UNIT 3

IOT ENABLING TECHNOLOGIES

3	**IoT Enabling Technologies**	**IoT Enabling Technologies --** Wireless Sensor Networks , Cloud Computing ,Big Data Analytics, Communication Protocols,Embedded Systems	**08**

INRODUCTION:

Machine -to-machine (M2M) services have revolutionized the wireless world leading to the evolution of a plethora of technologies and services to support M2M. M2M services are closely tied to the IoT device world, and hence the mobile technologies and services that have evolved to support M2M are part of IoT ecosystem as well.

[3] IoT ENABLING TECHNOLOGIES

3.1 Wireless Sensor Networks

Sensors:

- Sensing is tending to be ubiquitous. Sensors are being touted as the eyes and ears of next-generation software applications. A number of technologies especially miniaturization, networking, communication, and so on are contributing immensely to the unprecedented success of the sensing paradigm. Sensors are becoming exceptionally tiny to be easily disposable, disappearing, and yet elegantly deft.
- Therefore, sensors, which are typically low-cost, power, and memory systems, are gradually and graciously penetrative, pervasive, and persuasive. Sensors are becoming smart in the sense that they are able to conserve and preserve their battery energy in order to prolong their lives.
- Smart sensors are capable of buffering and transmitting the data captured or generated. Sensors are increasingly complying with the mesh topology toward increased manoeuvrability and reliability. Sensors are mainly for environmental and asset monitoring.
- All kinds of physical, mechanical, electrical, electronics, and IT systems are being fitted with a variety of sensors for monitoring, measuring, and managing various aspects, conditions, and situations of the systems. For example, all kinds of vehicles and their body parts are being fitted with smart sensors in order to proactively and pre-emptively attend their needs in time so that any kind of collapse

and failure can be prevented. Smartphones are being embedded with numerous sensors.

WSN:

- A wireless sensor network (WSN) is a network formed by a large number of sensor nodes where each node is equipped with a sensor to detect different physical phenomena such as light, heat, pressure, presence, and gas.
- WSNs are regarded as a revolutionary information gathering method to build next-generation people-centric IoT applications.

WSN Application:

Architecture of an Energy Harvesting Terminal for a Wireless Sensor Network

- A wireless sensor terminal generally consists of a sensor that is used for sensing the surroundings and a master control unit (MCU) for processing the collected data and for performing other system control activities.
- A wireless chip is also present for providing support for wireless communications. Instead of a dry cell battery, a power IC that is matched to the power-generating element in the wireless sensor network (WSN) is present in the wireless sensor network node. These components are depicted in Figure.
- The power generating element used should be carefully selected after taking into con-sideration the type of energy that is collected from the surrounding environment, that is, whether it is vibration, light, or heat. The most common elements which are used are as follows:
  - **Solar**
  - **Piezoelectric**
  - **Thermoelectric**
- It is also necessary to ensure that the power IC to be used with the power-generating element should be able to efficiently collect the power from that element without loss, and that it is capable of supplying the stabilized power to a later stage IC.

- The generated power for each WSN changes as per the size and the generating environment. When integrating energy harvester into a device, it is necessary to identify the following carefully:
    - ➢ What type of energy will be obtained
    - ➢ What size of an energy harvester can actually fit on a device
    - ➢ What will be the balance present in the device between consumption power and the generation power
- Another important aspect to be considered for choice of power IC is that it should match the power generating element present in the WSN.
- To be specific, the voltage or current output characteristics of the power generating element will vary according to the element, and it is mandatory to choose a power IC that will provide optimal results.

Figure:

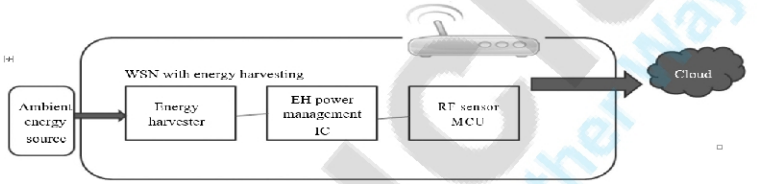

Figure 2.9 Energy harvesting in WSN.

It is also very important to ensure correct choice of wireless communication mechanism for a WSN terminal. Following are the key parameters to be kept in mind for choice of wireless communication channel:

- ➢ **Communication distance**
- ➢ **Type of network that is going to be built**
- ➢ **The amount of data which are transmitted**
- ➢ **The type of application under consideration**
- ➢ **Power consumption requirements**

Out of the parameters listed above, in the context of energy harvesting, the critical aspect to be considered is to reduce power consumption. So, the wireless technologies that are commonly used are ZigBee and Bluetooth low energy (BLE).

- One important aspect to be considered for energy harvesting is striking a balance between generated power and consumed power. This is critical mainly because of the fact that the device will not work if the power generated is lesser than the power consumed.
- Although the power generating features of power generating elements are continuously improving, it is challenging to continuously supply power to a device.

- One approach is to collect and store the generated power in a capacitor and then supply the power for sensor operation at regular time intervals. This will help to provide a method to balance power generation with power consumption.

In order to balance the generated power to the consumed power, developers need to correctly calculate factors such as:

- Power collection time for power collecting element
- Usable electric load

This calculation requires trial and error even when generated power and estimated power can be calculated accurately.

- When the values of generated power and consumed power are not accurate, it is a good practice to calculate optimal values in each instance.
- Implementing this estimation effort is highly challenging in a real-time scenario. There is a component called energy harvesting starter kit that helps speed up development of energy harvesting for a WSN.
- This kit has an RF component that typically works at 2.4 GHz, and the component also contains a protocol implementation that is customized for low-power consumption. It is also possible to change the protocol to ZigBee or BLE by replacing the corresponding chip.
- Development of devices that use energy harvesting power ICs are growing in a quick paced manner and has found diverse applications in diverse fields.
- In some situations, energy harvesting provides battery free WSN terminals, whereas in other cases, energy harvesting extends battery life.

3.2 CLOUD COMPUTING:

- Cloud computing refers to a model of computing in which IT-based services are made available to the end users on a pay-to-use basis over the Internet.
- The IT services include software applications, platforms for building applications and huge amounts of storage space, and other infra-structural components, which are needed by the various organizations.
- Cloud computing provides a cost-effective and viable alternative for deploying IT-based city strategies and IT-based society initiatives, as the usage of cloud models for deploying these services does not involve any capital expenditure.

- Cloud-based technologies are already creating a wave of IT innovation across the cities because of the cost effectiveness and simplicity of use, which is offered by this model.

Example of Cloud Computing in IoT:

[1] Cloud Computing for Smart Airport:

Present day airports across the world are embracing cloud computing because of the immense cost benefits offered by it.
The main crux of cloud computing is anytime, anywhere access to all types of resources which are included as part of IT ecosystem as and when the user requires it.
The cost benefit part of it stems from the fact that the user needs to pay only as per the usage.

Following are the main benefits offered by cloud computing to airports:

- The infrastructural components which are required for maintaining the entire IT infrastructure of the airports is provided and maintained by the cloud service provider. This removes the capital expenditure component from the airport infrastructure management which in turn provides huge cost benefits for the airport authorities.
- From an environmental perspective, as cloud-based solutions typically use only pooled hardware resources, there is less energy consumption which helps to reduce carbon emissions. Additionally, through the use of shared resources, e-waste can be reduced by a substantial margin.

Apart from the airport authorities, facility to use cloud computing services at airports becomes a very handy option for many air travel passengers to store and access data created by them while in transit at airports and access high-end applications, which are hosted in cloud infrastructure without any infrastructure limitations.

[2] Cloud Computing in Health Care Sector:

- Present day health care organizations are in tremendous pressure to cut down infrastructure cost and replace their existing aging infrastructure. In addition to this, heath care sector generates huge amounts of data on a continuous basis like electronic medical record (EMR) and other patient-related data like scanning reports which have huge sizes.
- For storing and managing such huge amounts of data, significant investment is required by the health care organizations.

- Cloud computing provides lucrative options for the health care organizations to implement new technologies for diverse aspects like electronic management of health care records which otherwise requires significant infrastructure investments.
- Health care organizations can utilize the services offered by cloud service providers to replace their aging infrastructure with new applications and solutions which offer more flexibility.
- The main use cases of cloud computing in the health care sector are summarized in Figure 10.7.

FIGURE:

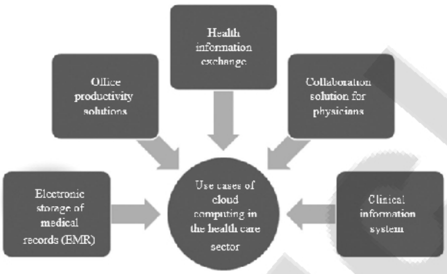

Figure 10.7 Use cases of cloud computing in health care.

3.3 BIG DATA ANALTYICS

- Big data represents huge volumes of data in petabytes, exabytes, and zettabytes in near future. As we move around the globe, we leave a trail of data behind us.
- Business to consumer (B2C) and consumer to consumer (C2C) e-commerce systems, and business to business (B2B) e-business transactions, online ticketing, and payments, web 1.0 (simple web), web 2.0 (social web), web 3.0 (semantic web), web 4.0 (smart web), still and dynamic images, and so on are the prominent and dominant sources for data.
- Sensors and actuators are deployed in plenty in specific environments for context awareness and for enabling the occupants and owners of the environments with a new set of hitherto unforeseen services.
- In short, every kind of integration, interaction, orchestration, automation, acceleration, augmentation, and operation produces streams of decision enabling data to be plucked and put into transactional and analytical data stores for initiating analytics and mining activities.
- Big data is the general term used to represent massive amounts of data that are not stored in the relational form in traditional enterprise- scale databases.

- New-generation database systems are based on symmetric multiprocessing (SMP) and massively parallel processing (MPP) techniques. These are being framed in order to store, aggregate, filter, mine, and analyse big data efficiently.

The following are the general characteristics of big data:

- Data storage is defined in the order of petabytes, exabytes, and so on in volume to the current storage limits (gigabytes and terabytes).
- There can be multiple structures (structured, semi structured, and less-structured) for big data.
- Multiple types of data sources (sensors, machines, mobiles, social sites, etc.) and resources for big data.
- Data are time-sensitive (near real-time as well as real-time). That means big data consists of data collected with relevance to the time zones so that time-sensitive insights can be extracted.

Example of Big Data Analytic in IoT:

[1] Big Data Analytics in the Health Care Sector:

Different types of data get into health care systems from wide range of devices like fitness devices, genomics research, social media networks, and a variety of other sources.

Most of this data have huge sizes, and they are of different formats which include both structured and unstructured types of data.

Hence, big data analytics has also found a lot of traction into the health care sector off late. If big data analytics is used effectively in the health care sector, it can provide lot of benefits like:

- Detection and prevention of infections at an early stage
- Providing right kind of treatment based on the correct identification of disease symptoms
- Early identification of new types of pathogens
- Devising new drug discovery mechanisms against the new type of pathogens

There are different stakeholders for the application of big data analytics in health care sector.

Each of them has a different expectation about the outcome of big data analytics in the health care sector. The different stakeholders are summarized in Figure 10.8.

FIGURE:

Figure 10.8 Stakeholders of big data analytics in health care sector.

- ***Patients*:** They want an application which would provide them a dashboard to compare the services and the associated costs of the various health care providers. This would help the patients to choose the most cost-effective health care provider for them.
- ***Researchers**:* They want to use big data analytical tools to perform predictive modelling and other types of sophisticated statistical analyses in order to derive valuable insights and find out ways to solve unsolved problems which exist in the health care sector.
- ***Pharmaceutical companies*:** They want to use big data analytics to identify the causes of dis-eases quickly, identify candidates for specific types of drugs, and design efficient clinical trials in order to prevent failures. Pharmaceutical companies are also interested to use big data analytics to predict future disease trends so that they channelize their drug discovery attempts in those directions.
- ***Providers*:** They want to use big data tools and technologies in order to get quick and real-time access to patient information. This will help them in their decision-making process and will in turn go a long way in providing timely and quick medical care to the patients.
- ***Payers*:** They want to use big data to help them stratify population risk and guide them to adopt more sustainable business models that would promote their growth and development.

The different use cases for big data analytics in health care are shown in Figure 10.9.

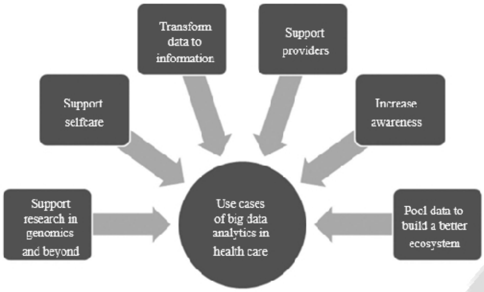

Figure 10.9 Use cases of big data analytics in health care.

[2] Big Data Analytics for Smarter Transport:

- As vehicles become networked devices, automakers and wireless telecommunication carriers are able to collect different kinds of data, especially driver-generated data such as automotive performance and driving patterns.
- Further on, hundreds of sensors embodied in every advanced vehicle produce a large amount of tactic as well as strategic data to be carefully collected and subjected to a stream of polished investigations that ultimately assist handsomely to finalize the viable means of bringing in more assuaging automations.
- In a nutshell, the amount of data generated by smart cars is expected to grow dramatically over the upcoming years. This emphasizes the need for high-performance data analytics solutions in order to conceptualize cognitive services for next-generation vehicles.
- The combination of significant rise in the production of connected car sales and a growing amount of information coming from the connected cars will result in the collection of some 11.1 petabytes of connected car data by 2020 according to a new IHS Automotive study.
- Today, auto manufacturers are systematically using the data they collect from connected cars for things like internal diagnostics, location, and vehicle status. Thus, the real-time analytics of vehicles' data is to seed a breed of innovations for car makers, owners, and occupants.
- With the faster proliferation and penetration of promising connectivity technologies, vehicles are being empowered to have newer capabilities through seamless and spontaneous interactions with other vehicles on the road, vehicle manufacturers and mechanics, insurance providers, product vendors, and so on.
- With cloud connectivity, a bevy of nimbler services and applications can be made available to drivers and occupants. Besides making driving simpler, safer, and satisfying, those inside vehicles could be more productive through e-learning, e-commerce, entertainment, gaming, and infotainment.

- Application platforms are emerging and inspiring worldwide software developers to conceptualize and concretize sophisticated services for vehicles and their users.
- The platform features include data and application integration, data-driven knowledge discovery and dissemination, information visualization, and so on.
- Through these vehicle-specific and cloud-based application development platforms, a growing array of next-generation vehicle-enablement services and applications are being created and deposited in cloud application stores to be accessed and used by smartphones and in-vehicle infotainment systems and dashboards to substantially elevate the comfort, care, choice, and convenience levels of vehicle owners, drivers, and occupants.

3.4 COMMUNICATION PROTOCOLS

- One definition of IoT is connecting devices to the Internet that were not previously connected. A factory owner may connect high-powered lights.
- A triathlete may connect a battery-powered heart-rate monitor.
- A home or building automation provider may connect a wireless sensor with no line power source.
- But the important thing here is that in all the above cases the *thing* must communicate through the Internet to be considered an *IoT* node. Since it must use the Internet, it must also adhere to the Internet engineering task force (IETF) Internet Protocol Suite.
- However, the Internet has historically connected resource -rich devices with lots of power, memory, and connection options. As such, its protocols have been considered too heavy to apply wholesale applications in the emerging IoT.
- There are other aspects of the IoT that also drive modifications to IETF's work. In particular, networks of IoT end nodes will be lossy, and the devices attached to them will be very low power, saddled with constrained resources, and expected to live for years.
- The requirements for both the network and its end devices might look like Table . This new model needs new, lighter weight protocols that do not require a large amount of resources.
- Considering these unique needs, gaining a deeper knowledge of IoT connectivity and data transmission protocols is paramount. This chapter is specifically crafted for that.

Table: -The IoT Devices Networking Requirements

IoT End Network Requiren	Networking Style Impact
Self-healing/scalable	Mesh capable
Secure	Scalable to no, low, medium, and high secu without overburdening clients
End-node addressability	Device-specific addressing scalable to thousands of nodes
Device Requirements	**Messaging Protocol Impact**
Low power/battery-operate	Lightweight connection, preamble, packet
Limited memory	Small client footprint, persistent state in cas overflow
Low cost	Ties to memory footprint

3.6 EMBEDDED SYSTEM

- Unlike traditional computer-based systems, IoT devices are "embedded" within other devices in order to provide enhanced functionality without exposing the user to the complexities of a computer.
- The users interact with the device in a natural way, similar to their interactions with any other objects in the world. In this way, an embedded system has an interface that conforms to the expectations and needs of the users.
- Establishing a natural interface requires that the embedded system interface with the physical world directly through sensors, which read the state of the world, and actuators, which change the state of the world.
- Embedded systems are part and parcel of every modern electronic component. These are low power consumption units that are used to run specific tasks for example remote controls, washing machines, microwave ovens, RFID tags , sensors, actuators and thermostats used in various applications, networking hardware such as switches, routers, modems, mobile phones, PDAs, etc.

- Usually embedded devices are a part of a larger device where they perform specific task of the device.
- For example, embedded systems are used as networked thermostats in Heating, Ventilation and Air Conditioning (HVAC) systems, in Home Automation embedded systems are used as wired or wireless networking to automate and control lights, security, audio/visual systems, sense climate change, monitoring, etc.
- Embedded systems will also be at the cornerstone for the deployment of many Internet of Things (IoT) solutions, especially within certain industry verticals and Industrial Internet of Things (IIoT) applications.
- Major players in embedded system hardware and software developments are aiming to bring these transformations into their products to take advantage of growing IoT market.
- The areas that are going to transform are Real Time Operating Systems (RTOS) and microprocessors and microcontrollers, followed by memory footprints and networking, open source communities and developers.