare spectrum, which is split into 40 bands with 2 MHz spacing among 2.4000 GHz and 2.4835 GHz, starting at 2402 MHz, is used by the radios to interact.

Among the 40 channels, there are three commercial channels (Ch. 37, 38, and 39) as well as 37 data channels (Ch. 0-36).

The BLE radio transmits data using 1 Mbps and 1 bit per transmission. The transmitter is made to quickly send small quantities of information.

In order to smooth out spectrum shifts, the BLE transmitter uses Gaussian Frequency-Shift Keying (GFSK), which involves processing information bursts using a Gaussian filtration mechanism first.

**Data Link Layer**

The part that connects right away with the physical level is the Bluetooth Low Energy (BLE) connection level (PHY). It is in charge of interaction building and maintenance as well as promotion and analysis.

Advertising channels and data channels are the two categories into which link level connections are divided.

During a data transmission, the 37 data streams are rotated using a frequency hopping mechanism.

It has a single package structure that is applied to all packages for the information stream and advertisements.

The identification approach uses devices that find one another through advertising channels, one device advertising and another device evaluating.

A crucial process that completes the discovery stage is filtering. In order to get advertising products, it is essential. The two types of screening are passive and active.

A Scanner converts into an Originator and starts the Bluetooth® Low Energy (BLE) Link Layer connecting process once it has received enough information to decide which Advertiser to connect to (such as its MAC identification).

**Question 8:** Watch the following lecture and provide a summary of it. "How does 5G fit into the future of IoT? - Webinar" (https://www.youtube.com/watch?v=TilgPBzPasg).

**Answer:** In the next years, 5G is anticipated to spark a global technology revolution that will benefit a variety of industries and promote innovation. As industry experts strive to move toward IoT and next-generation technologies, people's lifestyles, businesses, and civilization as a whole would tremendously benefit.

The time to prepare for what happens ahead is right here. In order to stay competitive, businesses must understand the implications of 5G and the opportunities it would present to those that are better positioned to utilise IoT.

The Internet of Things (IoT) is playing a significant role in the current technological shift, and as 5G is fast adopted, IoT acceptability will rise.

Global specifications and the accessibility of 5G for IoT suggest that products and services may be made available everywhere. Utilizing the magnitude of the cellular industry and the millions of connected cellphones enables further advancement of devices, networking technology, and network provider expertise. It also provides for financial effectiveness, reliability, and safety.

IoT services will be able to better control infrastructure characteristics with 5G and adjust them to the needs of the target scenario. Related approaches, such as networking periphery computation, may go one step further by allowing the application to run in several remote data centres close to the IoT device rather than a main cloud data centre.

Therefore, it is crucial to plan ahead for IoT solutions. The operation and cost of the connected item may be affected in the long run by the choices made at this time.

The introduction of 5G would open up various new opportunities. Organizations must work with partners that have the capacity and stamina to invest over the next five to ten years, as well as partners who have the requisite competitive place, in order to profit from this.

**Question 9:** Watch the following lecture and provide a summary of it. "Webinar: Lightweight & Scalable IoT Messaging with MQTT" (https://www.youtube.com/watch?v=TyRxxx6IBqw).

**Answer:** The Internet of Things (IoT) is faced with a number of difficulties, such as unreliable communication channels, resource-constrained devices, low bandwidth and high latency situations, the need for bi-directional communication, security, and real-time data sharing.

On top of TCP/IP, MQTT is a lightweight messaging protocol for the Internet of Things (IoT) that is intended for dependable connection over unpredictable networks. It has a low burden and is simple to use.

An MQTT broker designed for business applications is called HiveMQ. It features an effective extension system that supports more than 10 million simultaneous links. More than 150 of the biggest IoT installations in the world utilise it, and it is designed for high availability. Its client is based on the Java MQTT package created by BMW Cat-IT and HiveMQ. Open source, incredibly quick, and has little overead, this software was created specifically for devices and backends.

HiveMQ and Kafka both offer live message monitoring, topic mappings for fusing MQTT and Kafka topics, sophisticated backpressure mechanisms for Kafka integration, HiveMQ control centre integration for cluster-wide monitoring, durability guarantees so that even when cluster nodes go offline, messages are not lost, and control centre RBAC integration.