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NATIONAL SCHOOL OF ARTS AND CRAFTS - MEKNES

Software Engineering and Intelligent Systems(GI-ILSI)

SMART OFFICE PROJECT

IoT Implementation Report

Project Context

This project was realized within the scope of the IoT module.
Concept: Design and Simulation of an Intelligent Office Environment using Packet Tracer.

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Contents

List of Figures

Chapter 1

Introduction

1.1 Project Context

In the era of Digital Transformation, the Internet of Things (IoT) has become a cornerstone of modern infrastructure management. The concept of a "Smart Office" integrates network devices, sensors, and automated controls to create a workspace that is not only efficient but also safe and comfortable for its occupants.

This project, realized as part of the IoT module at the National School of Arts and Crafts (ENSAM) Meknes, aims to simulate a fully functional Smart Office environment using Cisco Packet Tracer. The simulation demonstrates how various IoT components can interact within a structured network to provide real-time monitoring and automation.

1.2 Objectives

The primary objectives of this project are:

- **Automation:** reducing manual intervention for standard operations like lighting and temperature control.
- **Security:** implementing access control for restricted areas using RFID technology.
- **Safety:** deploying a responsive fire detection system that triggers automated countermeasures.
- **Energy Efficiency:** utilizing motion sensors to ensure resources (lights, fans) are only used when needed.

1.3 Tools Used

The project was designed and tested using **Cisco Packet Tracer v8.2**. This powerful simulation tool allows for the creation of complex network topologies and the programming of IoT devices using Python/JavaScript, mimicking real-world behavior. The visual design of the office layout was enhanced using a 3D model background (`3D_OFFICE_MODEL_used_for_background.png`) to provide a realistic spatial context for the device placement.

Figure 1.1: 3D Model of the Office Layout used in Simulation

Chapter 2

Project Description & Strategy

2.1 Office Layout Zones

The Smart Office is divided into several distinct functional zones, each equipped with specific IoT devices tailored to its requirements:

Entrance: Equipped with a main access door and RFID readers for general staff entry.

Director Room: A secure zone requiring specific authorization. It contains a personal HVAC system, lighting automation, and fire safety sensors.

Conference Rooms (x3): Designed for meetings, these rooms feature climate control and fire monitoring systems managed via a dedicated gateway zone.

Work Area: The central hub for employees, featuring multiple desks. It is equipped with advanced HVAC (Heating and Cooling), smart lighting triggered by presence, and environmental sensors.

Break Areas Hygiene: Includes a main Break Area, Mini Break rooms, and Toilets. These zones focus on comfort and hygiene, featuring automated ventilation fans and lighting.

2.2 Network Topology Design

The network is structured hierarchically to ensure stability and logical separation. A central router connects the local office network to the external world (Simulated Cloud), while a main switch distributes connectivity to the IoT Server, Administration Station, and Zone Gateways.

2.2.1 Connection Details

- **Router (Default Gateway):** `192.168.1.1`
- **Cloud PT:** `192.168.1.2`
- **Admin PC:** `192.168.1.100` (Managed via DHCP)
- **IoT Server:** `192.168.1.10`

2.2.2 Logical Topology Diagram

The following diagram illustrates the network architecture implemented in Packet Tracer.

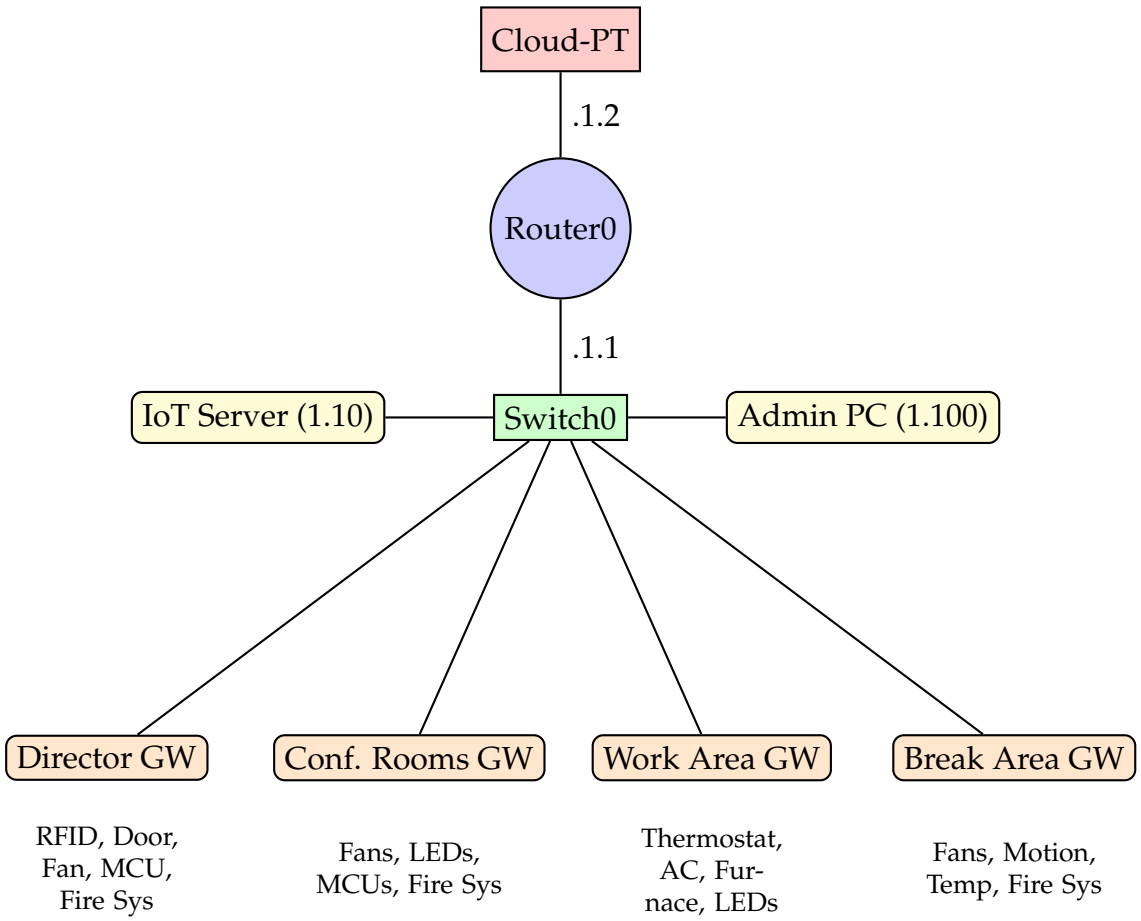


Figure 2.1: Network Topology Structure

2.3 Global Topology View

Below is the actual implementation in Packet Tracer (Global View).

Figure 2.2: Global Network Topology in Packet Tracer

2.4 Device Connectivity Functionality

The following table details the distribution of devices across the different logical zones.

Zone	Gateway	Wireless Devices	Wired Connections
Director Office	DLC100 Director	Fan, RFID Reader, Door, Entrance Door, MCU Note: Director MCU controls sensors.	Fire Monitor, Fire Sprinkler (Ethernet)
Conf. Rooms	DLC100 Conf	Fans, MCUs (one per room).	Fire Sprinkler, Fire Monitor (via dedicated Switch)
Work Area	DLC100 Work	Furnace, Thermostat, AC, MCUs (Lighting control).	None (Mostly Wireless)
Break/Toilets	DLC100 Break	Fans (Ventilation), MCUs, Motion Sensors.	Fire Sprinkler, Fire Monitor (via dedicated Switch)

Table 2.1: Device Connectivity Matrix

Chapter 3

Implementation Details

3.1 Network Configuration

The network relies on a robust IP addressing scheme managed by a DHCP server for end devices, while critical infrastructure (Servers, Gateways) uses static addressing.

- **DHCP Scope:** `192.168.1.100 - 192.168.1.200`
- **Wireless Security:** WPA2-PSK is used on all DLC100 Gateways to ensure secure communication between IoT sensors and the controller.
- **VLANs:** Although a flat network is used for simplicity in this simulation, logical separation is achieved through the distinct SSIDs of the gateways (e.g., `HomeGateway_Director`, `HomeGateway_Conf`).

3.2 IoT Server Configuration

The central brain of the Smart Office is the IoT Server (`192.168.1.10`). It hosts the registration service for all smart devices and runs the automation logic (Conditions).

3.2.1 Server Access

Administrators can access the server via the web browser from the Admin PC.

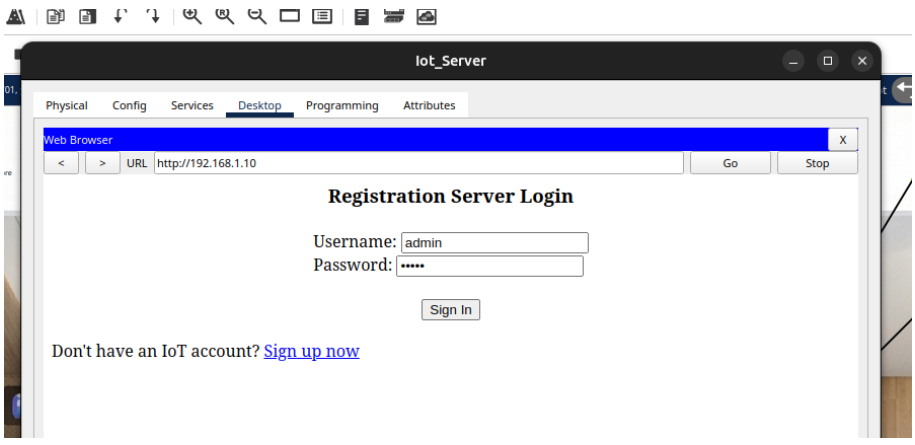


Figure 3.1: IoT Server Login Interface

3.2.2 Device Registration

Once connected to the correct Gateway and configured with the Remote Server IP, devices appear in the server's device list.

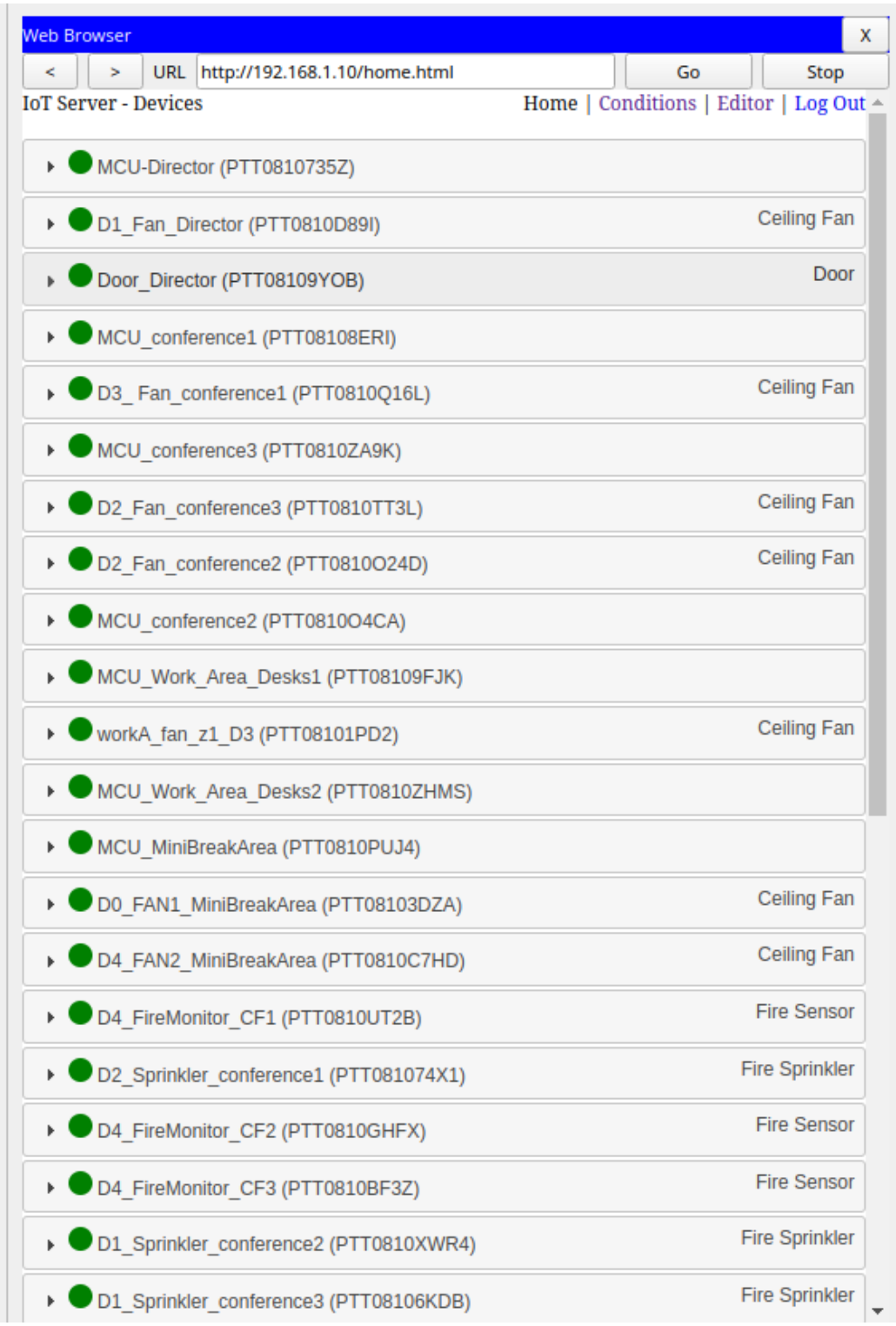
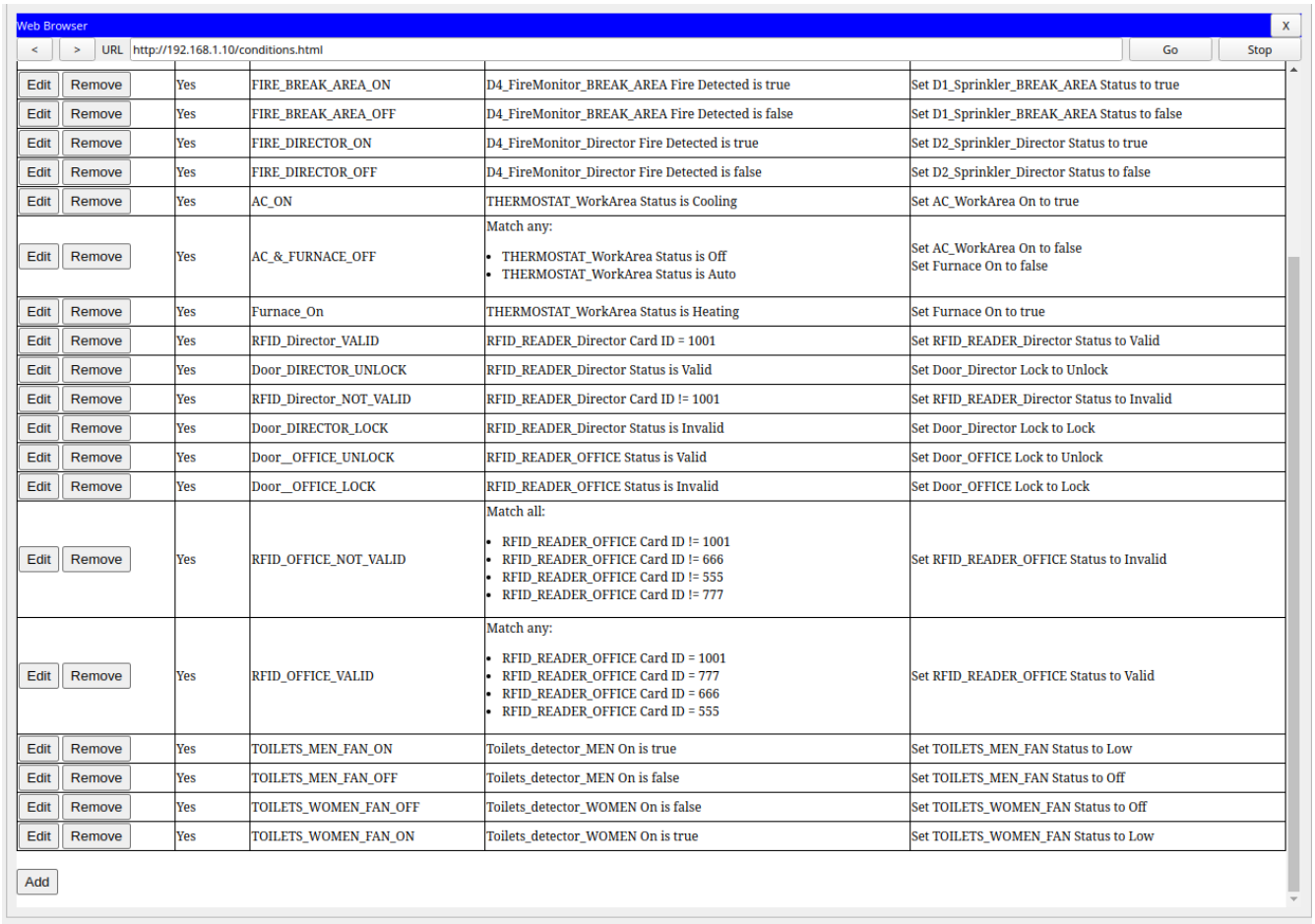


Figure 3.2: Registered IoT Devices List

3.2.3 Automation Logic (Conditions)

The smart behavior is defined using "If-This-Then-That" style rules on the server. Examples of implemented rules:

- **Fire Safety:** `IF Smoke Level > 0.1 THEN Turn ON Sprinkler`
- **Thermostat:** `IF Temp < 18 THEN Turn ON Furnace`
- **Lighting:** `IF Motion NOT Detected THEN Turn Light OFF`



Edit Remove	Yes	FIRE_BREAK_AREA_ON	D4_FireMonitor_BREAK_AREA Fire Detected is true	Set D1_Sprinkler_BREAK_AREA Status to true
Edit Remove	Yes	FIRE_BREAK_AREA_OFF	D4_FireMonitor_BREAK_AREA Fire Detected is false	Set D1_Sprinkler_BREAK_AREA Status to false
Edit Remove	Yes	FIRE_DIRECTOR_ON	D4_FireMonitor_Director Fire Detected is true	Set D2_Sprinkler_Director Status to true
Edit Remove	Yes	FIRE_DIRECTOR_OFF	D4_FireMonitor_Director Fire Detected is false	Set D2_Sprinkler_Director Status to false
Edit Remove	Yes	AC_ON	THERMOSTAT_WorkArea Status is Cooling	Set AC_WorkArea On to true
Edit Remove	Yes	AC_&_FURNACE_OFF	Match any: • THERMOSTAT_WorkArea Status is Off • THERMOSTAT_WorkArea Status is Auto	Set AC_WorkArea On to false Set Furnace On to false
Edit Remove	Yes	Furnace_On	THERMOSTAT_WorkArea Status is Heating	Set Furnace On to true
Edit Remove	Yes	RFID_Director_VALID	RFID_READER_Director Card ID = 1001	Set RFID_READER_Director Status to Valid
Edit Remove	Yes	Door_DIRECTOR_UNLOCK	RFID_READER_Director Status is Valid	Set Door_Director Lock to Unlock
Edit Remove	Yes	RFID_Director_NOT_VALID	RFID_READER_Director Card ID != 1001	Set RFID_READER_Director Status to Invalid
Edit Remove	Yes	Door_DIRECTOR_LOCK	RFID_READER_Director Status is Invalid	Set Door_Director Lock to Lock
Edit Remove	Yes	Door__OFFICE_UNLOCK	RFID_READER_OFFICE Status is Valid	Set Door_OFFICE Lock to Unlock
Edit Remove	Yes	Door__OFFICE_LOCK	RFID_READER_OFFICE Status is Invalid	Set Door_OFFICE Lock to Lock
Edit Remove	Yes	RFID_OFFICE_NOT_VALID	Match all: • RFID_READER_OFFICE Card ID != 1001 • RFID_READER_OFFICE Card ID != 666 • RFID_READER_OFFICE Card ID != 555 • RFID_READER_OFFICE Card ID != 777	Set RFID_READER_OFFICE Status to Invalid
Edit Remove	Yes	RFID_OFFICE_VALID	Match any: • RFID_READER_OFFICE Card ID = 1001 • RFID_READER_OFFICE Card ID = 777 • RFID_READER_OFFICE Card ID = 666 • RFID_READER_OFFICE Card ID = 555	Set RFID_READER_OFFICE Status to Valid
Edit Remove	Yes	TOILETS_MEN_FAN_ON	Toilets_detector_MEN On is true	Set TOILETS_MEN_FAN Status to Low
Edit Remove	Yes	TOILETS_MEN_FAN_OFF	Toilets_detector_MEN On is false	Set TOILETS_MEN_FAN Status to Off
Edit Remove	Yes	TOILETS_WOMEN_FAN_OFF	Toilets_detector_WOMEN On is false	Set TOILETS_WOMEN_FAN Status to Off
Edit Remove	Yes	TOILETS_WOMEN_FAN_ON	Toilets_detector_WOMEN On is true	Set TOILETS_WOMEN_FAN Status to Low

Add

Figure 3.3: Automation Rules (Conditions) on IoT Server

3.3 MCU Programming Logic

Some complex behaviors require local processing on Microcontrollers (MCUs). For instance, the motion-activated lighting logic is handled by a Python script running on the MCU to ensure low latency.

Sample Python Logic for Motion Sensor

```
from gpio import *
from time import *

def main():
    while True:
        motion = digitalRead(0)
        if motion == HIGH:
            customWrite(1, '2') # Turn LED ON
        else:
            customWrite(1, '0') # Turn LED OFF
        delay(1000)

if __name__ == "__main__":
    main()
```

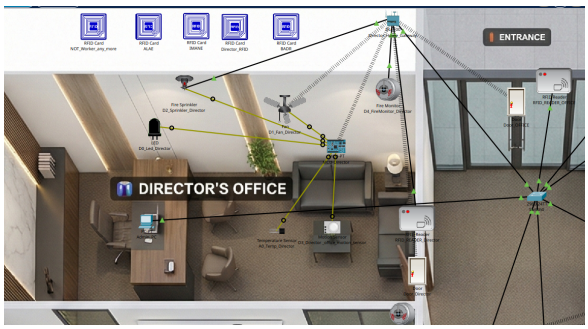
Chapter 4

Scenarios & Functional Testing

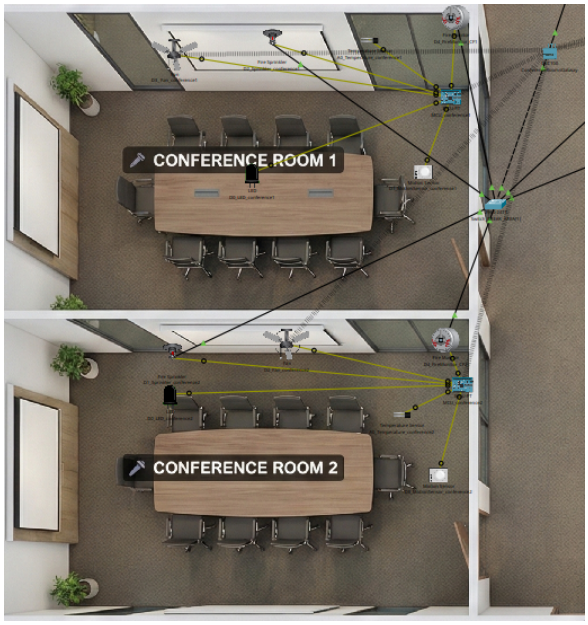
This section presents the validation of the implemented features through specific scenarios. Verification is done by visualizing the state changes in the Packet Tracer simulation.

4.1 Zone Layouts

Before diving into scenarios, here are detailed views of each working zone.



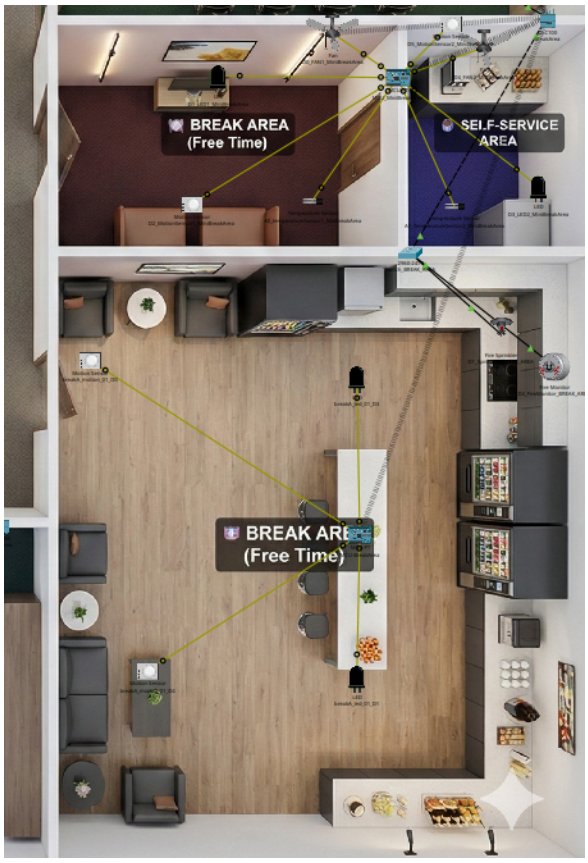
(a) Director Office



(b) Conference Rooms

Figure 4.1: Secure and Meeting Zones

(a) Main Work Area



(b) Break Service Areas

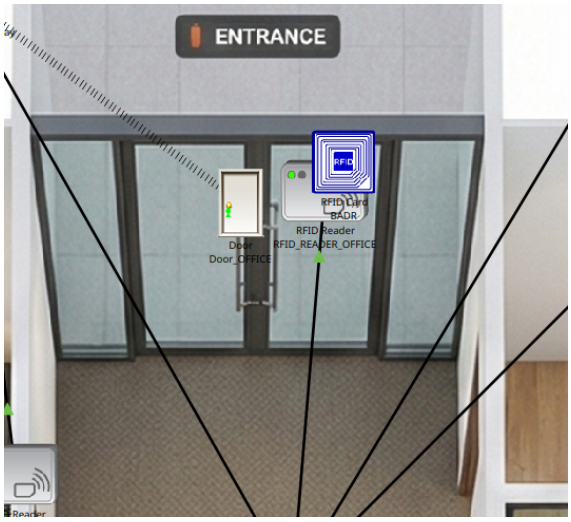
Figure 4.2: Operational and Common Zones

4.2 Scenario 1: Access Control System

The security system ensures that only authorized personnel can enter the office, and only the Director can access their private office.

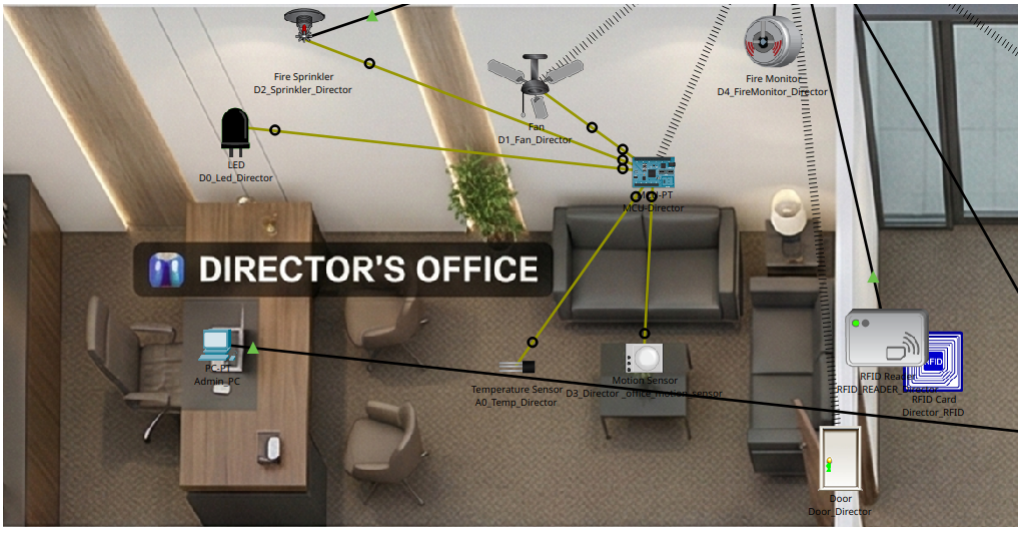
Scenario: General Office Access

Test: Presenting a valid Employee Card to the Main Entrance RFID reader.
Result: The door unlocks (Green Light / Open State).



Scenario: Director Office Access

Test: Presenting the Director's Card to the Director's Office RFID reader.
Result: The Director's door opens.

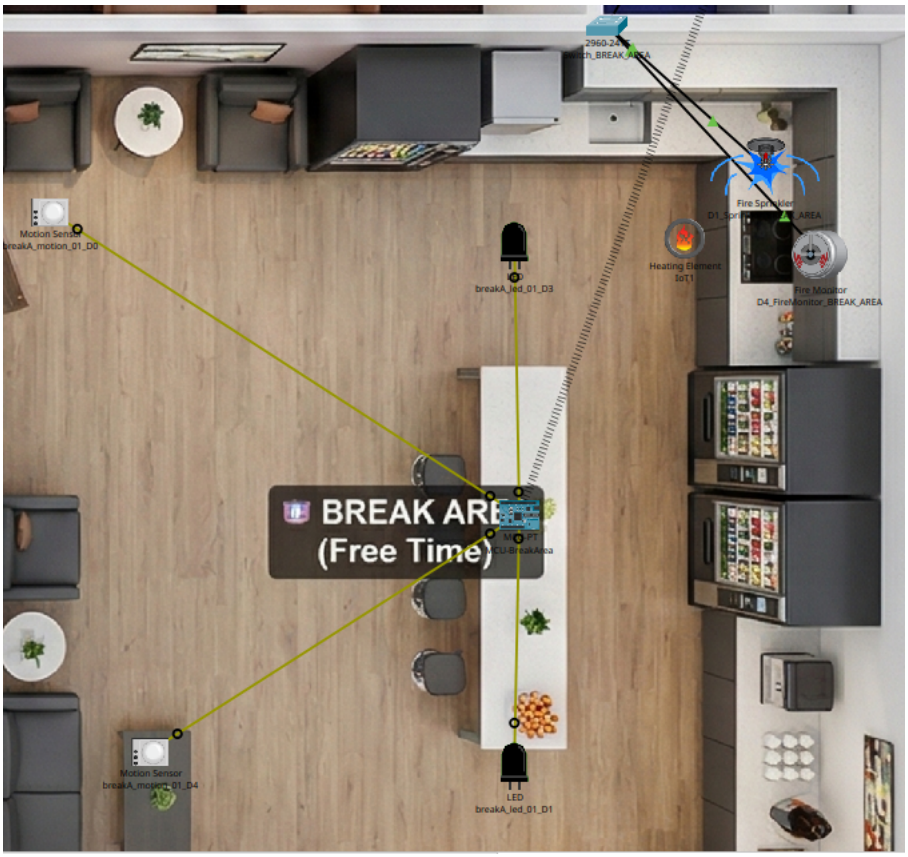


4.3 Scenario 2: Fire Safety System

The fire safety system is critical. A fire monitor detects smoke and triggers the sprinkler system immediately to suppress the fire.

Scenario: Fire Detection Suppression

Test: Forcing a fire simulation (Alt+Click) on a smoke detector.
Result: The Fire Monitor activates (Red Alarm) and the Sprinkler starts spraying water.



Web Browser — URL http://192.168.1.10/conditions.html — Go — Stop

IoT Server - Device Conditions — Home | Conditions | Editor | Log Out

Actions	Enabled	Name	Condition	Actions
Edit Remove	Yes	Office_fire_on	Match any: • D4_FireMonitor_CF1 Fire Detected is true • D4_FireMonitor_CF2 Fire Detected is true • D4_FireMonitor_CF3 Fire Detected is true	Set D2_Sprinkler_conference1 Status to true Set D1_Sprinkler_conference2 Status to true Set D1_Sprinkler_conference3 Status to true
Edit Remove	Yes	office_fire_off	Match all: • D4_FireMonitor_CF1 Fire Detected is false • D4_FireMonitor_CF2 Fire Detected is false • D4_FireMonitor_CF3 Fire Detected is false	Set D2_Sprinkler_conference1 Status to false Set D1_Sprinkler_conference2 Status to false Set D1_Sprinkler_conference3 Status to false
Edit Remove	Yes	FIRE_BREAK_AREA_ON	D4_FireMonitor_BREAK_AREA Fire Detected is true	Set D1_Sprinkler_BREAK_AREA Status to true
Edit Remove	Yes	FIRE_BREAK_AREA_OFF	D4_FireMonitor_BREAK_AREA Fire Detected is false	Set D1_Sprinkler_BREAK_AREA Status to false
Edit Remove	Yes	FIRE_DIRECTOR_ON	D4_FireMonitor_Director Fire Detected is true	Set D2_Sprinkler_Director Status to true
Edit Remove	Yes	FIRE_DIRECTOR_OFF	D4_FireMonitor_Director Fire Detected is false	Set D2_Sprinkler_Director Status to false

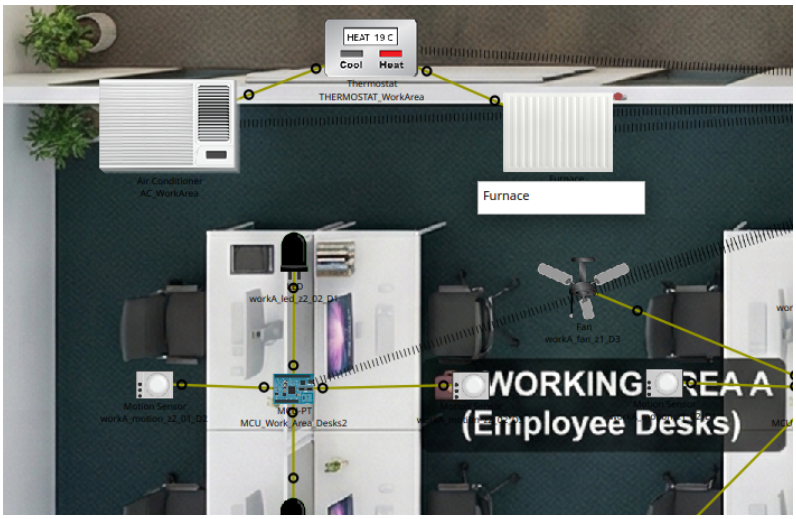
Figure 4.3: Server Rule Validation

4.4 Scenario 3: Smart HVAC Systems

In the Work Area, the temperature is automatically regulated to ensure employee comfort.

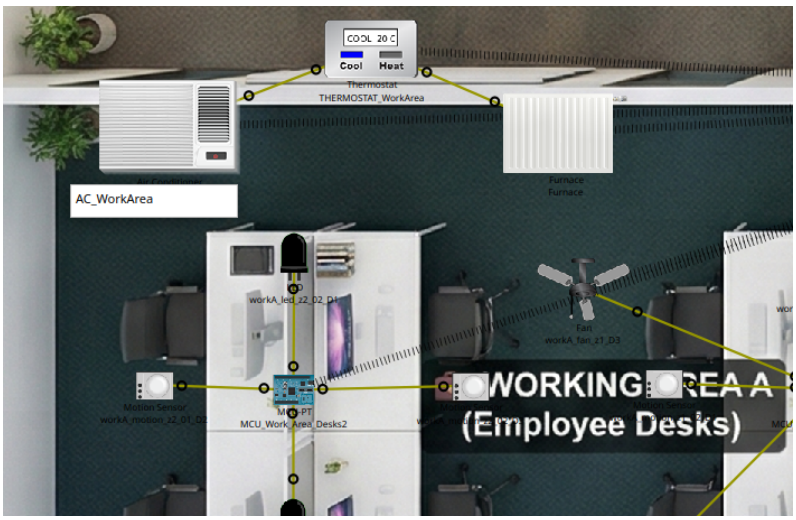
Scenario: Heating Mode

Test: Set Thermostat to "Heat" or lower ambient temp.
Result: The Furnace glows red, indicating it is generating heat.



Scenario: Cooling Mode

Test: Set Thermostat to "Cool" or raise ambient temp.
Result: The Air Conditioner activates (blowing air animation).

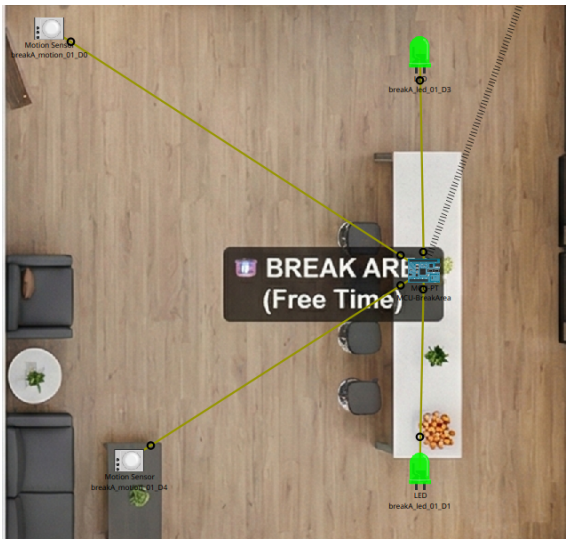


4.5 Scenario 4: Motion-Activated Lighting

To save energy, lights in the workspace and common areas only turn on when presence is detected.

Scenario: Lighting Automation

Test: Simulating motion near the sensor (Mouse Hover).
Result: The LED light turns ON instantly.



4.6 Scenario 5: Smart Hygiene (Ventilation)

In the toilets, ventilation fans are automated based on occupancy to ensure air quality.

Scenario: Toilet Ventilation

Test: Entering the toilet area (Motion Detected).
Result: The Ceiling Fan activates.

Chapter 5

Conclusion

The "Smart Office" project successfully demonstrates the potential of the Internet of Things in transforming traditional workspaces into intelligent, efficient, and secure environments. Through the use of Cisco Packet Tracer, we were able to design, simulate, and validate a complex network architecture that integrates various IoT sensors and actuators.

5.1 Key Achievements

- **Comprehensive Topology:** Successfully designed a scalable network integrating Cloud, Routing, and Wireless Gateway technologies.
- **Functional Automation:** Implemented key logic for lighting, HVAC, and Fire Safety that works reliably under test conditions.
- **Security Integration:** Demonstrated the effectiveness of RFID-based access control for physical security.

This project has provided invaluable hands-on experience with IoT protocols, network logic, and automation strategies, serving as a solid foundation for future real-world implementations.

We extend our sincere gratitude to Mr. Brahim Bakkas for his guidance and the opportunity to work on this inspiring project.