IoT Based Systems
UEC640

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THAPAR INSTITUTE
OF ENGINEERING & TECHNOLOGY
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Subject : IoT Based Systems
Code : UEC640

Unit : #1 [Introduction to IoT]
Lecture : #1

Topics covered:

- Syllabus, CLOs, Text and Reference books
- IoT definition
- Characteristics of IoT
- Features of IoT system
- Advantages and disadvantages
- IoT echo system
- IoT architecture
- IoT applications

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Syllabus

UEC640: IOT based Systems				
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Course Objective: The objective of this course is to impart necessary and practical knowledge of components of Internet of Things and develop skills required to build real-life IoT based projects.

Syllabus

Introduction to IoT: Architectural Overview, Design principles and needed capabilities, IoT Applications, Sensing, Actuation, Basics of Networking, M2M and IoT Technology Fundamentals- Devices and gateways, Data management, Business processes in IoT, Everything as a Service(XaaS), Role of Cloud in IoT, Security aspects in IoT.

Elements of IoT: Hardware Components- Computing (Arduino, Raspberry Pi), Communication, Sensing, Actuation, Basics of Sensor Networks. I/O interfaces. Software Components- Programming API's (using Python/Node.js/Arduino) for Communication Protocols-MQTT, ZigBee, Bluetooth, CoAP, UDP, TCP.

IoT Application: Development Solution framework for IoT applications-Implementation of Device integration, Data acquisition and integration

IoT Case Studies: IoT case studies and mini projects based on Industrial automation, Transportation, Agriculture, Home Automation

CLOs

The student will be able to:

1. Understand internet of Things and its hardware and software components
2. Understand the design aspects of hardware and software components of IoT
3. Design Interface for I/O devices, sensors & communication modules
4. Analyze and process of data from sensors
5. Apply IoT knowledge to Implement basic IoT applications on embedded platform

Text Books

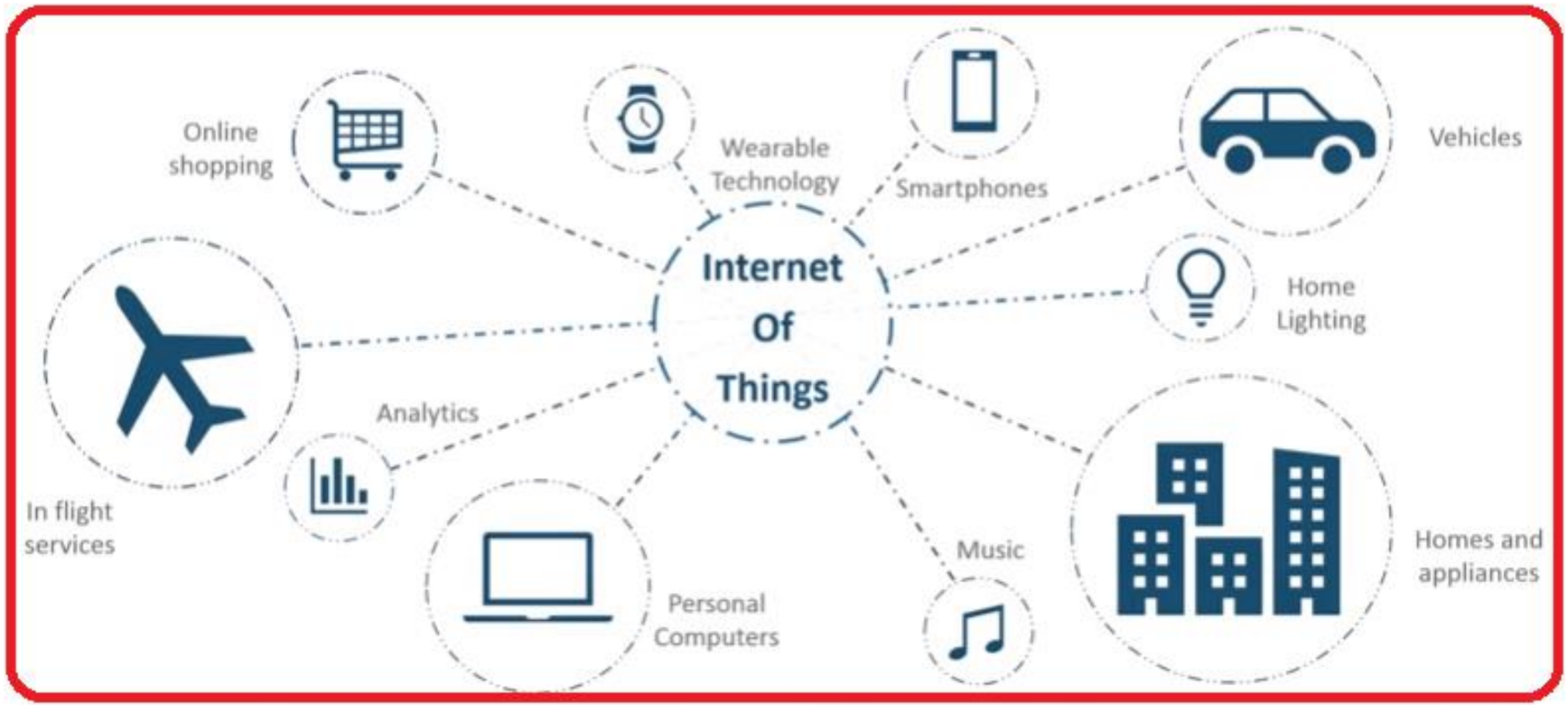
1. Pethuru Raj and Anupama C. Raman, “The Internet of Things: Enabling Technologies, Platforms, and Use Cases”, CRC Press.
2. Vijay Madisetti, Arshdeep Bahga, İnternet of Things, “A Hands on Approach”, University Press.

Reference Books

1. Dr. SRN Reddy, Rachit Thukral and Manasi Mishra, “Introduction to Internetof Things: A practical Approach”, ETI Labs.
2. Adrian McEwen, “Designing the Internet of Things”,Wiley.
3. Raj Kamal, “Internet of Things: Architecture and Design”, Mc Graw Hill.
4. Cuno Pfister, “Getting Started with the Internet of Things”, O Reilly Media.

Definition of IoT

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**.

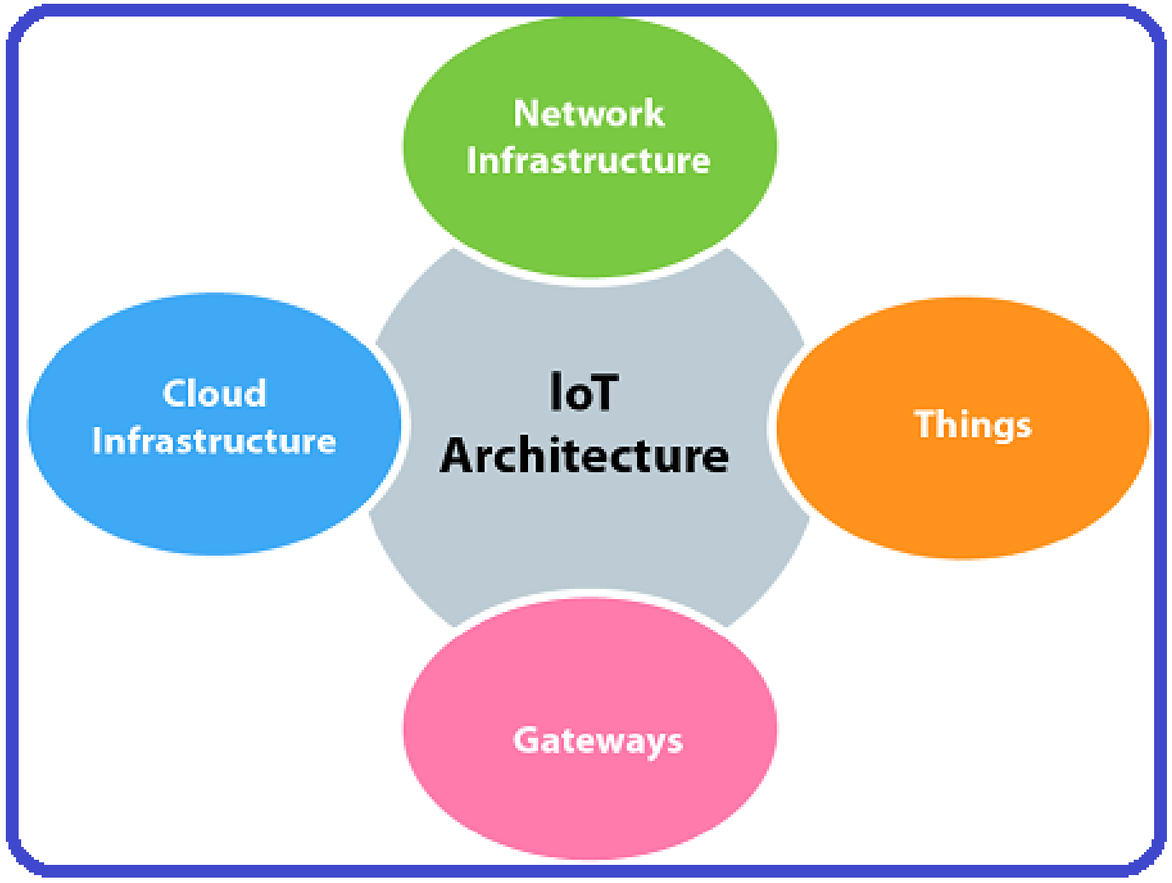


Reference: Vijay Madisetti, Arshdeep Bahga, "Internet of Things: A Hands-On Approach

How IoT Works?

❖The entire **process** starts with the **devices** themselves, such as smart phones, digital watches, electronic appliances which **securely** communicate with an **internet of things** platform.

❖**IoT** platform **collects** and **combines** data from multiple devices and platforms and applies **analytics** to share the most valuable data with applications to address **industry-specific** needs.



Real-life example

Amit, in **between** his **road trip** notices some **problem** with the **check engine light**, however, he doesn't know the **intensity** of the problem. The good part is that the **sensor** that **triggers** the check engine light **monitors** the **pressur**e in the **inner brake** line.

This **sensor** is one of the **many sensors** present in the car which constantly **communicate** with **each other**. A component called the **diagnostic bus** gathers the **data** from all these sensors and then **passes** it to the **gateway** in the car. The gateway **collects** and **sorts** the data from **different** sensors.

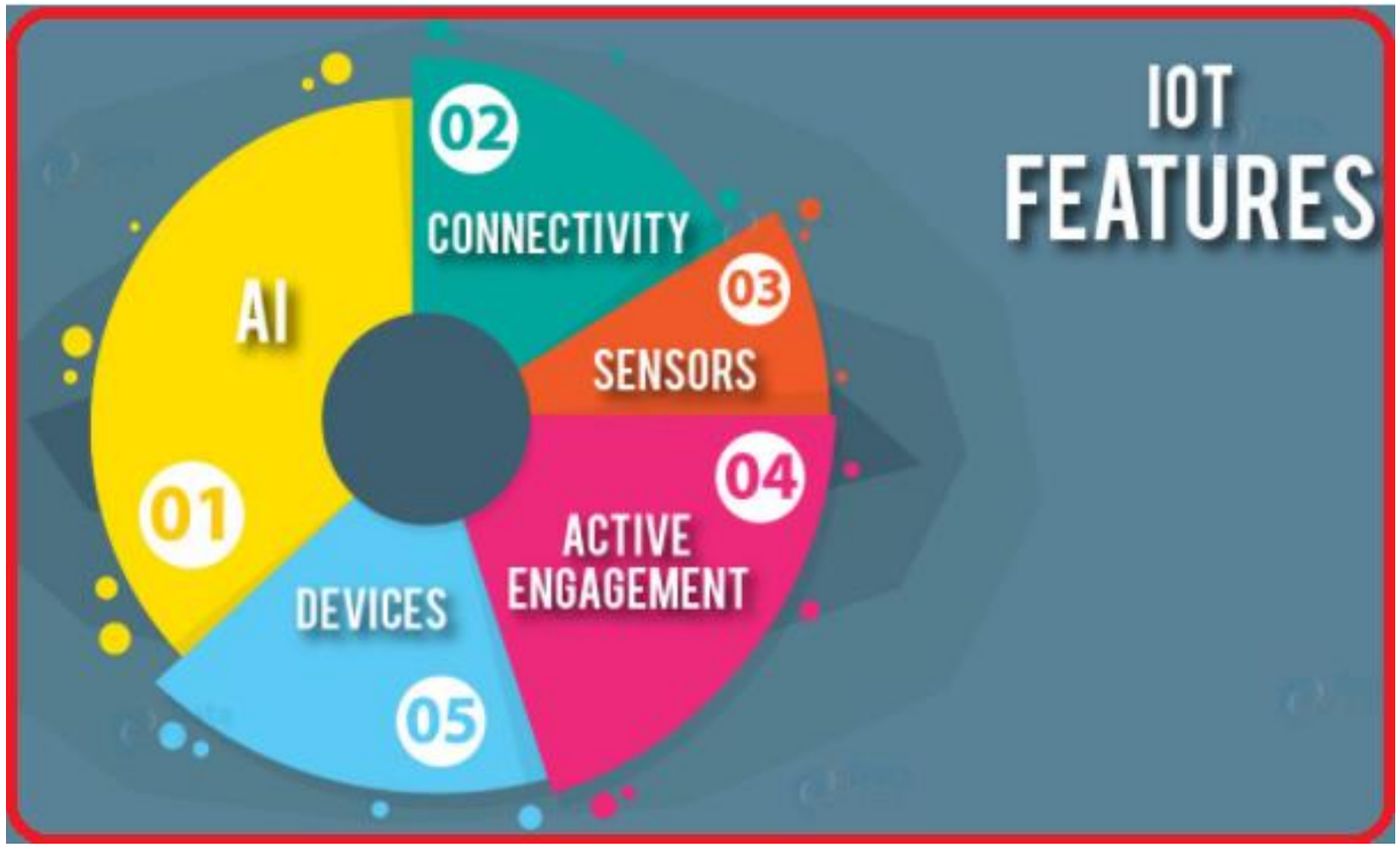
Before this **connection** to happen, the **car's gateway** and platform must **register** with each other and **confirm** a secure **communication**. The platform **keeps** on constantly **gathering** and **storing** information from **hundreds of cars** worldwide, building a **record** in a **database**.

The **manufacturer** has added **rules and logic** to the platform. The platform **triggers** an **alert** in his car, after **sensing** the **brake fluid** has dropped **below** the **recommended** level. The manufacturer then **sends** him an **appointment** for **servicing** of his car, and the **car's problem** is **rectified.**

Characteristics of IoT

- **Dynamic** & **Self-Adapting**
- **Self-Configuring**
- **Interoperable** Communication Protocols
- **Unique** Identity
- **Integrated** into Information Network

Features of IoT



❖**AI**– IoT technically makes **things smart**, meaning that it **enhances** different aspects of life through proper **usage** of that **data**, networks, and **algorithms**. This can **range** from something as simple as improving or enhancing your **refrigerator** by embedding it with **sensors** that **automatically** detect when **milk** and **eggs** run low, to **placing** an order with your **choice** of the **grocer**.

❖**Connectivity**–The notion of networking doesn't always have to restrict to large networks, it can also **exist** on a **smaller** and cheaper scale without **compromising** its **efficiency**. IoT **comes** into the picture and **creates** these **small networks** between its system devices.

❖**Sensors**–The true essence of IoT would not hold effective without sensors. They are basically the reason and the crux of why this technology stands out. They play a major role in defining boundaries of IOT by converting it from a passive to an active network.

❖**Active Engagement**–Today's interaction between different connected technologies happens through passive engagement. IoT has set an example by bringing in active content, product, or service engagement.

❖**Devices**–Devices are more powerful, cheaper and smaller over time, Internet of Things purposely makes use of small devices to deliver its **scalability**, **versatility**, and **accuracy**.

Advantages and Disadvantages of (IoT)

Advantages

Internet of things facilitates the several advantages in day-to-day life in the business sector. Some of its benefits are given below:

❖**Efficient resource utilization:** If we know the functionality and the way that how each device work we definitely increase the efficient resource utilization as well as monitor natural resources.

❖**Minimize human effort:** As the devices of IoT interact and communicate with each other and do lot of task for us, then they minimize the human effort.

❖**Save time:** As it reduces the human effort then it definitely saves out time. Time is the primary factor which can save through IoT platform.

❖**Enhance Data Collection:** Using star or mesh network more number of sensor nodes can be connected thereby data collection may enhance.

❖**Improve security:** Now, if we have a system that all these things are interconnected then we can make the system more secure and efficient.

Disadvantages

As the Internet of things facilitates a set of benefits, it also creates a significant set of challenges. Some of the IoT challenges are given below:

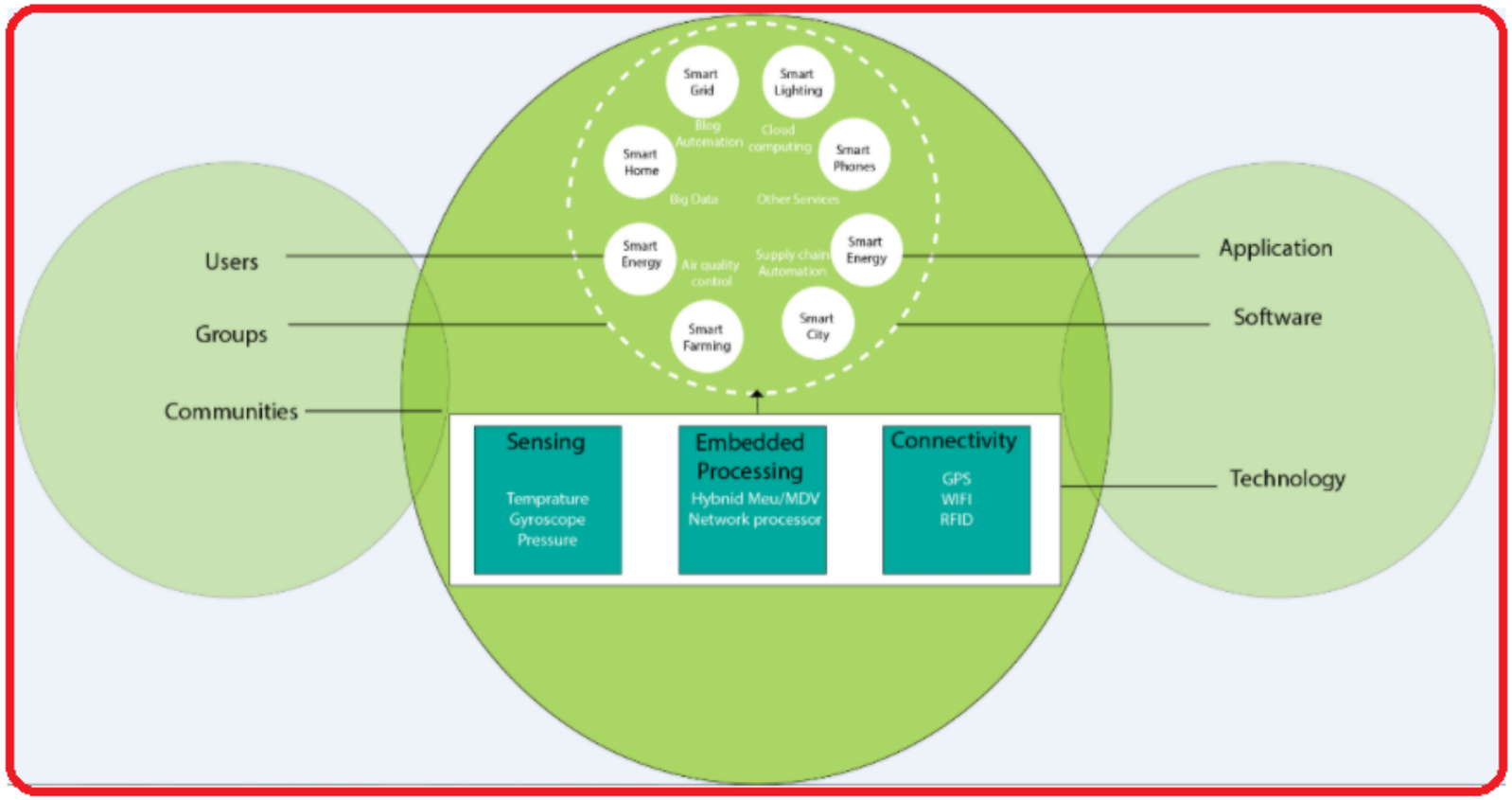
❖**Security:** As the IoT systems are interconnected and communicate over networks. The system offers little control despite any security measures, and it can be lead the various kinds of network attacks.

❖**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.

IoT Ecosystem

❖The IoT is itself an **ecosystem** of network devices that **transfer** the data. It is also well **interconnected** with **Big Data** and **Cloud Computing**.



❖**Sensing, Embedded processing, Connectivity:** The IoT ecosystem **senses** its **surrounding** like temperature, gyroscope, pressure, etc. and make the **embedded processing** using devices.

❖These devices are **connected** through any type of devices such as **GPS**, **WiFi**, **RFID**, etc. over the **networks**.

❖**Smart devices and environment, Cloud Computing, Big Data:** The data **transfer** or **receive** through smart **devices** and **environments** are communicated through **Cloud Computing** or others **Servers** and stored as **Big Data**.

❖**Technology, Software, Application:** The IoT **ecosystem** uses any of different technologies, software and application to **communicate** and **connect** with smart devices and environment.

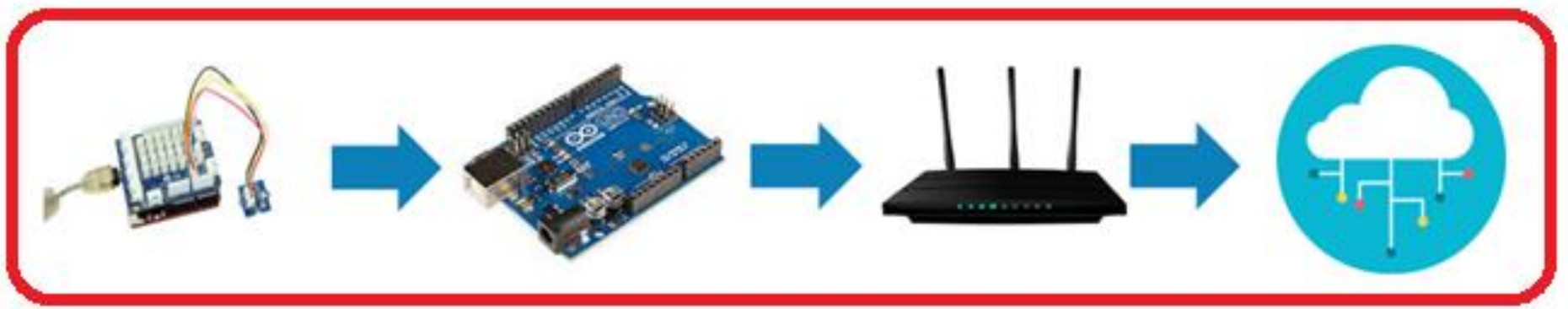
❖**Users or groups of community:** The **product** or **services** generated by the IoT ecosystem are consumed by the **users** or the **group** of communities to serve the **smart life**.

IoT Architecture

The IoT architecture **differs** from their **functional** area and their **solutions**. However, the IoT architecture technology mainly consists of **four** major **components**:

Components of IoT Architecture

- ❖Sensors/Devices
- ❖Gateways and Networks
- ❖Cloud/Management Service Layer
- ❖Application Layer



Following are the primary **stages** (layers) of IoT that provides the **solution** for IoT architecture.

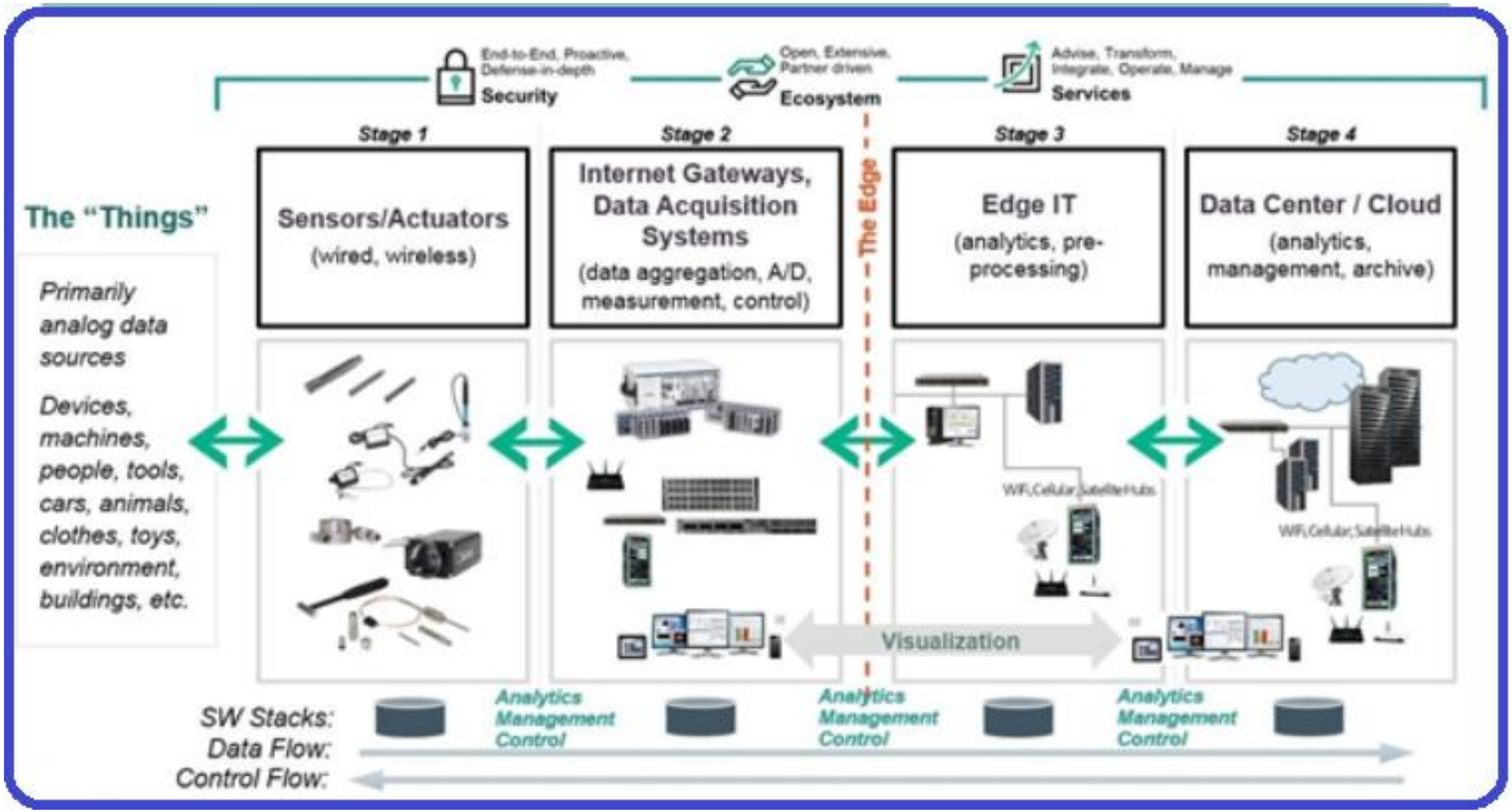
❖**Sensors/Actuators:** Sensors or Actuators are the **devices** that are **able** to **emit**, **accept** and **process** data over the network. These sensors or actuators may be **connected** either through **wired** or **wireless**. This contains GPS, Electrochemical, Gyroscope, RFID, etc. Most of the sensors **need** connectivity through sensors **gateways**. The connection of sensors or actuators can be through a **Local Area Network** (LAN) or **Personal Area Network** (PAN).

❖**Gateways and Data Acquisition:** As the large numbers of data are produced by this sensors and actuators need the high-speed **Gateways** and **Networks** to transfer the data. This **network** can be of type Local Area Network (LAN such as **WiFi, Ethernet**, etc.), Wide Area Network (WAN such as **GSM, 5G**, etc.).

❖**Edge IT:** Edge in the **IoT Architecture** is the hardware (**PC/desktop**) and software gateways that analyze and pre-process the data **before** transferring it to the **cloud**. If the data read from the **sensors** and g**ateways** are not changed from its **previous reading** value then it **does not transfer** over the cloud, this **saves the data** used.

❖**Data center/ Cloud:** The **Data Center** or **Cloud** comes under the **Management Services** which process the information through **analytics**, management of device and **security controls**. **Beside** this security controls and device management the cloud **transfer** the data to the end users **application** such as **Retail**, Healthcare, **Emergency**, Environment, and **Energy** etc.

4 Stage IoT solutions Architecture

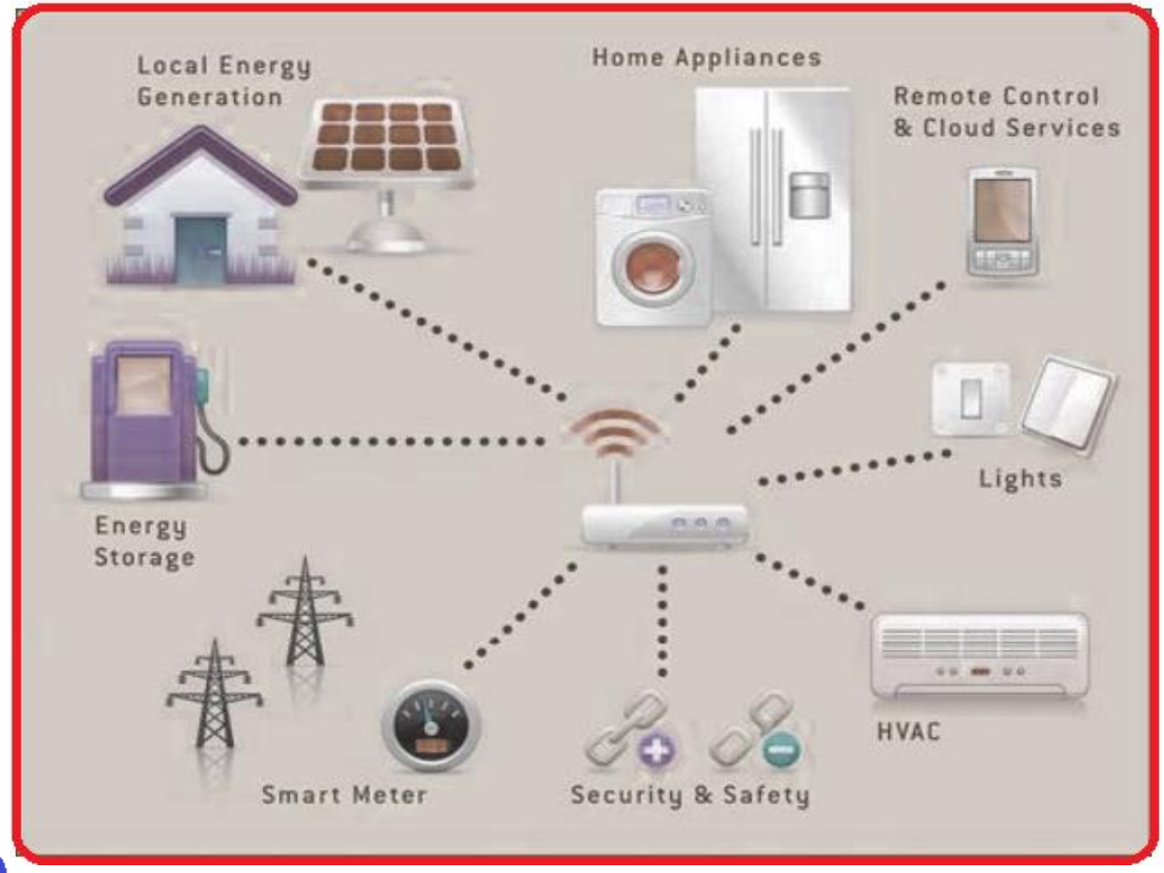


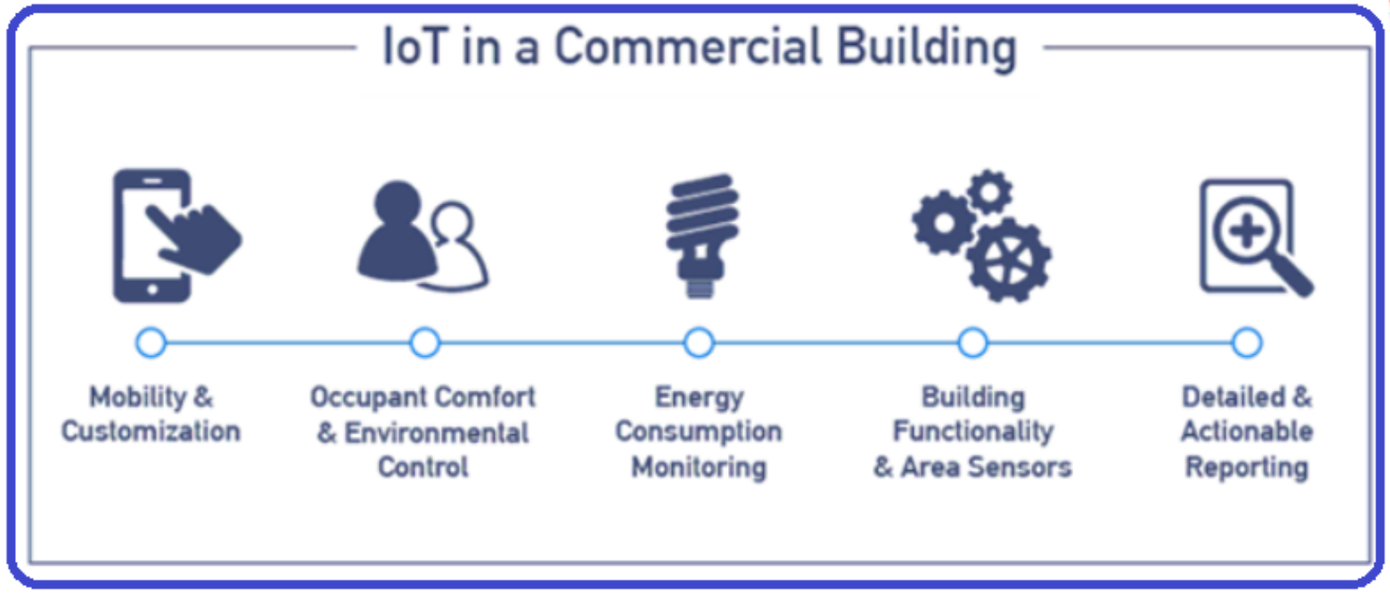
IoT Application/Domain

IoT Energy Domain

Residential Energy

❖IoT provides a **mature way** to **analyze** and **optimize** the use of the device as well as the **entire system** of a home. It may be changing the device setting, simply switching **on/off** or **dimming** lights to optimize energy use.





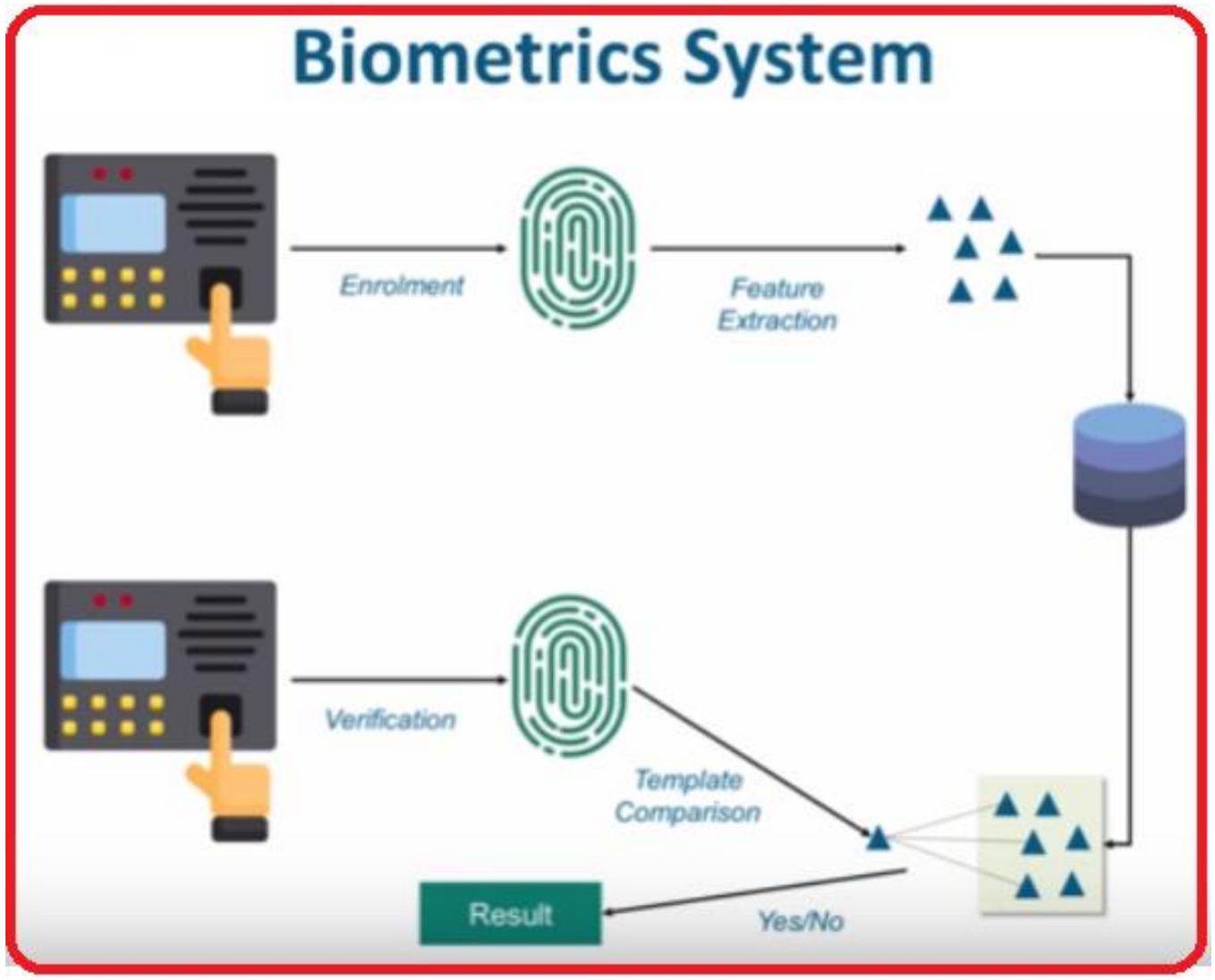
Commercial Energy

❖**Wastage** of energy widely **impacts** any business enterprises in their **cost of production**. IoT **provides** a specific way for **monitoring** and **maintaining** a **low cost** and **high level** of care.

IoT Biometrics Domain

❖IoT plays a **vital role** in the **Biometrics security** system such as a **fingerprint** system, **voice recognition** system, **eye scanner** system etc.

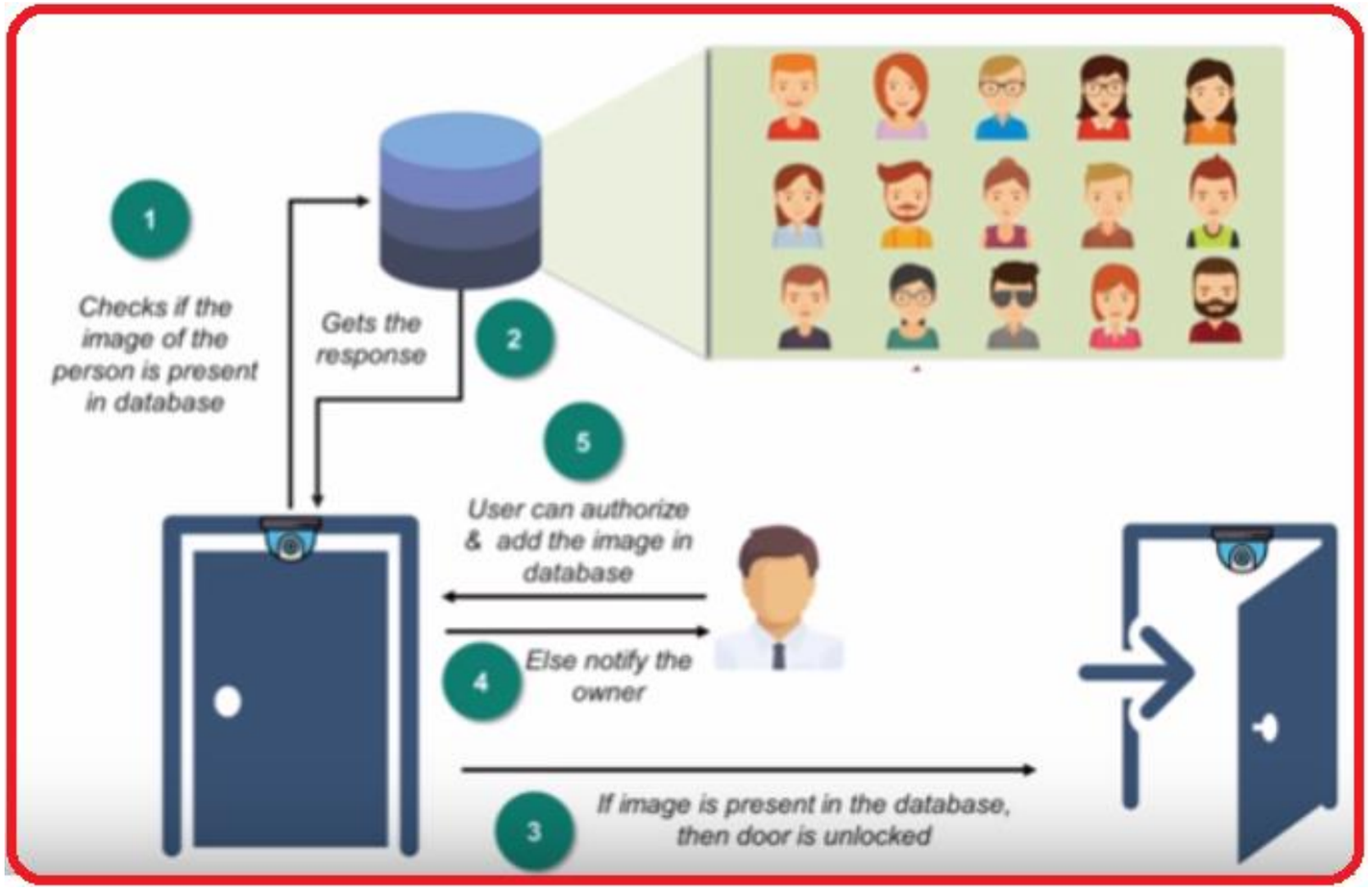
❖Now, a **biometric system** is something that we always encounter in our daily life. We always either use a **fingerprint** sensor or an **eye-scanning** system, depends on organization to organization.



IoT in Security Camera & Door Unlock System

❖Here, we **place** a **camera** on the **top foot** of the **door** which in turn **clicks** the photo of a **person** who comes **into frame**.

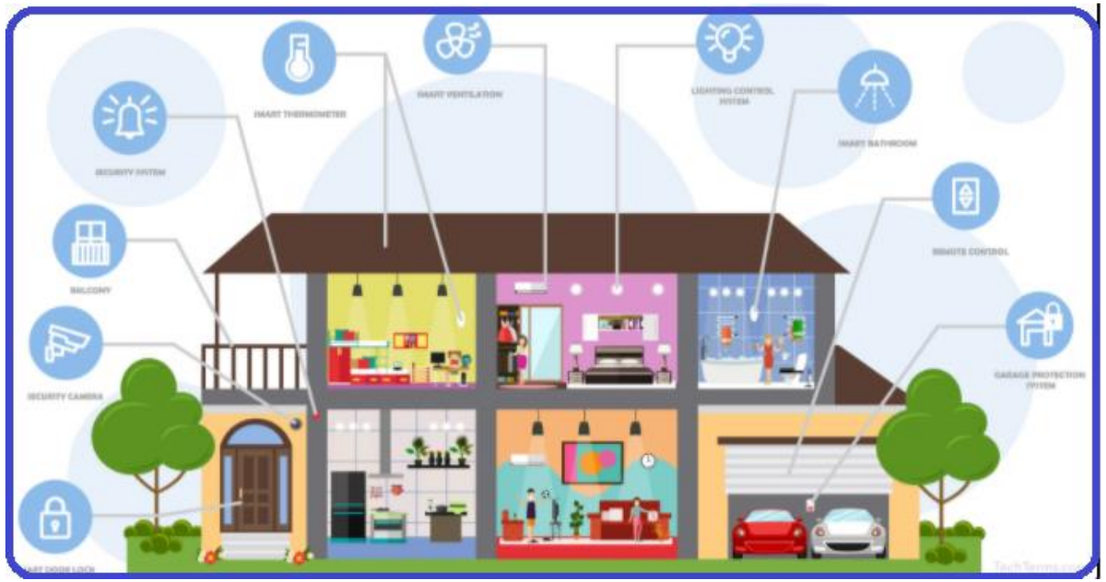
❖Now, this photo is **sent** to an **analytical system** which in turn **compares** this with **all** the photos it **possesses** to **identify** whether to let the **user open** the **door** or not.



❖Now, if it **does not** find the **photo** of that person then it can **notify** the concern that a person is trying to access this door **would** you like to **authorize** this **person**? or would you like to **deny** the **access** to this person?

IoT in Smart Home and Smart City Application

Starting from **energy management** where the **power controls** system in the AC appliances where we use the **thermostat**, all this is managed to cut down the **power consumption** that's taking place. A **door management** system, **security management** system, **water management** system are the part of this as well.



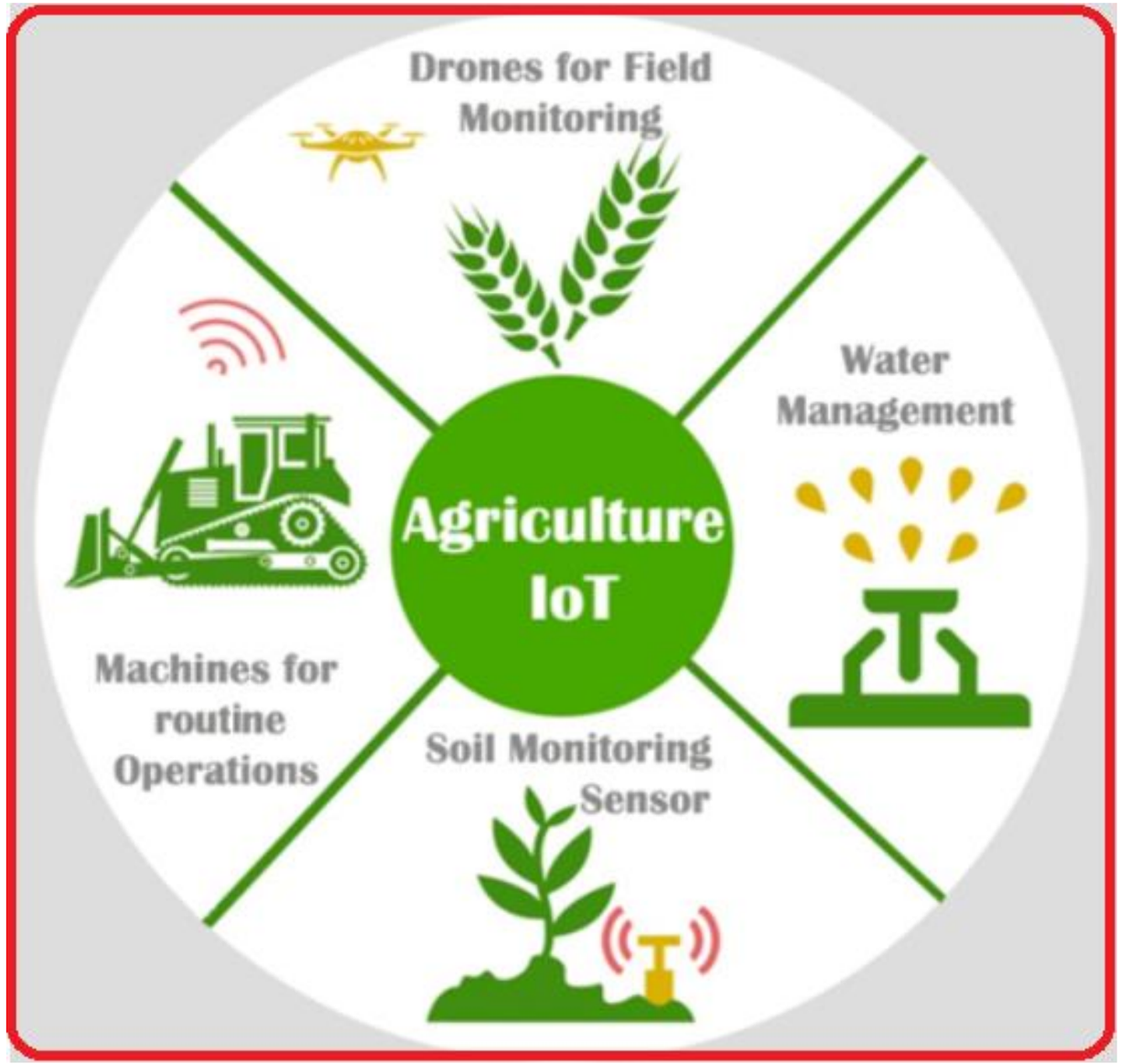
Now, a **smart home** usually is going to be a base of a **smart city**. The **smart city** is an evolution of a smart home. Here, it is not just the sensors of a **single home** that is connected, here its correlation or a network or a connection between various organizations, various domains as well as **multiple segments** of that city as a whole.

IoT Smart Agriculture Domain

Using **smart farming** through IoT technologies helps farmer to **reduce waste** generation and **increase** the **productivity.** There are several **IoT technologies** available that work on agriculture domain. Some of them are:

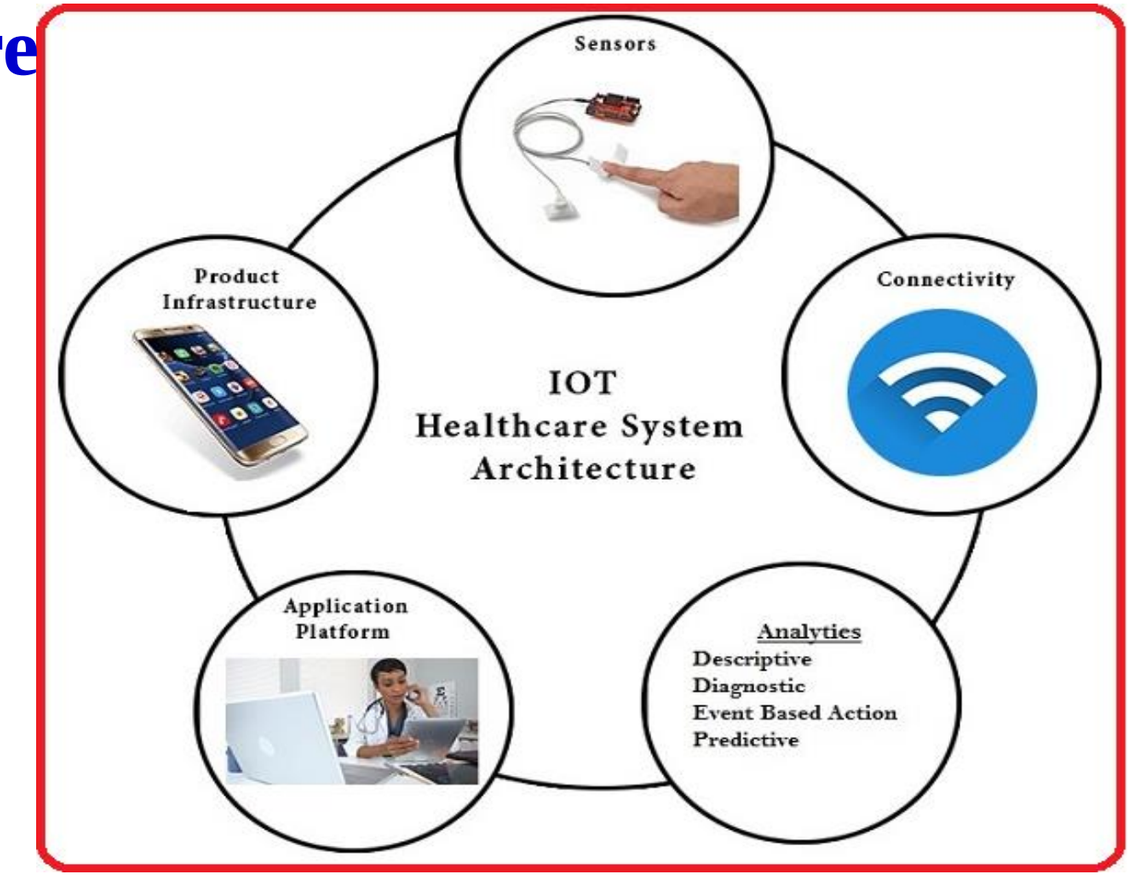
- ❖**Drones** for field monitoring
- ❖**Sensor** for soil monitoring
- ❖**Water pump** for water sully
- ❖**Machines** for routine operation

One of the parts of **smart agriculture** using IoT is **smart irrigation** system. In the smart irrigation system, IoT checks the **moisture level** in the environment or in the **water lanes** that the farmer has created.



Internet of Things (IoT) in Healthcare

IoT technology brings numerous applications in **healthcare**, from remote monitoring to smart sensors to **medical device integration**. It keeps the patients safe and healthy as well as improves the **physician delivers** care towards the patients.

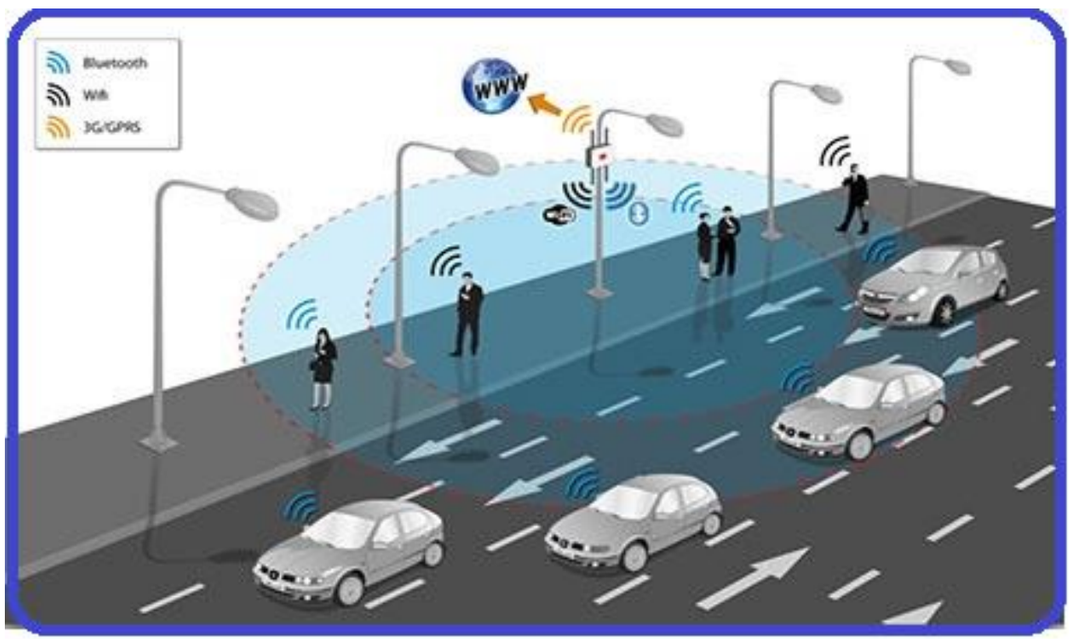


IoT challenges in Healthcare

- ❖Data security & privacy
- ❖Integration: multiple devices & protocols
- ❖Data overload & accuracy
- ❖Cost

Internet of Things (IoT) in Transportation

Internet of Things (IoT) has crucial applications in the transportation system. IoT plays an important role in all the field of transportation as a**ir-transportation**, **water-transportation**, and land transportation. All the component of these transportation fields is built with smart devices (**sensors, processors**) and interconnected through **cloud server** or different servers that transmit data to networks.



Connected to every means of travel

IoT in **transportation** is not only for **traveling** from **one place** to **another**, but it also makes safer, greener and more convenient. For example, a **smart car** performs work simultaneously such as **navigation,** communication, e**ntertainment**, efficient, more **reliable travel**.

References

1. Vijay Madisetti, Arshdeep Bahga, "**Internet of Things: A Hands-On Approach**"
2. Adrian McEwen, Hakim Cassimally, "**Designing the Internet of Things**", John Wiley (2014), 1st ed.
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4. https://robojax.com/learn/arduino/
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Thanks !