SNS COLLEGE OF TECHNOLOGY

(An Autonomous Institution)

Re-accredited by NAAC with A++ grade, Accredited by NBA(CSE, IT, ECE, EEE & Mechanical)
Approvedy by AICTE, New Delhi, Recognized by UGC, Affiliated to Anna University, Chennai

Internet of Things

Department of Computer Applications

COURSE : 19CAE725 : Internet of Things
UNIT II : Specification & Integration with Application Development
CLASS : II Semester / I MCA

IOT Platforms Design Methodology

Introduction

- **Designing IoT systems can be a complex and challenging task as these systems involve interactions between various components such as IoT devices and network resources, web services, analytics components, application and database servers.**
- **IoT system designers often tend to design IoT systems keeping specific products/services in mind.**
- **So that designs are tied to specific product/service choices made. But it make updating the system design to add new features or replacing a particular product/service choice for a component becomes very complex, and in many cases may require complete re-design of the system.**

Introduction

- **Here we discuss a generic design methodology for IoT system design which is independent of specific product, service or programming language.**
- **IoT systems designed with the proposed methodology have reduced design, testing and maintenance time, better interoperability and reduced complexity.'**

IOT Platforms Design Methodology

It includes:

- ➢ Purpose & Requirements Specification
- ➢ Process Specification
- ➢ Domain Model Specification
- ➢ Information Model Specification
- ➢ Service Specification

IOT Platforms Design Methodology

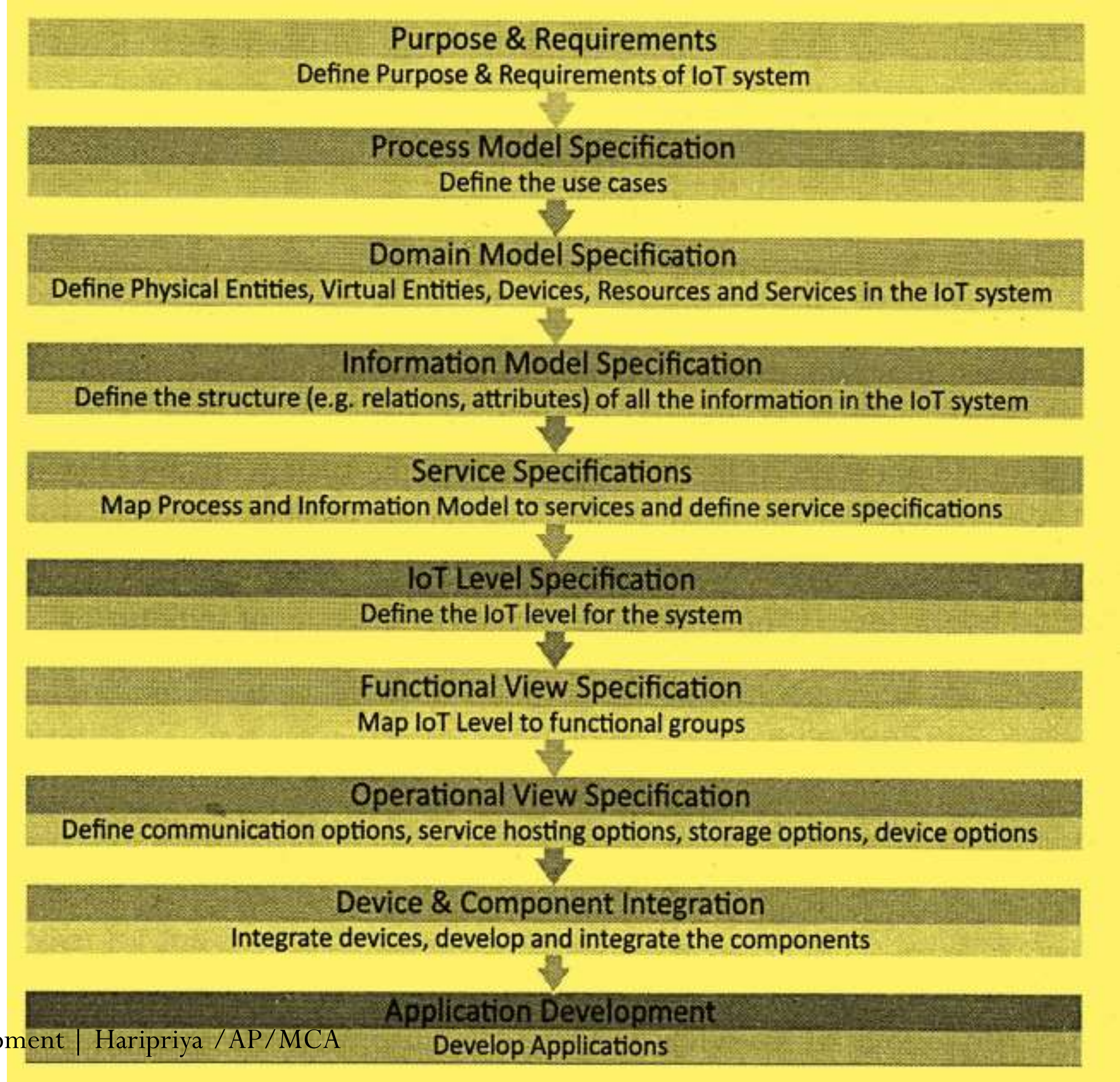
- IoT Level Specifications
- Functional view Specification
- Operational View Specification
- Device & component Integration
- Application Development

Purpose & Requirements Specification

The first step in IoT system design methodology is to define the purpose and requirements of the system. In this step, the system purpose, behavior and requirements are captured.

Purpose & Requirements Specification

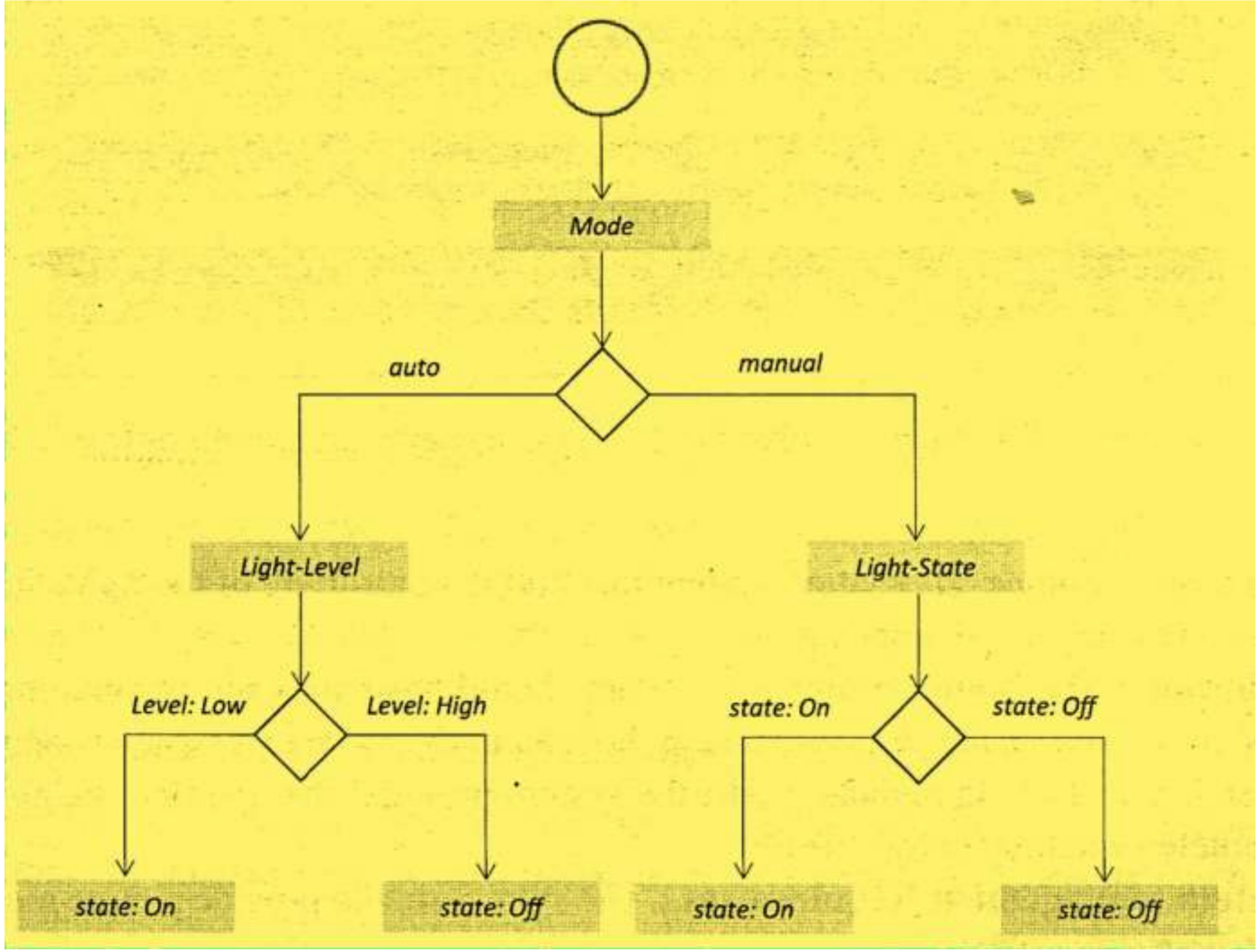
Purpose : A home automation system that allows controlling of the lights in a home remotely using a web application.
Behavior : The home automation system should have auto and manual modes. In auto mode, the system measures the light level in the room and switches on the light when it gets dark. In manual mode, the system provides the option of manually and remotely switching on/off the light.
System Management Requirement : The system should provide remote monitoring and control functions.



Process Specification

- **Purpose :** A home automation system that allows controlling of the lights in a home remotely using a web application.
- **Behavior :** The home automation system should have auto and manual modes. In auto mode, the system measures the light level in the room and switches on the light when it gets dark. In manual mode, the system provides the option of manually and remotely switching on/off the light.
- **System Management Requirement :** The system should provide remote monitoring and control functions.
- **Data Analysis Requirement :** The system should perform local analysis of the data.
- **Application Deployment Requirement :** The application should be deployed locally on the device, but should be accessible remotely
- **Security Requirement :** The system should have basic user authentication capability.

Process Specification(second step)



In this step, the use cases of the IoT system are formally described based on and derived from the purpose and requirement specifications.

Domain Model Specification

- The third step in the IoT design methodology is to define the Domain Model.
- The domain model describes the main concepts, entities and objects in the domain of IoT system to be designed. Domain model defines the attributes of the objects and relationships between objects.
- Domain model provides an abstract representation of the concepts, objects and entities in the IoT domain, independent of any specific technology or platform.

Domain Model Specification

The entities, objects and concepts defined in the domain model include:

Physical Entity : Physical Entity is a discrete and identifiable entity in the physical environment (e.g. a room, a light, an appliance, a car, etc.).

Virtual Entity : Virtual Entity is a representation of the Physical Entity in the digital world.

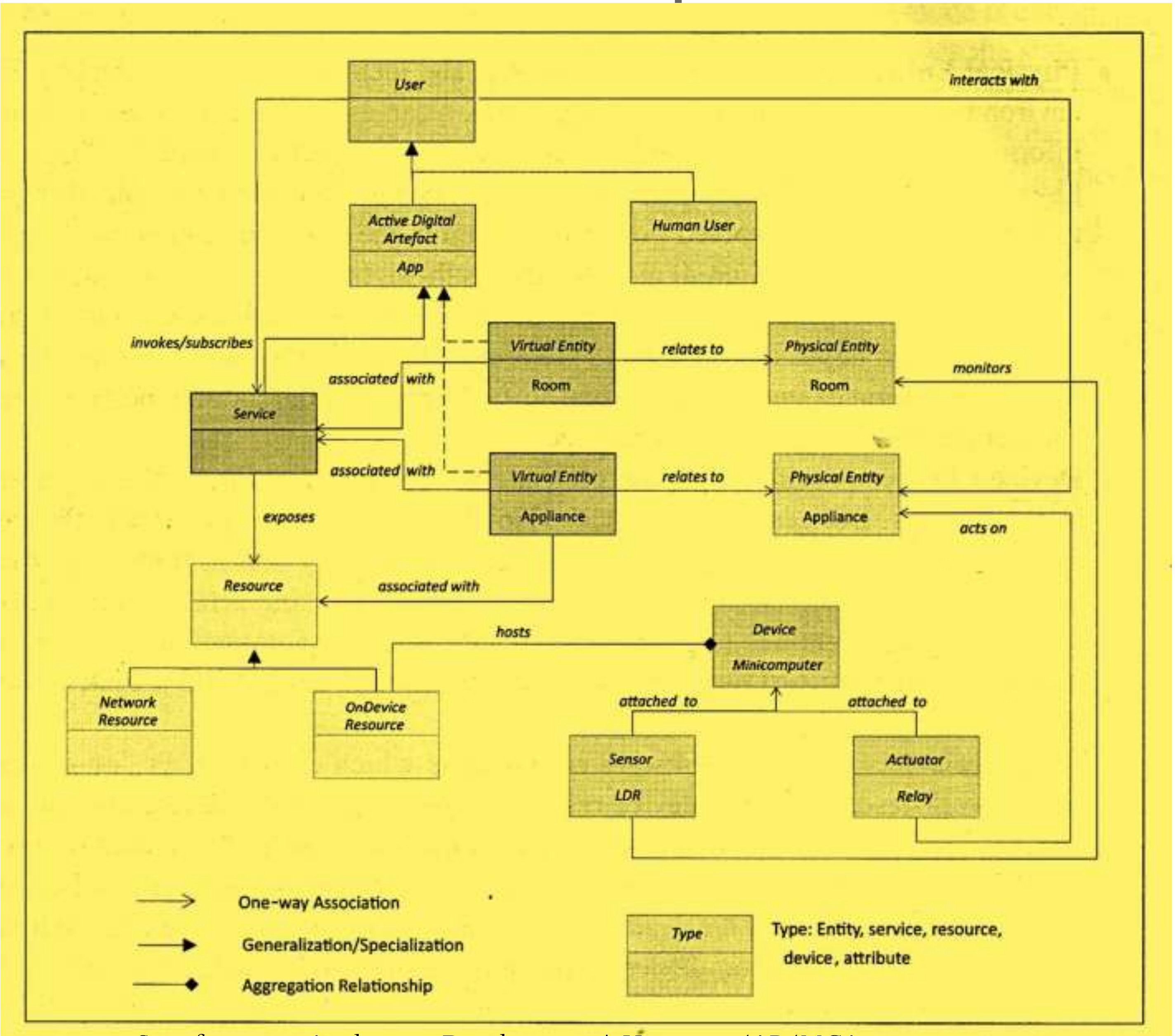
Device provides a medium for interactions between Physical Entities and Virtual Entities. Devices are either attached to Physical Entities or placed near Physical Entities.

Domain Model Specification

Resource :- Resources are software components which can be either "on-device" or "network-resources". On-device resources are hosted on the device and include software components that either provide information on or enable actuation upon the Physical Entity to which the device is attached.

Service : Services provide an interface for interacting with the Physical Entity. Services access the resources hosted on the device or the network resources to obtain information about the Physical Entity or perform actuation upon the Physical Entity.

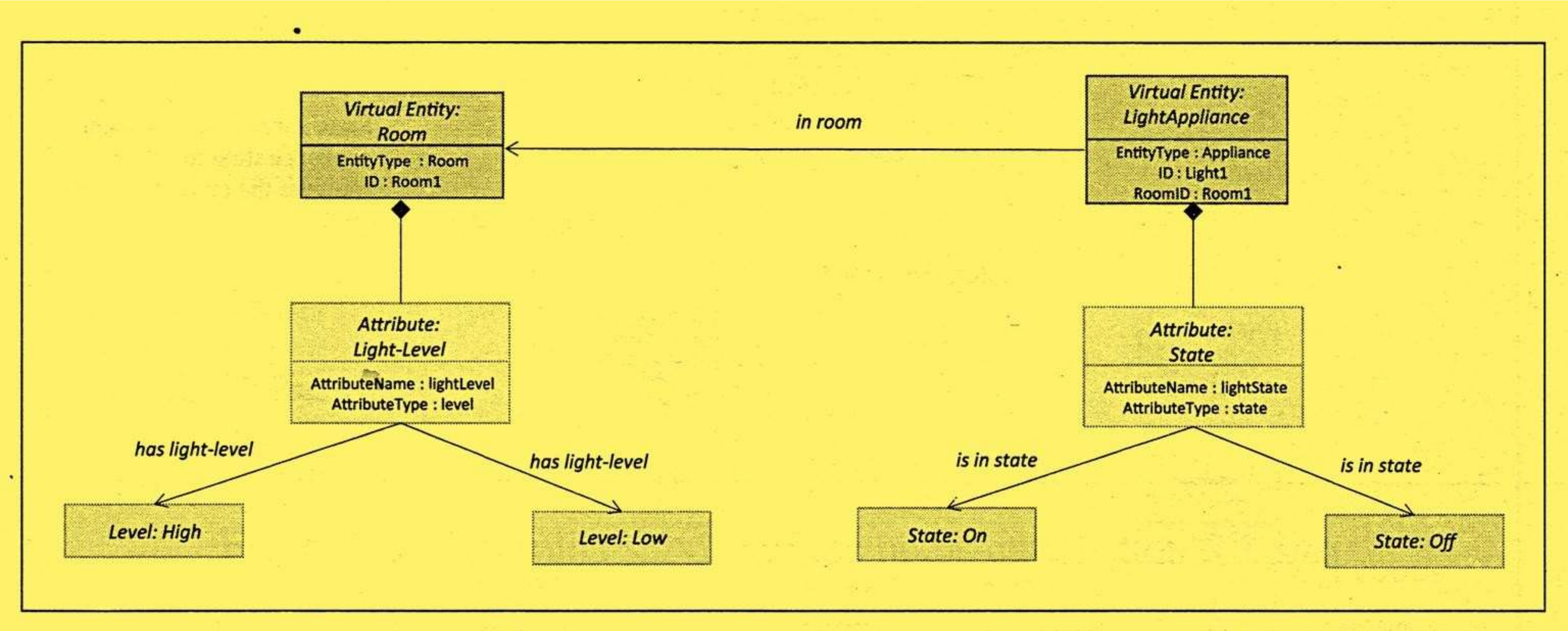
Domain Model Specification



Information Model Specification

- The fourth step in the IoT design methodology is to define the Information Model.
- Information Model defines the structure of all the information in the IoT system, for example, attributes of Virtual Entities, relations, etc.
- Information model does not describe the specifics of how the information is represented or stored.
- To define the information model, we first list the Virtual Entities defined in the Domain Model.
- Information model adds more details to the Virtual Entities by defining their attributes and relations

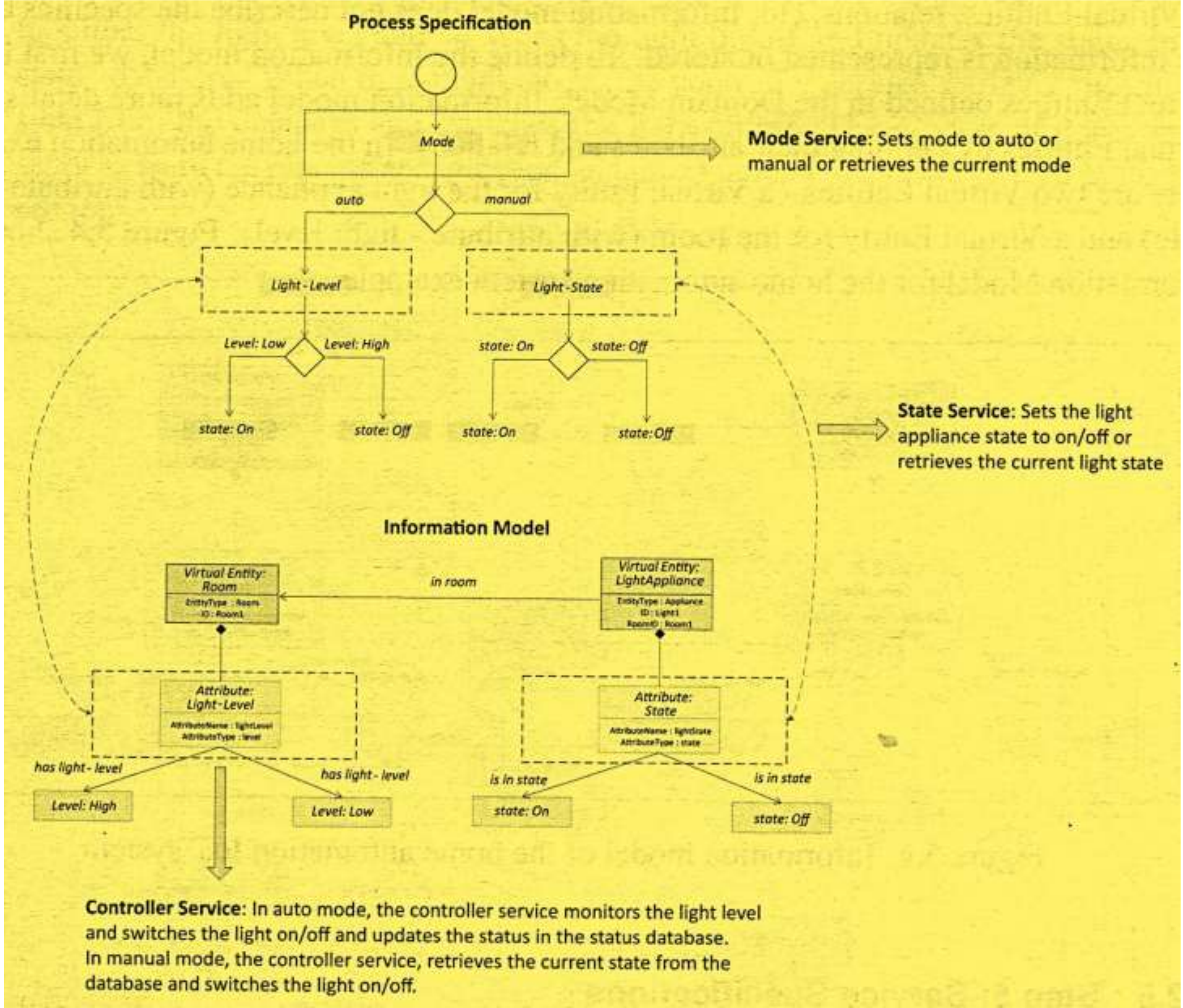
Information Model Specification



Service Specification

- The fifth step in the IoT design methodology is to define the service specifications. Service specifications define the services in the IoT system, service types, service inputs/output, service endpoints, service schedules, service preconditions and service effects.

rvice Specification



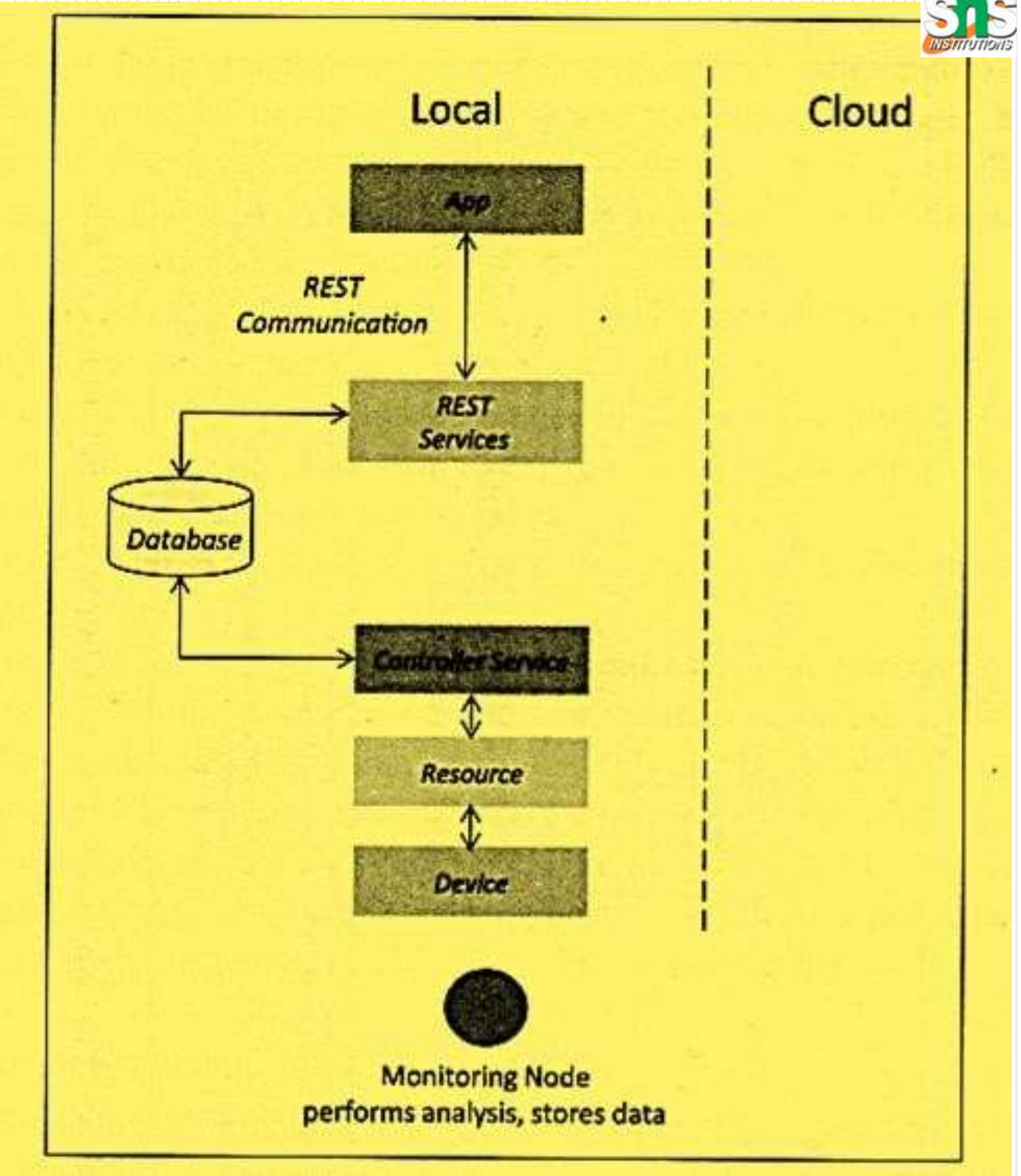
From the process specification and information model, we identify the states and attributes.

For each state and attribute we define a service.

These services either change the state or attribute values or retrieve the current values.

IoT Level Specifications

The sixth step in the IoT design methodology is to define the IoT level for the system.



Functional View Specification(seventh step)

The Functional View (FV) defines the functions of the IoT systems grouped into various Functional Groups (FGs).

Each Functional Group either provides functionalities for interacting with instances of concepts defined in the Domain Model or provides information related to these concepts.

Specification

The Functional Groups (FG) included in a Functional View include:

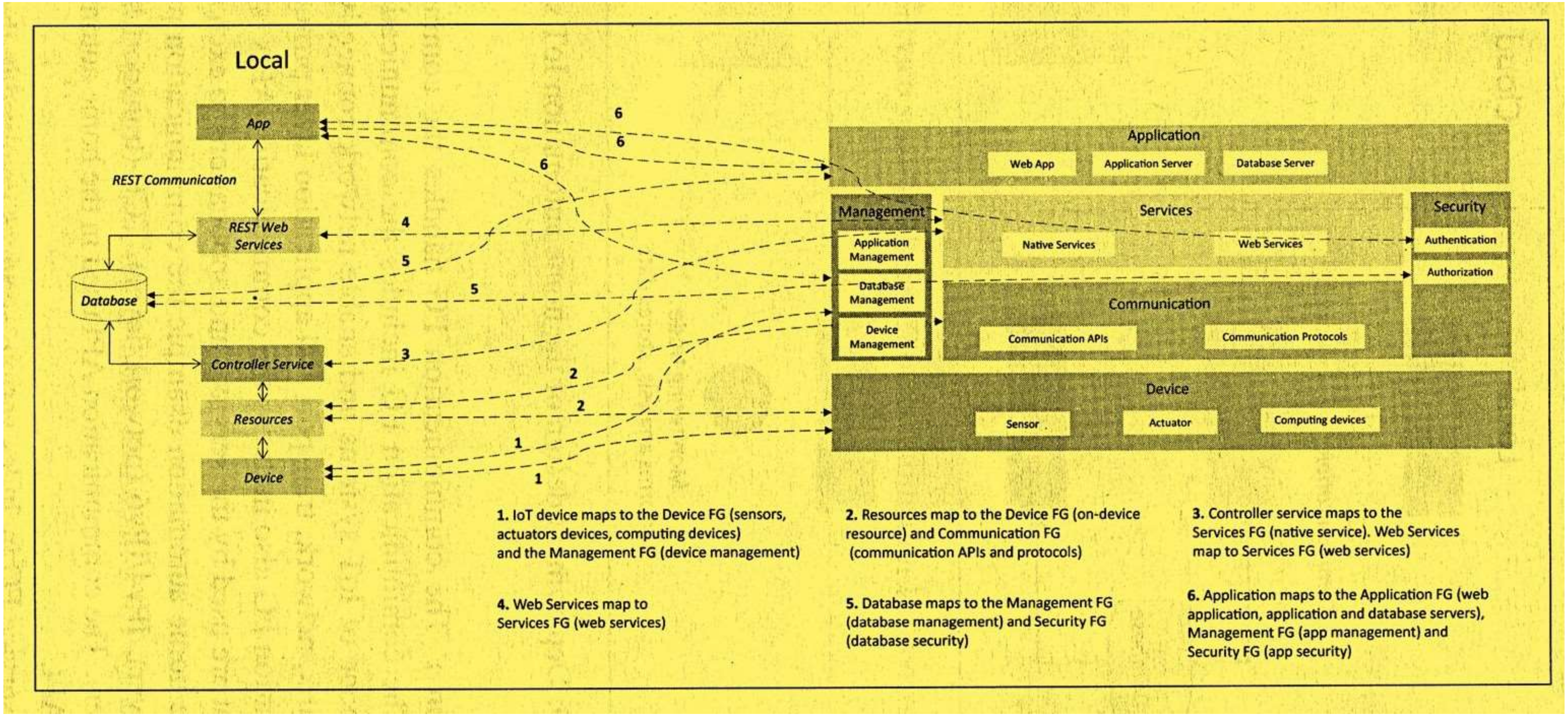
- **Device :** The device FG contains devices for monitoring and control. In the home automation example. the device FG includes a single board mini-computer, a light sensor and relay switch(actuator).
- **Communication** : The communication FG handles the communication for the IoT system. The communication FG includes the communication protocols that form the backbone of IoT systems and enable network connectivity.

The communication FG also includes the communication APIs (such as REST and WebSocket) that are used by the services and applications to exchange data over the network.

Functional view Specification

- Services : The service FG includes various services involved in the IoT system such as services for device monitoring , device control services, data publishing services and services for device discovery.
- Management : The management FG includes all functionalities that are needed to configure and manage the loT system .
- Security : The security FG includes security mechanisms for the loT system such as authentication, authorization, data security, etc.
- Application : The application FG includes applications that provide an interface to the users to control and monitor various aspects of the IoT system. Applications also allow users to view the system status and the processed data.

Functional view Specification



Operational View Specification

In this step, various options pertaining to the IoT system deployment and operation are defined, such as, service hosting options, storage options, device options, application hosting options, etc.

Operational View specifications for the home automation example are as follows:

- Devices: Computing device (Raspberry Pi), light dependent resistor (sensor), relay switch (actuator).
- Communication APIs: REST APIs
- Communication Protocol s: Link Layer - 802.11, Network Layer - 1Pv4/1Pv6, Transport TCP, Application - HTTP.

Operational View Specification

Operational View specifications for the home automation example are as follows:

Services:

- Controller Service - Hosted on device, implemented in Python and run as a native service.
- Mode service - REST-fol web service, hosted on device, implemented with Django-REST Framework.
- State service - REST-ful web service, hosted on device, implemented with Django-REST Framework.

Application:

- Web Application - Django Web Application, Application Server - Django App Server, Database Server - MySQL.

Operational View Specification

Operational View specifications for the home automation example are as follows:

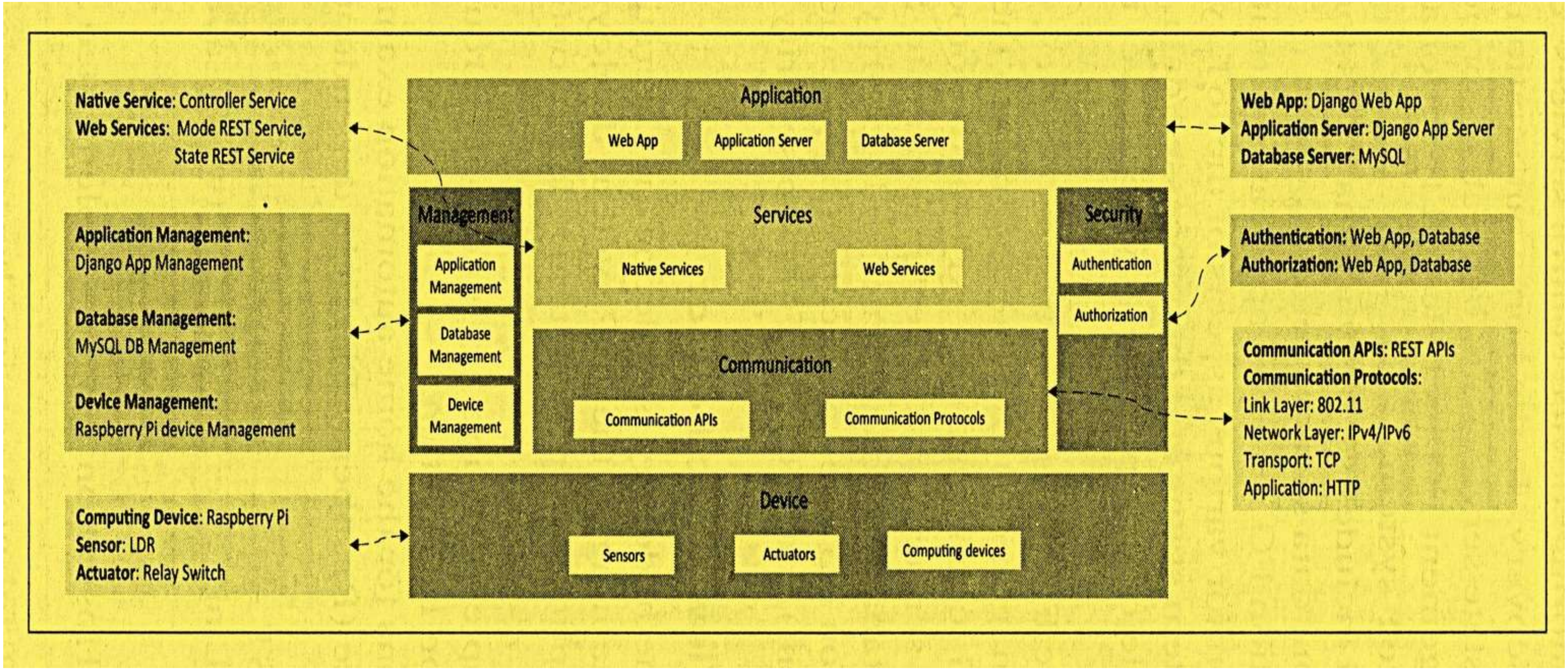
Security:

- Authentication: Web App, Database Authorization: Web App, Database

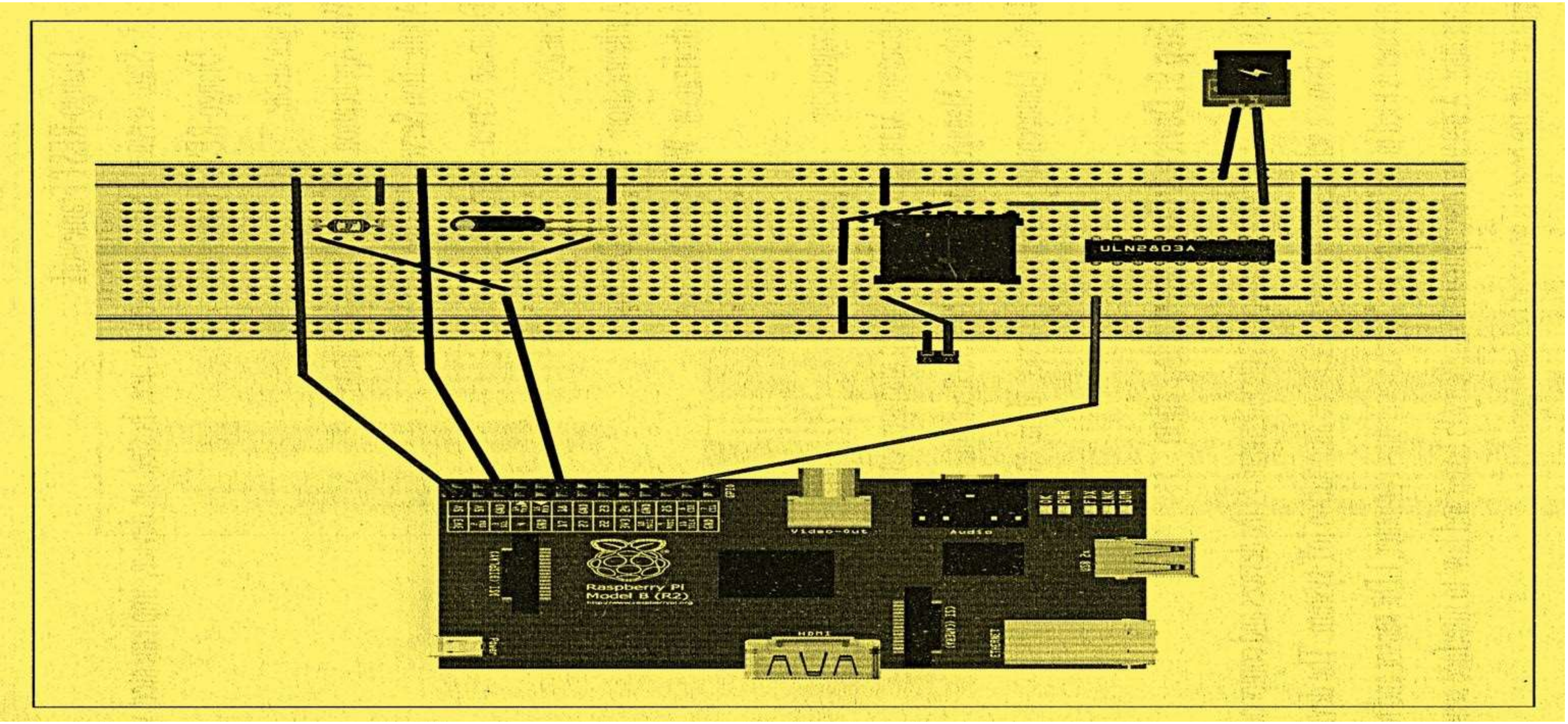
Management:

- Application Management - Django App Management Database Management - MySQL DB Management, Device Management - Raspberry Pi device Management.

Operational View Specification



Device & component Integration

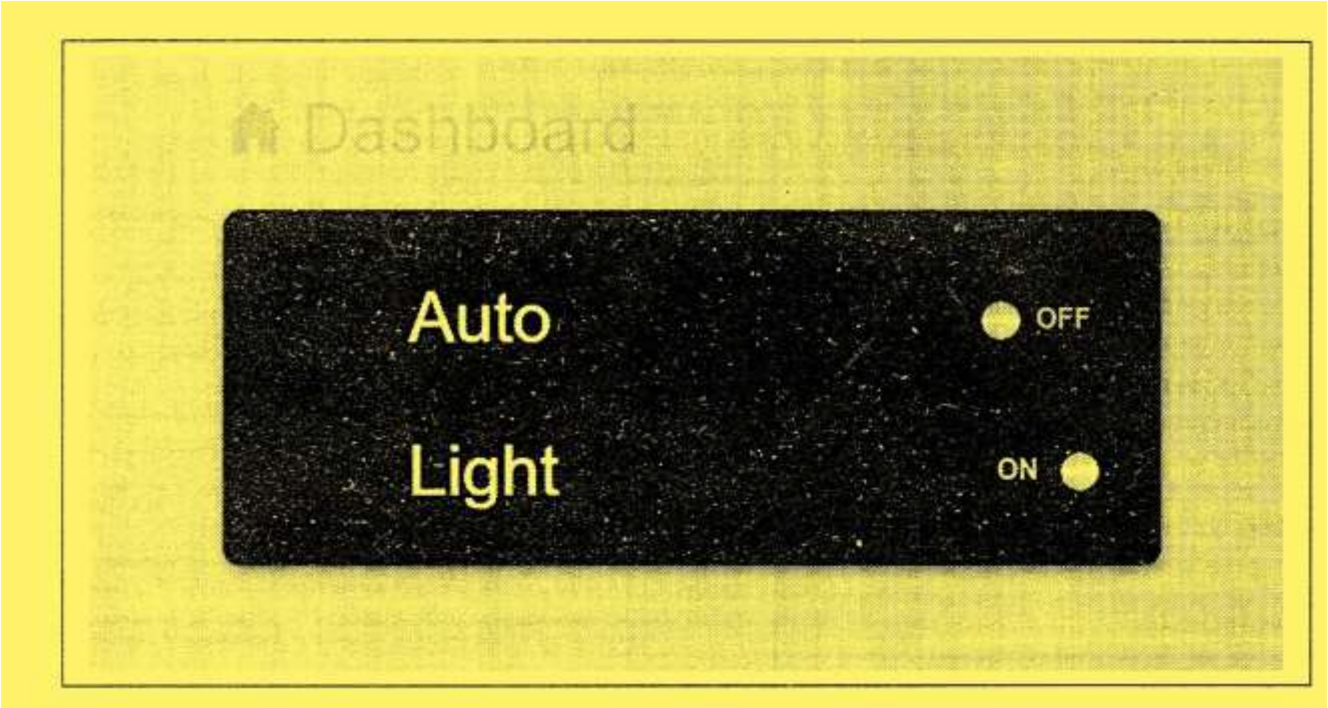


The devices and components used in this example are Raspberry Pi mini computer, LDR sensor and relay switch actuator.

Application Development

- The application has controls for the mode (auto on or auto off) and the light (on or off).
- In the auto mode, the IoT system controls the light appliance automatically based on the lighting conditions in the room.
- When auto mode is enabled the light control in the application is disabled and it reflects the current state of the light.
- When the auto mode is disabled, the light control is enabled and it is used for manually controlling the light.

Application Development



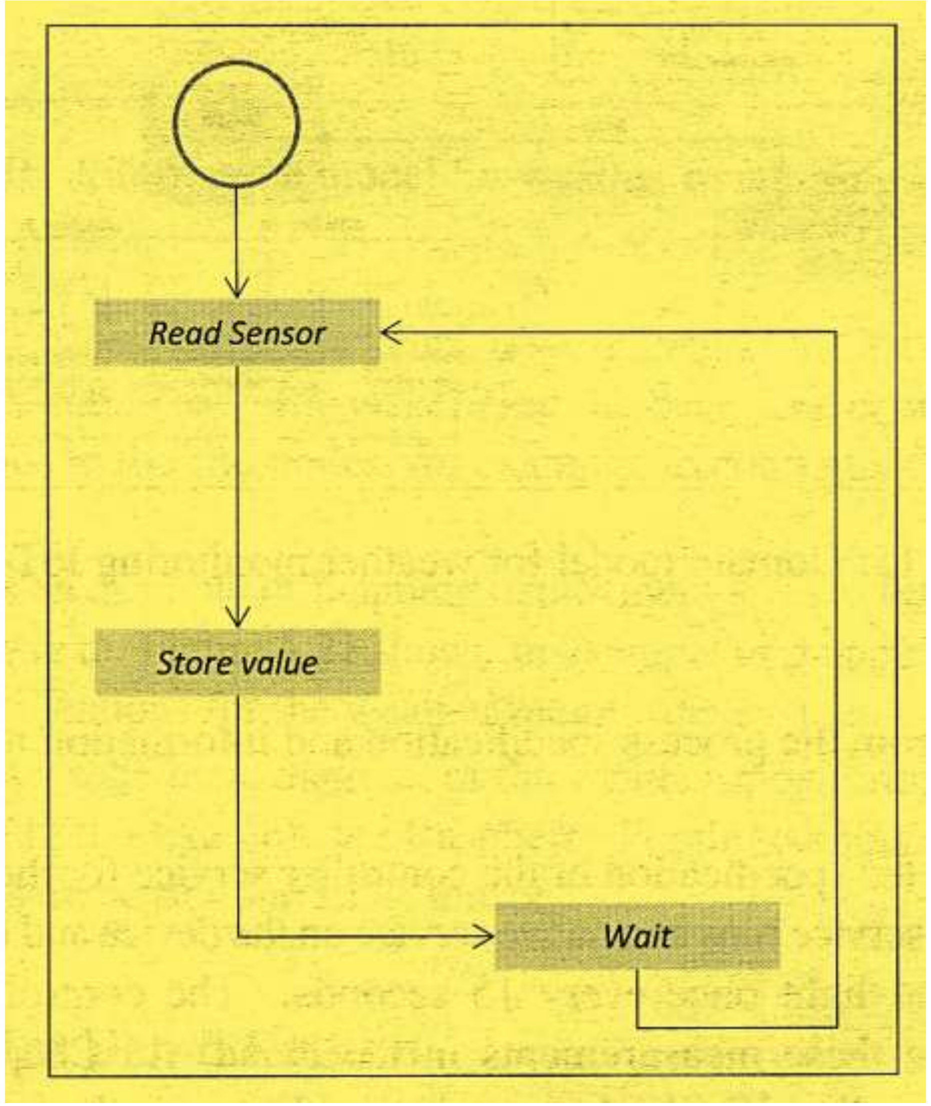
Case Study Weather Monitoring System

- The purpose of the weather monitoring system is to collect data on environmental conditions such as temperature, pressure, humidity and light in an area using multiple end nodes.
- The end nodes send the data to the cloud where the data is aggregated and analyzed.

Case Study Weather Monitoring System

Figure shows the process specification for the weather monitoring system.

The process specification shows that the sensors are read after fixed intervals and the sensor measurements are stored.



Case Study Weather Monitoring System

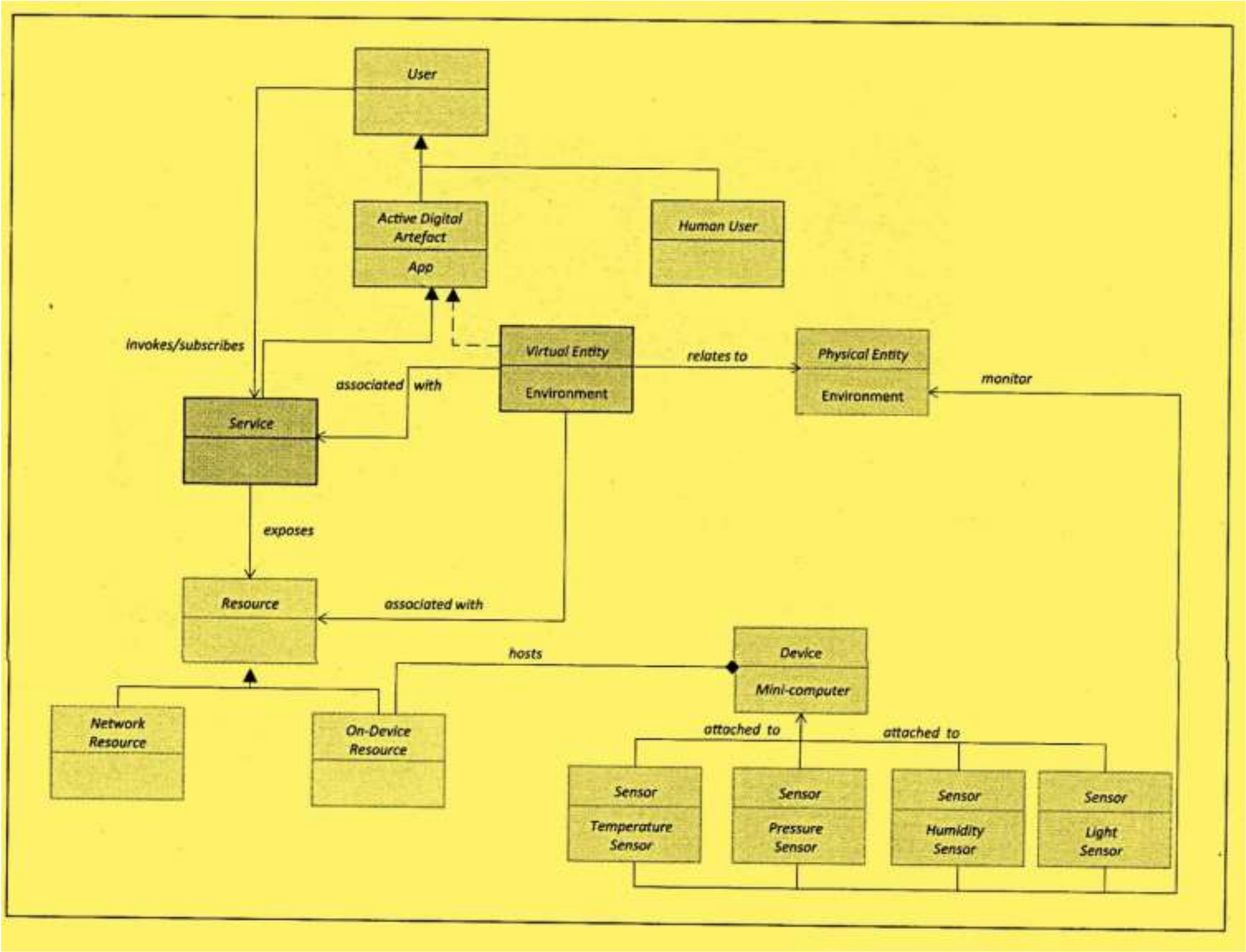
In this domain model the physical entity is the environment which is being monitored .

There is a virtual entity for the environment. Devices include temperature sensor, pressure sensor, humidity sensor, light sensor and single-board mini computer.

Resources are software components which can be either on-device or network-resources.

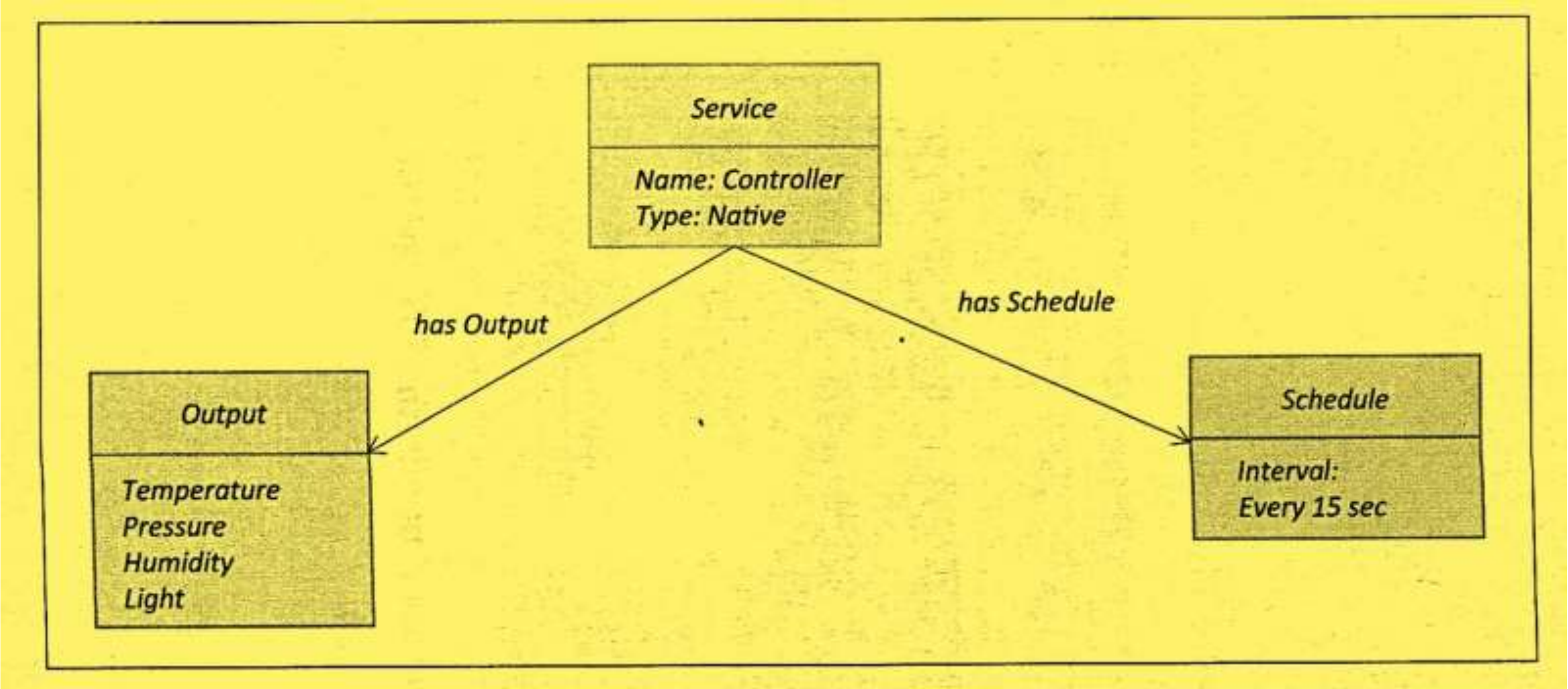
Services include the controller service that monitors the temperature , pressure deriving the services from the process specification and information model for the weather monitoring system, humidity and light and sends the readings to the deriving the services from the process specification and information model for the weather monitoring system.

Case Study Weather Monitoring System(domain model)



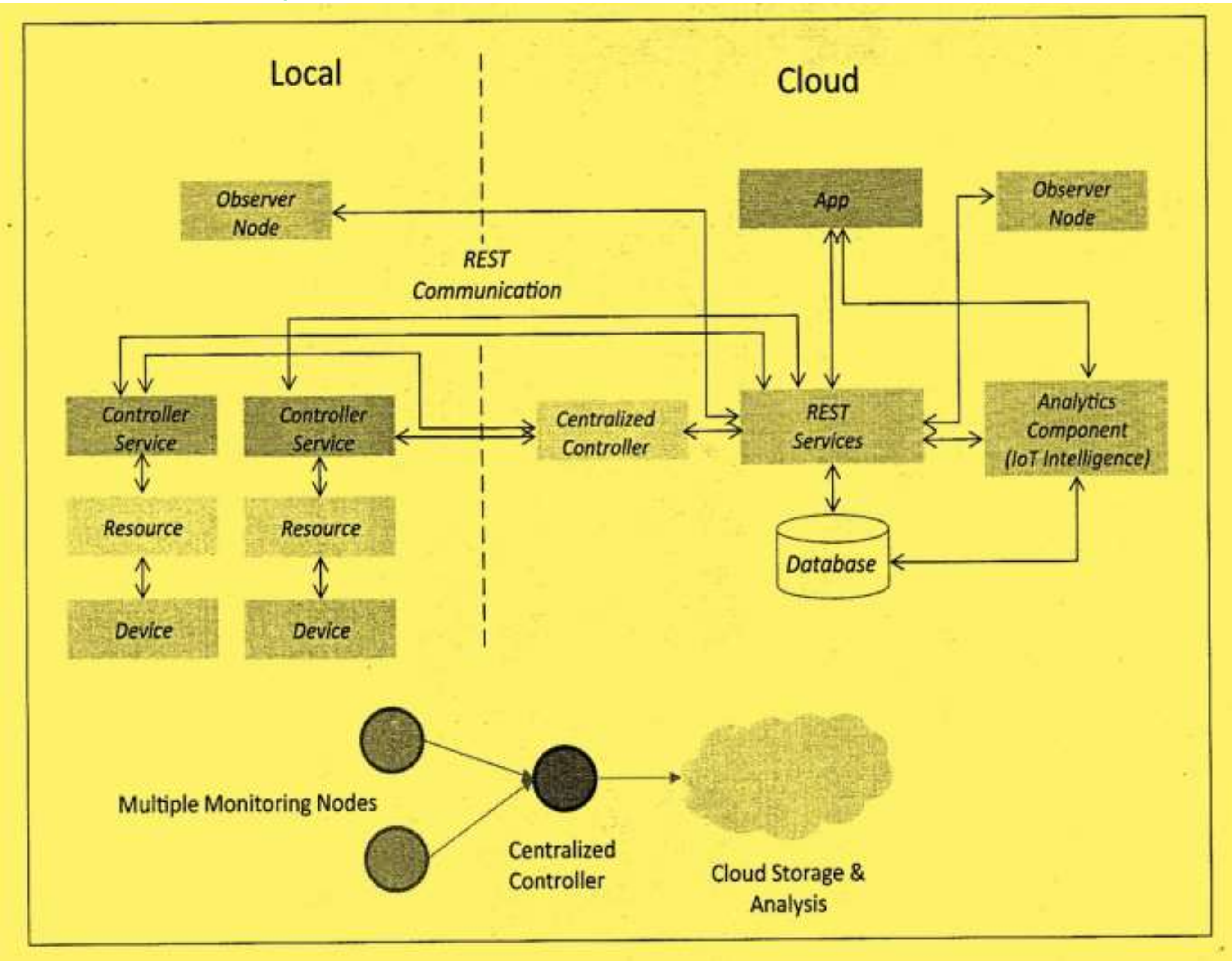
Case Study Weather Monitoring System(controller service)

- The controller service runs as a native service on the device and monitors temperature, pressure, humidity and light once every 15 seconds.
- The controller service calls the REST service to store these measurements in the cloud.

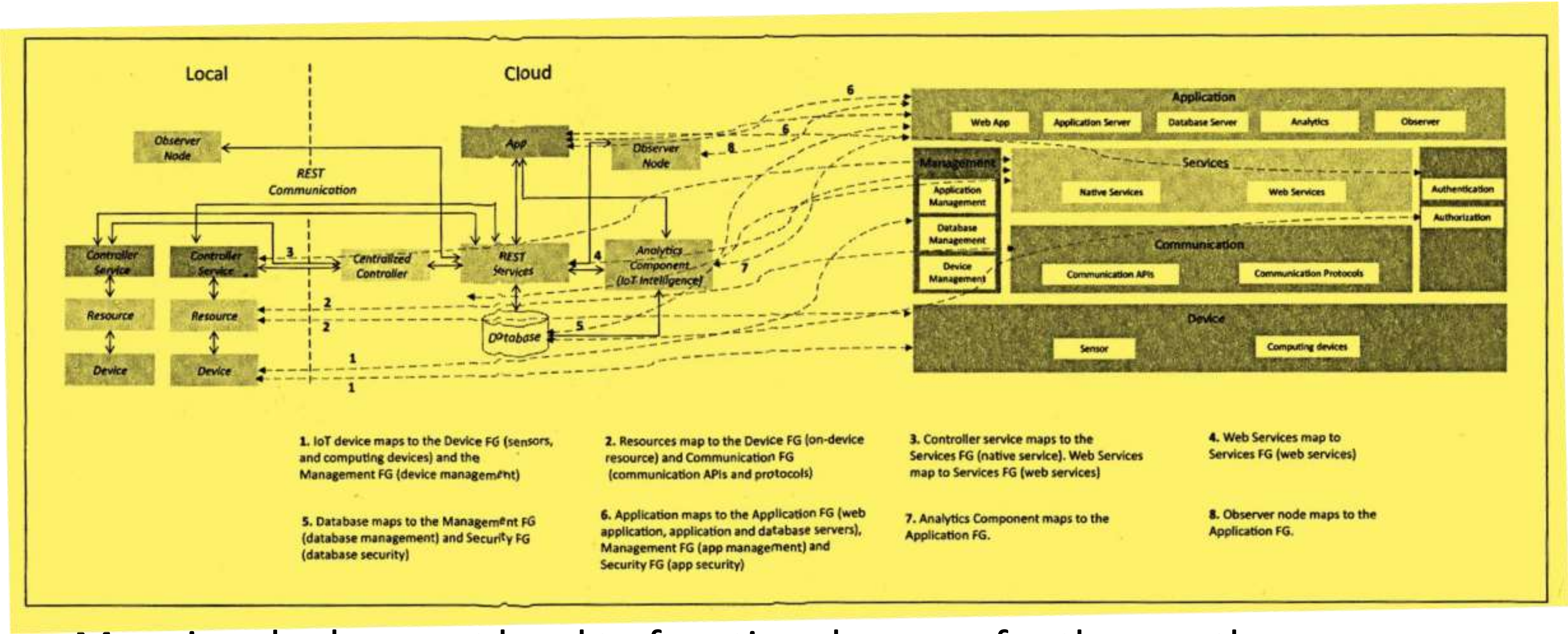


Case Study Weather Monitoring System (deployment design for the system)

- The system consists of multiple nodes placed in different locations for monitoring temperature, humidity and pressure in an area.
- The end nodes are equipped with various sensors .
- The end nodes send the data to the cloud and the data is stored in a cloud database.
- The analysis of data is done in the cloud to aggregate the data and make predictions

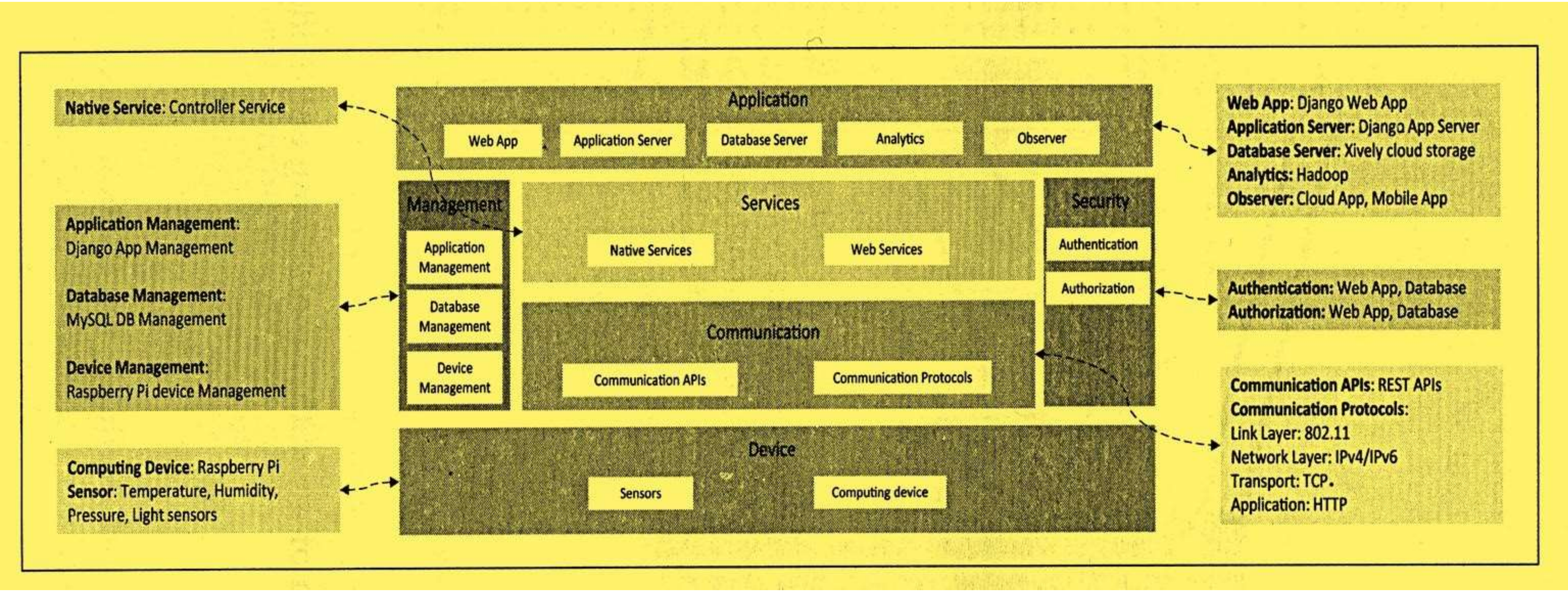


Case Study Weather Monitoring System)



Mapping deployment level to functional groups for the weather monitoring system.

Case Study Weather Monitoring System

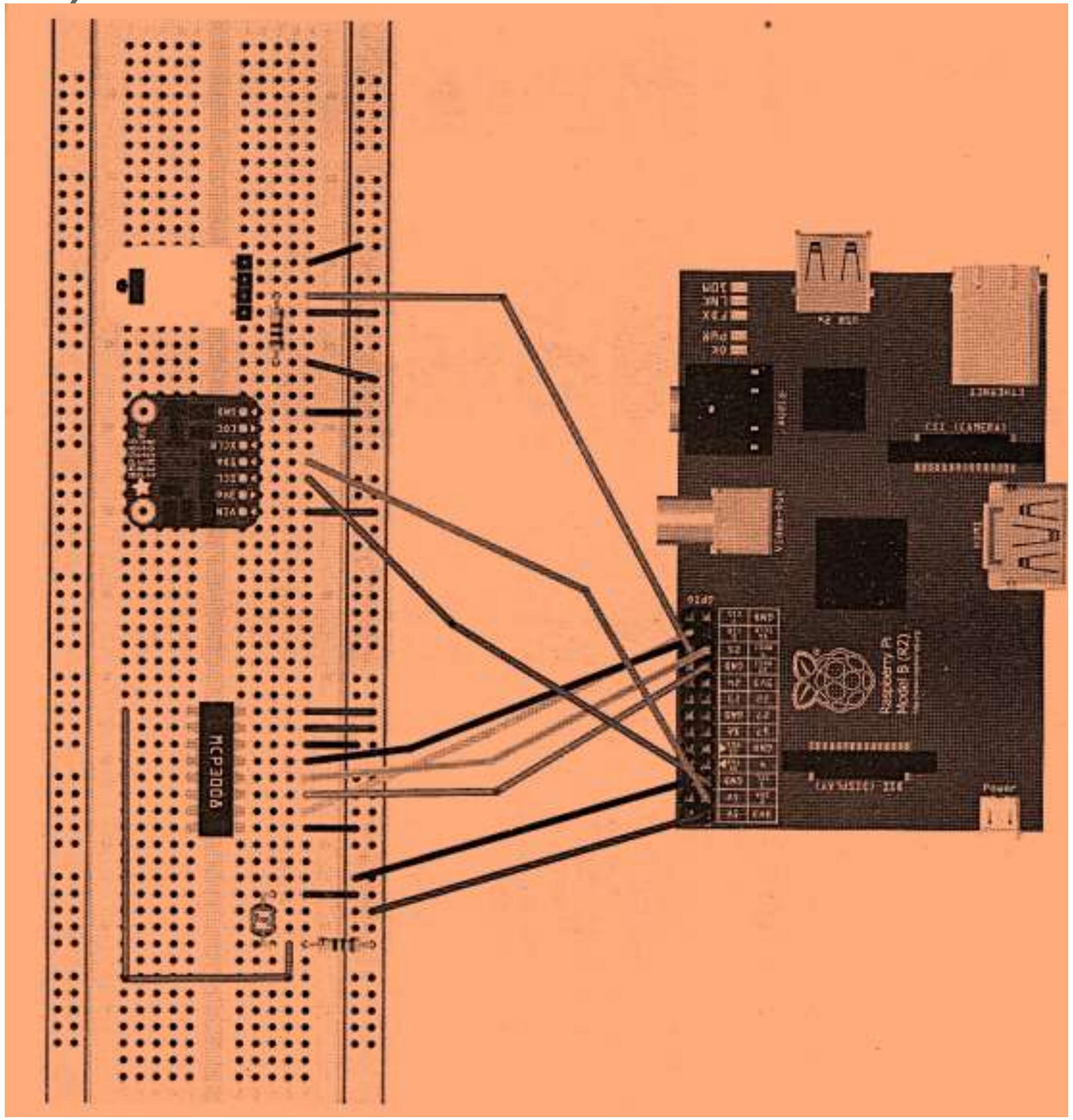


Mapping functional Groups to operational view specifications for the weather monitoring system.

Case Study Weather Monitoring System(controller service)

The schematic diagram of the weather monitoring system.

The devices and components used in this example are Raspberry Pi mini computer, temperature sensor, humidity sensor, pressure sensor and LDR sensor.



Summary

Generic design methodology for IoT system design which is independent of specific product, service or programming language. Designing Steps are

1. Define the purpose and requirements of the system.
2. Define use cases of the IoT system are formally described based on the purpose and requirement specifications.
3. Define the Domain Model which describes the main concepts, entities and objects in the domain of IoT system to be designed.
4. Define the Information Model which defines the structure of all the information in the IoT system.

Summary

Generic design methodology for IoT system design which is independent of specific product, service or programming language. Designing Steps are

5 Define the Functional View which defines the functions of the IoT systems grouped into various Functional Groups.

6.Define the service specifications which define the services in the IoT system, service types, service inputs/output, service endpoints, service schedules, service preconditions and service effects.

7.Define the Deployment & Operational View Specifications in which various options pertaining to the IoT system deployment and operation are defined.

8.The eight step is the integration of the devices and components.

9.The final step in the IoT design methodology is to develop the IoT application.

Impacts of IoT

Economic Growth

Several economic analyses, The current global IoT market has been valued at about $2 trillion, with estimates of its predicted value over the next five to ten years varying from $4 trillion to $11 trillion.

Economic Sectors:

- Agriculture
- Energy
- Health Care:
- Infrastructure and Smart Cities
- Manufacturing Integration
- Transport
- Social and Cultural Impacts

Impacts of IoT

Agriculture:

- precision agriculture, with the goal of optimizing production and efficiency while reducing costs and environmental impacts.
- For farming operations, it involves analysis of detailed, often real-time data on weather, soil and air quality, water supply, pest populations, crop maturity, and other factors such as the cost and availability of equipment and labor.
- Field sensors test soil moisture and chemical balance, which can be coupled with location technologies to enable precise irrigation and fertilization.
- Drones and satellites can be used to take detailed images of fields, giving farmers information about crop yield, nutrient deficiencies, and weed locations.
- For ranching and animal operations, radio frequency identification (RFID) chips and electronic identification readers (EID) help monitor animal movements, feeding patterns, and breeding capabilities, while maintaining detailed records on individual animals.

Impacts of IoT

Energy :Within the energy sector, **the IoT may impact both production and delivery**, for example through facilitating monitoring of oil wellheads and pipelines.

When IoT components are embedded into parts of the electrical grid, the resulting infrastructure is commonly referred to as the "smart grid."

This use of **IoT enables greater control by utilities over the flow of electricity and can enhance the efficiency of grid operations**.

It can also expedite the integration of microgenerators into the grid.

Impacts of IoT

- **Smart-grid technology** can also provide consumers with greater knowledge and control of their energy usage through the use of smart meters in the home or office.
- Connection of smart meters to a building’s HVAC, lighting, and other systems can result in “smart buildings” that integrate the operation of those systems.
- Smart buildings use sensors and other data to automatically adjust room temperatures, lighting, and overall energy usage, resulting in greater efficiency and lower energy cost.
- Information from adjacent buildings may be further integrated to provide additional efficiencies in a neighborhood or larger division in a city.

Impacts of IoT

Health Care:

- The IoT has many applications in the health care field, in both health monitoring and treatment, including telemedicine and telehealth.
- Applications may involve the use of medical technology and the Internet to provide long-distance health care and education. Medical devices—which can be wearable or non wearable, or even implantable, injectable, or ingestible—can permit remote tracking of a patient's vital signs, chronic conditions, or other indicators of health and wellness.
- Wireless medical devices may be used not only in hospital settings but also in remote monitoring and care, freeing patients from sustained or recurring hospital visits.

Impacts of IoT

- Manufacturing Integration of IoT technologies into manufacturing and supply chain logistics is predicted to have a transformative effect on the sector.
- The biggest impact may be realized in optimization of operations, making manufacturing processes more efficient.
- Efficiencies can be achieved by connecting components of factories to optimize production, but also by connecting components of inventory and shipping for supply chain optimization.
- Another application is predictive maintenance, which uses sensors to monitor machinery and factory infrastructure for damage .

Impacts of IoT

- Transportation systems are becoming increasingly connected. New motor vehicles are equipped with features such as global positioning systems (GPS) and in-vehicle entertainment, as well as advanced driver assistance systems (ADAS), which utilize sensors in the vehicle to assist the driver, for example with parking and emergency braking.
- Further connection of vehicle systems enables fully autonomous or self-driving automobiles, which are predicted to be commercialized in the next 5-20 years.

Impacts of IoT

- **Infrastructure and Smart Cities:** The capabilities of the smart grid, smart buildings, and ITS combined with IoT components in other public utilities—such as roadways, sewage and water transport and treatment, public transportation, and waste removal—can contribute to more integrated and functional infrastructure, especially in cities. For example, traffic authorities can use cameras and embedded sensors to manage traffic flow and help reduce congestion.47 IoT components embedded in street lights or other infrastructure elements can provide functions such as advanced lighting control, environmental monitoring, and even assistance for drivers in finding parking spaces.48 Smart garbage cans can signal waste removal teams when they are full, streamlining the routes that garbage trucks take.

Impacts of IoT

- Social and Cultural Impacts The IoT may create webs of connections that will fundamentally transform the way people and things interact with each other. The emerging cyberspace platform created by the IoT and SMAC has been described as potentially making cities “like ‘computers’ in open air,” where citizens engage with the city “in a real-time and ongoing loop of information

Question?

Thank you