217529- Internet of Things

Unit Number: 3

Unit Name: **Introduction & IOT Technologies behind smart and intelligent devices**

Unit Outcomes: CO3

Explain the concept of Internet of Things and identify the technologies that make up the internet of things

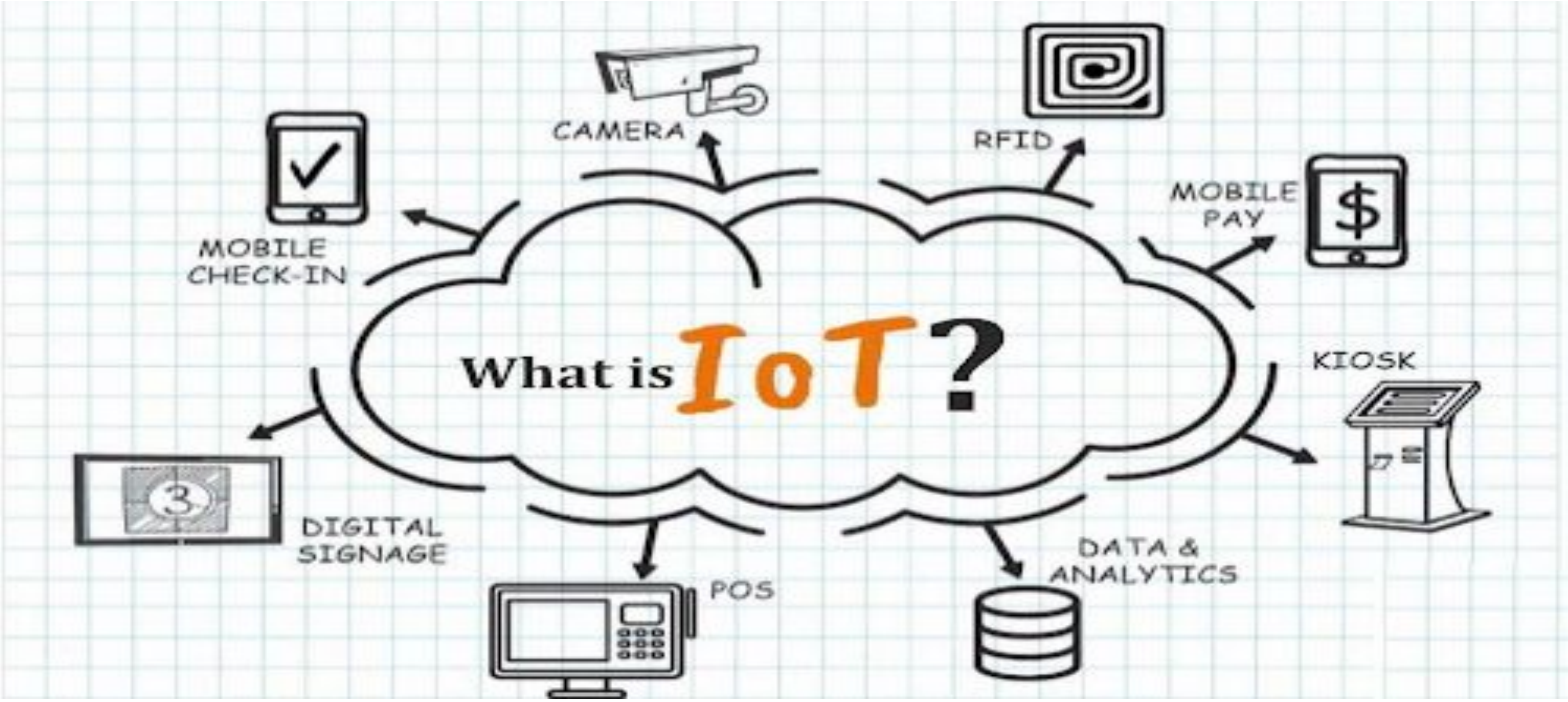
Syllabus

- IoT Concepts, Introduction to IOT Communications, Telemetry vs IOT, Applications of IOT Communications, People, Processes and Devices.
- Automation, asset management, telemetry, transportation, telematics. Telemetry and Telemetric; Report ocation, logistics, tracking and remote assistance; Next generation kiosks, self-service technology; Cellular IOT connectivity services.

Introduction..

- Internet of Things, popularly known as IoT, is "a process or phenomenon in which all devices are connected to the Internet and communicate with each other." or The 'Thing' in IoT can be any device with any kind of built-in-sensors with the ability to collect and transfer data over a network without manual intervention

- These devices can also be normal devices and smart. Devices can also be there. Let me give you some examples
  - Automation home
  - smart City
  - Smart grid
  - Industrial internet
  - Connected course
  - Smart retail
  - Energy engagement



IoT? (Some Industry Definitions)

- A network connecting (either wired or wireless) devices, or ‘things’, that is characterized by autonomous provisioning, management, and monitoring. The IoT is innately analytical and integrated **(IDC)**

- IoT is the next evolution of the Internet, connecting the unconnected people, processes, data, and things in your business today **(Cisco)**

- IoT devices as those capable of two-way data transmission (excluding passive sensors and RFID tags). It includes connections using multiple communication methods such as cellular, short range and others. **(GSMA)**

- Sensors & actuators connected by networks to computing systems. These systems can monitor or manage the health and actions of connected objects and machines. Connected sensors can also monitor the natural world, people, and animal” **(McKinsey)**

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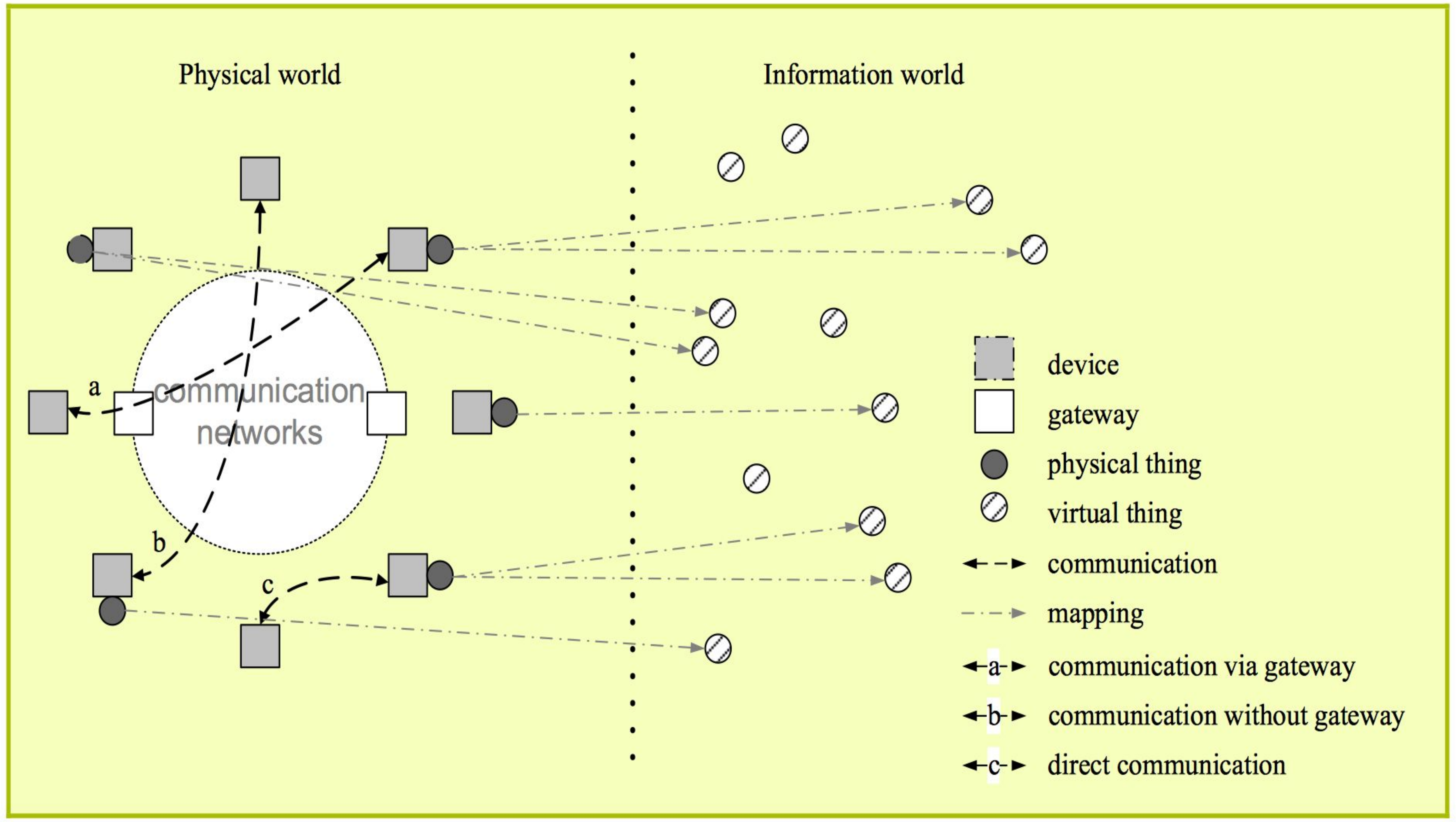
- "An IoT system is a network of networks where, typically, a massive number of objects, things, sensors or devices are connected through communications and information infrastructure to provide value-added services via intelligent data processing and management for different applications (e.g. smart cities, smart health, smart grid, smart home, smart transportation, and smart shopping)." **(IEEE)**

- ITU Definition

- **Physical things**
  Exist in the physical world and are capable of being sensed, actuated and connected.
  Examples: industrial robots, goods and electrical equipment.

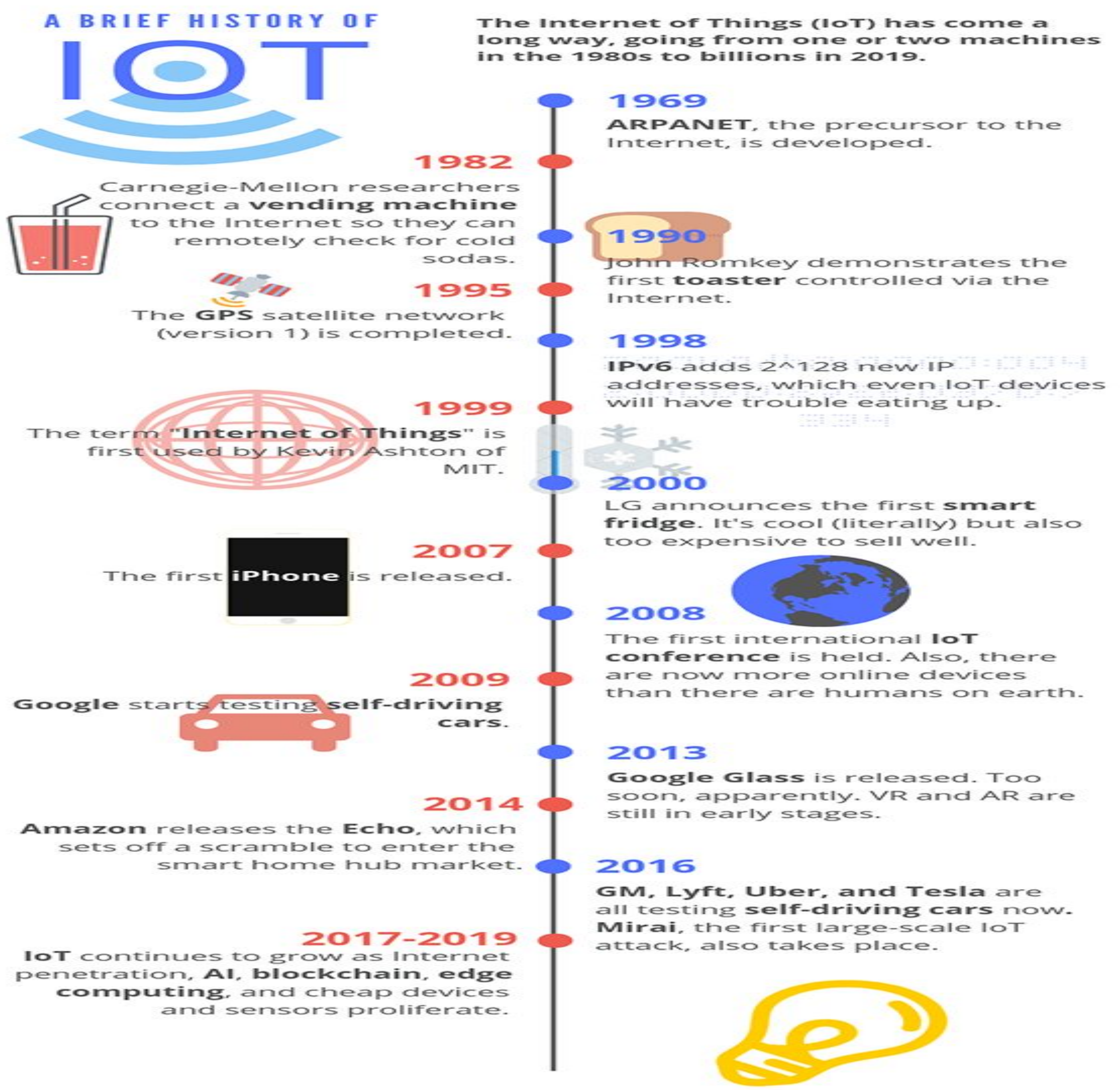
- **Virtual things**

  Exist in the information world and are capable of being stored, processed and accessed.
  Examples: Multimedia content, application software.



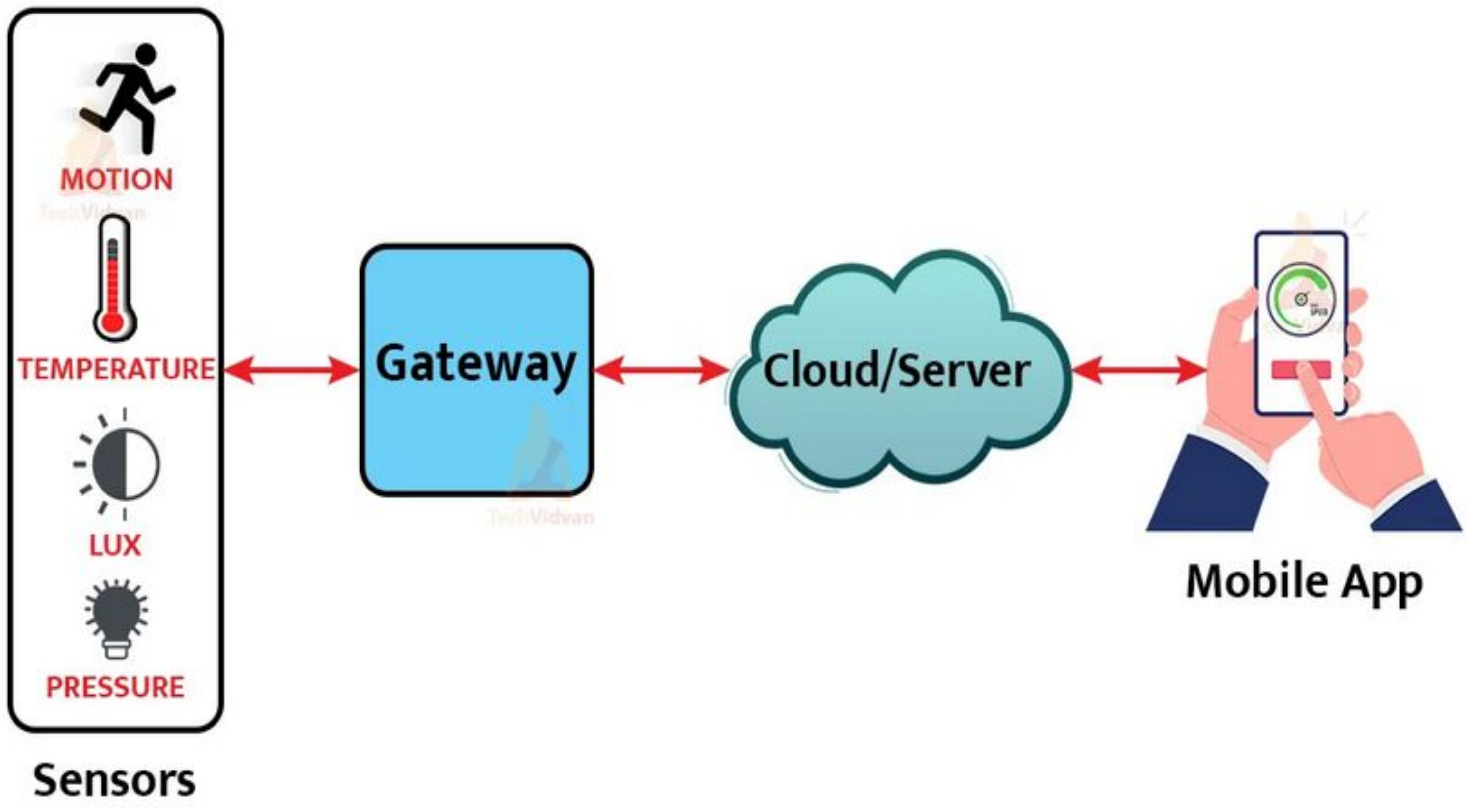
History

- The term "The Internet of Things" (IoT) was coined by Kevin Ashton in a presentation to Proctor & Gamble in 1999. He is a co-founder of MIT's Auto-ID Lab.
- He pioneered RFID (used in bar code detector) for the supply-chain management domain. He also started Zensi, a company that makes energy sensing and monitoring technology.
- However, IoT was "born" sometime between 2008 and 2009. In 2010, the number of everyday physical objects and devices connected to the Internet was around 12.5 billion.
- Nowadays there are about 25 billion of devices connected to the IoT. More or less a smart device per person.

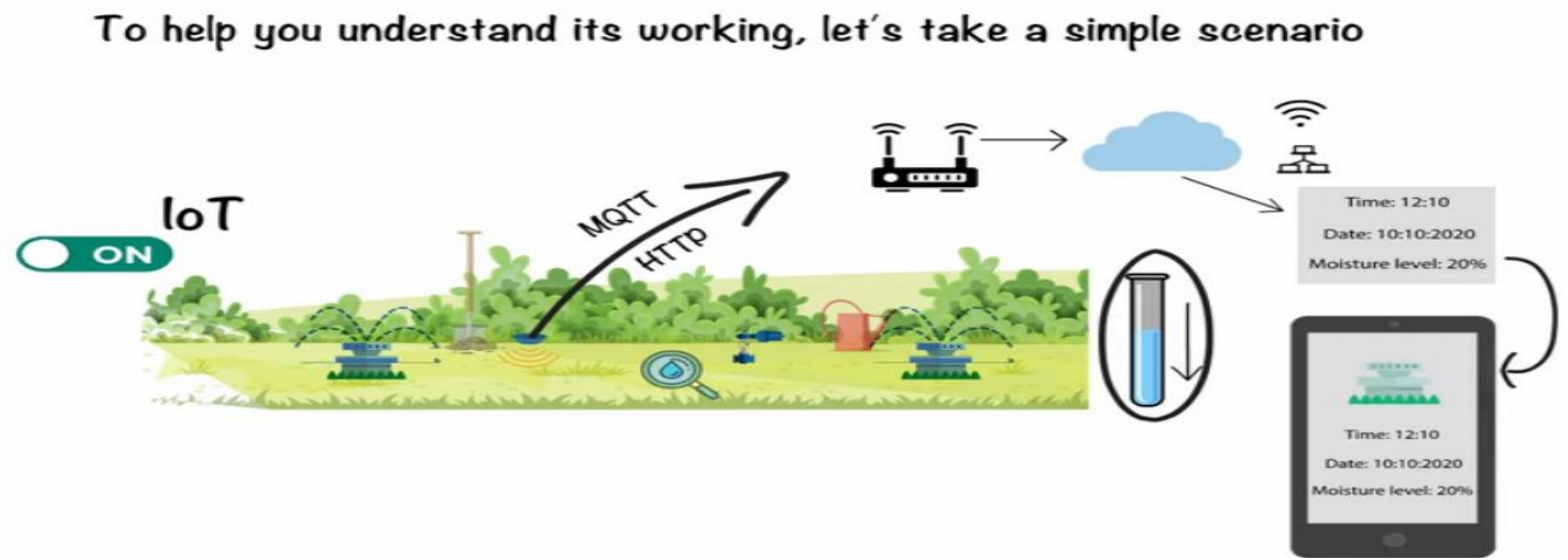


HOW IoT Works?

- The IoT consists of sensors and devices collecting data from their surroundings. This data is then sent to the cloud by means of Wi-Fi, Bluetooth, LPWAN, satellite, or being connected directly to the internet via Ethernet.
- When the data reaches the cloud, it is then processed by software programs. The information is then made available to the consumer in a user-friendly way.
- This information is communicated to the user to either check on the system or take action and affect the system.



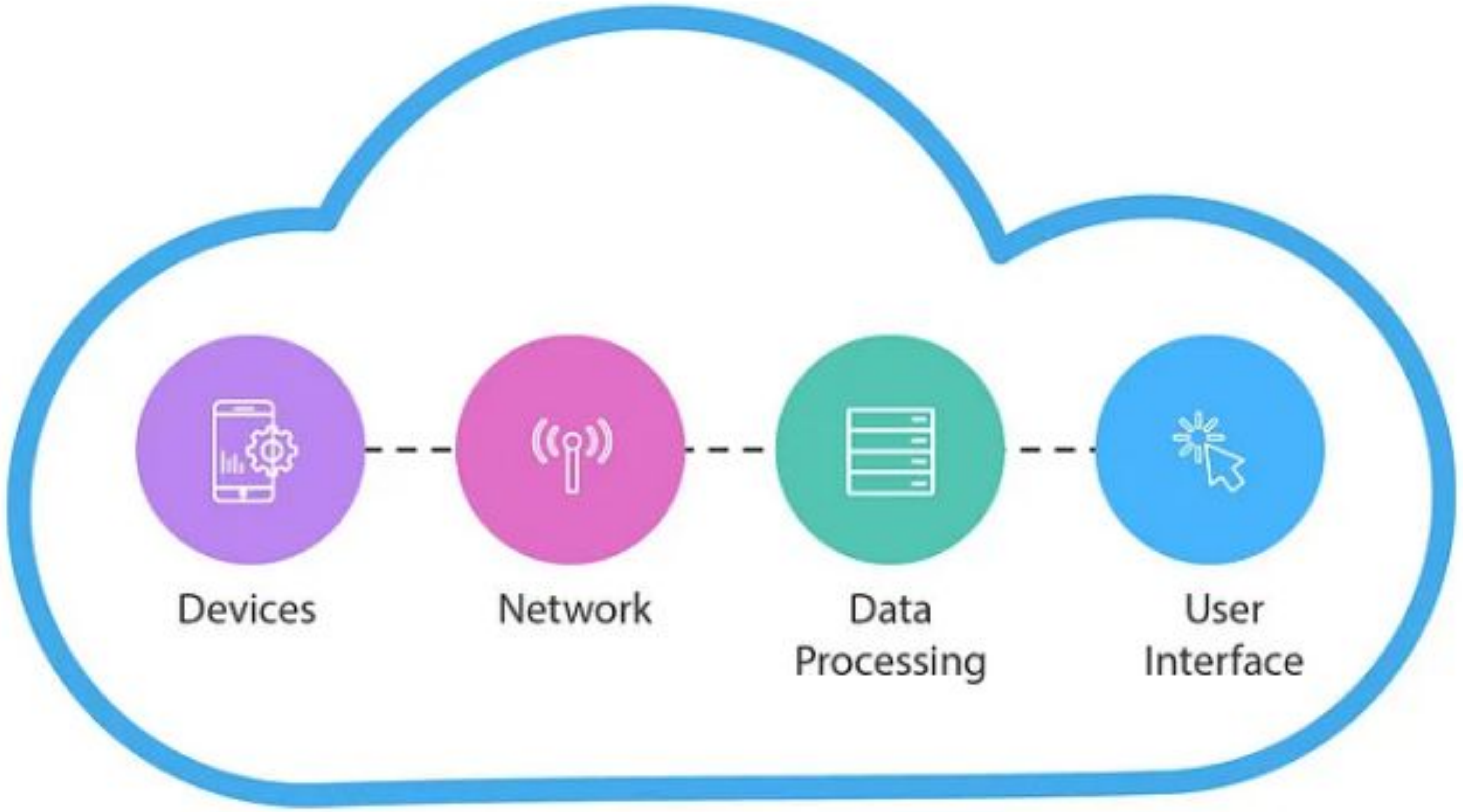
Example



- For Example we need to sprinkle water in Garden in specific time or when specific data received as an inout to IoT system. MQTT is an OASIS standard messaging protocol for the Internet of Things (IoT). It is designed as an extremely lightweight publish/subscribe messaging transport that is ideal for connecting remote devices with a small code footprint and minimal network. HTTP stands for Hypertext Transfer Protocol. · It is a protocol used to access the data on the World Wide Web (www).

Component of IOT

- **IoT has 4 components that describe the functioning of most of the IoT systems:**



1. Devices: Sensors gather the information at the point of activity. It could be biological, environmental, visual, auditory, or any combination of these. Things or Devices are the primary physical objects that are being monitored. Smart sensors attached to these devices are continuously collecting data from the device and transmitting it to next layer i.e. gateway.
2. Connectivity: The sensors can be connected to the cloud through various mediums of communication and transports such as cellular networks, satellite networks, Wi-Fi, Bluetooth, wide-area networks (WAN), low power wide area network and many more.
3. Data processing: Analytics is the process of converting analog data from interconnected smart devices and sensors into usable insights that can be processed, interpreted, and used for detailed analysis. Intelligent analytics is a must for IoT technology for management and improvement of the entire system.
4. User Interface: User interfaces are the visible, tangible part of the IoT system which can be accessible by users. Designers will have to make sure a well-designed user interface for minimum effort for users and encourage more interactions.

Characteristics of IoT

- **1. Intelligence:** IoT systems are extensively liked in the market because of their intelligence. A combination of algorithms and computer enables the system to inform change in the environment and take appropriate actions. For example – Systems are intelligent enough to sense a sudden spike in temperature and trigger an alarm for fire.

- **2. Connectivity:** Connectivity is the main characteristic of IoT as it enables the system to send data and stay connected to other devices. It provides system network accessibility and function collaboratively.

- **3. Expressing:** IoT is all about interacting intelligently with the outer environment and humans. Expressing enables this interactivity. Expressing allows us to show output into the real world and input from people and the environment.

- **4. Sensing:** Sensitivity means aware of the changes around us. Sensor technologies provide us with the means to create an experience that reflects an awareness of changes in the physical world and the people in it. It helps in expressing. This forms the input for the IoT system and provides a better understanding of the complex world around us.

- **5. Energy:** Everything in this world is driven by energy. IoT systems are created smart enough to synthesize energy from the outer environment and conserve it. It is also made energy efficient to work for a longer duration.

- **6. Security:** Safety and security is the most important feature of any system. If the system is not secure to cyber attack and illegal intervention, nobody will use it. IoT systems deal with personal data; that's why it's an obligation that all safety measure should be taken care of in this system. All IoT systems are secure enough to deal with personal data.

Advantages of IoT

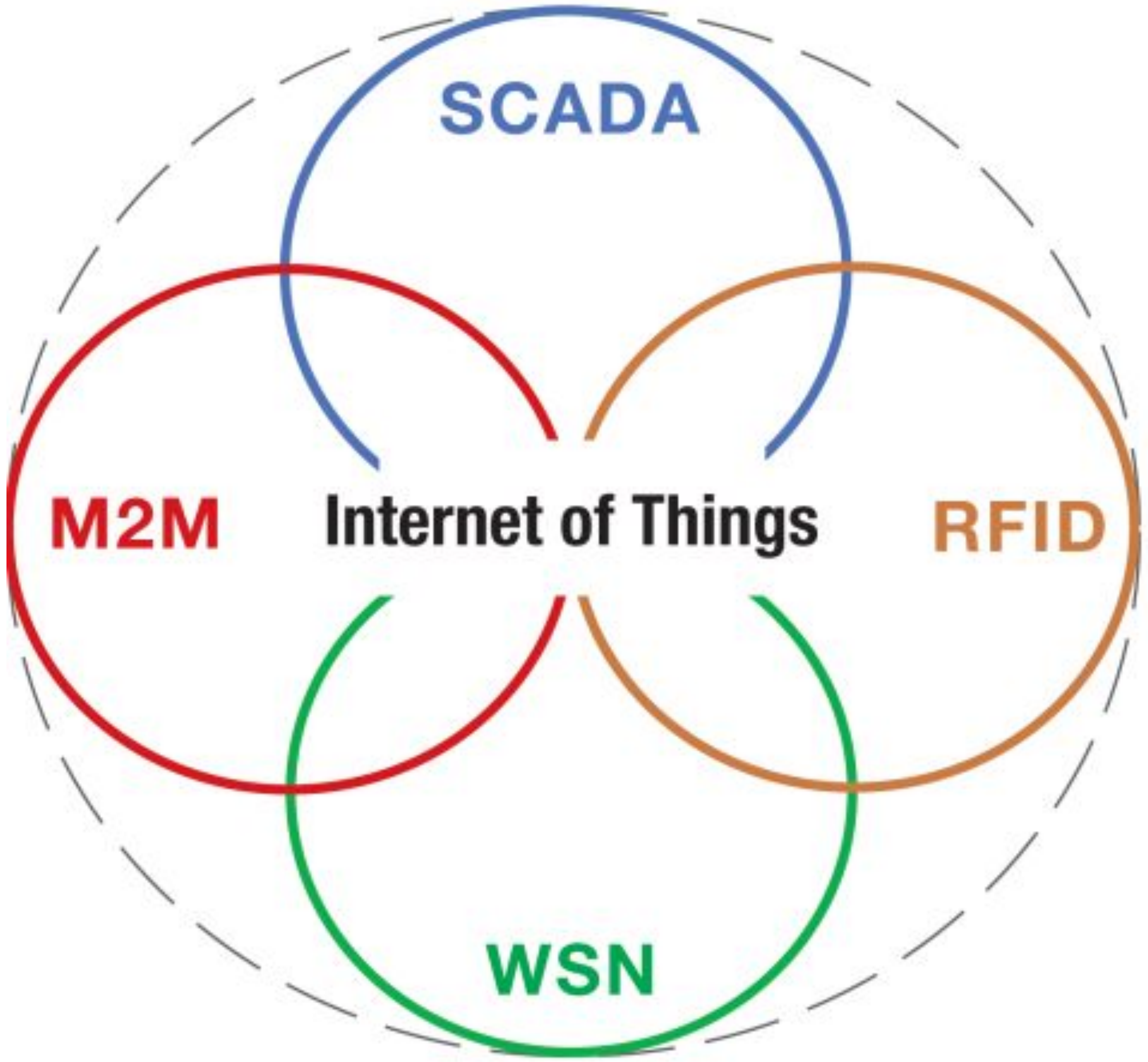
- Internet of things facilitates the several advantages in day-to-day life in the business sector. Some of its benefits are given below:
  - Efficient resource utilization: If we know the functionality and the way that how each device work we definitely increase the efficient resource utilization as 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:
  - 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 of IoT

- 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: IoT technology creates an ecosystem of connected devices. However, during this process, the system may offer little authentication control despite sufficient security measures.
  - Privacy: The use of IoT, exposes a substantial amount of personal data, in extreme detail, without the user's active participation. This creates lots of privacy issues.
  - Flexibility: There is a huge concern regarding the flexibility of an IoT system. It is mainly regarding integrating with another system as there are many diverse systems involved in the process.
  - Complexity: The design of the IoT system is also quite complicated. Moreover, it's deployment and maintenance also not very easy.
  - Compliance: IoT has its own set of rules and regulations. However, because of its complexity, the task of compliance is quite challenging.

Four pillars of IOT

- There are four pillars that unify the Internet of things. They all help you to communicate and connect with people and devices, and they work together to create a new Internet Age: an Internet Age where we can do things we never thought we could, and where we become more connected than ever before.
- M2M [Machine to Machine]
- SCADA [Supervisory Control and Data Acquisition:]
- WSN [Wireless Sensor Network]
- RFID [Radio-frequency identification]



Piller 1: M2M: Machine to Machine

- **M2M stands for machine-to-machine, mobile-to-machine, and machine-to-mobile Communications.**

- The automatic communications between devices without any or with very little human intervention. It often refers to a system of remote sensors that is continuously transmitting data to a central system.

- To simplify, M2M is where two or more machines directly communicate and exchange information to each other through either a wired or a wireless connection.

- Machine to Machine (M2M) can be defined as a “direct, point-to-point” communication standard between devices usually of the same type. It’s also meant for a specific on-premise application, which can be through wired or “non-Internet”-based wireless methods, such as Zigbee, RFID, Bluetooth, Wi-Fi, BLE, LoRaWAN, Sigfox, 6LoWPAN, and more.

Piller 1: M2M: Machine to Machine

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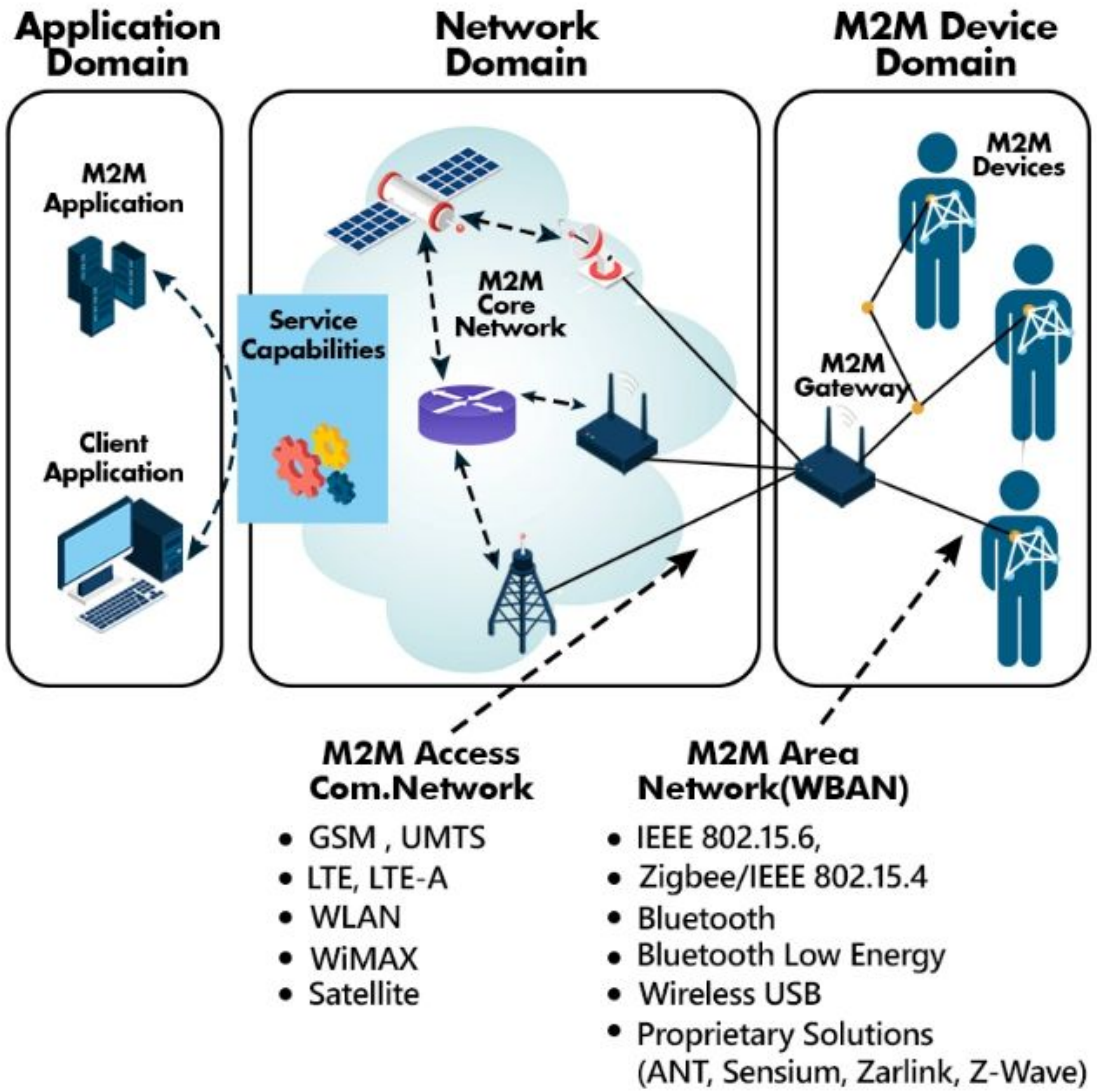


- **The three main domains of M2M architecture are:**

1. **M2M application:** As the name suggests, the M2M application domain offers applications to use M2M technology conveniently. Examples include server and end-user applications.

2. **M2M network domain:** M2M network domain acts as a bridge between the M2M application domain and the M2M device domain. It is made of two parts called the M2M core and M2M service capabilities.

3. **M2M device domain:** M2M device domain contains all the devices that can connect to the M2M network easily. The device domain can also be called the M2M area network. The M2M device domain includes devices that can connect directly over a network, devices that cannot directly connect to a network and may perhaps require an M2M gateway and proprietary devices.

Working of M2M

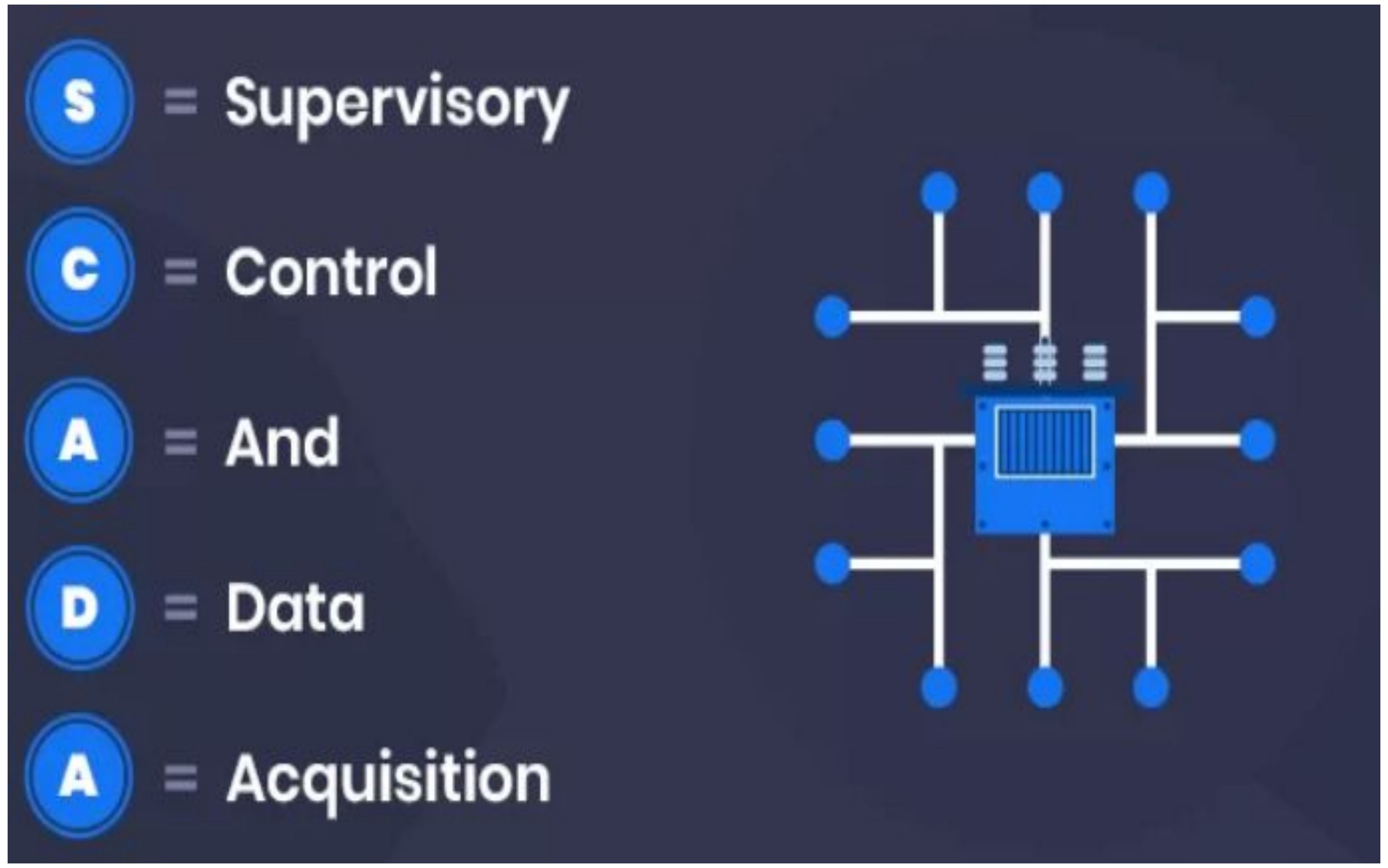
- M2M devices send data across a network by sensing information.
- M2M stands for "machine-to-machine" communication. It refers to the automated exchange of data and information between two or more machines or devices, without requiring human intervention.
- M2M communication is often used in the context of the Internet of Things (IoT), where sensors and other devices are connected to a network and exchange information with each other in real-time. For example, a smart thermostat may communicate with a smart meter to adjust the temperature in a building based on the energy usage and weather conditions.
- M2M communication can be achieved using various technologies and protocols, including cellular networks, Wi-Fi, Bluetooth, Zigbee, and MQTT. The data exchanged between machines can be in various formats, such as text, numbers, images, or video.
- M2M communication enables automation and remote monitoring of various processes and systems, leading to increased efficiency, productivity, and cost savings. It has applications in various industries, including manufacturing, transportation, healthcare, and agriculture.

Difference between M2M and IoT

M2M	IoT
M2M means direct machine to machine communication	IoT means Internet of Things – a network of internet-connected devices able to sensor, collect and exchange information
Created for businesses to connect with machines	Evolved from M2M and created for both businesses and consumers
Hardware-based	Hardware and software-based
Usually wired connection	Wireless connection
Does not require internet connection	Requires internet connection
2+ machines communicating	Network with thousands of devices communicating
Supports point-to-point communication	Supports Cloud communication
Communicates through a proprietary cellular or wired network	Communicates on standards-based IP networks
Best for small-scale applications	Easy to large-scale applications
M2M applications include vending machines, ATMs, smart meters	IoT applications include smart cities, offices and homes, telehealth, connected cars and EV charging networks, wearables

Piller 2 Supervisory Control and Data Acquisition SCADA

- SCADA stands for Supervisory Control and Data Acquisition. As the name suggests, this system is used to monitor, collect data from and automatically control the production process.



It is a system used for monitoring and controlling industrial processes and equipment in real-time.
SCADA systems are commonly used in industries such as oil and gas, power generation, water and wastewater, manufacturing, and transportation.

- What Is SCADA Used For?

SCADA systems are critical for ensuring the safe and efficient operation of industrial processes, and are an important component of the Industrial Internet of Things (IIoT).

Piller 2 Supervisory Control and Data Acquisition SCADA

- A SCADA system is a combination of hardware and software that enables the automation of industrial processes by capturing Operational Technology (OT) real-time data.

- SCADA is a monitoring system which is used to remotely observe and control industrial processes. It is a type of Industrial Control System (ICS). Before we move on to SCADA, we need to talk about ICSs.

- SCADA connects the sensors that monitor equipment like motors, pumps, and valves to an onsite or remote server. A SCADA system empowers organizations to:

  - Control processes locally or at remote locations

  - Acquire, analyze and display real-time data

  - Directly interact with industrial equipment such as sensors, valves, pumps, and motors

  - Record and archive events for future reference or report creation.

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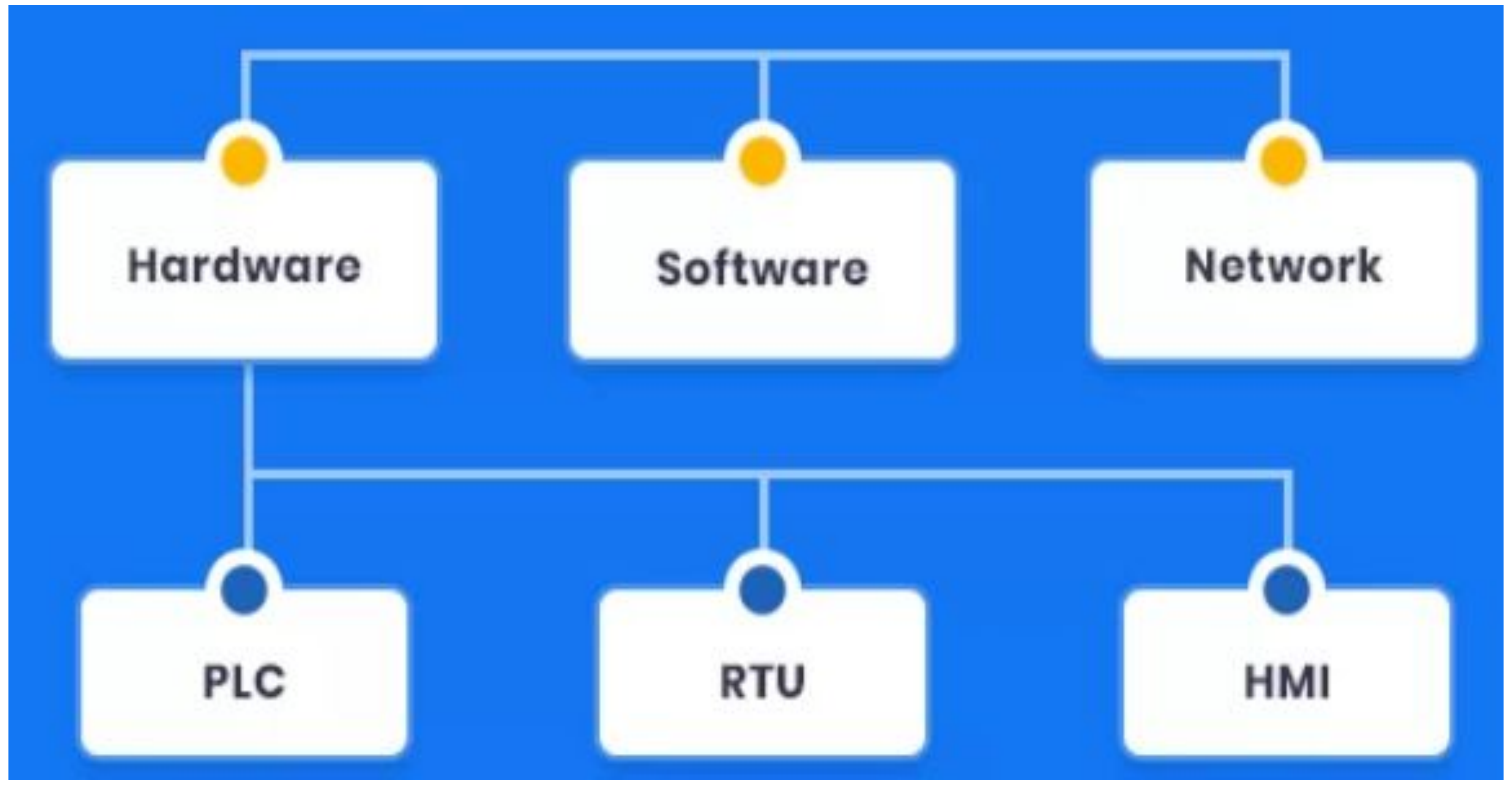
- **Basic components and the functions they perform individually.**



- Examples of a SCADA system
  - Smart City
  - Smart Manufacturing

1. **Peripherals**: including sensors, measuring devices, converters and actuators.

2. **Intermediate data collection stations:** are remote terminal units RTU (Remote Terminal Units) or PLC (Programmable Logic Controllers) that communicate with actuators.

3. **Communication system:** includes industrial communication networks, telecommunication equipment and multiplexing converters that transmit field-level data to control blocks and servers.

4. **Monitoring control system:** includes SCADA software and HMI (Human Machine Interface).

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- **A typical SCADA system consists of the following components:**
- **Supervisory computer:** This is the main computer that runs the SCADA software and is used to monitor and control the industrial process.
- **Remote Terminal Units (RTUs):** These are hardware devices that are installed at remote locations to collect data from sensors and other devices, and transmit it to the supervisory computer. They can also control actuators and other devices.
- **Human-Machine Interface (HMI):** This is a graphical user interface that allows operators to monitor and control the industrial process using a computer or other device.
- **Communication network:** This is the network that connects the RTUs and the supervisory computer, and allows data to be transmitted between them.

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- **The main functions of a SCADA system are as follows:**
- **Data acquisition:** The SCADA system collects data from various sensors and other devices installed at remote locations.
- **Data visualization:** The SCADA system displays the collected data in real-time on the HMI, allowing operators to monitor the industrial process.
- **Data control:** The SCADA system allows operators to control the industrial process by sending commands to the RTUs.
- **Alarm management:** The SCADA system monitors the data collected from the sensors and raises alarms if any parameters go out of specified limits.
- **Data storage and analysis:** The SCADA system stores the collected data in a database for further analysis and reporting.

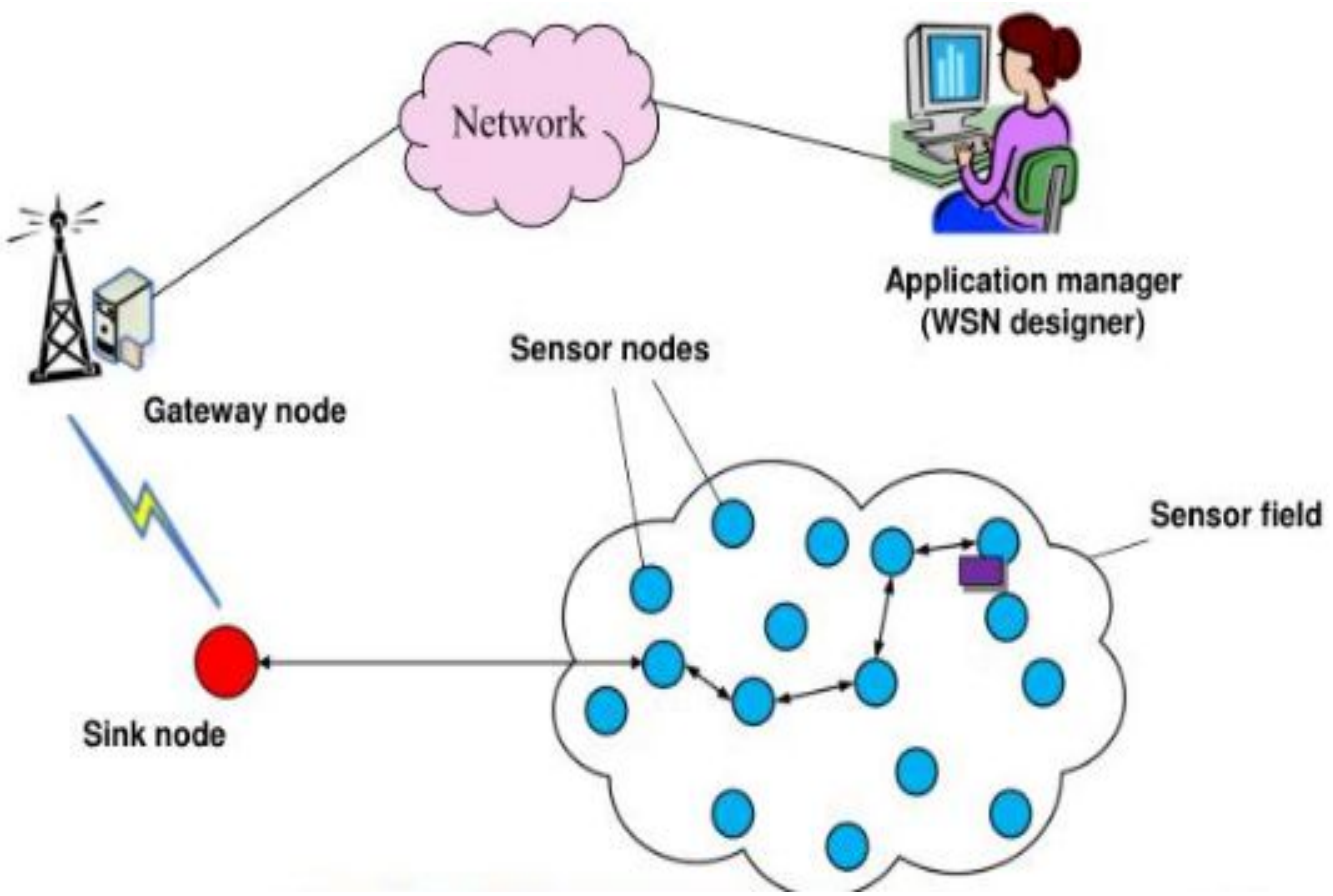
SCADA System Work

- The first step in the process is the collection of analogue data. There are many types of sensors designed to record pressure, temperature, humidity, and various other factors.
- The sensor data is collected by the PLC (controller) and forwarded to the centralised SCADA station which is usually present in a remote location.
- The central location receives data from multiple PLCs which are usually located across a wide spread of area. With the help of the HMI, the user (e.g. manager or supervisor) can view the gathered information in an organised fashion, such as in the form of a table or graph.
- This refined data may then be fed into the CMMS. This software helps detect any anomalies in the data and then generate reports and work orders.
- The work orders define the problem, solutions, and required resources. Human workers can then intervene and perform the required maintenance or repair work on the equipment which caused the irregularity in the first place.

Piller 3: WSN: Wireless Server Network

- A wireless sensor network (WSN) is a wireless network that contains distributed independent sensor devices that are meant to monitor physical or environmental conditions. A WSN consists of a set of connected tiny sensor nodes, which communicate with each other and exchange information and data. These nodes obtain information on the environment such as temperature, pressure, humidity or pollutant, and send this information to a base station. The latter sends the info to a wired network or activates an alarm or an action, depending on the type and magnitude of data monitored.

- Typical applications include weather and forest monitoring, battlefield surveillance, physical monitoring of environmental conditions such as pressure, temperature, vibration, pollutants, or tracing human and animal movement in forests and borders.



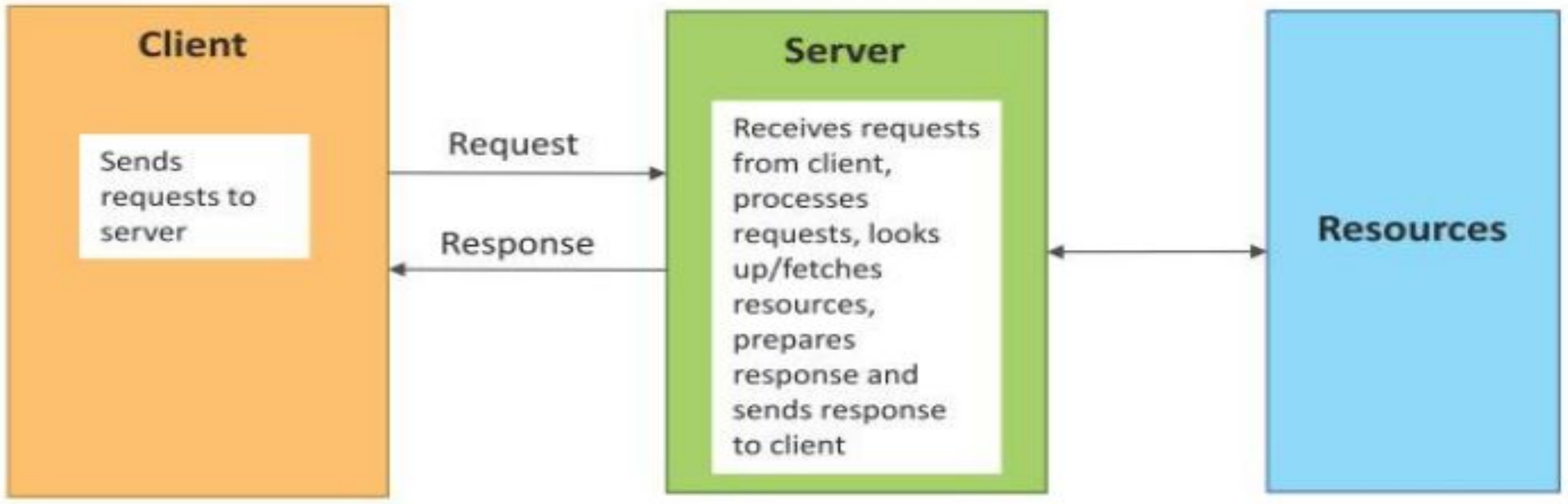
- They use the same transmission medium (which is air) for wireless transmission as wireless local area networks (WLANs). For nodes in a local area network to communicate properly, standard access protocols like IEEE 802.11 are available. However, this and the other protocols cannot be directly applied to WSNs.

Piller 4:RFID : Radio-frequency identification

- **RFID (radio frequency identification)** is a form of wireless communication that incorporates the use of electromagnetic or electrostatic coupling in the radio frequency portion of the electromagnetic spectrum to uniquely identify an object, animal or person.
- There are two types of RFID :
  - Passive RFID – In this device, RF tags are not attached by a power supply and passive RF tag stored their power. When it is emitted from active antennas and the RF tag are used specific frequency like 125-134MHZ as low frequency, 13.56MHZ as a high frequency and 856MHZ to 960MHZ as ultra-high frequency.
  - Active RFID – In this device, RF tags are attached by a power supply that emits a signal and there is an antenna which receives the data.
- Application of RFID :
  - It utilized in tracking shipping containers, trucks and railroad, cars. It uses in Asset tracking. It utilized in credit-card shaped for access application. It uses in Personnel tracking. Controlling access to restricted areas. It uses ID badging. Supply chain management. Counterfeit prevention (e.g., in the pharmaceutical industry).

Introduction to IOT Communications Model

Request-Response:

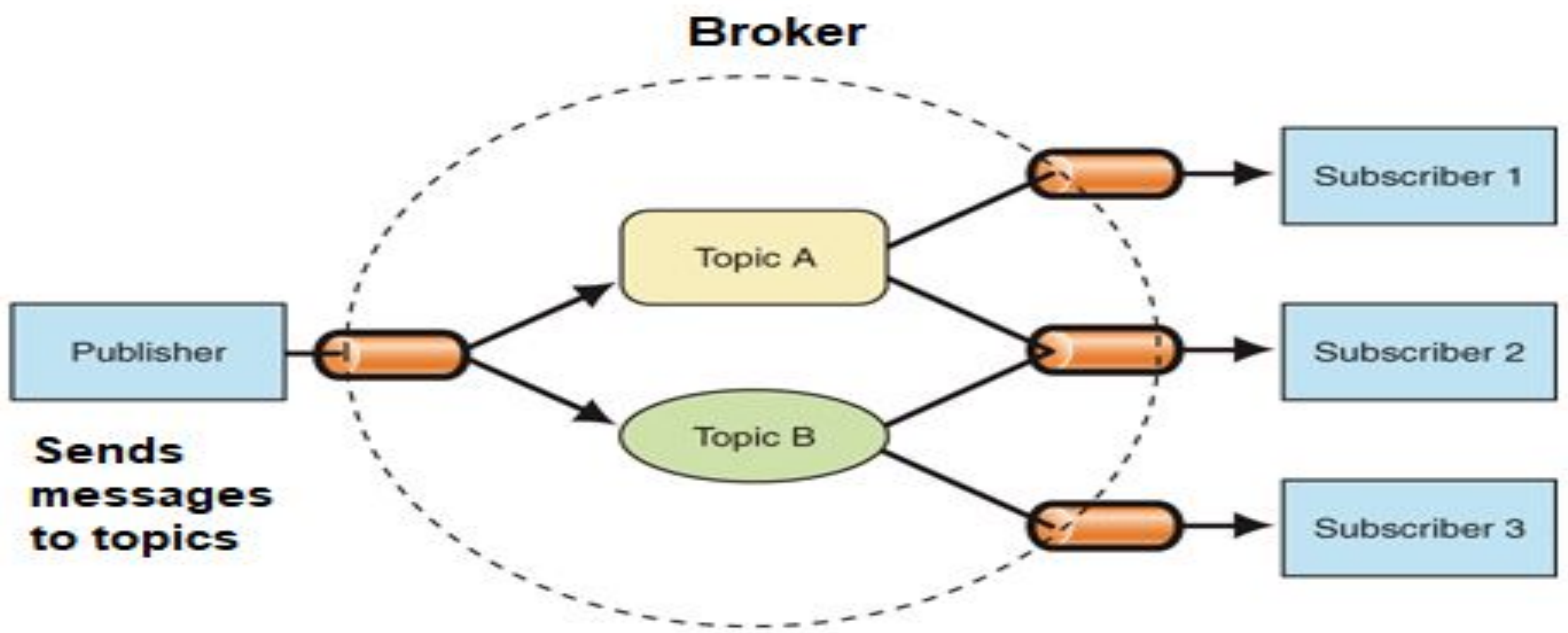


- Here client sends requests to the server and the server responds to the requests. When the server receives a request, it decides how to respond, fetches the data, retrieves resource representation, prepares the response, and then sends the response to the client.

- HTTP works as a request-response protocol between a client and server. A web browser may be the client, and an application on a computer that hosts a web site may be the server

- Example: Sending a spreadsheet to the printer — the spreadsheet program is the client.

Publish-Subscribe



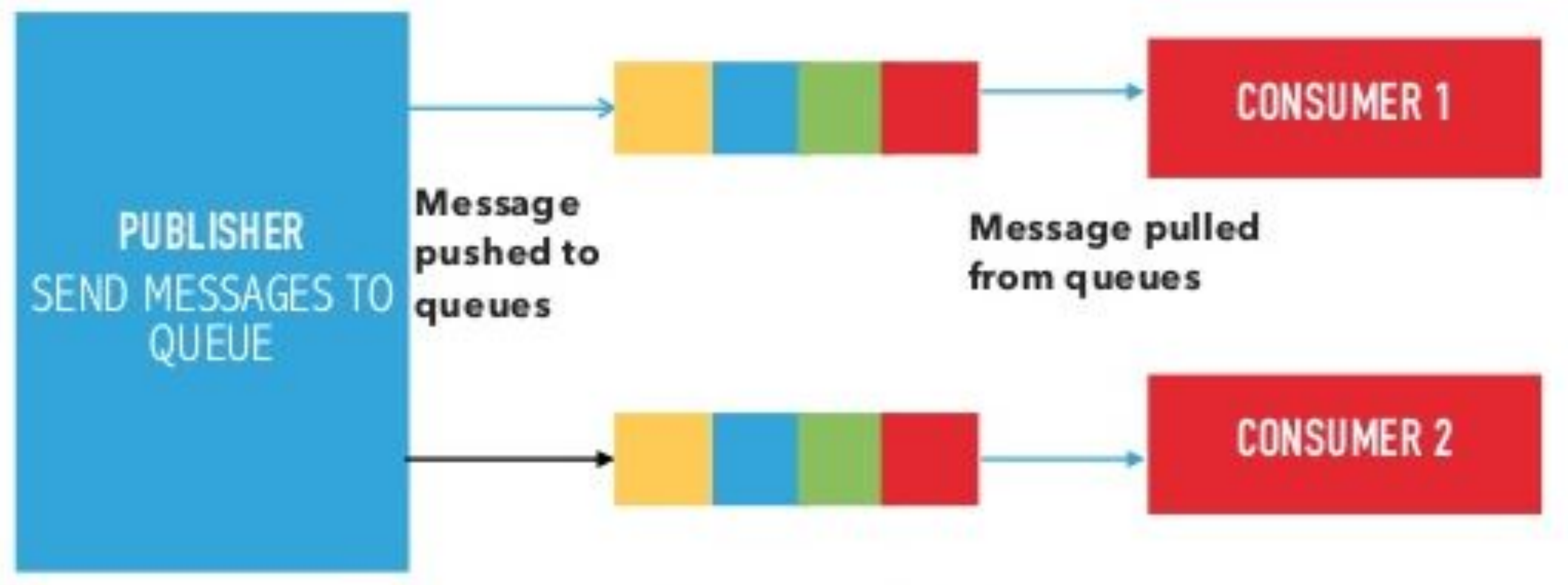
- Publish-Subscribe is a communication model that involves publishers, brokers and consumers. Publishers are the source of data. Publishers send the data to the topics which are managed by the broker. Publishers are not aware of the consumers.

- Consumers subscribe to the topics which are managed by the broker. When the broker receive data for a topic from the publisher, it sends the data to all the subscribed consumers.

- Example: Public sensors with a massive base of uniform users that will use the data

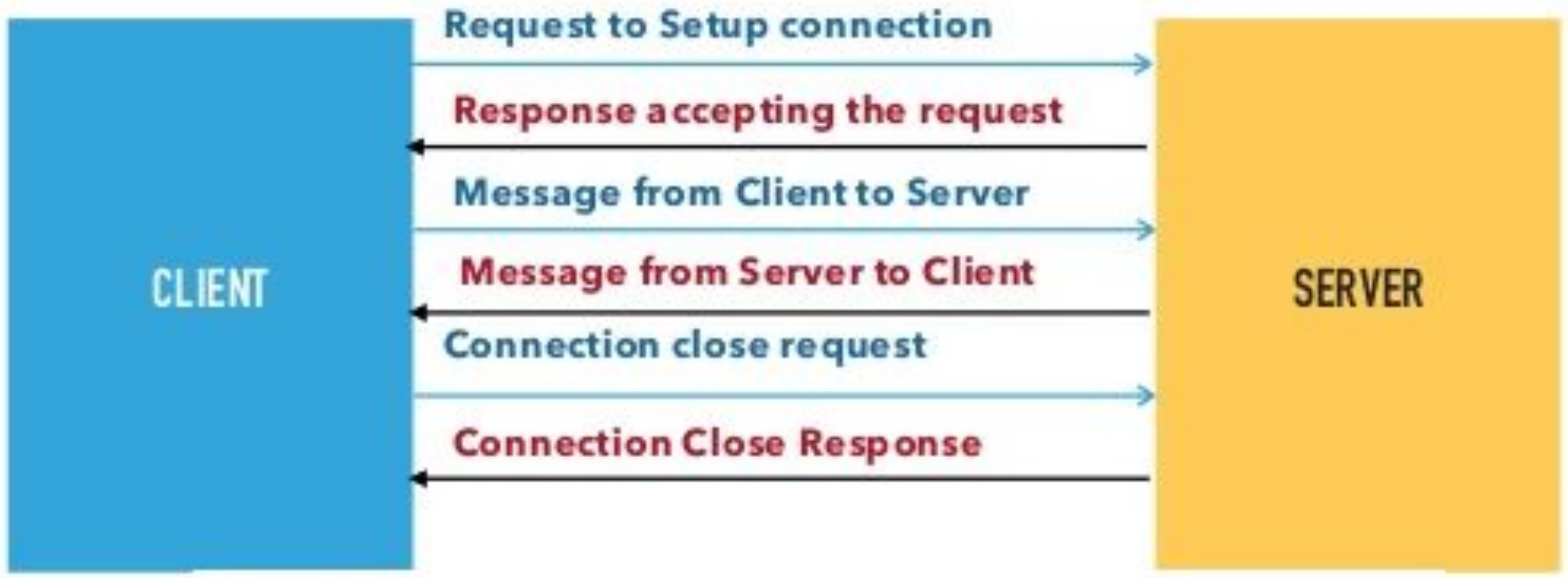
Introduction to IOT Communications Model

Push-Pull



- Push-Pull is a communication model in which the data producers push the data to queues and the consumers Pull the data from the Queues.
- Producers do not need to be aware of the consumers. Queues help in decoupling the messaging between the Producers and Consumers. Queues also act as a buffer which helps in situations when there is a mismatch between the rate at which the producers push data and the rate at which the consumer pull data
- Example: Queues help in decoupling the messaging between the producers and consumers.

Exclusive Pair



- Exclusive Pair is a bidirectional, fully duplex communication model that uses a persistent connection between the client and server.
- Connection is setup it remains open until the client sends a request to close the connection. Client and server can send messages to each other after connection setup.
- Exclusive pair is stateful communication model and the server is aware of all the open connections.
- Example: The WebSocket-based communication API.

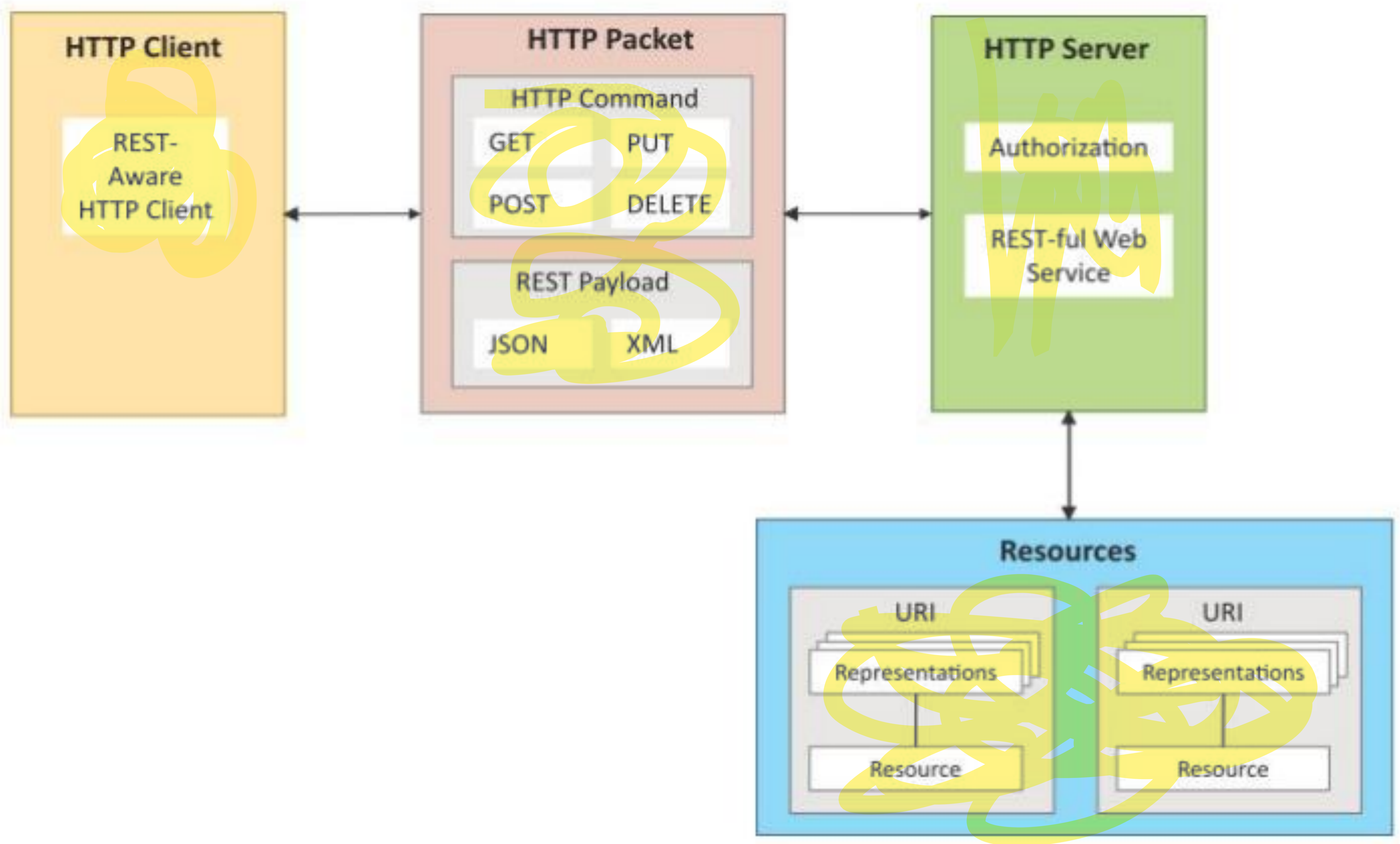
IOT Communication API's

- IoT APIs are the points of interaction between an IoT device and the internet and/or other elements within the network. As API management company Axway puts it, "APIs are tightly linked with IoT because they allow you to securely expose connected devices to customers, go-to-market channels and other applications in your IT infrastructure."
- There are two types of API support
  - REST based communication APIs (Request-Response BasedModel)
  - WebSocket based Communication APIs (Exclusive PairBasedModel)

REST based communication APIs (Request-Response BasedModel)

- REST is acronym for Representational State Transfer. It follows request response model. Representational State Transfer (REST) is a set of architectural principles by which you can design web services and web APIs that focus on a system's resources and how resource states are addressed and transferred. The REST architectural constraints are as follows:

- **The below figure shows the communication between client server with REST APIs**



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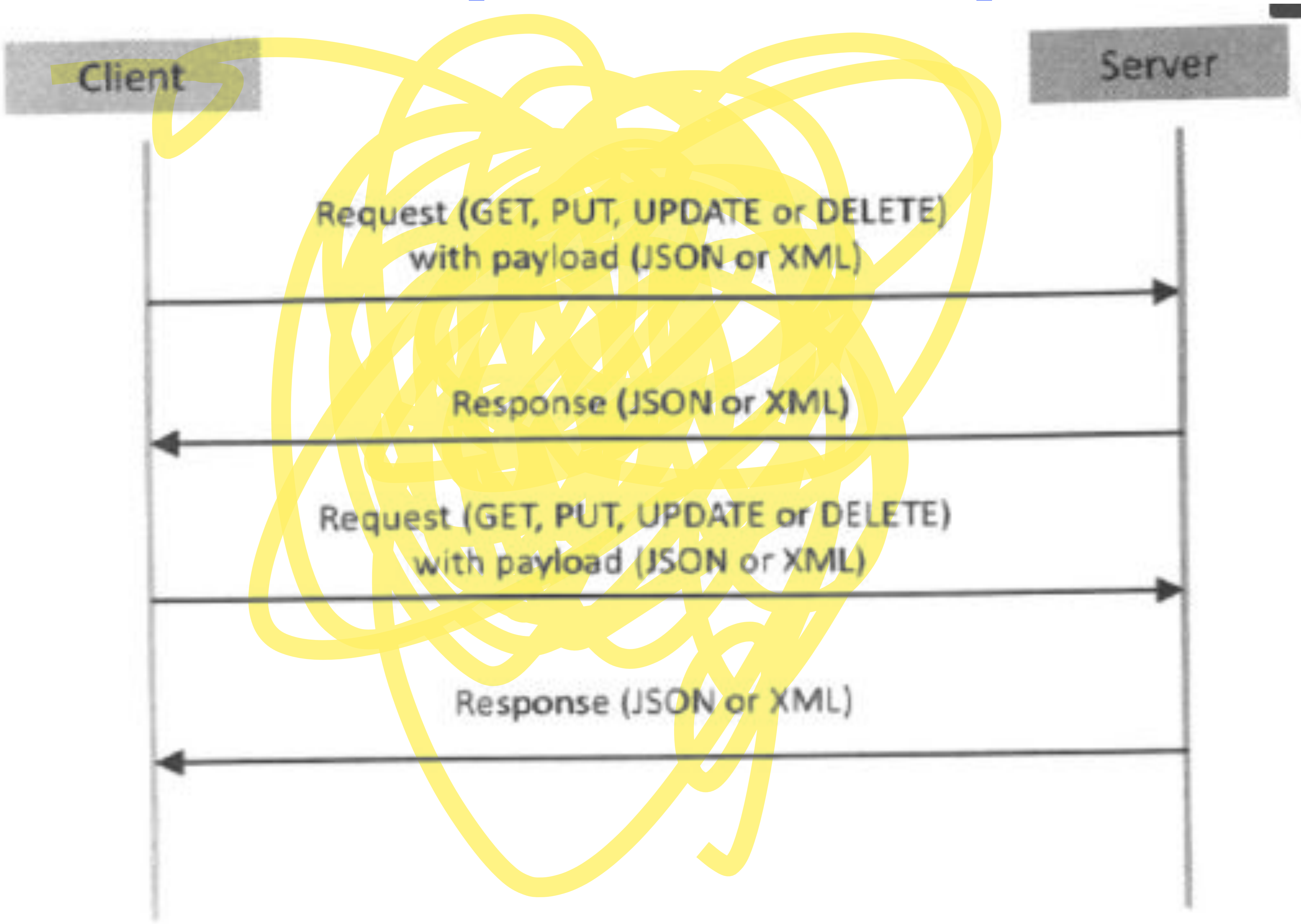
- REST architecture constraints are as follows:
  - Client-Server: The principle behind client-server constraint is the separation of concerns. Separation allows client and server to be independently developed and updated.
  - Stateless: Each request from client to server must contain all the info. Necessary to understand the request, and cannot take advantage of any stored context on the server.
  - Cache-able: Cache constraint requires that the data within a response to a request be implicitly or explicitly labelled as cache-able or non-cacheable. If a response is cacheable, then a client cache is given the right to reuse that response data for later, equivalent requests.
  - Layered System: constraints the behaviour of components such that each component cannot see beyond the immediate layer with which they are interacting.
  - User Interface: constraint requires that the method of communication between a client and a server must be uniform.
  - Code on Demand: Servers can provide executable code or scripts for clients to execute in their context. This constraint is the only one that is optional.

The Request-Response model used by REST:



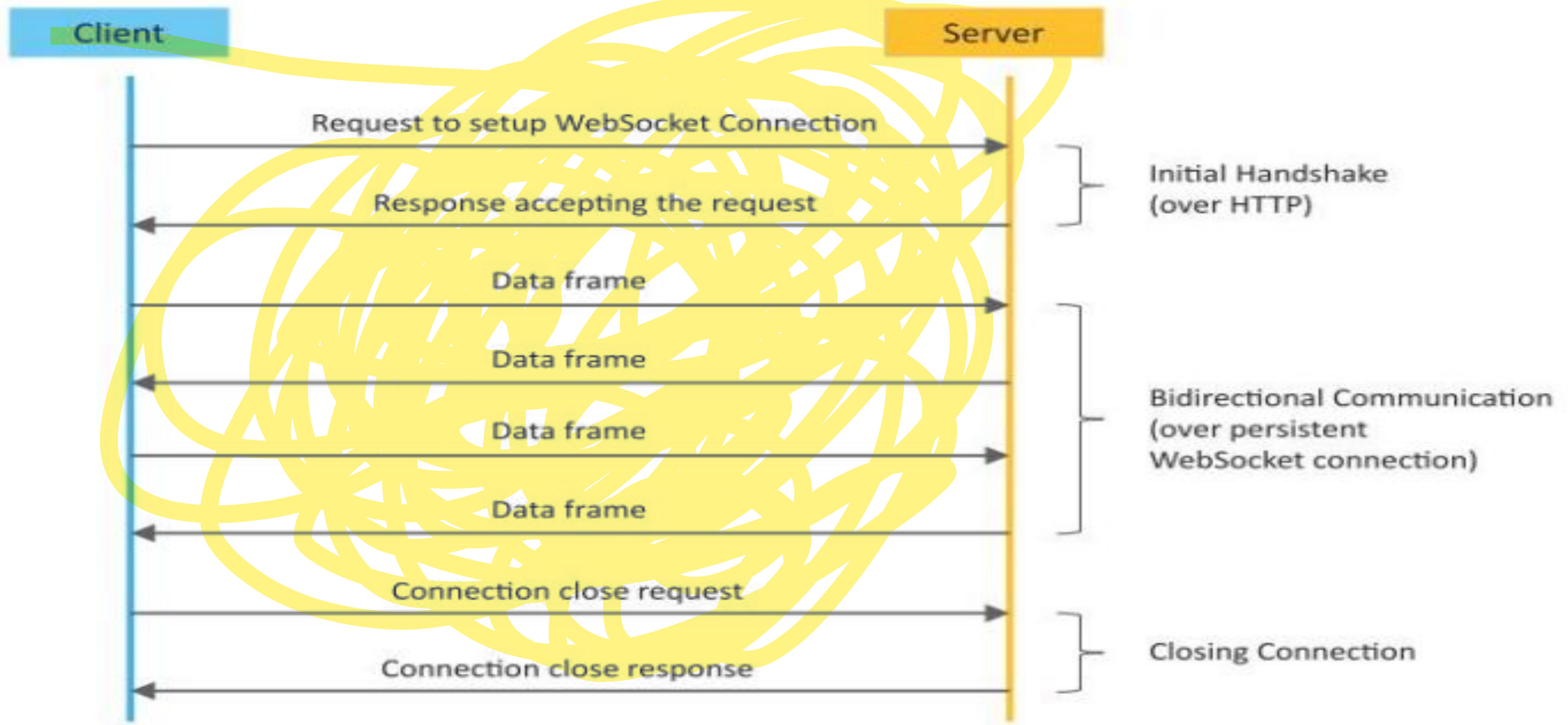
- RESTful web service is a collection of resources which are represented by URIs.
- RESTful web API has a base URI(e.g: http://example.com/api/tasks/).
- The clients and requests to these URIs using the methods defined by the HTTP protocol(e.g: GET, PUT, POST or DELETE).
- A RESTful web service can support various internet media types Following table showing HTTP request method and action

HTTP Method	Resource Type	Action	Example
GET	Collection URI	List all the resources in a collection	http://example.com/api/tasks/ (list all tasks)
GET	Element URI	Get information about a resource	http://example.com/api/tasks/1/ (get information on task-1)
POST	Collection URI	Create a new resource	http://example.com/api/tasks/ (create a new task from data provided in the request)
POST	Element URI	Generally not used	
PUT	Collection URI	Replace the entire collection with another collection	http://example.com/api/tasks/ (replace entire collection with data provided in the request)
PUT	Element URI	Update a resource	http://example.com/api/tasks/1/ (update task-1 with data provided in the request)
DELETE	Collection URI	Delete the entire collection	http://example.com/api/tasks/ (delete all tasks)
DELETE	Element URI	Delete a resource	http://example.com/api/tasks/1/ (delete task-1)

WebSocket based Communication APIs (Exclusive PairBasedModel)

- WebSocket APIs allow bi-directional, full duplex communication between clients and servers. WebSocket APIs follow the exclusive pair communication model. WebSocket APIs allow full duplex communication and do not require new connection to be setup for each message to be sent.

- WebSocket communication begins with a connection setup request sent by the client to server. This request (is known as WebSocket handshake) is sent over the HTTP and server interprets it as an upgrade request. If server supports this websocket protocol, then it responds to the WebSocket handshake response. After connection setup, the client and server can send data/message to each other in full-duplex mode. This API is used to reduce network traffic and latency as there is no overhead for connection setup and termination request for each message. It suitable in IoT application that has low latency and high throughput requirements.

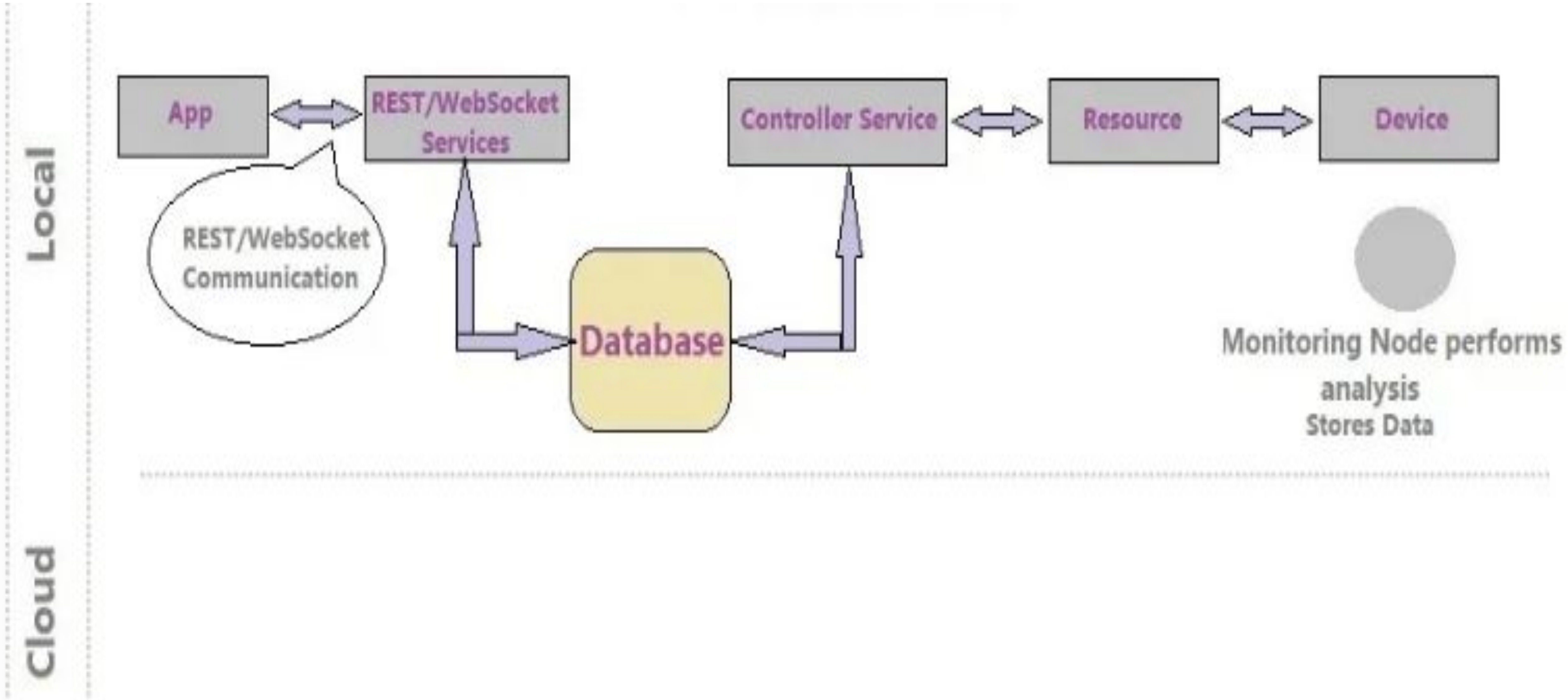


IoT Levels & Deployment Template

- **Developing an IoT Level Template system consists of the following components:**
- **Device:** These may be sensors or actuators capable of identifying, remote sensing, or monitoring.
- **Resources:** These are software components on IoT devices for accessing and processing. storing software components or controlling actuators connected to the device. Resources also include software components that enable network access.
- **Controller Service**: It is a service that runs on the device and interacts with web services. The controller service sends data from the device to the web service and receives commands from the application via web services for controlling the device.
- **Database**: Stores data generated from the device. Database can be either local or in the cloud and stores the data generated by the IoT device.
- **Web Service**: It provides a link between IoT devices, applications, databases, and analysis components. Web services serve as a link between the IoT device, application, database and analysis components. Web service can be either implemented using HTTP and REST principles (REST service) or using WebSocket protocol (WebSocket service).
- **Analysis Component:** It performs an analysis of the data generated by the lol device and generates results in a form which are easy for the user to understand. .
- **Application:** It provides a system for the user to view the system status and view product data. It also allows users to control and monitor various aspects of the IoT system. IoT applications provide an interface that the users can use to control and monitor various aspects of the IoT system. Applications also allow users to view the system status and view the processed

Level of IOT

- **Level 1**
- Level-1 IoT systems have a single node that performs sensing and/or actuation, stores data, performs analysis and host the application. Suitable for modeling low cost and low complexity solutions where the data involved is not big and analysis requirement are not computationally intensive. An e.g., of IoT Level1 is Home automation.



- **Level 2**
- IoT Level2 has a single node that performs sensing and/or actuating and local analysis as shown in fig. Data is stored in cloud and application is usually cloud based. Level2 IoT systems are suitable for solutions where data are involved is big, however, the primary analysis requirement is not computationally intensive and can be done locally itself. An e,g., of Level2 IoT system for Smart

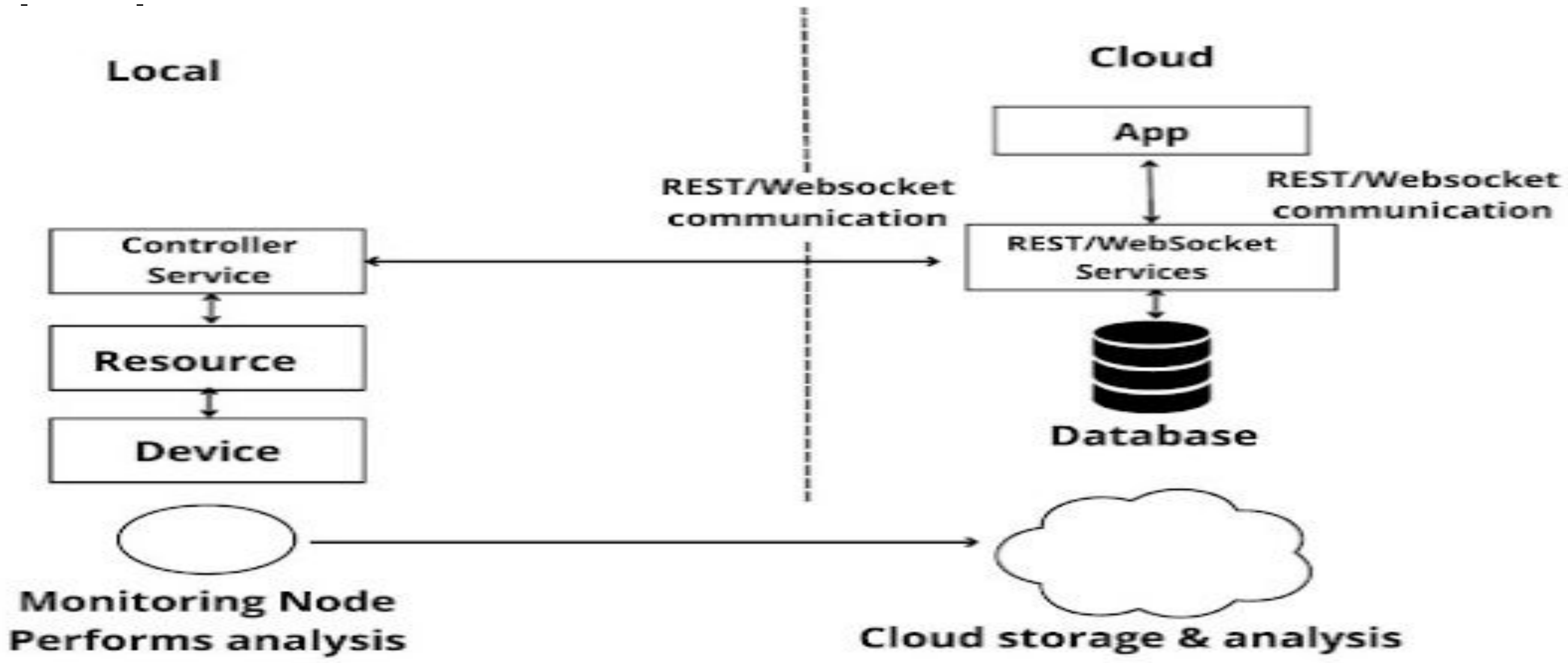


Fig. IoT Level-2

Level of IOT

- **Level 3**
- This System has a single node. Data is stored and analyzed in the cloud application is cloud based as shown in fig. Level3 IoT systems are suitable for solutions where the data involved is big and analysis requirements are computationally intensive.

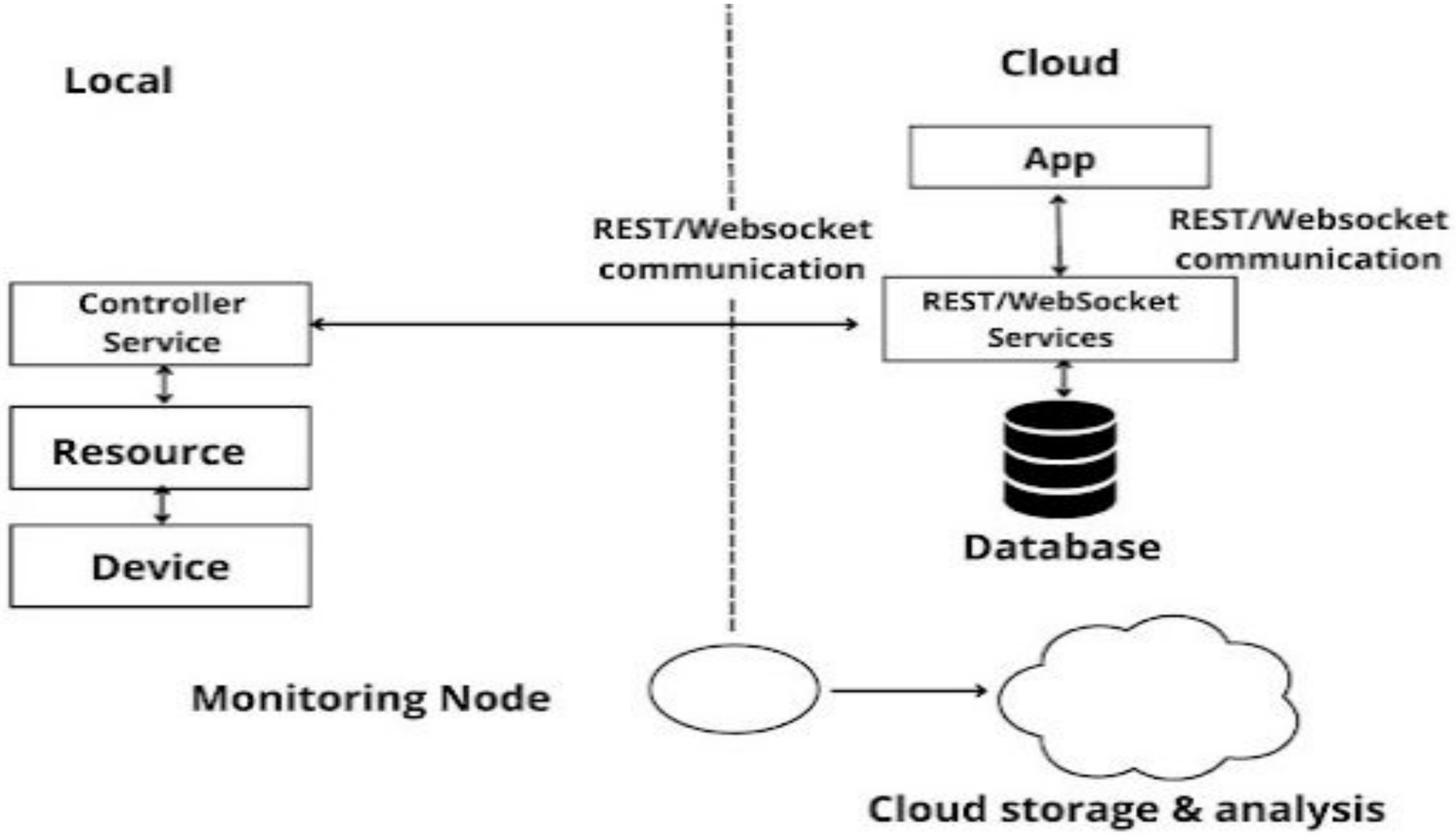


Fig. IoT Level-3

- **Level 4**
- At this level, multiple nodes collect information and store it in the cloud. Local and rent server nodes are used to grant and receive information collected in the cloud from various devices. Observer nodes can process information and use it for applications but not perform control functions, this level is the best solution where data involvement is big, requirement analysis is comprehensive and multiple nodes are required,

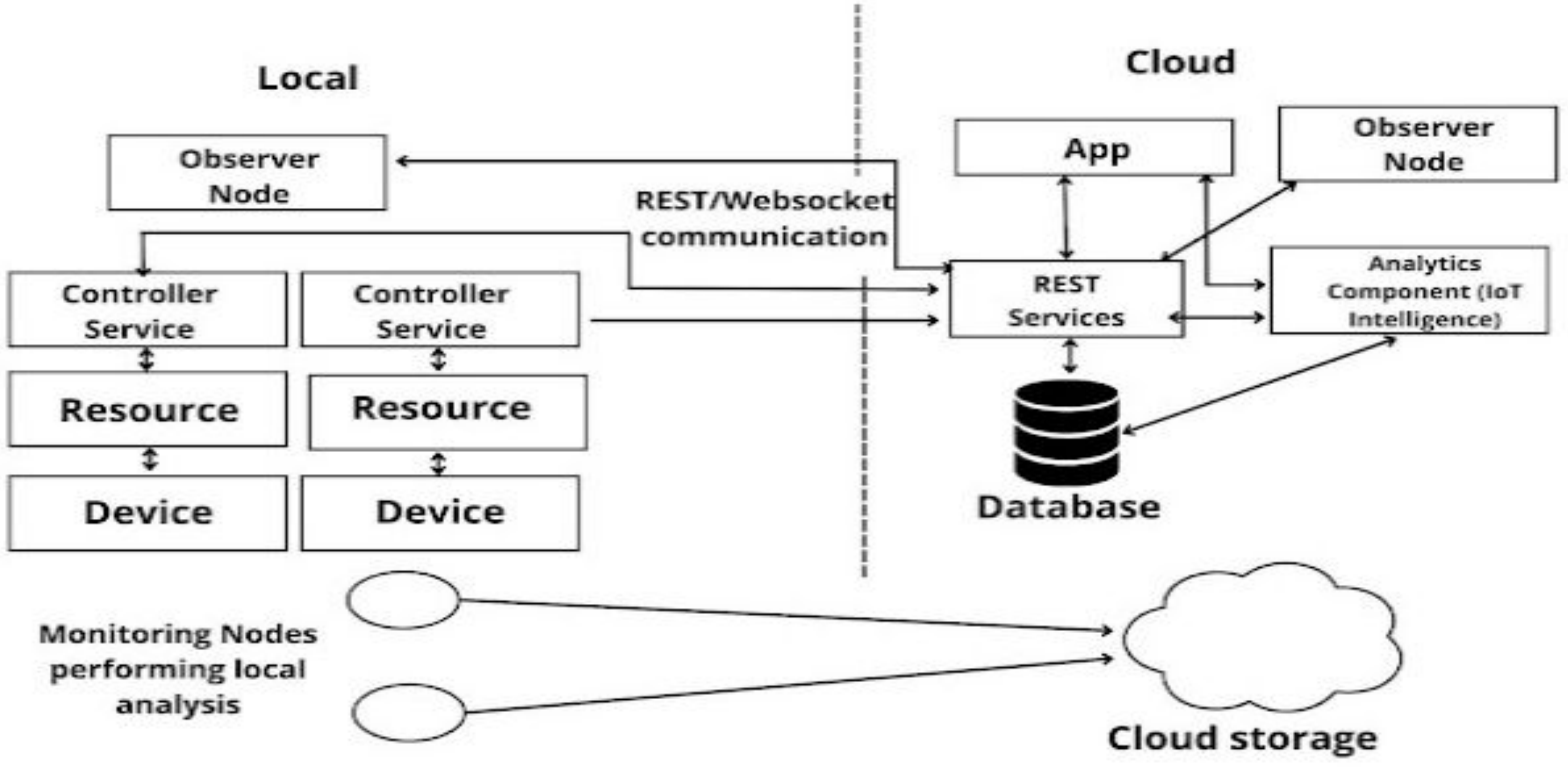


Fig. IoT Level-4

Level of IOT

- **Level 5**
- In this level Nodes present locally are of two types end odes and coordinator nodes End nodes collect data and perform sensing or actuation or both. Coordinator nodes collect data from end nodes and send it to the cloud. Data is stored and analyzed in the cloud. This level is best for WSN, where the data involved is big and the requirement analysis is comprehensive.

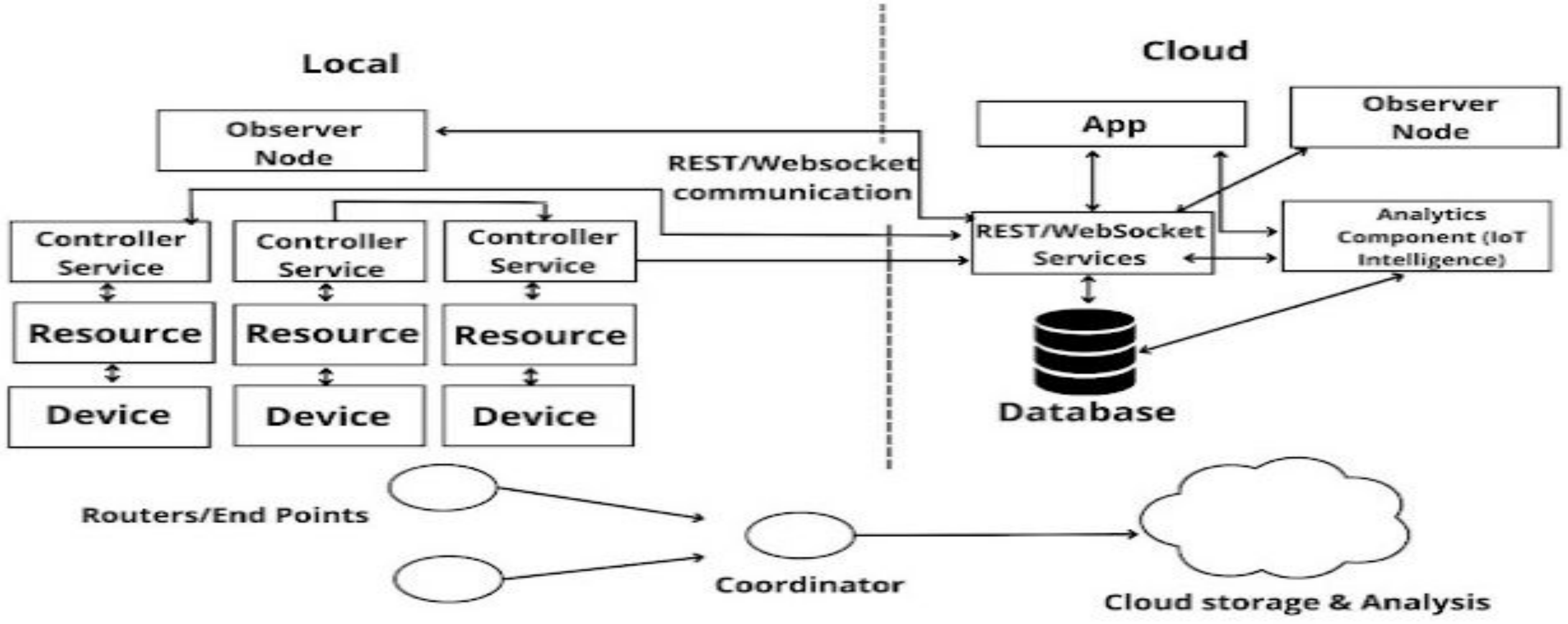


Fig. **IoT Level-5**

- **Level 6**
- At this level, the application is also cloud-based and data is stored in the cloud-like of levels. Multiple independent end nodes perform sensing and actuation and send d to the cloud. The analytics components analyze the data and store the results in the cloud database. The results are visualized with a cloud-based application. The centralized controller is aware of the status of all the end nodes and sends control commands to the nodes.

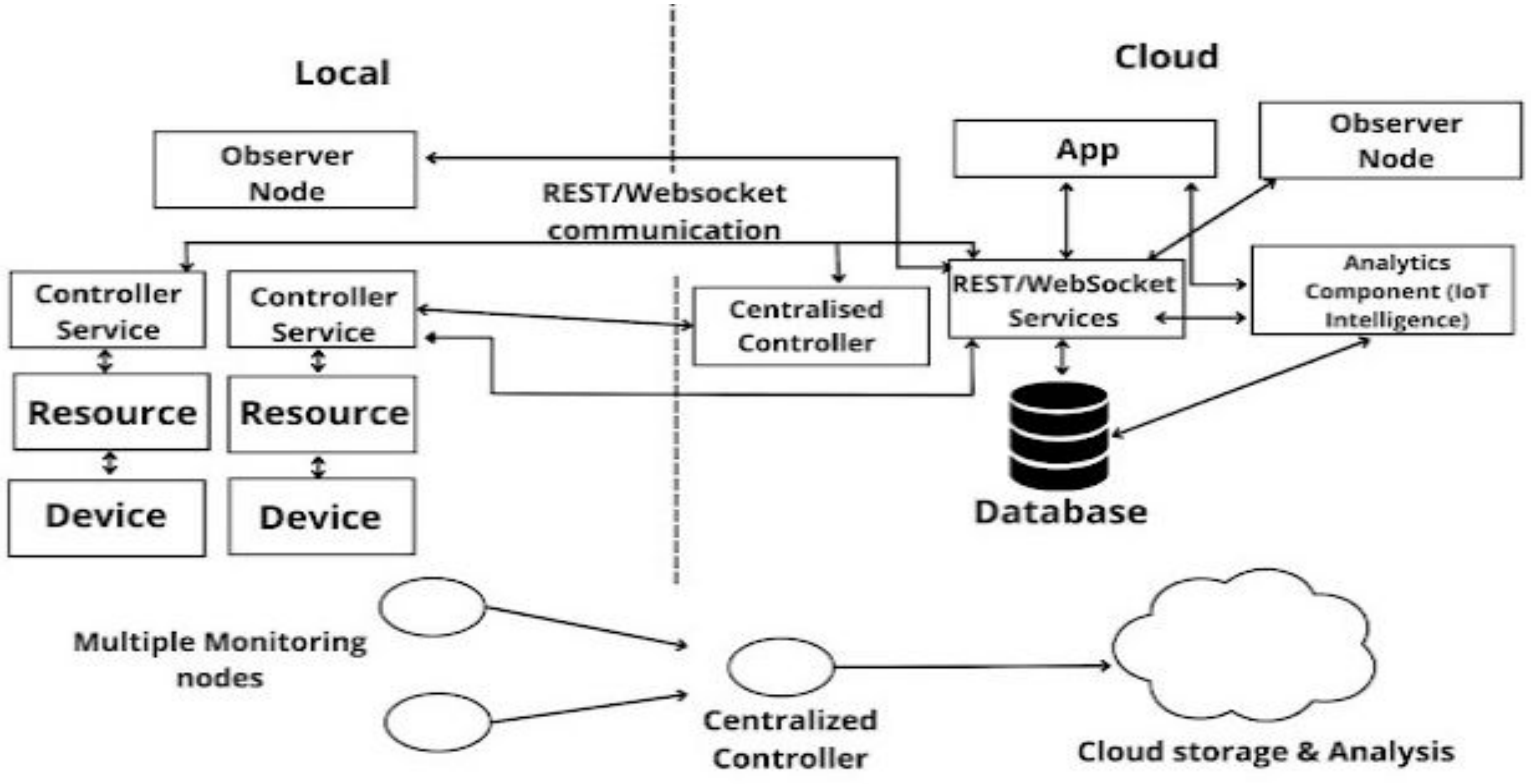


Fig. **IoT Level-6**

Question Bank

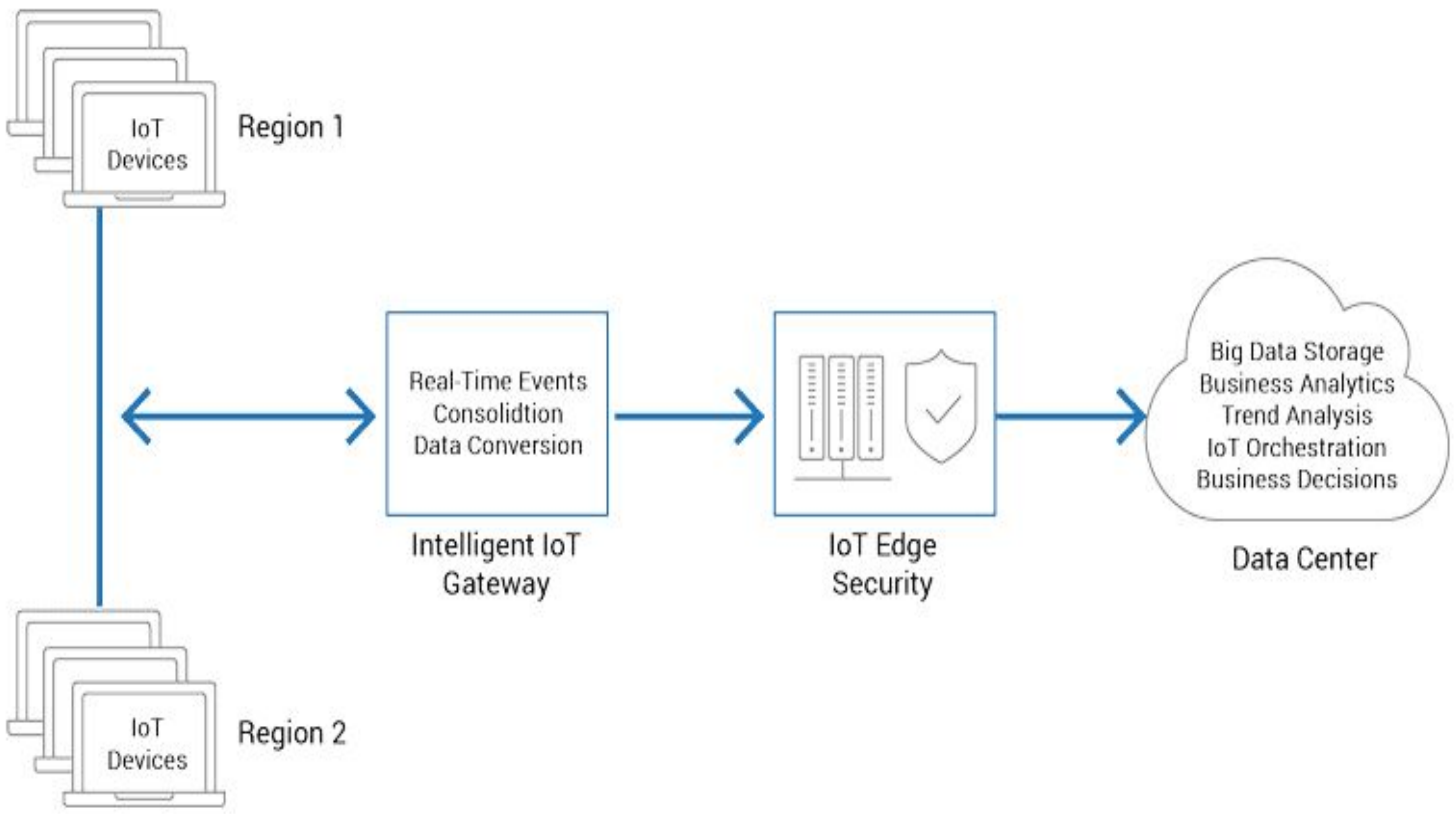
- Define IOT and explain the characteristics of IoT.
- Explain IoT component with suitable diagram [oct 2022]
- Make note on IoT Functional Blocks
- Make note on IoT communication APIs. [oct 2022]
- Explain IoT Communication model with suitable diagram
- Elaborate the functions of IoT Level3 with diagram
- Explain the functions of IoT Level5 with diagram
- Describe the functions IoT Level6 with block diagram.

Telemetry

- **Telemetry automatically collects, transmits and measures data from remote sources, using sensors and other devices to collect data. It uses communication systems to transmit the data back to a central location. Subsequently, the data is analyzed to monitor and control the remote system.**
- Telemetry data helps improve customer experiences and monitor security, application health, quality and performance. Although telemetry refers to wireless data transfer mechanisms such as radio, ultrasonic, or infrared systems, it is not limited and includes data transferred over other media such as optical links, telephones, computer networks, and other wired communications.
- Traditional examples of telemetry are:
    - Monitoring data from space crafts, Animal tracking devices, Automobile sensors for fuel level, engine heat, vehicle speed and more, Heart monitors (EKG), Convicted felon ankle bracelets, Wearables such as Fitbit health monitoring devices
- Telemetry provides the ability to access data from remote locations. Very often, these locations are difficult or expensive to get to and have limited access to power and physical networks.

IoT telemetry architecture

- IoT telemetry architecture includes the components shown below



- **IoT Devices – IoT devices are independent network nodes that communicate across IP networks or often directly with IoT gateway systems.**
- **M2M IoT – Protocols communicate with the local IoT gateway or alternately with central data enter or cloud locations.**
- **IoT Gateway – the intelligent IoT gateway performs a set of functions including,**
  - **Protocol translation between M2M IoT protocols and central datacenter and cloud applications**
  - **Consolidation of upstream IoT communications to WAN-optimized data communications**
  - **Near real-time analytics and event management. IoT devices communicate with the gateway with low-latency network connections. Compute and other resource-intensive analytics can be performed locally for time-critical events**
  - **IoT gateways communicate using secure and encrypted protocols.**
- **Datacenter – IoT data ingested is often processed by:**
  - **Business applications that monitor and act upon the telemetry data. IoT data from multiple locations are analyzed centrally with a complete view of all deployed devices.**
  - **Storing the incoming data stream in various big-data repositories for long-term storage and analysis**
  - **IoT device management software systems that provide orchestrations, software/firmware updates, health monitoring and overall management. New IoT devices can be deployed and on-boarded with centralized systems.**

IoT Telemetry Protocols

- IoT devices communicate using several network protocols. IoT devices used for telemetry such as remote sensors have the following requirements:
- Low Power – Many IoT devices are powered from an embedded battery. New battery technologies have life expectancies of 10 to 20 years.
- Low-Code Footprint – IoT devices are required to be as small as possible. This requires lightweight protocols that do not need heavy computing or wireless transmission power requirements.
- Low Bandwidth – Higher bandwidth transmissions require higher power and additional hardware footprints.
- Local Intelligent IoT Gateways – The closer this system is to the IoT device, the lower the power required to transmit to this receiving system.

Cont..

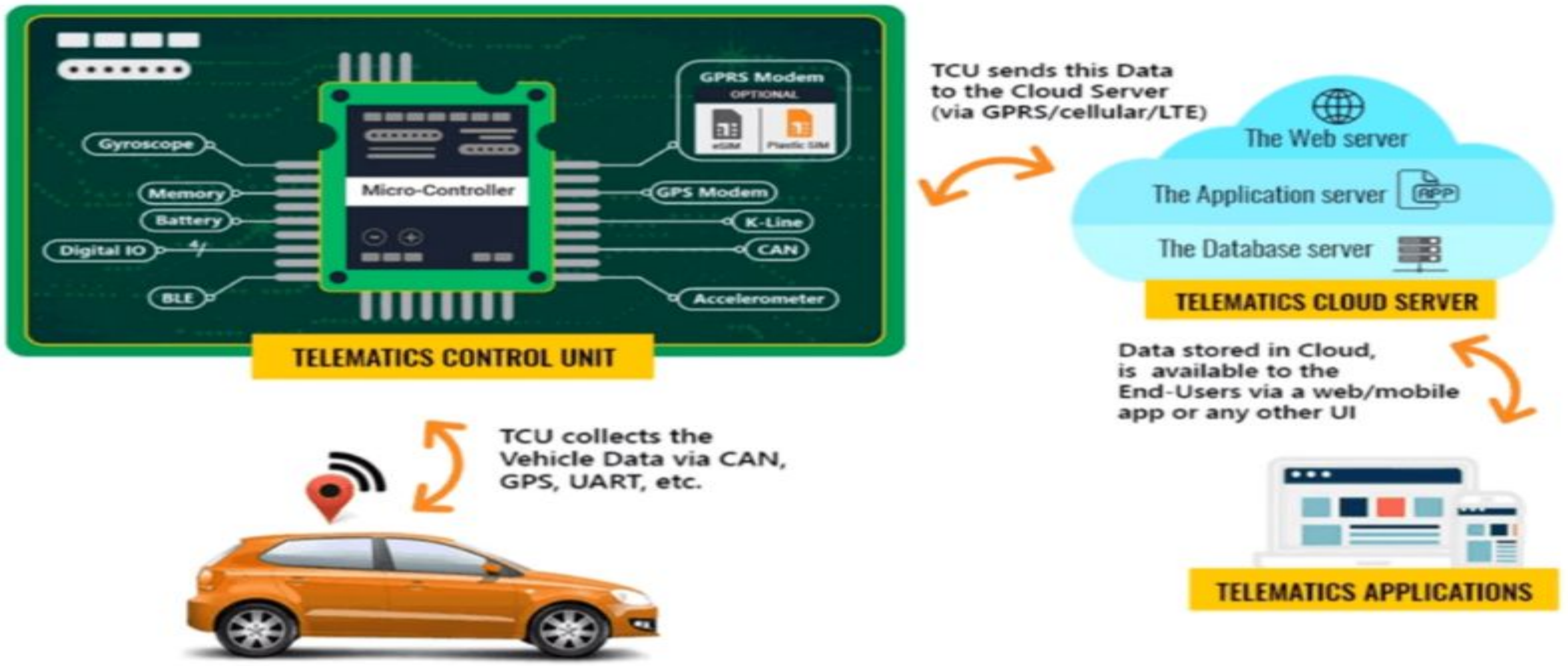
- IoT telemetry communications between the devices and the receiving system are performed by several protocols. Each protocol has benefits and flaws.
- MQTT – The Message Queuing Telemetry Transport (MQTT) protocol runs over TCP/IP and was designed for embedded hardware devices with limited embedded components and low power requirements. This protocol uses a publish-subscribe approach, which is inactive between transmissions and data retrievals. MQTT requires an intelligent IoT gateway.
- CoAP – Constrained Application Protocol (CoAP) was designed to run on devices constrained by low power and lossy networks. The protocol runs on UDP and is easily translatable to HTTP. CoAP can be routed over IP networks and supports IP multicast for M2M communications between other IoT devices.
- HTTP – This protocol is often combined with the Restful API protocol and is routable across the internet but is insecure.
- HTTPS – This protocol is secure and robust but has high power and processing requirements to encrypt data traffic and requires remote management of certificates.
- Alternative protocols
    - XMPP – IM-based protocol, simple addressing scheme, Advanced Message Queuing Protocol (AMQP) – Server to Server, Streaming Text-Oriented Messaging Protocol (STOMP), Data Distribution Service (DDS) – Device to Device, OPC UA, Web Application Messaging Protocol (WAMP)

Telematics..

- A telematics system operates by integrating a machine into an asset, including a tracking device or other real-time monitoring tools. The device then gathers critical asset performance information. Once the information is collected, the device sends it to a computer system, where it will be compiled, interpreted, and reviewed.

- Data is collected using various methods, including hard-wired or self-fit gadgets and smartphone apps. The system considers multiple factors, such as natural conditions.

- For example: When we say that a vehicle is integrated with telematics, it essentially means that it is fitted with a crash-resistant black box with a complex electronic control unit inside. This black-box, also referred to as the T-Box in automotive engineering parlance, is a telematics control unit.



Benefits..

- Some of the key benefits offered by the implementation of telematics are:
- Navigation – Telematics provides turn-by-turn navigation assistance to guide drivers easily to their locations. When drivers are able to access shortest routes to destinations, they are also able to save on fuel costs.
- Safety – Telematics devices collect safety-related information such as call for assistance during a crisis, emergency requests, stolen vehicle tracking, etc. and provide timely help to the vehicle occupants. Telematics also collects driving behavior data such as sharp braking, acceleration, etc. This information can be used to educate drivers so that they stay safe on the roads.
- Vehicle Performance – Users receive important vehicle health reports through the telematics system. This information can be very useful for fleet managers, as they can then schedule vehicle maintenance accordingly.
- Vehicle Visibility – Telematics empowers organizations so that they can track the location of their vehicles. Fleet managers can use the vehicle location data to make timely route adjustments while responding to traffic congestion, weather conditions, etc. This way, they can switch resources around and ensure that there is no delay in deliveries.
- Connectivity to Internet – The driver and passengers in the vehicle can utilize live weather forecasts, news bulletins and even information from social networking apps.
- Reduced Administrative Costs – Administration and compliance is simplified as telematics devices can be integrated with third-party apps that generate various types of reports.

Challenges of Telematics

- **Power dependency: Vehicle GPS trackers must be powered to function. Nevertheless, both battery-powered and complex-wired tools have drawbacks. One must charge battery-powered devices regularly to prevent being stuck in an urgent situation with no way to summon help. Hard-wired car trackers power up from the battery pack and can drain it if the wires are not correctly installed.**

- **Privacy concerns: People are understandably worried about their moves being tracked and recorded on a remote server. Before placing a GPS tracker in a car used by anyone except yourself – whether it's your wife, kid, or employee – make sure to address any privacy issues they may have by clarifying why you want to configure a tracker and how you plan to use the data.**

- **Jamming: Sadly, GPS signals can be clogged by devices that interrupt GPS satellite messages. The only way to avoid this is to invest in a telematics system capable of detecting and reporting signal jamming.**

- **System installation can take some time: Mounting telematics may take roughly 15 minutes to a day. This is because the process may require dismantling and rebuilding the dashboards. Therefore, you should allow specialists to carry out this task on your behalf.**

- **Cost: Mounting a telematics system is costly, even if the consumer has the skill to do so, since one must purchase hardware and software. Prices vary depending on the global navigation satellite system (GNSS) and GPS. Cellular tracking is the least expensive, costing around $700. Nevertheless, the user must pay approximately $35 per month for online data. In passive wireless monitoring, the hardware costs $700, and the directory and network costs $800. Moreover, the average cost of satellite-based real-time tracking ranges between $5 and $100.**

Top 10 Applications of Telematics

- Safety monitoring
- Communication in real-time
- Detect harsh acceleration or braking
- Vehicle maintenance
- A risk assessment by insurance companies
- Logging fuel consumption
- Monitoring weather conditions
- Assist with performance and training
- Monitoring trailers and quasi assets
- Beyond standard geofencing

Applications..

Cont..

- IoT Applications for :
  - Home
  - Cities
  - Environment
  - Energy Systems
  - Retail
  - Logistics
  - Industry
  - Agriculture
  - Health & Lifestyle

Home Automation

- IoT applications for smart homes:
  - *Smart Lighting*
  - *Smart Appliances*
  - *Intrusion Detection*
  - *Smoke / Gas Detectors*

Cont..

Smart Lighting

- Smart lighting achieve **energy savings** by sensing the human movements and their environments and controlling the lights accordingly.
- Key enabling technologies for smart lighting include :
  - ***Solid state lighting (such as LED lights)***
  - ***IP-enabled lights***
- Wireless-enabled and Internet connected lights can be controlled remotely from IoT applications such as a mobile or web application.

Smart Appliances

- Smart appliances make the management easier and provide status information of appliances to the users remotely. ***E.g***: smart washer/dryer that can be controlled remotely and notify when the washing/drying cycle is complete.
- ***OpenRemote*** is an open source automation platform for smart home and building that can control various appliances using mobile and web applications.
- It comprises of three components:
  - a Controller → manages scheduling and runtime integration between devices.
  - a Designer → allows to create both configuration for the controller and user interface designs.
  - Control Panel → allows to interact with devices and control them.

Cont..

Intrusion Detection

- Home intrusion detection systems use *security cameras* and *sensors* to detect intrusions and raise alerts.
- The form of the alerts can be in form:
  - *SMS*
  - *Email*
  - *Image grab or a short video clip as an email attachment*

Smoke / Gas Detectors

- Smoke detectors are installed in homes and buildings to detect smoke that is typically an early sign of fire.
- It uses optical detection, ionization or air sampling techniques to detect smoke
- The form of the alert can be in form :
  - *Signals that send to a fire alarm system*
- Gas detector can detect the presence of harmful gases such as carbon monoxide (CO), liquid petroleum gas (LPG), etc.


Propane


Natural Gas

Carbon Monoxide

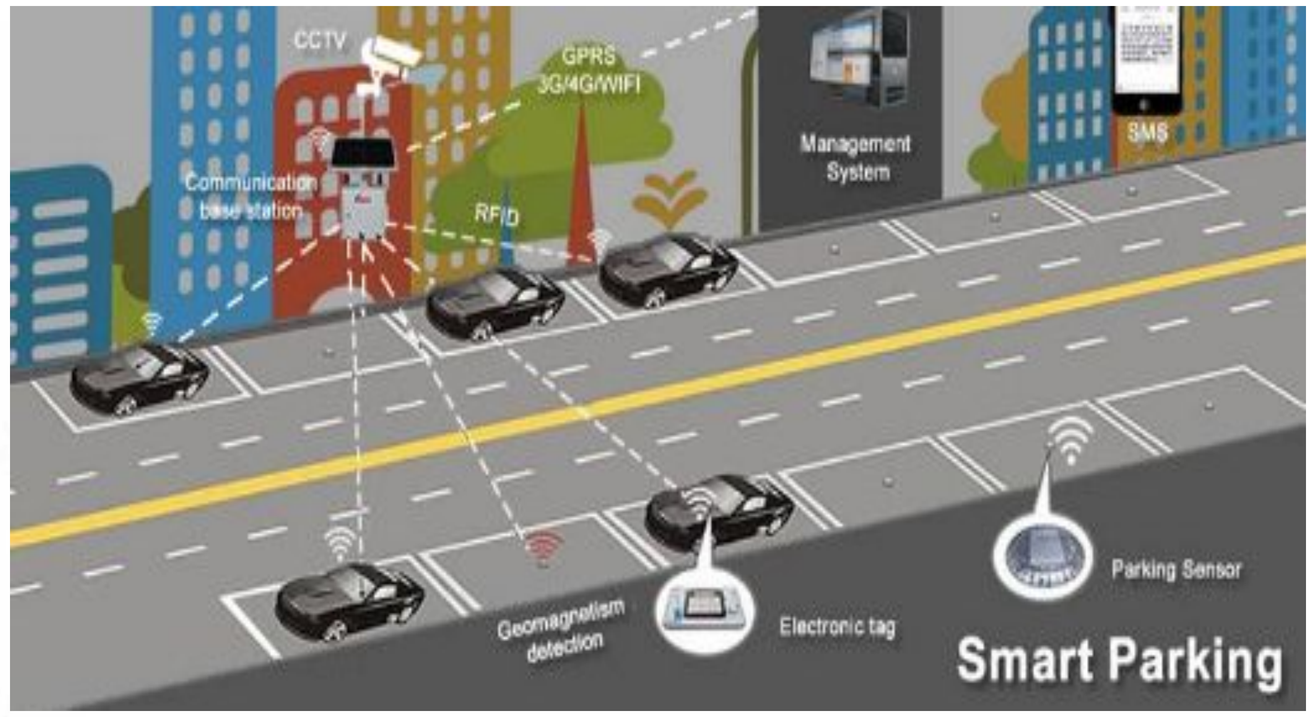
Smart Cities

- IoT applications for smart cities:
  1. *Smart Parking*
  2. *Smart Lighting for Road*
  3. *Smart Road*
  4. *Structural Health Monitoring*
  5. *Surveillance*
  6. *Emergency Response*

Cont..

Smart Parking

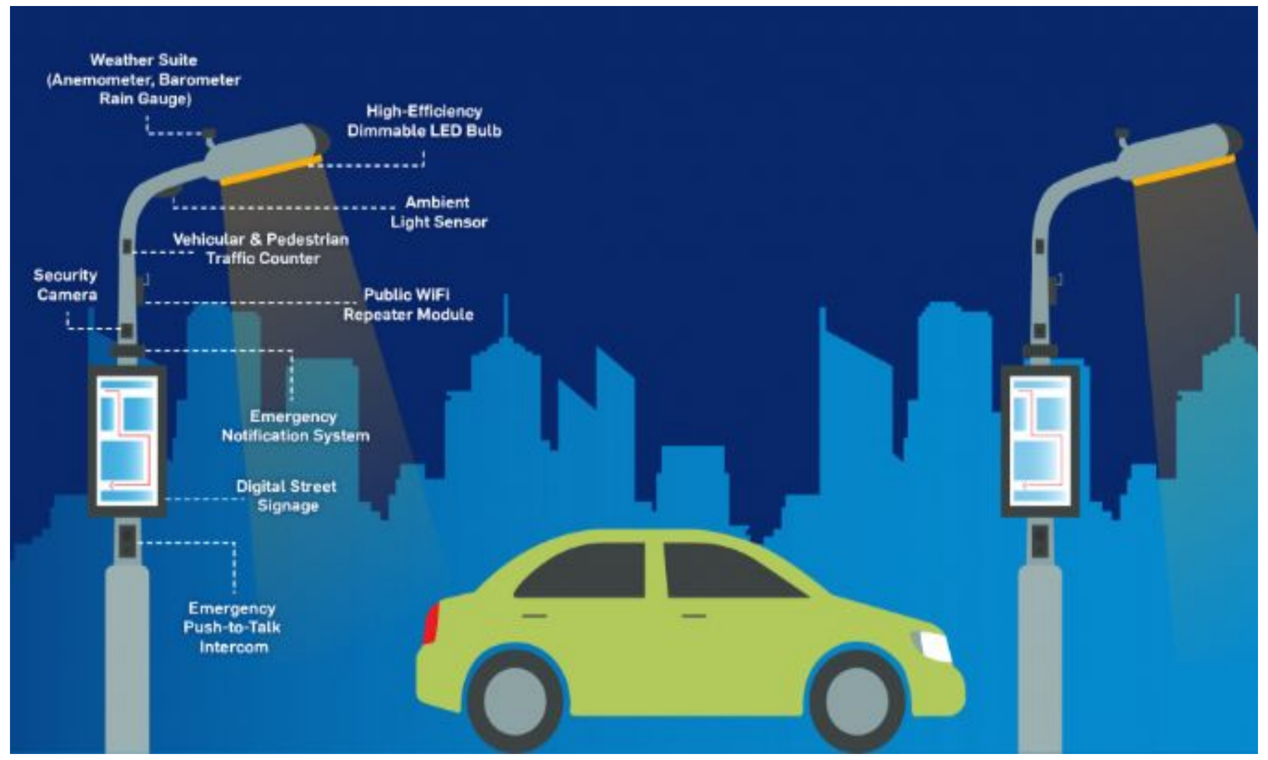
- Finding the parking space in the crowded city can be time consuming and frustrating
- Smart parking makes the search for parking space easier and convenient for driver.
- It can detect the number of empty parking slots and send the information over the Internet to the smart parking applications which can be accessed by the drivers using their smartphones, tablets, and in car navigation systems.
- Sensors are used for each parking slot to detect whether the slot is empty or not, and this information is aggregated by local controller and then sent over the Internet to database.



[iNELS SMART CITY | Smart street lighting - YouTube]

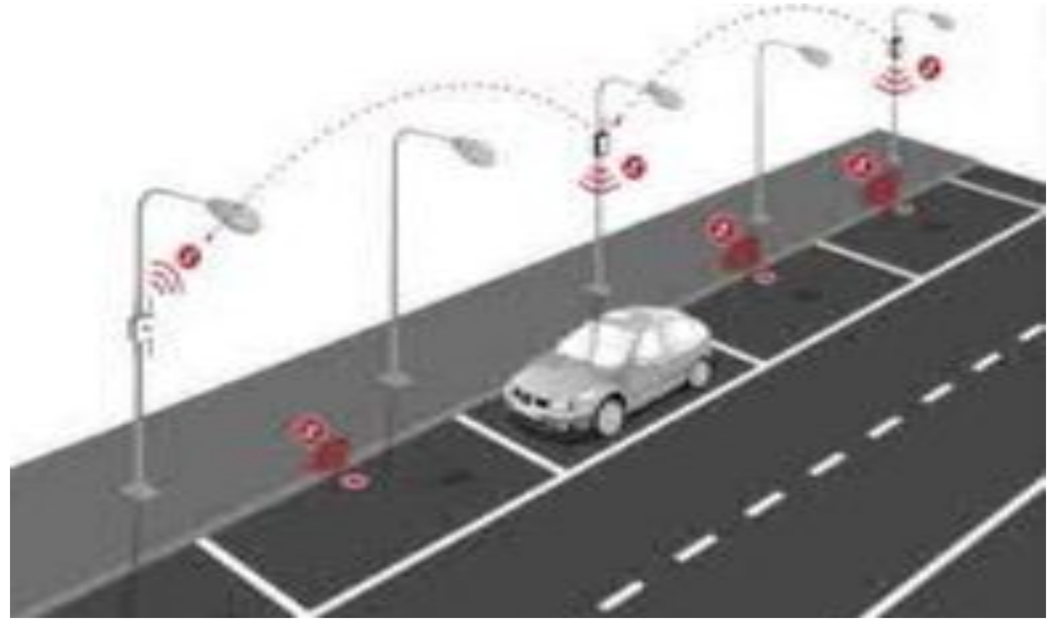
Smart Lighting for Roads

- It can help in saving energy
- Smart lighting for roads allows lighting to be dynamically controlled and also adaptive to ambient conditions.
- Smart light connected to the Internet can be controlled remotely to configure lighting schedules and lighting intensity.
- Custom lighting configurations can be set for different situations such as a foggy day, a festival, etc.



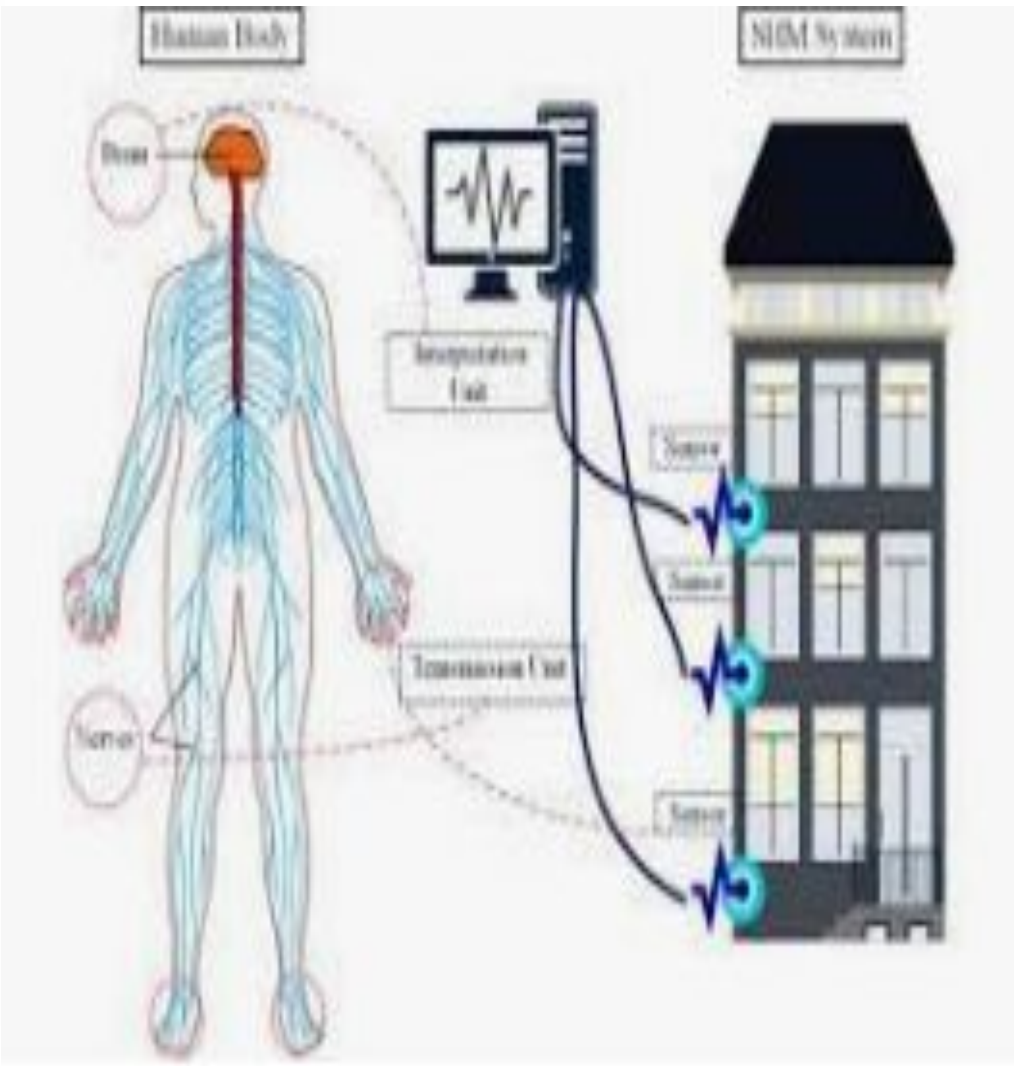
Smart Roads

- Smart Roads provides information on driving conditions, travel time estimates and alerts in case of poor driving conditions, traffic congestions and accidents.
- Such information can help in making the roads safer and help in reducing traffic jams
- Information sensed from the roads can be communicated via internet to cloud-based applications and social media and disseminated to the drivers who subscribe to such applications.



Cont..

Structural Health Monitoring



- It uses a network of sensors to monitor the vibration levels in the structures such as bridges and buildings.
- The data collected from these sensors is analyzed to assess the health of the structures.
- By analyzing the data it is possible to detect cracks and mechanical breakdowns, locate the damages to a structure and also calculate the remaining life of the structure.
- Using such systems, advance warnings can be given in the case of imminent failure of the structure.

Surveillance

- Surveillance of infrastructure, public transport and events in cities is required to ensure safety and security.
- City wide surveillance infrastructure comprising of large number of distributed and Internet connected video surveillance cameras can be created.
- The video feeds from surveillance cameras can be aggregated in cloud-based scalable storage solutions.
- Cloud-based video analytics applications can be developed to search for patterns of specific events from the video feeds.

Cont..

Emergency Response

- IoT systems can be used for monitoring the critical infrastructure cities such as buildings, gas, and water pipelines, public transport and power substations.
- IoT systems for critical infrastructure monitoring enable aggregation and sharing of information collected from lager number of sensors.
- Using cloud-based architectures, multi-modal information such as sensor data, audio, video feeds can be analyzed I near real-time to detect adverse events.
- The alert can be in the form :
  - Alerts sent to the public
  - Re-rerouting of traffic
  - Evacuations of the affected areas

Environment…

- IoT applications for smart environments:
  1. *Weather Monitoring*
  2. *Air Pollution Monitoring*
  3. *Noise Pollution Monitoring*
  4. *Forest Fire Detection*
  5. *River Flood Detection*

Cont..

Weather Monitoring

- It collects data from a number of sensor attached such as temperature, humidity, pressure, etc and send the data to cloud-based applications and store back-ends.
- The data collected in the cloud can then be analyzed and visualized by cloud-based applications.
- Weather alert can be sent to the subscribed users from such applications.
- AirPi is a weather and air quality monitoring kit capable of recording and uploading information about temperature, humidity, air pressure, light levels, UV levels, carbon monoxide, nitrogen dioxide and smoke level to the Internet.

Air Pollution Monitoring

- IoT based air pollution monitoring system can monitor emission of harmful gases by factories and automobiles using gaseous and meteorological sensors.
- The collected data can be analyzed to make informed decisions on pollutions control approaches.

Noise Pollution Monitoring

- Noise pollution monitoring can help in generating noise maps for cities.
- It can help the policy maker in making policies to control noise levels near residential areas, school and parks.
- It uses a number of noise monitoring stations that are deployed at different places in a city.
- The data on noise levels from the stations is collected on servers or in the cloud and then the collected data is aggregate to generate noise maps.

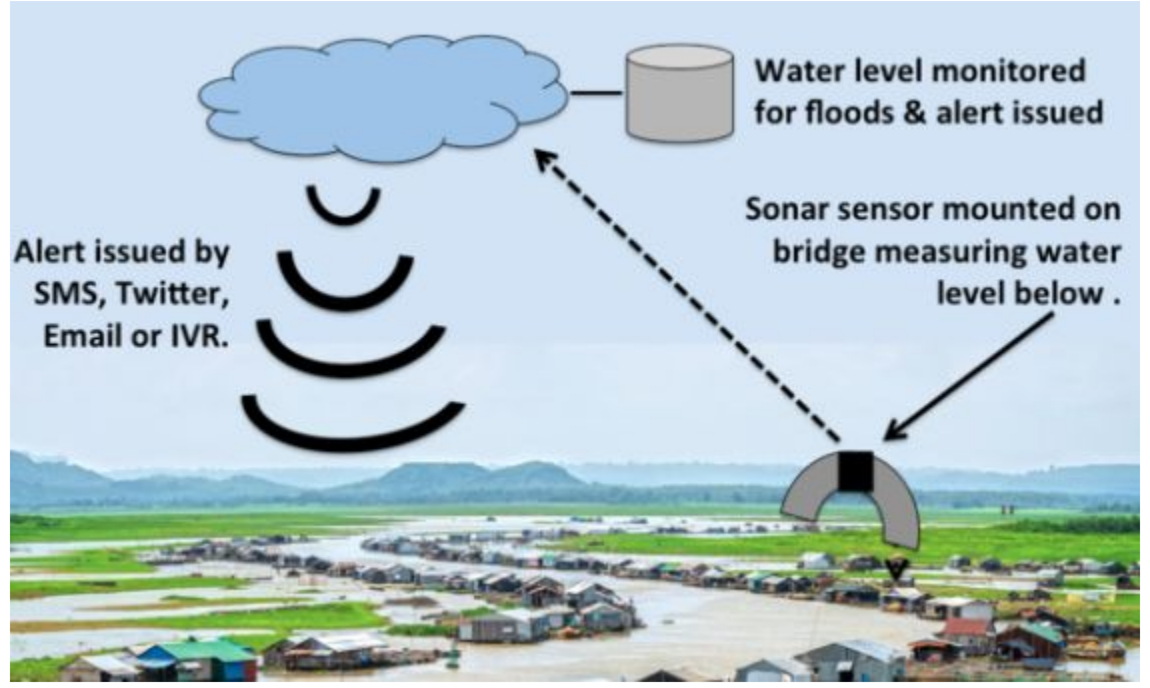
Cont..

Forest Fire Detection

- IoT based forest fire detection system use a number of monitoring nodes deployed at different location in a forest.
- Each monitoring node collects measurements on ambient condition including temperature, humidity, light levels, etc.
- Early detection of forest fires can help in minimizing the damage.

River Flood Detection

- IoT based river flood monitoring system uses a number of sensor nodes that monitor the water level using ultrasonic sensors and flow rate using velocity sensors.
- Data from these sensors is aggregated in a server or in the cloud, monitoring applications raise alerts when rapid increase in water level and flow rate is detected.



Energy..

- IoT applications for smart energy systems:
  1. *Smart Grid*
  2. *Renewable Energy Systems*
  3. *Prognostics*

Cont..

<u>Smart Grids</u>

- Smart grid technology provides predictive information and recommendation s to utilize, their suppliers, and their customers on how best to manage power.
- Smart grid collect the data regarding :
  - Electricity generation
  - Electricity consumption
  - Storage
  - Distribution and equipment health data
- By analyzing the data on power generation, transmission and consumption of smart grids can improve efficiency throughout the electric system.
- Storage collection and analysis of smarts grids data in the cloud can help in dynamic optimization of system operations, maintenance, and planning.
- Cloud-based monitoring of smart grids data can improve energy usage usage levels via energy feedback to users coupled with real-time pricing information.
- Condition monitoring data collected from power generation and transmission systems can help in detecting faults and predicting outages.

Cont..

Renewable Energy System

- Due to the variability in the output from renewable energy sources (such as solar and wind), integrating them into the grid can cause grid stability and reliability problems.
- IoT based systems integrated with the transformer at the point of interconnection measure the electrical variables and how much power is fed into the grid
- To ensure the grid stability, one solution is to simply cut off the overproductions.

Prognostics

- IoT based prognostic real-time health management systems can predict performance of machines of energy systems by analyzing the extent of deviation of a system from its normal operating profiles.
- In the system such as power grids, real time information is collected using specialized electrical sensors called Phasor Measurement Units (PMU)
- Analyzing massive amounts of maintenance data collected from sensors in energy systems and equipment can provide predictions for impending failures.
- OpenPDC is a set of applications for processing of streaming time-series data collected from Phasor Measurements Units (PMUs) in real-time.

Retail..

- IoT applications in smart retail systems:
  1. *Inventory Management*
  2. *Smart Payments*
  3. *Smart Vending Machines*

Cont..

Inventory Management

- IoT system using Radio Frequency Identification (RFID) tags can help inventory management and maintaining the right inventory levels.
- RFID tags attached to the products allow them to be tracked in the real-time so that the inventory levels can be determined accurately and products which are low on stock can be replenished.
- Tracking can be done using RFID readers attached to the retail store shelves or in the warehouse.

Smart Payments

- Smart payments solutions such as contact-less payments powered technologies such as Near field communication (NFC) and Bluetooth.
- NFC is a set of standards for smart-phones and other devices to communicate with each other by bringing them into proximity or by touching them
- Customer can store the credit card information in their NFC-enabled smart-phones and make payments by bringing the smart-phone near the point of sale terminals.
- NFC maybe used in combination with Bluetooth, where NFC initiates initial pairing of devices to establish a Bluetooth connection while the actual data transfer takes place over Bluetooth.

Smart Vending Machines

- Smart vending machines connected to the Internet allow remote monitoring of inventory levels, elastic pricing of products, promotions, and contact-less payments using NFC.
- Smart-phone applications that communicate with smart vending machines allow user preferences to be remembered and learned with time. E.g: when a user moves from one vending machine to the other and pair the smart-phone, the user preference and favorite product will be saved and then that data is used for predictive maintenance.
- Smart vending machines can communicated each others, so if a product out of stock in a machine, the user can be routed to nearest machine
- For perishable items, the smart vending machines can reduce the price as the expiry date nears.

Logistic..

- IoT applications for smart logistic systems:
  1. *Fleet Tracking*
  2. *Shipment Monitoring*
  3. *Remote Vehicle Diagnostics*

Cont..

- **Fleet Tracking**
  - Vehicle fleet tracking systems use GPS technology to track the locations of the vehicles in the real-time.
  - Cloud-based fleet tracking systems can be scaled up on demand to handle large number of vehicles,
  - The vehicle locations and routers data can be aggregated and analyzed for detecting bottlenecks I the supply chain such as traffic congestions on routes, assignments and generation of alternative routes, and supply chain optimization

Shipment Monitoring

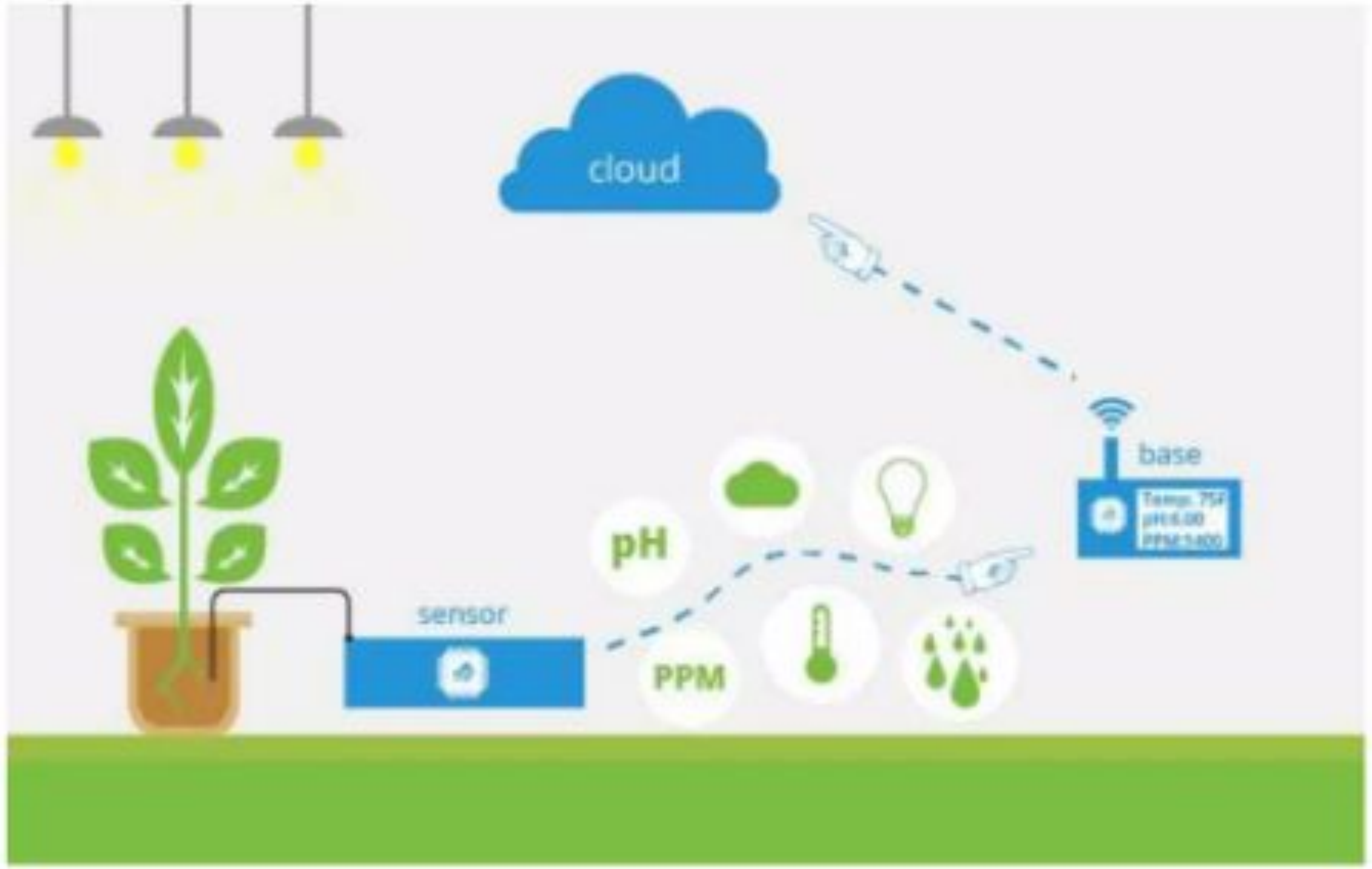
- Shipment monitoring solutions for transportation systems allow monitoring the conditions inside containers.
- E.g : Containers carrying fresh food produce can be monitored to prevent spoilage of food. IoT based shipment monitoring systems use sensors such as temperature, pressure, humidity, for instance, to monitor the conditions inside the containers and send the data to the cloud, where it can be analyzed to detect food spoilage.

Remote Vehicle Diagnostics

- It can detect faults in the vehicles or warn of impending faults.
- These diagnostic systems use on-board IoT devices for collecting data on vehicle operation such as speed, engine RPM, coolent temperature, fault code number and status of various vehicle sub-system.
- Modern commercial vehicles support on-board diagnostic (OBD) standard such as OBD-II
- OBD systems provide real-time data on the status of vehicle sub-systems and diagnostic trouble codes which allow rapidly identifying the faults in the vehicle.
- IoT based vehicle diagnostic systems can send the vehicle data to centralized servers or the cloud where it can be analyzed to generate alerts and suggest remedial actions.

Agriculture..

- IoT applications for smart agriculture:
  1. *Smart Irrigation*
  2. *Green House Control*



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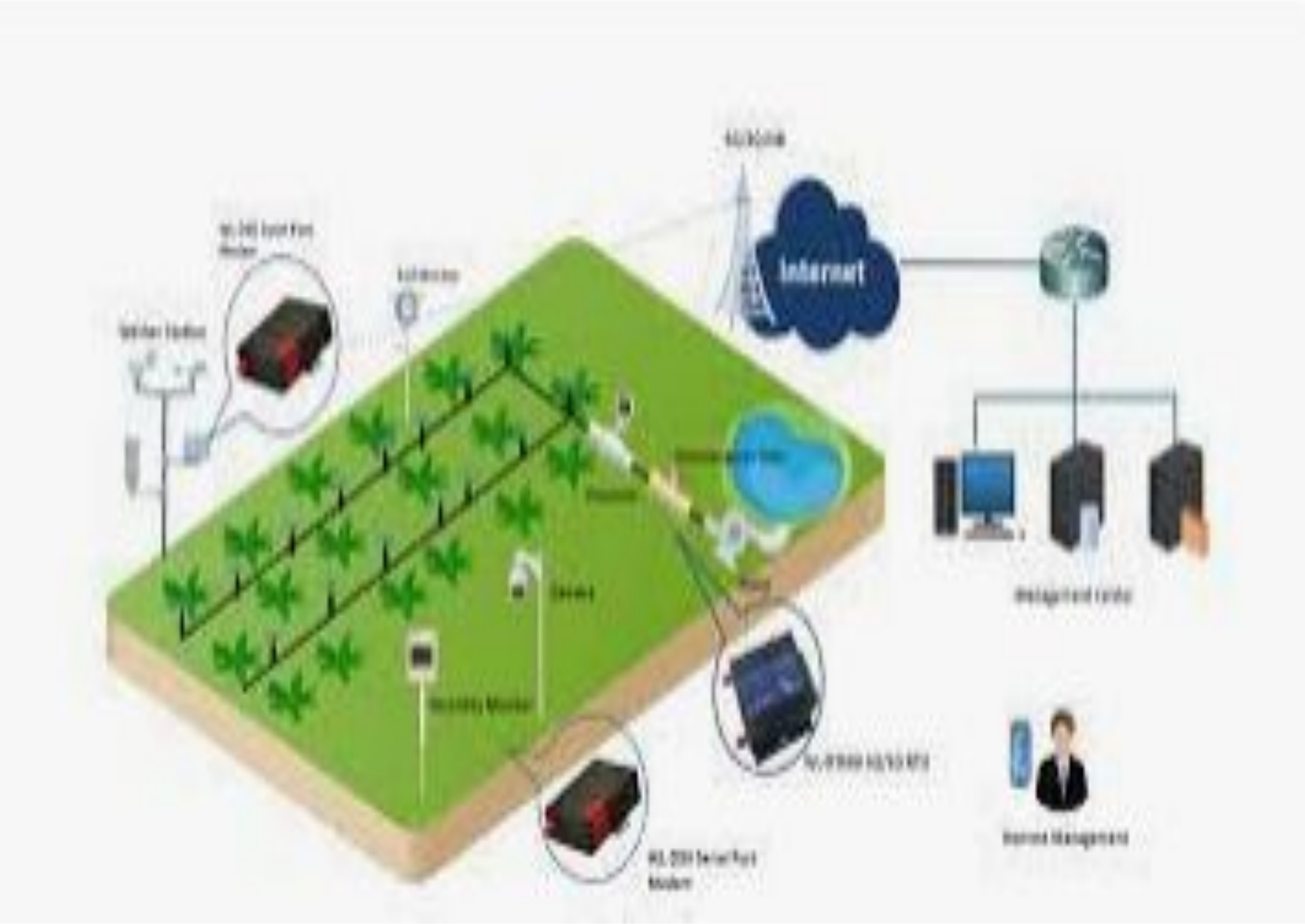
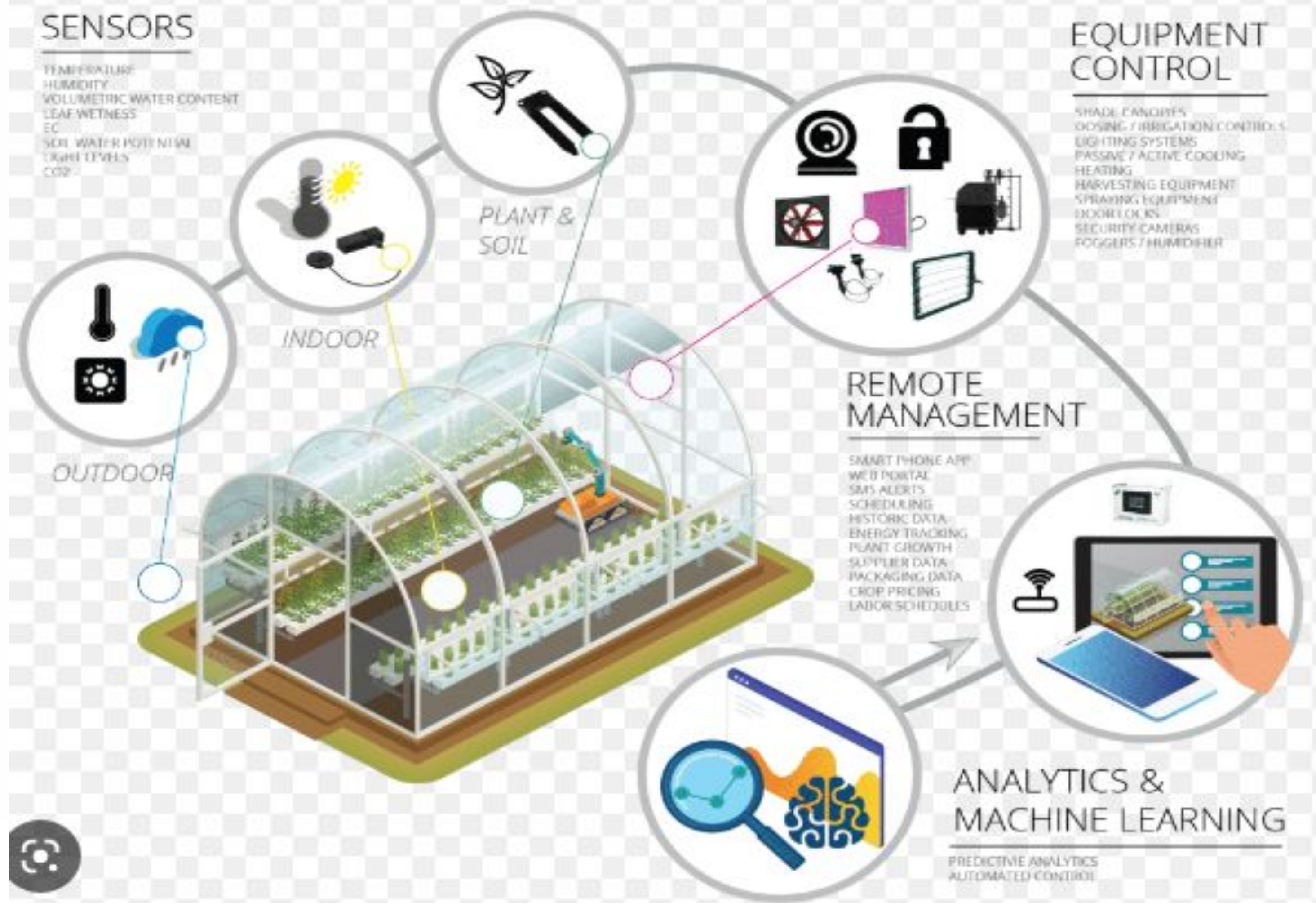
Smart Irrigation

- Smart irrigation system can improve crop yields while saving water.
- Smart irrigation systems use IoT devices with soil moisture sensors to determined the amount of moisture on the soil and release the flow of the water through the irrigation pipes only when the moisture levels go below a predefined threshold.
- It also collect moisture level measurements on the server on in the cloud where the collected data can be analyzed to plan watering schedules.
- *Cultivar's RainCould* is a device for smart irrigation that uses water valves, soil sensors, and a WiFi enabled programmable computer. [*http://ecultivar.com/rain-cloud-product-project/*]



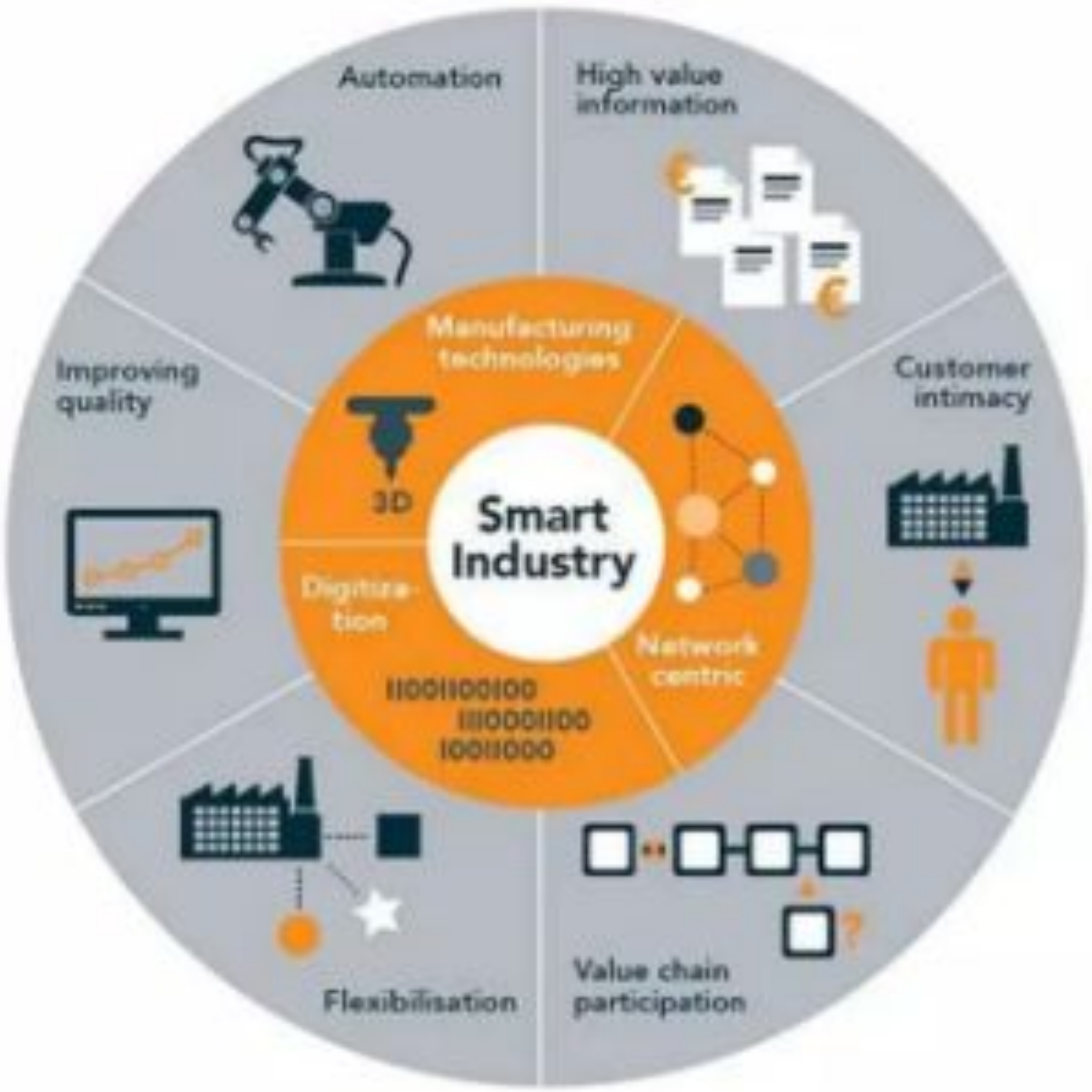
Green House Control

- It controls temperature, humidity, soil, moisture, light, and carbon dioxide level that are monitored by sensors and climatological conditions that are controlled automatically using actuation devices.
- IoT systems play an importance role in green house control and help in improving productivity.
- The data collected from various sensors is stored on centralized servers or in the cloud where analysis is performed to optimize the control strategies and also correlate the productivity with different control strategies.



Industry..

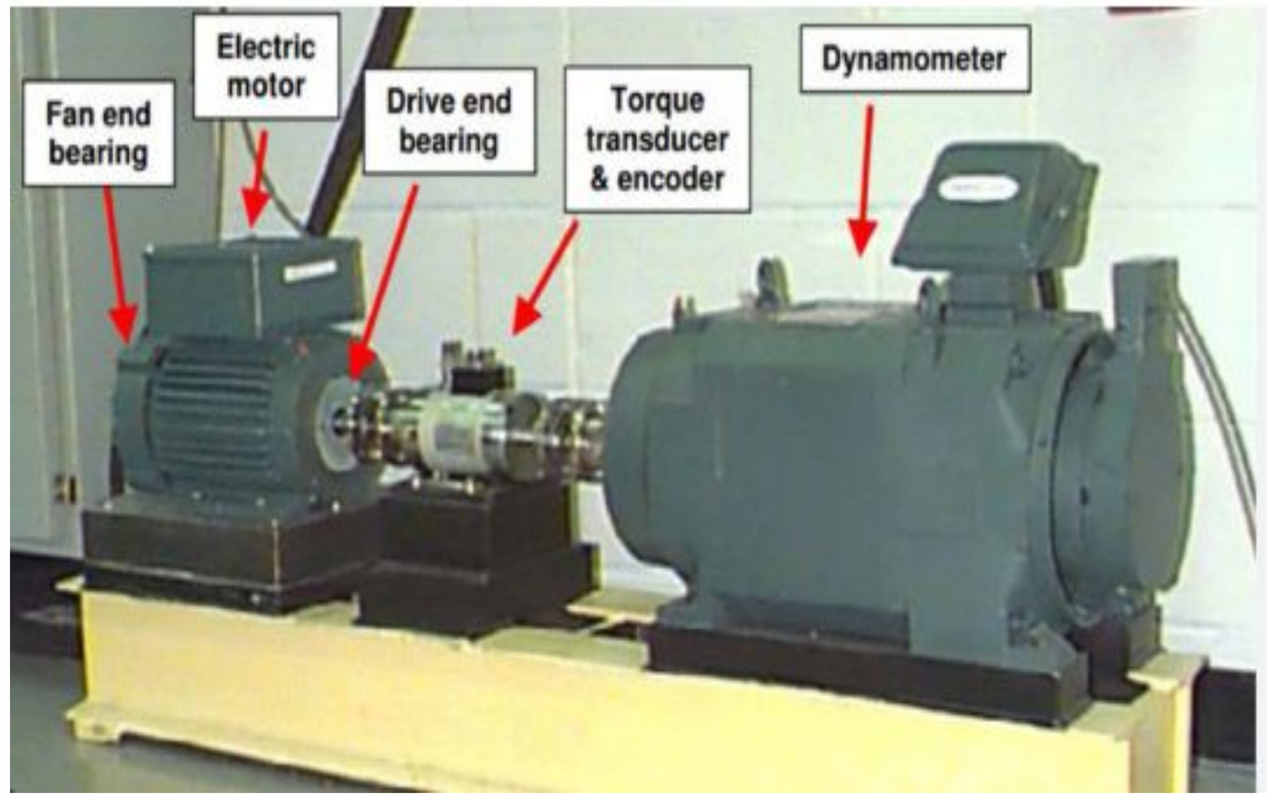
- IoT applications in smart industry:
  1. *Machine Diagnosis & Prognosis*
  2. *Indoor Air Quality Monitoring*



Cont..

Machine Diagnosis & Prognosis

- Machine prognosis refers to predicting the performance of machine by analyzing the data on the current operating conditions and how much deviations exist from the normal operating condition.
- Machine diagnosis refers to determining the cause of a machine fault.
- Sensors in machine can monitor the operating conditions such as temperature and vibration levels, sensor data measurements are done on timescales of few milliseconds to few seconds which leads to generation of massive amount of data.
- Case-based reasoning (CBR) is a commonly used method that finds solutions to new problems based on past experience.
- CBR is an effective technique for problem solving in the fields in which it is hard to establish a quantitative mathematical model, such as machine diagnosis and prognosis.



Indoor Air Quality Monitoring

- Harmful and toxic gases such as carbon monoxide (CO), nitrogen monoxide (NO), Nitrogen Dioxide, etc can cause serious health problem of the workers.
- IoT based gas monitoring systems can help in monitoring the indoor air quality using various gas sensors.
- The indoor air quality can be placed for different locations
- Wireless sensor networks based IoT devices can identify the hazardous zones, so that corrective measures can be taken to ensure proper ventilation.

Health and Lifestyle..

- IoT applications in smart health & lifestyle:
  1. Health & Fitness Monitoring
  2. Wearable Electronics

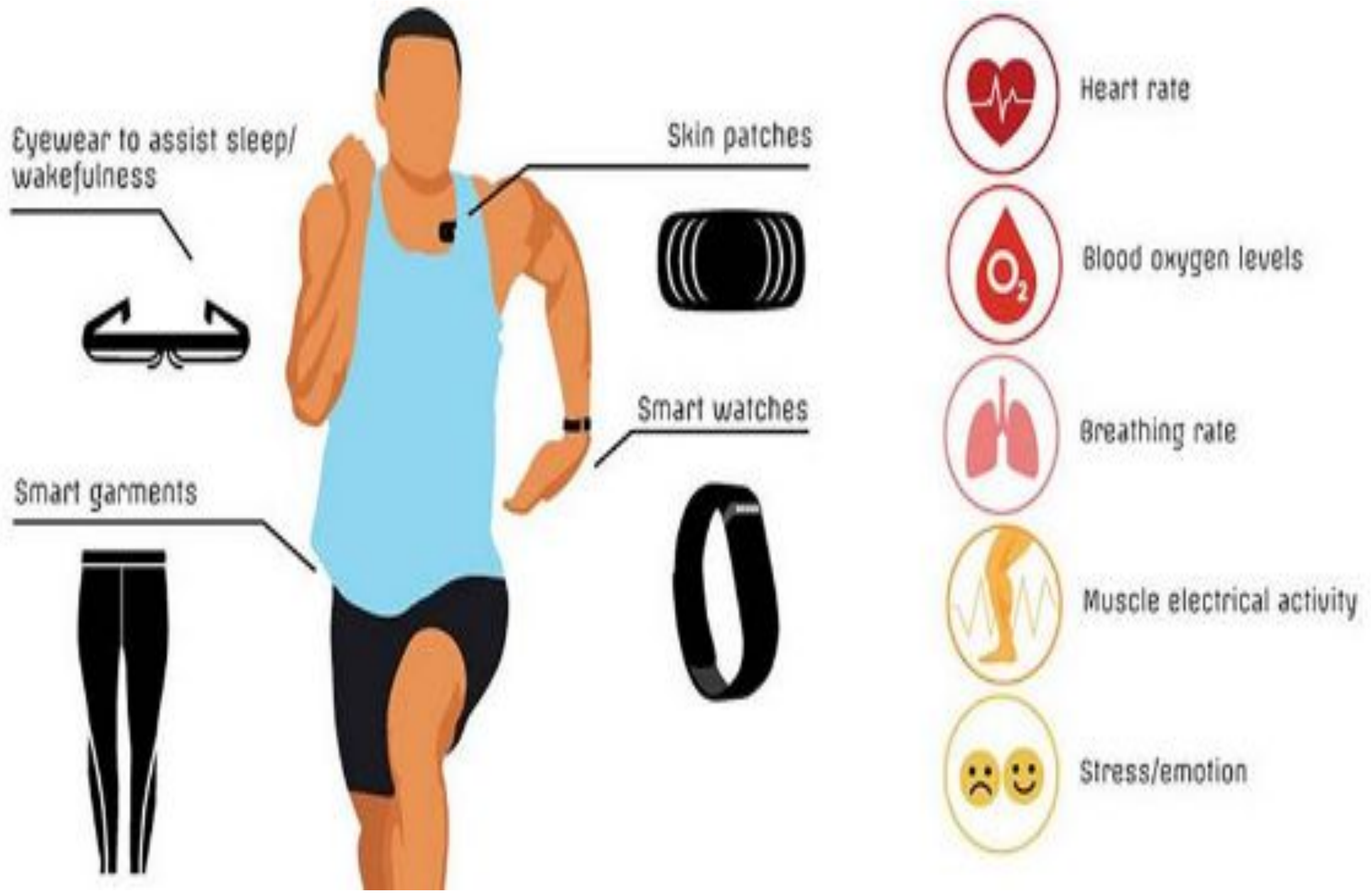
Cont..

Health & Fitness Monitoring

- Wearable IoT devices allow to continuous monitoring of physiological parameters such as blood pressure, heart rate, body temperature, etc than can help in continuous health and fitness monitoring.
- It can analyze the collected health-care data to determine any health conditions or anomalies.
- The wearable devices may can be in various form such as:
  - Belts
  - Wrist-bands

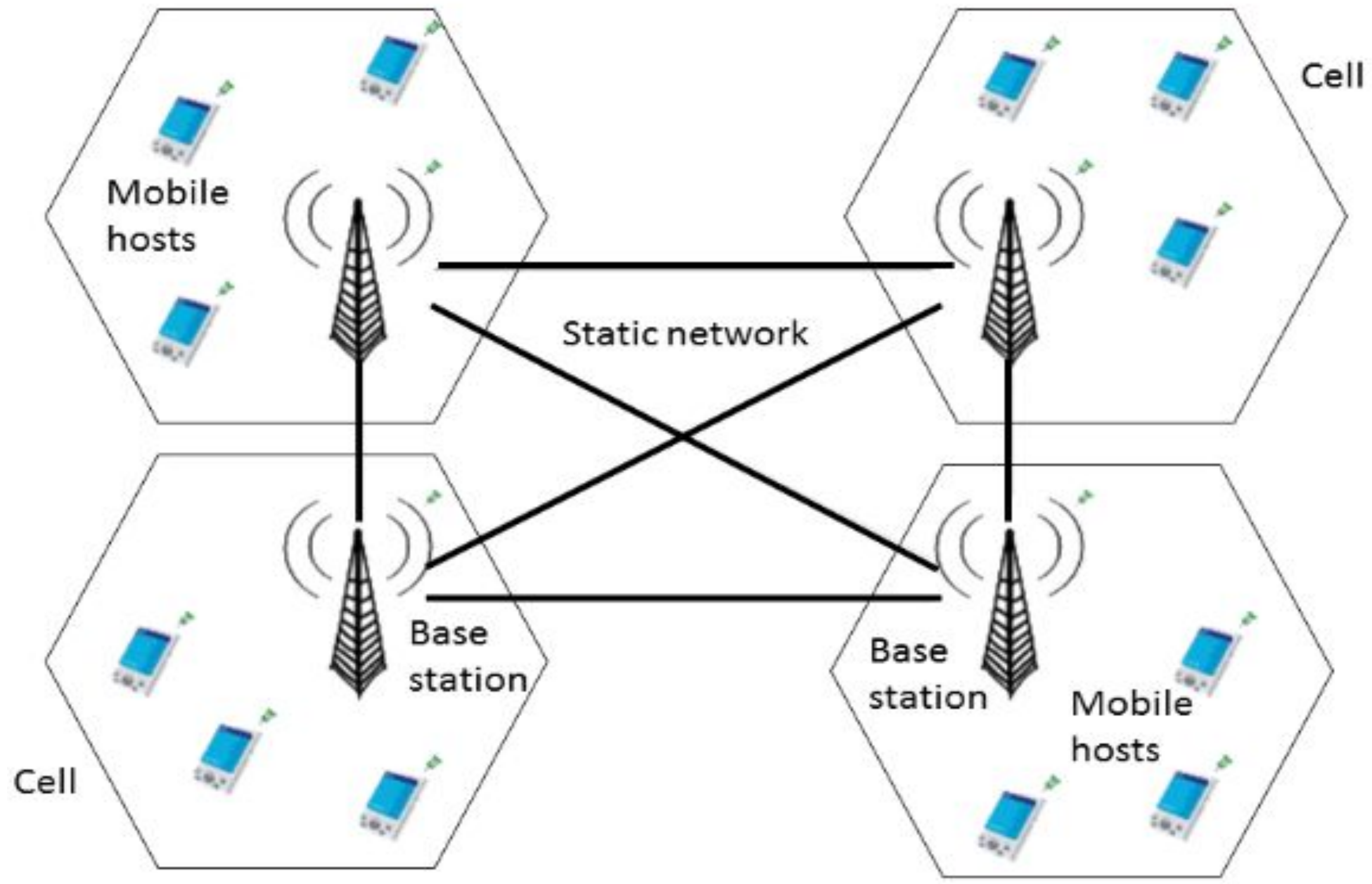
Wearable Electronics

- Wearable electronics such as wearable gadgets (smart watch, smart glasses, wristbands, etc) provide various functions and features to assist us in our daily activities and making us lead healthy lifestyles.
- Using the smart watch, the users can search the internet, play audio/video files, make calls, play games, etc.
- Smart glasses allows users to tae photos and record videos, get map directions, check flight status or search internet using voice commands
- Smart shoes can monitor the walking or running speeds and jumps with the help of embedded sensors and be paired with smart-phone to visualize the data.
- Smart wristbands can tract the daily exercise and calories burnt.



Cellular IoT

- Cellular IoT allows a wide variety of machines and devices to communicate with each other, via a mobile data connection provided by cellular networks. These machines and devices are classified as IoT devices, which stands for Internet Of Things.
- Cellular IoT connects physical objects by piggybacking on the cellular networks.
- Piggybacking: In general, piggybacking involves the unauthorized use of resources, whether that is wireless access, a user session, or even processing power. "piggybacking" refers to a situation where an unauthorized party gains access to some system in connection with an authorized party. This can happen in several ways, including piggybacking on public wireless networks, and piggybacking into a password-protected system.



Cont..

- **Cellular IoT is one of the most popular types of Internet of Things connectivity, primarily because it:**
  - **Has excellent coverage**
  - **Simplifies global deployment**
  - **Works right out of the box**
  - **Establishes secure connections**
  - **Performs well in mobile, indoor, and outdoor applications**
  - **Supports low and high bandwidth applications**
- While cellular networks were designed for phones, they're highly versatile, and cellular technology has evolved to accommodate a wider range of devices and use cases over time. Like smartphones and other mobile devices, cellular IoT devices can use 2G, 3G, 4G, and 5G networks. But they don't use data the same way as phones, and with billions of low-power devices relying on cellular technology, specialized cellular networks have also been developed specifically for IoT: LTE-M and NB-IoT.

What is LTE-M?

- **Considering the Internet of Things is literally part of the name, NB-IoT was designed for the IoT. NB-IoT stands for “Narrowband-IoT” and is great for areas without robust LTE coverage or when bandwidth requirements are relatively minimal. Again, per its name, NB-IoT uses just a narrow band of the full bandwidth available.**

- **Available globally where GSM is the flag-bearer (such as much of Europe, Africa, and Asia), NB-IoT devices consume very little power and provide less data throughout than LTE-M (approximately 60KB down and 30KB up). Compared to LTE-M’s bandwidth of 1.4 MHz, NB-IoT operates on 200 KHz, providing longer range and better indoor penetration.**

- **Certain use cases like smart cities (e.g. parking meters, utility monitoring), parking garages, indoor deployments, and agricultural settings are great examples of suitable NB-IoT implementations.**

What is NB-IoT?

- You can probably hazard a guess that LTE-M is closely related to the popular LTE (Long-Term Evolution) wireless standard. The countries that support LTE encompass a vast list primarily comprised of the Americas and parts of Europe.
- LTE-M effectively stands for "Long-Term Evolution for Machines" and allows for IoT devices to piggyback on existing LTE networks. It was designed in a power-conscious manner for applications that require low-to-medium data throughput. With a bandwidth of 1.4 MHz (compared to 20 MHz for LTE), LTE-M provides great range but less throughput than LTE (approximately 375KB down and 300KB up). LTE-M also offers cell tower handoff features, making it a great mobility solution (even across multiple regions).
- Asset tracking, wearables, home security, and home/business monitoring are all great examples of use cases for LTE-M in the IoT.

Cellular IoT Benefits:

- The advantages of cellular connectivity with IoT are extensive:
  - Coverage: Cellular networks are ubiquitous, mature, and reliable.
  - Global Reach: There is no other network technology with the reach of cellular.
  - Security: SIM-based authentication and utilization of VPN tunnels makes cellular the most secure option.
  - Installation: Works out-of-the-box without requiring local installation or technical expertise.
  - Low/No power: Cellular modules can consume ~8mA of power and networks are still available in the case of a power outage.
- When it comes to security, coverage, and usability, it’s hard to compete with cellular.

Next generation kiosks, self-service technology

- **A kiosk is a digital machine that businesses can utilize to give customers the ability to make purchases independently. This provides an excellent opportunity for companies looking forward to improving their customer and business relations, not to mention allowing them to generate more income and valuable information about their market.**

- Types of Kiosks

- There are many types of kiosks, and those can be best used for several different applications. Some might seem futuristic or high-tech, but they are not uncommon in many places throughout the world, and there are lots of varieties. These kiosks can help customers find their way around an establishment, place orders, make payments, or gain access to Internet connectivity. Regardless of how these kiosks were developed, they play a significant role when it comes to interacting directly with customers since they facilitate quick and easy ways to interact with employees (or machines).

- In years past, business owners relied on big-box stores for all their electronic needs. Today, however, we have our pick of packaging and distribution methods for the kiosks we choose. That is set to change even further as technology has the potential to fundamentally increase efficiency in various retail settings. There are essentially two kinds of options: non-interactive and interactive kiosks.

Non-Interactive Kiosks

- The use of non-interactive kiosks has helped to improve shopping experiences. These are stand-alone displays that deliver a variety of messages and can be used in countless ways to provide important information while conveying information as well. These kiosks are basically to convey only information related to a product, brand, and so forth. Some examples of non-interactive kiosks are as follows:
  - Informational Kiosks : This is a computer-like device combining specialized hardware, software and connectivity options, designed to provide certain information to people in public places.
  - Products Kiosks: the product kiosk, which is specifically used to showcase a new product.
  - Promotional Kiosks: Promotional Kiosk are a folding, reusable kiosk structures used majorly for Promotional Activities. The Promotional Kiosk are highly used due to its portability, reusability and stability.

Interactive Kiosks

- **Interactive kiosks are those that customers can use in different ways to access a specific resource or avail of something, usually at shopping centres, malls, parking areas, etc. Because these kiosks function on user interaction and demand, these devices are available to a wide variety of businesses and businesses-in-general, including restaurants, service providers, and even destinations such as malls and airports.**

- Types of Interactive Kiosks
  - Self-Service kiosks
  - Internet Kiosks
  - Parking Kiosks

Benefits of Kiosks

- Now that we have reviewed the various types of kiosks, so it's time to discuss why they are worth purchasing or renting. They are an investment, aren't they? After all, whichever option you choose, you will be investing in the maintenance or development of your brand. That being said, let's understand why they are worth buying!

- **Save Money:** Interactive kiosks are suitable for customers. They don't ask for a salary and can provide customers with any information they might need. And since you're not paying to hire people, which means more money to buy even more products! Kiosks also reduce overhead costs because you don't have to pay rent or hire people to run the business. Placing a vending machine outside is an excellent way of getting noticed and attracting sales. Interactive kiosks can eliminate the need for staffing; you won't have to worry about red tape, sick leave, maternity leave, or firing someone if they don't work out; after all, these machines are made for that exact purpose!

- **Increase Reach:** While most people think of kiosks as a way to promote their products and services, they're not just for in-store shopping but are increasingly being installed outside retail establishments, such as hotels. This is for two reasons: one, many companies want to extend the reach of their advertising efforts; and two, these can be operated by trained professionals who know how to perform various tasks efficiently. So, having a kiosk can increase customer reach and significantly benefit your business.

- **Improve Customer Experience:** A great thing about having a kiosk in a retail store or parking lot is that it considerably improves the customer experience. Most people have a sense of freedom and superiority when they are not interrupted while making a purchase, and that's what a kiosk provides them with. Remember, improved customer experience means more customer revisits, so every business owner should consider installing a kiosk to gain more profits.

Last Exam 2022 SPPU Question Asked

a) Illustrate the various IoT communication APIs? [8]

b) With the help of following sectors explain how IoT technology is impacting on the end-to-end value chain in the logistics sector : [10]

i) Route generation & scheduling

ii) Fleet tracking

iii) Shipment monitoring

iv) Remote vehicle diagnostics

OR

a) Demonstrate the IoT component with a neat diagram. [9]

b) What is Piggybacking? What is the necessity of security and privacy of IoT? [9]