**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:** M2M, or machine-to-machine interaction, is a term derived by telemetry technologies that relates to information sharing among multiple machines (typically) via the Network without user intervention. Although most individuals, including some IT experts, accept these phrases as substitutes and employ them equally, this doesn't take a genius to detect one fundamental difference between two. M2M, the forerunner of IoT, is being used as the basic technique in telemetry for years, well prior to the development of the Internet altogether, because it entailed an interface among two or maybe multiple devices without user involvement. The Internet of Things concept, on the contrary, has expanded from the roots given out by M2M and aspires to provide considerably greater capability. It makes advantage of Internet accessibility not just to facilitate communications among a group of similar devices, but additionally to link diverse equipment and services in an attempt to combine multiple technological frameworks and create dynamic and completely incorporated channels throughout diverse contexts.

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| **M2M vs IoT** | | |
| **Ser** | **M2M** | **IoT** |
|  | Machines | Sensors |
|  | Hardware based | Software based |
|  | Vertical applications | Horizontal applications |
|  | Deployed in closed system | Connects to a larger system |
|  | Machines communicating with machines | Machines communicating with machines, humans with machines, machines with humans |
|  | Uses non IP protocols | Uses IP protocols |
|  | Can use the cloud, but not required to | Uses the cloud |
|  | Machines use point to point communication, usually embedded in hardware | Devices use IP networks to communicate |
|  | Often one way communication | Back and forth communication |
|  | Main purpose is to monitor and control | Multiple applications, multilevel communications |
|  | Operates via triggered responses based on action | Can, but does not have to, operate on triggered responses |
|  | Limited integration options, devices must have complementary communication standards | Unlimited integration options, but requires software that manages communications/ protocols |
|  | Structured data | Structured and unstructured data |

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

**Answer:**

**Binary Phase Shift Keying**: Binary phase shift keying (BPSK), whereby "binary" relates to using two-phase shifts, is by far the very basic PSK variant (one for logic high, one for logic low).

Although a recipient may likely find it challenging to discern among a signal having a phase deviation of 90° as well as a signal having a stage deviation of 91°, it is immediately evident that perhaps the network will become highly reliable whether there's a bigger difference among those two cycles. The greatest variation among the logic-high and logic-low stages is 180° since we just got 360° of phase to deal with. However, we understand how changing a sine wave output by 180° is equivalent to reversing it; hence, BPSK may be thought of as merely reversing the signal in reaction with one logic level and left it untouched in reaction to another logic level.

**Time division multiple access (TDMA)**

TDMA uses a stream, but somehow it enables multiple clients to utilise the identical stream at what seems to be the similar moment. An analogue may be the static picture frame speeds in theatre, which, at roughly 30 frames per second, provide the sense of constant flow but are essentially a temporal shifting activity.

Multiple clients can utilize the very identical frequencies in various ways using a 2-time slot TDMA framework: User 1 is granted access to the frequencies for a really brief amount of duration, possibly 50 milliseconds. The connection then returns to user 2, who is given 50 milliseconds. It then loops again to client one, who receives another 50 milliseconds, so on and so forth.

Because this procedure is so quick, each client believes they possess full usage of the wavelength band. To have even greater than two talks happening together at the similar moment with 2-time interval TDMA, additional frequency band is required. If it's additional 2-time period TDMA channels, two wavelengths may reportedly accommodate four talks at the same moment, thanks 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 return 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 connections of geographically scattered and specialised devices which observe and store environmental natural parameters and convey the acquired information to a centralized point. Temperature, noise, levels of pollution, moisture, and air may all be measured by WSNs.

A WSN is made up of "nodes," which can range among a few to hundreds or even thousands, with every unit linked to additional devices. Every such entity generally consists of numerous components, including a transceiver module with an inner transmitter or a link to an outer transmitter, a micro - controller, an electrical circuit for integrating with devices, and a source of energy, which is generally a battery or an integrated shape of power harvesting. While microstructure proportions are still to be achieved, a sensing unit may range in scale out of a shoebox to (conceivably) a particle of sand. Sensing unit prices vary equally, spanning from several dollars to hundreds of dollars based on unit complexity. Power, storage, processing ability, and transmission capacity are all constrained by design and budget limits. A WSN's architecture can range between a basic star topology to a sophisticated multi-hop wireless mesh networks. Dissemination might take the form of forwarding or overflowing.

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| **Ser** | **WSN** | **IoT** |
|  | WSN consists of a network of only sensors. | IOT has a gateway which can be used to connect to internetworks (having routers, switches, APs etc). |
|  | WSN runs IPv4 and features a sink (not a gateway). | IOT runs IPv6 in the sensor network (802.15.4 MAC/PHY) and IPv4 on the inter-network portion. |
|  | Routing protocols in NetSim WSN include, DSR, AODV, OLSR, and ZRP. | Routing protocols in NetSim IoT include, AODV and RPL. |

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

**Answer:**

**Physical Layer**

The physical level requirements in the Ethernet regulations explain the sorts of connections that may be used to form the network, specify the architecture, and offer additional important criteria like the optimum wire separation distance, speed limit, and encoding strategy. Physical Level Standards are a crucial aspect of constructing a robust Ethernet connection since it reduce the impact of issues such as distortion and interference. Physical layer requirements have a real impact on the MAC process.

**Data Link Layer**

The Ethernet framework's principal job is to wrap the information it gets out from networking level standard in a frame before transmitting it over the channel. The frame is made up of a header, a footer (trailer), and information via the network level. The header and footer are separated among sections that include specialised details required to deliver every package to its target.

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

**Answer:**

**Physical Layer**

For the physical level, the first 802.11 guideline provides two types of spread spectrum modulation: frequency hopping (802.11 FHSS) and direct sequence modulation (802.11 DSSS). Both specifications provide for a 2.4GHz working bandwidth and transmission speeds of 1 and 2Mbps. Another initially physical layer transmits information at 1 and 2Mbps using infrared passive reflections methods; nevertheless, this protocol has still not yet adopted in devices.

The IEEE produced two additions to the 802.11 protocol in late 1999: 802.11a and 802.11b. The 802.11a protocol specifies up to 54 Mbps performance in the 5.8GHz band range utilising orthogonal frequency - division multiplexing (OFDM) transmission. The IEEE 802.11b protocol is a data transmission enhancement of the original 802.11 DSSS, offering 2.4GHz functioning alongside extra bandwidths of 5.5 and 11 Mbps.

Nowadays, the majority of businesses adopting wireless LANs use 802.11b based solutions. The 802.11 DSSS transmitters can communicate with 802.11b access points, whereas the 802.11 FHSS radios cannot.

**Data Link Layer**

The data link layer of 802.11 is divided into two sub - layers: Logical Link Control (LLC) and Media Access Control (MAC) (MAC). The similar 802.2 LLC and 48-bit addresses as previous 802 LANs are used by 802.11, enabling for fairly simple crossover from wlan to IEEE wired connections, however the MAC is exclusive to Wireless lans.

The 802.11 MAC is conceptually identical to 802.3 in that it is intended to allow many clients on a common media by letting the transmitter detect the channel prior to using it. The Carrier Sense Multiple Access with Collision Detection (CSMA/ CD) standard governs how Ethernet terminals gain acquisition to the line and identify and manage conflicts that happen whenever two or more units attempt to connect across the LAN at the same time in 802.3 Ethernet LANs.

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

**Answer:**

**Physical Layer**

This protocol allows for a diverse set of PHY solutions in ISM channels spanning from 2.4 GHz to sub-GHz. Data transfer rates of 20 kbps, 40 kbps, 100 kbps and 250 kbps are possible with IEEE 802.15.4. The basic construction is based on a 10 m length and a transmission throughput of 250 kbps. Much reduced data rates are conceivable to significantly minimise energy consumption. IEEE 802.15.4 governs the physical level RF transceiver and band allocation, as well as various power and channel control aspects. There are currently six PHYs described depending on the spectrum band and information capacity required. Four of these use Direct Sequence Spread Spectrum frequency hopping methods (DSSS). All the physical information services and the administrative sector have a unique package format in order to preserve a simple interaction with the MAC.

**Data Link Layer**

The IEEE 802.15.4 MAC level serves as a bridge across the physical and application level. Because IEEE 802.15.4 does not define an application level, it's usually an application platform like Zigbee, RF4CE, MiWi, and so on.

The IEEE 802.15.4 MAC provides the interface to the application layer using two elements:

* **MAC Management Service:** This is referred to as the MAC Layer Management Entity, or MLME. It implements the application protocols that allow layers administration activities to be performed or retrieved. The IEEE 802.15.4 MAC MLME is indeed in charge of managing an item library for the MAC level. The MAC protocol PAN information base, or PIB, is the name given to this repository. For database transfer operations, the MLME additionally has accessibility to MCPS technologies.
* **MAC Data Service:** This is known as the MAC Common Port Layer, or MCPS. Under the IEEE 802.15.4 MAC, this object offers information transportation functions among neighbor MACs.

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

**Answer:**

**Physical Layer**

The analogue transmission hardware necessary for translating digitized signals well over airwaves is housed in the Bluetooth® Low Energy (BLE) physical layer (PHY). It is the network stack's bottom level, providing operations to the link layer.

The radios communicates using the 2.4 GHz Commercial, Technical, and Healthcare spectrum, which is divided into 40 bands with 2 MHz intervals between 2.4000 GHz to 2.4835 GHz, beginning at 2402 MHz.

There are three commercial channels (Ch. 37, 38, and 39) and 37 data channels among the 40 channels (Ch. 0-36).

For transferring information, the BLE radio uses 1 Mbps and 1 bit each signal. The transmitter is designed to convey tiny amounts of information fast.

The BLE transmitter employs Gaussian Frequency-Shift Keying (GFSK), in which information bursts being processed using a Gaussian filtration system prior having used to change the carriers band to level out spectrum changes.

**Data Link Layer**

The Bluetooth® Low Energy (BLE) link level is the component which communicates immediately with the physical level (PHY). It is in charge of promoting, analyzing, and establishing/maintaining relationships.

Link level connections are classified into two kinds: advertising channels and data channels.

A frequency hopping method is utilised to rotate across the 37 data streams during a data transmission.

It features a single package structure that is utilized for all advertisement and information stream packages.

The identification method includes of machines which locate each other via advertising channels, with one device promoting and some other analyzing.

Screening is a vital operation that accomplishes the detection phase. It is necessary in order to get advertisement packages. Screening is classified into two kinds: passive and active.

When a Scanners has gathered sufficient data to make decisions which Advertiser to join to (such as its MAC identity), it transforms into an Originator, commencing a Bluetooth® Low Energy (BLE) Link Layer connectivity procedure.

**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:** 5G is expected to stimulate worldwide technological revolution in the years ahead, benefiting sectors and fostering creativity. People 's lifestyles, businesses, and civilization would benefit greatly as sector leaders continue to shift to next-generation technologies and IoT.

Now would be the opportunity to get ready for whatever comes next. Companies must comprehend the ramifications of 5G and the possibilities it would offer to firms that are better placed to adopt IoT in order to remain competitive.

The Internet of Things (IoT) is serving an important role in technological transition, and as all 5G quickly being implemented, IoT acceptance would increase.

Worldwide standards and availability of 5G for IoT imply that goods and solutions can be expanded internationally. Taking use of the cellular sector's size and millions of linked cellphones allows for financial effectiveness, dependability, safety, and continual improvement of gadgets, networking technology, and network provider skills.

Using 5G, IoT services would have greater command over infrastructure parameters and would be able to tailor them to the demands of the target scenario. Related techniques, like as networking periphery computation, might carry it a step beyond by enabling the program to execute in dispersed data centres adjacent to the IoT gadget instead of a centralised cloud data centre.

It is consequently critical to plan before time for IoT solutions. The decisions chosen now may have long-term consequences on the functionality and price of the linked product.

5G would introduce several additional possibilities. To reap the benefits of this, businesses must engage with collaborators that possess the capability and endurance to spend during the next 5 to 10 years, and also collaborators which possess the necessary market position.

**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:** IoT faces many challenges which includes unreliable communication channels, resource constrained devices, low bandwidth and high latency environments, bi-directional communication is required, security and instantaneous data exchange.

MQTT is an IoT lightweight messaging protocol on top of TCP/ IP which has minimal overhead, easy to use and is designed for reliable communication over unreliable channels.

HiveMQ is an MQTT broker built for enterprise applications. It has a powerful extension system which scales to more than 10 million concurrent connections. It is built for high availability and used by more than 150 of the largest IoT deployments in the world. Its client is based on java MQTT library which is developed by HiveMQ and BMW Cat-IT. Specifically designed for devices and backends, is open source and extremely fast and has low overead.

HiveMQ with Kafka has live monitoring of messages, topic mappings for combining MQTT with Kafka topics, advanced backpressure mechanisms for Kafka integration, HiveMQ control center integration for cluster wide monitoring, durability guarantees so even when cluster nodes die online messages are not lost and control center RBAC integration.