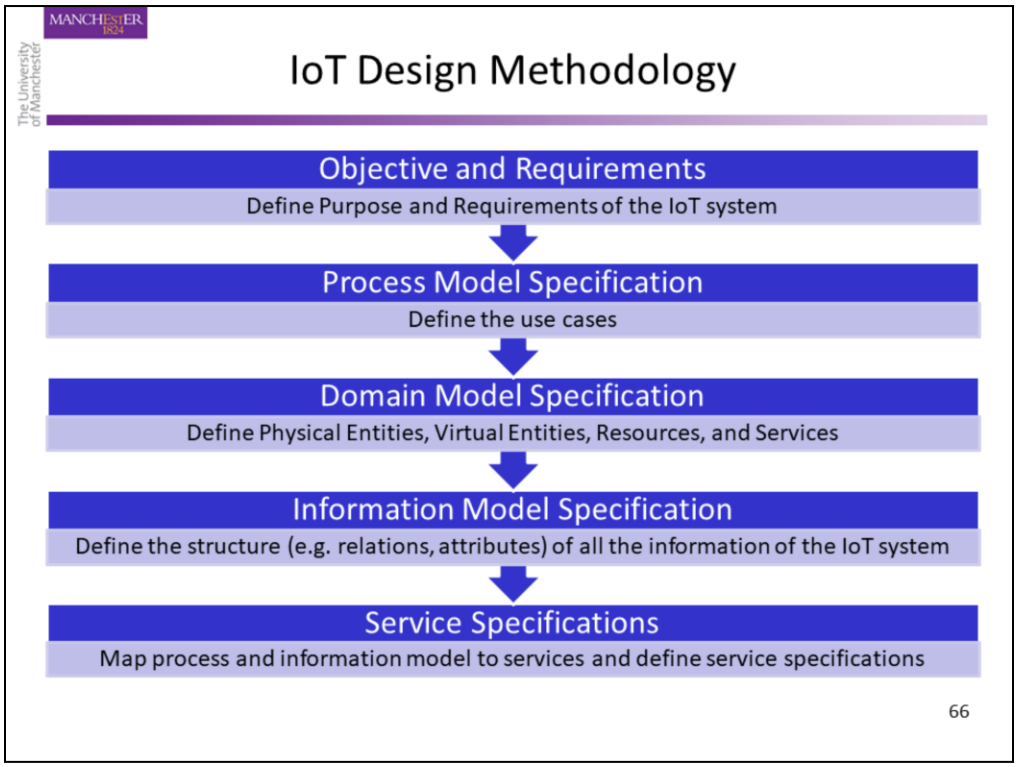
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IoT Design Methodology
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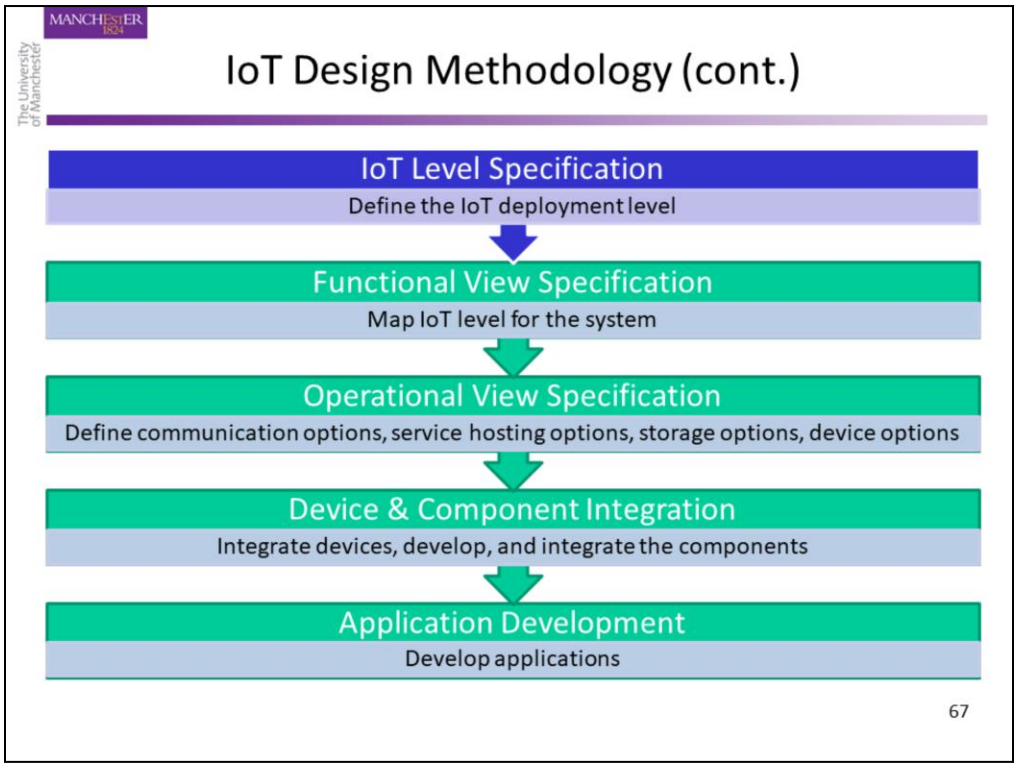
Map process and information model to services and define service specifications
66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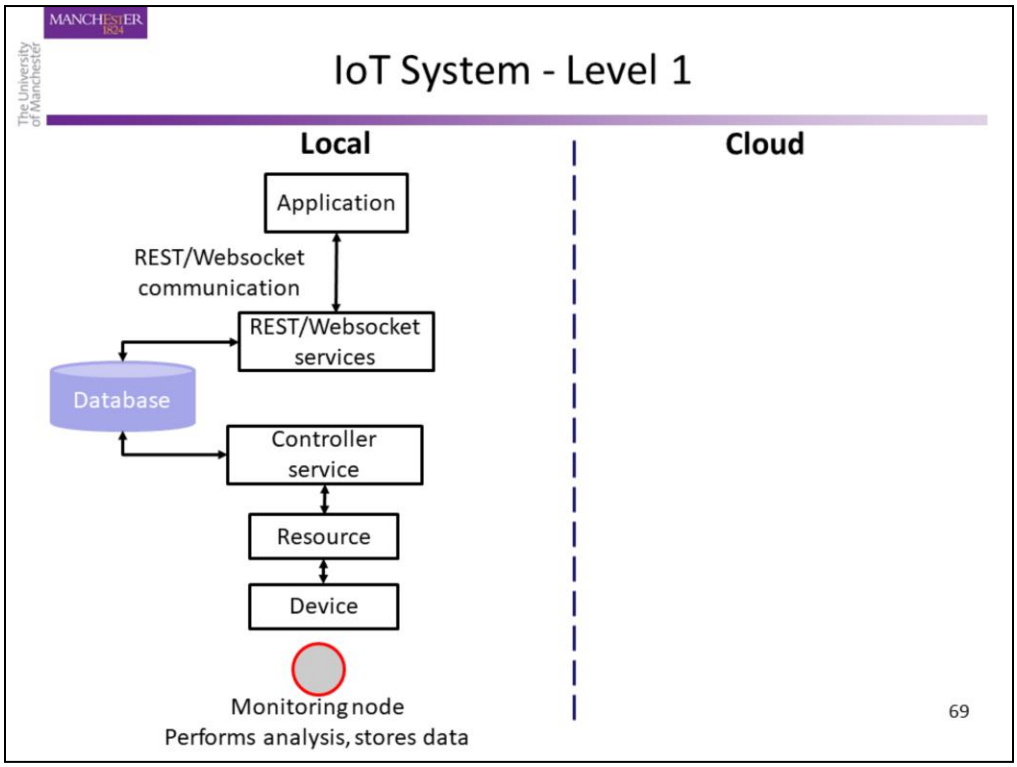
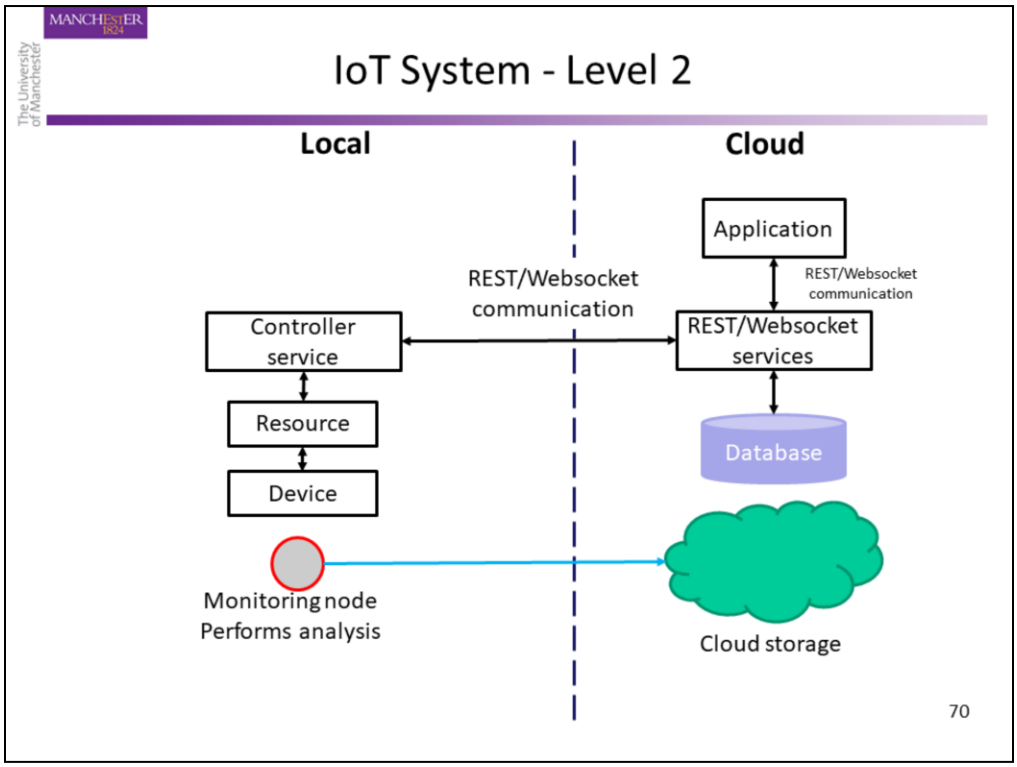
IoT Design Methodology (cont.)
IoT Level Specification
Define the IoT deployment level
Functional View Specification
Map IoT level for the system
Operational View Specification
Define communication options, service hosting options, storage options, device options
Device & Component Integration
Integrate devices, develop, and integrate the components
Application Development
Develop applications
67

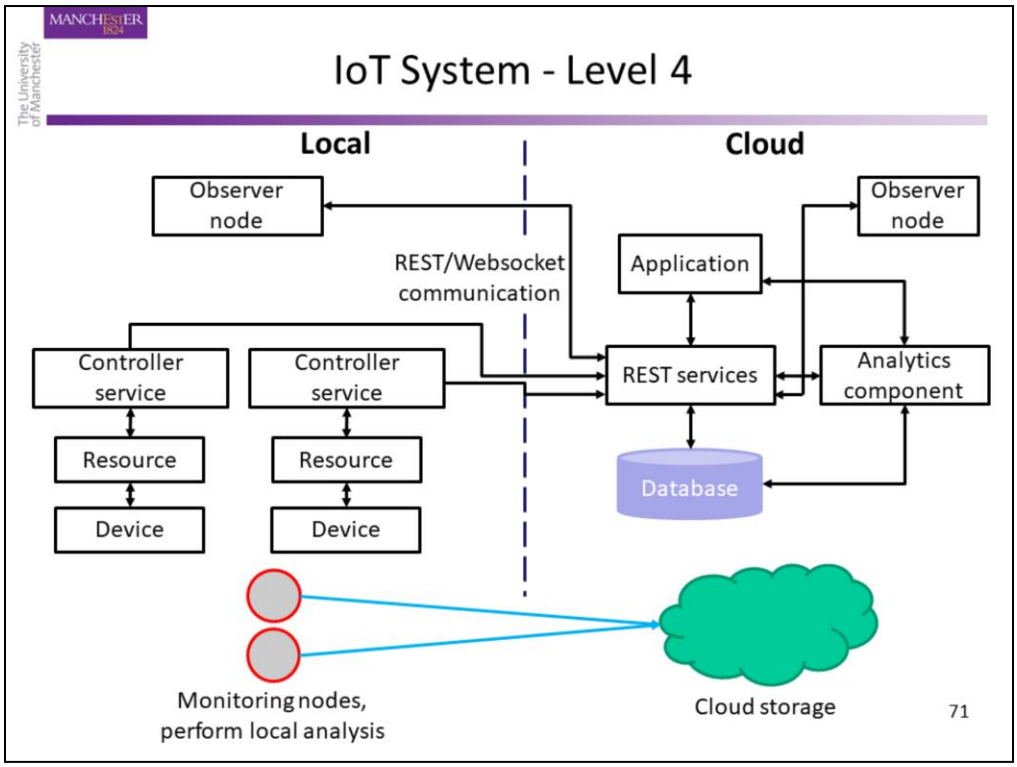
# IOT LEVEL SPECIFICATION (STEP 6)



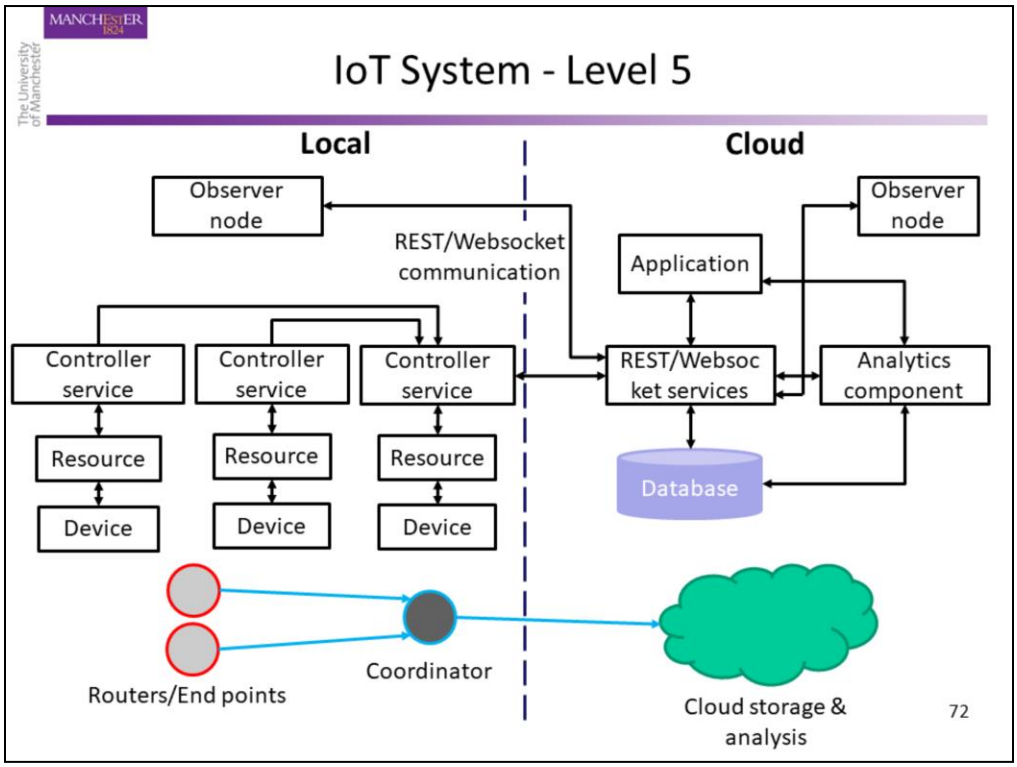

- Typically applicable for low cost and low complexity systems
- **Example**: home automation system
- Controls the status of lights and appliances within a home.
- Information about the status of each light/device is stored in a local database.
- REST can retrieve and program actions on the status of each light/device through (relay) switches.
- The controller monitors the IoT physical devices (light and appliances) through the info maintained in the database.
- Access to the Internet is supported and thus the application can be accessed remotely.
    - E.g. turn-on heating as you drive home.
    - Can the car decide that upon its location (foreground vs. background technology)?



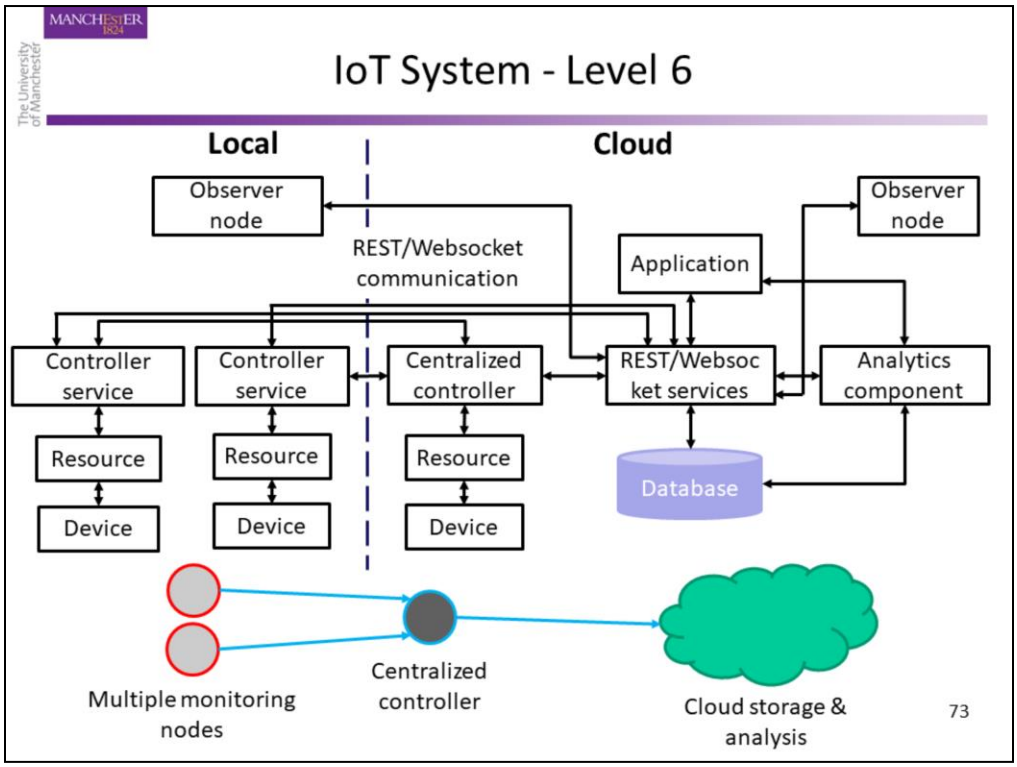

- Similar to IoT level 1 but the data is now stored in the cloud and application is served in the Cloud.
- This level is more appropriate when a larger set of data is collected but data analysis is still rather locally performed.
- **Example**: soil moisture monitoring and irrigation system in greenhouses.
- Moisture sensors and solenoid valves (actuators) are the physical devices.
- Moisture data is sent to the cloud and commands are transmitted to the valves by the controller.
- Cloud-based application draws irrigation schedules based on info stored in the cloud database.




- Multiple nodes perform local analysis
- The data is stored in the cloud and the application is cloud-based
- **New component**: Observer nodes both locally and in the cloud
- Observer node can always invoke available information and process it for applications but cannot perform control functions.
- **Example**: Noise monitoring across an area by multiple sound sensors independently. Each node has its own control services and passes the data to a database in the cloud.
- Data analysis takes place in the cloud.
- An application, for example, can be used to visualize the aggregated data.




- Multiple end nodes and one coordinator node. Resembles of wireless sensor networks; a primary enabling technology for IoT systems.
- End nodes perform sensing and/or actuation.
- The coordinator gathers and sends data to the cloud through REST services.
- The data is stored and analysed in the cloud through cloud-based applications.
- Level 5 systems are appropriate for wireless sensor networks where the data volume is significant and the requirements for analysis highly demanding.
- **Example**: Forest fire detection.
- This system requires a large of number of sensors due to large land area involved and the types of data collected, e.g., humidity, temperature, and carbon dioxide levels.
- The coordinator node can act as a gateway propagating the data over the Internet into the cloud.
- Predictions can be made in the cloud by aggregating and analysing the data.
- An application can be used to visualize the analysis results and/or the raw data.




- Level 6 systems contain many independent end nodes that perform sensing and/or actuation and send data to the cloud.
- Data is processed and stored in the cloud.
- Cloud-based applications can be used to visualize data and infer further data.
- The centralized controller keeps track of ALL nodes and executes control commands to all individual nodes.
- **Example**: Weather monitoring. A very large number of sensors that records temperature, pressure, and humidity.
- Sensors transmit these parameters in real-time through Websocket services.

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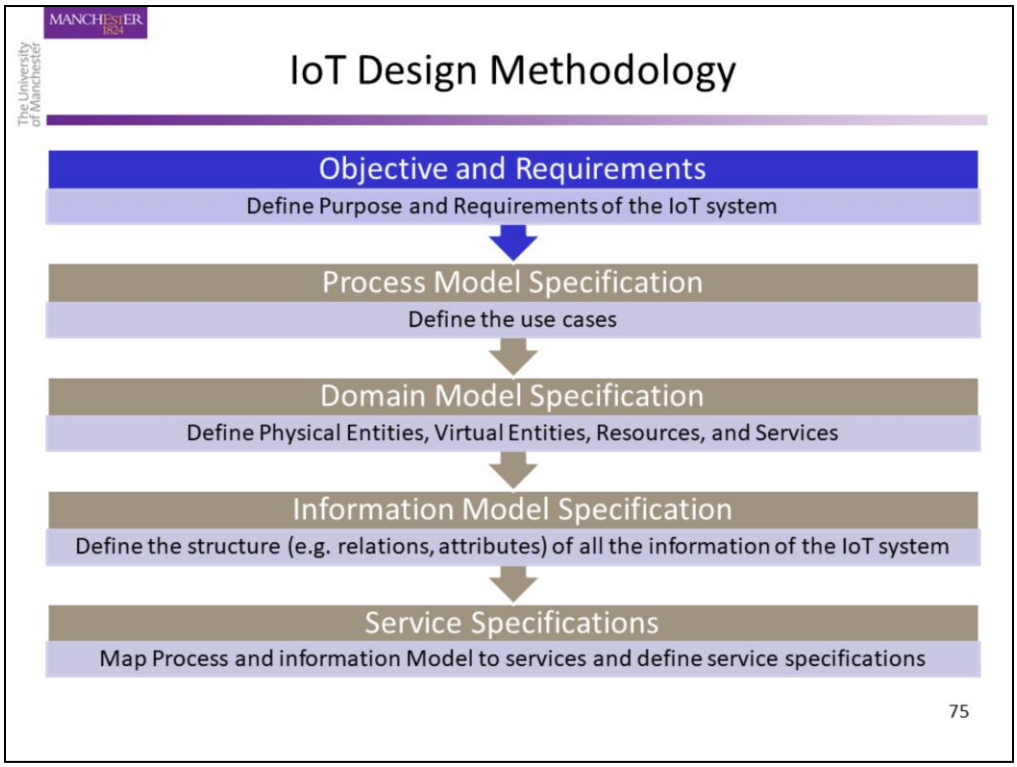
# CASE STUDY: HOME AUTOMATION IOT SYSTEM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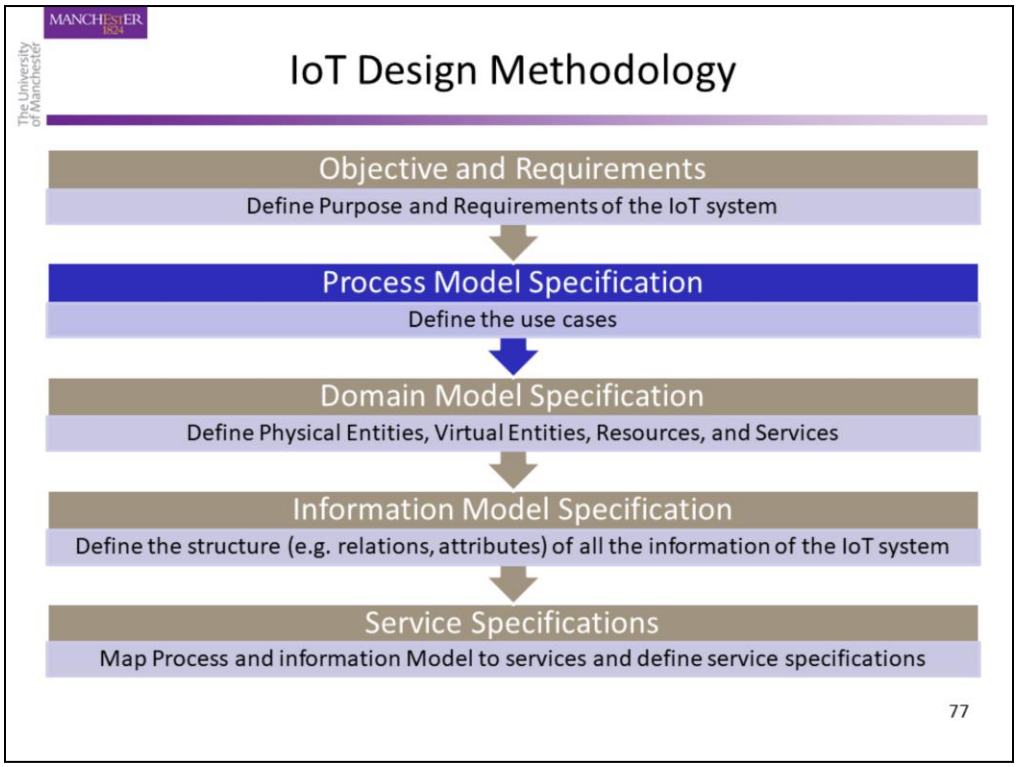
# Step 1: Objective & Requirements

- Purpose: Remotely control lights in a household with a web application
  - Auto and manual mode
    - In auto mode, monitor level of lighting and act
    - In manual mode, user can remotely control the light state
- System management requirement
  - The system should support remote monitoring and control
- Data analysis requirement
  - Only local data analysis will be performed
- Application deployment requirement
  - Deploy the application locally but allow remote access
- Security requirement
  - Basic user authentication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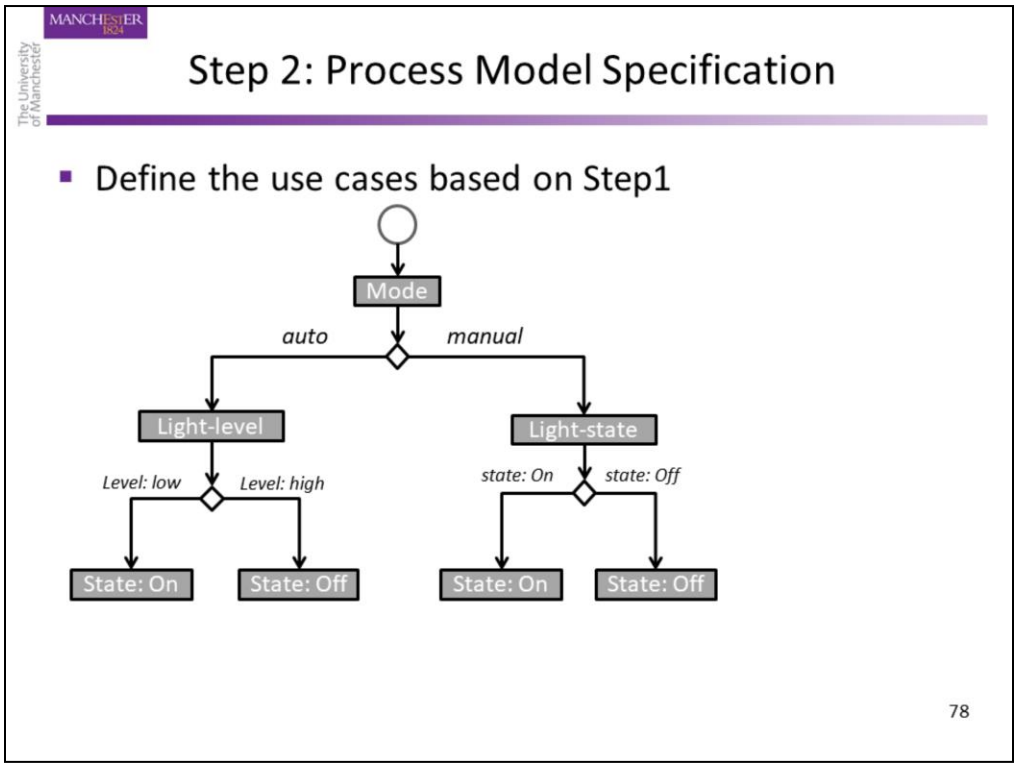
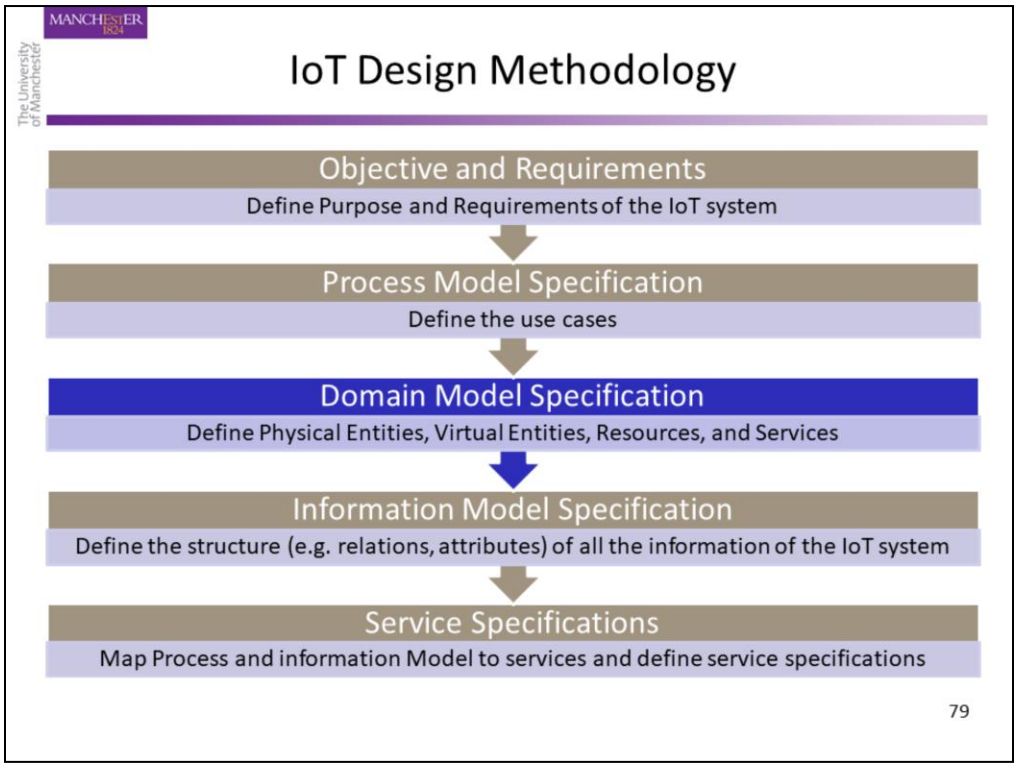



- In a process diagram, the circle denotes the start of a process, the diamond denotes a decision box, and a rectangle box depicts a state or attribute.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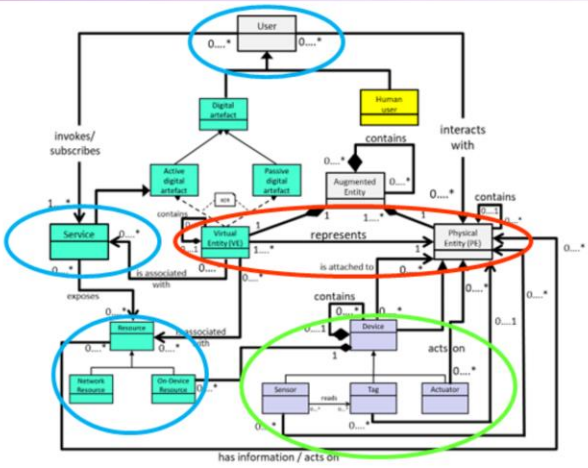
# Step 3: Domain Model Specification

- Determine
  - Users
  - VEs and PEs
  - Devices
  - Resources
  - Services
- Relations among these components

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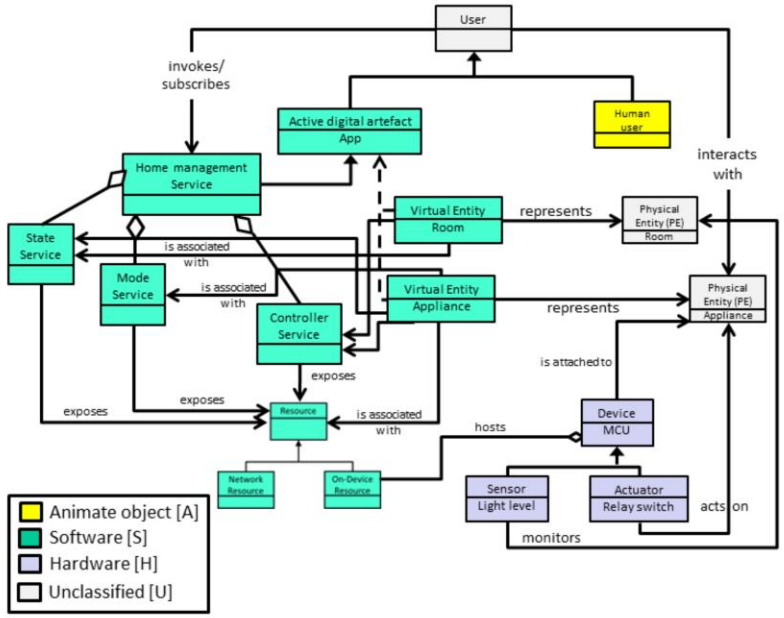
# Home Automation Domain Model

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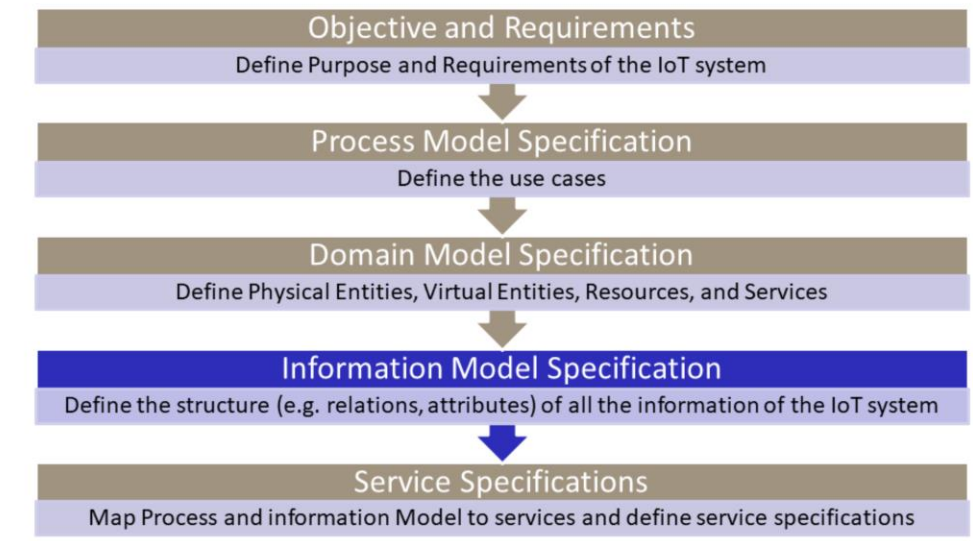
# IoT Design Methodology

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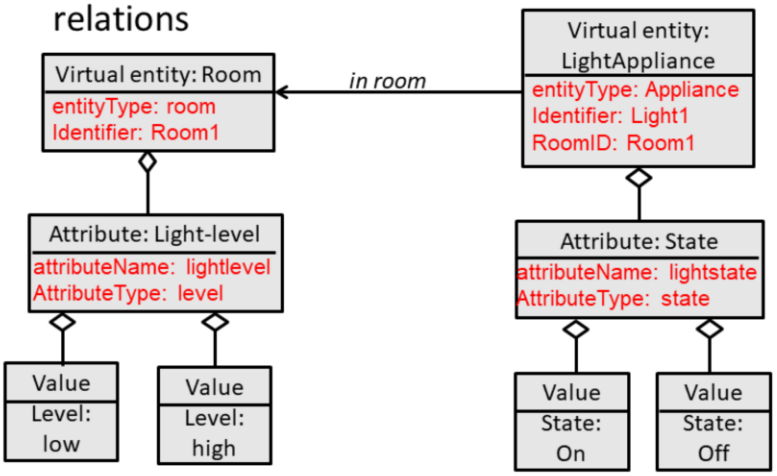
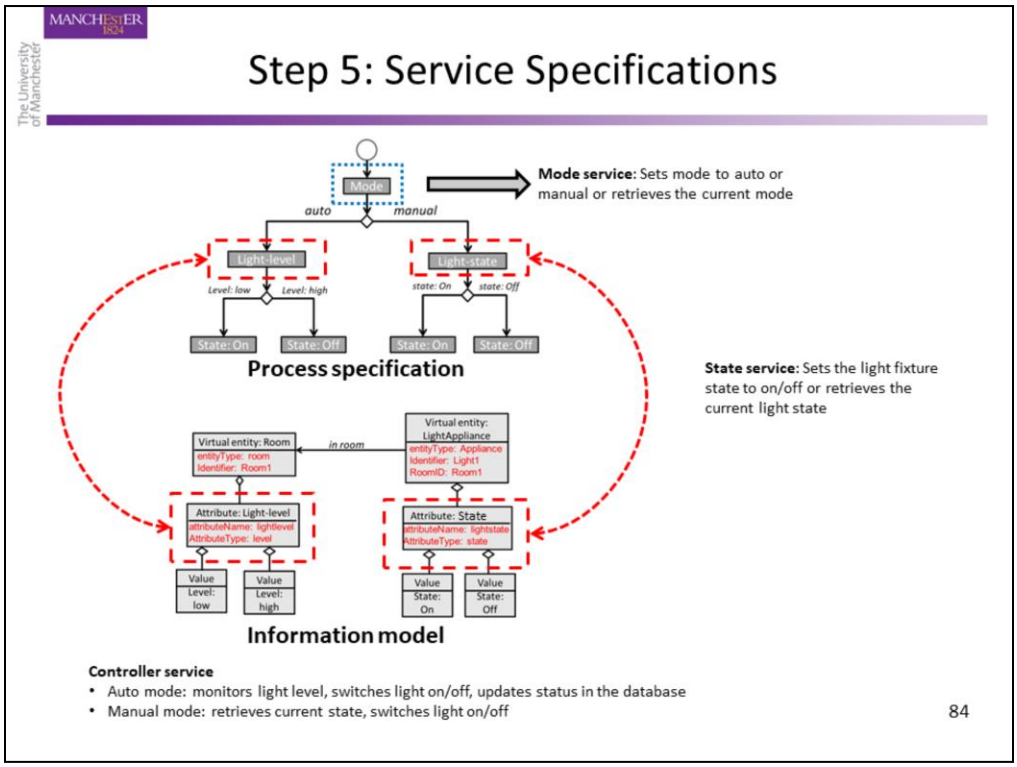
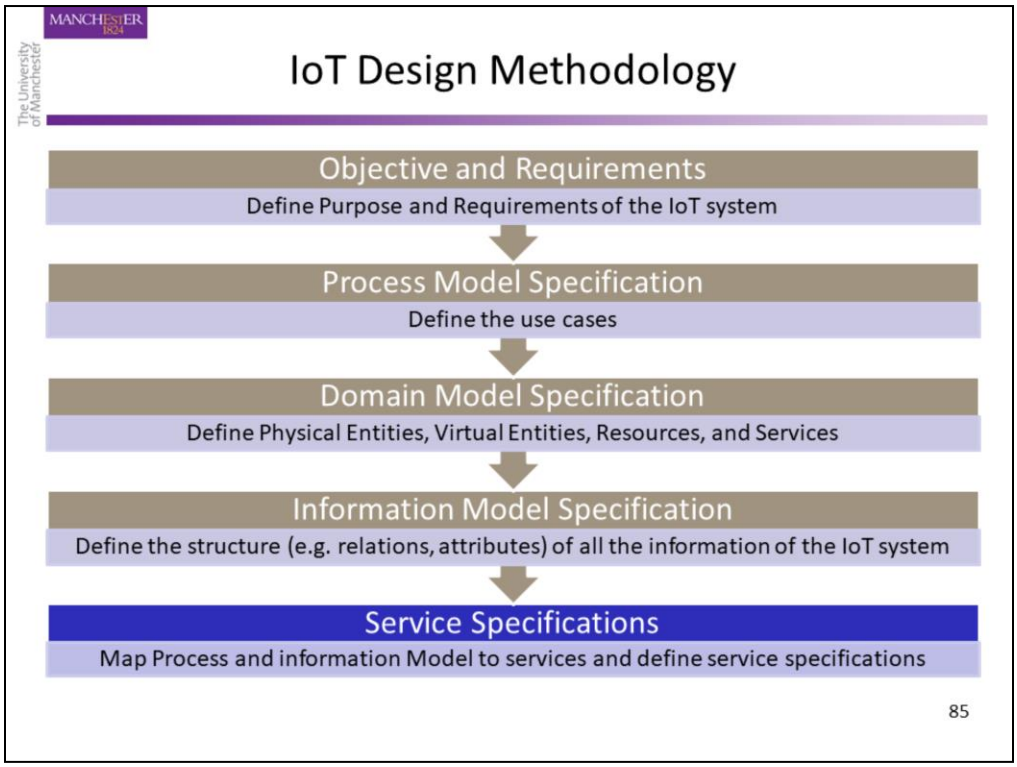
# Step 4: Information Model Specification

- List all the VEs of the system
- Determine the attributes of each VE and their relations






- The services employed in the home automation system are derived by the **process specification** and the **information model**
- From the process specification and information model, the states and attributes can be identified.
- For each state and attribute, a service is defined where these services either change the state or attribute values or retrieve the current value.
- The service specifications (described in detail in the next few slides) include the service types, service input/output, service endpoints, service schedules, service preconditions, and service effects.
- The Mode service can be a RESTful web service that sets the mode to auto or manual (PUT request) or retrieves current mode (GET request).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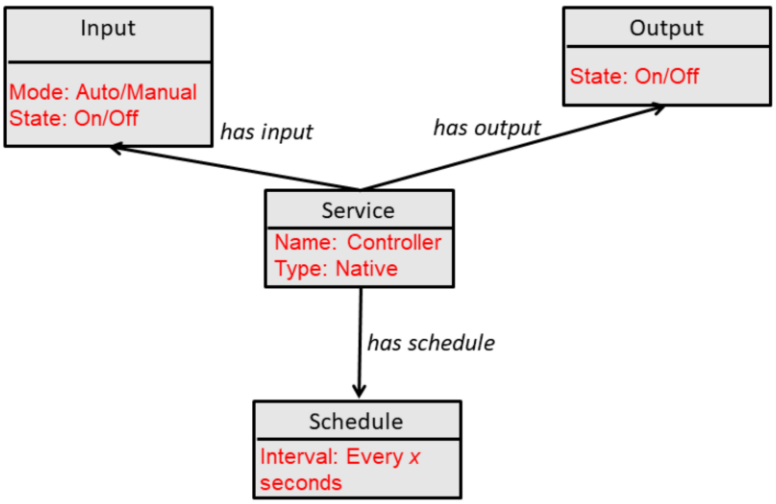
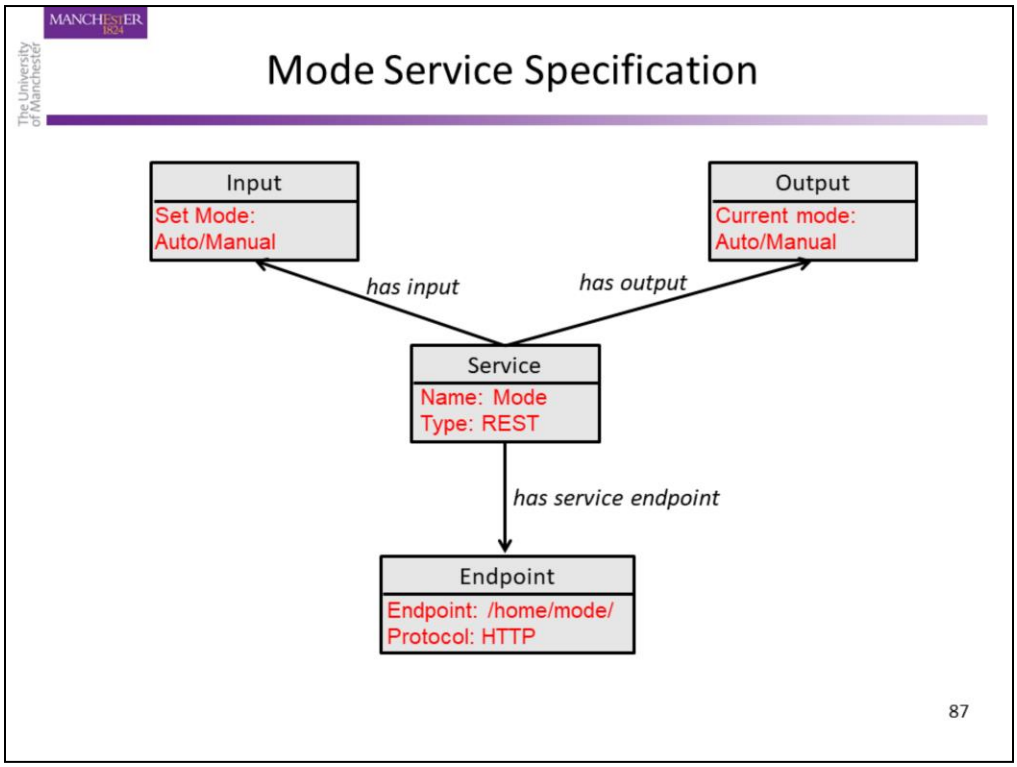
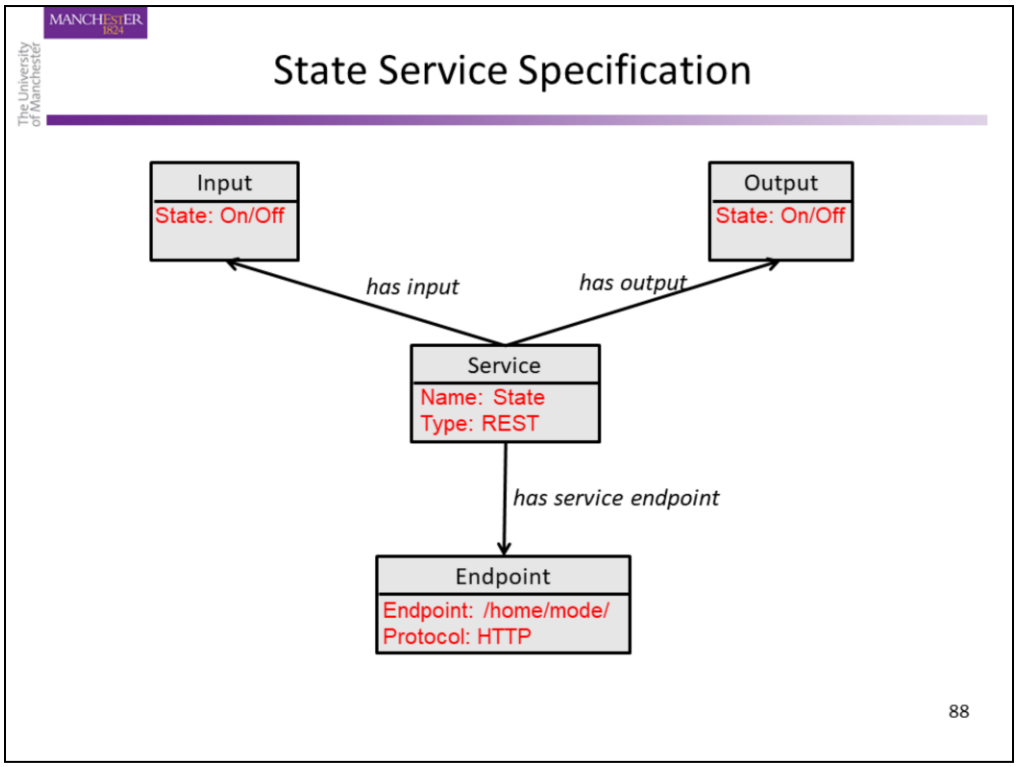
# Controller Service Specification



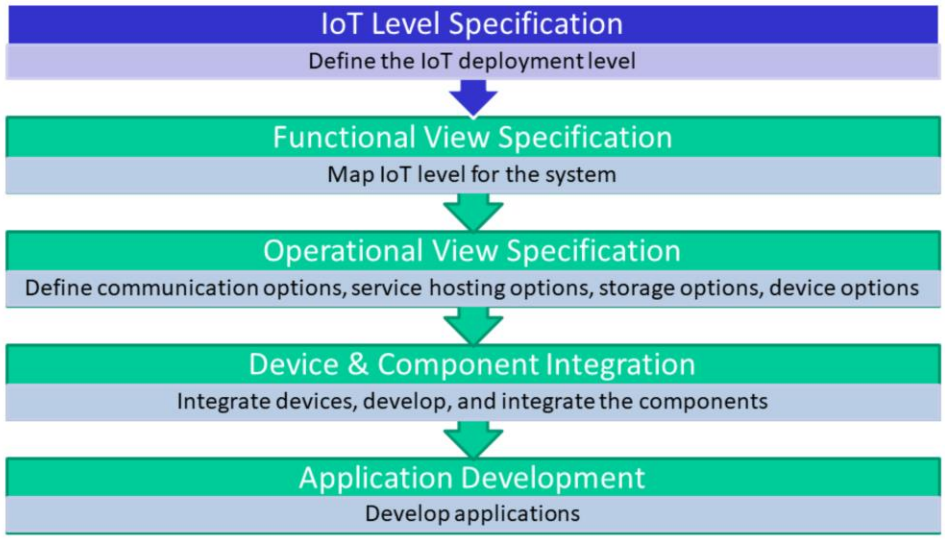



- Mode service is a RESTful web service setting the mode (PUT request) or retrieving the mode (GET request)
- The mode info is stored/retrieved from a database.




- State service is a RESTful web service that switches on and off the light similarly using PUT and GET requests.
- The state info is stored/retrieved from a database.
- A similar service can be described for the “Light-level” attribute.

# IoT Design Methodology (cont.)

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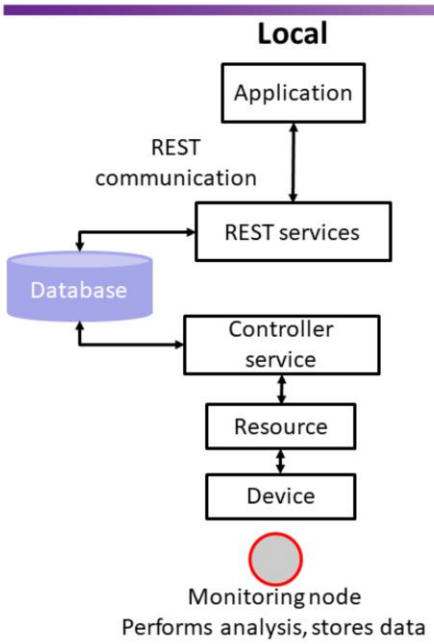
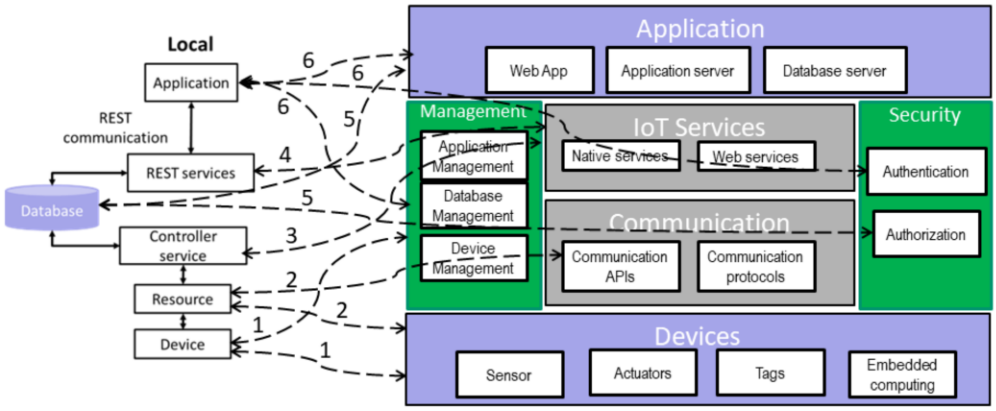
# Step 6: IoT (Deployment) Level Specification



# Mapping System Deployment to FGs




1. IoT Device map to the Device FG and the Management FG (device management)

2. Resources map to the Device FG (on-device resource) and Communication FG (communication APIs and protocols)

3. Controller service maps to the Services FG (native service).

4. Web Services map to Services FG (web services)

5. Database maps to the Management FG (database management) and Security FG (database security)

6. Application maps to the Application FG (web application, application and database servers), Management FG (app management) and Security FG (app security)

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# CASE STUDY: WEATHER MONITORING STATION

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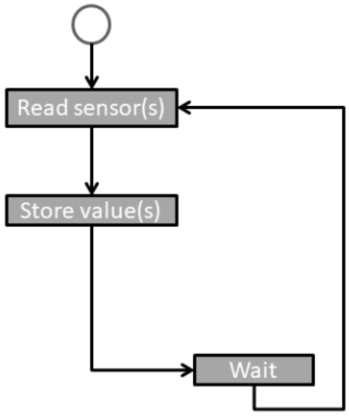
# Step 1: Objective & Requirements

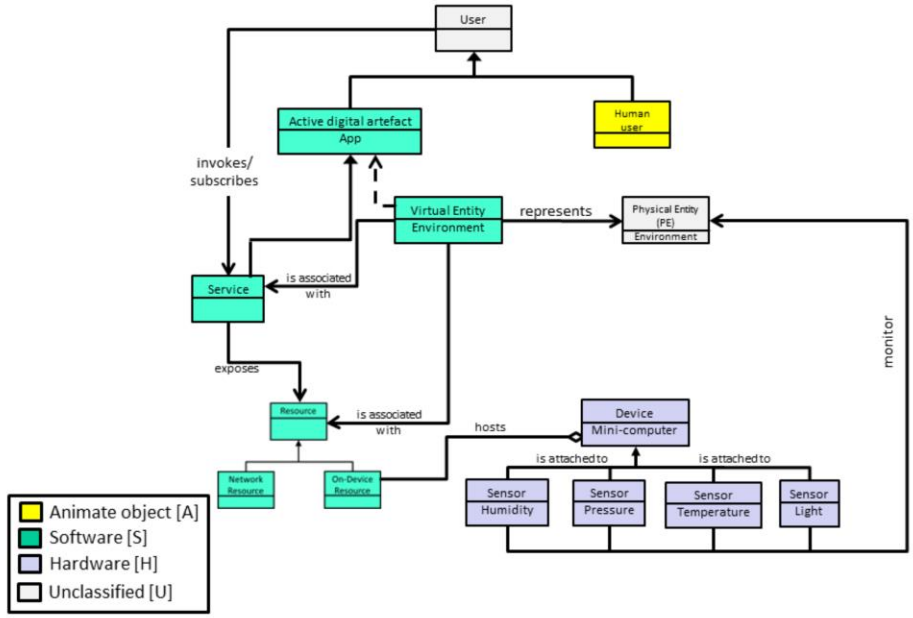
- Purpose: Gather environmental data, such as temperature, humidity, pressure, light level from multiple locations
  - **Multiple edge nodes**
- System management requirement
  - The system should support **remote** monitoring and storing of information
  - **Data capturing occurs periodically** (e.g., 10 sec)
  - User can potentially configure the monitoring interval
- Data analysis requirement
  - Data analysis is **not performed locally but rather at the back end**
- Security requirement
  - Ensure that only authorized devices communicate environmental data

# Step 2: Process Model Specification

- Define the use cases based on Step 1
- Essentially one node is considered for simplicity



# Step 3: Weather Station Domain Model

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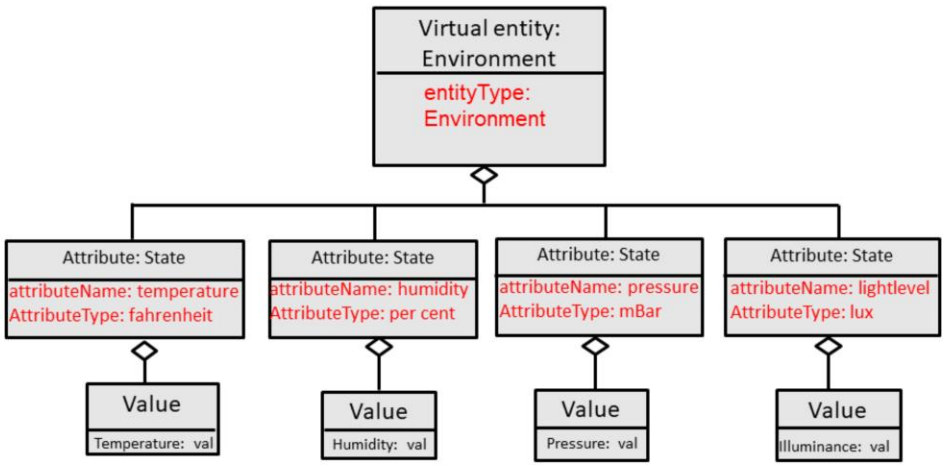
# Step 4: Information Model Specification

- List all the VEs of the system
- Determine the attributes of each VE and their relations

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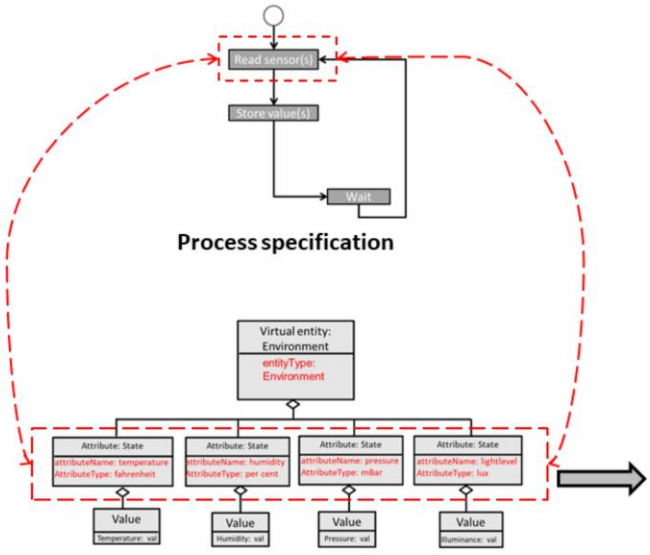
# Step 5: Service Specifications




**Process specification**




**Information model**

**Controller service:** Runs as a native service on the device. Gets the current temperature, pressure, humidity, and light reading and sends to the cloud database.

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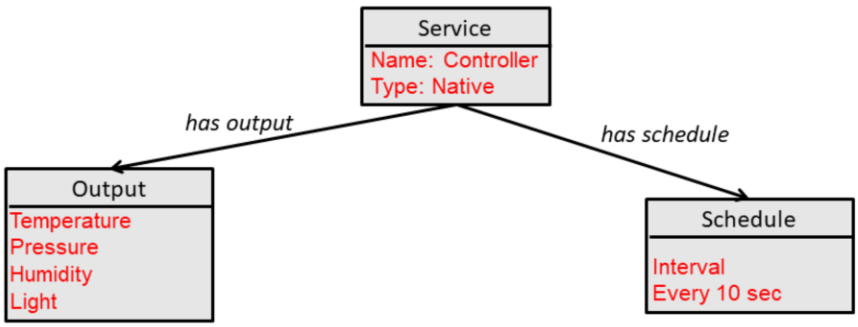
# Controller Service Specification

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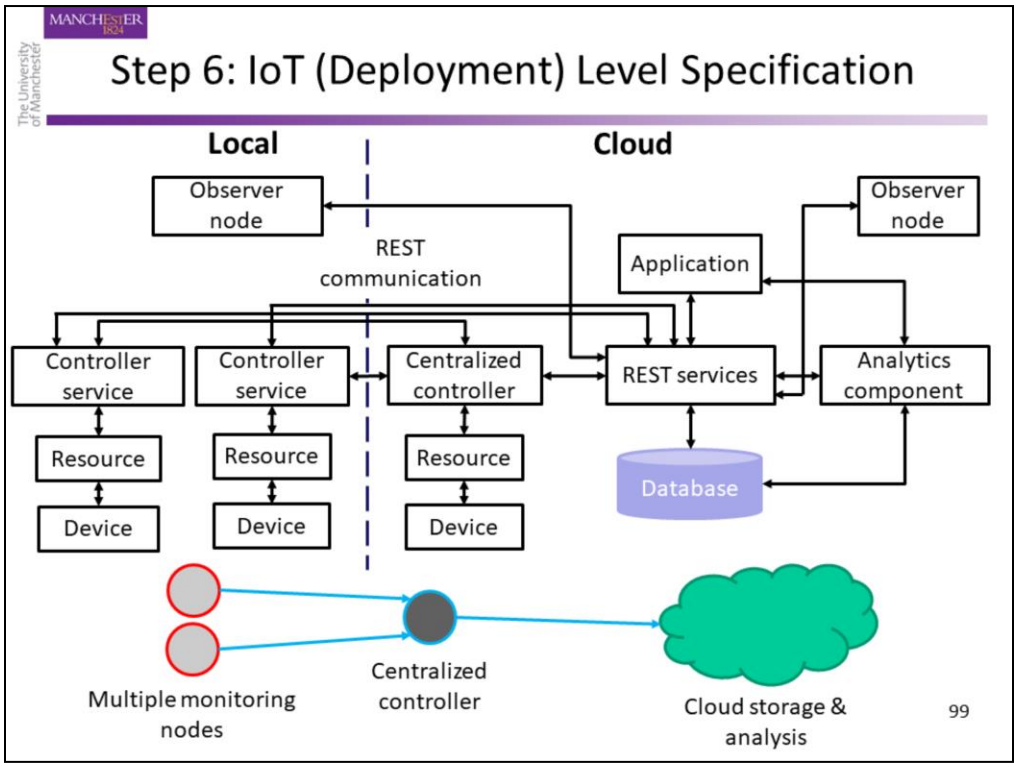
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Step 6: IoT (Deployment) Level Specification
Local
Cloud
Observer node
REST communication
Application
Observer node
Controller service
Controller service
Centralized controller
REST services
Analytics component
Resource
Resource
Resource
Database
Device
Device
Device
Multiple monitoring nodes
Centralized controller
Cloud storage & analysis
99