Q13. Define IoT with its features, limitations and applications:

- ☐ The concept of connecting any device (physical object) to the internet and to other connected devices.
- ☐ IBM writes that IoT refers to " the growing range of internet connected devices that captures or generate an enormous amount of information every day.
- ☐ The Internet of things as "the vast network of devices connected to the internet , including smartphones, and tablets and almost anything with a sensor on it.These things collect and exchange data.
- ☐ IoT is the network of physical objects that contain embedded technology to communicate and sense or interact with their internal states or the external environment.

Features :-

1. Connectivity:
Connectivity refers to establish a proper connection between all the things of IoT to IoT platform it may be server or cloud. After connecting the IoT devices, it needs a high speed messaging between the devices and cloud to enable reliable, secure and bi-directional communication.

2. Sensing:
The sensor devices used in IoT technologies detect and measure any change in the environment and report on their status. IoT technology brings passive networks to active networks. Without sensors, there could not hold an effective or true IoT environment

3. Active Engagement:
IoT makes the connected technology, product, or services to active engagement between each other.

4. Analyzing:
After connecting all the relevant things, it comes to real-time analyzing the data collected and use them to build effective business intelligence.

5. Scalability: I
oT devices should be designed in such a way that they can be scaled up or down easily on demand. In general, IoT is being used from smart home automation to automating large factories and work stations, so the use cases vary in scale.

6. Dynamic Nature:
For any IoT use case, the first and foremost step is to collecting and converting data in such a way that means business decisions can be made out of it. In this whole process, various components of IoT need to change their state dynamically. For example, the input of a temperature sensor will vary continuously based on weather conditions, locations, etc. IoT devices should be designed this keeping in mind.

7. Energy :
From end components to connectivity and analytics layers, the whole ecosystems demand a lot of energy. While designing an IoT ecosystem, we need to consider design methodology such that energy consumption is minimal.

8. Integration: IoT integrates various cross-domain models to enrich user experience. It also ensures proper trade-off between infrastructure and operational costs.

Applications :-

1. BusinessAnalytics

IoT devices embedded in machines generate a large amount of data that is being used by BI (Business Intelligence tools) such as Power BI to generate useful insights and predict future outcomes.

With the help of business analytics tools, the data generated from IoT are used to study customer behavior to increase customer satisfaction rates and provide a better customer experience.
In the near future, BI tools will be embedded within things such as wearable health monitoring systems, which can make instant decisions based on the current data

Data recorded from the user's behavior and everyday habits will give better opportunities for the caretakers and hospitals to tackle any sickness in advance.

2. Medicine and Health care

Health care has been a major user of IoT applications, where IoT applications are helping the users to gather statistical data and further control and automate the medical process.

According to a recent survey, the IoT market share has been increased from USD $298 Billion in the year 2014 to USD $700 Billion in the year 2017.

IoT technology is being embedded in health care devices, including wearable and implantable devices used to monitor and improve patients' medical conditions. With the advancement in IoT in the medical and health care domain, investors and the public will benefit in many ways.

3. Entertainment System:
Several smart apps such as car navigation systems and voice assistance systems are already making their way to the cars. With the help of IoT, these features have been embedded in vehicles. Automakers have partnered with Google for their apps such as google maps, google assistant,and Play store services.

4. Smart city
Smart city IoT application is designed to provide improved and better-living conditions. With the growth in technology and population, IoT will play a major role in managing the city and population. Many services such as energy-saving lights, weather reporting systems, and streetlights will be embedded with IoT solutions for sustainable and cost-effective reasons

5. Smart Home:
home automation has seen rapid growth in recent times. Consumers have been provided with services like lightning control for their homes, voice-based controlling, smart air quality adjustment, AI experience, and smart locks with the IoT enabled in homes.

Limitations

- **Security:** As the IoT systems are interconnected and communicate over networks. The system offers little control despite any security measures, and it can be lead the various kinds of network attacks.
- **Privacy:** Even without the active participation on the user, the IoT system provides substantial personal data in maximum detail.
- **Complexity:** The designing, developing, and maintaining and enabling the large technology to IoT system is quite complicated.

Q14 Write the difference between consumer IoT and industrical IoT

	Industrial IoT	Consumer IoT
Benefit	IoT devices aim at improving complex industrial processes by supporting industrial equipment	CIoT devices automate daily tasks through consumer devices
Lifespan	These are robust devices that are designed for performance amidst extreme conditions	The lifespan of these devices is short and are constantly replaced by new versions
Goal	IIoT devices are aimed at safety and sustainability	CIoT devices are aimed at providing convenience
Network	These devices expand over wide networks. Their large-scale networks collect data from numerous data points	These devices run on smaller networks powered by data from a few points
Installation	Deployment of IIoT devices is done in remote areas and inaccessible terrains	These devices run on smaller networks powered by data from a few points
Power	These devices are primary battery-powered	These devices need a regular power supply
Impact	Malfunctioning of IIoT systems has widespread impact and may have fatal consequences	Malfunctioning of CIoT systems has local impact
Cost-Effectiveness	IIoT devices have high levels of robustness, scalability, security, and network longevity. They are expensive to deploy but have a longer life span	CIoT devices that are cost-effective but have and lower levels of robustness, scalability, security, and network longevity

Que 13

https://www.techtarget.com/iotagenda/definition/MQTT-MQ-Telemetry-Transport

https://www.spiceworks.com/tech/iot/articles/what-is-mqtt/

MQTT (Message Queuing Telemetry Transport) is a lightweight and widely used publish-subscribe messaging protocol designed for constrained devices and low-bandwidth, high-latency, or unreliable networks. It works on the client-server model and is often used in scenarios where efficiency, low overhead, and real-time communication are crucial, such as in the Internet of Things (IoT) applications.

Here's a brief overview of how MQTT works:

Publish-Subscribe Model:

- In MQTT, there are two main entities: publishers and subscribers.
- Publishers are devices or applications that send messages (publish) to a specific topic.
- Subscribers express interest in specific topics and receive messages related to those topics.

Broker:

- The MQTT broker is a server that acts as an intermediary between publishers and subscribers.
- Publishers send messages to the broker, and subscribers receive messages from the broker.
- The broker manages the distribution of messages based on the topics and the interests expressed by subscribers.

Message:

- Messages in MQTT are published to topics.
- Topics are hierarchical and provide a way to categorize and organize messages.
- Subscribers can express interest in specific topics, allowing them to receive messages related to those topics.

Quality of Service (QoS):

- MQTT supports different levels of Quality of Service to ensure message delivery.
- QoS levels include:
    - 0 (At most once): The message is delivered at most once, and delivery is not confirmed.
    - 1 (At least once): The message is delivered at least once, and delivery is confirmed.
    - 2 (Exactly once): The message is delivered exactly once by using a four-step handshake.

Connection Establishment:

- Clients (publishers and subscribers) connect to the MQTT broker.
- The connection can be secured using TLS/SSL for encryption and authentication.
- Clients can establish both short-lived and persistent connections.

Message Flow:

- Publishers send messages to the broker by specifying a topic and the content of the message.
- Subscribers express interest in specific topics by subscribing to them on the broker.

- When a message is published to a topic, the broker forwards the message to all subscribers interested in that topic.

Retained Messages:

- MQTT supports the concept of retained messages, where the broker retains the last message sent on a specific topic.
- When a new subscriber subscribes to a topic, it immediately receives the last retained message for that topic.

Last Will and Testament (LWT):

- Clients can specify a "Last Will and Testament" message when connecting to the broker.
- This message is defined by the client and will be sent by the broker to a specified topic if the client unexpectedly disconnects.

In summary, MQTT operates on a publish-subscribe model, with a broker facilitating communication between publishers and subscribers. It uses lightweight messages, supports various Quality of Service levels, and is designed for efficient communication in resource-constrained and unreliable network environments.

15 What is data ingestion? Explain the working process of data processing pipelines in IoT

https://hevodata.com/learn/data-ingestion-pipeline/

Q16 Describe sensors, Actuators and Transducers with its types and features.

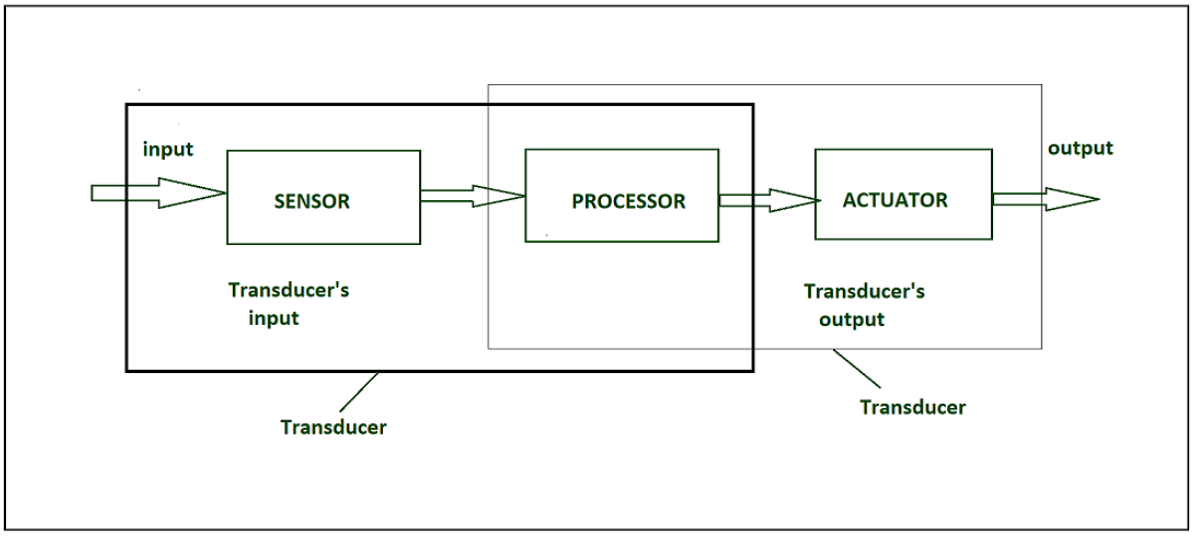
https://dzone.com/articles/type-of-sensors-and-actuators-in-iot

. Sensors:

- A sensor is a device that detects and measures physical properties or changes in the environment and converts this information into an electrical or digital signal. Sensors play a crucial role in collecting data for various

applications, including industrial automation, consumer electronics, healthcare, and the Internet of Things (IoT).

- A Sensor is a characteristic of any device or material to detect the presence of a particular physical quantity. The output of the sensor is a signal, which is converted to human readable form. It performs some function of input by sensing or feeling the physical changes in the characteristics of a system in response to stimuli.
- The input can be light, heat, motion, moisture, pressure, or any other environmental phenomena. sensors play a pivotal role in IoT which will make an ecosystem for collecting, analyzing, and processing data about a specific environment so that it can be monitored, managed, and controlled more easily and efficiently. Sensors bridge the gap between the physical world and the logical world.



Types of sensor

We live in the world of sensors, there are different types of sensors in our homes, offices, cars etc. by working to make our lives easier by turning on

the lights by detecting our presence, adjusting the room temperature, detect smoke or fire, make us delicious coffee, and automatic door closing and so on. here we will discuss types of sensors one by one in detail:

- **Temperature sensors: Monitoring temperature of used devices in industrial applications. it is used to measure temperature. this can be air temperature, liquid temperature or the temperature of solid. It can be analog or digital. In an Analog Temperature Sensor, the change in the Temperature correspond to change in its physical property like resistance or voltage. LM35 is a classic Analog Temperature Sensor. In Digital Temperature Sensor, the output is a discrete digital value, DS1621 is digital sensor which generates 9 bits temperature data.**
- **Accelerometer sensors: It measures the rate of change of velocity and this sensor generate magnitude and acceleration of the acceleration. Accelerometer sensor sensor ADXL335 provides 3 axes (X,Y, and Z) values in analog voltage. it is used in car electronics, ships, and agricultural machines.**
- **Radiation sensors: Radiation Sensors/Detectors are electronic devices that sense the presence of alpha, beta, or gamma particles and provide signals to counters and display devices. Radiation detectors are used for surveys and sample counting.**
- **Position sensors: Position Sensors are electronic devices used to sense the positions of valves, doors, throttles, etc. and supply signals to the inputs of control or display devices. Key specifications include sensor type, sensor function, measurement**

range, and features that are specific to the sensor type. Position sensors are used wherever positional information is needed in a myriad of control applications. A common position transducer is a so-called string-pot, or string potentiometer.

- Gas sensors: It measures and detects concentration of different gases which is present in the atmosphere or any other environment.
- Torque sensors: This sensor is used for measuring the rotating torque and it is used to measure the speed of the rotation.
- Optical sensors: it is also called photosensors which can detect light waves at different points in the light spectrum including ultraviolet light, visible light, and infrared light. it is extensively used in smartphone, robotics and Blu-ray players.
- Proximity sensors: This sensor is used to detect the distance between two objects or detect the presence of an object. it is used in elevators, parking lots, automobiles, robotics, and numerous other environment.
- Touch sensors: Touch sensing devices detect physical contact on a monitored surface. Touch sensors are used extensively in electronic devices to support trackpad and touchscreen technologies. They’re also used in many other systems, such as elevators, robotics and soap dispensers.
- Image sensor: it is used for distance measurement, pattern matching, color checking, structured lighting, and motion capture and it is also used in different applications such as 3D imaging,

video/broadcast, space, security, automotive, biometrics, medical, and machine vision.

Features of sensors :-

- Sensitivity: Ability to detect small changes in the measured quantity.
- Accuracy: Degree of precision in measurement.
- Resolution: Smallest detectable change in the measured quantity.
- Response Time: Time taken to respond to a change in the environment.
- Range: The range of values the sensor can measure.
- Linearity: Relationship between input and output is linear.
- Drift: Changes in sensor readings over time.

2. Actuators:

An actuator is a device that converts electrical signals or energy into physical motion. Actuators are essential components in systems where control and automation of physical processes are required. They are commonly used in robotics, industrial machinery, and various mechatronic applications.

An actuator is a machine component or system that moves or controls the mechanism of the system. Sensors in the device sense the environment, then control signals are generated for the actuators according to the actions needed to perform.

1. Hydraulic: These actuators harness hydraulic power to perform mechanical functions and operations. Generally, these types of actuators are powered by a cylinder or a fluid motor. According to the requirements and recommendations, the mechanical motion is converted into oscillatory, linear, or rotary.

2. Pneumatic: Pneumatic actuators create two types of motions, rotary or linear. They are powered by a vacuum or compressed air at high pressure to implement the required type of motion. Compared to other types of actuators, pneumatic actuators are low-cost and low-maintenance actuators.

3. Electrical: In these actuators, a motor converts electrical energy into mechanical motion. These actuators are powered by electricity and provide precision control. These actuators are heavily used in industrial settings to automate mechanical operations.

4. Thermal: The thermal actuators have thermal-sensitive material fitted inside, which is used to produce linear motion. The word thermal implies that these actuators are used in response to temperature changes. The most popular use case includes shutting off valves and operating latches or switches.

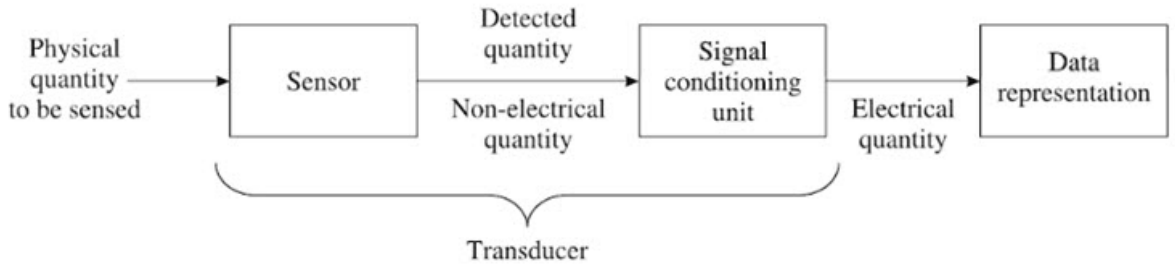
5. Magnetic: These types of actuators convert electromagnetic energy into mechanical output and operate in a linear or rotary direction. Magnetic actuators can provide continuous mechanical operation and are popularly used in the automotive and aerospace industries.

Features of Actuators:

- Speed: Rate at which the actuator can move.
- Force or Torque: The capability to exert force or rotational force.
- Precision: Degree of accuracy in positioning.
- Power Consumption: Amount of energy required for operation.
- Responsiveness: Time taken to respond to a control signal.
- Durability: Ability to withstand repeated use.

Transducers:

A transducer is a device that converts one form of energy into another. It can function both as a sensor and an actuator, depending on the application. Transducers are versatile devices used for measurement, control, and signal processing.



Types :-

Piezoelectric Transducer

A piezoelectric transducer is a special kind of sensor, and the main function of this transducer is to convert mechanical energy into electrical energy. In the same way, electrical energy can be transformed into mechanical energy.

. Mechanical Transducers

As mentioned earlier, mechanical transducers are a set of primary sensing elements that respond to changes in a physical quantity with a mechanical output. As an example, a Bimetallic Strip is a mechanical Transducer, which reacts to changes in temperature and responds with mechanical displacement. The mechanical transducers are differentiated from electrical transducers as their output signals are mechanical.

- Optical Transducers: Convert light or optical signals into electrical signals.
- Thermoelectric Transducers: Convert temperature differences into electrical voltage
- Electromagnetic Transducers: Convert electrical energy to magnetic or vice versa.
- Electrochemical Transducers: Involve chemical reactions and electrical energy.

Features of Transducers:

- Sensitivity: Ability to respond to small changes in input.
- Linearity: Relationship between input and output is linear.
- Frequency Response: Range of frequencies the transducer can handle.
- Accuracy: Precision in converting one form of energy to another.
- Dynamic Range: Range of input values over which the transducer operates effectively.