Module 5

IOT CASE STUDIES AND FUTURE TRENDS

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Vehicular IoT

Introduction :

- The increasing number of vehicles gives rise to the problem of parking. However, the evolution of IoT helps to form a connected vehicular environment to manage the transportation systems efficiently.
- Vehicular IoT systems have penetrated different aspects of the transportation ecosystem, including on-road to off-road traffic management, driver safety for heavy to small vehicles, and security in public transportation.
- In a connected vehicular environment, vehicles are capable of communicating and sharing their information.
- IoT enables a vehicle to sense its internal and external environments to make certain autonomous decisions.
- With the help of IoT infrastructure, a vehicle owner can easily track his vehicle.

Architecture of Vehicular IOT

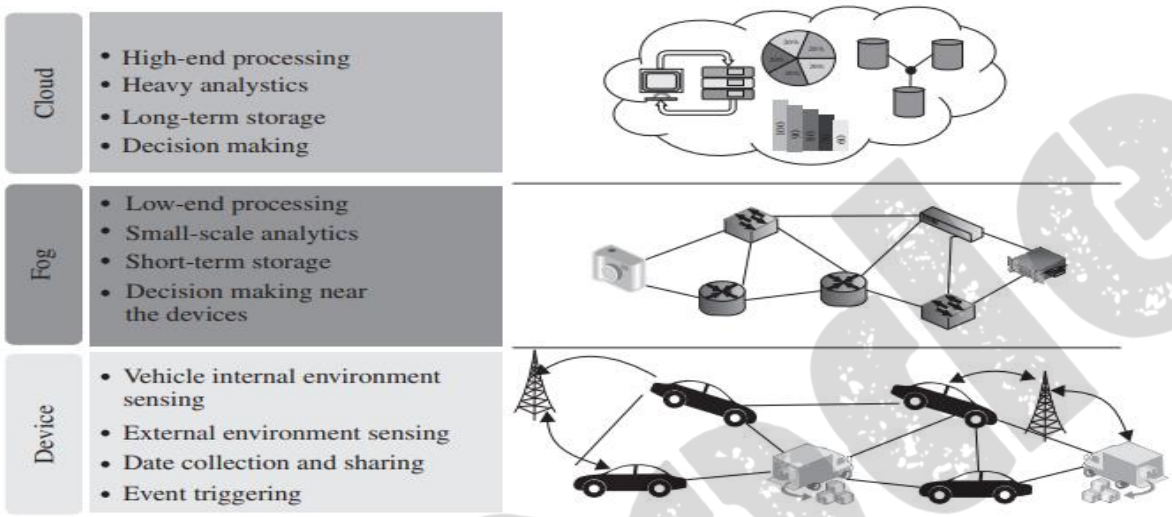
The architecture of the vehicular IoT is divided into three sublayers:

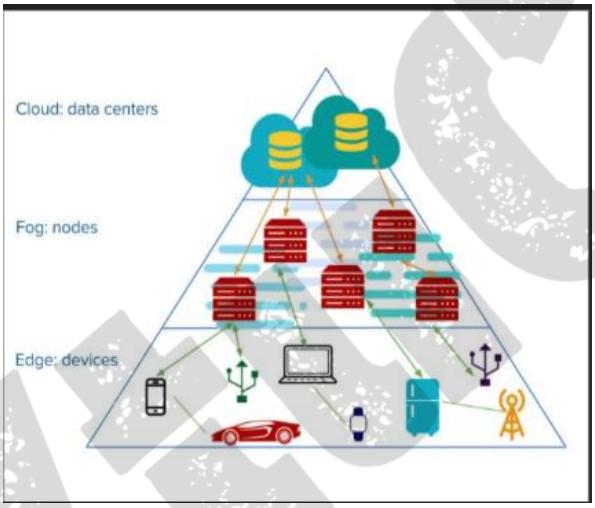
Device , Fog and Cloud

1. Device :

- The device layer is the bottom-most layer
- This layer consists of the basic infrastructure of the scenario of the connected vehicle.
- This layer includes the vehicles and road side units (RSU).
- These vehicles contain certain sensors which gather the internal information of the vehicles.
- The RSU works as a local centralized unit that manages the data from the vehicles.
- 2. Fog :
- Fast decision making is essential to avoid accidents and traffic mismanagement.
- Fog computing plays a crucial role by providing decisions in real-time.

- The fog layer helps to minimize data transmission time in a vehicular IoT system.
- 3. Cloud :
- cloud computing helps to handle processes that involve a huge amount of data.
- Cloud computing is responsible for long term storage of the data.





Components of vehicular IoT

- The components required for vehicular IoT systems are
- 1.sensors : sensors monitor different environmental conditions and help to make the system more economical, efficient, and robust. There are two types of sensors: internal and external sensors.

• **Internal sensors**	• **External sensors**
• sensors are placed within the vehicle. • The vehicles are equipped with different electronic components such as processing boards and actuators. • The internal sensors in a vehicle are connected with the processor board, to which they transmit the sensed data. Further, the sensed data are processed by the board to take certain predefined actions	• External sensors quantify information of the environment outside the vehicle. • Sensors to sense vacant parking lots. • On-road cameras to capture still images and videos. • Camera sensors to capture the image of license plate of an vehicle at the traffic signal.
• Example : GPS, fuel gauge, ultrasonic sensors, proximity sensors, accelerometer, pressure sensors, and temperature sensors	• Example : Temperature, Rainfall, and light sensors

- 2. Satellites : Satellites help the system to track vehicles and detect on-road crashes. The satellite image is also useful for detecting on-road congestions and road blocks.
- 3. Wireless connectivity : For transmitting the sensed data from multiple sensors to RSU (roadside unit) and from RSUs to the cloud, connectivity plays an indispensable role. Communication technologies, such as Wi-Fi, Bluetooth, and GSM, are common in the vehicular IoT systems.
- 4. Road Side Unit (RSU): The RSUs are equipped with sensors, communication units, and fog devices. Vehicular IoT systems deal with time critical applications, which need to take decisions in real time. The RSU transmits the sensed data to the cloud end. RSU s also work as an intermediate communication agent between two vehicles.
- 5. Cloud and fog computing: Fog computing handles the light-weight processes geographically closer to the vehicles than the cloud. This is suitable for fast decision making in vehicular IOT systems. Cloud computing determines regular on-road congestion and predictions. Cloud end needs to process a huge amount of instantaneous data as well as historical data.
- 6. Analytics: Data analytics is required to predict on-road traffic conditions that may occur at a location after an hour.

Advantages of vehicular IoT

- Few advantages of vehicular IOT includes :
- (i) Easy tracking: The tracking of vehicles is an essential part of vehicular IoT. The system must know from which location and which vehicle the system is receiving the information. The system can collect information at a remote location.

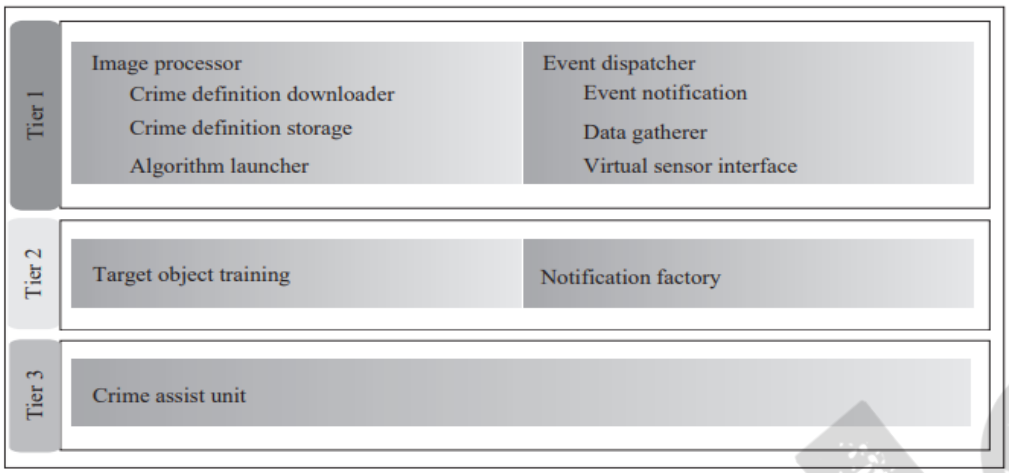
- (ii) Fast decision making : Fast and active decision making are pertinent for avoiding accidents. In the vehicular IoT environment, cloud and fog computing help to make fast decisions with the data received from the sensor-based devices.

(iii) Connected vehicles: A vehicular IoT system provides an opportunity to remain connected and share information among different vehicles.

- (iv) Easy management: vehicular IoT systems consist of different types of sensors, a communication unit, processing devices, and GPS. The connectivity among different components in a vehicular IoT enables systems to track every activity in and around the vehicle. the IoT infrastructure helps in managing the huge number of users located at different geographical coordinates.
- (v) Safety : Safety is one of the most important advantages of a vehicular IoT system. The internal and external sensors placed at different locations play an important role in providing safety to the vehicle, its occupants, as well as the people around it.
- (vi) Record : The record may be of any form, such as video footage, still images, and documentation. By taking advantage of cloud and fog computing architecture, the vehicular IoT systems keep all the required records in its database.

Crime assistance in a smart IoT transportation system

- This is a case study on smart safety in a vehicular IoT infrastructure.
- The system highlights a fog framework for intelligent public safety in vehicular environments (fog-FISVER)
- The primary aim of this system is to ensure smart transportation safety (STS) in public bus services.
- This includes following three steps :
- (i) The vehicle is equipped with a smart surveillance system, which is capable of executing video processing and detecting criminal activity in real time.
- (ii) A fog computing architecture works as the mediator between a vehicle and a police vehicle.
- (iii) A mobile application is used to report the crime to a nearby police agent.
- Fog-FISVER is based on a three-tiered architecture:
- (i) Tier1 : This tier accumulates the real sensed data from within the vehicle and processes it to detect possible criminal activities.
- This tier is responsible for creating crime-level metadata and transferring the required information to the next tier.
- Tier 1 consists of two subsystems: Image processor and event dispatcher.



- Image Processor : developers have used a deep learning approach for enabling image processing techniques. A raspberry pi-3 processor board is used which is equipped with high quality camera. The image processor stores a set of crime object templates in the fog.
- This consists of three parts :

a) Crime definition downloader	(b) Crime definition storage	(c) Algorithm launcher:
This checks for presence of new crime object template definitions in fog.	The crime definition storage is used to store all the possible crime object template definitions.	This is used to match the template with the video captured by the camera.

- Event Dispatcher : The event dispatcher is responsible for accumulating the data sensed from vehicles and the image processor.
- The components of the event dispatcher are as follows:

(a) Event notifier	(b) Data gatherer	(c) Virtual sensor interface
It transfers the data to the fog-FISVER STS fog infrastructure	This is an intermediate component between the event notifier and the physical sensor; it helps to gather sensed data	The virtual sensor interface helps to maintain a particular procedure to gather data. This component also cooperates to register the sensors in the system.

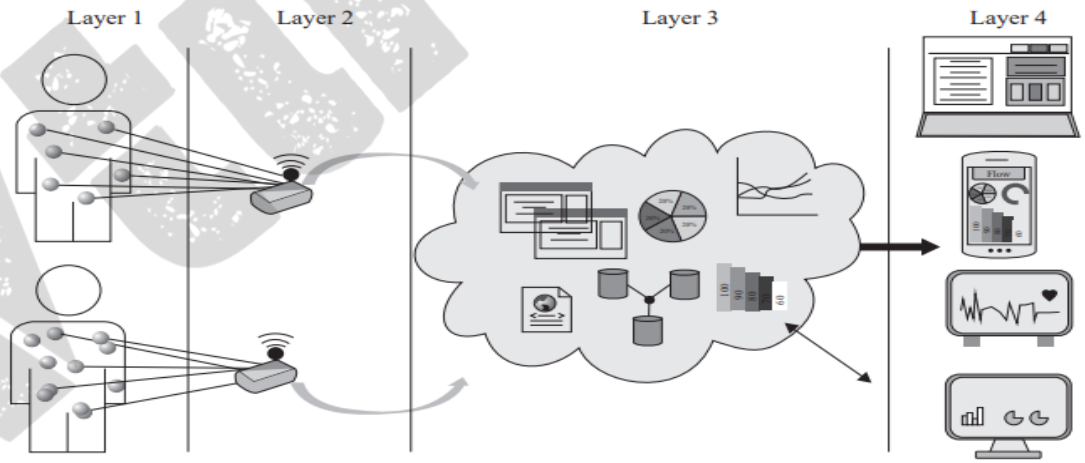
- (ii) Tier 2—FISVER STS Fog Infrastructure:
- This tier has three responsibilities :
- keep updating the new object template definitions
- classifying events
- finding the most suitable police vehicle to notify the event.

- FISVER STS fog infrastructure is divided into two sub-components

Target Object Training	Notification Factory
creating, updating, and storing the crime object definition	This sub-component receives notification about the events in a different vehicle with the installed system.

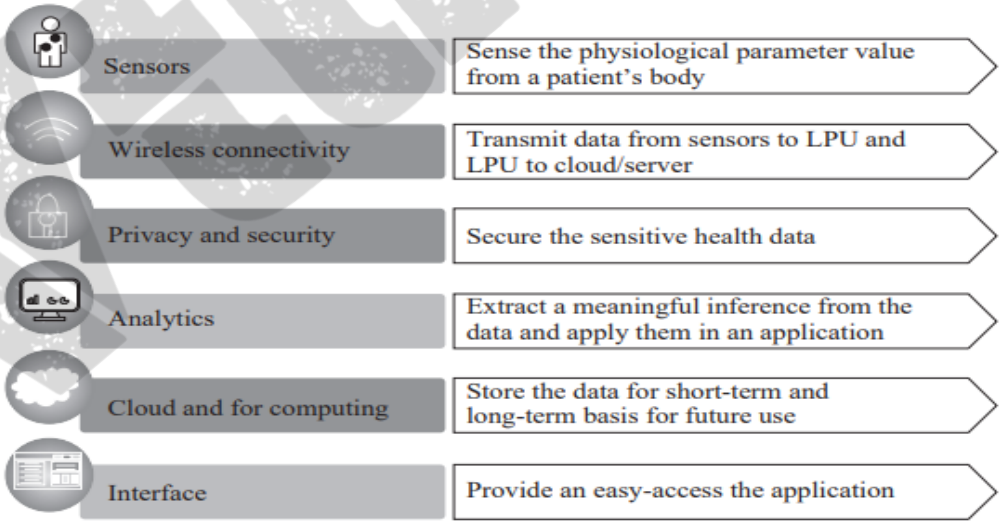
- (iii) Tier 3 :
- This consists of mobile applications that are executed on the users' devices. The application helps a user, who witnesses a crime, to notify the police.

Healthcare IoT

- IoT-enabled healthcare devices are in wide use around the globe for diagnosing human diseases, monitoring human health conditions, caring/monitoring for elders, children, and even infants.
- IoT-based healthcare systems and services help to increase the quality of life for common human beings.
- IoT-based healthcare devices provide access and knowledge about human physiological conditions through hand held devices.
- Users can be aware of the risks in acquiring various diseases and take necessary precautions to avoid preventable diseases.
- The sensors are specifically designed to measure and quantify different physiological conditions of its users/patients.
- It has 4 layers.
- 

- (i) Layer 1: Layer 1 contains different physiological sensors that are placed on the human body.
- (ii) Layer 2 : Layer 1 delivers data to Layer 2 for short-term storage and low-level processing. The devices that belong to Layer 2 are commonly known as local processing units (LPU) or centralized hubs. These units collect the sensed data from the physiological sensors attached to the body and processes it.

- (iii) Layer 3 : This layer consists of cloud architecture or high-end servers. Post analysis of data, some inferences or results are provided.
- (iv) Layer 4 : The end-users directly interact with Layer 4 through cellphones, computers, and tablets.
- Components of Healthcare IOT
- i) Sensors : Layer 1 mainly consists of physiological sensors that collect the physiological parameters of the patient.
- Few sensors are pulse and oxygen in blood (spo2), airflow, temperature etc.
- (ii) Wireless Connectivity : the communication between the wearable sensors and local processing unit is through either wired or wireless connectivity. i.e Bluetooth and Zigbee.
- The communication between the LPU and the cloud or server takes place with Internet connectivity such as WiFi and WLAN.
- the communication between the LPU and the cloud or server takes place with Internet connectivity such as WiFi and WLAN.
- (iii) Privacy and Security : if any of the health data of a patient is missing or theft, it leads to serious security breach and ensuing lawsuits. Hence different healthcare service providers and organizations are implementing healthcare data encryption and protection schemes.
- (iv) Analytics : This helps to convert the raw data into information. This enables several actors such as doctors, nurses, and patients, access the healthcare information in a different customized format. Analytics is also used for diagnosing a disease from the raw physiological data available.



- (v) Cloud and Fog Computing : the sensors produce a huge amount of heterogeneous data. These data are used for checking the patient's history, current health status, and future for diagnosing different diseases and the symptoms of the patient. cloud storage

space is used to store health data. cloud storage space is scalable, where payment is made as per the usage of space.

- (vi) Interface : The interface is the most important component for users in a healthcare IoT system. The user interface must be designed in such a way that it can depict all the required information clearly and, if necessary, reformat or represent it such that it is easy to understand.

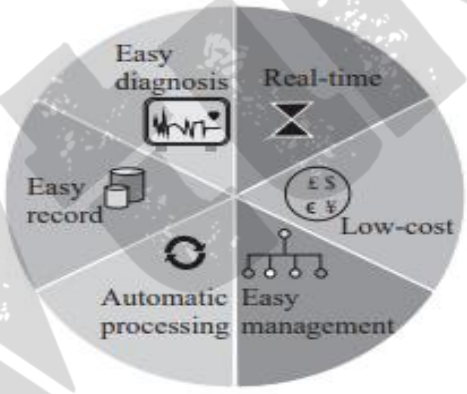
Advantages of healthcare IoT

1.Real-time : A healthcare IoT system enables users, such as doctors, end users at the patient-side, and staff in a healthcare unit, to receive real-time updates about the healthcare IoT components.

healthcare IoT system can enable a doctor to observe a patient's health condition in real-time even from a remote location, and can suggest the type of care to be provided to the patient.

the staff in a healthcare unit are better aware of the current situation of their unit, which includes the number of patients admitted, availability of the doctors and bed, total revenue of the unit

- 2. Low cost :
- an authorized user can easily find the availability of the beds in a hospital with simple Internet connectivity and a web-browser-based portal.
- The user need not visit the hospital physically to check the availability of beds and facilities.
- 3. Easy management : healthcare IoT facilitates easy and robust management of all the entities (such as users, medical devices, facilities, costs, and security)
- 4. Automatic processing: Healthcare IoT enables end-to-end automatic processing in different units and also consolidates the information across the whole chain: from a patient's registration to discharge.



- 5. Easy record-keeping : A healthcare unit must also track its condition and financial transactions for further development of the unit. A healthcare IoT enables the user to keep these records in a safe environment and deliver them to the authorized user as per requirement.
- 6. Easy diagnosis : The diagnosis of the disease becomes easier with the help of certain learning mechanisms along with the availability of prior datasets.

Risk in healthcare IoT

Loss of connectivity : Intermittent connectivity may result in data loss, which may result in a life-threatening situations for the patient. Proper and continuous connectivity is essential in a healthcare IoT system.

Security: The healthcare system must keep the data confidential. This data should not be accessible to any unauthorized person but in IOT, the risk of data tampering and unauthorized access is quite high.

Error: A huge amount of data needs to be fed into the system in order to perform accurate analytics. errors in data may lead to misinterpretation of symptoms and lead to the wrong diagnosis of the patient. It is a challenging task to construct an error-free system.

Case study – AmbuSens system

- The Smart Wireless Applications and Networking (SWAN) laboratory at the Indian Institute of Technology Kharagpur developed a system: AmbuSens. The system was primarily funded by the Ministry of Human Resource and Development (MHRD) of the Government of India.
- The primary objectives of the AmbuSens system are :
- 1. Digitization and standardization of the healthcare data, which can be easily accessed by the registered hospital authorities.
- 2. Real-time monitoring of the patients who are in transit from one hospital to another.
- 3. Accessibility by which multiple doctors can access the patient's health data at the same time.
- 4. Provision of confidentiality to the health data of the patients in the cloud.

The detailed layered architecture of the AmbuSens system is depicted in Figure.

(i) Layer 1 : This layer consists of multiple wireless body area network (WBAN) attached to a patient's body. These WBANs acquire the physiological data from the patient and transmit them to the upper layer.

(ii) Layer 2 : Layer 2 is responsible for handling the cloud-related functions. WBANs attached to the different patients deliver data to the cloud end. A huge volume of health data is produced by the WBANs, which are handled by the cloud with the help of big data analytics for providing real-time analysis.

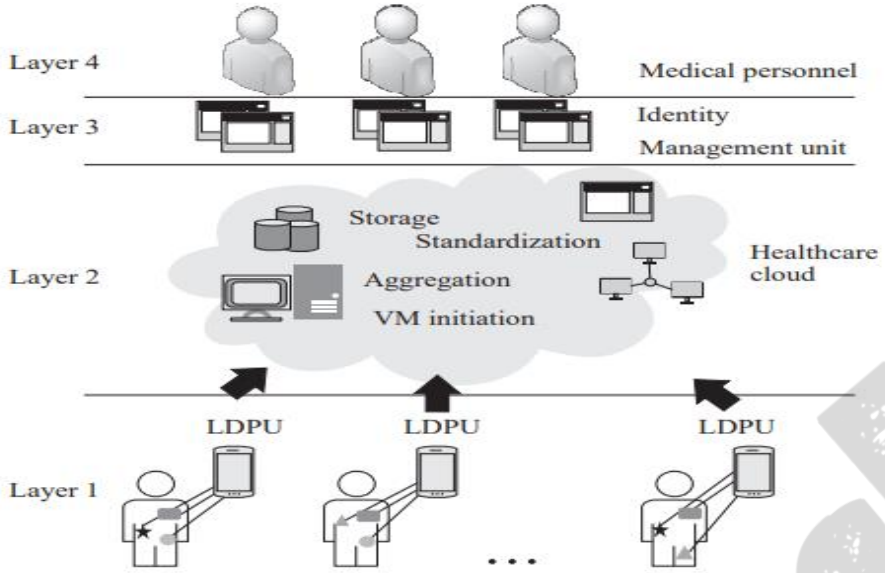
(iii) Layer 3 : In the AmbuSens system, the identity of the patients remains anonymous. AmbuSens system, at different time instants, a new hash value is generated for the patients. The entire hashing mechanism of the AmbuSens is performed in this layer.

(iv) Layer 4: The users simply register into the system and use it as per requirement

- Hardware : In the AmbuSens system, a variety of hardware components are used such as sensors, communication units, and other computing devices.
- Sensors : WBAN is formed using Optical Pulse Sensing Probe, Electrocardiogram (ECG) unit and sensor, Electromyogram (EMG) sensor, Temperature sensor and Galvanic Skin Response (GSR) sensor.

Local Data Processing Unit (LDPU) : An LDPU is a small processing board with limited computation capabilities. All the sensors attached to the human body sense and transmit the sensed data to a centralized device, which is called an LDPU. it transmits the data to the cloud for

long-term storage and heavy processing .



- Communication Module : Each sensor node consists of a Bluetooth (IEEE 802.15.1 standard) module. The communication between the sensor nodes and the LDPU takes place with the help of Bluetooth, which supports a maximum communication range of 10 meters in line-of-sight. The LDPU delivers the data to the cloud with 3G/4G communication.

IOT Analytics

- The term “machine learning” was coined by Arthur Lee Samuel, in 1959.
- He defined machine learning as a “field of study that gives computers the ability to learn without being explicitly programmed”.
- ML is a powerful tool that allows a computer to learn from past experiences and its mistakes and improve itself without user intervention.
- The main components of ML are statistics, mathematics, and computer science for drawing inferences, constructing ML models, and implementation, respectively.

Advantages of ML

i) Self-learner : An ML-empowered system is capable of learning from its prior and run-time experiences, which helps in improving its performance continuously.

(ii) Time-efficient:ML tools are capable of producing faster results as compared to human interpretation

(iii) Self-guided:An ML tool uses a huge amount of data for producing its results. These tools have the capability of analyzing the huge amount of data for identifying trends autonomously

- (iv) Minimum Human Interaction Required: In an ML algorithm, the human does not need to participate in every step of its execution. The ML algorithm trains itself automatically, based on available data inputs

- (v) Diverse Data Handling:IoT systems consist of different sensors and produce diverse and multi-dimensional data, which are easily analyzed by ML algorithms.
- (vi) Diverse Applications : ML is flexible and can be applied to different application domains such as healthcare, industry, smart traffic, smart home, and many others.

Challenges in ML

- A few major challenges in ML are listed as follows:
- (i) Data Description : The data acquired from different sensors are required to be informative and meaningful.
- (ii) Amount of Data : The availability of a huge amount of data is a challenge in ML
- (iii) Erroneous Data : Erroneous data misleads the ML model, its identification is crucial.
- (iv) Selection of Model : the proper selection of the model is pertinent for ML.
- (v) Quality of Model : the quality of the model is essential in an ML-based system.

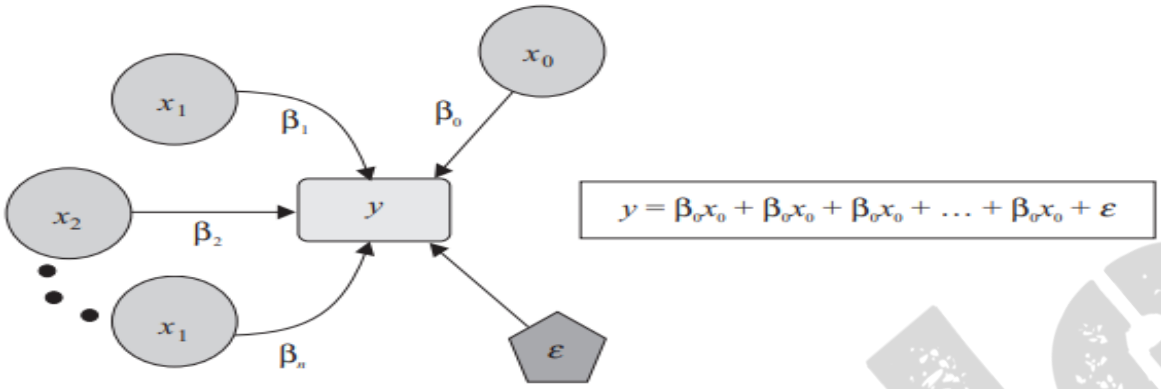
Types of ML

- ML algorithms consist of four categories:
- (i) Supervised
- (ii) Unsupervised
- (iii) Semi-supervised
- (iv) Reinforcement Learning.
- Labeled data contain certain meaningful tags, known as labels. Typically, the labels correspond to the characteristics or properties of the objects. For example, in a dataset containing the images of two birds, a particular sample is tagged as a crow or a pigeon.
- The unlabeled dataset does not have any tags associated with them. For example, a dataset containing the images of a bird without mentioning its name.

Supervised Learning

- This type of learning supervises machine using labeled datasets.
- Supervised ML algorithms are popular in solving classification and regression problems.
- the classification deals with predictive models that are capable of approximating a mapping function from input data to categorical output.
- There are different classification algorithms in ML.
- (i) k-nearest neighbor (KNN), (ii) decision tree (DT), and (iii) random forest (RF).
- Regression provides the mapping function from input data to numerical output.
- regression estimates the relationship among a set of dependent variables with independent variables.
- Let x and y be the independent and dependent variables respectively.
- A simple regression model is represented as :

$$y = \sum_{i=0}^{n} \beta_i x_i + \epsilon$$



Unsupervised Learning

- Unsupervised learning algorithms use unlabeled datasets to find scientific trends.
- unsupervised learning does not use any labels in its operations.
- the ML algorithms in this category try to identify the nature and properties of the input equation and the nature of the formulae responsible for solving it.
- Unsupervised learning is usually applied to solve two types of problems: clustering and association.
- Clustering divides the data into multiple groups
- Association discovers the relationship or association among the data in a dataset

Semi-Supervised Learning

- Semi-supervised learning belongs to a category between supervised and unsupervised learning.
- Algorithms use a combination of both labeled and unlabeled datasets for training.
- Labeled data are typically expensive and are relatively difficult to label correctly.
- Unlabeled data is less expensive than labeled data.
- semi-supervised learning includes both labeled and unlabeled dataset to design the learning model.
- semi-supervised learning uses mostly unlabeled data, which makes it efficient to use, and capable of overcoming samples with missing labels

(iv)Reinforcement Learning: Reinforcement learning establishes a pattern with the help of its experiences by interacting with the environment