UNIT I FUNDAMENDALS OF IOT

Definition and Characteristics of IoT, Sensors, Actuators, Physical Design of IoT – IoT Protocols, IoT communication models, IoT Communication APIs, IoT enabled Technologies – Wireless Sensor Networks, Cloud Computing, Embedded Systems, IoT Levels and Templates, Domain Specific IoTs – Home, City, Environment, Energy, Agriculture and Industry.

IoT Levels and Templates

The various levels of IoT systems with increasing completely. IoT system comprises of the following components:

1. **Device**: An IoT device allow identification, remote sensing, actuating and remote monitoring capabilities.
2. **Resources**: Resources are software components on the device for accessing and storing information for controlling actuator connected to the device also include software components that enable network access for the device.
3. **Controller service**: Controller Service is a native service that runs on the device and interact with the web services. Controller service sends data from the device to the web service receive command from the application from controlling the device.
4. **Database**: Database can be either local or in the cloud and stores the data generated by the IoT device.
5. **Web service**: Serve as a link between the device, application database and analysis components. Web Services can be implemented using HTTP and REST principles or using website protocol.

A comparison of restaurant website is provided below:

Stateless/stateful:

Rest services stateless in nature. Each request contain all the information needed to process it. Requests are independent of each other. Website on the other hand is stateful in nature where the server maintains the state and is aware of all the open connections.

Directional / Bi- directional:

REST service operate over http and unidirectional. Request is always sent by a client and the server response to the request. And other hand website is a bi directional product server to send message to each other

Request response / full duplex:

REST service follower request response Communications model where the client sends request and the server response to the request. Website and the other hand Allow full-duplex Communications between the client and server, it means both client and server can send messages to can independently.

TCP connections:

For REST Service each http request involves setting up a new TCP connection. Websocket on the other hand involves a single TCP connection over which the client and server communicate in a full duplex mode.

Headache Overhead:

REST service operate over http, and each request is independent of others . Thus each request carries http header which is an overhead. Due to the overhead of http headers, REST is not suitable for real time applications left hand does not involve overhead of headers. After the initial handshake the client and server exchange messages with minimal frame information.

Scalability:

Scalability is easier in this case of the REST services of request are independent and no state information needs to be maintained by the server. Thus both horizontal out and vertical scaling solutions are possible for REST services. For webSockets horizontal scaling can be cumbersome due to stateful nature of the communication. Since the server maintains the state of our connection, vertical scaling is easier for Websocket than horizontal scaling.

Analysis component:

The analysis component is responsible for analyzing the IoT data and generate results in the form which are easy for the user to understand. Analysis of IoT data can be performed either locally or in the cloud. Analyzed results are stored in the local or cloud database.

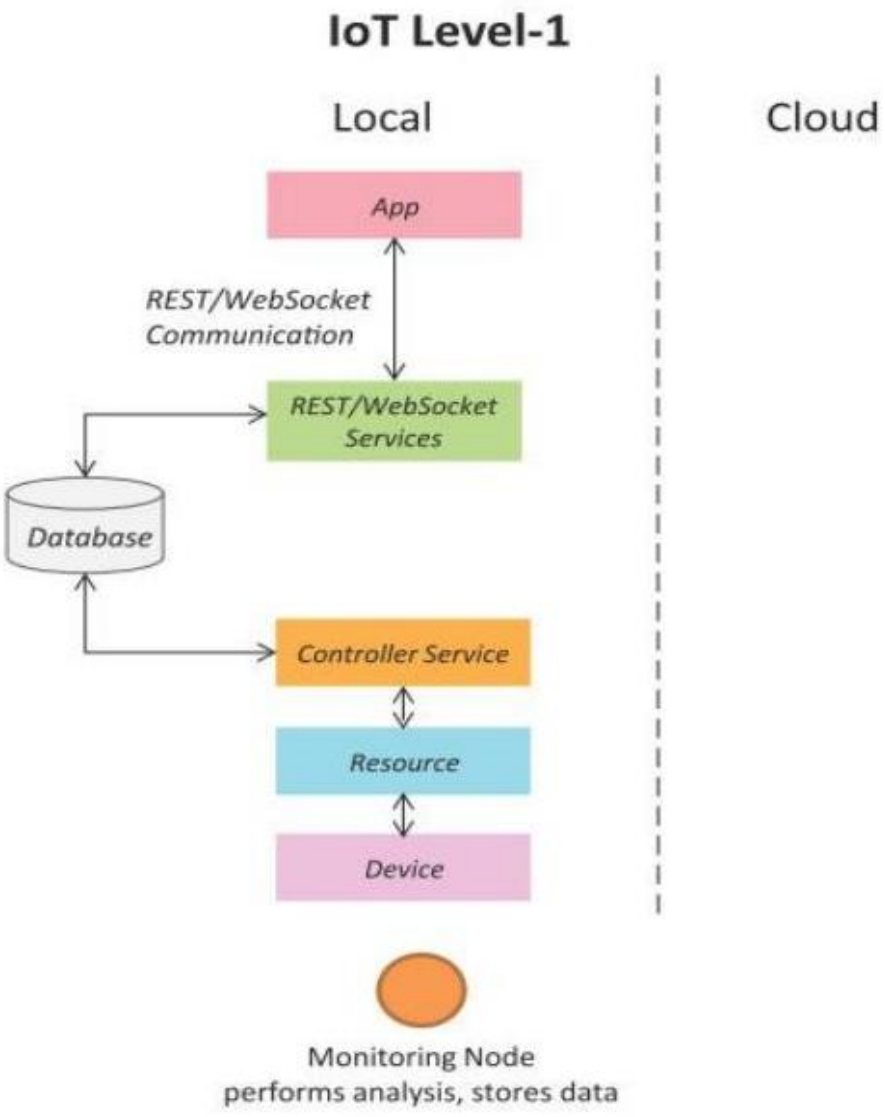
Application: IoT applications provide an interface that the user can use to control and monitor various aspects of the IoT system. Applications also allow user to view the system status and view the processed data.

IoT Levels: 1~6

	Device	Compute	Store	Comm
Level 1	1	Local	Local	Device (Serverless)
Level 2	1	Local	Cloud	Device
Level 3	1	Cloud	Cloud	Device
Level 4	N	Local	Cloud	Device
Level 5	N	Local	Cloud	Gateway (at local)
Level 6	N	Cloud	Cloud	Data Plane: Device Control Plane: Controller (at cloud)

IoT level 1:

Level One IoT system has a single node / device that performs sensing and/or actuation, stores data, reforms analysis and the host to the application. Level 1 IoT systems are suitable for modeling low cost and low complexity solutions where the data involving is not big and the analysis requirements are not computationally intensive.



Let us now consider done example of Level 1 IoT **system for home automation**. This system consists of the single node that allows controlling the lights and appliances in your home remotely. The device used in this system interface with their lights and appliances using electronic relay switches.

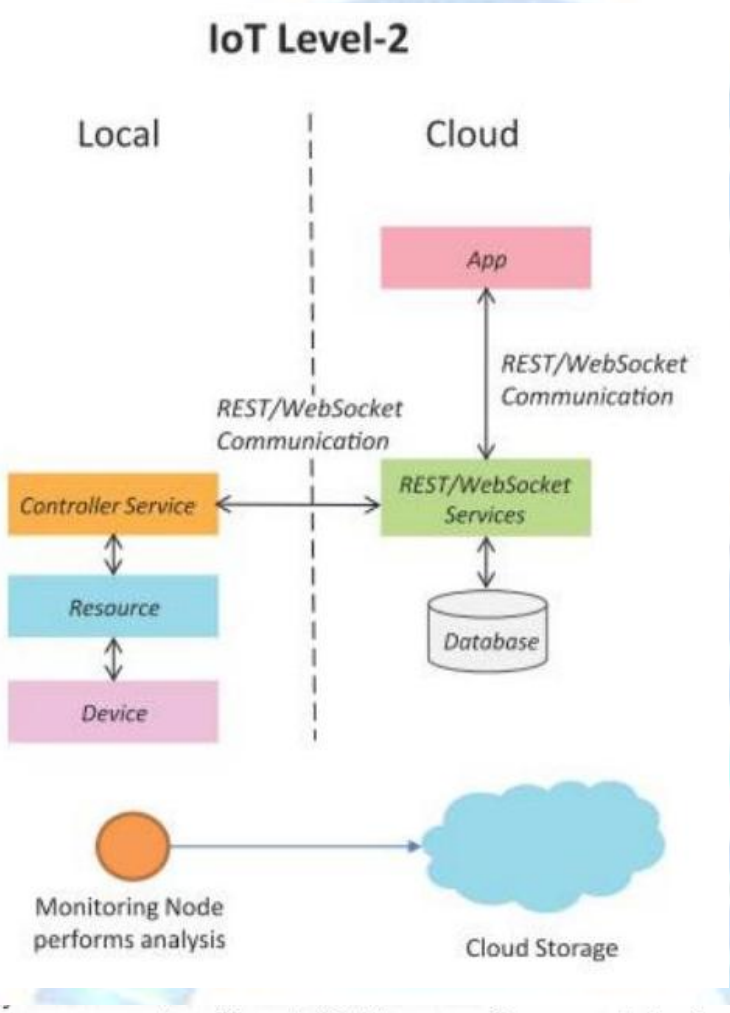
The status information of each light or appliance is maintained in a local database. REST service deployed locally Allow retrieving and updating the state of each light or appliances in the status database.

The controller service continuously monitors the state of each light or appliance and triggers the relay switches accordingly. The applications which are deployed locally has a user interface for controlling the lights or appliances. since the device is connected to the internet, the application can be

accessed remotely as well.

IoT level 2:

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 systems are suitable for solutions where the data in world is big, however the primary analysis requirement is not computationally intensive and can be done local itself.



Construct an example of Level 2 IoT system for smart irrigation. The system consists of the single node that monitor the soil moisture level and control segregation system. The device used in this system collect soil moisture data from sensor the controller service continuously monitor the moisture level. If the monster level drops below a threshold t , the irrigation system is turned on.

For controlling the irrigation system actuators such as solenoid valve can be used.. Rest Web Services is used for storing and retrieving data which is stored in the cloud database. A cloud based application is used for visualizing the moisture level over a period of time, which can help in making decisions about irrigation schedules.

IoT Level 3:

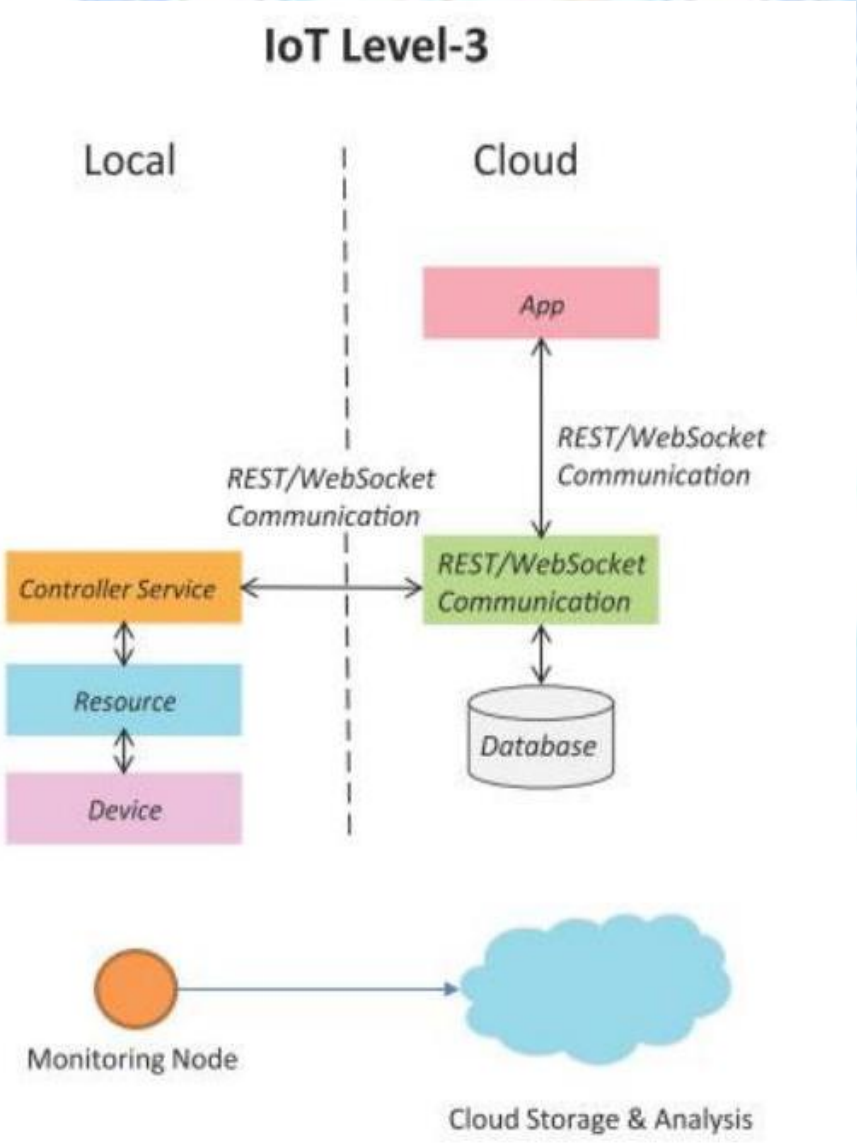
Level 3 system has a single node. Data is stored and analyzed in the cloud application is cloud-

based. Level 3 IoT system suitable for solutions where the data involved is big and analysis requirements computationally intensive. Level-3 IoT systems are suitable for solutions where the data involved is big and the analysis requirements are computationally intensive.

Let us considered example of Level 3 IoT **system tracking** package handling. The system consists of a single node that monitors the vibration level for package being shipped.

The device in the system uses accelerometer and gyroscope sensor for monitoring vibration levels. The controller service sends sensor data to the cloud in real time using a website service. The data is stored in the cloud and also visualized using a cloud-based application.

The analysis component in the cloud can Trigger alert the vibration level becomes greater than threshold. The benefit of using WebSocket service instead of the REST service this example the sensor data can be sent in real time to the cloud. Cloud based application can subscribe to the sensor data feeds for you in the real-time data.



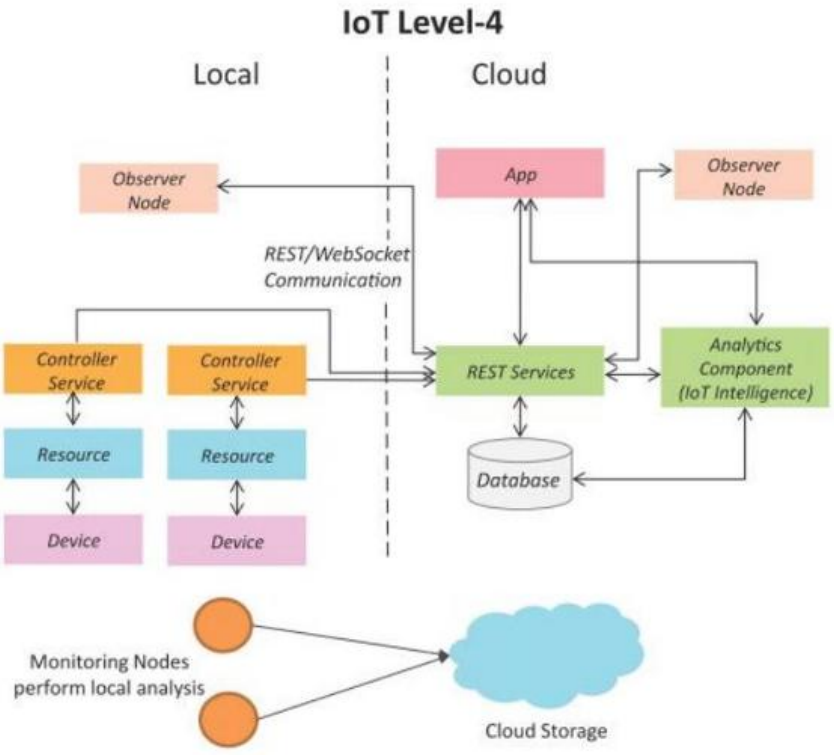
IoT level 4

A level 4 IoT system has multiple notes that perform local analysis. Data is stored in the cloud and application is cloud based, level 4 contains local and cloud-based observer notes which can subscribe to and receive information collected in the cloud from IoT devices.

Observer node can process information and use it for various applications; however, observer notes do not perform any control function. 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.

let us consider an example of level four IoT system **for noise monitoring**. The system consists of multiple notes placed in different locations for monitoring noise level in an area. In this example with sound sensor. Nodes are independent of each other each node runs in one controller service that sends the data to the cloud. The data is stored in a cloud database the analysis of the data collected from a number of notes is done in the cloud.

- 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.

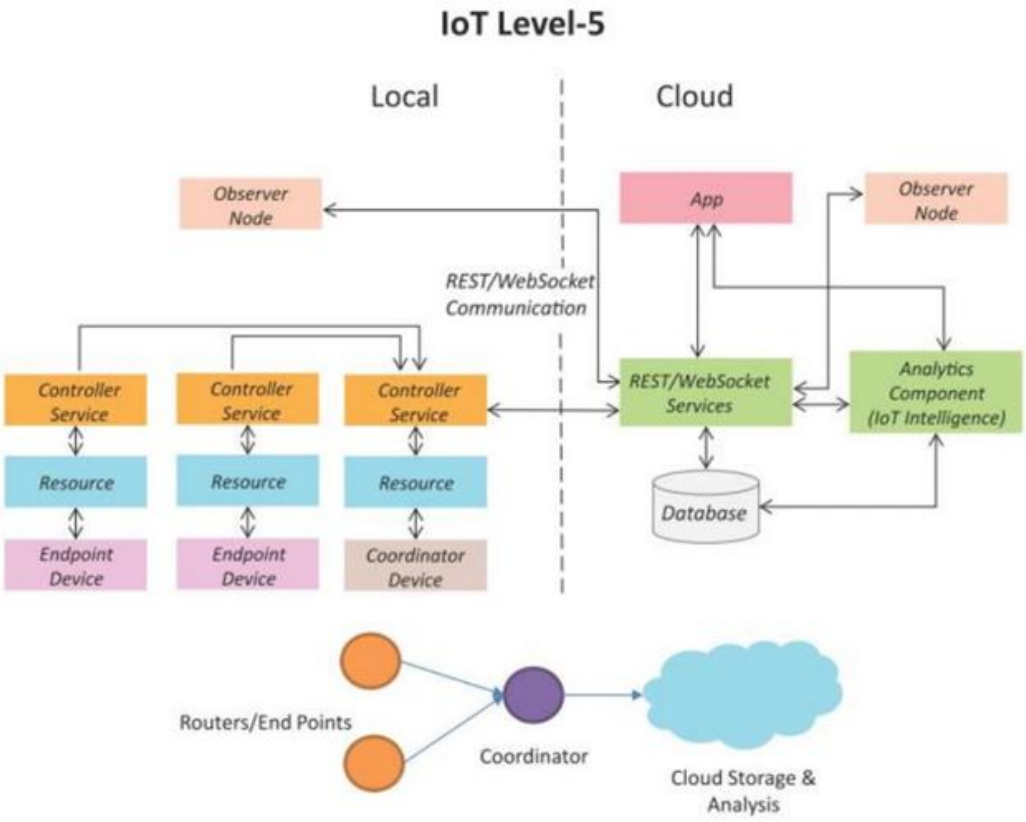


IoT Level 5:

IoT system has multiple end nodes and one coordinator notes and notes that perform sensing and / or actuation. Coordinator node collects data from the entry and send to the cloud. Data is stored and analyzed in the cloud and applications is cloud based.

Level 5 IoT system are suitable for **forest fire detection**. The system consists of multiple nodes placed in different locations for monitoring temperature, humidity and carbon dioxide levels in a forest. The endnotes in this example are equipped with various sensors such as temperature humidity and to CO2. The coordinator node collects the data from the end nodes and act as a Gateway that provides internet connectivity to the IoT system. The controller service on the coordinator device sends the collected data to the cloud. The data is stored in the cloud database. The analysis of the data is done in the computing cloud to aggregate the data and make prediction.

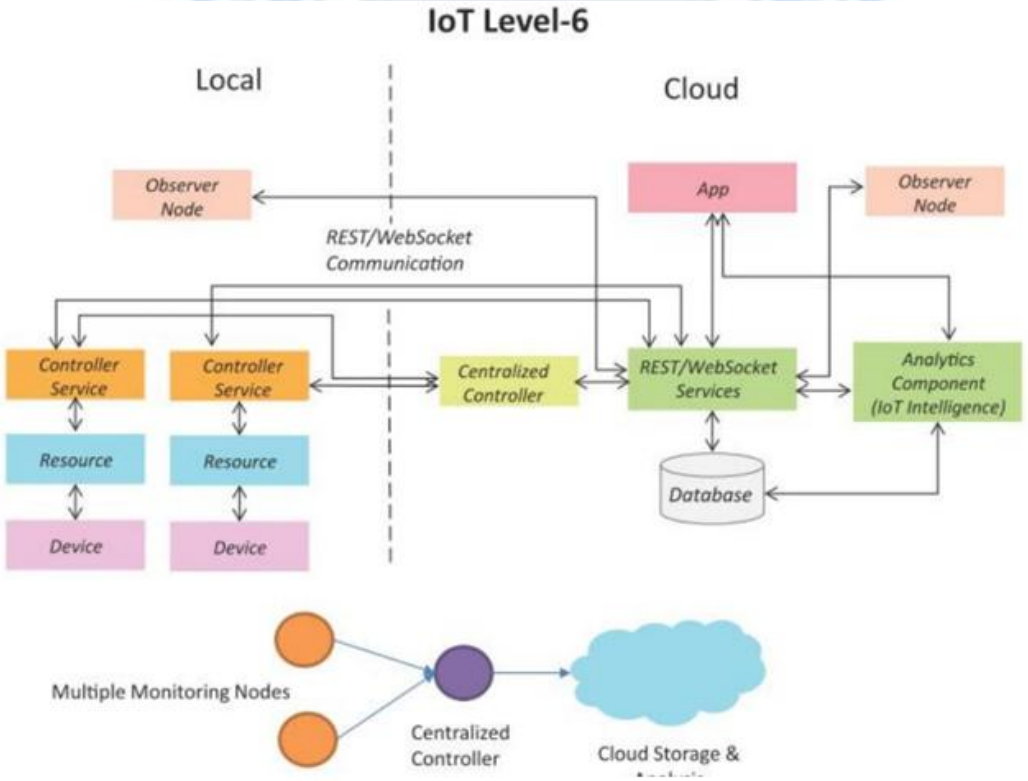
- A level-5 IoT system has multiple end nodes and one coordinator node.
- The end nodes that perform sensing and/or actuation.
- Coordinator node collects data from the end nodes and sends to the cloud.
- Data is stored and analyzed in the cloud and application is cloud-based.
- Level-5 IoT systems are 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:

IoT Level 6 system has multiple Independent and nodes that perform sensing and / or actuations and send data to the cloud. Data is stored in the cloud and applications is cloud based. 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.



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 notes and send control commands to the notes.

Let us consider an example of the level 6 IoT system for **weather monitoring**. The system consists of multiple nodes placed in different location for monitoring temperature, humidity and pressure in an area. The end nodes are equipped with various sensors such as temperature, pressure and humidity. The end nodes send the data to the cloud in real time using a WebSocket service. The data is stored in a cloud database. The analysis of the data is done in the cloud to aggregate the data and make predictions. A cloud-based applications is used for visualizing the data.