Chapter 1

Introduction to IoT

Book website:

What WE will learn IN THIS CHAPTER

- IoT definition
- Characteristics of IoT
- Physical Design of IoT
- Logical Design of IoT
- IoT Protocols
- IoT Levels & Deployment Templates
- Syllabus link

- http://www.gvpce.ac.in/syllabi/B.Tech15-16/IT/INTERNET%20OF%20THINGS15-16.pdf

Defination of IoT

The Internet of Things (IoT) is the network of physical objects or "things" embedded with electronics, software, sensors, and network connectivity, which enables these objects to collect and exchange data.

IoT allows objects to be sensed and controlled remotely across existing network infrastructure, creating opportunities for more direct integration between the physical world and computer-based systems, and resulting in improved efficiency, accuracy and economic benefit

Another defination

- The Internet of Things (IoT) refers to the ever-growing network of physical objects that feature an IP address for internet connectivity, and the communication that occurs between these objects and other Internet-enabled devices and systems.
- In simple words, Internet of Things (IoT) is an ecosystem of connected physical objects that are accessible through the internet.
- It is also referred to as Machine-to-Machine (M2M), Skynet or Internet of Everything.

- "Things," in the IoT sense, can refer to a wide variety of devices such as heart monitoring implants, biochip transponders on farm animals, electric clams in coastal waters, automobiles with built-in sensors, DNA analysis devices for environmental/food/pathogen monitoring or field operation devices that assist fire-fighters in search and rescue operations.

- These devices collect useful data with the help of various existing technologies and then autonomously flow the data between other devices.

Cont….

- The concept of the Internet of Things first became popular in 1999, through the Auto-ID Center at MIT and related market-analysis publications.
- Radio-frequency identification (RFID) was seen as a prerequisite for the IoT at that point. If all objects and people in daily life were equipped with identifiers, computers could manage and inventory them. Besides using RFID, the tagging of things may be achieved through such technologies as near field communication, barcodes, QR codes, bluetooth, and digital watermarking.

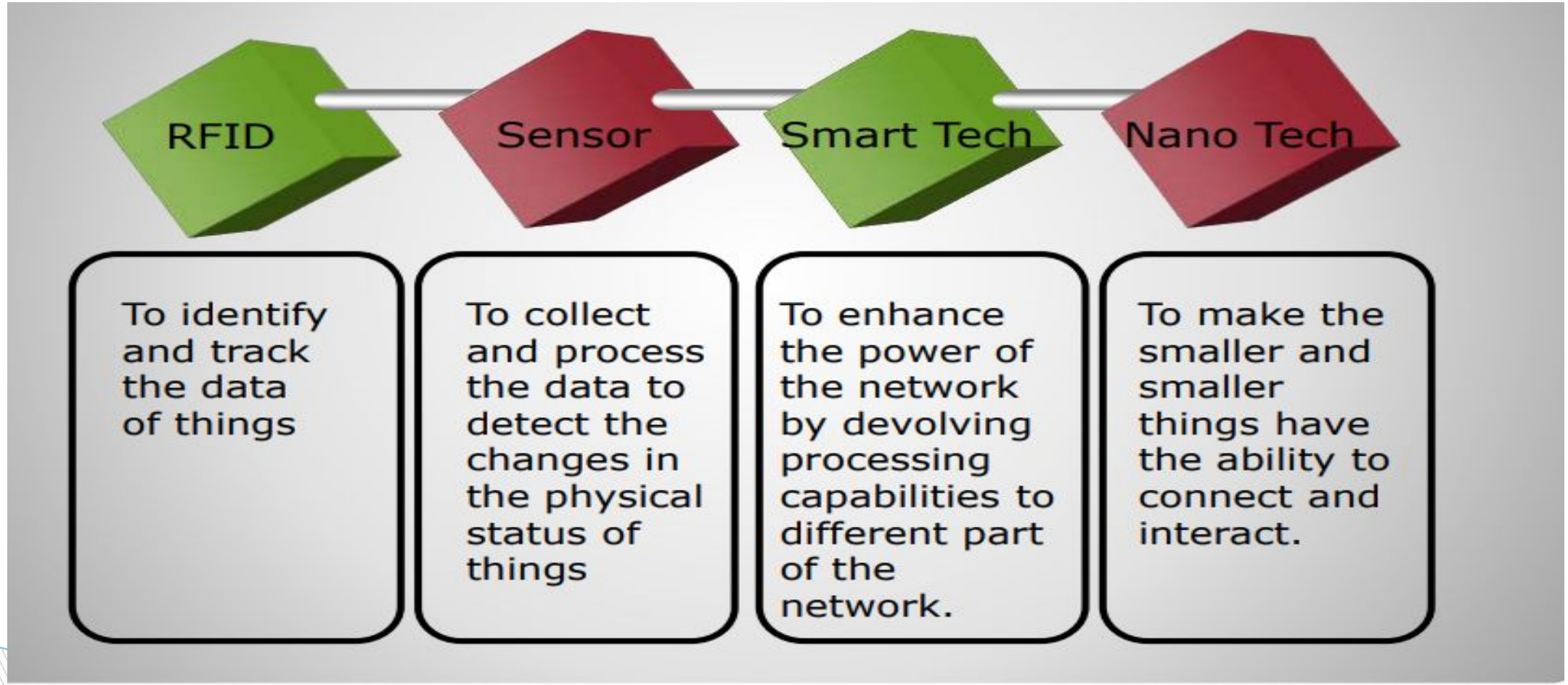
How IoT Works?

- Internet of Things is not the result of a single novel technology; instead, several complementary technical developments provide capabilities that taken together help to bridge the gap between the virtual and physical world

How IoT Works? Cont…

- **These capabilities include:**
- Communication and cooperation
- Addressability
- Identification
- Sensing
- Actuation
- Embedded information processing
- Localization
- User interfaces

How IoT Works? Cont…



Characteristics of IoT

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

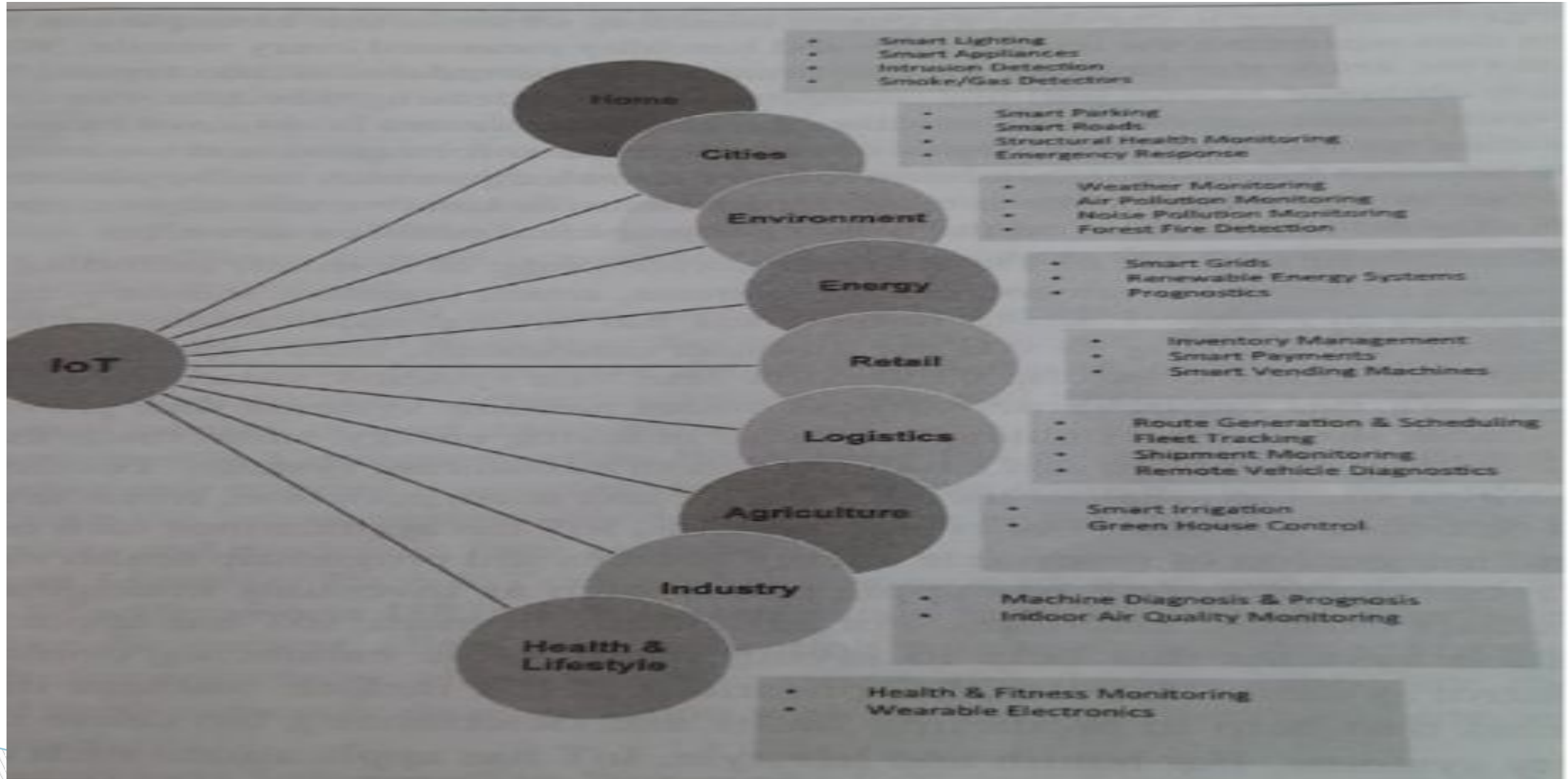


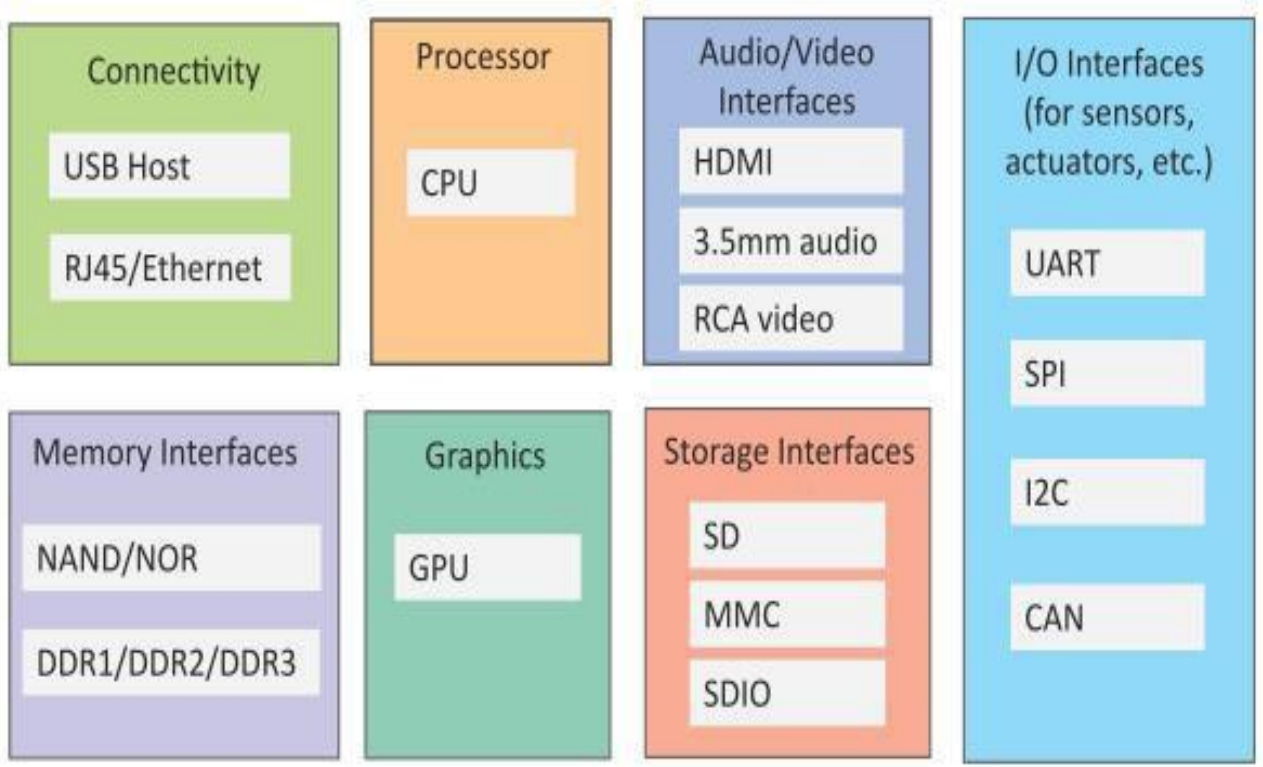
Figure 1.2: Applications of IoT

Physical Design of IoT

- The "Things" in IoT usually refers to IoT devices which have unique identities and can perform remote sensing, processing,actuating and monitoring capabilities.
- IoT devices can:
  - Exchange data with other connected devices and applications (directly or indirectly), or
  - Collect data from other devices and process the data locally or globally
  - Send the data to centralized servers or cloud-based application back-ends for processing the data, or
  - Perform some tasks locally and other tasks within the IoT infrastructure, based on temporal and space constraints

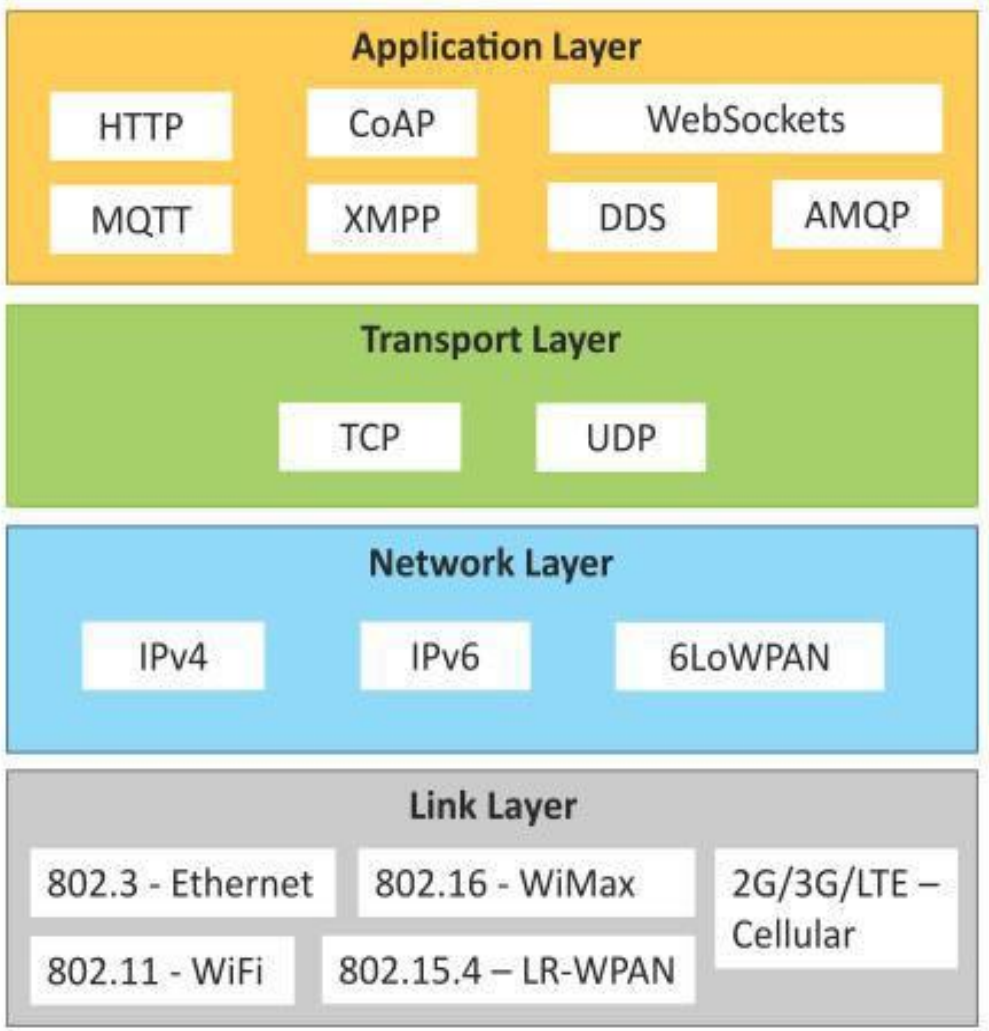
Generic block diagram of an IoT Device

- An IoT device may consist of several interfaces for connections to other devices, both wired and wireless.
  - I/O interfaces for sensors
  - Interfaces for Internet connectivity
  - Memory and storage interfaces
  - Audio/video interfaces



IoT Protocols

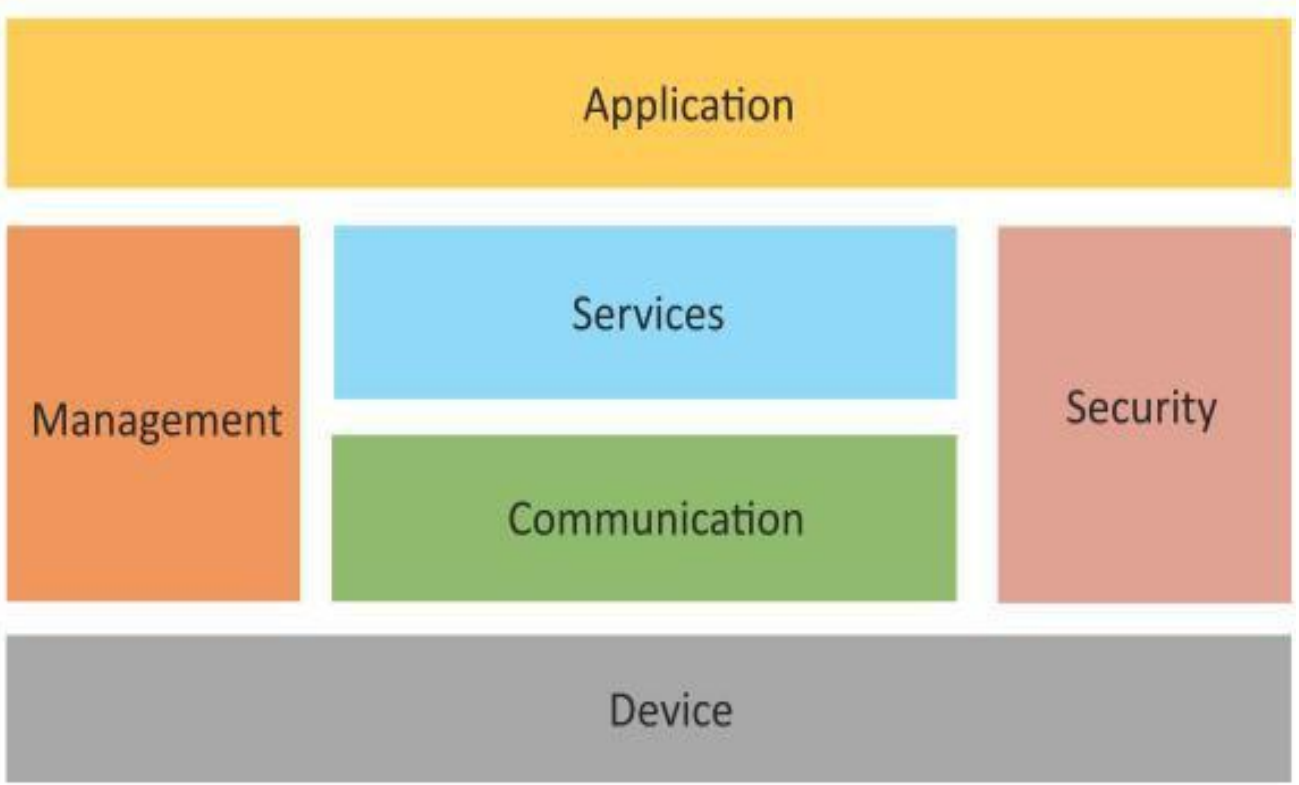
- **Link Layer**
  - 802.3 – Ethernet
  - 802.11 – WiFi
  - 802.16 – WiMax
  - 802.15.4 – LR-WPAN
  - 2G/3G/4G
- **Network/Internet Layer**
  - IPv4
  - IPv6
  - 6LoWPAN
- **Transport Layer**
  - TCP
  - UDP
- **Application Layer**
  - HTTP
  - CoAP
  - WebSocket
  - MQTT
  - XMPP



Logical Design of IoT

- Logical design of an IoT system refers to an abstract representation of the entities and processes without going into the low-level specifics of the implementation.

- An IoT system comprises of a number of functional blocks that provide the system the capabilities for identification, sensing, actuation, communication, and management.



Logical Design of IoT cont….

functional blocks are:

- **Device**: An IoT system comprises of devices that provide sensing, actuation, monitoring and control functions.
- **Communication:** Handles the communication for the IoT system.
- **Services**: services for device monitoring, device control service, data publishing services and services for device discovery.
- **Management**: this blocks provides various functions to govern the IoT system.
- **Security:** this block secures the IoT system and by providing functions such as authentication , authorization, message and content integrity, and data security.
- **Application**: This is an interface that the users can use to control and monitor various aspects of the IoT system. Application also allow users to view the system status and view or analyze the processed data.

Communication models

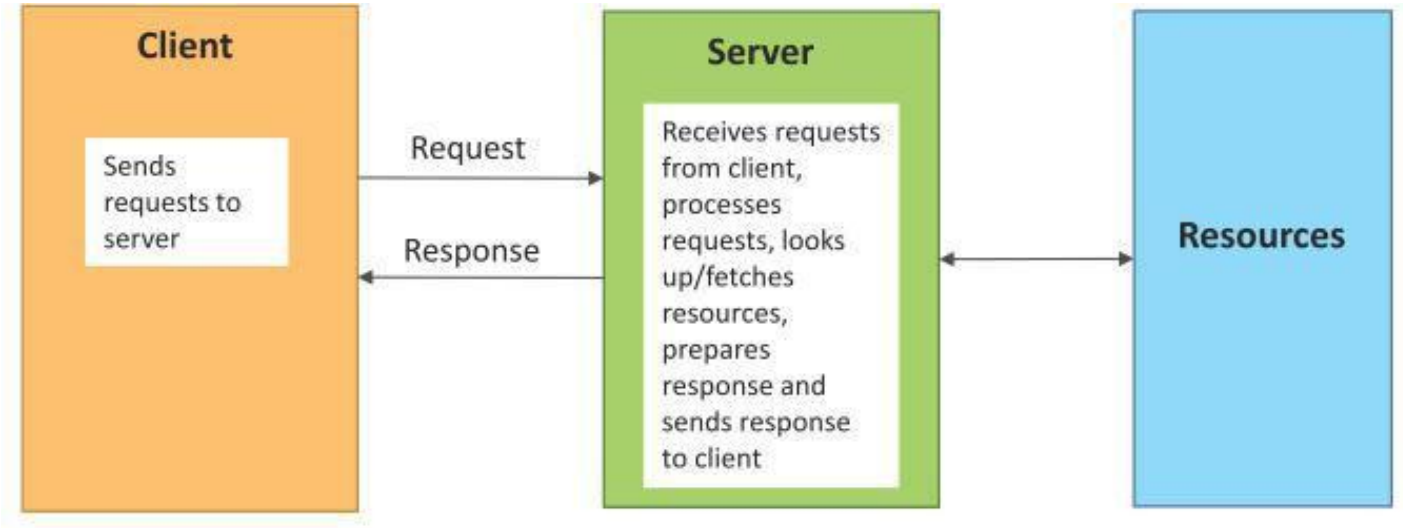
- Request-Response communication model
- Publish-Subscribe communication model
- Push-Pull communication model
- Exclusive Pair communication model

Communication models

Request-Response communication model

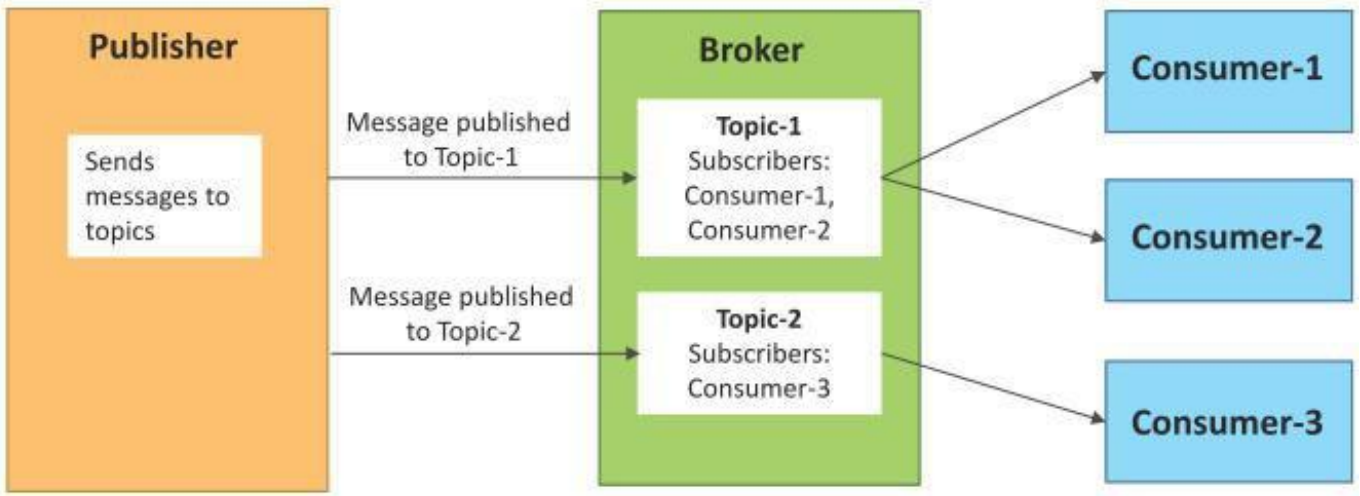
- Request-Response is a communication model in which the client sends requests to the server and the server responds to the requests.

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



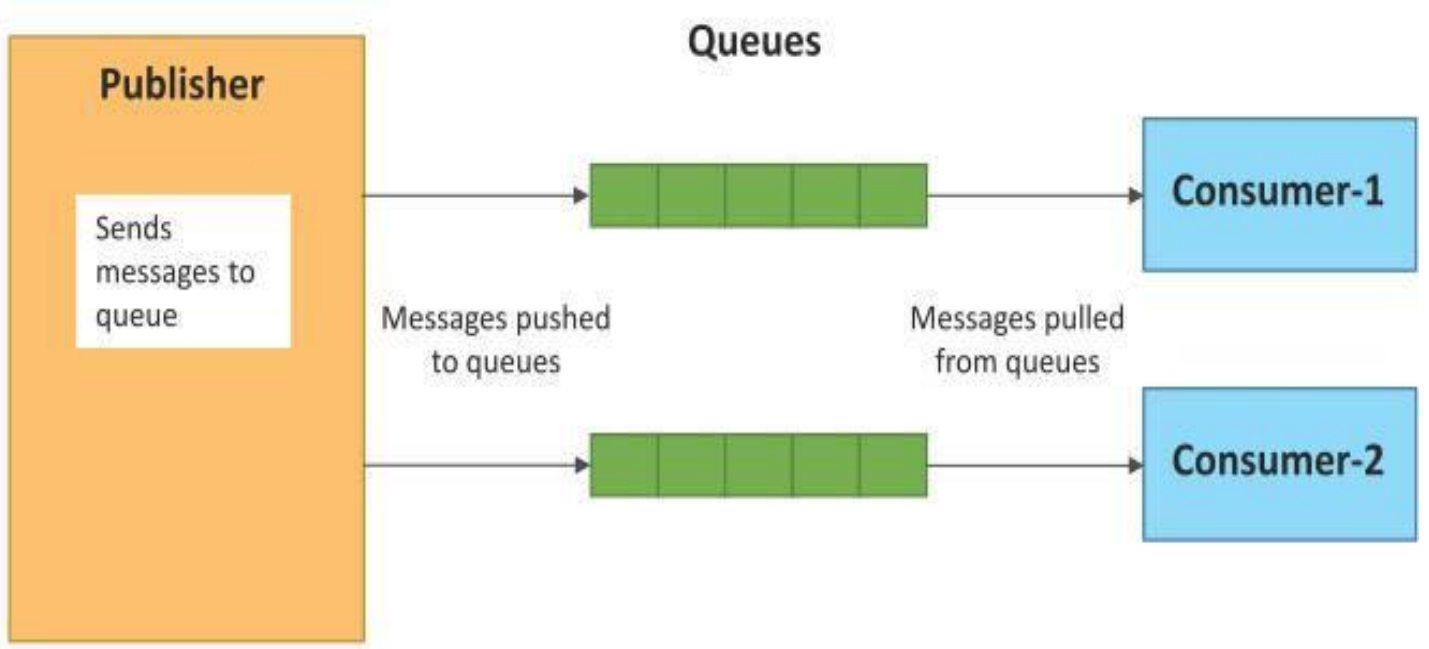
Publish-Subscribe communication model

- 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 receives data for a topic from the publisher, it sends the data to all the subscribed consumers.



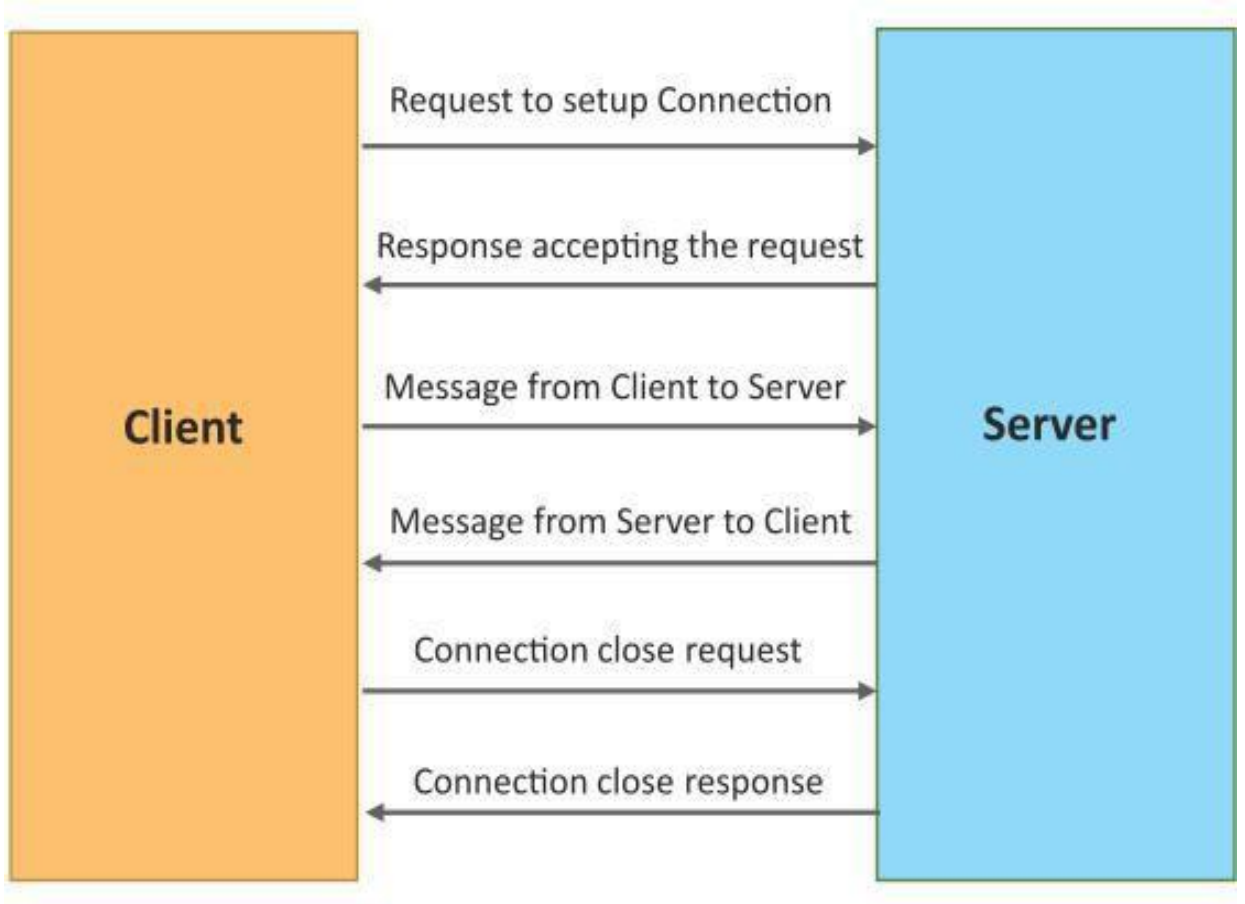
Push-Pull communication model

- 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 rate at which the consumers pull data.



Exclusive Pair communication model

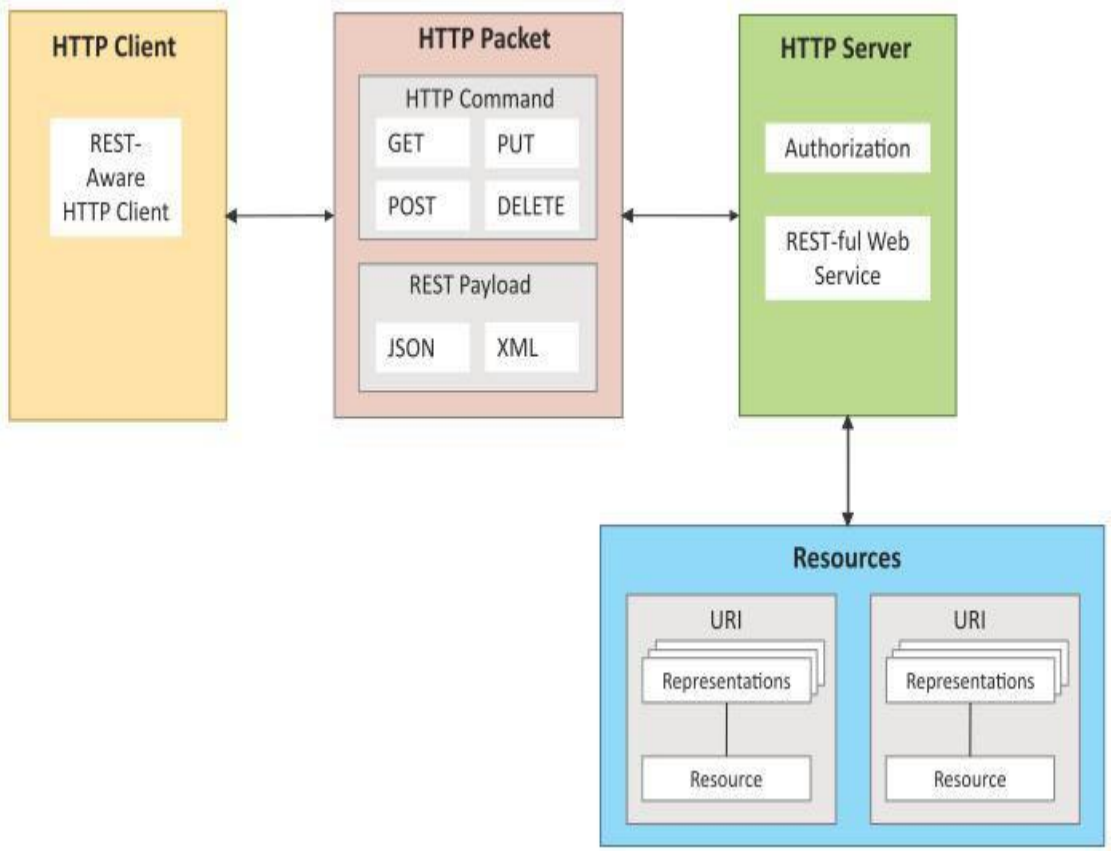
- Exclusive Pair is a bidirectional, fully duplex communication model that uses a persistent connection between the client and server.
- Once the connection is setup it remains open until the client sends a request to close the connection.
- Client and server can send messages to each other after connection setup.



IOT communication APIs

- REST-based Communication APIs
- 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.
- REST APIs follow the request-response communication model.
- The REST architectural constraints apply to the components, connectors, and data elements, within a distributed hypermedia system.

rest pdf



Feature of REST

- Client-server
- Stateless
- Catch_able
- Layered system
- Uniform Interface
- Code on demand

Request-response model by rest Api

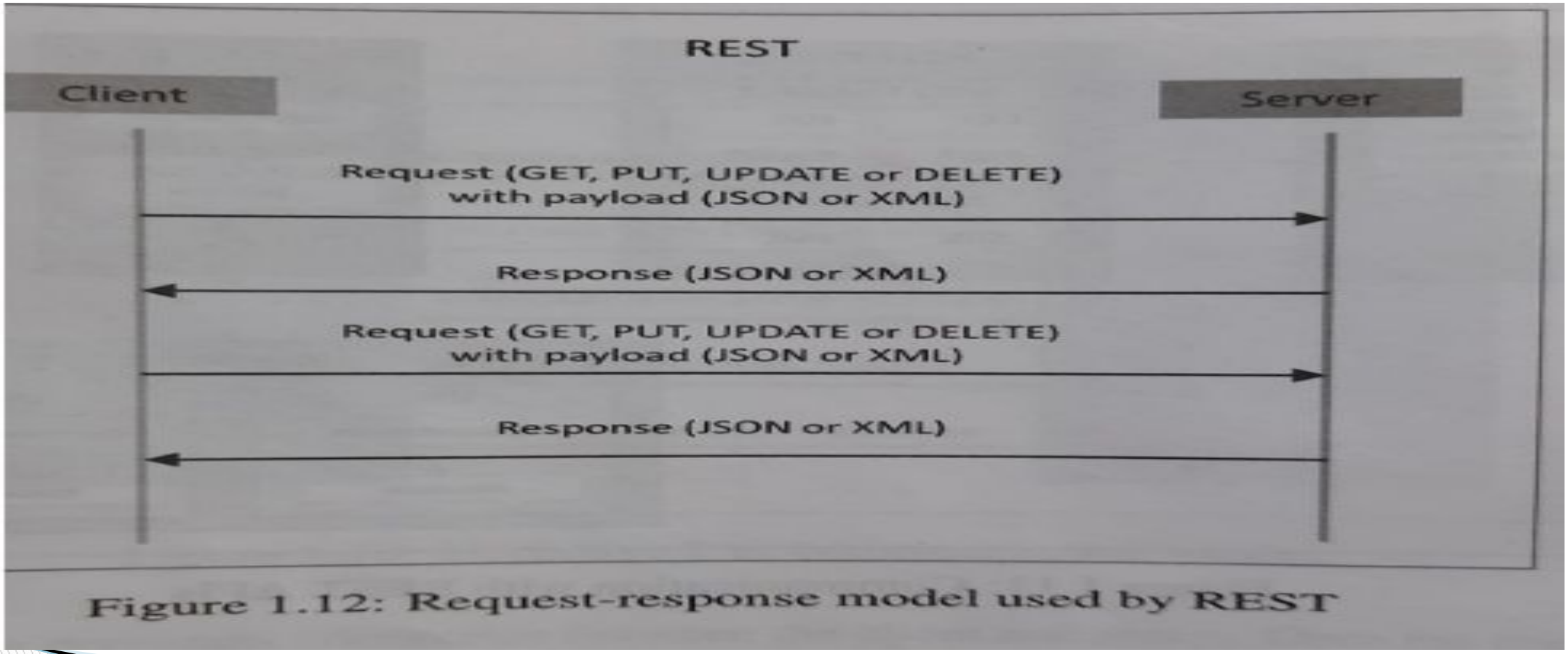
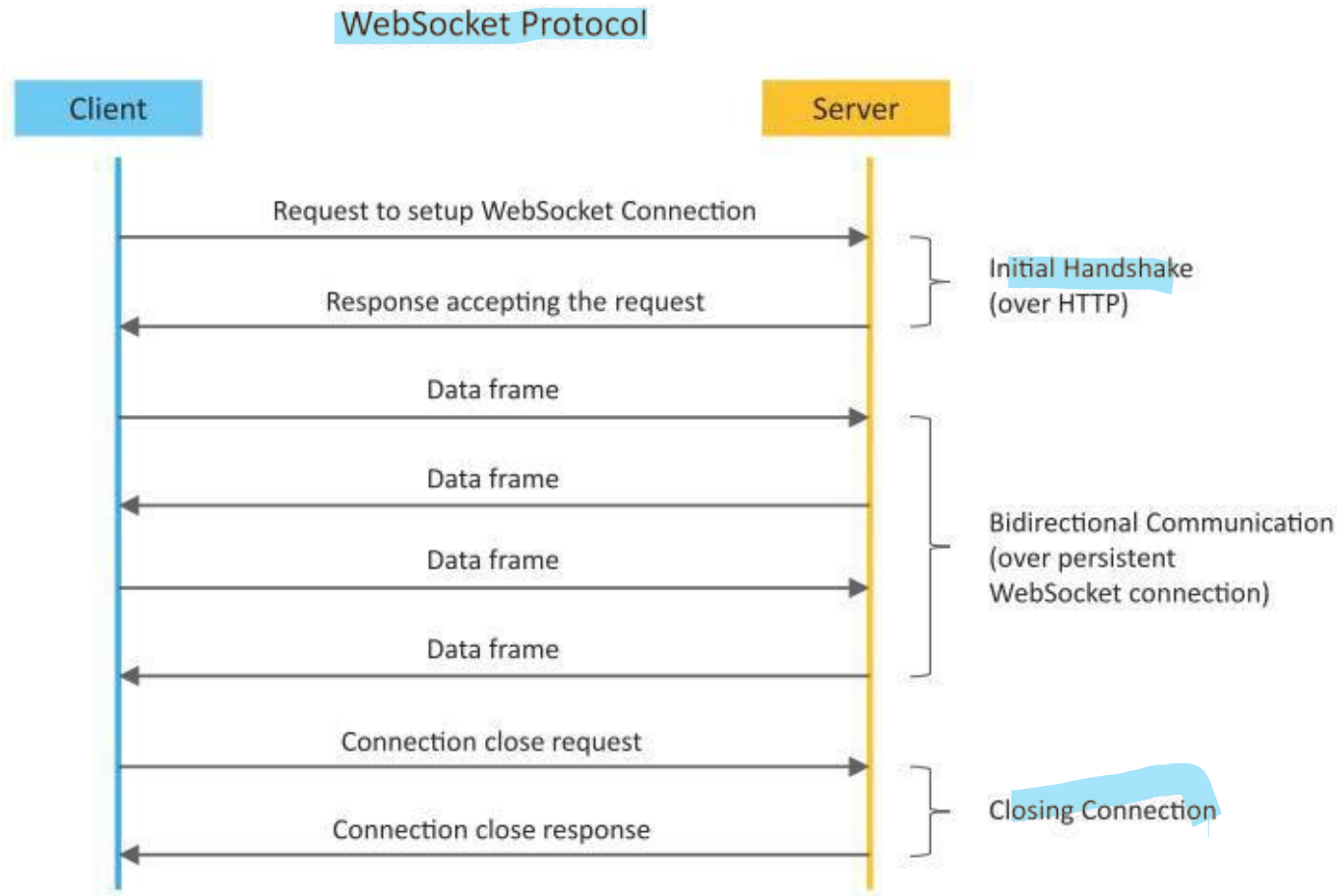


Figure 1.12: Request-response model used by REST

WebSocket-based Communication APIs

- WebSocket APIs allow bi- directional, full duplex communication between clients and servers.
- WebSocket APIs follow the exclusive pair communication model



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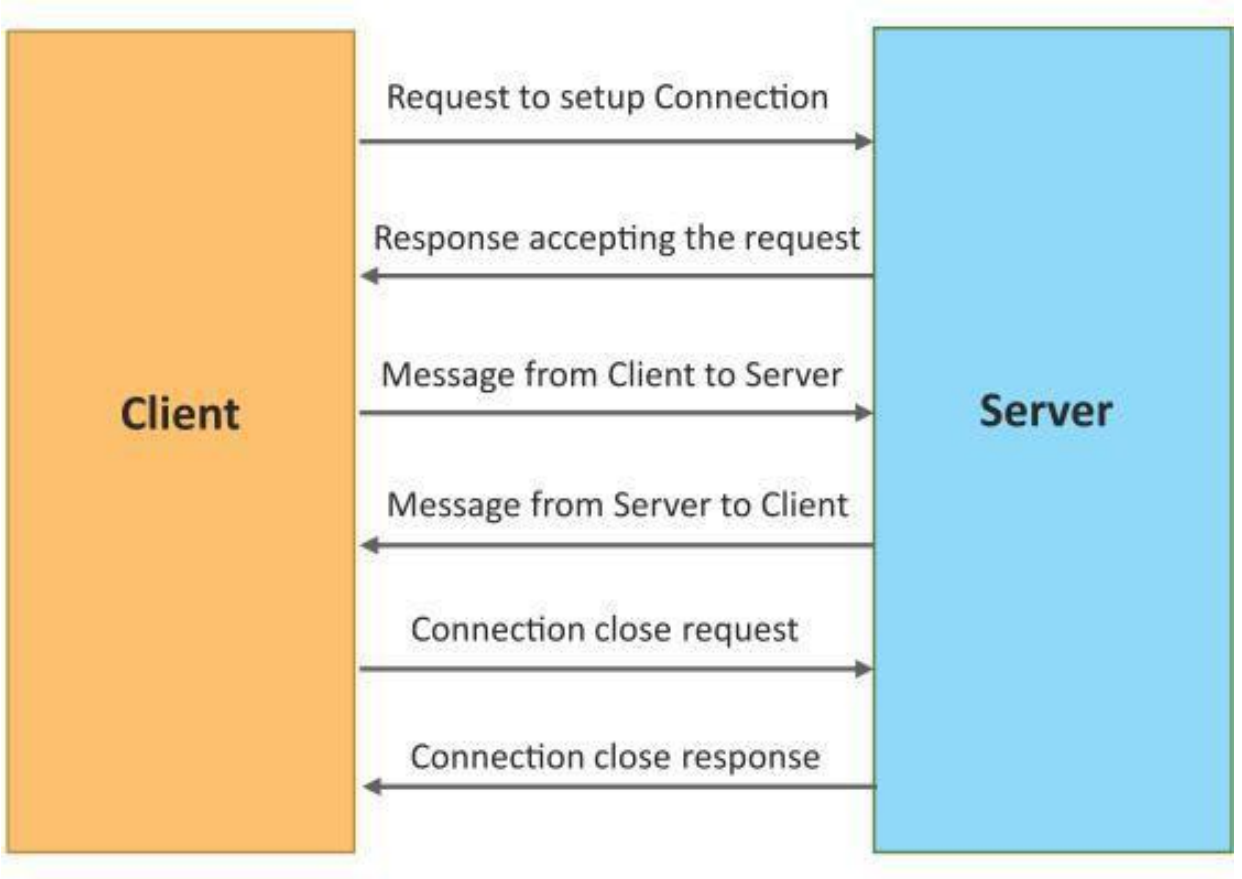


IoT enabling technologies

- Wireless Sensor Networks(WSNs)
- Cloud Computing(IaaS, PaaS, SaaS)
- Big Data Analytics(volume, velocity,Variety)
- Communication Protocols
- Embedded Systems

- WSNs: Collection of sensor nodes which are used monitor the environmental and physical conditions, indoor air quality monitoring, surveillance systems etc….

IoT enabling technologies cont…..

Cloud computing:

It is a transformative computing system which involves delivering applications and services over the internet.

- Cloud computing involves provisioning of computing, networking and storage resources on demand.
- Cloud computing services are offered to users in different forms
- IaaS(Infrastructure-as-a-Service): It provides the users the ability to provising computing and storage resources.
- These resources are provided to the users as virtual machine instances and virtual storage.
- User can start stop configure and manage the virtual machine instances and storage.
- Users can deploy operating systems and applications of their choice on the virtual resources provision in the cloud.

Iot enabling technologies cont…..

PaaS(Platform-as-a-Service):

- It provides the users the ability to develop and deploy in the cloud using the development tools ,API s, Software libraries and service provided by the cloud service provider.
- The users themselves are responsible for developing deploying configuring and managing applications on the cloud infrastructure.

SaaS(software-as-a-Service):

- It provides the users a complete software applications are the user interface to the applications itself.
- SaaS applications are platform Independent and can be accessed from various client devices such as workstations , laptop ,tablets and smart phones runniging different pperating systems

IoT Levels & Deployment Templates

An IoT system comprises of the following components:

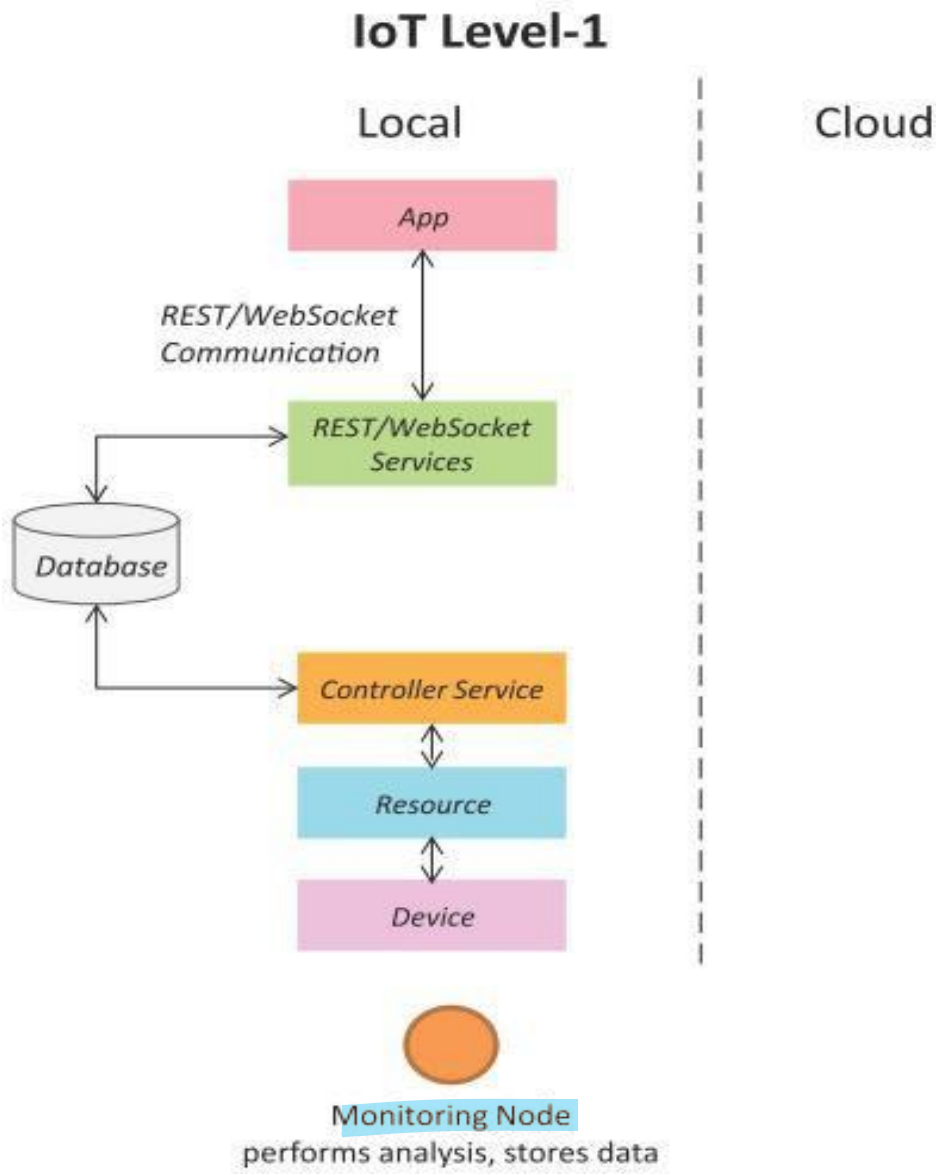
- **Device**: An IoT device allows identification, remote sensing, actuating and remote monitoring capabilities.
- **Resource**: Resources are software components on the IoT device for accessing, processing, and storing sensor information, or controlling actuators connected to the device. Resources also include the software components that enable network access for the device.
- **Controller Service**: Controller service is a native service that runs on the device and interacts with the web services. Controller service sends data from the device to the web service and receives commands from the application (via web services) for controlling the device.

IoT Levels & Deployment Templates

- **Database**: Database can be either local or in the cloud and stores the data generated by the IoT device.
- **Web Service**: 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**: The Analysis Component is responsible for analyzing the IoT data and generate results in a form which are easy for the user to understand.
- **Application**: 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 data.

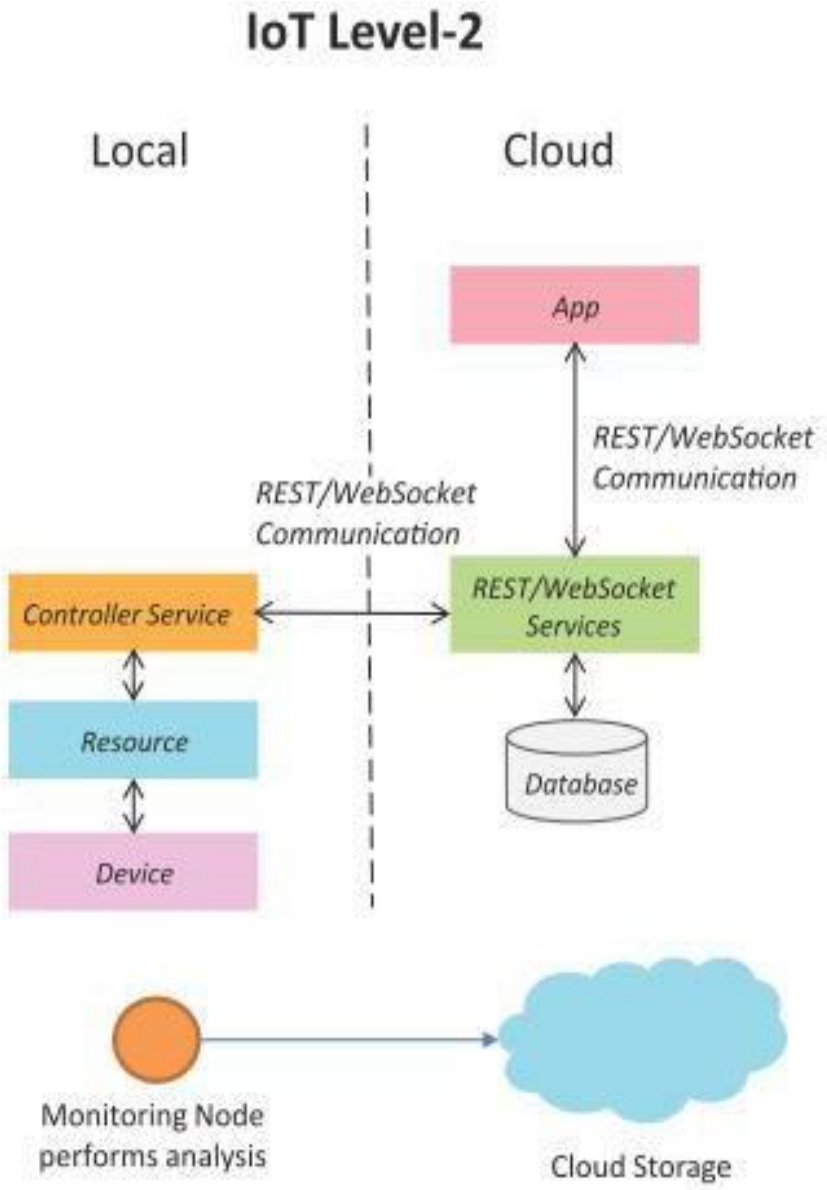
IoT Level-1

- A level-1 IoT system has a single node/device that performs sensing and/or actuation, stores data, performs analysis and hosts the application
- Level-1 IoT systems are suitable for modeling low- cost and low-complexity solutions where the data involved is not big and the analysis requirements are not computationally intensive.



IoT Level-2

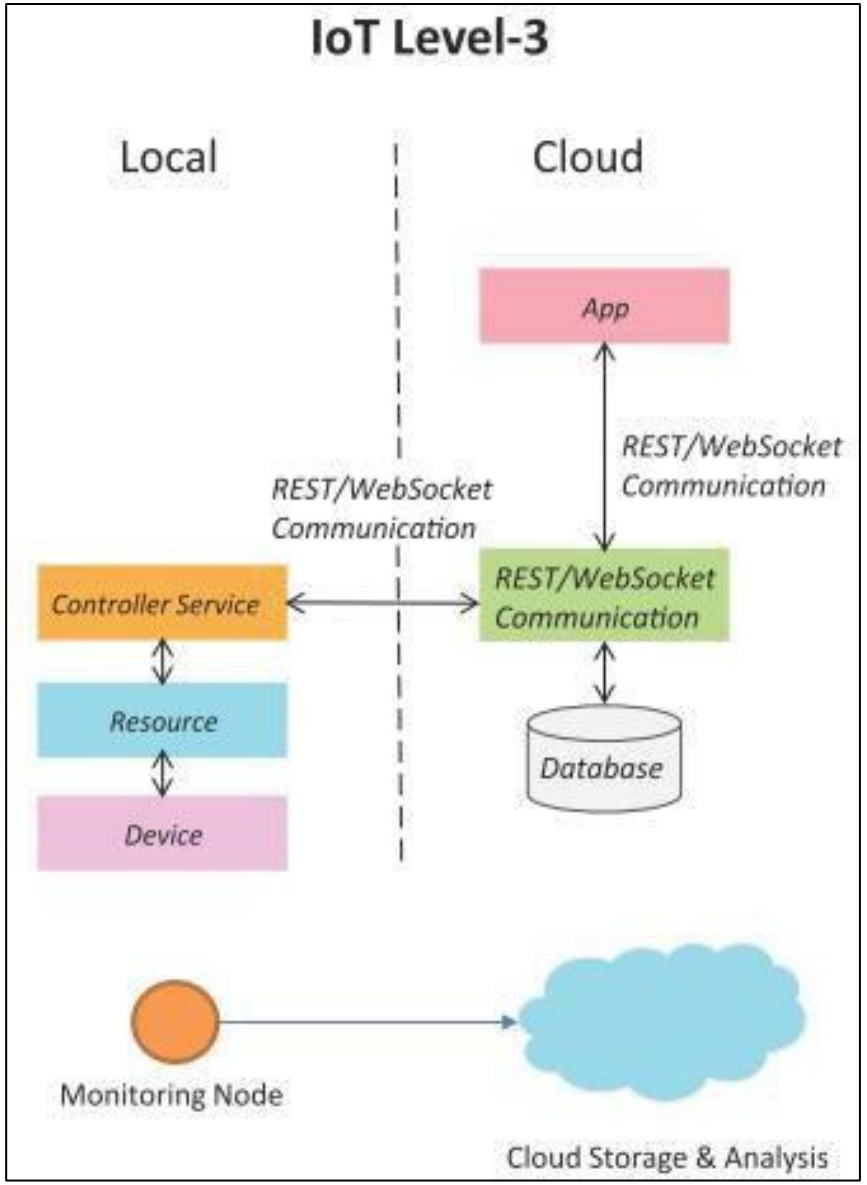
- A level-2 IoT system has a single node that performs sensing and/or actuation and local analysis.
- Data is stored in the cloud and application is usually cloud- based.
- Level-2 IoT systems are suitable for solutions where the data involved is big, however, the primary analysis requirement is not computationally intensive and can be done locally itself.



Smart irrigation

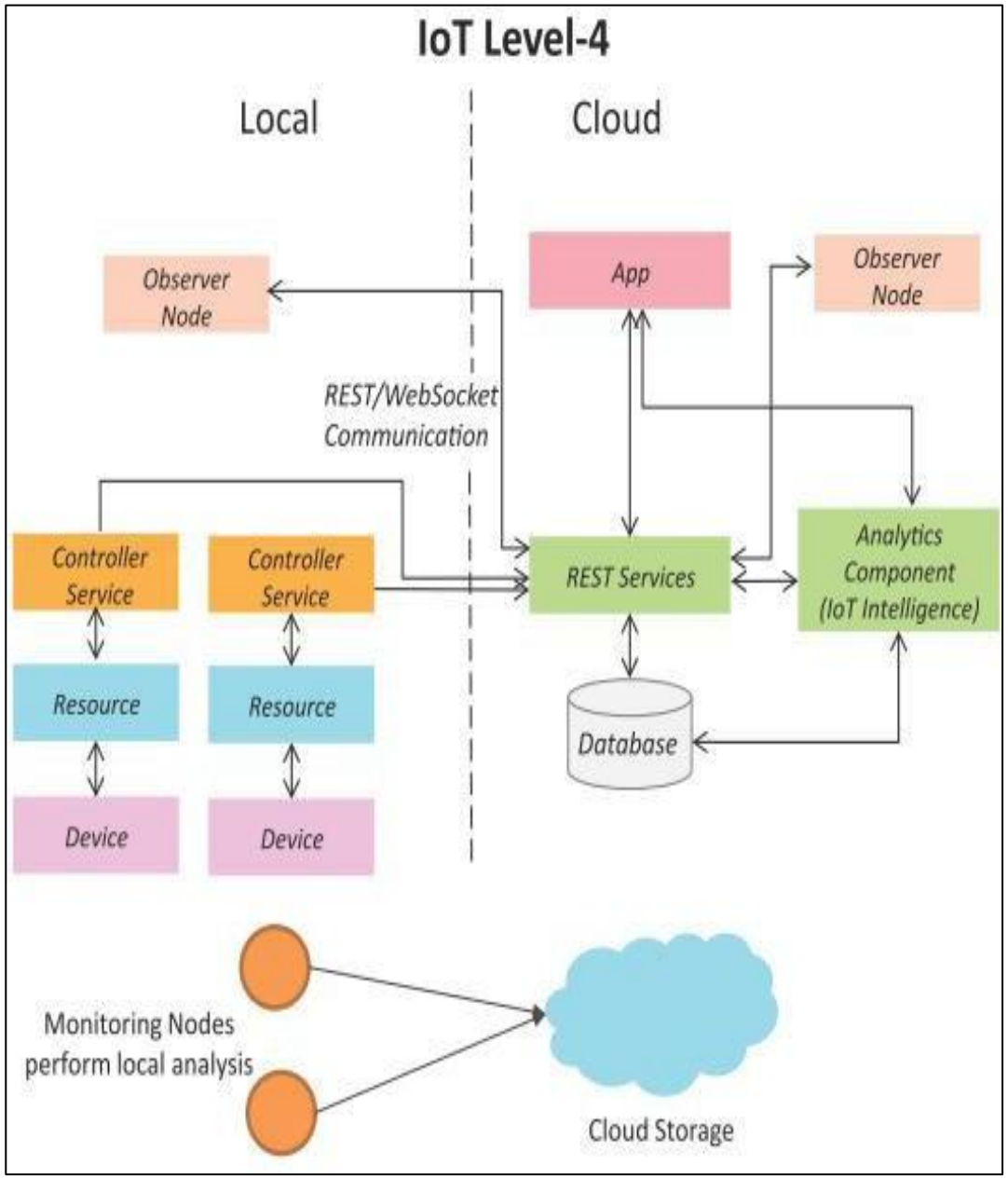
IoT Level-3

- A level-3 IoT system has a single node. Data is stored and analyzed in the cloud and application is cloud-based.
- Level-3 IoT systems are suitable for solutions where the data involved is big and the analysis requirements are computationally intensive.



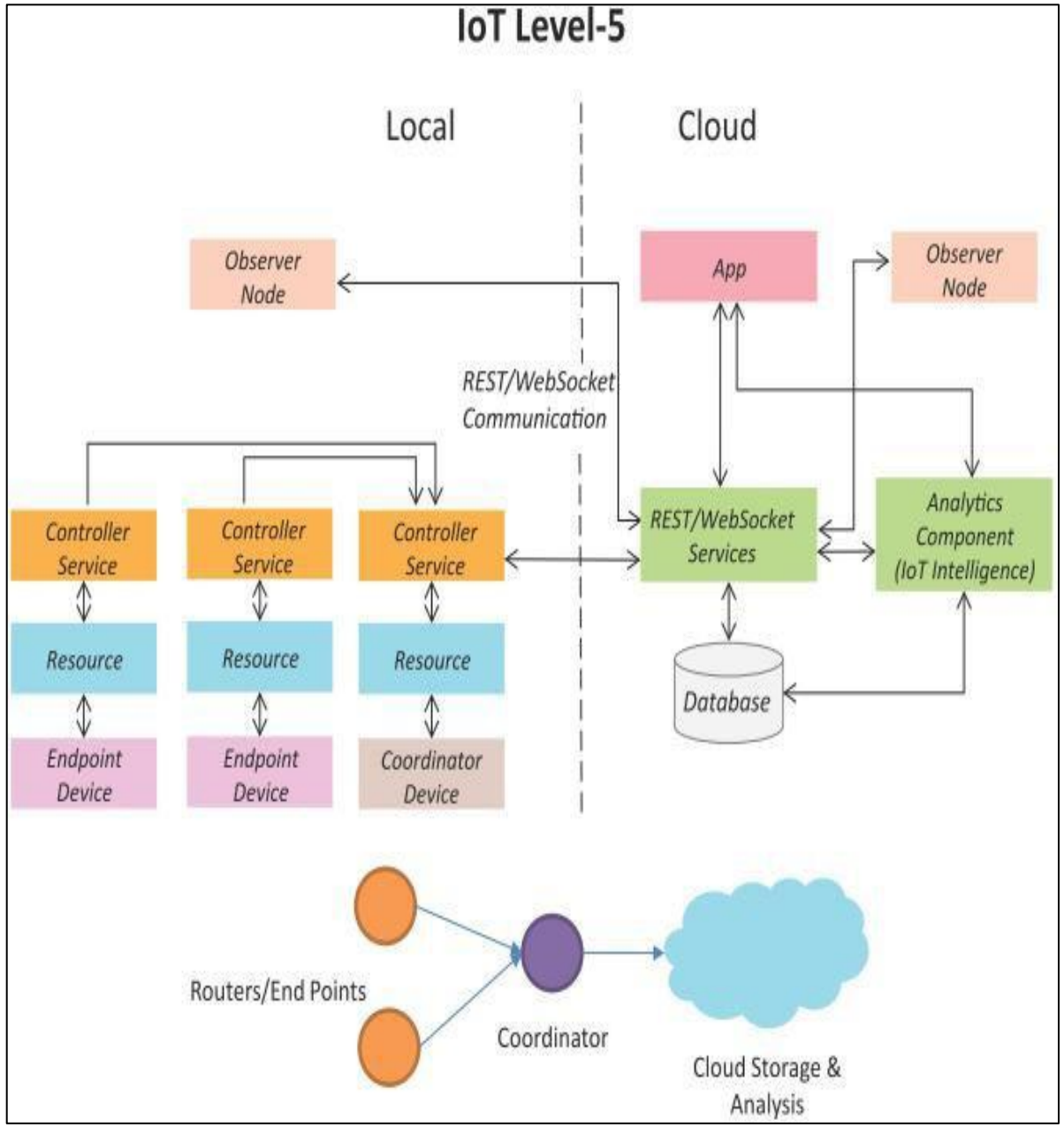
IoT Level-4

- A level-4 IoT system has multiple nodes that perform local analysis. Data is stored in the cloud and application is cloud-based.
- Level-4 contains local and cloud- based observer nodes which can subscribe to and receive information collected in the cloud from IoT devices.
- Level-4 IoT systems are suitable for solutions where multiple nodes are required, the data involved is big and the analysis requirements are computationally intensive.



IoT Level-5

- A level-5 IoT system has multiple end nodes and one coordinator node.
- The end nodes that perform sensing and/or actuation.
- Coordinator node collects data from the end nodes and sends to the cloud.
- Data is stored and analyzed in the cloud and application is cloud-based.
- Level-5 IoT systems are suitable for solutions based on wireless sensor networks, in which the data involved is big and the analysis requirements are computationally intensive.



IoT Level-6

- A level-6 IoT system has multiple independent end nodes that perform sensing and/or actuation and send data to the cloud.
- Data is stored in the cloud and application is cloud-based.
- The analytics component analyzes the data and stores the results in the cloud database.
- The results are visualized with the cloud-based application.
- The centralized controller is aware of the status of all the end nodes and sends control commands to the nodes.