Network project

IOT

Smart Home System

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- ## IOT – Smart Home

The Internet of Things (IoT) is a network of interconnected devices embedded with sensors and software, enabling them to communicate and exchange data.

In smart homes, IoT is employed to integrate and automate various appliances, devices, and systems. Its use in smart homes enhances convenience by allowing remote control and monitoring of home devices via smartphones or voice commands.

IoT in smart homes contributes to energy efficiency by optimizing usage patterns and allowing for adaptive control of lighting, heating, and other utilities.

IoT integration in smart homes aims to create more comfortable, secure, and efficient living spaces by leveraging interconnected technologies.

- ## Protocols of IOT

1. MQTT (Message Queuing Telemetry Transport)

It is a lightweight message protocol crafted to facilitate effective device communication through a publish-subscribe approach, specifically within IoT environments. Employing a client-server structure, it involves three key elements: publishers, subscribers, and a broker, enabling seamless interaction among devices.

1. Publishers: These are devices or applications that generate data and publish it to a specific "topic" on the MQTT broker. A topic acts as a channel for communication, and multiple publishers can send messages to the same topic.

2. Subscribers: Devices or applications that are interested in receiving data subscribe to specific topics on the MQTT broker. Subscribers can receive messages from one or multiple topics they're subscribed to.

3. Broker: The MQTT broker is a server that acts as an intermediary between publishers and subscribers. It receives messages published by the publishers and delivers them to the appropriate subscribers based on their topic subscriptions. The broker manages the routing of messages, maintaining the information about which clients are publishing to which topics and which clients are subscribed to which topics.

2. CoAP (Constrained Application Protocol)

It is a specialized web transfer protocol designed for IoT devices operating in constrained environments. It enables efficient communication between devices with limited resources, such as sensors or small embedded systems, over low-power, low-bandwidth, or unreliable networks like UDP (User Datagram Protocol).

2.1 How CoAp Works

1. Request-Response Model: CoAP employs a request-response model similar to HTTP, enabling devices to communicate by exchanging requests and responses. Devices can make simple requests (GET, POST, PUT, DELETE) to retrieve or modify resources on other devices.

2. UDP-based Communication: CoAP operates over UDP, UDP is lighter than TCP. This reduces overhead and suits environments where devices have limited processing power or network bandwidth.

3. Lightweight Header: CoAP uses a compact header, reducing the overhead of each message and making it more suitable for communication among resource-constrained devices.

4. Resource-Oriented Communication: CoAP follows a RESTful design, where resources on devices are uniquely identified by a URI. Devices can interact with these resources using CoAP's methods, allowing for efficient handling and manipulation of resources.

5. Observing Resources: CoAP includes an observe feature that allows devices to "subscribe" to resources. When a change occurs in the observed resource, the server can notify subscribed clients about the changes, facilitating real-time communication and updates.

3. Difference between MQTT and CoAp

MQTT operates on a publish-subscribe model, while CoAP uses a request-response approach. MQTT typically uses TCP for communication, whereas CoAP is designed for UDP-based communication. MQTT offers a robust broker-based system, while CoAP focuses on lightweight, RESTful interactions suited for resource-constrained IoT environments.

- # Performance Evaluation of IoT Networks

As IoT networks become integral to various sectors, understanding the impact of topologies and scales on performance is crucial.

This explores the efficiency, scalability, and reliability of different network configurations.

1. Topologies in IoT Networks:

1.1 **Star Topology:** Simplifies network management but may face scalability challenges.

1.2 **Mesh Topology:** Enhances reliability with multiple communication paths but requires careful scalability management.

1.3 **Bus Topology:** Simplifies design but introduces vulnerabilities.

1.4 **Ring Topology:** Minimizes cabling but may be susceptible to disruptions.

2. Scale of IoT Networks:

2.1 **Small-scale:** Focuses on efficiency, response times, and energy consumption.

2.2 **Medium-scale:** Emphasizes network robustness and adaptability.

2.3 **Large-scale:** Addresses scalability, security, and data stream handling for smart cities and industrial IoT.

- ## Energy Consumption and Optimization of IoT Networks

With the widespread deployment of IoT devices, energy consumption has emerged as a pivotal concern. The efficient utilization of energy resources is essential not only for the longevity of IoT devices but also for minimizing environmental impact and ensuring the continuous and reliable operation of networked systems.

1. Challenges in Energy Consumption:

1.1 **Limited Power Sources**: Many IoT devices operate on constrained power sources, necessitating careful management to avoid premature battery depletion.

1.2 **Wireless Communication Overhead:** The wireless nature of IoT communication introduces energy inefficiencies, particularly in scenarios involving frequent data transmissions.

1.3 **Diverse Device Profiles:** The heterogeneity of devices within IoT networks adds complexity, as each device may have its unique energy consumption characteristics.

2. Optimization Strategies:

2.1 **Low-Power Hardware Design:** Developing and implementing energy-efficient hardware components and sensors can reduce the overall energy footprint of IoT devices.

2.2 **Energy-Aware Communication Protocols:** Optimizing communication protocols minimizes data exchanges, conserving energy in wireless IoT networks.

2.3 **Dynamic Power Management:** Implementing dynamic power management techniques, such as sleep modes and wake-up scheduling, enables devices to conserve energy during periods of inactivity.

2.4 **Energy Harvesting Technologies:** Integrating energy harvesting solutions, such as solar or kinetic energy, enables IoT devices to generate power autonomously, reducing reliance on traditional power sources.

- ## Project Description

-The setup involves a home gateway linked to a tablet or smartphone.

-Within the project, the outdoor area includes a garden equipped with a lawn sprinkler for watering plants and a water drain to manage excess water.

There is a motion detector and outdoor camera to capture movement around the house. An RFID reader authenticates entry using RFID cards, permitting only the homeowner's card to unlock the entrance door.

-The garage area features a door that opens only upon detecting motion for a vehicle's entry.
For managing the exhaust emissions from old cars, smoke, carbon monoxide, and carbon dioxide detectors are installed. In case of danger, a blower, siren, and window are activated to reduce risks associated with emitted smoke.

-The bedroom automatically locks its door when no motion is detected outside the room for safety. Motion triggers the lights and unlocks the door.
The room includes features such as window, an air conditioner, and a music player. All devices deactivate when the room is unoccupied and can only be activated remotely through the smartphone.

-In the kitchen, the door automatically locks when no outside motion is detected, ensuring safety. Motion prompts the door to open and triggers the lighting system.
Within this space, there are appliances such as a ceiling fan, coffee machine, and boiler.
A humidity detector regulates moisture levels by deactivating the coffee machine and boiler and activating the ceiling fan if humidity exceeds normal levels.

- ## Project Objective

This project aims to establish a comprehensive smart home environment using IoT principles, integrating devices indoors and outdoors to enhance convenience, efficiency, and safety.

One primary aim is to establish flawless connectivity among home devices for centralized control via a smartphone or tablet, allowing remote management of household functions.

Another focus is on safety, achieved through implementing motion detectors, camera, RFID authentication to ensure secure access control to potential risks.

- ## Used Simulator

Cisco Packet Tracer.

- ## Used Protocols

The smartphone establishes a connection with the home gateway to enable communication with various devices via the DHCP (Dynamic Host Configuration Protocol).

In this setup, the home gateway serves as the DHCP server, responsible for assigning unique IP addresses automatically to each IoT device. This method simplifies network setup.

Each device's limitations are listed by connecting to the smartphone through the home gateway, accessing a web service, and inputting the home gateway's IP address using the HTTPS protocol.
This approach promotes effective and dependable communication among the IoT devices and the larger network framework.

- **Used Devices**

Number	Device	Function
1.	Smart Phone/Tablet	Connect to home getaway to access smart device.
2.	Home Gateway	Used to register smart device and give IP address to it, then you can remotely manage through a web interface hosted.
3.	RFID Reader	Read the ID of an RFID Card, transmit that ID to check whether it's correct to validate the user's entrance to home.
4.	RFID Card	Interacts with the RFID Reader.
5.	Smart Door	It opens once there's motion detected outside the rooms/home.
6.	Motion Detector	Connect to home getaway and provide Detection of motion outside the home or outside the rooms.
7.	Webcam	Monitoring what's happening outside, it works when the detector detect motion outdoor.
8.	Lawn Sprinkler	Sprinkler that puts out water.
9.	Water Drain	Employed to absorb surplus water within the garden area to enhance safety.

10.	Smart Window	Opens once the room is unlocked if needed, it closes once the air conditioner is ON.
11.	Siren	Provide sound as alarm when there's smoke detected at the garage.
12.	Blower	Activated upon smoke detection to reduce its presence within the garage space.
13.	Garage Door	Automatically opens when there is a car coming.
14.	Carbon Monoxide Detector	Detects the level of the carbon monoxide, siren will be turned on when the level > 20%.
15.	Carbon Dioxide Detector	Detects the level of the carbon dioxide, siren will be turned on when the level > 40%.
16.	Smoke Detector	Detects the level of the smoke of old cars, siren will be turned on when the level > 50%.
17.	Old Car	Used as simulator at the garage, which provides car smokes.
18.	Light	Used to enlighten the room/kitchen when there is motion detected.
19.	Portable Music Player	Plays music when the bedroom's door is unlocked.
20.	Air Conditioner	Used to reduce the temperature of the room when it's too hot.
21.	Appliance	Used as coffee machine at kitchen.
22.	Humidifier	Used as boiler at kitchen.
23.	Humidity Monitor	Detects the level of the humidity at the kitchen, boiler/coffee machine will be turned off and ceiling fan will be turned on when the level = 85%.
24.	Ceiling Fan	Used to ventilate the home environment.

- **Snapshot of simulation**

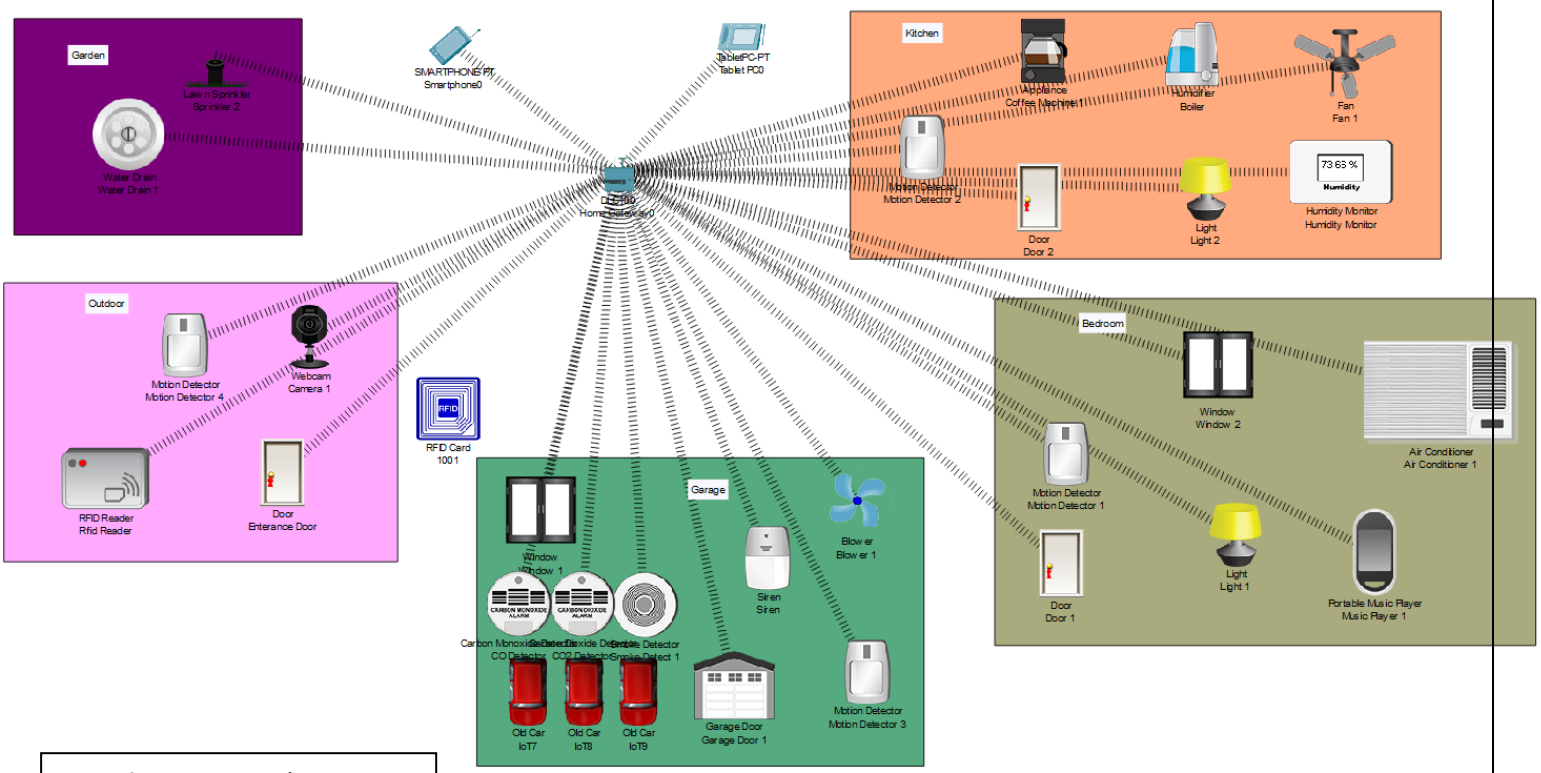


Figure -1 Simulation.

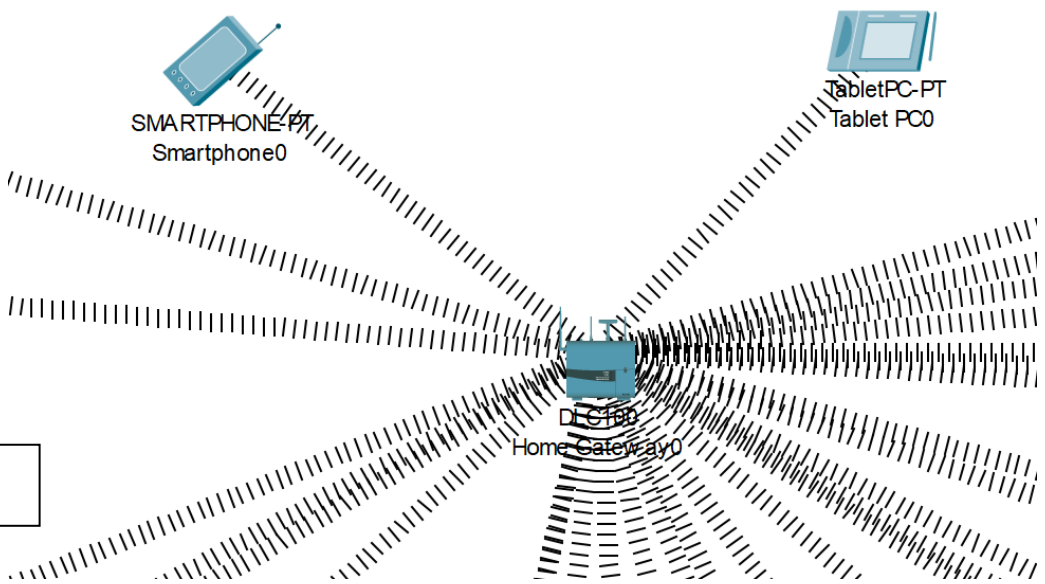


Figure-2 Network topology.

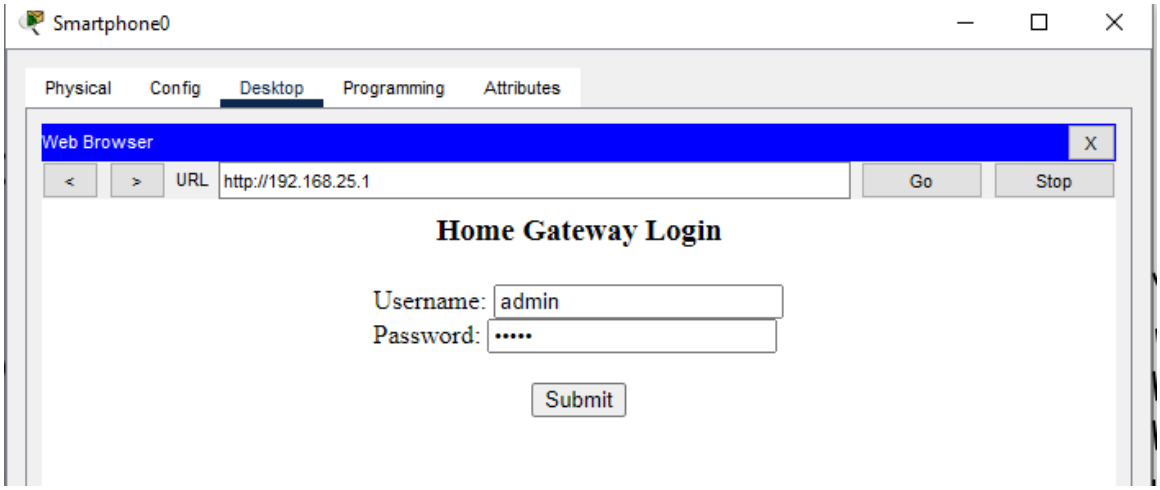


Figure-3 Login to Home Gateway.

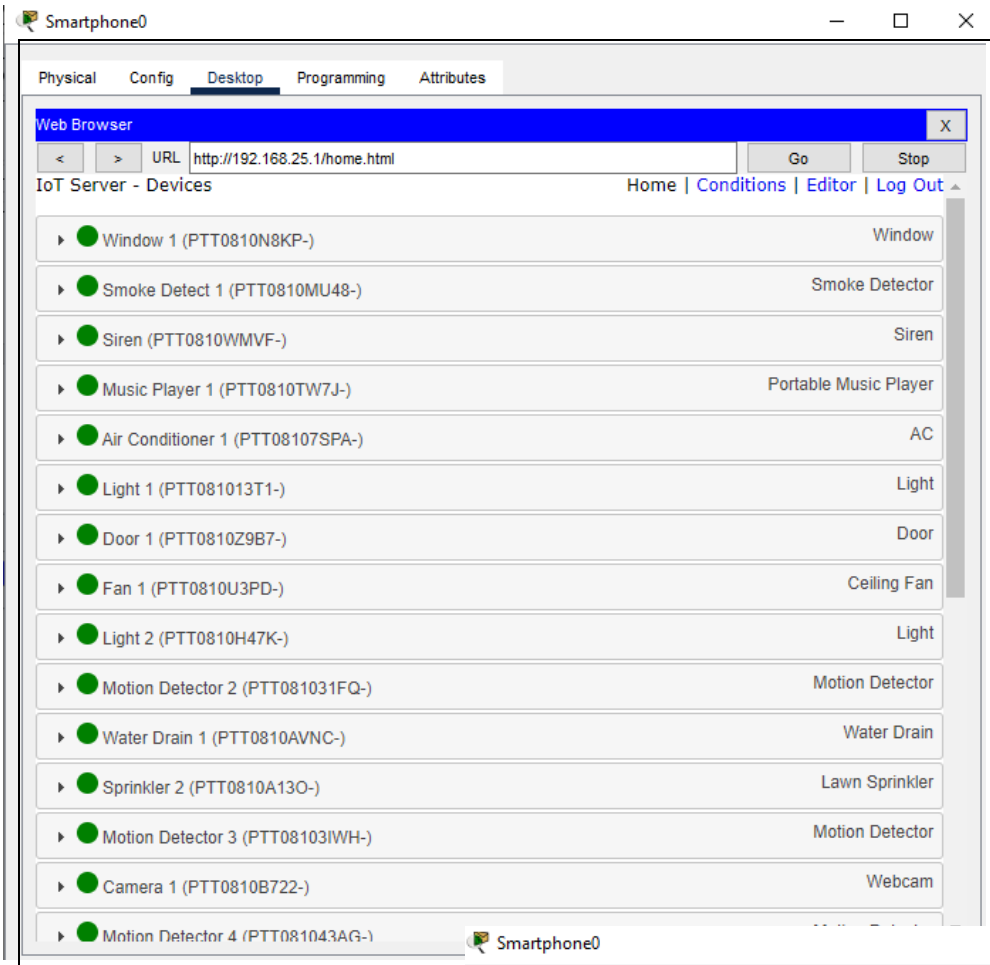
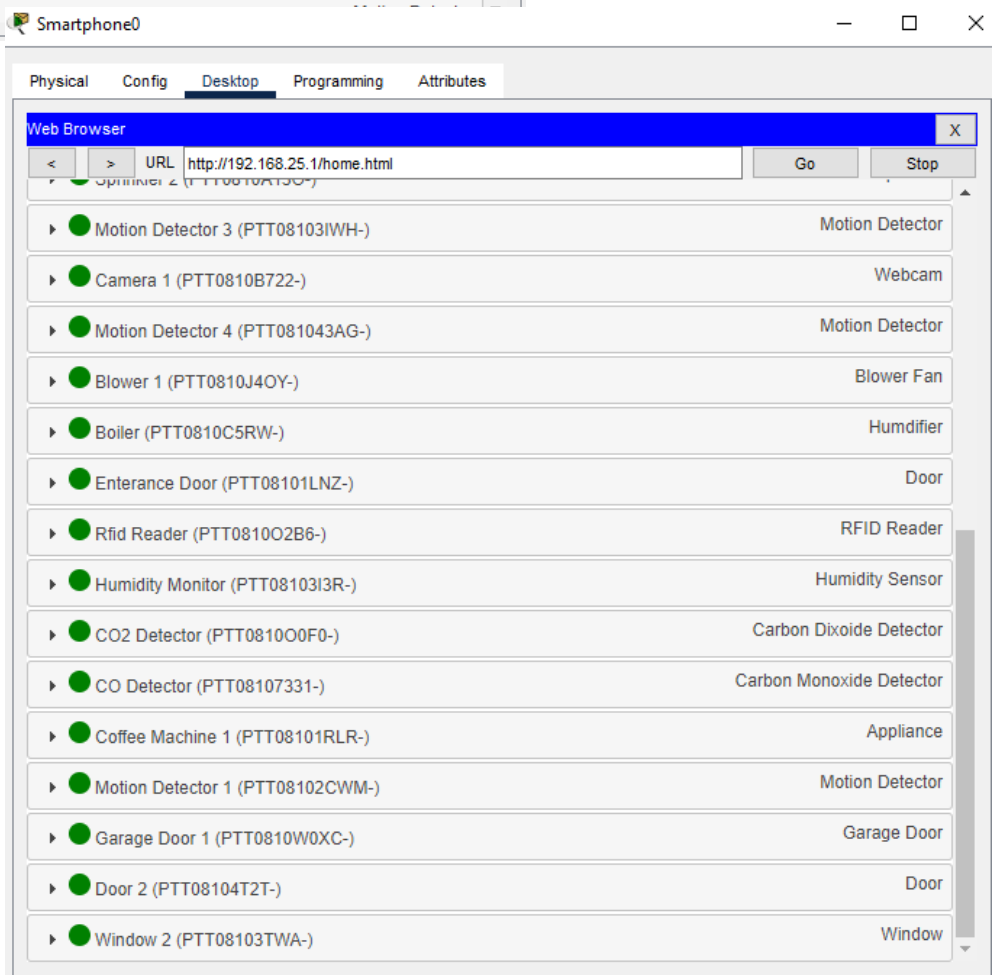
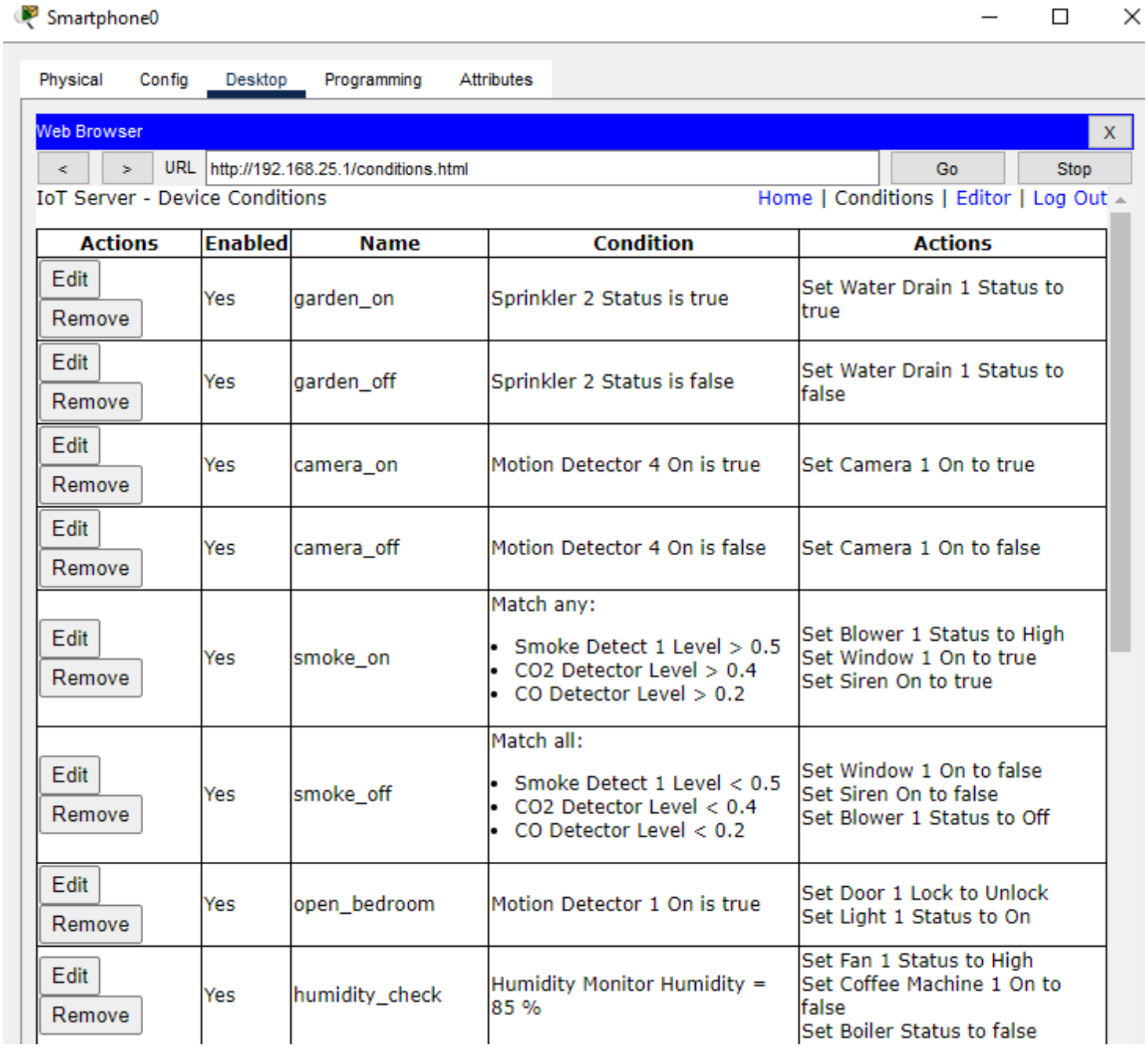


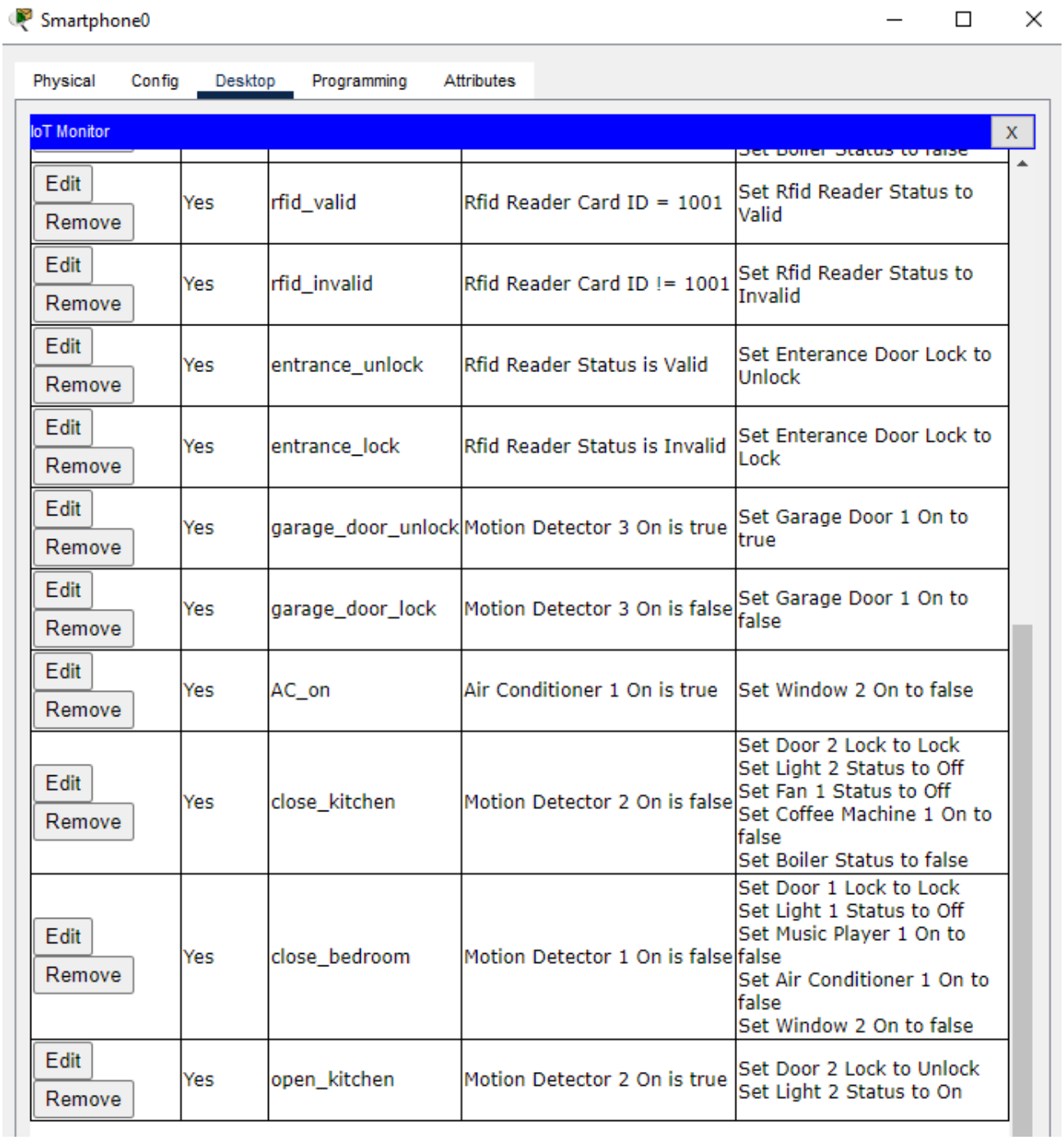
Figure-4,5 Connected Devices.





Actions	Enabled	Name	Condition	Actions
Edit Remove	Yes	garden_on	Sprinkler 2 Status is true	Set Water Drain 1 Status to true
Edit Remove	Yes	garden_off	Sprinkler 2 Status is false	Set Water Drain 1 Status to false
Edit Remove	Yes	camera_on	Motion Detector 4 On is true	Set Camera 1 On to true
Edit Remove	Yes	camera_off	Motion Detector 4 On is false	Set Camera 1 On to false
Edit Remove	Yes	smoke_on	Match any: • Smoke Detect 1 Level > 0.5 • CO2 Detector Level > 0.4 • CO Detector Level > 0.2	Set Blower 1 Status to High Set Window 1 On to true Set Siren On to true
Edit Remove	Yes	smoke_off	Match all: • Smoke Detect 1 Level < 0.5 • CO2 Detector Level < 0.4 • CO Detector Level < 0.2	Set Window 1 On to false Set Siren On to false Set Blower 1 Status to Off
Edit Remove	Yes	open_bedroom	Motion Detector 1 On is true	Set Door 1 Lock to Unlock Set Light 1 Status to On
Edit Remove	Yes	humidity_check	Humidity Monitor Humidity = 85 %	Set Fan 1 Status to High Set Coffee Machine 1 On to false Set Boiler Status to false

Figure-6 Project Constraints.



Edit Remove	Yes	rfid_valid	Rfid Reader Card ID = 1001	Set Rfid Reader Status to Valid
Edit Remove	Yes	rfid_invalid	Rfid Reader Card ID != 1001	Set Rfid Reader Status to Invalid
Edit Remove	Yes	entrance_unlock	Rfid Reader Status is Valid	Set Enterance Door Lock to Unlock
Edit Remove	Yes	entrance_lock	Rfid Reader Status is Invalid	Set Enterance Door Lock to Lock
Edit Remove	Yes	garage_door_unlock	Motion Detector 3 On is true	Set Garage Door 1 On to true
Edit Remove	Yes	garage_door_lock	Motion Detector 3 On is false	Set Garage Door 1 On to false
Edit Remove	Yes	AC_on	Air Conditioner 1 On is true	Set Window 2 On to false
Edit Remove	Yes	close_kitchen	Motion Detector 2 On is false	Set Door 2 Lock to Lock Set Light 2 Status to Off Set Fan 1 Status to Off Set Coffee Machine 1 On to false Set Boiler Status to false
Edit Remove	Yes	close_bedroom	Motion Detector 1 On is false	Set Door 1 Lock to Lock Set Light 1 Status to Off Set Music Player 1 On to false Set Air Conditioner 1 On to false Set Window 2 On to false
Edit Remove	Yes	open_kitchen	Motion Detector 2 On is true	Set Door 2 Lock to Unlock Set Light 2 Status to On

Figure-7 Project Constraints.

- ## Description of constraints

1. When the Lawn Sprinkler is turned on, the Water Drain absorbs excess water, and it deactivates when the sprinkler is turned off.

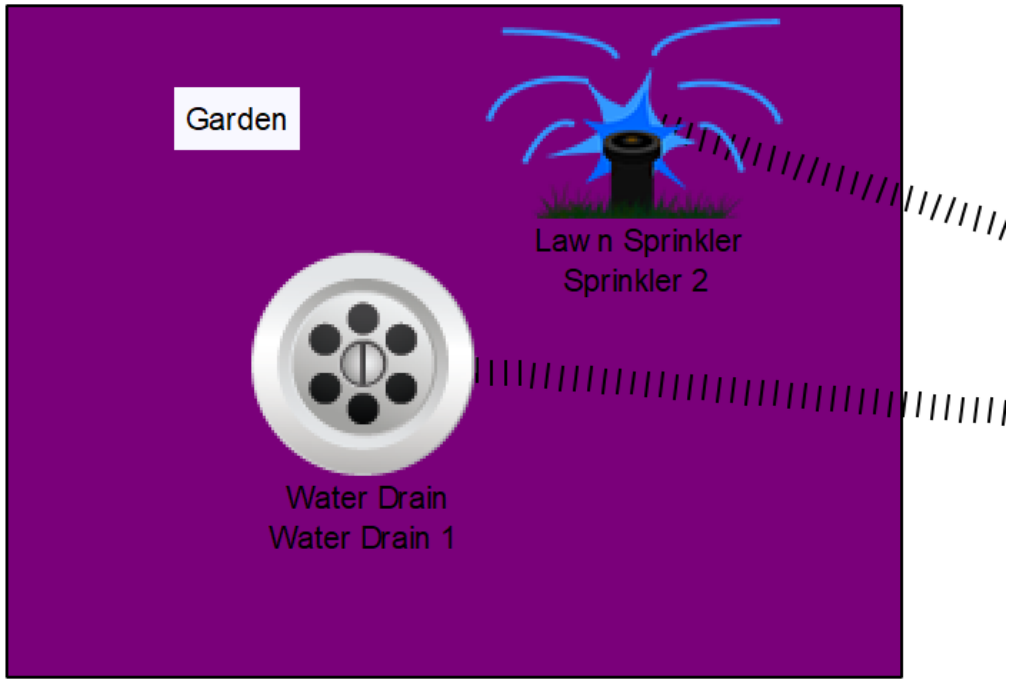


Figure-8 Garden Area.

2. When outdoor motion is detected by the motion detector, the webcam captures who is outside in that area.

3. The entrance door unlocks upon the recognition of the RFID ID card by the RFID reader otherwise, the entrance door remains locked.

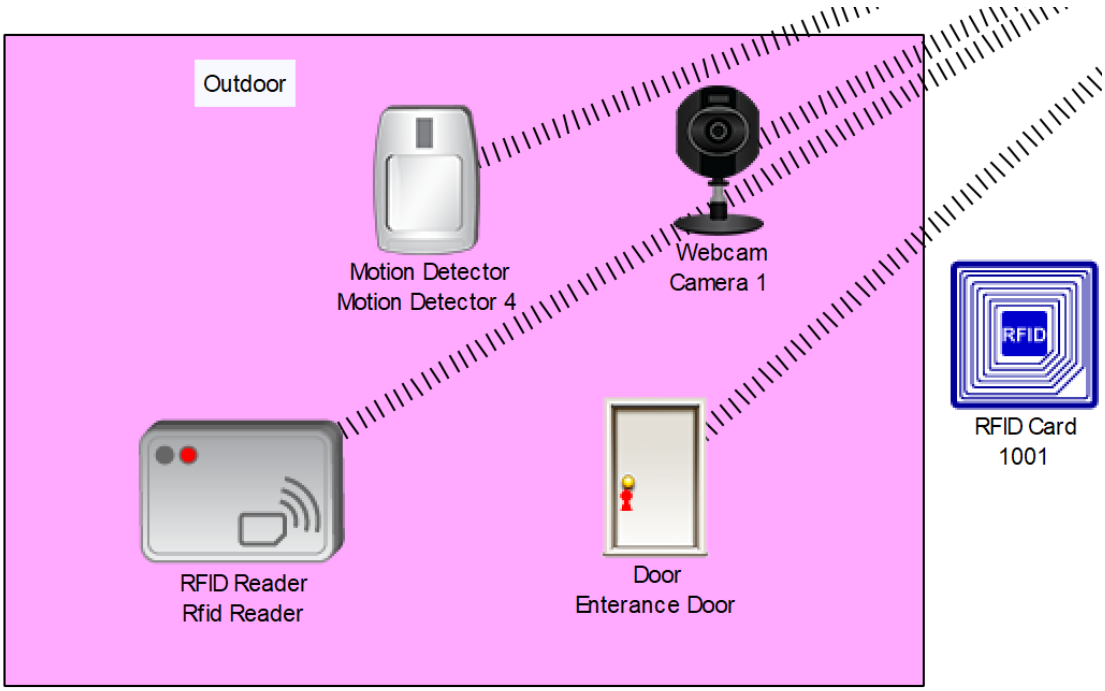


Figure-8 Outdoor Locked.

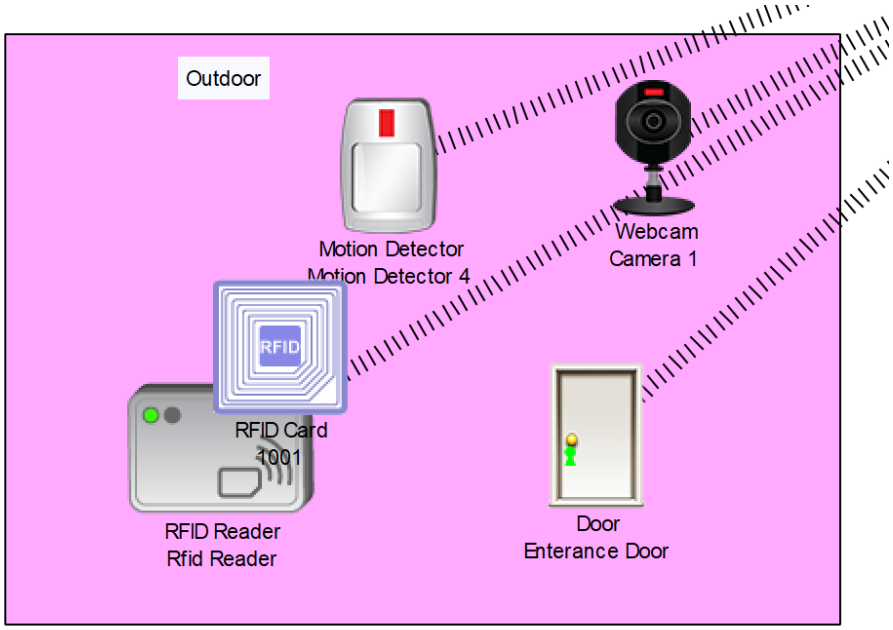


Figure-9 Outdoor Unlocked.

4. When the motion detector senses a car entering, it automatically opens the garage door, otherwise, it remains secured.

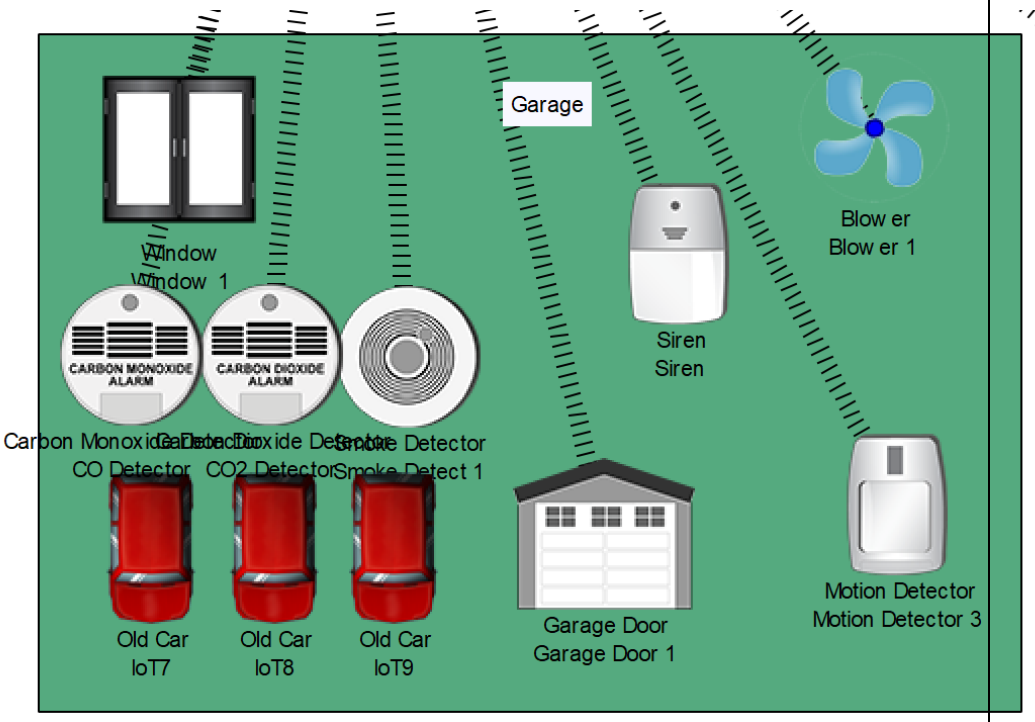


Figure-10 Garage Locked.

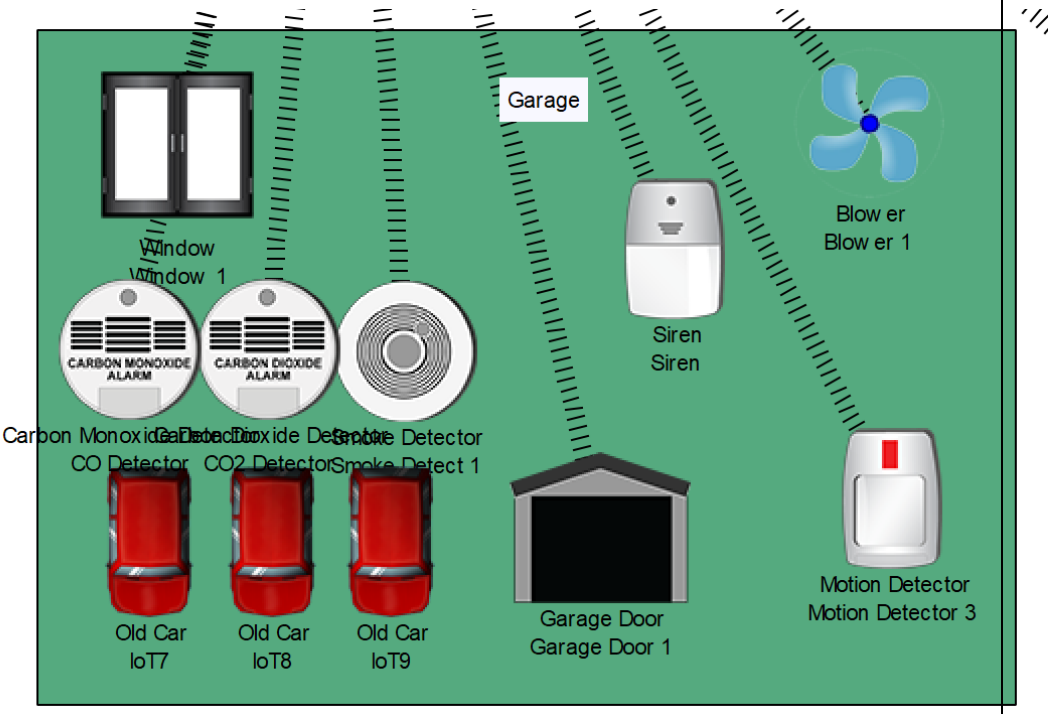


Figure-11 Garage Unlocked.

5. When excessive smoke from an older car's exhaust fills the garage, the smoke detector triggers if the smoke level exceeds 50%, the CO detector activates at smoke level exceeds 20%, the CO2 detector is triggered when the smoke level rises above 40%.
   Upon activation of any of these detectors, the blower switches to high, the window opens, and the siren activates.
   These safety measures persist until all detectors return to their normal levels.

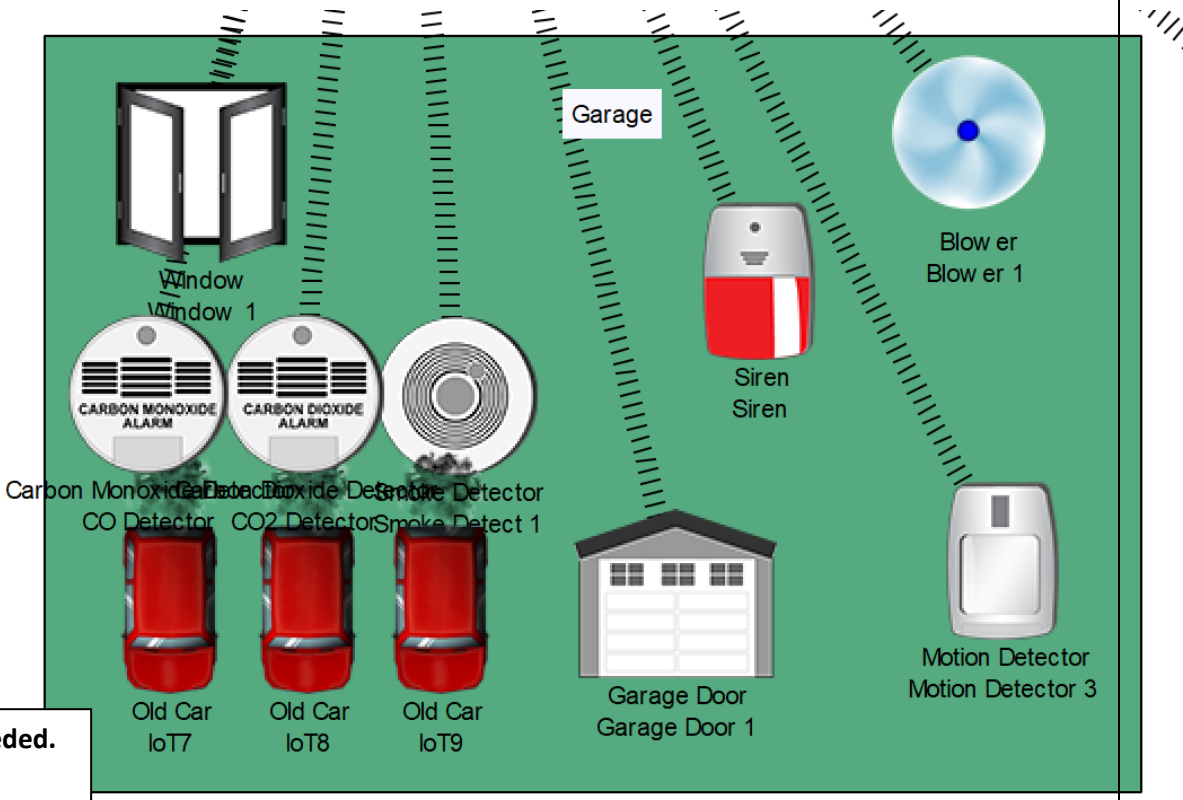
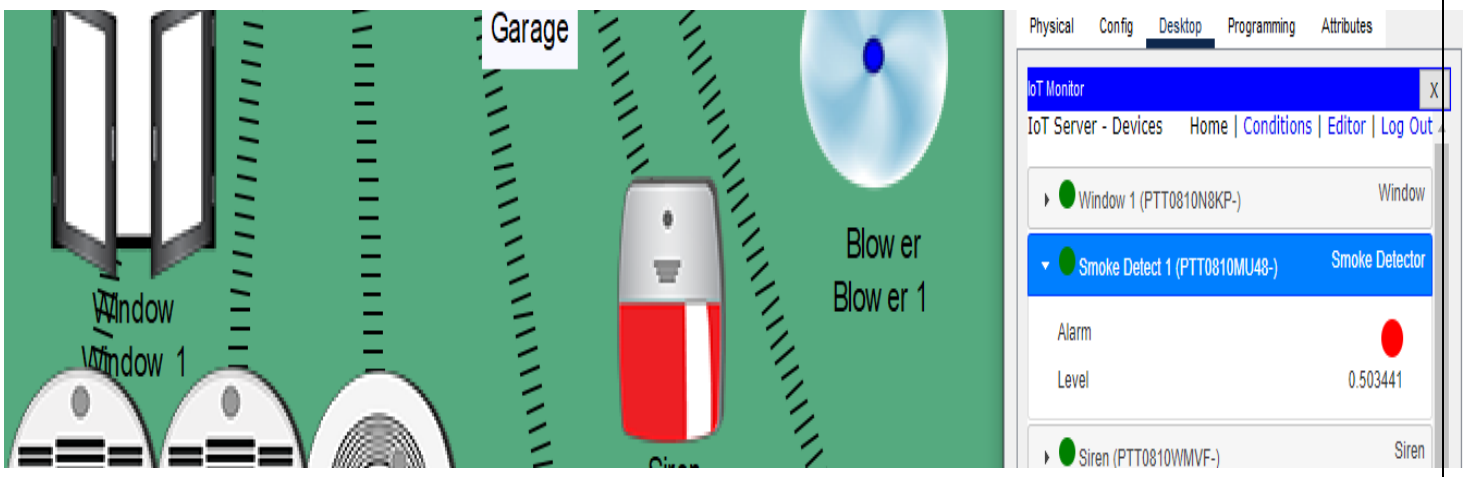


Figure-12,13 Smoke level exceeded.



6. When the motion detector senses someone is about to enter the bedroom, the door automatically opens and the light is turned on, when the door is unlocked the person can open the window, air conditioner and music player, otherwise, if there is no motion the door remains locked.

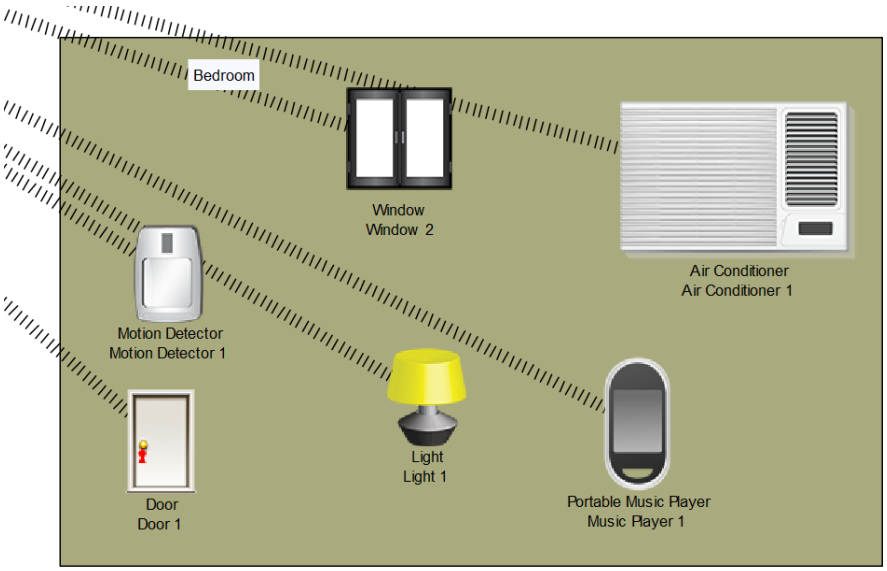


Figure-14 Bedroom Locked.

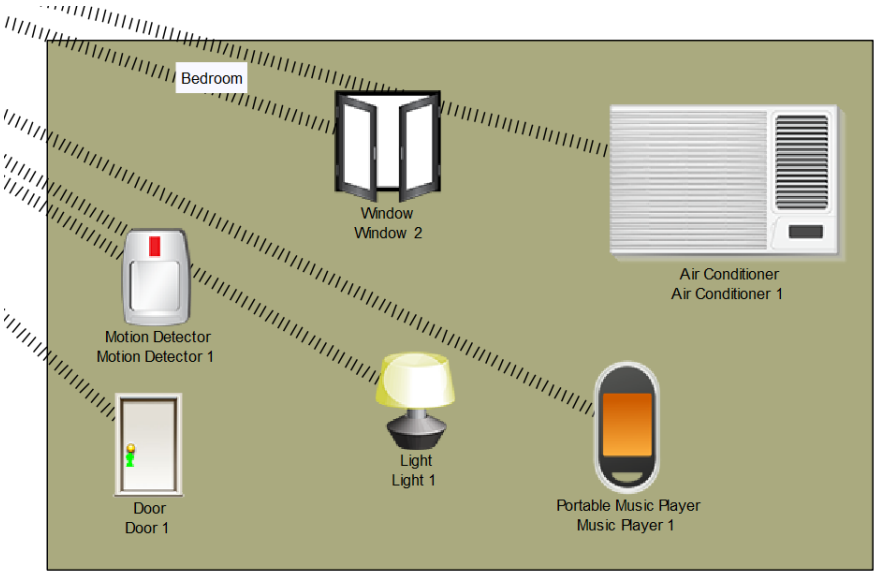


Figure-15 Bedroom Unlocked.

7. Once the air conditioner is ON in the bedroom, the window is turned off automatically.

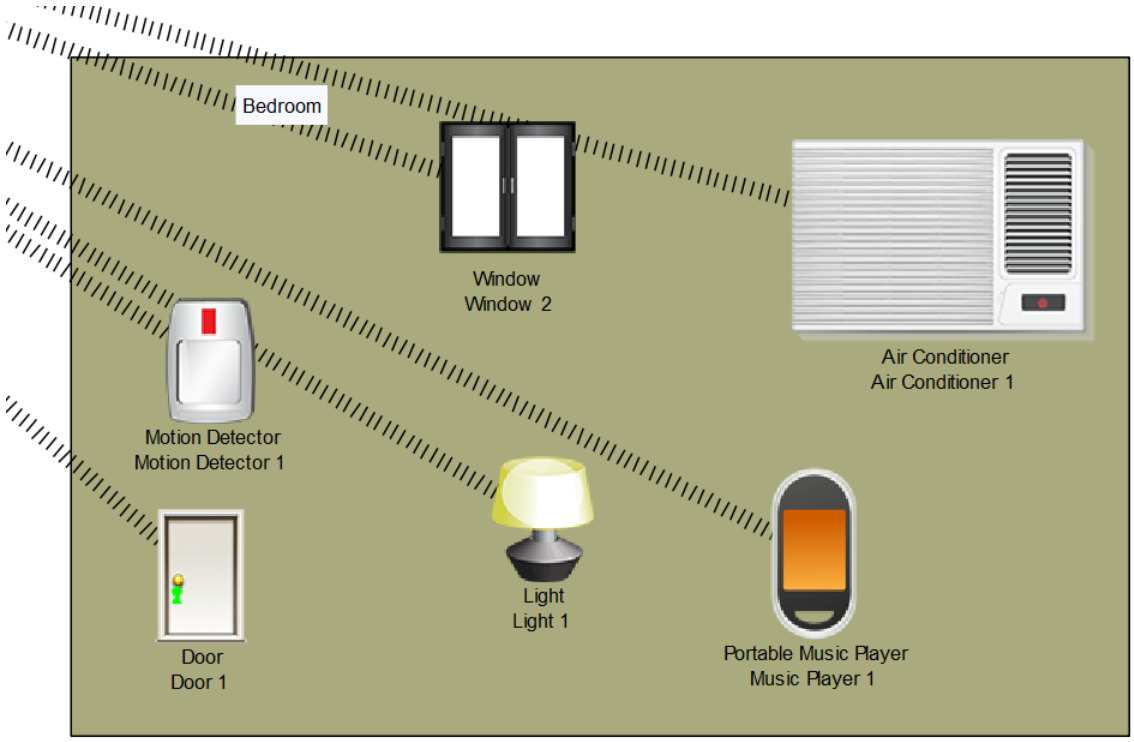


Figure-16 AC on.

8. When the motion detector senses someone is about to enter the kitchen, the door automatically opens and the light is turned on, when the door is unlocked the person can turn on the ceiling fan, boiler and coffee machine, otherwise, if there is no motion the door remains locked.

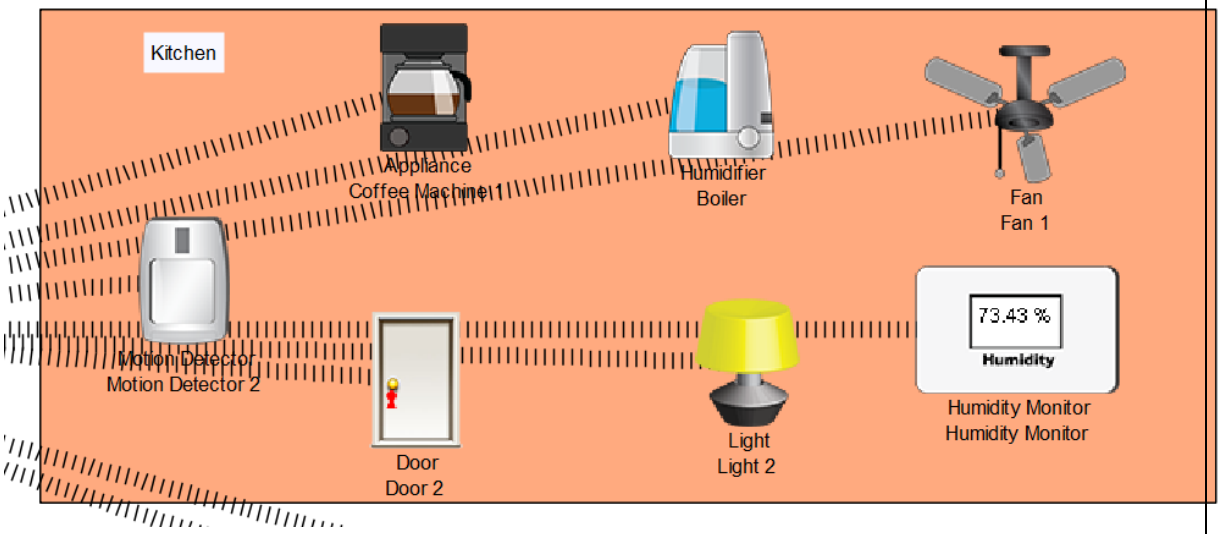


Figure-17 Kitchen Locked.

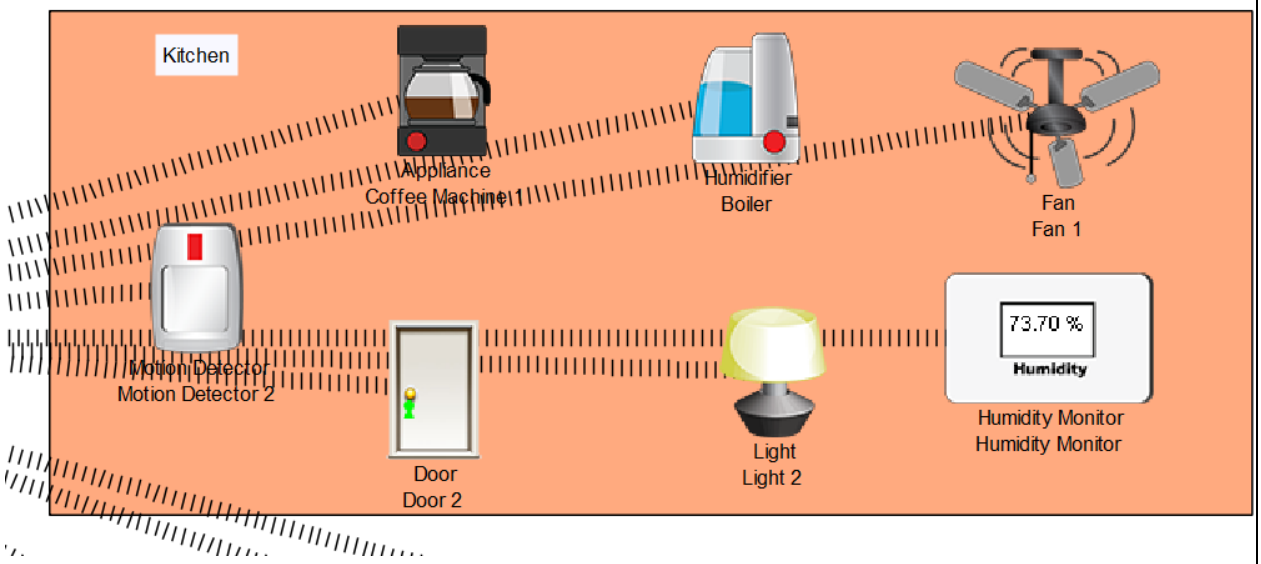


Figure-18 Kitchen Unlocked.

9. When the humidity monitor's level = 85%, the ceiling fan is turned on, coffee machine and boiler are turned off to reduce humidity level.

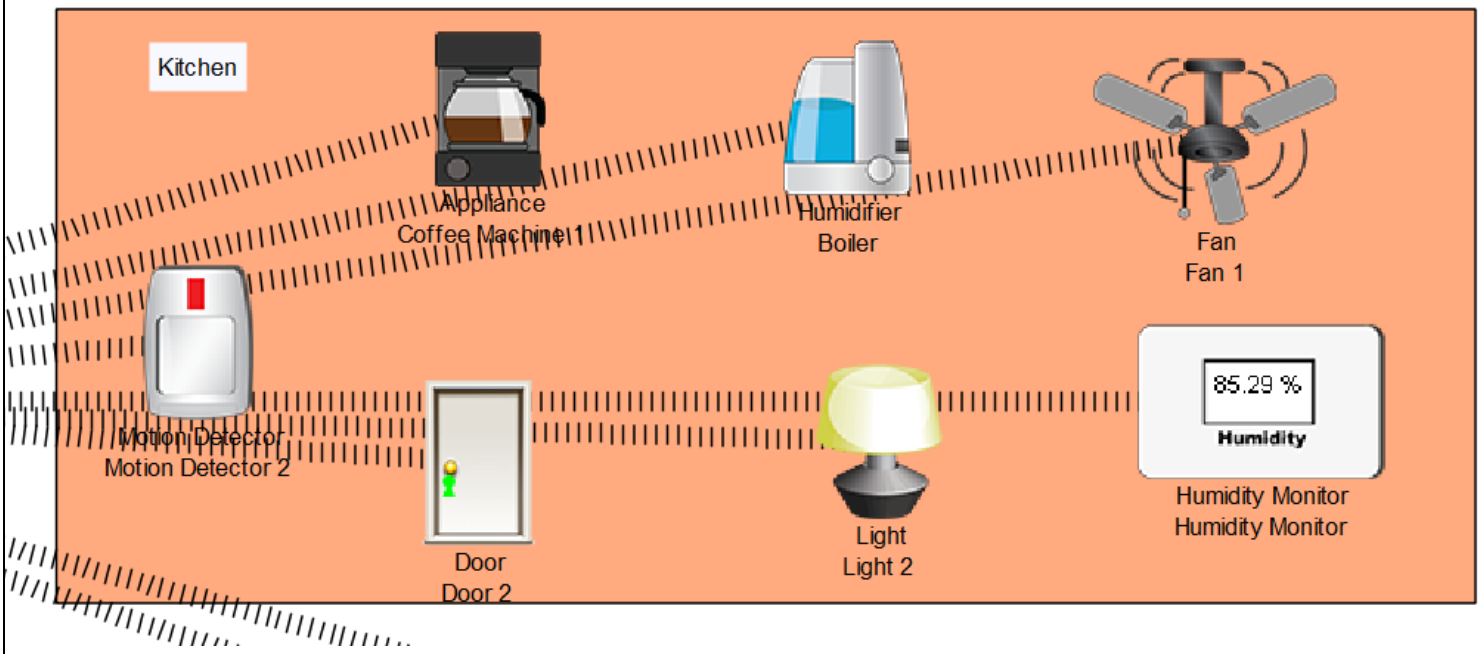


Figure-19 Humidity check.

- ## In conclusion

The Internet of Things (IoT) has emerged as a transformative force, reshaping the way we interact with and manage our living spaces. This project has presented a comprehensive IoT home automation that intricately weaves together technology, security, and user-centric design to create an intelligent and responsive environment.

The project's strength lies in its holistic approach, covering various areas of the home, from the garden to the bedroom and garage. Through the deployment of sensors, detectors, and control mechanisms, each space is imbued with smart features that adapt to the occupants' needs, enhancing both convenience and safety.

Security is a paramount consideration in the project, evident in features such as RFID authentication, motion-triggered locking mechanisms, and detectors for hazardous emissions. These elements contribute to a sense of safety and well-being, aligning with the core principles of a modern, connected home.

The seamless communication between devices is facilitated by established protocols like DHCP and HTTPS. The use of DHCP simplifies network setup, while HTTPS ensures secure interactions, safeguarding user data and privacy. The smartphone acts as a central hub, enabling users to remotely control and monitor their home, underscoring the project's commitment to user convenience.

In conclusion, this IoT home automation project stands as a testament to the potential of smart technologies to redefine our living spaces. By fusing innovation with practicality, security, and user-centered design, the project encapsulates the essence of the IoT revolution—a future where homes are not just smart but also responsive to the diverse needs and preferences of their occupants. As we embrace the era of IoT, projects like these pave the way for a more connected, efficient, and intelligent way of living.

Thus, the objective of our experiment has been achieved.