Internet of Things
Unit - I

By - Monu Kumar (JRF)

Internet Of Things

1. The Internet of Things (IoT) describes the network of physical objects—“things”—that are embedded with sensors, software and other technologies for the purpose of connecting and exchanging data with other devices and systems over the internet.
2. The internet of things or IoT, is a network of interrelated devices that connect and exchange data with other IoT devices and the cloud.
3. IoT devices are typically embedded with technology such as sensors and software and can include mechanical and digital machines and consumer objects.
4. With IoT, data is transferable over a network without requiring human-to-human or human-to-computer interactions.
5. A *thing* in the internet of things can be a person with a heart monitor implant, a farm animal with a biochip transponder, an automobile that has built-in sensors to alert the driver when tire pressure is low or any other natural or man-made object that can be assigned an Internet Protocol address and is able to transfer data over a network.

How does IoT work?

1. An IoT ecosystem consists of web-enabled smart devices that use embedded systems such as processors, sensors and communication hardware - to collect, send and act on data they acquire from their environments.
2. IoT devices share the sensor data they collect by connecting to an IoT gateway, which acts as a central hub where IoT devices can send data. Before the data is shared, it can also be sent to an edge device where that data is analyzed locally. Analyzing data locally reduces the volume of data sent to the cloud, which minimizes bandwidth consumption.
3. Sometimes, these devices communicate with other related devices and act on the information they get from one another. The devices do most of the work without human intervention, although people can interact with the devices - for example to set them up, give them instructions or access the data.
4. The connectivity, networking and communication protocols used with these web-enabled devices largely depend on the specific IoT applications deployed.

Why is Internet of Things(IoT) so important?

1. Over the past few years, IoT has become one of the most important technologies of the 21st century. Now that we can connect everyday objects—kitchen appliances, cars, thermostats, baby monitors—to the internet via embedded devices, seamless communication is possible between people, processes and things.
2. By means of low-cost computing, the cloud, big data, analytics and mobile technologies, physical things can share and collect data with minimal human intervention.
3. In this hyperconnected world, digital systems can record, monitor and adjust each interaction between connected things. The physical world meets the digital world—and they cooperate.

What are the benefits of IoT to organizations?

IoT offers several benefits to organizations. Some benefits are industry-specific and some are applicable across multiple industries. Common benefits for businesses include the following:

1. **Monitors overall business processes.**
2. **Improves the customer experience.**
3. **Saves time and money.**
4. **Enhances employee productivity.**
5. **Provides integration and adaptable business models.**
6. **Enables better business decisions.**
7. **Generates more revenue.**

What are the pros and cons of IoT?

Some of the advantages of IoT include the following:

1. **Enables access to information from anywhere at any time on any device.**
2. **Improves communication between connected electronic devices.**
3. **Enables the transfer of data packets over a connected network, which can save time and money.**
4. **Collects large amounts of data from multiple devices, aiding both users and manufacturers.**
5. **Analyzes data at the edge, reducing the amount of data that needs to be sent to the cloud.**
6. **Automates tasks to improve the quality of a business's services and reduces the need for human intervention.**
7. **Enables healthcare patients to be cared for continually and more effectively.**

What are the pros and cons of IoT?

Some of the disadvantages of IoT include the following:

1. **Increases the attack surface as the number of connected devices grows. As more information is shared between devices, the potential for a hacker to steal confidential information increases.**
2. **Makes device management challenging as the number of IoT devices increases. Organizations might eventually have to deal with a massive number of IoT devices and collecting and managing the data from all those devices could be challenging.**
3. **Has the potential to corrupt other connected devices if there's a bug in the system.**
4. **Increases compatibility issues between devices, as there's no international standard of compatibility for IoT. This makes it difficult for devices from different manufacturers to communicate with each other.**

IoT Standards

Notable organizations that are involved in the development of IoT standards include the following:

1. **International Electrotechnical Commission.**
2. **Institute of Electrical and Electronics Engineers (IEEE).**
3. **Industrial Internet Consortium.**
4. **Open Connectivity Foundation.**
5. **Thread Group.**
6. **Connectivity Standards Alliance.**

IoT Frameworks

IoT frameworks include the following:

1. **Amazon Web Services (AWS) IoT is a cloud computing platform for IoT released by Amazon. This framework is designed to enable smart devices to easily connect and securely interact with the AWS cloud and other connected devices.**
2. **Arm Mbed IoT is an open source platform to develop apps for IoT based on Arm microcontrollers. The goal of this IoT platform is to provide a scalable, connected and secure environment for IoT devices by integrating Mbed tools and services.**
3. **Microsoft Azure IoT Suite platform is a set of services that let users interact with and receive data from their IoT devices, as well as perform various operations over data, such as multidimensional analysis, transformation and aggregation, and visualize those operations in a way that's suitable for business.**
4. **Calvin is an open source IoT platform from Ericsson designed for building and managing distributed applications that let devices talk to each other. Calvin includes a development framework for application developers, as well as a runtime environment for handling the running application.**

Consumer and Enterprise IoT Applications

1. There are numerous real-world applications of the internet of things, ranging from consumer IoT and enterprise IoT to manufacturing and IIoT. IoT applications span numerous verticals, including automotive, telecom and energy.
2. In the consumer segment, for example, smart homes that are equipped with smart thermostats, smart appliances and connected heating, lighting and electronic devices can be controlled remotely via computers and smartphones.
3. Wearable devices with sensors and software can collect and analyze user data, sending messages to other technologies about the users with the aim of making users' lives easier and more comfortable. Wearable devices are also used for public safety - for example, by improving first responders' response times during emergencies by providing optimized routes to a location or by tracking construction workers' or firefighters' vital signs at life-threatening sites.
4. In healthcare, IoT gives providers the ability to monitor patients more closely using an analysis of the data that's generated. Hospitals often use IoT systems to complete tasks such as inventory management for both pharmaceuticals and medical instruments.

Consumer and Enterprise IoT Applications

5. Smart buildings can, for instance, reduce energy costs using sensors that detect how many occupants are in a room. The temperature can adjust automatically - for example, turning the air conditioner on if sensors detect a conference room is full or turning the heat down if everyone in the office has gone home.
6. In agriculture, IoT-based smart farming systems can help monitor light, temperature, humidity and soil moisture of crop fields using connected sensors. IoT is also instrumental in automating irrigation systems.
7. In a smart city, IoT sensors and deployments, such as smart streetlights and smart meters, can help alleviate traffic, conserve energy, monitor and address environmental concerns and improve sanitation.

What are the IoT Applications?

1. The Internet of Things can be used in many different aspects of life, in both the private and public sectors. Thanks to IoT, people can track things like lost pets, their house's security systems or appliance maintenance schedule.
2. Consumers can use the IoT to help them make restaurant reservations, monitor their exercise progress and overall health, and receive coupons for a store only by virtue of walking by the business in question.
3. Businesses can use IoT to monitor supply chains, track customers' spending habits as well collect their feedback, monitor and maintain inventory levels, and engage in predictive maintenance of their machines and devices.
4. The IoT also proves helpful in ITIL, which is a set of IT service management, an important detail, since IT departments are called on to do more and more in a world that's getting increasingly digital, with more reliance on wireless networks.
5. Blockchain, which is being increasingly used as a more efficient and secure method of transaction and data processing, is a natural beneficiary of IoT technology. We can expect to see IoT and Blockchain coming together more often in the future.

Top Applications of IoT

But how do different industries apply the Internet of Things to make things more efficient?

Top Applications of IoT

1. IoT Applications in Agriculture: For indoor planting, IoT makes monitoring and management of micro-climate conditions a reality, which in turn increases production. For outside planting, devices using IoT technology can sense soil moisture and nutrients, in conjunction with weather data, better control smart irrigation and fertilizer systems. If the sprinkler systems dispense water only when needed, for example, this prevents wasting a precious resource.
2. IoT Applications in Consumer Use: For the private citizen, IoT devices in the form of wearables and smart homes make life easier. Wearables cover accessories such as Fitbit, smartphones, Apple watches, health monitors, to name a few. These devices improve entertainment, network connectivity, health, and fitness. Smart homes take care of things like activating environmental controls so that your house is at peak comfort when you come home. Dinner that requires either an oven or a crockpot can be started remotely, so the food is ready when you arrive. Security is made more accessible as well, with the consumer having the ability to control appliances and lights remotely, as well as activating a smart lock to allow the appropriate people to enter the house even if they don't have a key.

Top Applications of IoT

3. **IoT Applications in Healthcare: First and foremost, wearable IoT devices let hospitals monitor their patients' health at home, thereby reducing hospital stays while still providing up to the minute real-time information that could save lives. In hospitals, smart beds keep the staff informed as to the availability, thereby cutting wait time for free space. Putting IoT sensors on critical equipment means fewer breakdowns and increased reliability, which can mean the difference between life and death. Elderly care becomes significantly more comfortable with IoT. In addition to the above-mentioned real-time home monitoring, sensors can also determine if a patient has fallen or is suffering a heart attack.**

Functions of Human Computer Interaction(HCI) in the context of IoT

The functions of Human-Computer Interaction (HCI) in the context of the Internet of Things (IOT) are crucial for ensuring that IOT systems and devices are user-friendly, efficient, and provide a positive user experience. Here are some of the key functions of HCI in the context of IOT:

1. User-Centered Design: HCI principles place the user at the center of the design process. In the IOT, this means understanding user needs, behaviours, and preferences to design IOT systems that meet their requirements. This user-centric approach is essential for creating devices and interfaces that people can easily interact with.
2. Usability Testing: HCI methodologies, such as usability testing and user feedback, are used to evaluate the effectiveness and efficiency of IOT interfaces. This helps in identifying and resolving usability issues, ensuring that users can easily set up, control, and monitor IOT devices.

Functions of Human Computer Interaction(HCI) in the context of IoT

3. Interface Design: HCI experts design intuitive and aesthetically pleasing interfaces for controlling and monitoring IOT devices. These interfaces should be easy to navigate, understand, and visually appealing to enhance the user experience.
4. Accessibility: Accessibility is a core aspect of HCI. When applied to IOT, it ensures that devices and interfaces are designed to accommodate users with disabilities, such as those who are visually impaired, hearing impaired, or have mobility limitations. IOT technology should be accessible to a broad range of users.
5. Feedback and Adaptation: HCI can be used to design systems that gather user feedback and adapt based on user interactions. IOT devices can learn from user behaviour and preferences, improving their performance and efficiency over time.

Functions of Human Computer Interaction(HCI) in the context of IoT

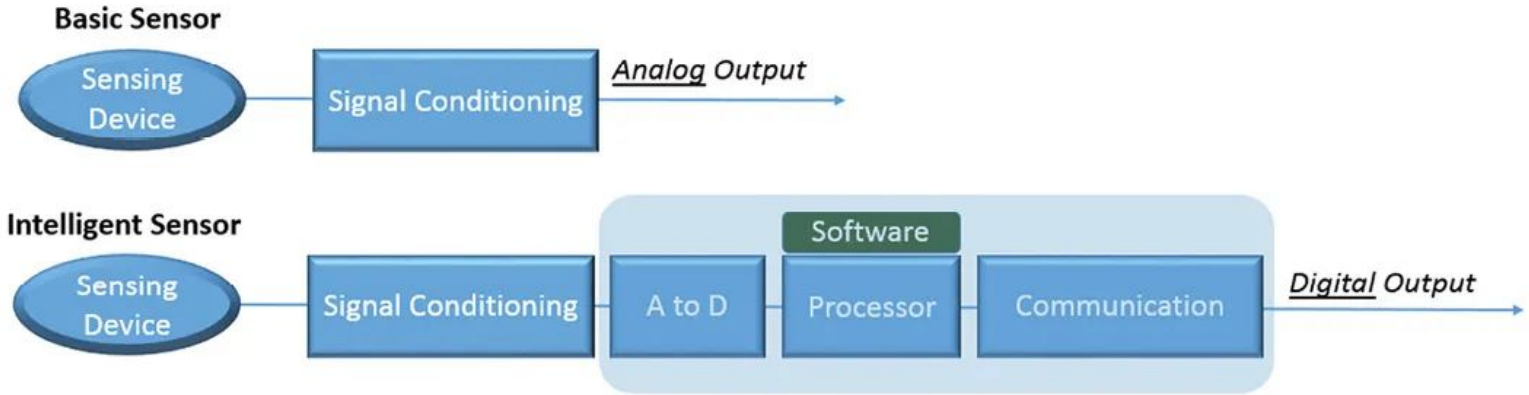
6. Customization: HCI allows for personalization and customization of IOT systems to match individual user needs and preferences. Users should have the ability to tailor the behaviour of IOT devices to their liking.
7. Integration of Multimodal Interfaces: HCI in IOT can involve the integration of multiple interaction modes, including voice commands, touchscreens, gesture control, and more. This accommodates various user preferences and abilities.
8. Emphasis on Privacy and Security: HCI principles can be applied to design user-friendly security and privacy features in IOT devices. Users need to have control over their data and feel confident that their privacy is protected.

Functions of Human Computer Interaction(HCI) in the context of IoT

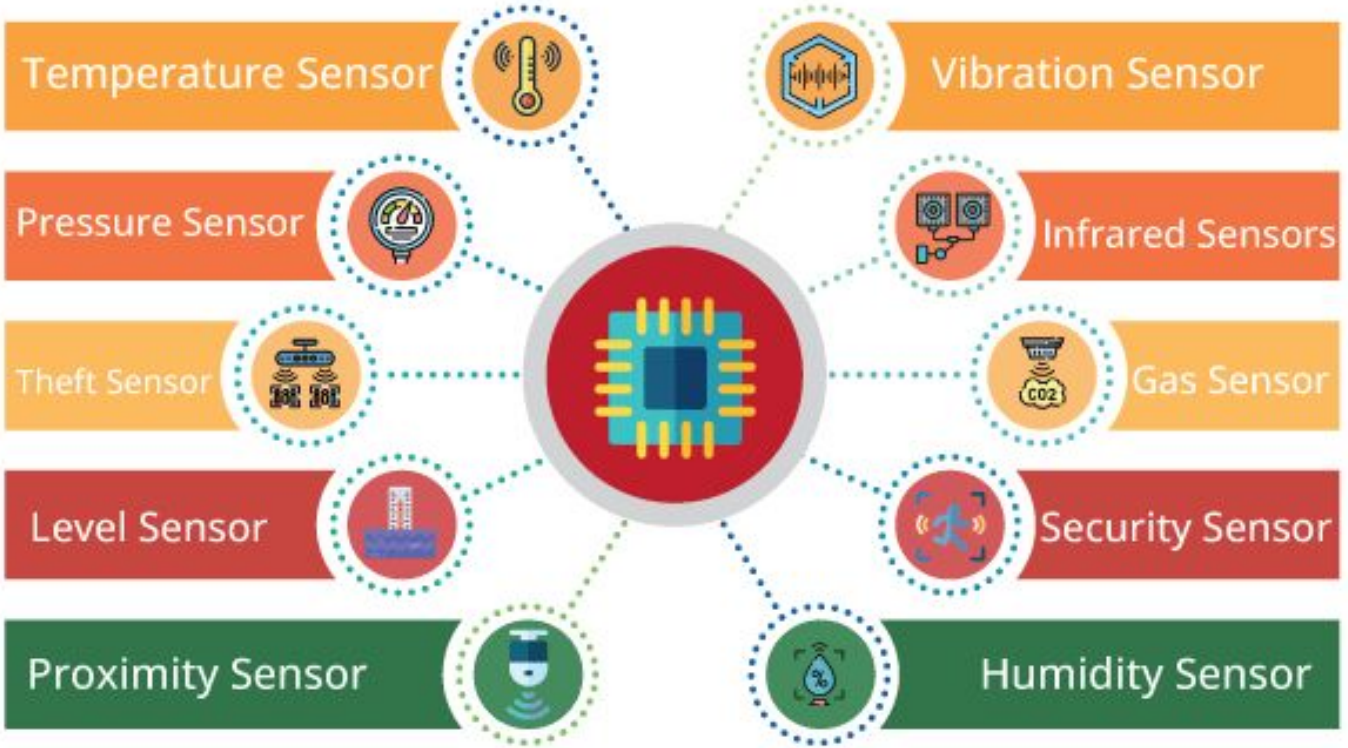
9. Reducing Cognitive Load: HCI aims to minimize the cognitive load on users when interacting with IOT systems. Clear and intuitive interfaces, as well as well-organized information, reduce the mental effort required to operate devices.
10. Continuous Improvement: HCI principles support the iterative improvement of IOT systems based on user feedback and evolving needs. Continuous monitoring and user testing help in keeping IOT systems up to date and aligned with changing user requirements.

Sensors

1. Sensors are used for sensing things and devices etc.
2. A device that provides a usable output in response to a specified measurement. The sensor attains a physical parameter and converts it into a signal suitable for processing (e.g. electrical, mechanical, optical) the characteristics of any device or material to detect the presence of a particular physical quantity.
3. The output of the sensor is a signal which is converted to a human-readable form like changes in characteristics, changes in resistance, capacitance, impedance etc.



Types of Sensors



Classification of Sensors

- Passive & Active
- Analog & digital
- Scalar & vector

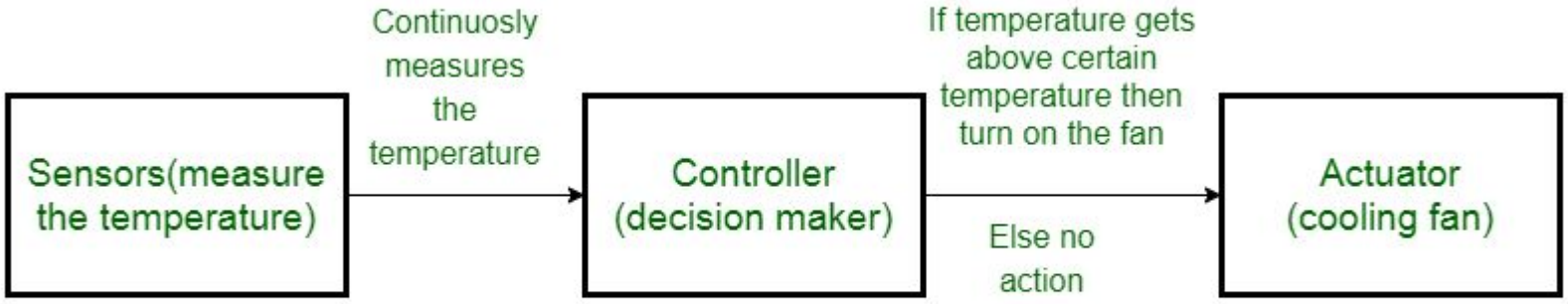
1. Passive Sensor – Can not independently sense the input.
   Ex- Accelerometer, soil moisture, water level and temperature sensors.
2. Active Sensor – Independently sense the input.
   Example- Radar, sounder and laser altimeter sensors.
3. Analog Sensor – The response or output of the sensor is some continuous function of its input parameter.
   Ex- Temperature sensor, LDR, analog pressure sensor and analog hall effect.
4. Digital sensor – Response in binary nature. Design to overcome the disadvantages of analog sensors. Along with the analog sensor, it also comprises extra electronics for bit conversion.
   Example – Passive infrared (PIR) sensor and digital temperature sensor(DS1620).

Classification of Sensors

5. Scalar sensor – Detects the input parameter only based on its magnitude. The answer for the sensor is a function of magnitude of some input parameter. Not affected by the direction of input parameters.
   Example – temperature, gas, strain, color and smoke sensor.
6. Vector sensor – The response of the sensor depends on the magnitude of the direction and orientation of input parameter.
   Example – Accelerometer, gyroscope, magnetic field and motion detector sensors.

Actuators

1. An IoT device is made up of a Physical object (“thing”) + Controller (“brain”) + Sensors + Actuators + Networks (Internet).
2. 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.
3. A servo motor is an example of an actuator. They are linear or rotatory actuators, can move to a given specified angular or linear position.
4. We can use servo motors for IoT applications and make the motor rotate to 90 degrees, 180 degrees, etc., as per our need.
5. The following diagram shows what actuators do, the controller directs the actuator based on the



Types of Actuators

1. Hydraulic Actuators – A hydraulic actuator uses hydraulic power to perform a mechanical operation. They are actuated by a cylinder or fluid motor. The mechanical motion is converted to rotary, linear, or oscillatory motion, according to the need of the IoT device. Ex- construction equipment uses hydraulic actuators because hydraulic actuators can generate a large amount of force.

Advantages :

- Hydraulic actuators can produce a large magnitude of force and high speed.
- Used in welding, clamping, etc.
- Used for lowering or raising the vehicles in car transport carriers.

Disadvantages :

- Hydraulic fluid leaks can cause efficiency loss and issues of cleaning.
- It is expensive.
- It requires noise reduction equipment, heat exchangers, and high maintenance systems.

Types of Actuators

2. Pneumatic Actuators – A pneumatic actuator uses energy formed by vacuum or compressed air at high pressure to convert into either linear or rotary motion. Example- Used in robotics, use sensors that work like human fingers by using compressed air.

Advantages :

- **They are a low-cost option and are used at extreme temperatures where using air is a safer option than chemicals.**
- **They need low maintenance, are durable, and have a long operational life.**
- **It is very quick in starting and stopping the motion.**

Disadvantages :

- **Loss of pressure can make it less efficient.**
- **The air compressor should be running continuously.**
- **Air can be polluted, and it needs maintenance.**

Types of Actuators

3. Electrical Actuators – An electric actuator uses electrical energy, is usually actuated by a motor that converts electrical energy into mechanical torque. An example of an electric actuator is a solenoid based electric bell.

Advantages :

- It has many applications in various industries as it can automate industrial valves.
- It produces less noise and is safe to use since there are no fluid leakages.
- It can be re-programmed and it provides the highest control precision positioning.

Disadvantages :

- It is expensive.
- It depends a lot on environmental conditions.

Types of Actuators

Other actuators are –

4. Thermal/Magnetic Actuators – These are actuated by thermal or mechanical energy. Shape Memory Alloys (SMAs) or Magnetic Shape-Memory Alloys (MSMAs) are used by these actuators. An example of a thermal/magnetic actuator can be a piezo motor using SMA.
5. Mechanical Actuators – A mechanical actuator executes movement by converting rotary motion into linear motion. It involves pulleys, chains, gears, rails, and other devices to operate. Example – A crankshaft.
6. Soft Actuators
7. Shape Memory Polymers
8. Light Activated Polymers
9. With the expanding world of IoT, sensors and actuators will find more usage in commercial and domestic applications along with the pre-existing use in industry.