JAIPUR ENGINEERING COLLEGE AND RESEARCH CENTRE

Year & Sem – IV year & VIII Sem

Subject – Internet of Things & 8IT4-01

Unit – I

UNIT-I

Introduction to IoT

Vision

- *To establish outcome based excellence in teaching, learning and commitment to support IT Industry.*

Mission

- *To provide outcome based education.*
- *To provide fundamental & Intellectual knowledge with essential skills to meet current and future need of IT Industry across the globe.*
- *To inculcate the philosophy of continuous learning, ethical values & Social Responsibility.*

COURSE OUTCOMES (CO)

CO1: Understand the revolution of internet in field of cloud, wireless network, embedded system and mobile devices.

CO2: Apply IOT design concepts in various dimensions implementing software and hardware.

CO3: Analyze various M2M and IOT architectures.

CO4: Design and develop various applications in IOT.

MAPPING OF CO & PO

Subject	Code	L/T/P	CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
IOT	8IT4-01	L	Understand the revolution of internet in field of cloud, wireless network, embedded system and mobile devices.	H	H	M	M	M	M	-	–	M	M	M	H	H	H
		L	Apply IOT design concepts in various dimensions implementing software and hardware.	H	H	H	H	H	M	-	–	L	M	M	H	H	H
		L	Analyze various M2M and IoT architectures.	H	M	M	L	M	M	-	L	M	L	L	H	M	M
		L	Design and develop various applications in IOT.	H	M	H	H	H	M	M	L	H	H	H	H	H	H

SYLLABUS

RAJASTHAN TECHNICAL UNIVERSITY, KOTA

Scheme & Syllabus

IV Year- VII & VIII Semester: B. Tech. (Information Technology)

8IT4-01: Internet of Things

Credit: 3 **Max. Marks: 150(IA:30, ETE:120)**

3L+0T+0P **End Term Exam: 3 Hours**

SN	Contents	Hours
1	**Introduction:** Objective, scope and outcome of the course.	01
2	**Introduction to IoT:** Definition and characteristics of IoT, Design of IOT: Physical design of IOT, Logical Design of IOT- Functional Blocks, communication models, communication APIs, IOT enabling Technologies- Wireless Sensor Networks, Cloud computing, big data analytics, embedded systems. IOT Levels and deployment templates.	08
3	**IoT Hardware and Software:** Sensor and actuator, Humidity sensors, Ultrasonic sensor, Temperature Sensor, Arduino, Raspberry Pi, LiteOS, RIoTOS, Contiki OS, Tiny OS.	07
4	**Architecture and Reference Model:** Introduction, Reference Model and architecture, Representational State Transfer (REST) architectural style, Uniform Resource Identifiers (URIs). Challenges in IoT- Design challenges, Development challenges, Security challenges, Other challenges.	08
5	**IOT and M2M:** M2M, Difference and similarities between IOT and M2M, Software defined networks, network function virtualization, difference between SDN and NFV for IoT.	08
6	**Case study of IoT Applications:** Domain specific IOTs- Home automation, Cities, environment, Energy, Retail, Logistics, Agriculture, Industry, Health and Lifestyles.	08
	Total	40

LECTURE PLAN

Unit No./ Total Lecture Reqd.	Topics	Lect. Reqd.	Lect. No.
Unit-I (9	1. Introduction to subject and scope	1	1
	2. Definition and characteristics of IoT	1	2
	3. Physical design of IOT	1	3
	4. Logical Design of IOT	1	4
	5. Functional Blocks, communication models	1	5
	6. Communication APIs	1	6
	7. IOT enabling Technologies- Wireless Sensor Networks	1	7
	8. Cloud computing, big data analytics, embedded systems.	1	8
	9 IOT Levels and deployment templates	1	9
Unit-II (7)	1. IoT sensors	1	10
	2. IoT actuators	1	11
	3. Humidity sensor	1	12
	4. Ultrasonic sensor	1	13
	5. Temperature sensor	1	14
	6. Arduino and Raspberry Pi	1	15
	7. IoT OS	1	16
BC-1	ARM Processor	1	17

LECTURE PLAN

Unit No./ Total Lecture Reqd.	Topics	Lect. Reqd.	Lect. No.
Unit-III (9)	1. IoT architecture	1	18
	2. Reference model	1	19
	3. Representational state transfer (REST)	1	20
	4. Uniform resource identifier	1	21
	5. Challenges in IoT	1	22
	6. Design challenges	1	23
	7. Development challenges	1	24
	8. Security challenges	1	25
	9. Other challenges	1	26
Unit- IV (8)	1. Machine to Machine vs IoT	2	27
	2. Software defined networks	1	28
	3. Network function virtualization	1	29
	4. Difference between SDN and IoT	2	30
	5. Difference between NFV and IoT	2	31
Unit- V (8)	1. IoT applications	1	32
	2. Home automation	1	33
	3. Smart cities	1	34
	4. Environment and energy	1	35
	5. Retail	1	36
	6. Logistics	1	37
	7. Agriculture and Industries	1	38
	8. Health and lifestyle	1	39
BC-2	IoT Platforms	1	40

RECOMMENDED BOOKS

- **T1 :- “Vijay Madisetti and Arshdeep Bahga, “Internet of Things (A Hands-on-Approach), 1st Edition, VPT, 2014”.**
- **T2 :-** “Jan Holler , Vlasios Tsiatsis, Catherine Mulligan, Stefan Avesand, Stamatis Karnouskos, David Boyle, “From Machine-to-Machine to the Internet of Things: Introduction to a New Age of Intelligence”,1st Edition, Academic Press, 2014”.
- **T3 :-** “Getting Started with Raspberry Pi, Matt Richardson & Shawn Wallace, O’Reilly (SPD), 2014, ISBN: 9789350239759”.
- **T4:-** “Michael Margolis, “Arduino Cookbook”, 2nd edition, O’Reilly, 2012”.

SUBJECT DETAILED BLOWN UP FOR UNIT -I

TOPIC AS PER RTU SYLLABUS	BLOWN UP TOPICS (1x10 TIMES OF UNIV. SYLLABUS)	PROPOSED DATE	REVISED DATE
Introduction:Objective, Scope And Outcome Of The Course			
Unit # 1 **Introduction to IoT:** Definition and characteristics of IoT, Design of IOT: Physical design of IOT, Logical Design of IOT- Functional Blocks, communication models, communication APIs, IOT enabling Technologies- Wireless Sensor Networks, Cloud computing, big data analytics, embedded systems. IOT Levels and deployment templates.	1.1.Introduction-Definition and characterstics of IOT 1.2.Design of IOT: 1.2.1. Physical design of IOT 1.2.2. Logical design of IOT 1.2.2.1.Functional Blocks 1.2.2.2.Communication Models 1.2.2.3.Communication APIs 1.3.IOT enabling technologies 1.3.1.Wireless Sensor Networks 1.3.2.Cloud Computing 1.3.3.Big Data Analytics 1.3.4.Embedded Systems 1.4.IOT Levels 1.5.Deployment Templates		

BEFORE UNIT I WE FIRST DISCUSSED

- IoT and its definition
- History
- How IOT works
- Lifecycle
- Characteristics of IoT
- What internet of things do?
- How many IOT devices are today?
- Applications
- Real life applications
- Future with IOT

SO LETS START WITH HISTORY

HISTORY

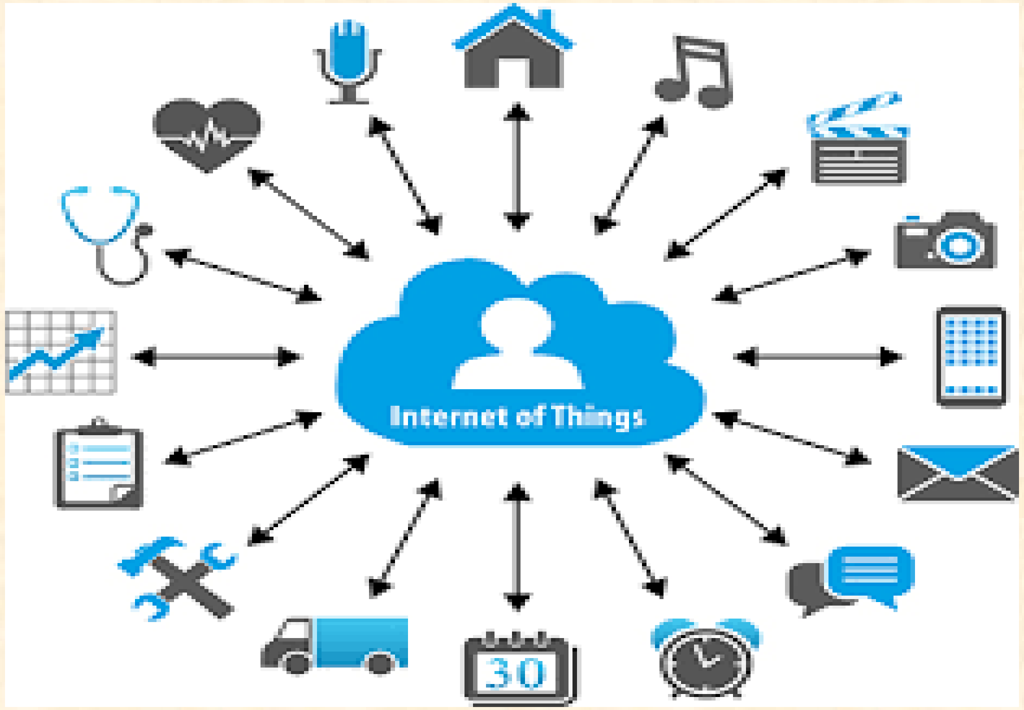

KEVIN ASHTON – "FATHER OF THE IOT"
He believed IoT could "turn the world into data" that could be used to make macro decisions on resource utilization.
"Information is a great way to reduce waste and increase efficiency, and that's really what the Internet of Things provides"

WHAT IS IOT??

- Internet Of Things is Fully Networked and Connected Devices sending analytics data back to cloud or data center.
- The definition of Internet of things is that it is the network in which every object or **thing is provided unique identifier** and data is transferred through a network without any verbal communication.
- Scope of IoT is not just limited to just connecting things to the internet, but it allows these things to communicate and exchange data, process them as well as control them while executing applications.

Internet of Things

IOT



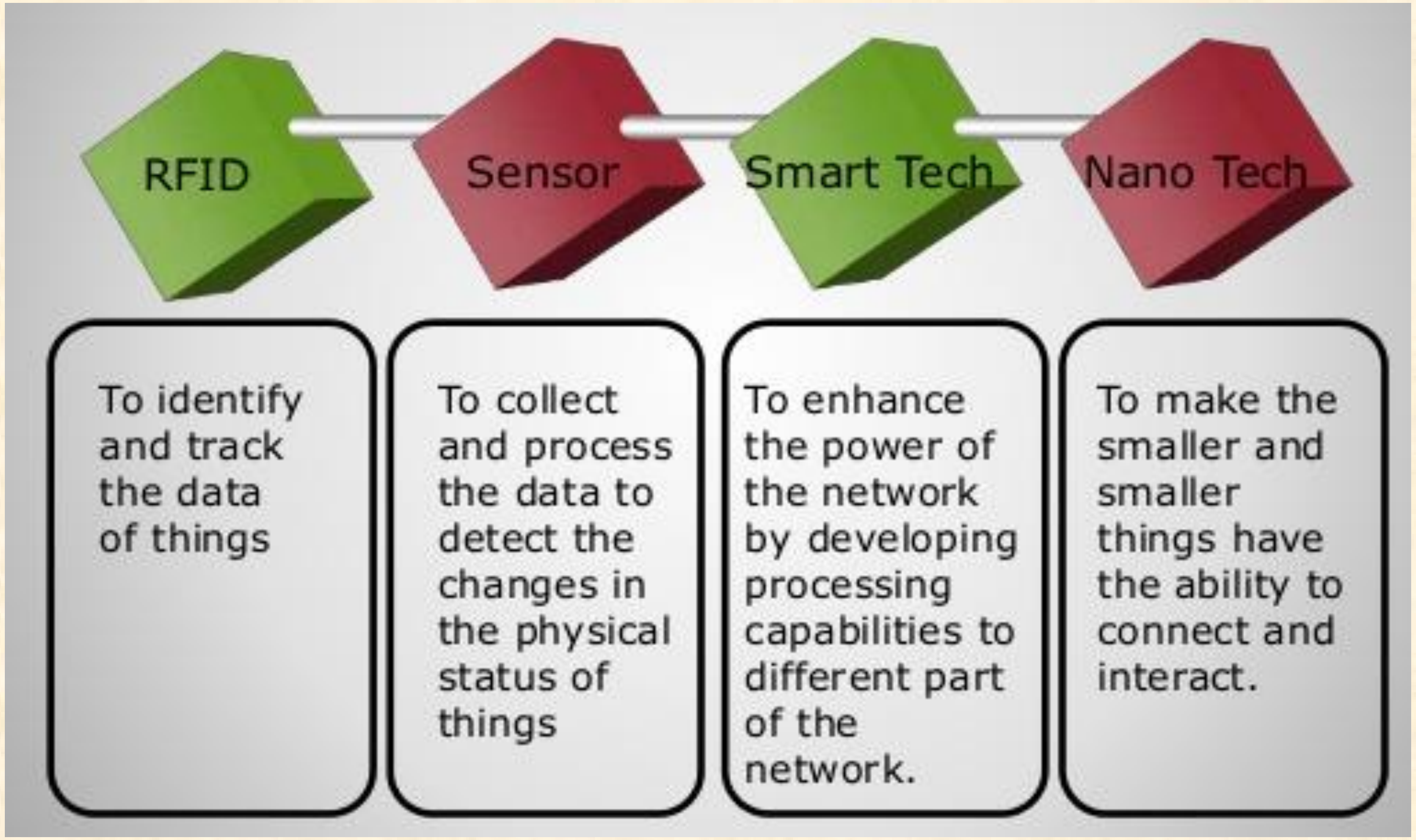
FORMAL DEFINITION OF IOT

- 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.

HOW IOT WORKS??

- Internet of Things (IoT), also sometimes referred to as the Internet of Everything (IoE), consists of all the web-enabled devices that collect, send and act on data they acquire from their surrounding environments using embedded sensors, processors and communication hardware.
- These devices, often called "connected" or "smart" devices, can sometimes talk to other related devices, a process called **machine-to-machine (M2M)** communication, and act on the information they get from one another.
- Humans can interact with the gadgets to set them up, give them instructions or access the data, but the devices do most of the work on their own without human intervention.

HOW IOT WORKS??



IOT LIFECYCLE

Internet of Things

COLLECTION

Devices and Sensors are collecting data everywhere.

- At your home
- In your car
- At the office
- In the manufacturing plant

COMMUNICATION

Sending data and events through networks to some destination

- A cloud platform
- Private data center
- Home network

ANALYSIS

Creating information from the data

- Visualizing the data
- Building reports
- Filtering data (paring it down)

ACTION

Taking action based on the information and data

- Communicate with another machine (m2m)
- Send a notification (sms, email, text)
- Talk to another system

CHARACTERISTICS OF IOT

- **Dynamic Global network & Self-Adapting** : Adapt the changes w.r.t changing contexts
- **Self Configuring** : Eg. Fetching latest s/w updates without manual intervention.
- **Interoperable Communication Protocols** : Communicate through various protocols
- **Unique Identity** : Such as Unique IP Address or a URI
- **Integrated into Information Network** : This allows to communicate and exchange data with other devices to perform certain analysis.

WHAT INTERNET OF THINGS DO?

Internet of Things

HOW MANY IOT DEVICES ARE THERE TODAY?

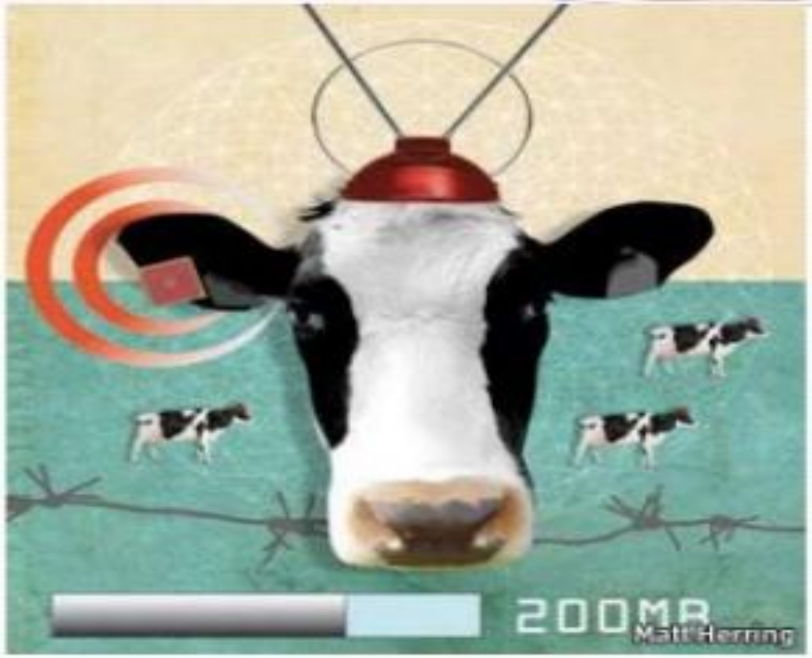
- In the year 2017 there were 8.4 billion IoT connected devices in the whole worldwide.
- While in the year 2018 it increased to 9.2 Billion.
- It is expected that in the year 2020 the IoT connected devices in the worldwide would be 20.8 Billion.

APPLICATIONS OF IOT

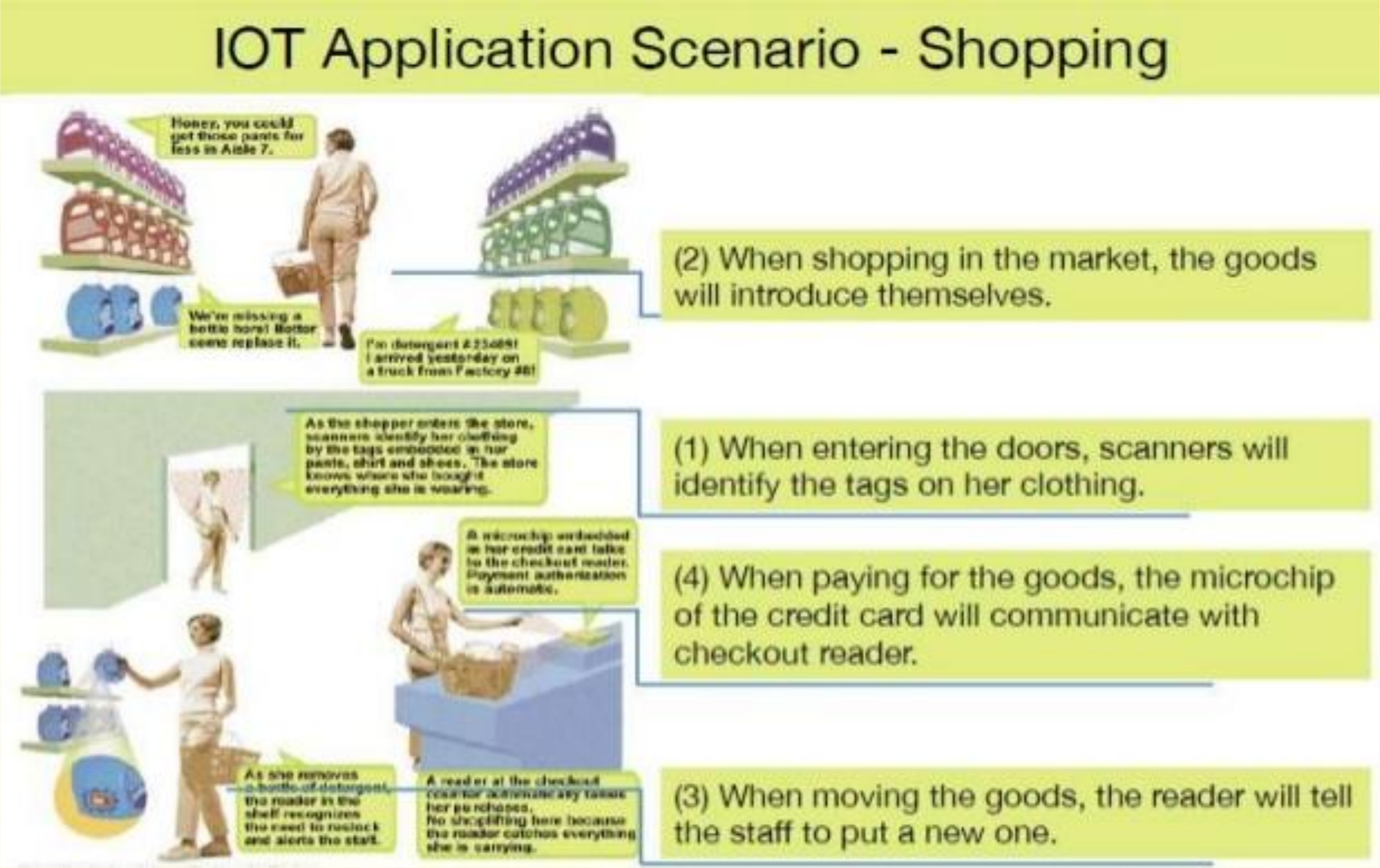

Smart Parking
Create USD 41Billion by providing visibility into the availability of parking spaces across the city.
TIRE RACK
42
Residents can identify and reserve the closest available space, traffic wardens can identify non-compliant usage, and municipalities can introduce demand-based pricing.

Internet of Things

SENSORS IN EVEN THE HOLY COW!!



In the world of IoT, even the cows will be connected and monitored. Sensors are implanted in the ears of cattle. This allows farmers to monitor cows' health and track their movements, ensuring a healthier, more plentiful supply of milk. On average, each cow generates about 200 MB of information per year.

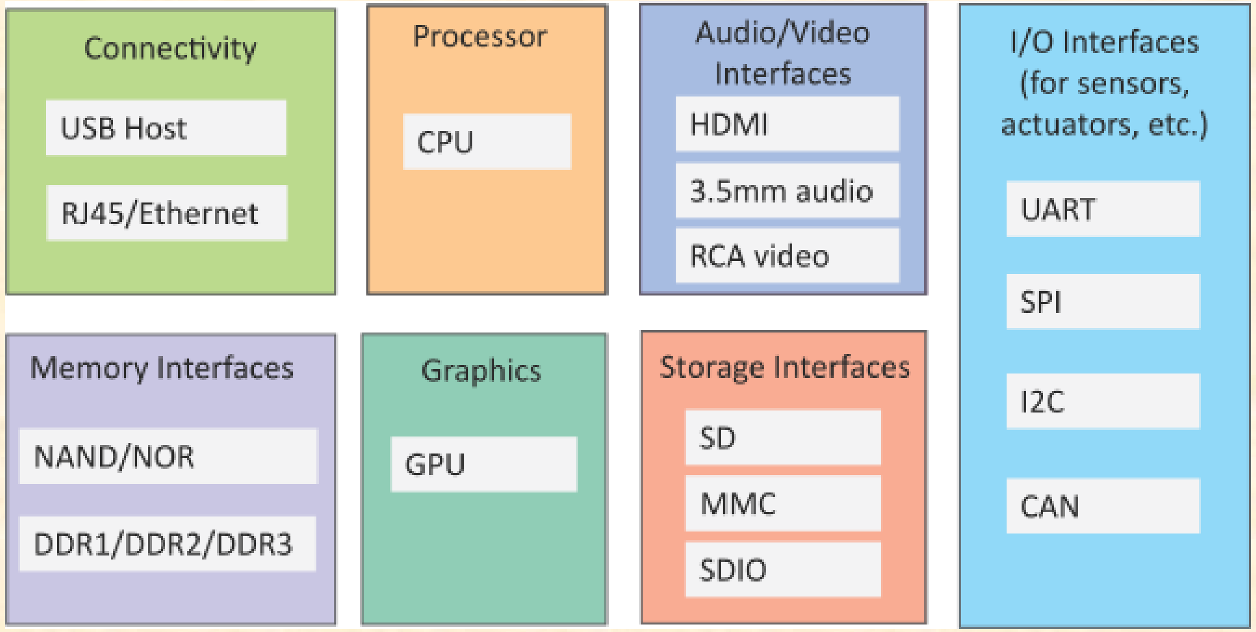

IOT Application Scenario - Shopping
Honey, you could get those pants for less in Aisle 7.
We're missing a bottle here! Better come replace it.
I'm detergent #23488! I arrived yesterday on a truck from Factory #8!
(2) When shopping in the market, the goods will introduce themselves.
As the shopper enters the store, scanners identify her clothing by the tags embedded in her pants, shirt and shoes. The store knows where she bought everything she is wearing.
(1) When entering the doors, scanners will identify the tags on her clothing.
A microchip embedded in her credit card talks to the checkout reader. Payment authorization is automatic.
(4) When paying for the goods, the microchip of the credit card will communicate with checkout reader.
(3) When moving the goods, the reader will tell the staff to put a new one.

THINGS IN IOT

- Refers to IoT devices which have unique identities that can perform sensing, actuating and monitoring capabilities.
- IoT devices can exchange data with other connected devices or collect data from other devices and process the data either locally or send the data to centralized servers or cloud – based application back-ends for processing the data.

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



FUTURE WITH IOT

- Internet of Things Wearable devices is the future. You can control your car with a smart watch like automatically parking it and for closing or to open the doors.
- Your wearable device may also detect the dangers around you. We already have devices that track our activity and exercise habits.
- In the near future, we may also be able to easily track our calorie intake and eating habits automatically. So everything is going to be easy except that making everything easy is tough.
- Here are some examples of IoT wearable devices that are already available in the market.

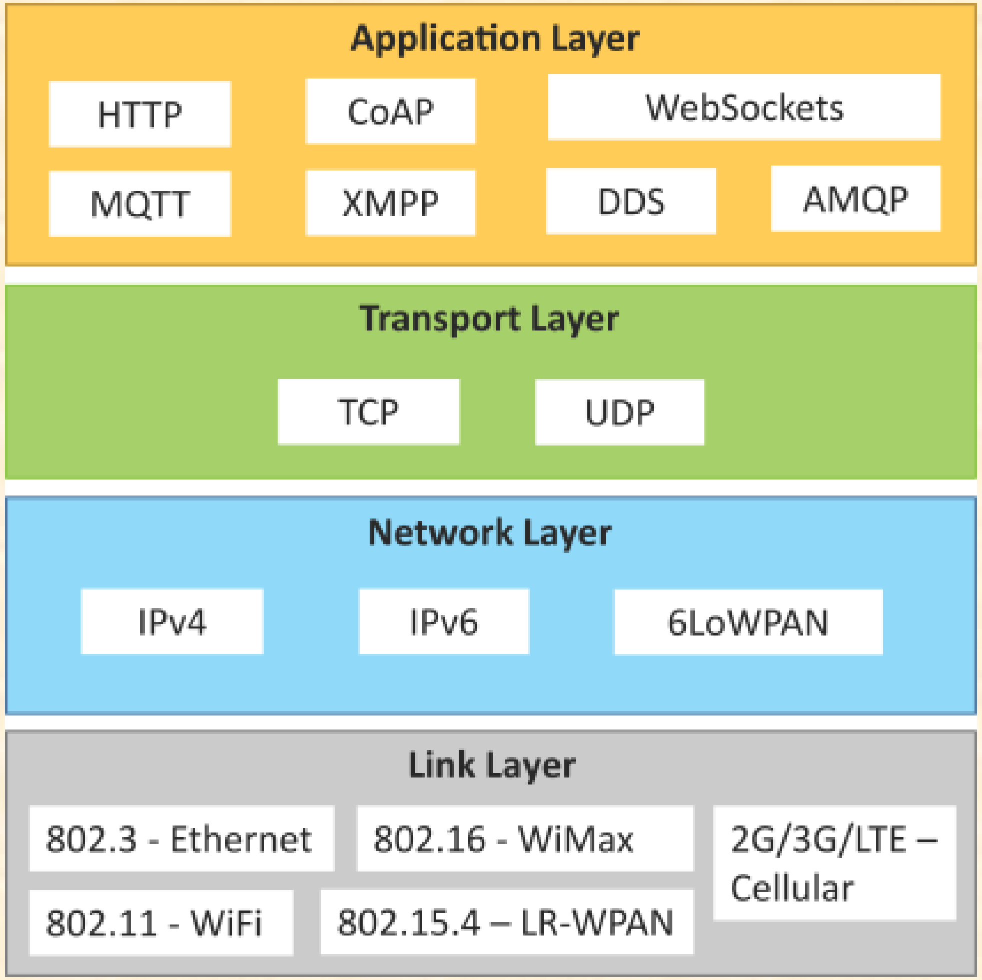
1. Sync Smart band Activity Tracker
2. Fitbit Surge Smart Watch
3. Hicon Wearable Smart Bracelet
4. Beddit Sleep tracker

PHYSICAL DESIGN OF IOT

- IOT Protocols
- Things in IOT

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…LINK LAYER…ETHERNET

Sr.No	Standard	Shared medium
1	802.3	Coaxial Cable…10BASE5
2	802.3.i	Copper Twisted pair …..10BASE-T
3	802.3.j	Fiber Optic……10BASE-F
4	802.3.ae	Fiber…..10Gbits/s

Data Rates are provided from 10Gbit/s to 40Gb/s and higher

IOT PROTOCOLS…LINK LAYER…WIFI

Sr.No	Standard	Operates in
1	802.11a	5 GHz band
2	802.11b and 802.11g	2.4GHz band
3	802.11.n	2.4/5 GHz bands
4	802.11.ac	5GHz band
5	802.11.ad	60Hz band

- Collection of Wireless LAN
- Data Rates from 1Mb/s to 6.75 Gb/s

IOT PROTOCOLS…LINK LAYER…WIMAX

Sr.No	Standard	Data Rate
1	802.16m	100Mb/s for mobile stations 1Gb/s for fixed stations

- Collection of Wireless Broadband standards
- Data Rates from 1.5Mb/s to 1 Gb/s

IOT PROTOCOLS…LINK LAYER…LR-WPAN

- Collection of standards for low-rate wireless personal area networks
- Basis for high level communication protocols such as Zigbee
- Data Rates from 40Kb/s to 250Kb/s
- Provide low-cost and low-speed communication for power constrained devices

IOT PROTOCOLS…LINK LAYER…2G/3G/4G – MOBILE COMMUNICATION

Sr.No	Standard	Operates in
1	2G	GSM-CDMA
2	3G	UMTS and CDMA 2000
3	4G	LTE

- Data Rates from 9.6Kb/s (for 2G) to up to 100Mb/s (for 4G)

IOT PROTOCOLS…NETWORK/INTERNET LAYER

- Responsible for sending of IP datagrams from source to destination network
- Performs the host addressing and packet routing
- Host identification is done using hierarchical IP addressing schemes such as IPV4 or IPV6

IOT PROTOCOLS…NETWORK LAYER

- IPV4
  - Used to identify the devices on a network using hierarchical addressing scheme
  - Uses 32-bit address scheme
- IPV6
  - Uses 128-bit address scheme
- 6LoWPAN (IPV6 over Low power Wireless Personal Area Network)
  - Used for devices with limited processing capacity
  - Operates in 2.4 Ghz
  - Data Rates of 250Kb/s

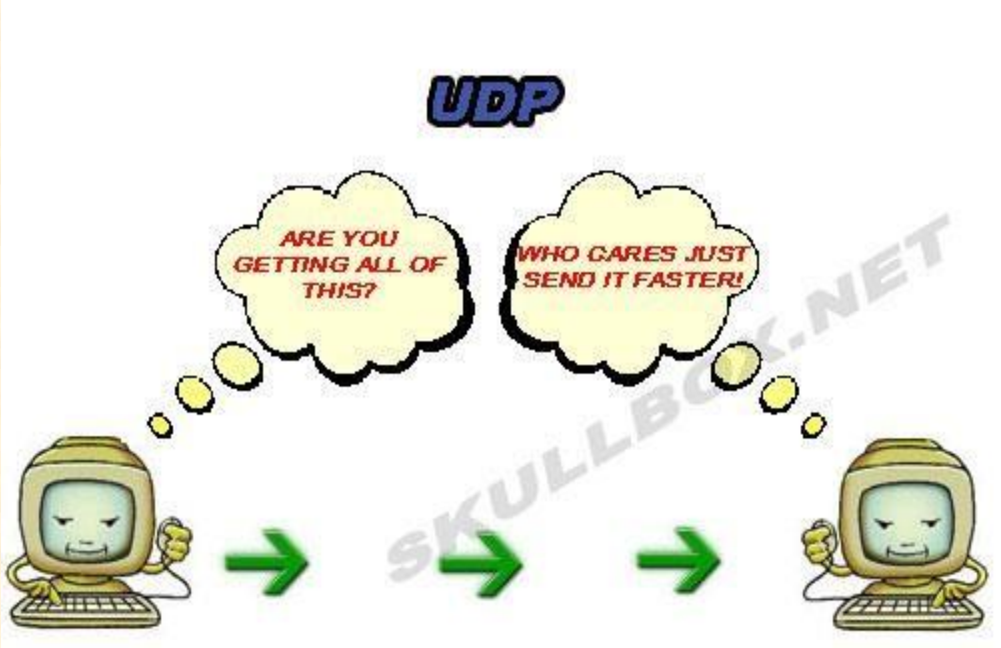
IOT PROTOCOLS…TRANSPORT LAYER

- Provide end-to-end message transfer capability independent of the underlying network
- It provides functions such as error control, segmentation, flow-control and congestion control

IOT PROTOCOLS…TCP

- Transmission Control Protocol
- Connection Oriented
- Ensures Reliable transmission
- Provides Error Detection Capability to ensure no duplicacy of packets and retransmit lost packets
- Flow Control capability to ensure the sending data rate is not too high for the receiver process
- Congestion control capability helps in avoiding congestion which leads to degradation of n/w performance

IOT PROTOCOLS…UDP



- User Datagram Protocol
- Connectionless
- Does not ensures Reliable transmission
- Does not do connection before transmitting
- Does not provide proper ordering of messages
- Transaction oriented and stateless

IOT PROTOCOLS…APPLICATION LAYER…HYPER TEXT TRANSFER PROTOCOL

- Forms foundation of World Wide Web(WWW)
- Includes commands such as GET,PUT, POST, HEAD, OPTIONS, TRACE..etc
- Follows a request-response model
- Uses Universal Resource Identifiers(URIs) to identify HTTP resources

IOT PROTOCOLS…APPLICATION LAYER…COAP

- Constrained Application Protocol
- Used for Machine to machine (M2M) applications meant for constrained devices and n/w's
- Web transfer protocol for IoT and uses request-response model
- Uses client –server architecture
- Supports methods such as GET, POST, PUT and DELETE

IOT PROTOCOLS…APPLICATION LAYER…WEBSOCKET

- Allows full-duplex communication over single socket
- Based on TCP
- Client can be a browser, IoT device or mobile application

IoT Protocols…Application Layer…MQTT

- Message Queue Telemetry Transport , light-weight messaging protocol
- Based on publish-subscribe model
- Well suited for constrained environments where devices have limited processing, low memory and n/w bandwith requirement

IOT PROTOCOLS…APPLICATION LAYER…XMPP

- Extensible messaging and presence protocol
- For Real time communication and streaming XML data between n/w entities
- Used for Applications such as Multi-party chat and voice/video calls.
- Decentralized protocol and uses client server architecture.

IOT PROTOCOLS…APPLICATION LAYER…DDS

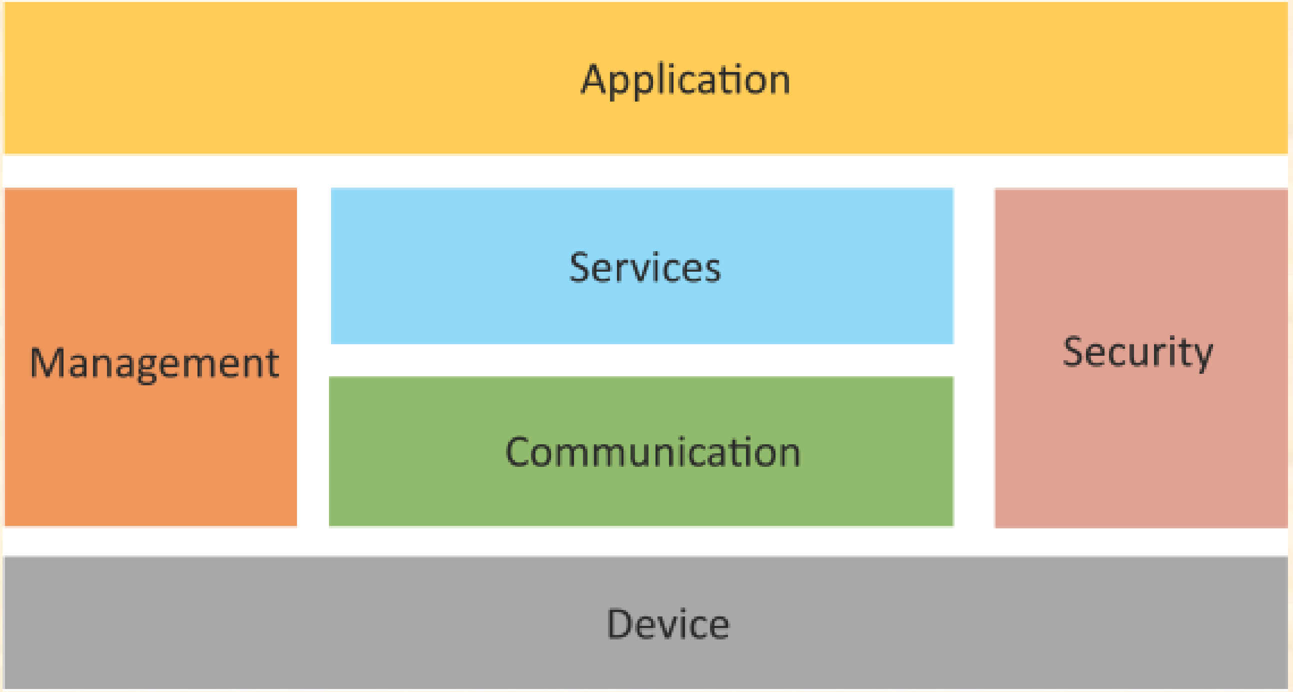
- Data Distribution service is a data-centric middleware standard for device-to-device or machine-to-machine communication.
- Publish subscribe model where publishers create topics to which subscribers can use.
- Provides Quality-of-service control and configurable reliability.

IOT PROTOCOLS…APPLICATION LAYER…AMQP

- Advanced Messaging Queuing Protocol used for business messaging.
- Supports both point-to-point and publisher/subscriber models, routing and queuing
- Broker here receives messages from publishers and route them over connections to consumers through messaging queues.

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

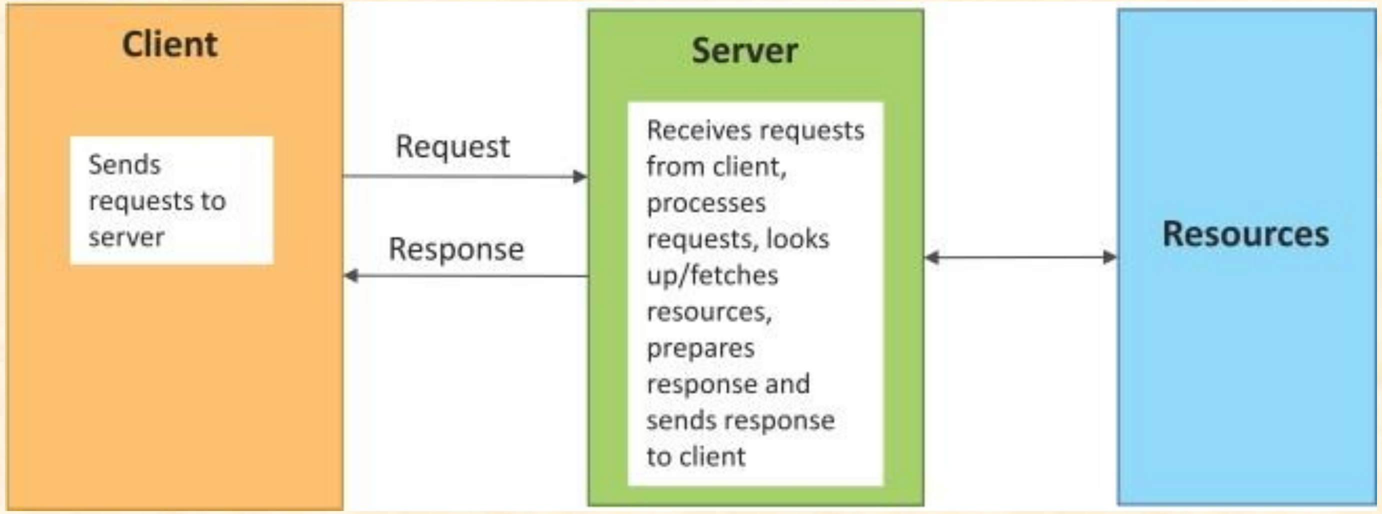


LOGICAL DESIGN OF IOT

- Device : Devices such as sensing, actuation, monitoring and control functions.
- Communication : IoT Protocols
- Services like device monitoring, device control services, data publishing services and device discovery
- Management : Functions to govern the system
- Security : Functions as authentication, authorization, message and content integrity, and data security
- Applications

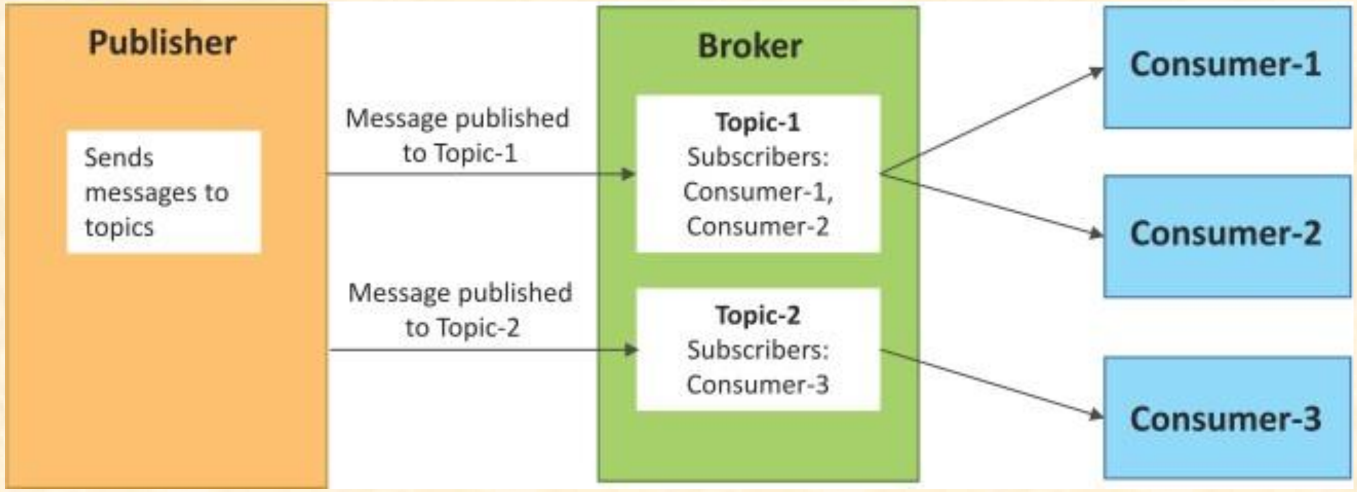
REQUEST–RESPONSE COMMUNICATION MODEL

- 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.
- Stateless communication model



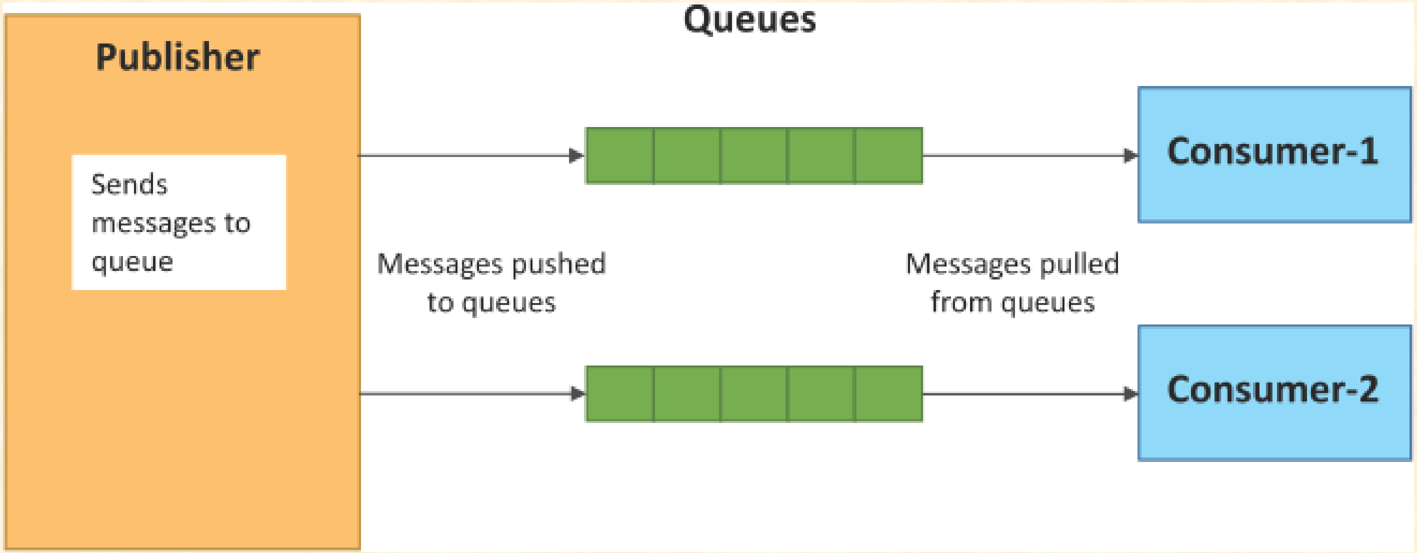
PUBLISH–SUBSCRIBE COMMUNICATION MODEL

- 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.



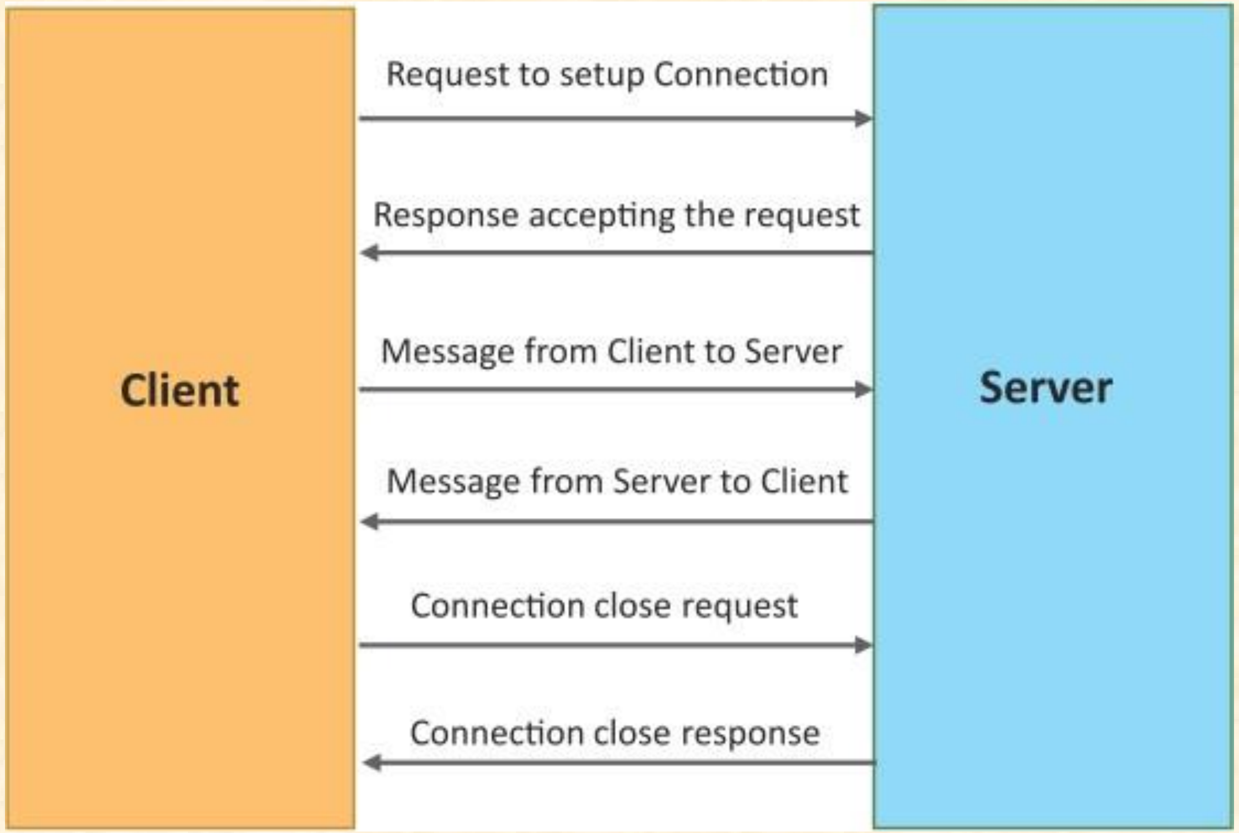
PUSH–PULL COMMUNICATION MODEL

- 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 at which the consumers pull data.



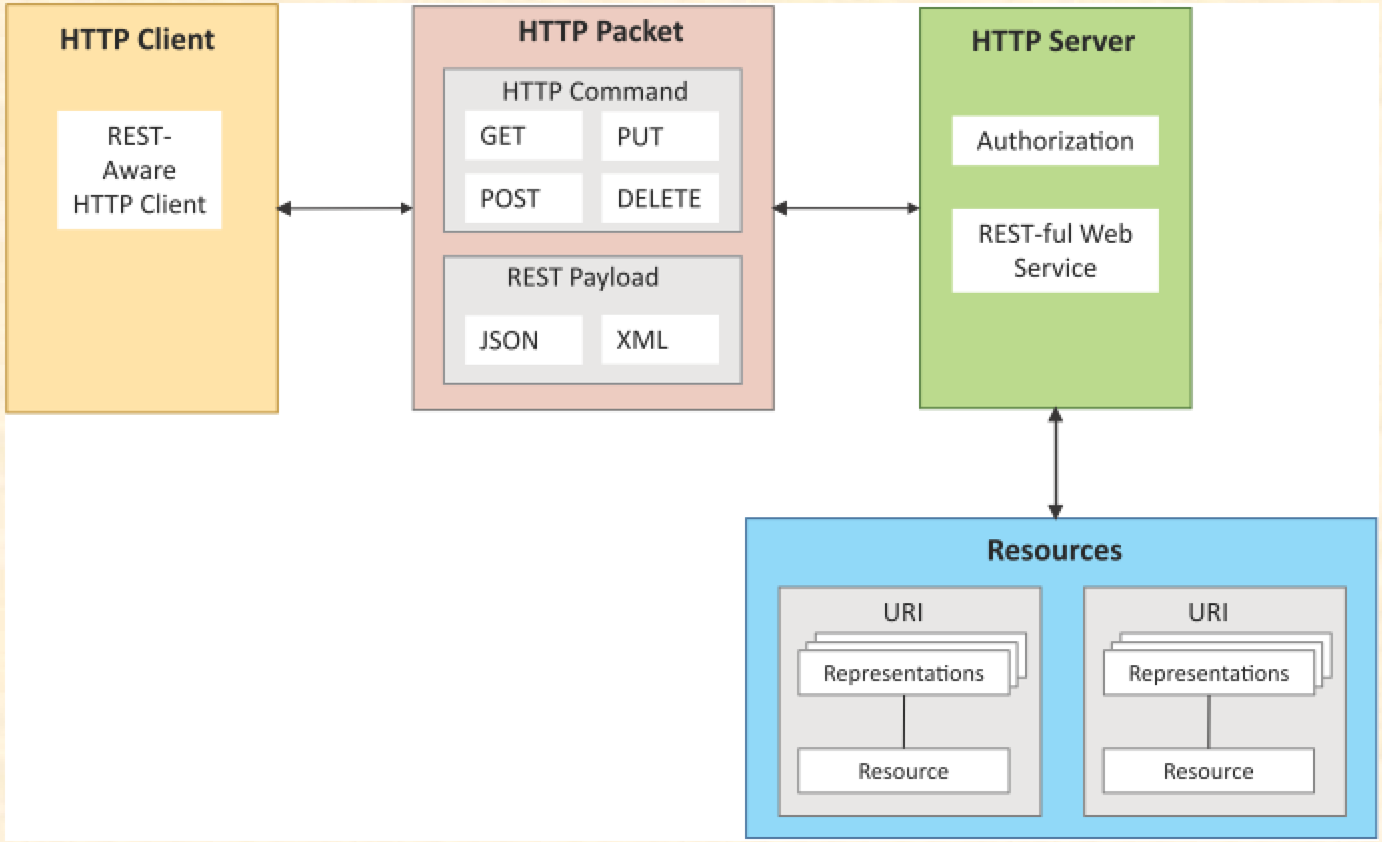
EXCLUSIVE PAIR COMMUNICATION MODEL

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



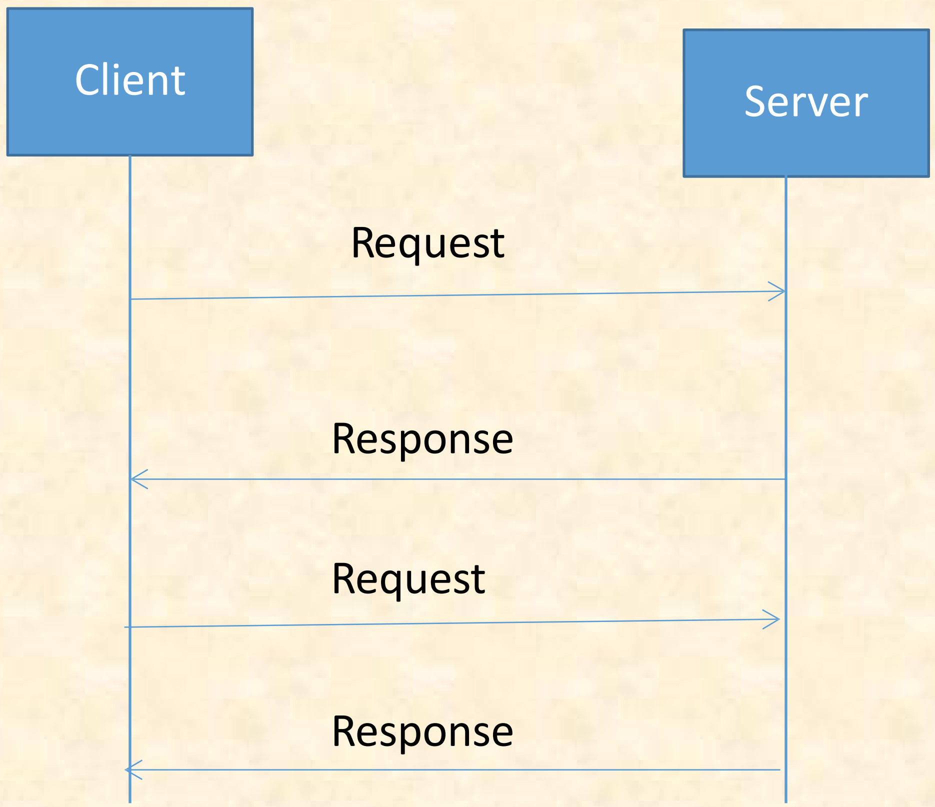
REST-BASED COMMUNICATION APIS

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



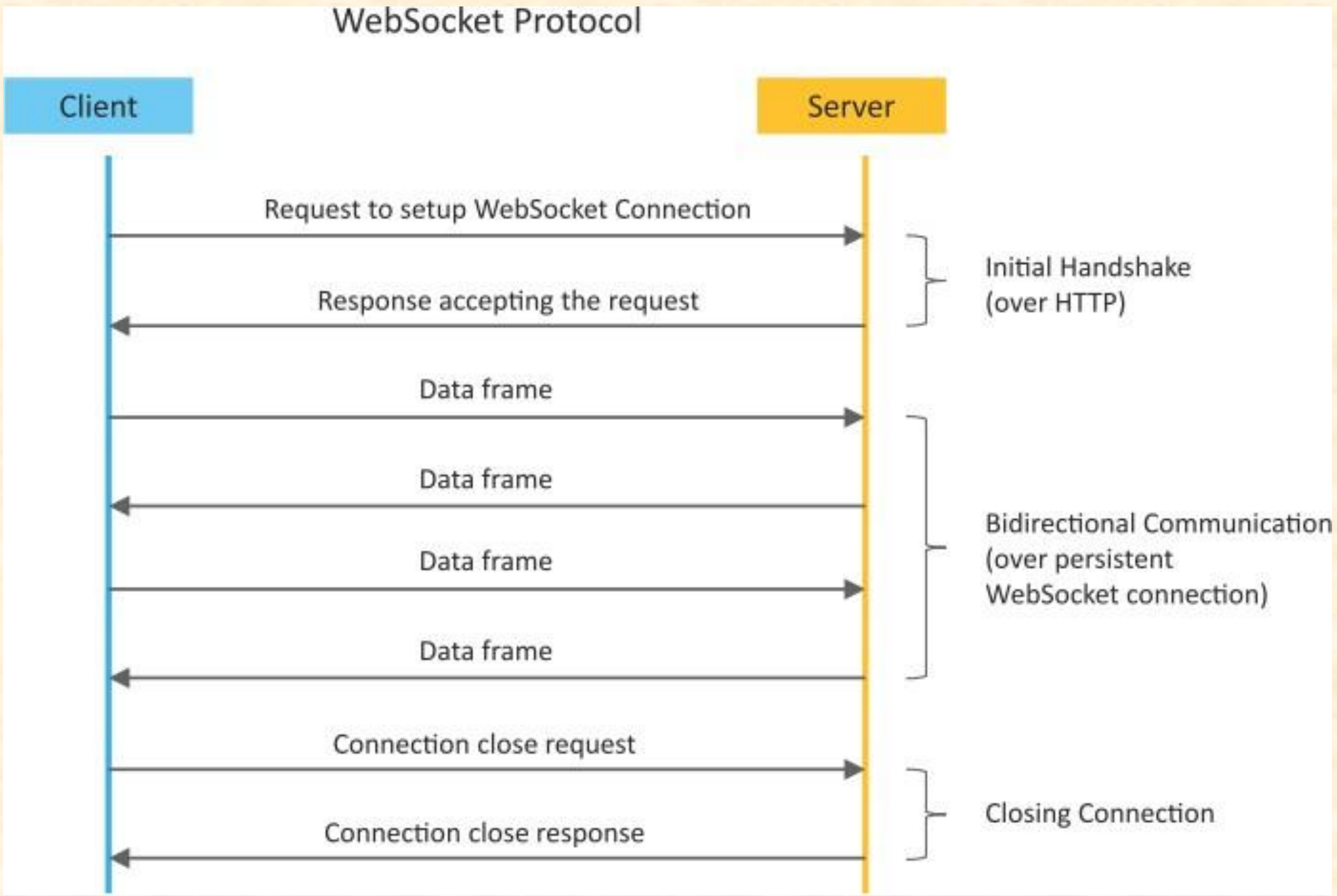
REST-BASED COMMUNICATION APIS CONSTRAINTS

- **Client – Server**
- **Stateless**
- **Cacheable**
- **Layered System**
- **Uniform Interface**
- **Code on demand**



WEBSOCKET-BASED COMMUNICATION APIS

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



DIFFERENCE BETWEEN REST AND WEBSOCKET-BASED COMMUNICATION APIS

Comparison Based on	REST	Websocket
State	Stateless	Stateful
Directional	Unidirectional	Bidirectional
Req-Res/Full Duplex	Follow Request Response Model	Exclusive Pair Model
TCP Connections	Each HTTP request involves setting up a new TCP Connection	Involves a single TCP Connection for all requests
Header Overhead	Each request carries HTTP Headers, hence not suitable for real-time	Does not involve overhead of headers.
Scalability	Both horizontal and vertical are easier	Only Vertical is easier

IOT ENABLING TECHNOLOGIES

- Wireless Sensor Network

- Cloud Computing

- Big Data Analytics

- Embedded Systems

WSN

- **Distributed Devices with sensors** used to monitor the environmental and physical conditions
- Consists of several **end-nodes acting as routers or coordinators too**
- **Coordinators collects data** from all nodes / **acts as gateway** that connects WSN to internet
- **Routers route the data packets** from end nodes to coordinators.

EXAMPLE OF WSNS IN IOT & PROTOCOLS USED

Example

- Weather monitoring system
- Indoor Air quality monitoring system
- Soil moisture monitoring system
- Survelliance systems
- Health monitoring systems

Protocols

- Zigbee

CLOUD COMPUTING

- **Deliver applications and services over internet**
- Provides computing, networking and storage resources on demand
- Cloud computing performs services such as Iaas, Paas and Saas
- Iaas : Rent Infrastructure
- Paas : supply an on-demand environment for developing, testing, delivering and managing software applications.
- Saas : method for delivering software applications over the Internet, on demand and typically on a subscription basis.

BIG DATA ANALYTICS

- Collection of data whose volume, velocity or variety is too large and difficult to store, manage, process and analyze the data using traditional databases.
- It involves data cleansing, processing and visualization
- Lots of data is being collected and warehoused
  - Web data, e-commerce
  - purchases at department/ grocery stores
  - Bank/Credit Card transactions
  - Social Network

BIG DATA ANALYTICS

Variety Includes different types of data

- Structured
- Unstructured
- SemiStructured
- All of above

BIG DATA ANALYTICS

Velocity Refers to speed at which data is processed

- Batch
- Real-time
- STreams

BIG DATA ANALYTICS

Volume refers to the amount of data

- Terabyte
- Records
- Transactions
- Files
- Tables

IOT LEVELS AND DEPLOYMENT TEMPLATES

An IoT system comprises the following components:

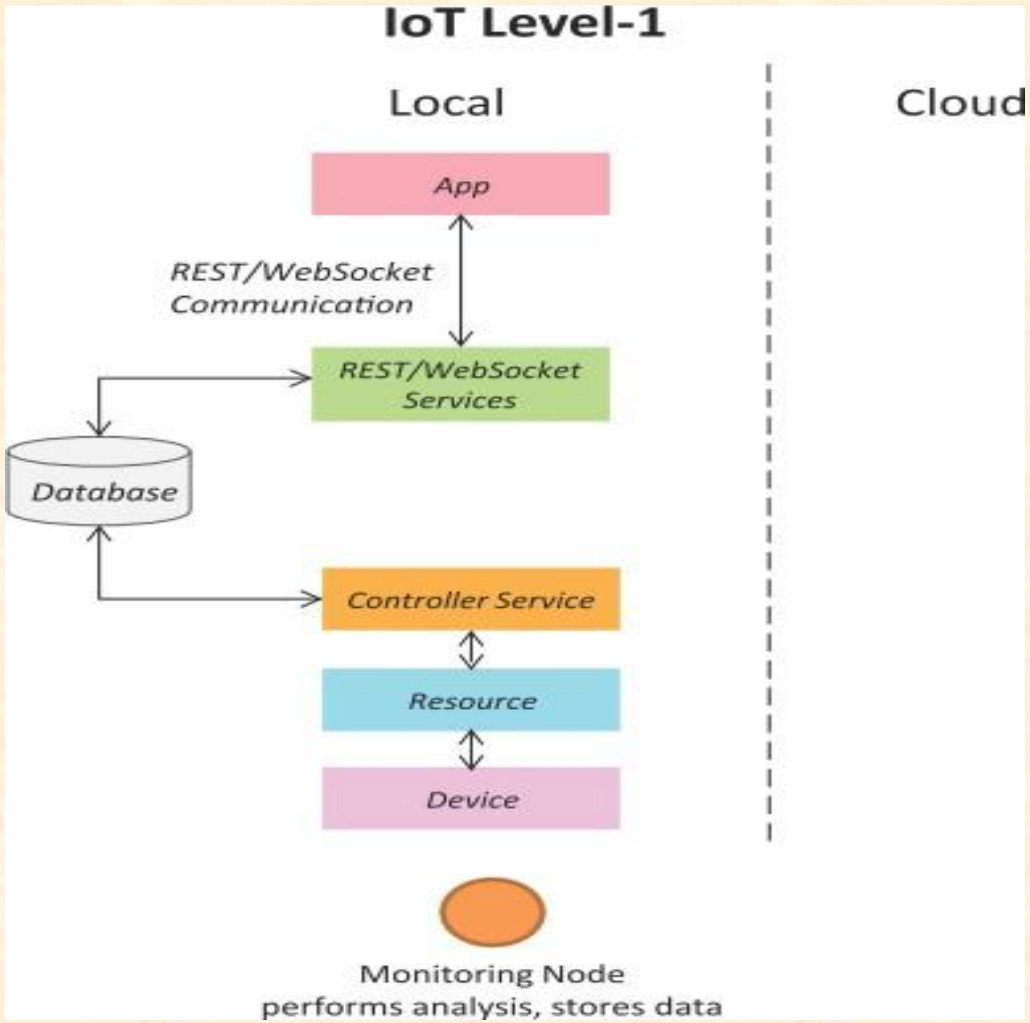
- **Device**: An IoT device allows identification, remote sensing, actuating and remote monitoring capabilities.
- **Resource**: Resources are software components on the IoT device for accessing, processing and storing sensor information, or for controlling actuators connected to the device. Resources 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 AND DEPLOYMENT TEMPLATES

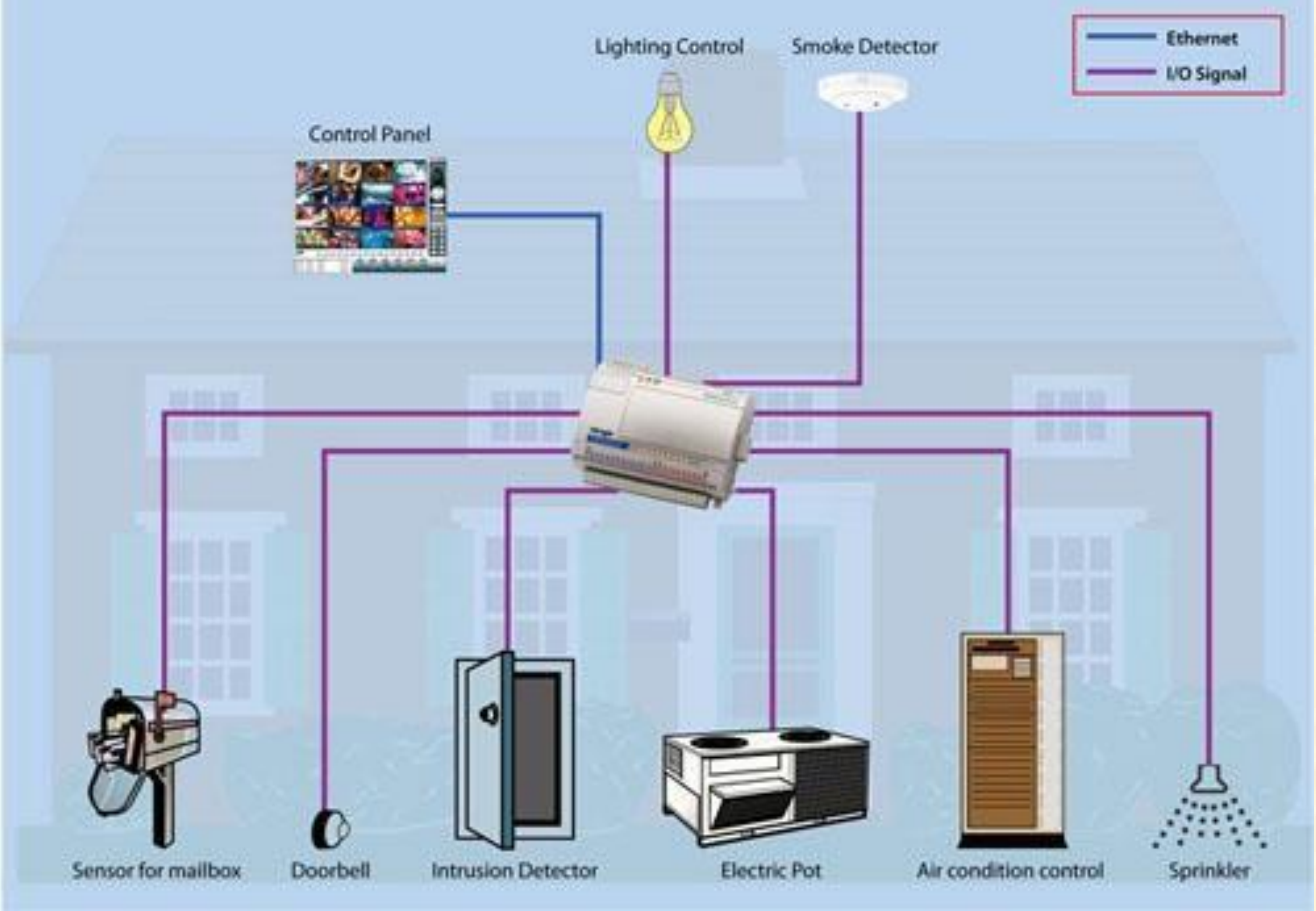
- **Database**: Database can be either local or in the cloud and stores the data generated by the IoT device.
- **Web Service**: Web services serve as a link between the IoT device, application, database and analysis components. Web service can be implemented using HTTP and REST principles (REST service) or using the WebSocket protocol (WebSocket service).
- **Analysis Component**: This is responsible for analyzing the IoT data and generating results in a form that is 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 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 **modelling low-cost and low-complexity solutions** where the data involved is not big and the **analysis requirements are not computationally intensive.**

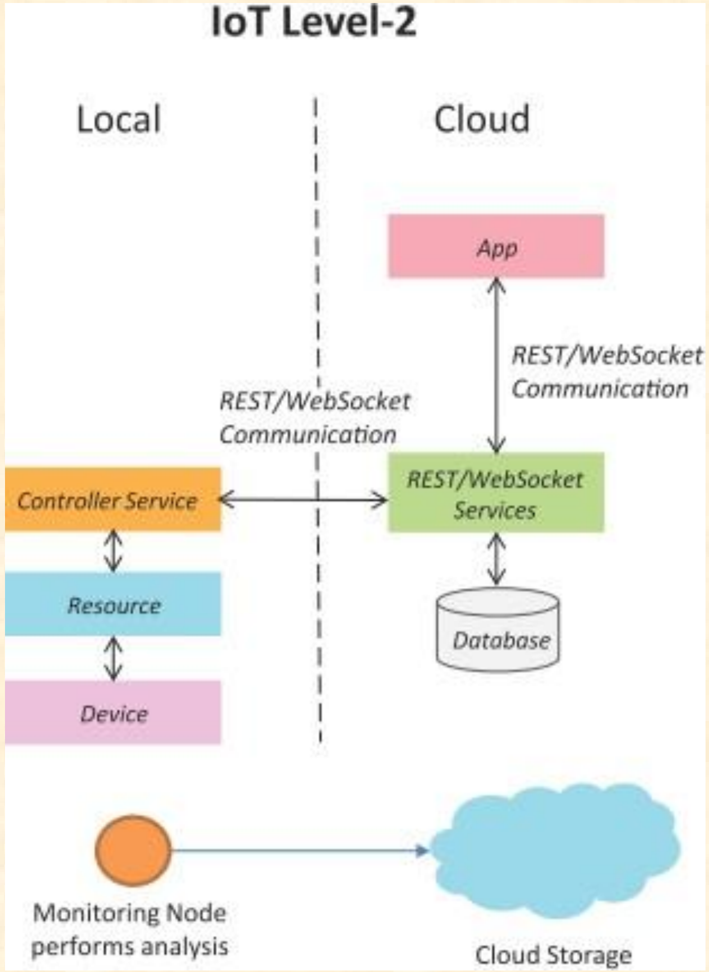


IOT – LEVEL 1 EXAMPLE …HOME AUTOMATION SYSTEM



IOT LEVEL-2

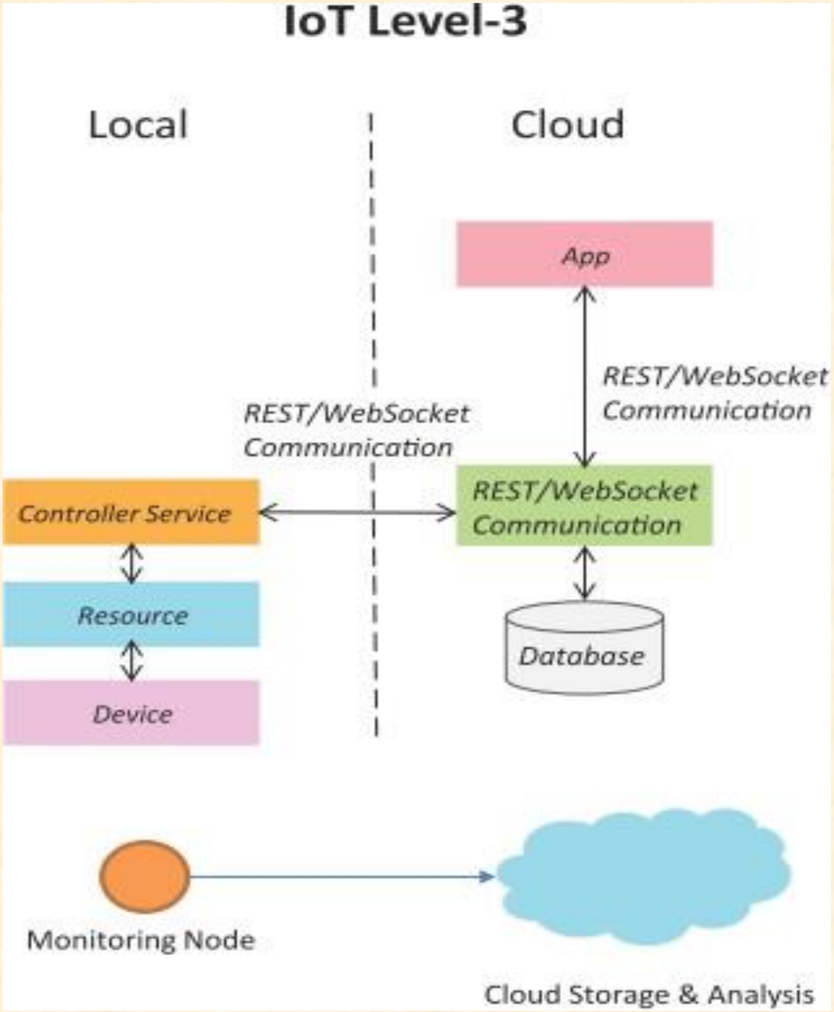
- A level-2 IoT system has a single node that performs sensing and/or actuation and local analysis.
- Data is stored in the cloud and the application is usually cloud-based.
- Level-2 IoT systems are suitable for solutions where the data involved is big; however, the primary analysis requirement is not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



IOT – LEVEL 2 EXAMPLE …SMART IRRIGATION

IOT LEVEL-3

- A level-3 IoT system has a single node. Data is stored and analyzed in the cloud and the 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.**



Sensors used accelrometer and gyroscope

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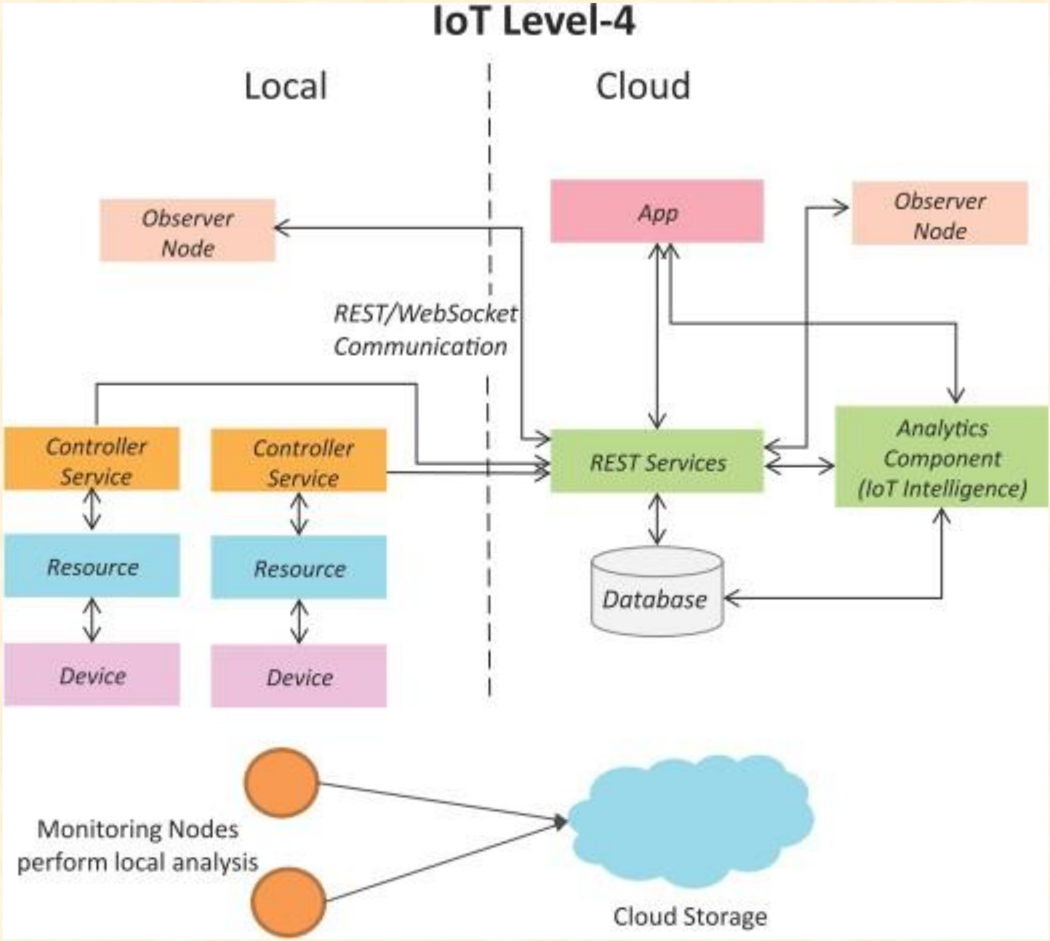
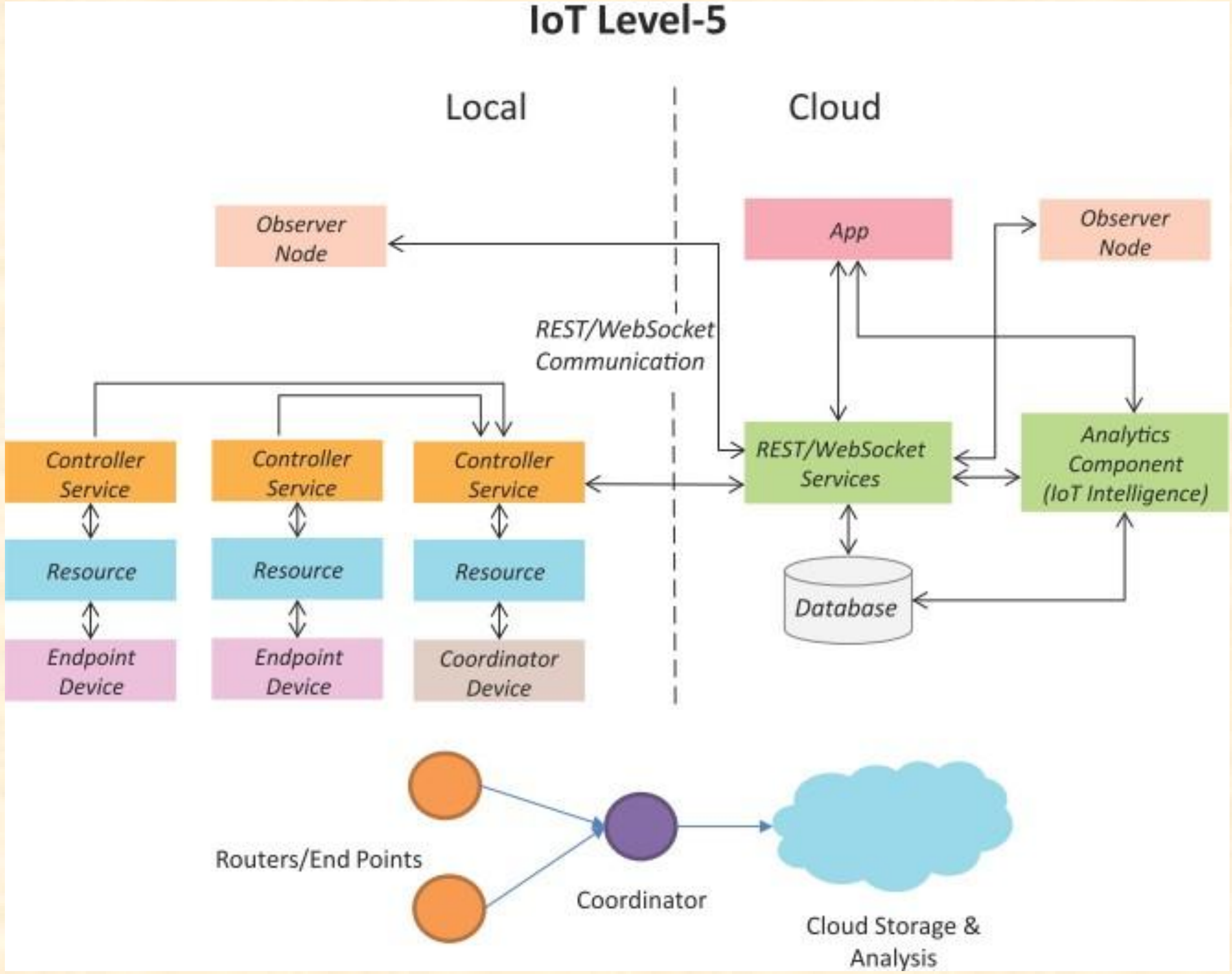
IOT LEVEL-4

- A level-4 IoT system has multiple nodes that perform local analysis. Data is stored in the cloud and the 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.



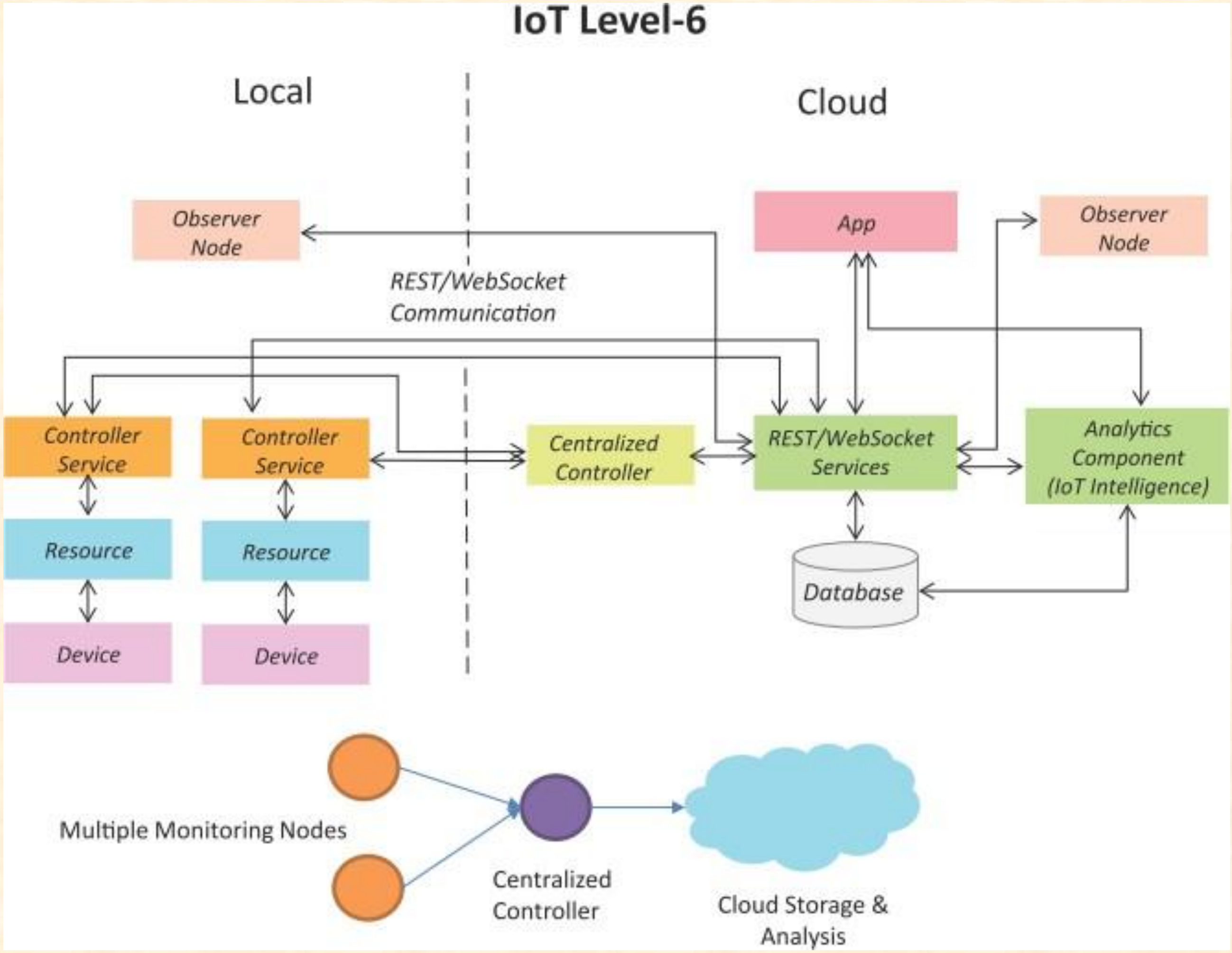
IOT LEVEL-5

- A level-5 IoT system has multiple end nodes and one coordinator node.
- The end nodes perform sensing and/or actuation.
- The coordinator node collects data from the end nodes and sends it to the cloud.
- Data is stored and analyzed in the cloud and the 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 the 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.



THANKS....