IOT APPLICATION DEVELOPMENT

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ABOUT
IOT-APPLICATION DEVELOPMENT

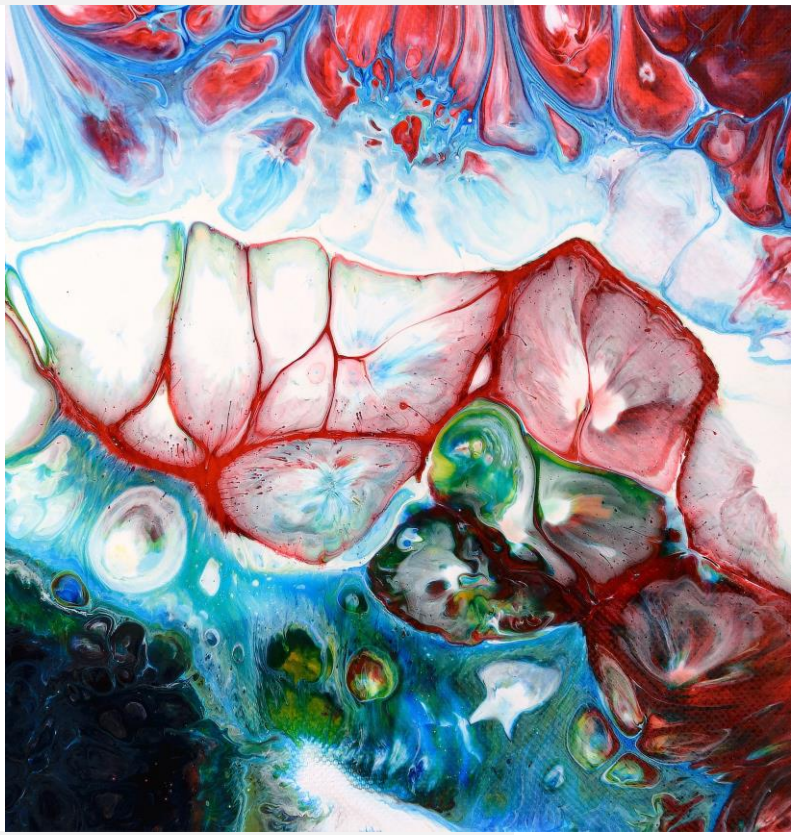
As a 4 Credit Course

- Theory & Lab
- Self Study – A Value Added Activity
- Mini-Project

VALUE-ADDED ACTIVITY

Any 1

- Company sponsored Project
- Participation in competitions
- Conference / Publications
- Your project app on Playstore
- Online Certification



MINI-PROJECT

Two members in a team

Any Domain

- Agriculture
- HealthCare
- Smart City
- Home Automation
- Logistics
- Industry
- Retail

Any technology

- Arduino
- Atmega micro-controller
- Raspberry-Pi (Lab provided) Programming :
  - C / C++
  - Java
  - Python (preferred)

Massimo Banzi

PROJECT INSPIRATION

Outline

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

Definition of IoT

- A dynamic global network infrastructure.
- Having self-configuring capabilities
- Based on standard and interoperable communication protocols.
- Physical and virtual "things" have identities, physical attributes, and virtual personalities.
- Use intelligent interfaces, and are seamlessly integrated into the information network.
- Often communicate data associated with users and their environments.

What is IoT?

Internet of Things (IoT) is an ecosystem of connected physical objects that are accessible through the internet. The 'thing' in IoT could be a person with a heart monitor or an automobile with built-in-sensors, i.e. objects that have been assigned an IP address and have the ability to collect and transfer data over a network without manual assistance or intervention. The embedded technology in the objects helps them to interact with internal states or the external environment, which in turn affects the decisions taken.

Characteristics of IoT

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

Physical Design of IoT

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*

• *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*

What is the scope of IoT?

- *Internet of Things can connect devices embedded in various systems to the internet. When devices/objects can represent themselves digitally, they can be controlled from anywhere. The connectivity then helps us capture more data from more places, ensuring more ways of increasing efficiency and improving safety and IoT security.*

- *IoT is a transformational force that can help companies improve performance through IoT analytics and **IoT Security** to deliver better results. Businesses in the utilities, oil & gas, insurance, manufacturing, transportation, infrastructure and retail sectors can reap the benefits of IoT by making more informed decisions, aided by the torrent of interactional and transactional data at their disposal.*

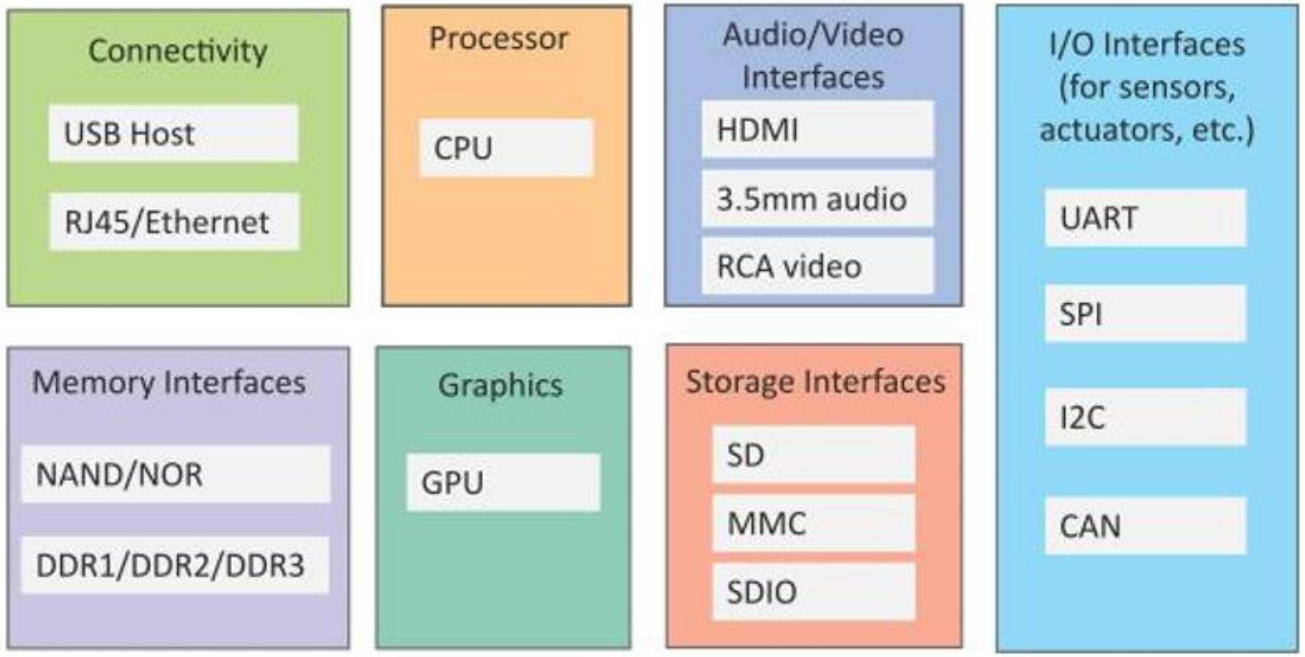
How can IoT help?

IoT platforms can help organizations reduce cost through improved process efficiency, asset utilization and productivity. With improved tracking of devices/objects using sensors and connectivity, they can benefit from real-time insights and analytics, which would help them make smarter decisions.

The growth and convergence of data, processes and things on the internet would make such connections more relevant and important, creating more opportunities for people, businesses and industries.

Generic Block Diagram

• 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.



UART - universal asynchronous receiver-transmitter

SPI - Serial Peripheral Interface

I2C - Inter-Integrated Circuit

CAN - Controller Area Network (CAN bus)

SD Card – Secure Digital Card

MMC – Multi-media Card

SDIO - Secure Digital Input Output

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

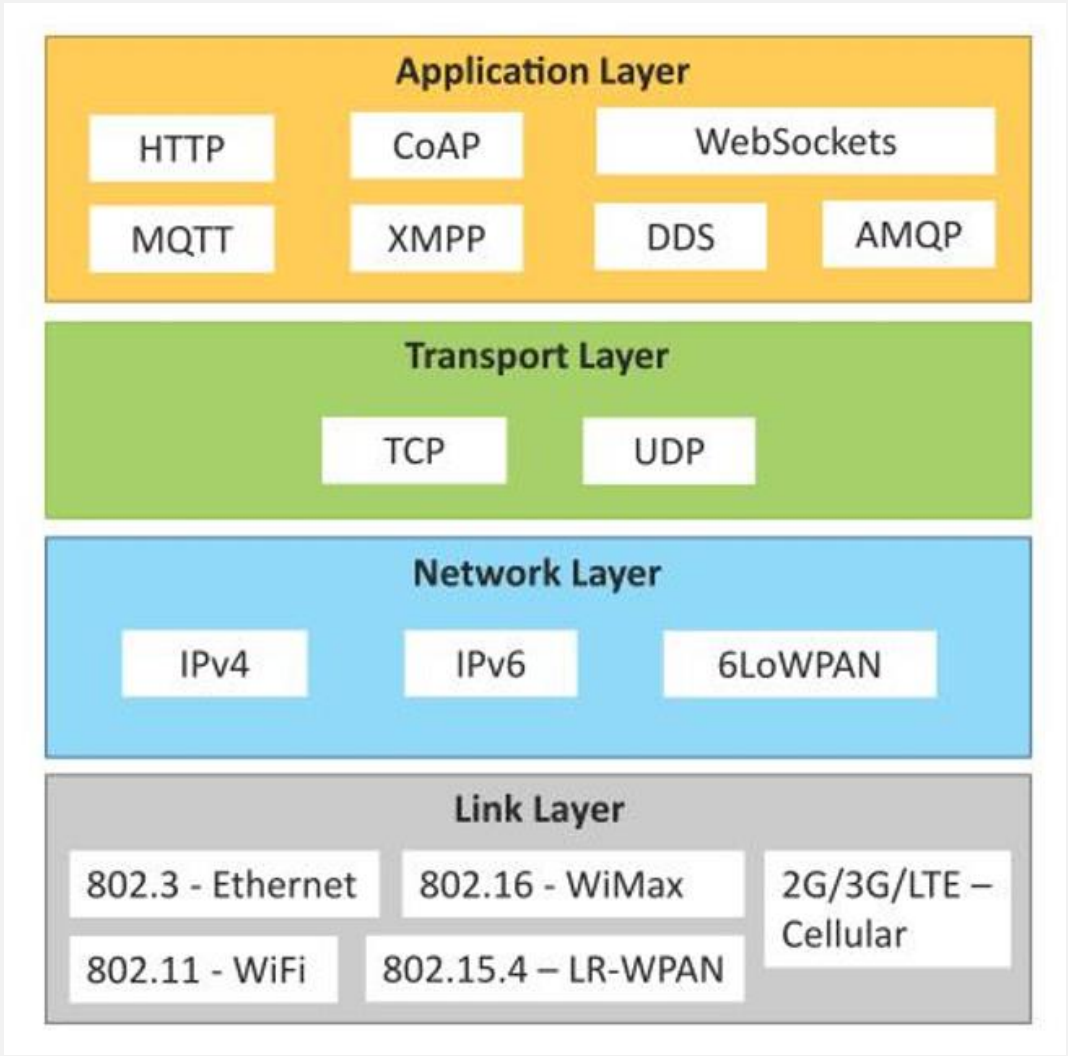
Transport Layer

• TCP • UDP •

Application Layer

• HTTP • CoAP • WebSocket • MQTT • XMPP • DDS • AMQP

IoT Protocols



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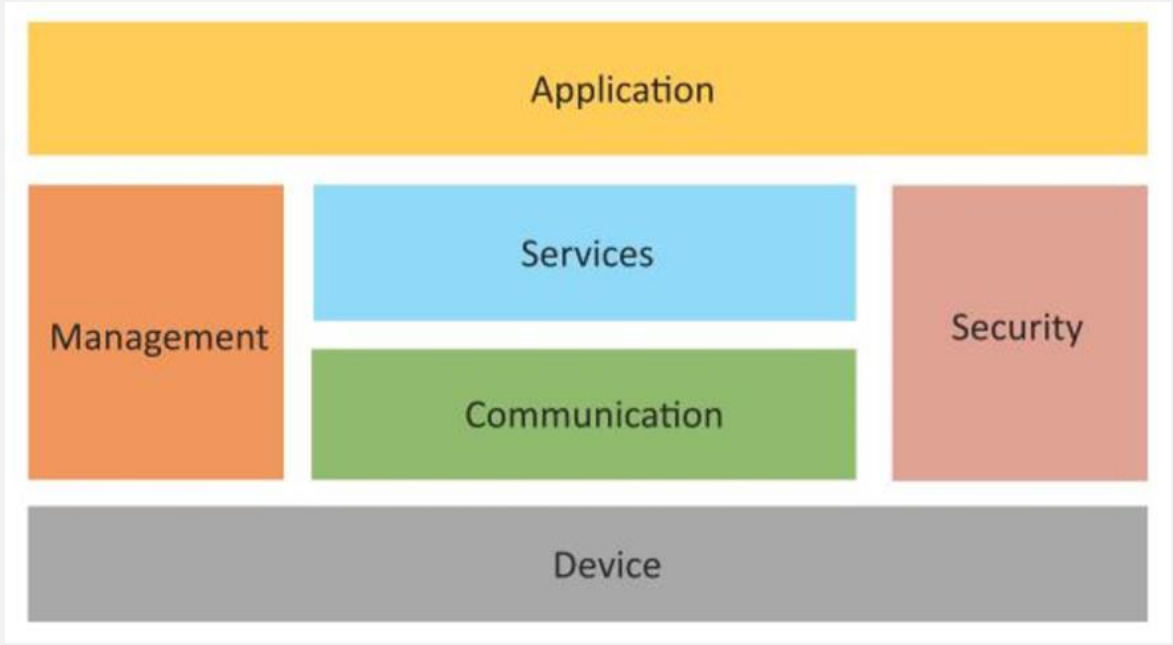
Logical Design of IoT

- 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.

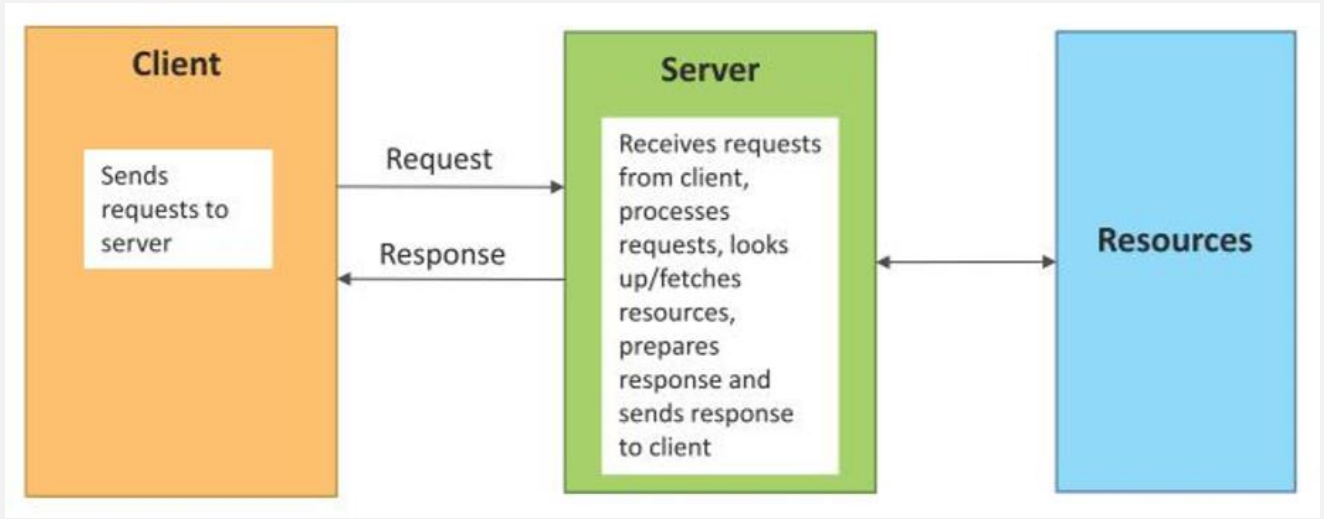
- An IoT system comprises of a number of functional blocks that provide the system the capabilities for identification, sensing, actuation, communication, and management.



Request-Response Model

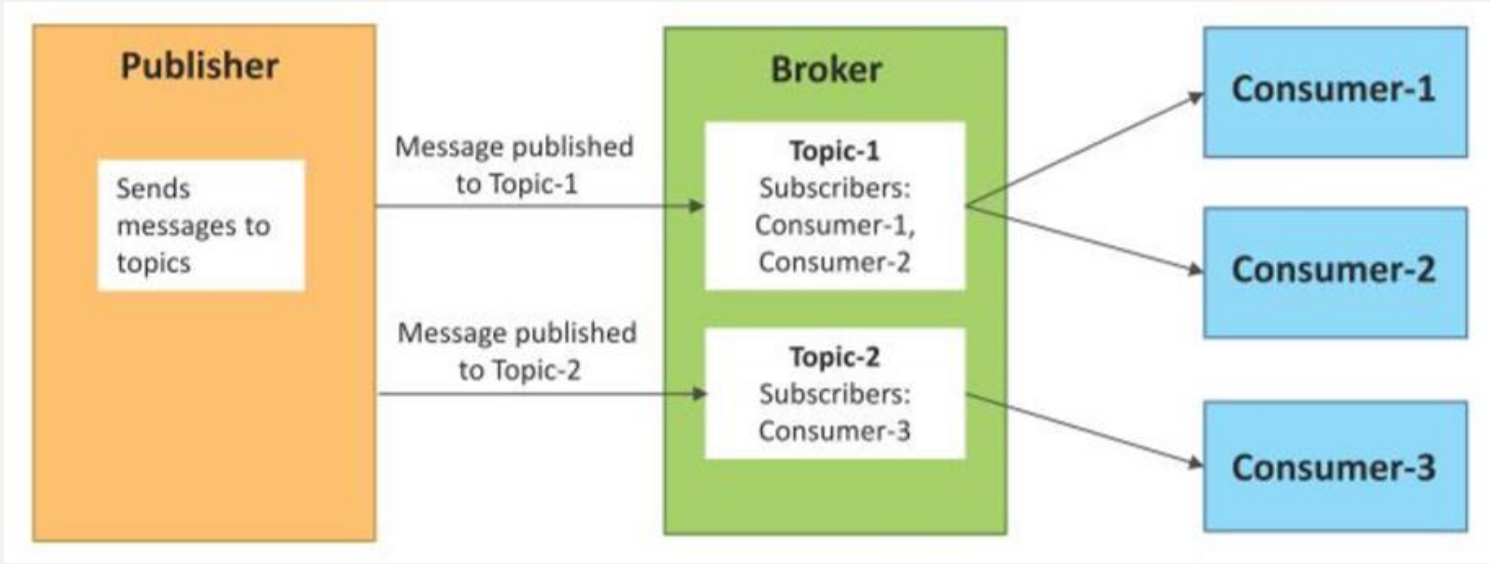
- Request-Response is a communication model in which the client sends requests to the server and the server responds to the requests.

- 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.



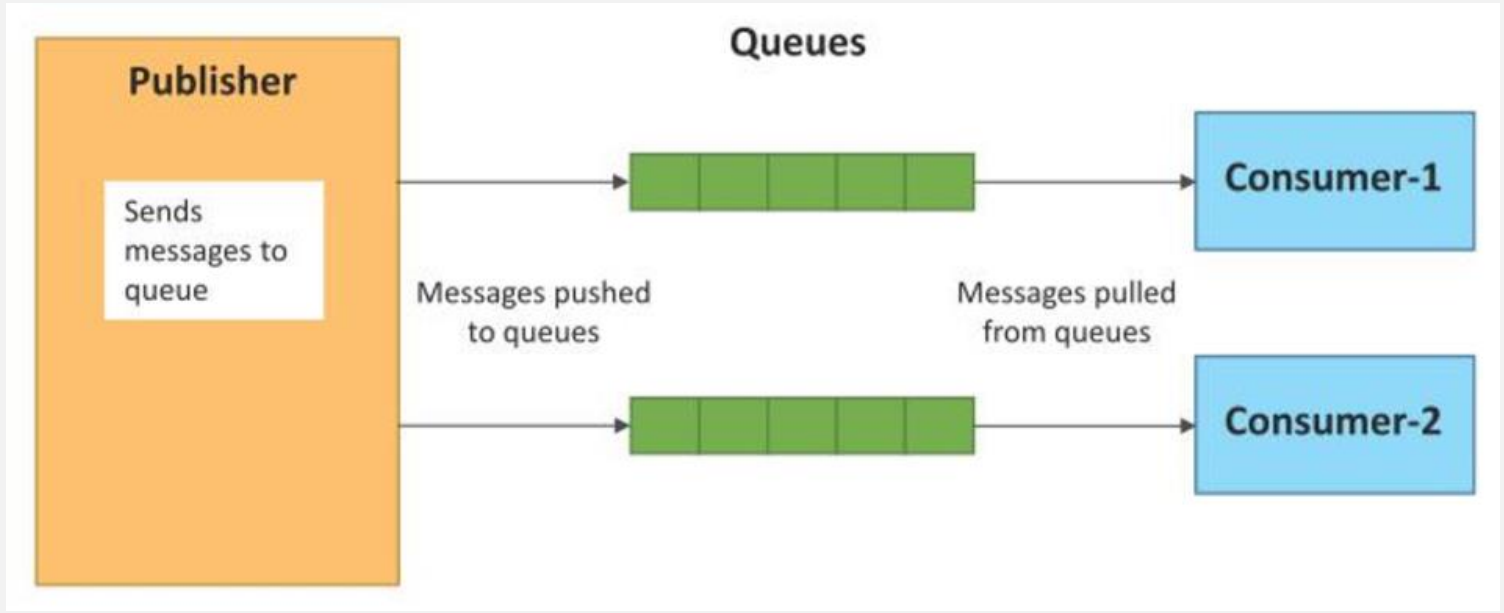
Publish-Subscribe Model

- 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 Commn. 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 at which the consumers pull data.

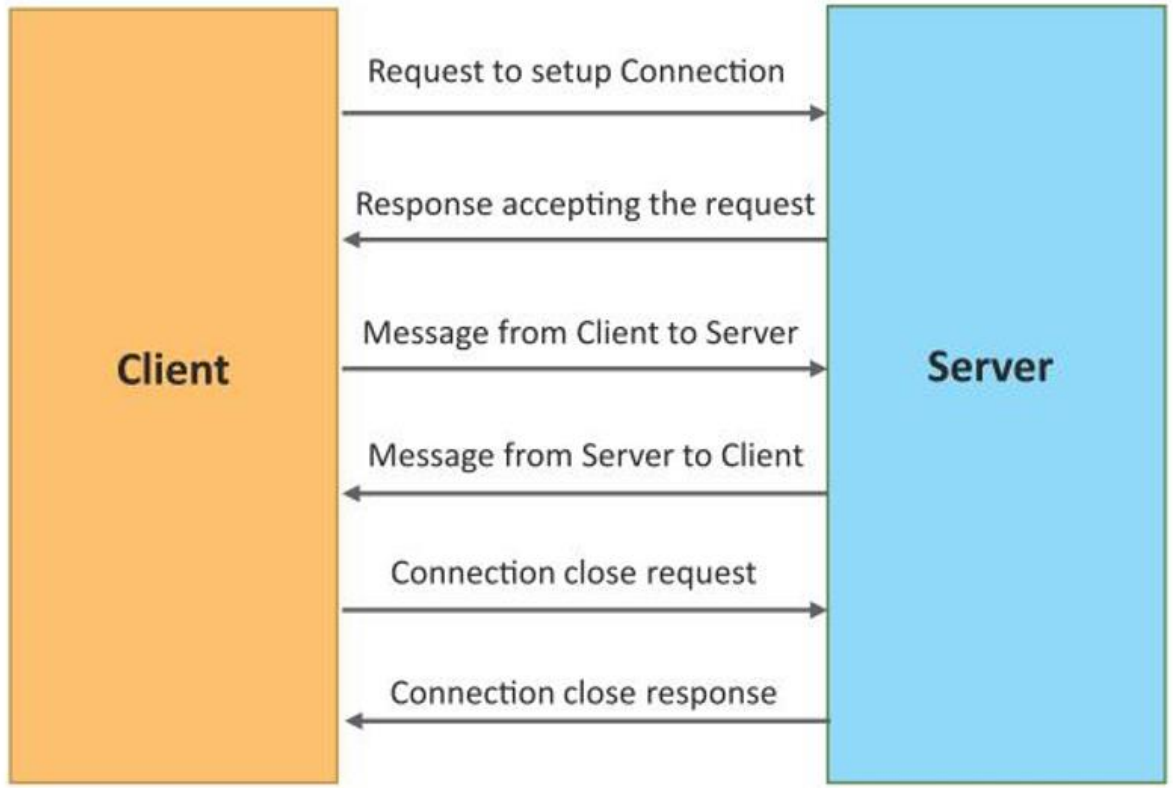


Exclusive Pair communication model

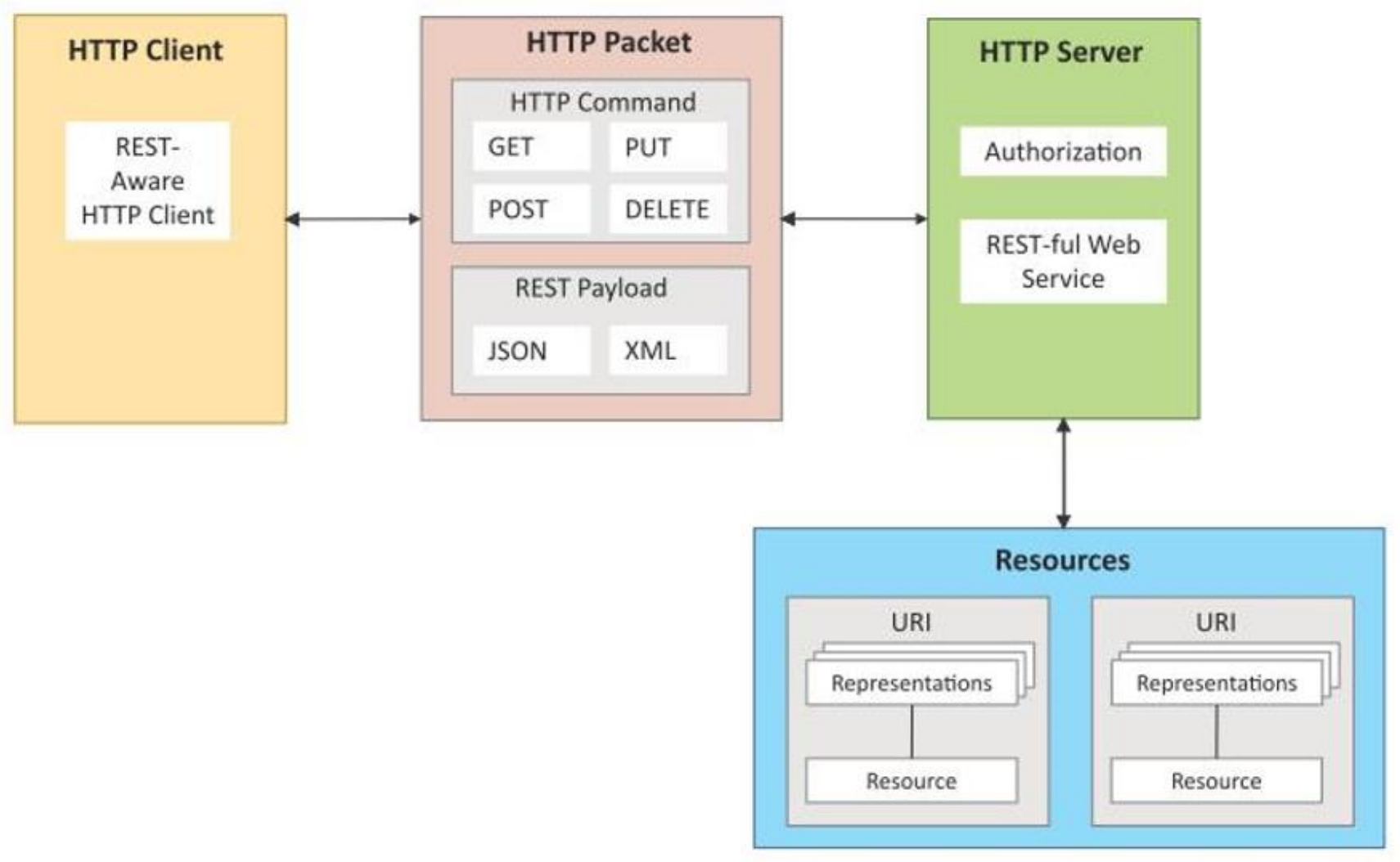
- Exclusive Pair is a bidirectional, fully duplex communication model that uses a persistent connection between the client and server.

- 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.



REST-based 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.

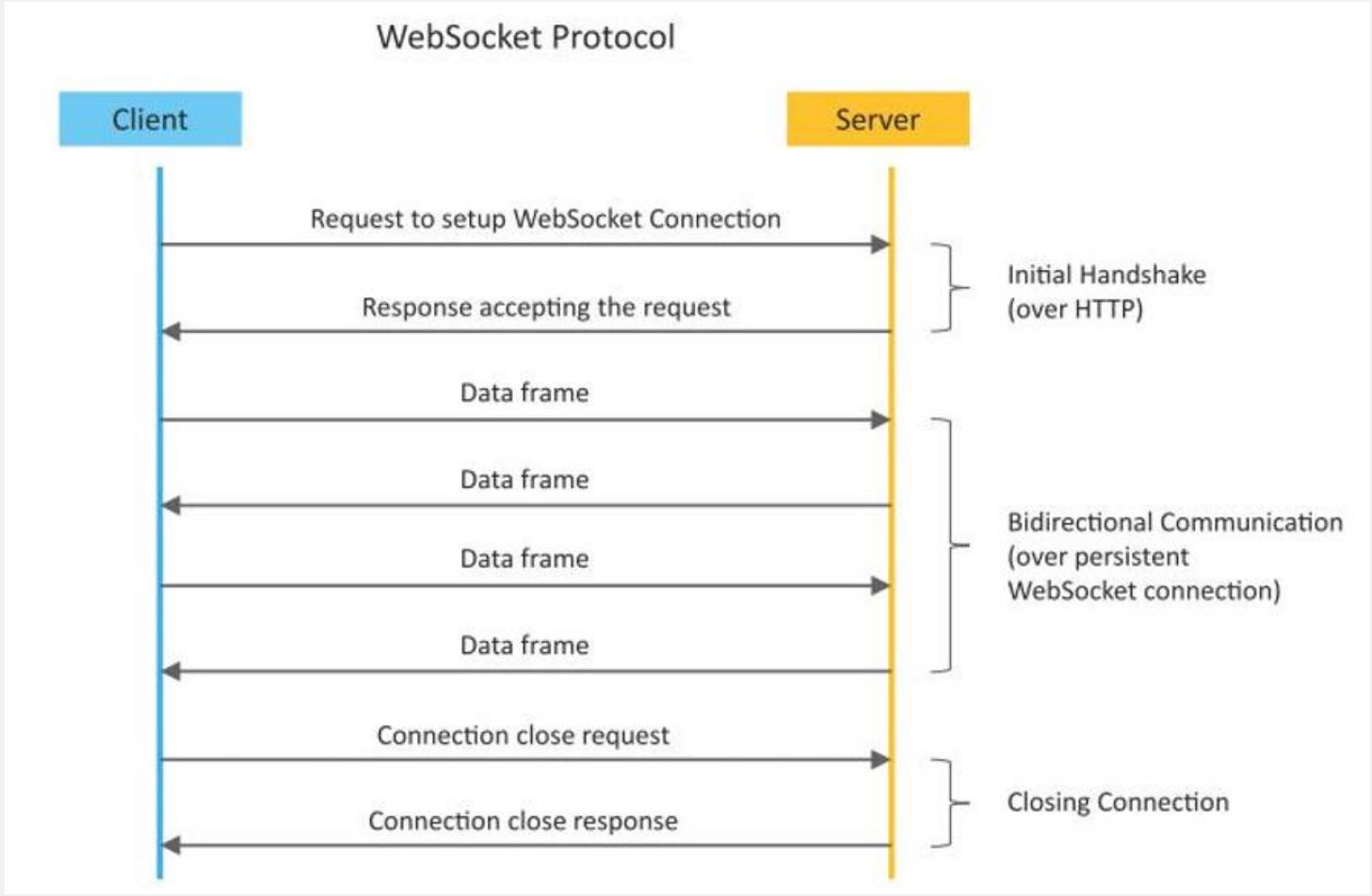
- REST APIs follow the request-response communication model.

- The REST architectural constraints apply to the components, connectors, and data elements, within a distributed hypermedia system.

WebSocket-based Communication APIs

- WebSocket APIs allow bidirectional, full duplex communication between clients and servers.

- WebSocket APIs follow the exclusive pair communication model



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.

Modern Day IoT Applications

- Smart Parking
- Structural health
- Noise Urban Maps
- Smartphone Detection
- Traffic Congestion
- Smart Lighting
- Waste Management
- Smart Roads
- Intelligent Shopping Applications
- Smart Product Management
- River Floods
- Smart Grid
- Tank level
- Photovoltaic Installations
- Water Flow
- Silos Stock Calculation
- Perimeter Access Control
- Liquid Presence
- Supply Chain Control
- NFC Payment
- Forest Fire Detection
- Air Pollution
- Snow Level Monitoring
- Earthquake Early Detection
- Water Leakages
- Radiation Levels
- Explosive and Hazardous Gases
- Landslide and Avalanche Prevention

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).

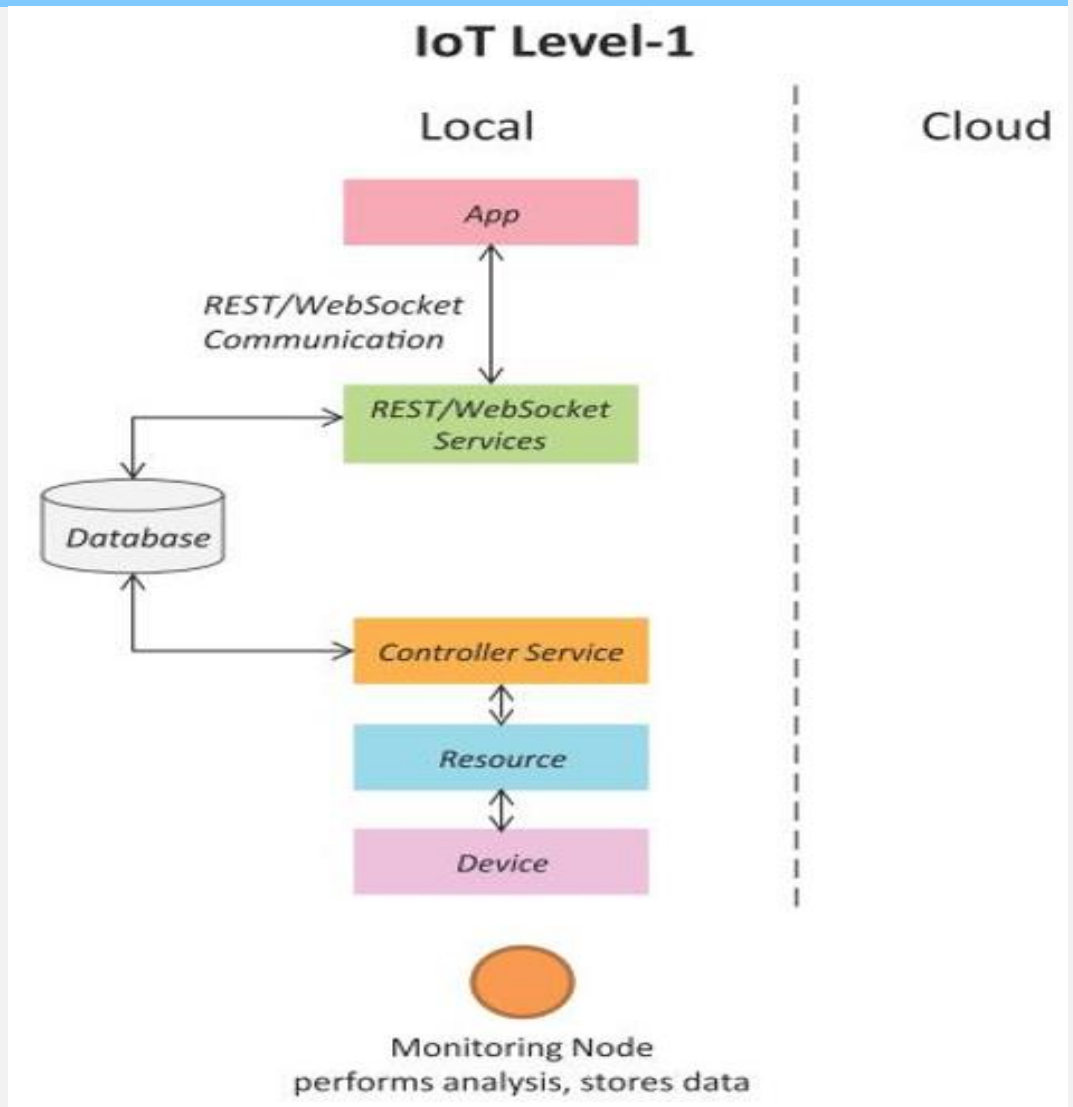
• **Analysis Component:** The Analysis Component is responsible for analysing the IoT data and generate results in a form which are easy for the user to understand.

• **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 Levels - 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 modelling low-cost and low-complexity solutions where the data involved is not big and the analysis requirements are not computationally intensive.

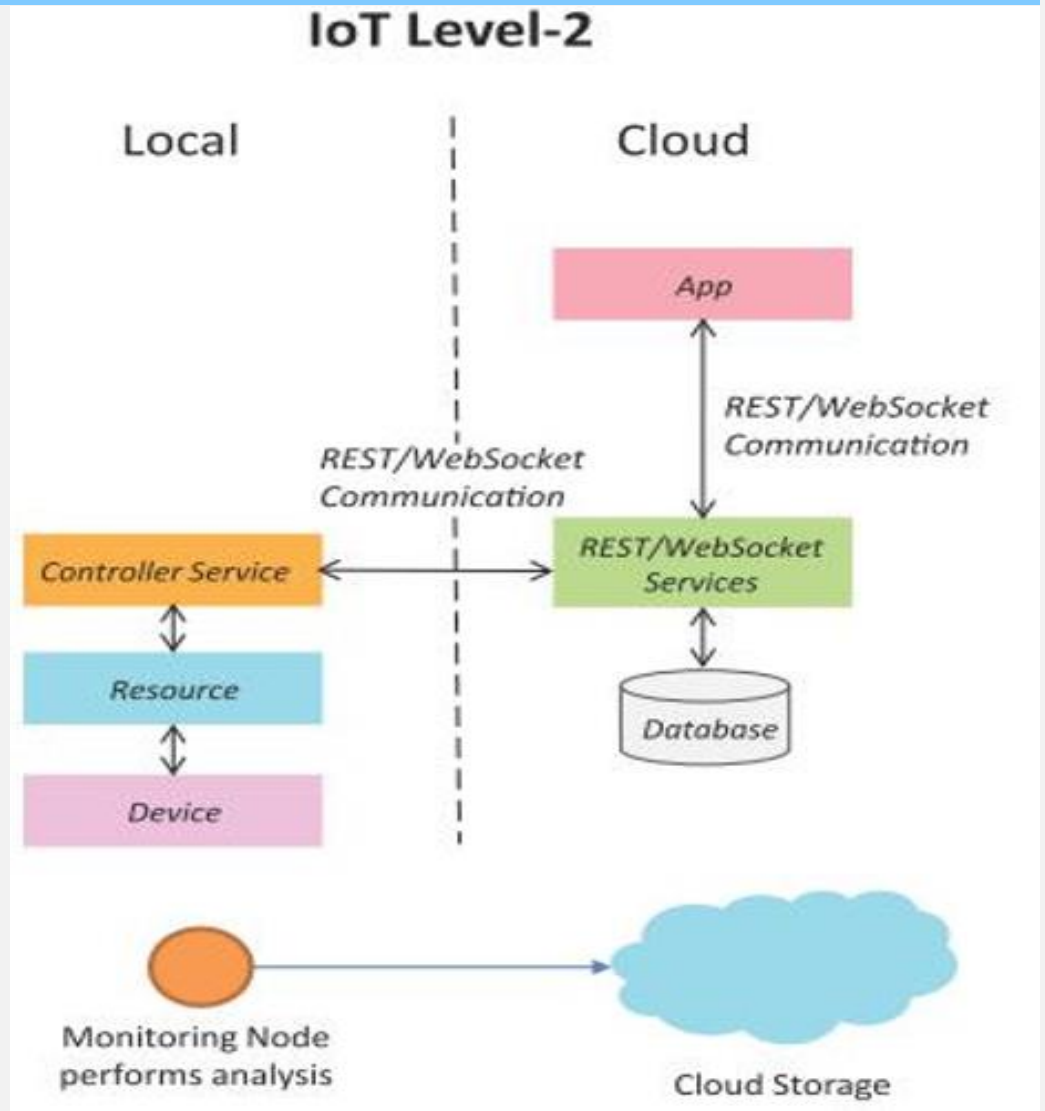


IoT Levels - 2

• 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.

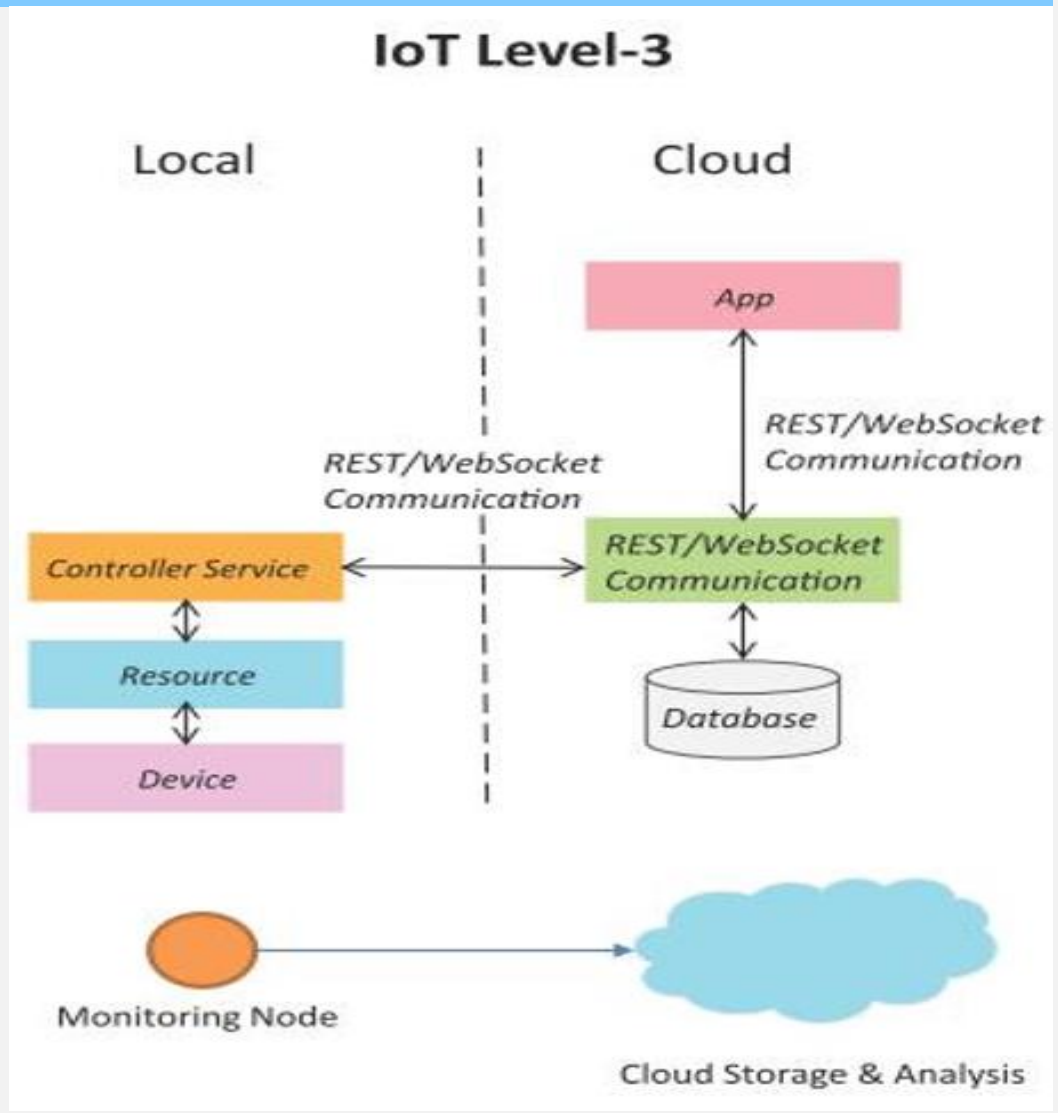
• Level-2 IoT systems are suitable for solutions where the data involved is big, however, the primary analysis requirement is not computationally intensive and can be done locally itself.



IoT Levels – 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.

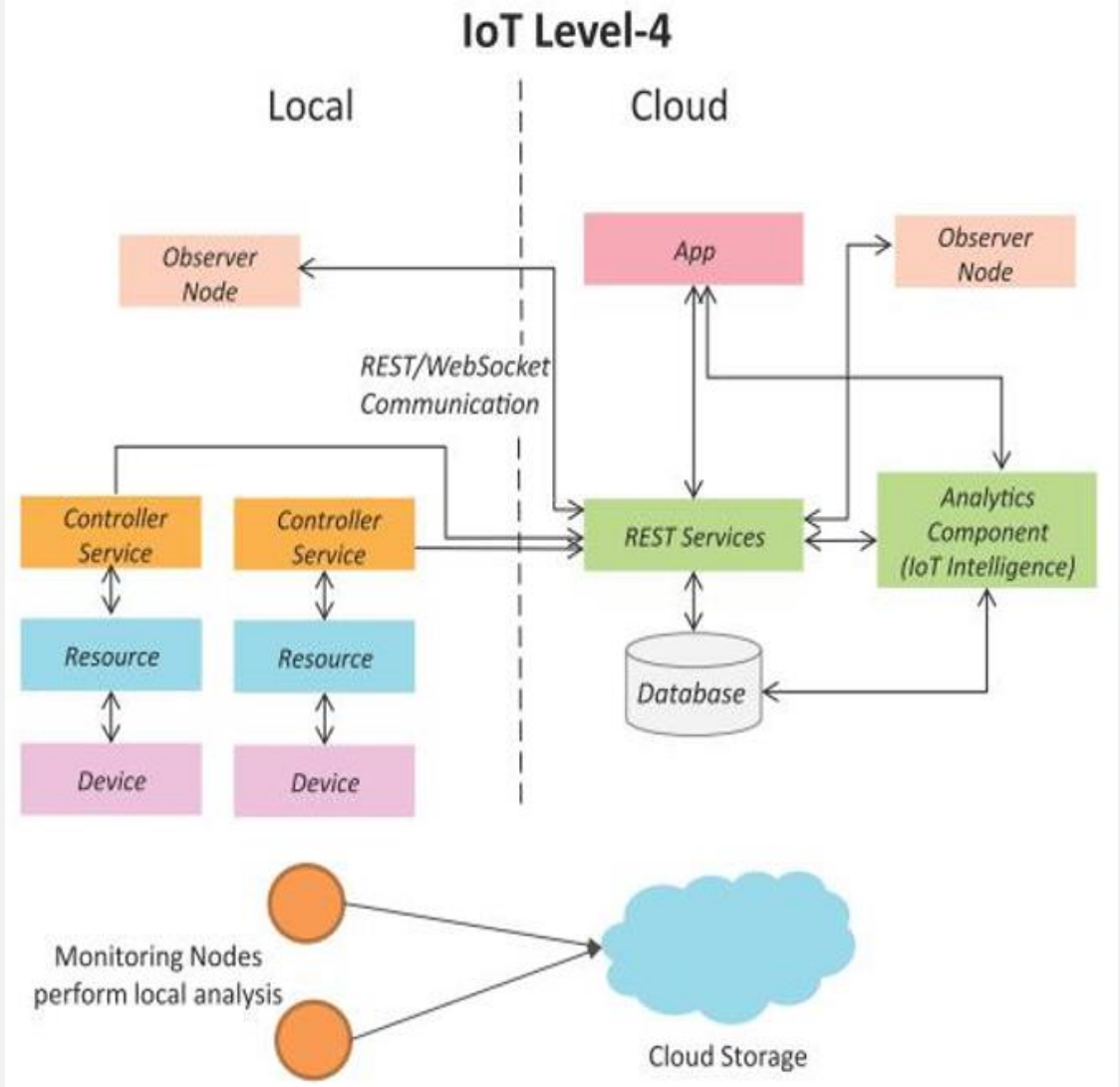


IoT Levels – 4

• 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.



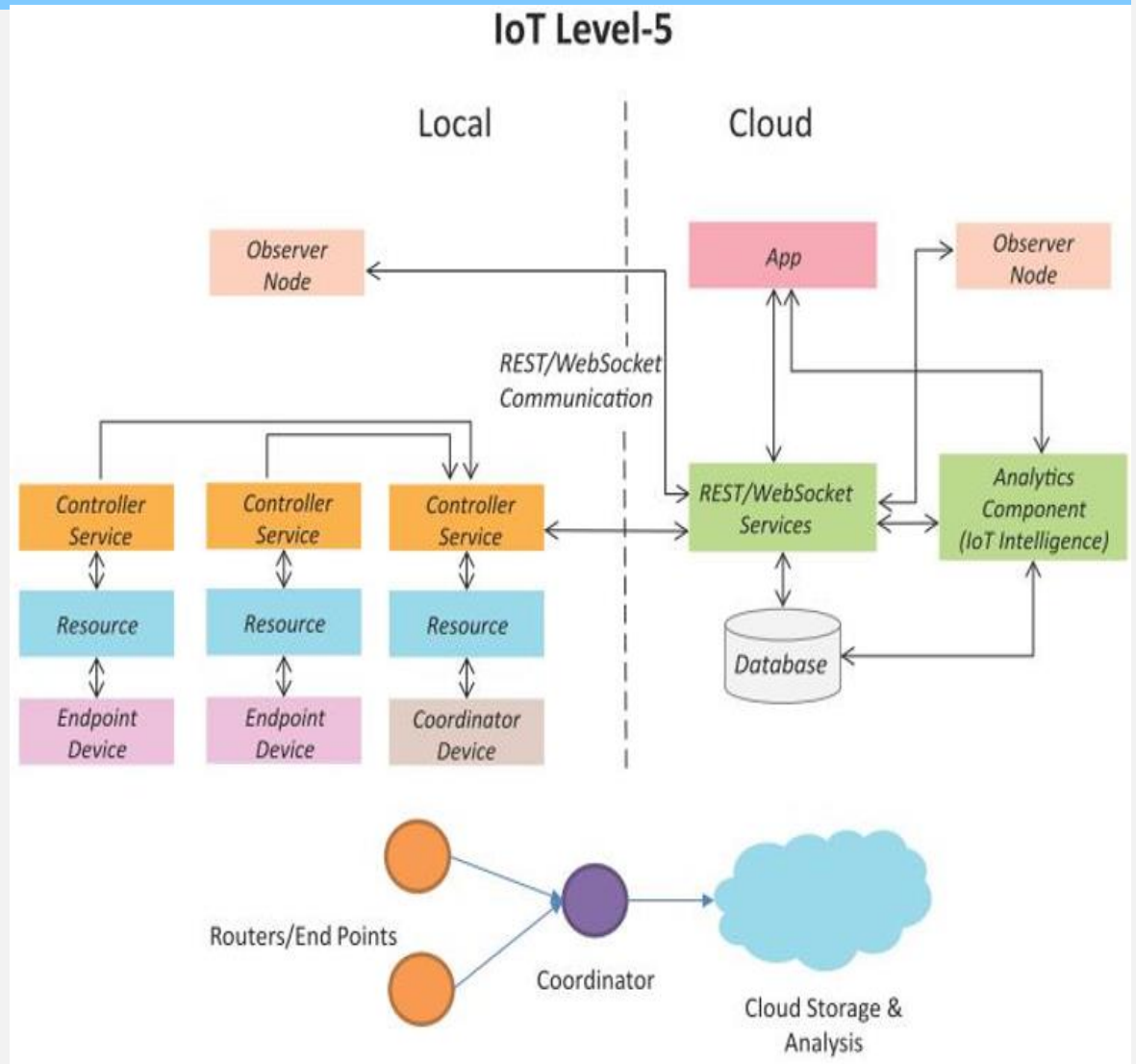
IoT Levels – 5

• 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 Levels – 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 analyses 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.