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Internal Assessment Test II – Dec. 2021

Sub:	**Internet of Things**							**Sub Code:**	**20MCA32**
Date:	**16/12//2021**	**Duration:**	**90 min's**	**Max Marks:**	**50**	**Sem:**	**III**	**Branch:**	**MCA**

Note : Answer FIVE FULL Questions, choosing ONE full question from each Module

		MARKS	OBE CO	OBE RBT
	PART I			
1	Define sensors and actuators; explain how actuators and sensors interact with physical world with the neat diagram. Classify actuators based on energy type.	[10]	CO2	L2
	OR			
2	Define smart object and explain the characteristics, Also provide the definition for SANET? Explain the advantages and disadvantages of it.	[10]	CO2	L1
	PART II			
3	List and explain different type of sensors with an example.	[10]	CO2	L2
	OR			
4	List out the limitations of the smart objects in WSNs and explain the data aggregation in WSN with a neat diagram.	[10]	CO2	L2

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	PART III			
5	What is ZigBee protocol stack? Explain 802.15.4 physical layer, MAC layer and security	[10]	CO2	L2
	OR			
6	What are different types of data and also explain the 4 different types of analysis with the neat diagram and an example	[10]	CO4	L2
	PART IV			
7	What is big data analytics. And explain the elements of HADOOP with a neat diagram	[10]	CO4	L2
	OR			
8	Explain neural network in Machine learning with the appropriate diagram and also explain supervised and unsupervised learning with an example each	[10]	CO4	L2
	PART V			
9	Explain the communication criteria's in detail	[10]	CO2	L2
	OR			
10	Explain LoRaWAN standard, alliance, MAC layer and security	[10]	CO2	L2

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Internal Assessment Test 2– Dec 2021

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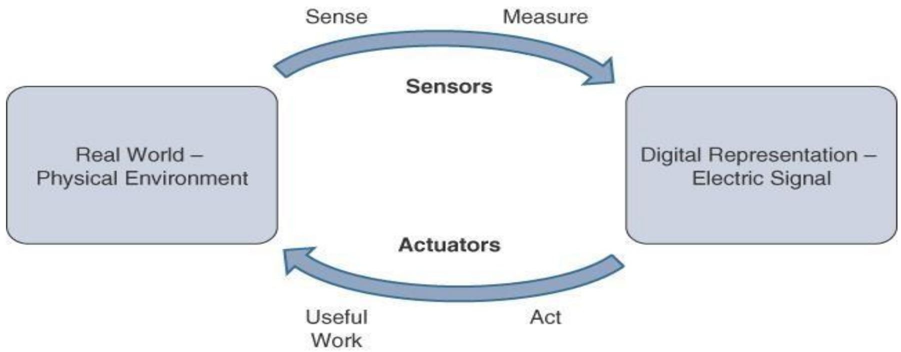
Date:	16/12/2021	Duration:	90 min's	Max Marks: 50	Sem	III		OBE

Q1. Define sensors and actuators; explain how actuators and sensors interact with physical world with the neat diagram. Classify actuators based on energy type.

A sensor measures some physical quantity and converts that measurement reading intoa digital representation.

Sensors are designed to sense and measure practically any measurable variable in the physical world. They convert their measurements (typically analog) into electric signals or digital representations that can be consumed by an intelligent agent (a device or a human).

Actuators, on the others hand, receive some type of control signal (commonly an electric signal or digital command) that triggers a physical effect, usually some type ofmotion, force,



and so on.

Type	Examples
Mechanical actuators	Lever, screw jack, hand crank
Electrical actuators	Thyristor, biopolar transistor, diode
Electromechanical actuators	AC motor, DC motor, step motor
Electromagnetic actuators	Electromagnet, linear solenoid
Hydraulic and pneumatic actuators	Hydraulic cylinder, pneumatic cylinder, piston, pressure control valves, air motors
Smart material actuators (includes thermal and magnetic actuators)	Shape memory alloy (SMA), ion exchange fluid, magnetorestrictive material, bimetallic strip, piezoelectric bimorph
Micro- and nanoactuators	Electrostatic motor, microvalve, comb drive

Q2. Define smart object and explain the characteristics, Also provide the definition for SANET? Explain the advantages and disadvantages of it.

Smart Objects

Smart objects are, quite simply, the building blocks of IoT. They are what transform everyday objects into a network of intelligent objects that are able to learn from and interact with their environment in a meaningful way. A *smart object*, is a device that has, at a minimum, the following four defining characteristics

- **Processing Unit:** A smart object has some type of processing unit for acquiring data, processing and analyzing sensing information received by the sensor(s), coordinating control signals to any actuators, and controlling a variety of functions on the smart object, including the communication and power systems.
- **Sensor(s) and /or actuator(s):** A smart object is capable of interacting with the physical world through sensors and actuators. A smart object does not need to contain

  both sensors and actuators. In fact, a smart object can contain one or multiple sensors and/or actuators, depending upon the application.
- **Communication Device:** The communication unit is responsible for connecting a smart object with other smart objects and the outside world (via the network). Communication devices for smart objects can be either wired or wireless.
- **Power Source:** Smart objects have components that need to be powered. Interestingly, the most significant power consumption usually comes from the communication unit of a smart object.

Sensor Networks:

- A sensor/actuator network (SANET), as the name suggests, is a network of sensors thatsense and measure their environment and/or actuators that act on their environment.
- The sensors and/or actuators in a SANET are capable of communicating and cooperating in a productive manner.
- SANETs offer highly coordinated sensing and actuation capabilities.
- Smart homes are a type of SANET that display this coordination between distributed sensors and actuators.
- For example, smart homes can have temperature sensors that are strategically networked with heating, ventilation, and air-conditioning (HVAC) actuators. When a sensor detects a specified temperature, this can trigger an actuator to take action and heat or cool the home as needed.

The following are some advantages and disadvantages that a wireless-based solution offers:

Advantages:

- Greater deployment flexibility (especially in extreme environments or hard-to-reachplaces)
- Simpler scaling to a large number of nodes
- Lower implementation costs
- Easier long-term maintenance
- Effortless introduction of new sensor/actuator nodes
- Better equipped to handle dynamic/rapid topology changes

Disadvantages:

- Potentially less secure (for example, hijacked access points)
- Typically, lower transmission speeds
- Greater level of impact/influence by environment

Q3. List and explain different type of sensors with an example.

Sensor Types	Description	Examples
Position	A position sensor measures the position of an object; the position measurement can be either in absolute terms (absolute position sensor) or in relative terms (displacement sensor). Position sensors can be linear, angular, or multi-axis.	Potentiometer, inclinometer, proximity sensor
Occupancy and motion	Occupancy sensors detect the presence of people and animals in a surveillance area, while motion sensors detect movement of people and objects. The difference between the two is that occupancy sensors generate a signal even when a person is stationary, whereas motion sensors do not.	Electric eye, radar
Velocity and acceleration	Velocity (speed of motion) sensors may be linear or angular, indicating how fast an object moves along a straight line or how fast it rotates. Acceleration sensors measure changes in velocity.	Accelerometer, gyroscope
Force	Force sensors detect whether a physical force is applied and whether the magnitude of force is beyond a threshold.	Force gauge, viscometer, tactile sensor (touch sensor)
Pressure	Pressure sensors are related to force sensors, measuring force applied by liquids or gases. Pressure is measured in terms of force per unit area.	Barometer, Bourdon gauge, piezometer
Flow	Flow sensors detect the rate of fluid flow. They measure the volume (mass flow) or rate (flow velocity) of fluid that has passed through a system in a given period of time.	Anemometer, mass flow sensor, water meter

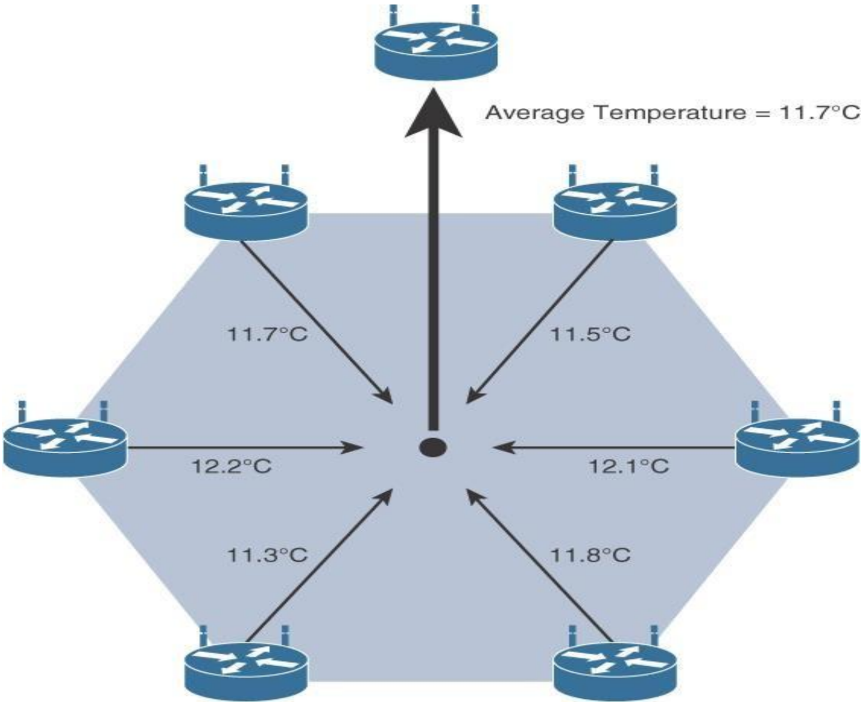
Q4. List out the limitations of the smart objects in WSNs and explain the data aggregation in WSN with a neat diagram.

Wireless Sensor Networks (WSNs)

Wireless sensor networks are made up of wirelessly connected smart objects, which are sometimes referred to as *motes*. The following are some of the most significant limitations of the smart objects in WSNs:

- Limited processing power
- Limited memory
- Lossy communication
- Limited transmission speeds
- Limited power

These limitations greatly influence how WSNs are designed, deployed, and utilized. Figure 2.3 below shows an example of such a data aggregation function in a WSN where temperature readings from a logical grouping of temperature sensors are aggregated as an average temperature reading.

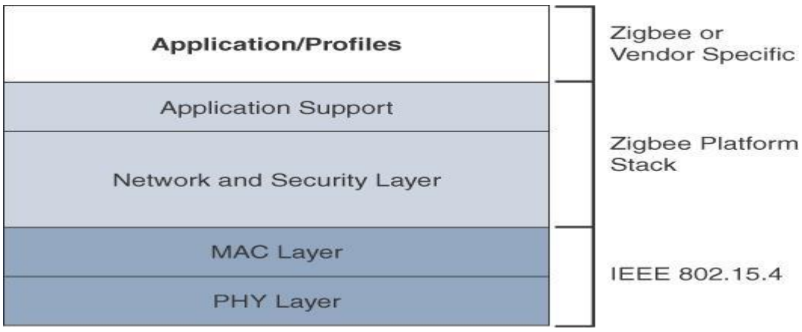


These data aggregation techniques are helpful in reducing the amount of overall traffic (and energy) in WSNs with very large numbers of deployed smart objects. Wirelessly connected smart objects generally have one of the following two communication patterns:

- **Event-driven:** Transmission of sensory information is triggered only when a smart object detects a particular event or predetermined threshold.
- **Periodic:** Transmission of sensory information occurs only at periodic intervals.

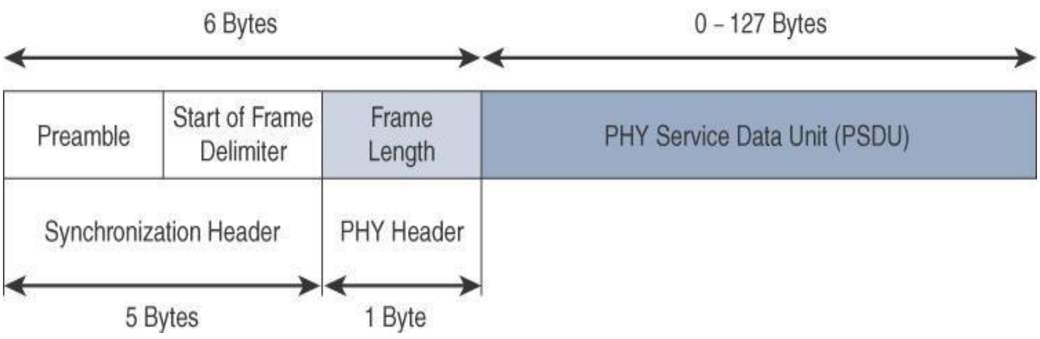
Q5. What is ZigBee protocol stack? Explain 802.15.4 physical layer, MAC layer and security

- **ZigBee:**
  - It is an IoT solution for interconnecting smart objects.
  - ZigBee solutions are aimed at smart objects and sensors that have low bandwidth andlow power needs.
  - The Zigbee specification has undergone several revisions.
  - In the 2006 revision, sets of commands and message types were introduced, and increased in number in the 2007 (called Zigbee pro) iteration, to achieve different functions for a device, such as metering, temperature, or lighting control.
  - These sets of commands and message types are called clusters.
  - Ultimately, these clusters from different functional domains or libraries form thebuilding blocks of Zigbee application profiles.
  - Vendors implementing pre-defined Zigbee application profiles like Home Automationor Smart Energy can ensure interoperability between their products.
  - The main areas where ZigBee is the most well-known include automation for commercial, retail, and home applications and smart energy.
  - In the industrial and commercial automation space, ZigBee-based devices can handlevarious functions, from measuring temperature and humidity to tracking assets.
  - For home automation, ZigBee can control lighting, thermostats, and security functions.
  - ZigBee Smart Energy brings together a variety of interoperable products, such as smartmeters, that can monitor and control the use and delivery of utilities, such as electricityand water.
  - The traditional ZigBee stack is illustrated in the below figure 2.6.

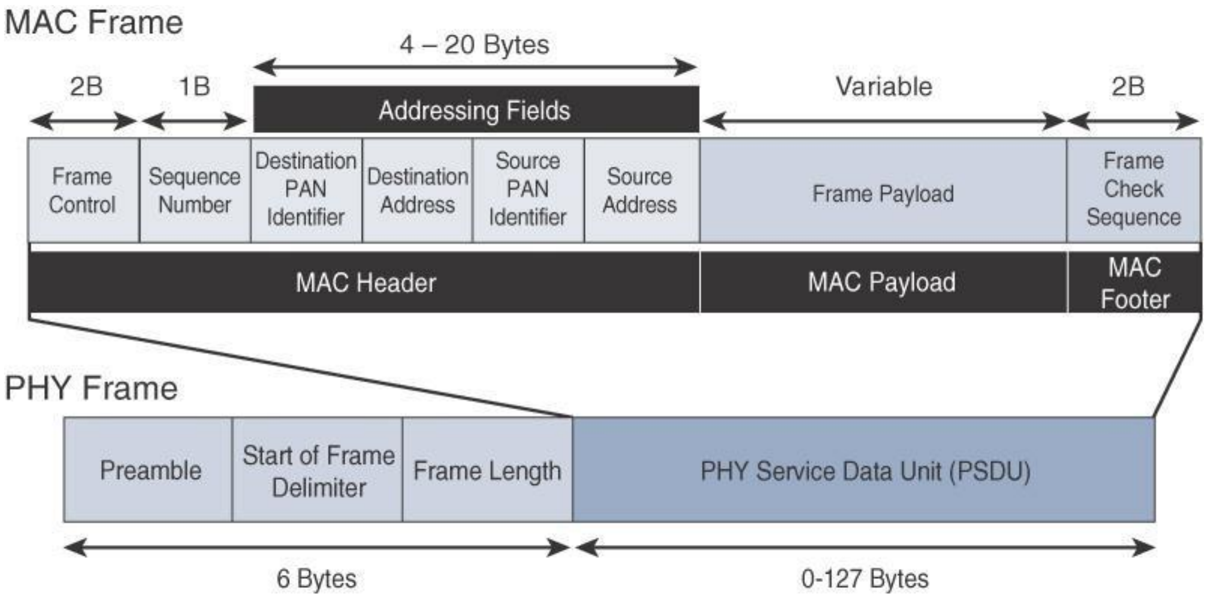


❖ **802.15.4 Physical and MAC Layer:**

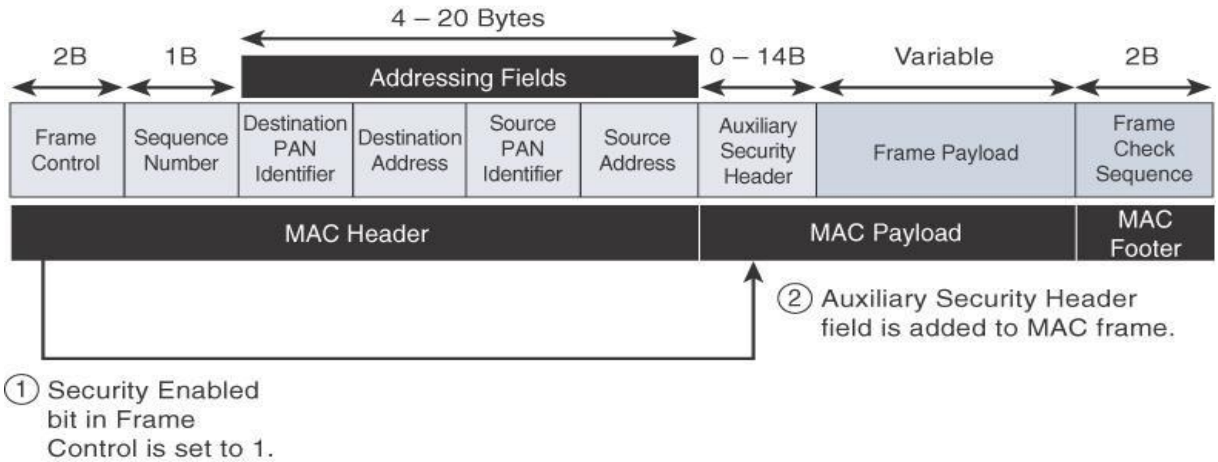
- The 802.15.4 standard supports an extensive number of PHY options that range from 2.4 GHz to sub-GHz frequencies in ISM bands.
- The original IEEE 802.15.4-2003 standard specified only three PHY options based ondirect sequence spread spectrum (DSSS) modulation.
- DSSS is a modulation technique in which a signal is intentionally spread in thefrequency domain, resulting in greater bandwidth.
- The original physical layer transmission options were as follows:
  - 2.4 GHz, 16 channels, with a data rate of 250 kbps
  - 915 MHz, 10 channels, with a data rate of 40 kbps
  - 868 MHz, 1 channel, with a data rate of 20 kbps
- IEEE 802.15.4-2006, 802.15.4-2011, and IEEE 802.15.4-2015 introduced additionalPHY communication options, including the following:
  - **OQPSK PHY:** This is DSSS PHY, employing offset quadrature phase-shiftkeying (OQPSK) modulation.
    - OQPSK is a modulation technique that uses four unique bit values thatare signaled by phase changes.
    - An offset function that is present during phase shifts allows data to betransmitted more reliably.
  - **BPSK PHY:** This is DSSS PHY, employing binary phase-shift keying (BPSK)modulation.
    - BPSK specifies two unique phase shifts as its data encoding scheme.
  - **ASK PHY:** This is parallel sequence spread spectrum (PSSS) PHY, employingamplitude shift keying (ASK) and BPSK modulation.
    - PSSS is an advanced encoding scheme that offers increased range,throughput, data rates, and signal integrity compared to DSSS.
    - ASK uses amplitude shifts instead of phase shifts to signal



- different bitvalues.



❖ **Security**

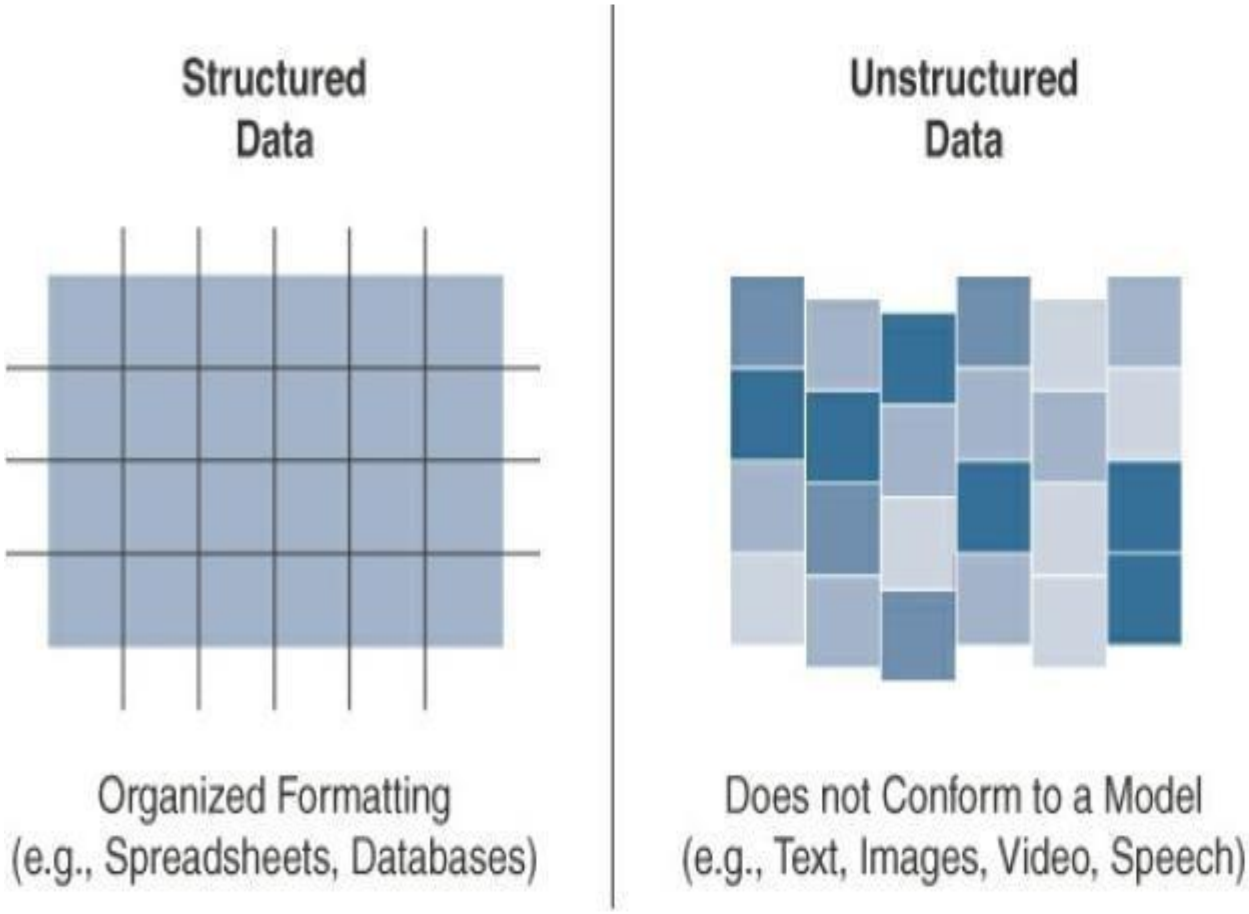


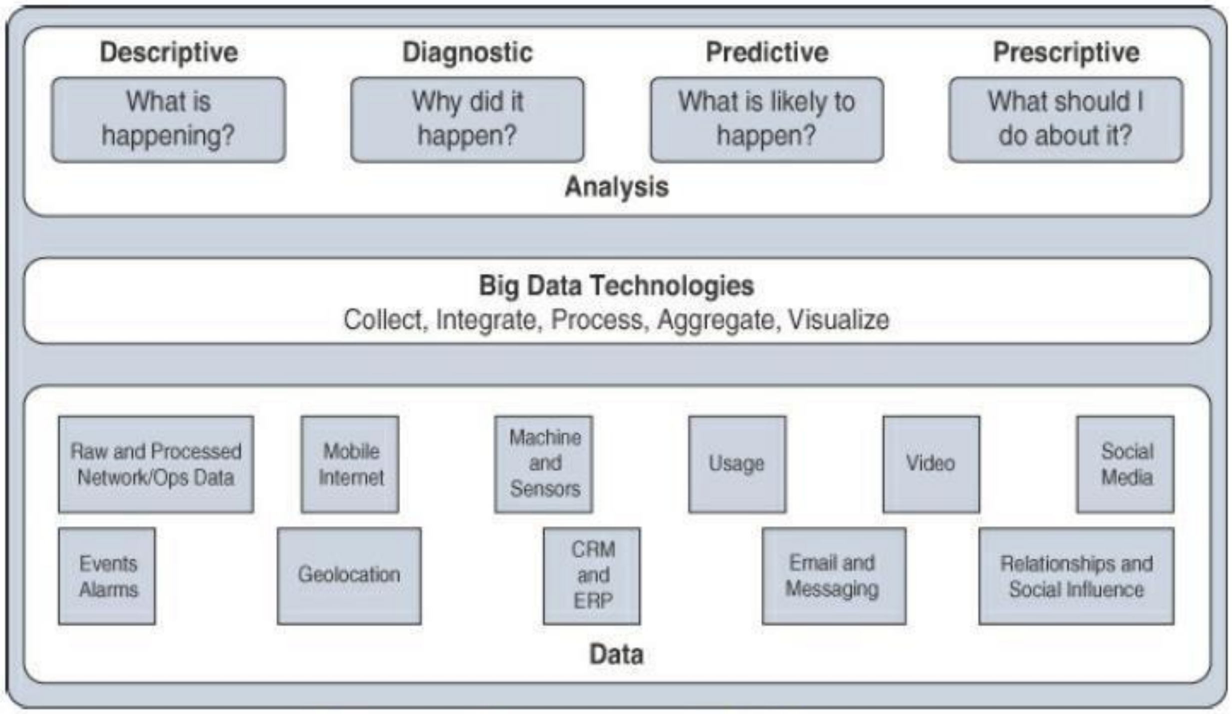
- The IEEE 802.15.4 specification uses Advanced Encryption Standard (AES) with a128-bit key length as the base encryption algorithm for securing its data.
- In addition to encrypting the data, AES in 802.15.4 also validates the data that is sent.
- This is accomplished by a message integrity code (MIC), which is calculated for theentire frame using the same AES key that is used for encryption.

Q6. What are different types of data and also explain the 4 different types of analysis with the neat diagram and an example

Structured Versus Unstructured Data

Structured data and unstructured data are important classifications as they typically require different toolsets from a data analytics perspective. Figure 7-2 provides a high-level comparison of structured data and unstructured data.





Types of Data Analysis Results

Descriptive: Descriptive data analysis tells you what is happening, either now or in the past. For example, a thermometer in a truck engine reports temperature values every second. From a descriptive analysis perspective, you can pull this data at any moment to gain insight into the current operating condition of the truck engine.
If the temperature value is too high, then there may be a cooling problem or the engine may be experiencing too much load.

■ **Diagnostic:** When you are interested in the “why,” diagnostic data analysis can provide the answer. Continuing with the example of the temperature sensor in the truck engine, you might wonder why the truck engine failed. Diagnostic analysis might show that the temperature of the engine was too high, and the engine overheated. Applying diagnostic analysis across the data generated by a wide range of smart objects can provide a clear picture of why a problem or an event occurred.

- **Predictive:** Predictive analysis aims to foretell problems or issues before they occur. For example, with historical values of temperatures for the truck engine, predictive analysis could provide an estimate on the remaining life of certain components in the engine. These components could then be proactively replaced before failure occurs. Or perhaps if temperature values of the truck engine start to rise slowly over time, this could indicate the need for an oil change or some other sort of engine cooling maintenance.
- **Prescriptive:** Prescriptive analysis goes a step beyond predictive and recommends solutions for upcoming problems. A prescriptive analysis of the temperature data from a truck engine might calculate various alternatives to cost-effectively maintain our truck. These calculations could range from the cost necessary for more frequent oil changes and cooling maintenance to installing new cooling equipment on the engine or upgrading to a lease on a model with a more powerful engine.

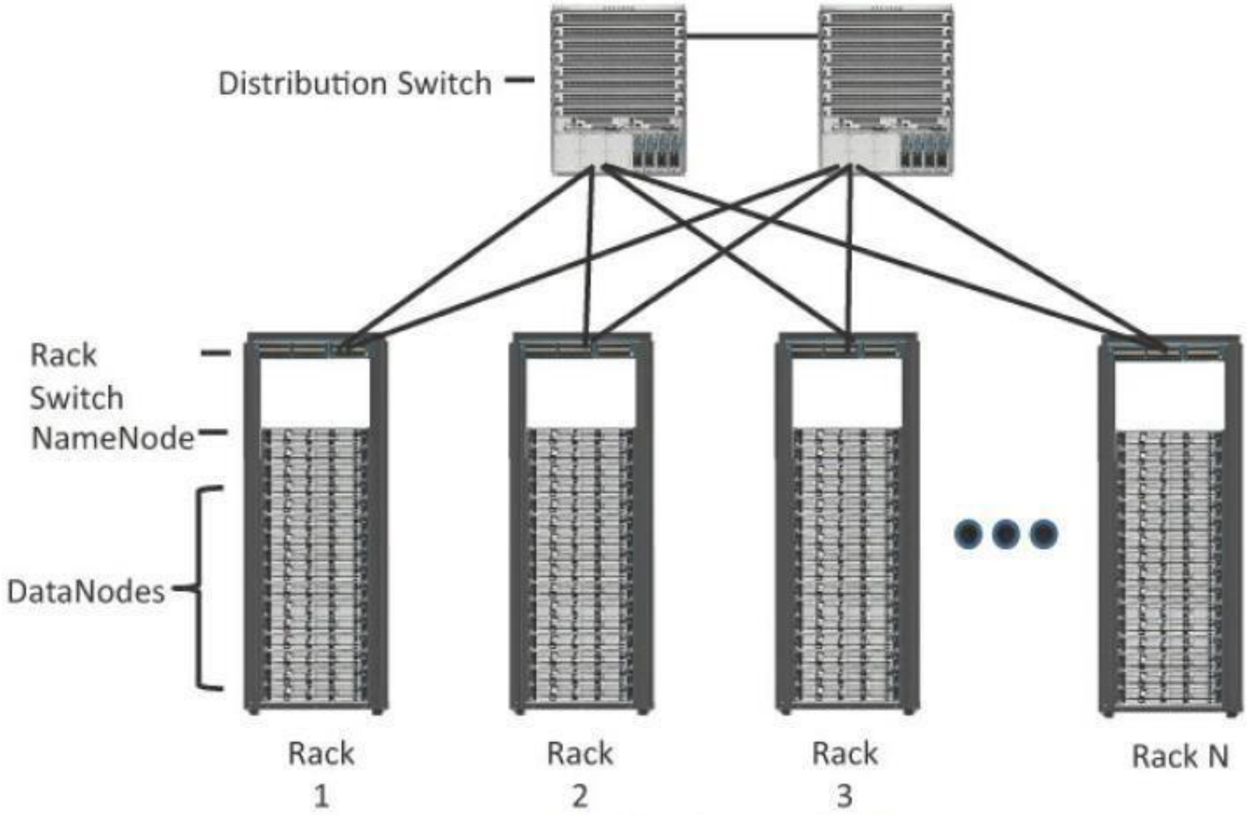
Prescriptive analysis looks at a variety of factors and makes the appropriate recommendation.

Q7. What is big data analytics. And explain the elements of HADOOP with a neat diagram Diagram

Hadoop

Hadoop is the most recent entrant into the data management market, but it is arguably the most popular choice as a data repository and processing engine. Hadoop was originally developed as a result of projects at Google and Yahoo!, and the original intent for Hadoop was to index millions of websites and quickly return search results for open source search engines. Initially, the project had two key elements:

- **Hadoop Distributed File System (HDFS):** A system for storing data across multiple nodes
- **MapReduce:** A distributed processing engine that splits a large task into smaller ones that can be run in parallel

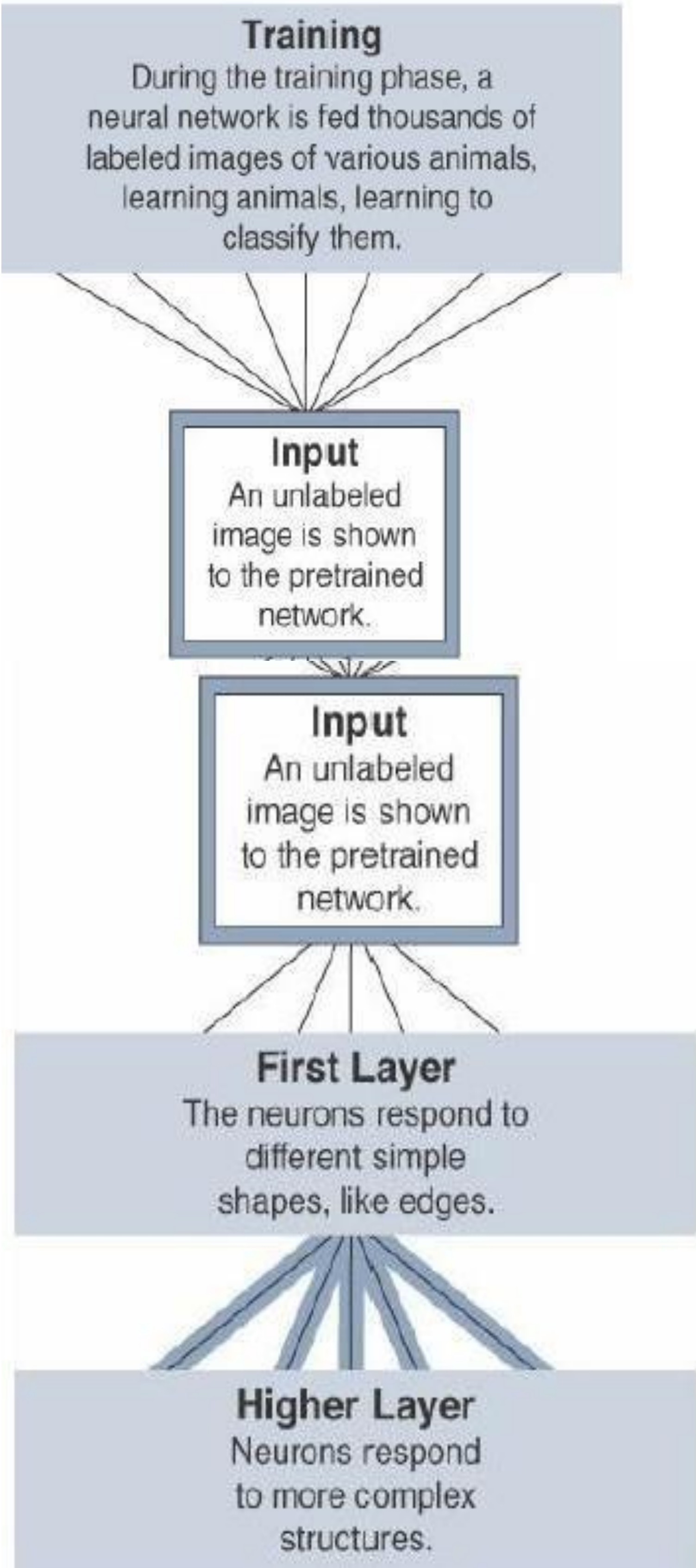


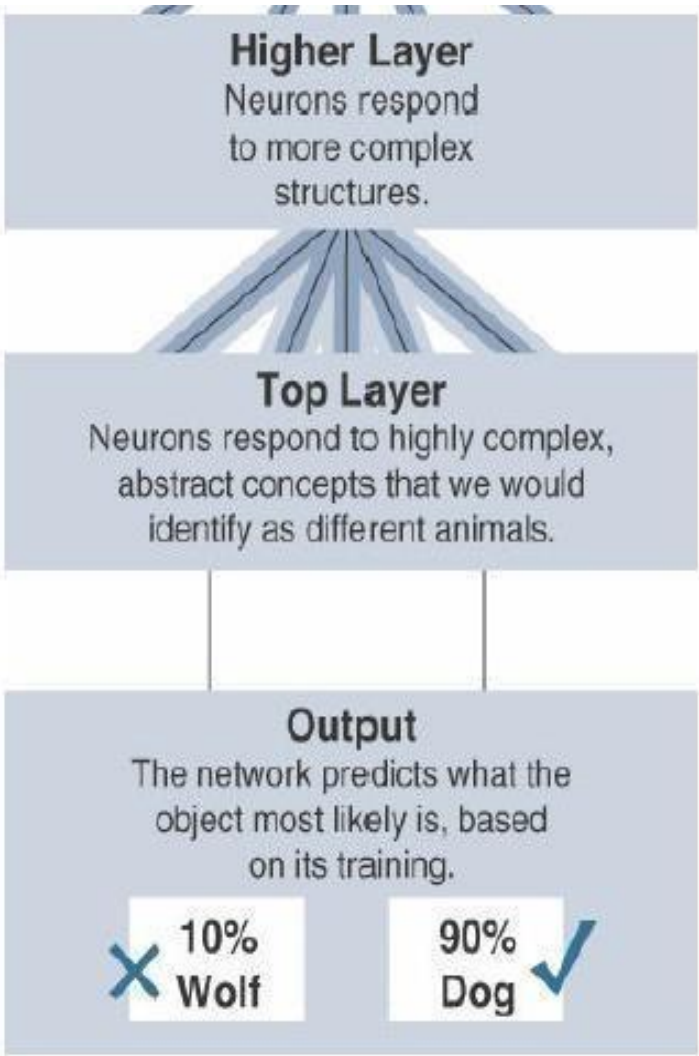
Distributed Hadoop Cluster

Q8. Explain neural network in Machine learning with the appropriate diagram and also explain supervised and unsupervised learning with an example each

Neural networks are ML methods
that mimic the way the human brain works. When you look at a human figure, multiple zones of your brain are activated to recognize colors, movements, facial expressions, and so on. Your brain combines these elements to conclude that the shape you are seeing is human. Neural networks mimic the same logic. The information goes through different algorithms (called *units*), each of which is in charge of processing an aspect of the information. The resulting value of one unit computation can be used directly or fed into another unit for further processing to occur. In this case, the neural network is said to have several layers.

How Neural Networks Recognize a Dog in a Photo

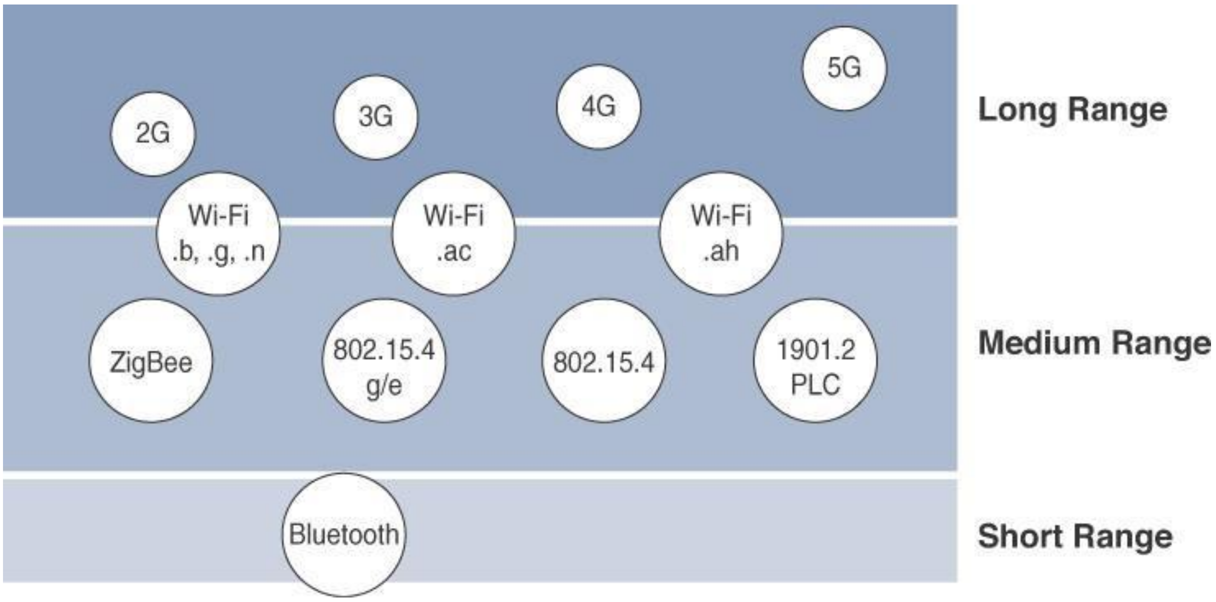




Q9. Explain the communication criteria's in detail

The characteristics and attributes considered when selecting and dealing with connecting smartobjects are

1)Range: It defines how far does the signal need to be propagated? That is, what will be the area of coverage for a selected wireless technology? The below figure 2.4 shows the range considered



- **Short Range:**

- The classical wired example is a serial cable.
- Wireless short-range technologies are often considered as an alternative to a serial cable, supporting tens of meters of maximum distance between two devices.
- Examples of short-range wireless technologies are IEEE 802.15.1 Bluetooth and IEEE 802.15.7 Visible Light Communications (VLC).
- These short-range communication methods are found in only a minority of IoTinstallations.

- **Medium Range:**
  - In the range of tens to hundreds of meters, many specifications and implementations are available.
  - The maximum distance is generally less than 1 mile between two devices.
- **Long Range**:
  - Distances greater than 1 mile between two devices require long-range technologies. Wireless examples are cellular (2G, 3G, 4G) and some applications of outdoor IEEE 802.11 Wi-Fi and Low-Power Wide-Area (LPWA) technologies.
  - LPWA communications have the ability to communicate over a large area without consuming much power.
  - These technologies are therefore ideal for battery-powered IoT sensors.
  - Found mainly in industrial networks, IEEE 802.3 over optical fiber and IEEE 1901 Broadband Power Line Communications are classified as long range but are not really considered IoT access technologies.

2) **Frequency Bands:**

- Radio spectrum is regulated by countries and/or organizations, such as the InternationalTelecommunication Union (ITU) and the Federal Communications Commission (FCC).
- These groups define the regulations and transmission requirements for various frequency bands.
- For example, portions of the spectrum are allocated to types of telecommunications such as radio, television, military, and so on.
- Focusing on IoT access technologies, the frequency bands leveraged by wireless communications are split between licensed and unlicensed bands.
- Licensed spectrum is generally applicable to IoT long-range access technologies and allocated to communications infrastructures deployed by services providers, public services (for example, first responders, military), broadcasters, and utilities.
- The ITU has also defined unlicensed spectrum for the industrial, scientific, and medical(ISM) portions of the radio bands.
- These frequencies are used in many communications technologies for short-range devices (SRDs).
- Unlicensed means that no guarantees or protections are offered in the ISM bands for device communications.

Power Consumption:

- Battery-powered nodes bring much more flexibility to IoT devices.
- These nodes are often classified by the required lifetimes of their batteries.
- A powered node has a direct connection to a power source, and communications areusually not limited by power consumption criteria.
- IoT wireless access technologies must address the needs of low power consumptionand connectivity for battery-powered nodes.
- This has led to the evolution of a new wireless environment known as Low-PowerWide-Area (LPWA).

Topology

- Among the access technologies available for connecting IoT devices, three maintopology schemes are dominant: star, mesh, and peer-to-peer.
- For long-range and short-range technologies, a star topology is prevalent, as seen withcellular, LPWA, and Bluetooth networks.
- Star topologies utilize a single central base station or controller to allow communications with endpoints.
- For medium-range technologies, a star, peer-to-peer, or mesh topology is common.
- Peer-to-peer topologies allow any device to communicate with any other device as longas they are in range of each other.
- Peer-to-peer topologies enable more complex formations, such as a mesh networkingtopology.

Constrained Devices:

Constrained nodes have limited resources that impact their networking feature set and capabilities.

Class	Definition
Class 0	This class of nodes is severely constrained, with less than 10 KB of memory and less than 100 KB of Flash processing and storage capability. These nodes are typically battery powered. They do not have the resources required to directly implement an IP stack and associated security mechanisms. An example of a Class 0 node is a push button that sends 1 byte of information when changing its status. This class is particularly well suited to leveraging new unlicensed LPWA wireless technology.
Class 1	While greater than Class 0, the processing and code space characteristics (approximately 10 KB RAM and approximately 100 KB Flash) of Class 1 are still lower than expected for a complete IP stack implementation. They cannot easily communicate with nodes employing a full IP stack. However, these nodes can implement an optimized stack specifically designed for constrained nodes, such as Constrained Application Protocol (CoAP). This allows Class 1 nodes to engage in meaningful conversations with the network without the help of a gateway, and provides support for the necessary security functions. Environmental sensors are an example of Class 1 nodes.
Class 2	Class 2 nodes are characterized by running full implementations of an IP stack on embedded devices. They contain more than 50 KB of memory and 250 KB of Flash, so they can be fully integrated in IP networks. A smart power meter is an example of a Class 2 node.

Q10. Explain LoRaWAN standard, alliance, MAC layer and security

LoRaWAN:

- It is an unlicensed-band LPWA(Low-Power Wide-Area) technology.

❖ **Standardization and Alliances**

- Optimized for long-range, two-way communications and low power consumption, thetechnology evolved from Layer 1 to a broader scope through the creation of the LoRa Alliance.
- The LoRa Alliance quickly achieved industry support and currently has hundreds ofmembers.

- LoRa Alliance uses the term LoRaWAN to refer to its architecture and its specificationsthat describe end-to-end LoRaWAN communications and protocols.
- Figure 2.16 provides a high-level overview of the LoRaWAN layers.

❖ **MAC Layer**

- The LoRaWAN specification documents three classes of LoRaWAN devices:
  - **Class A:**
    - This class is the default implementation.
    - Optimized for battery-powered nodes, it allows bidirectional communications, where a given node is able to receive downstreamtraffic after transmitting.
    - Two receive windows are available after each transmission.
  - **Class B:**
    - This class was designated "experimental" in LoRaWAN 1.0.1 untilit can be better defined.
    - A Class B node or endpoint should get additional receive windows compared to Class A, but gateways must be synchronized through abeaconing process.
  - **Class C:**
    - This class is particularly adapted for powered nodes.
    - This classification enables a node to be continuously listening by keeping its receive window open when not transmitting.

❖ **Security:**

- LoRaWAN endpoints must implement two layers of security, protectingcommunications and data privacy across the network.
- Security in a LoRaWAN deployment applies to different components of the architectureas shown in figure 2.19