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CSE3009: Internet Of Things

Project Review

On

"Smart Office For COVID-19 Destressing"

By

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1. Introduction

Offices and workspaces have been closed ever since owing to both health and security reasons. This has led to massive losses to both the companies in terms of productivity and government in terms of revenue. Research further suggests that office staff workers are not particularly healthy both physically and mentally owing to the 'work from home' paradigm.

Aim:

Due to the COVID 19 pandemic many corporation and organizations had to implement the work from home paradigm to, maintain employee safety which led to some tension due to online meetings, hence our projects aims to develop a handsfree office to minimize human component contact as low as possible using the wireless and IOT technology.

Objective:

1. To build a simulated model of an Hands Free Smart Office where the need to touch is infinitesimal as possible in the vicinity and outskirts of the office.
2. To imply a budget friendly model accessible both to large and small scale organizations, outweighing the installation cost in the long run.

Benefits:

1. Complete or near complete isolation of devices of common use.
2. Complete or near complete elimination of the need for human contact.
3. Reduction in overall energy usage.
4. Reduction in energy costs as solar energy is used for fulfilling most of the energy expenditure.

2. Literature Survey

[1] Installation of hands free fans and AC'S , Anti-Theft system , Surveillance system.

Limitations:

To many sensors used excessive data transfer and large computational data making the work area too

Compressed and obsolete, hence picked minor modules to maintain office integrity and increase cost effectiveness.

[2] Hands free garage system which opens and closes itself on a stimuli

Limitation:

The movement detection for the automation was expensive and too extensive hence used less expensive smoke detectors.

[3]

LIMITATION:

The project is good for large scale operations. If localised operations like switching one or two bulbs or a single ac is carried out, the project might cause complications or be too costly for operations on such a small scale.

[4]

- Installing an Intruder Detection System - like software with a centralised administrator to eliminate any insider threat.
- Installing computers to develop vectors based on connected systems and sensors and develop defence mechanisms for the same.

LIMITATION:

Very high computational cost.

High emphasis on security but may lead to poor performance owing to a large number of intermediary nodes.

[5]

- A large cloud shall be maintained for communication between office staff and also between related entities like personnel responsible for cleaning, coffee etc.
- The office staff shall use mobiles for energy conservation, monitoring of modules like wifi, data, GPS and internal heating and cooling etc.
- Energy distribution and monitoring is modelled after studying patterns in the office in localised spaces.

LIMITATION:

High computation cost during set-up. And additional cost for seasonal revisions.

3. Components Used

Basic set of Modules and sensors needed

Project Scenario	Reason for Introduction	Sensors/Actuators Used
Automated Door Lock	To introduce automation in door locking/unlocking and eliminate doors as a point of contact and hence probable hotspot of infection	RFID chip and scanners.
Automated Window	To introduce automation in window opening/closing and eliminate window as a probable hotspot of infection	***Sensors:*** Rain sensor, Photo sensor ***Actuators:*** The window lock, automated screw to close/open window
Solar Charged Battery	To introduce cost-efficiency in the project	Solar Cells
Theft Protection Mechanism	1. To reduce the possibility of a loss to the company. 2. To introduce cost efficiency by reducing the number of guards required. 3. Reducing number of guards reduces the possible chances of contact	***Sensor:*** Trip or motion sensor ***Actuator:*** Siren
Automated Coffee and Fan/AC	To eliminate the possibility of coffee	***Sensor:*** Trip or motion sensor

	machine or the fan/AC switch being a hotspot for infection	***Actuator:*** 1. Coffee dispenser 2. Fan/AC
Entertainment System	To introduce entertainment in the office while not adding to the possibility of an infection	***Sensor:*** The mobile receiver and transmitter connected via bluetooth to the music player ***Actuator:*** The music player + Speaker
Automated Street Lamp	To introduce vision near the organisation premises early in the day and then in the evening and night to facilitate better garage management	***Sensor:*** Photo sensor ***Actuator:*** The lamp bulb/LED
Automated Garage	To introduce automation in garage maintenance while reducing the possibility of human touch/contact.	***Sensor:*** RFID sensors and Motion sensor ***Actuator:*** Garage door
Fire Alarm + Sprinkler	To protect the economic and intelligent resources of the organisation	***Sensor:*** Infrared Heat detector ***Actuator:*** Siren + Water Sprinkler.

Sr. no.	Sensors/ Network devices used	Working Principle/ components	Application used in
1.	*WRT300N Router*	IEEE 802.11n protocol	Central hub for all IoT devices used in the scenario
2.	RFID	Scanner + Antenna	Used for maintaining attendance and garage admission.
3.	Rain Sensor	Resistive dipole based on moisture on the nickel poles on the sensor chip.	Used to find rains and high speed winds to open and shut the window automatically
4.	Photo Sensor	Resistive dipole based on the light energy received by the semiconductor used	Receives light has an output circuit used to provide electrical energy
5.	Solar Panels	photovoltaic effect	Uses the sensor and the solar cells to develop photo electricity
6.	Trip Sensor	Passive IR sensor in fire detection, Active IR sensor in Theft prevention modules	If the motion sensor is tripped the alarm rings and sends a message to the respective authorities.

7.	Smoke sensor	A radioactive material, usually depleted Uranium or Radium is sandwiched between semiconductors. The radioactive element reacts with smoke and conductivity suddenly increases that rings the alarm.	Detecte the CO2 in the environment and call in the required function .

Additional Components needed

Two custom-programmable MCUs or microprocessors. They have been used to:

1. Ensure that the fire water sprinkler water reservoir is maintained.

2. Ensure that the rain sensor converts its series resistance to parallel as soon as water touches it, increasing conductivity manifolds and facilitating the closing of windows. Similarly, as soon as the water contact is broken off, the sensors reopen the window and set resistance to series.

A laptop / mobile / computer to manage the IoT structure through a MQTT facilitated cloud.

Protocols Used

1. **Bluetooth**: Bluetooth has been used as the primary protocol for connectivity in the kitchen to play music.

2. **WiFi 4.0:** WiFi4.0, which has been referred to as its parent protocol IEEE802.11n has been used as the protocol to connect all IoT devices to the WRT300N router. This is done to reduce the possibility of dead ends.

3. **MQTT:** MQTT has been used as the primary protocol to connect the office server to a larger organisational cluster. This is done to facilitate network stability even during limited bandwidth and constrained weather conditions.

All the protocols have been discussed and enumerated in appendix A.

4. Proposed Architecture

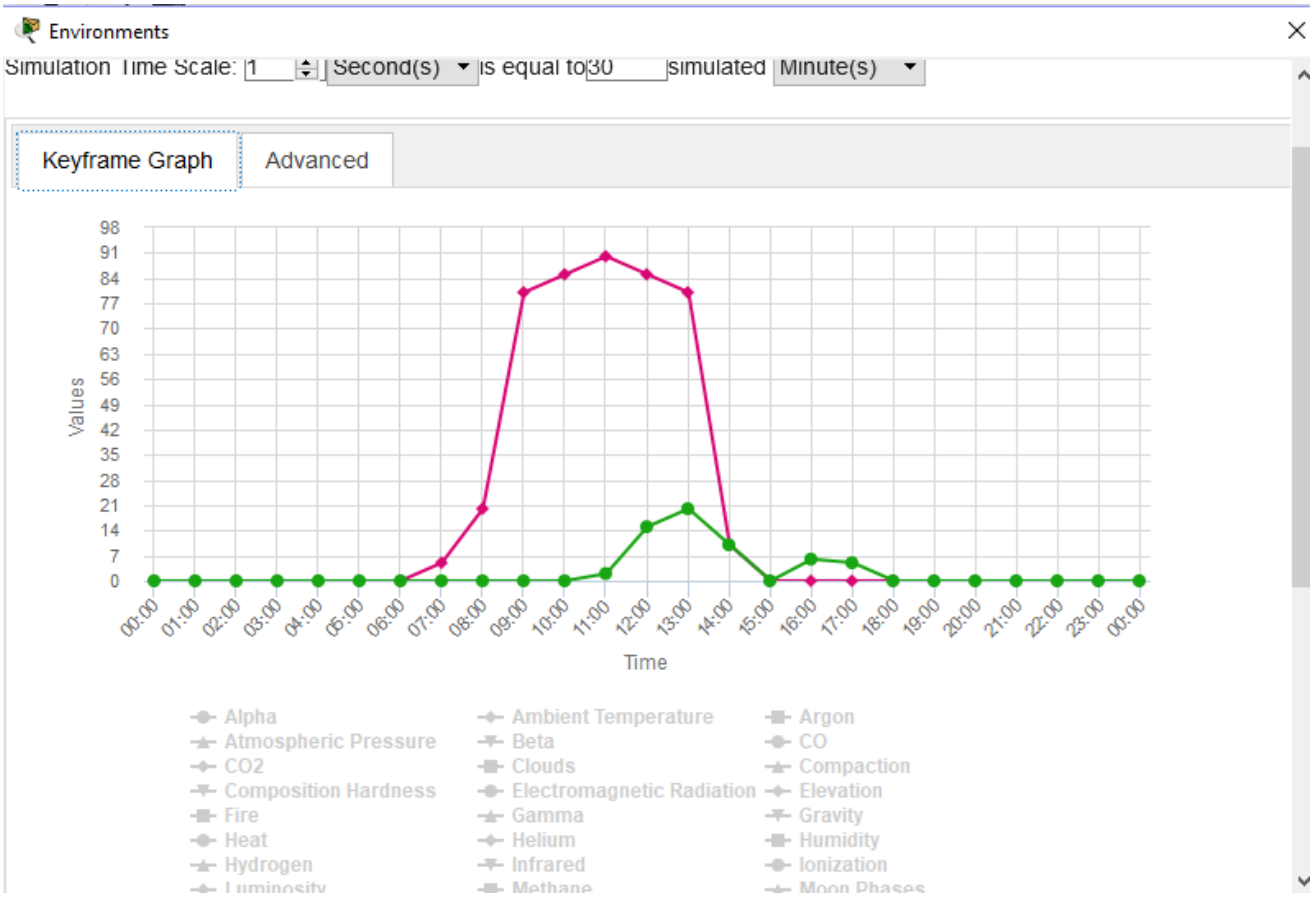
The Project does not obey any specific algorithm. It is a use-case suggestion model. So, we have set up a basic office as depicted in the image in this section. The office is subject to real-world variables like rainfall, wind, sunshine etc., the option to which was available in the simulation software.

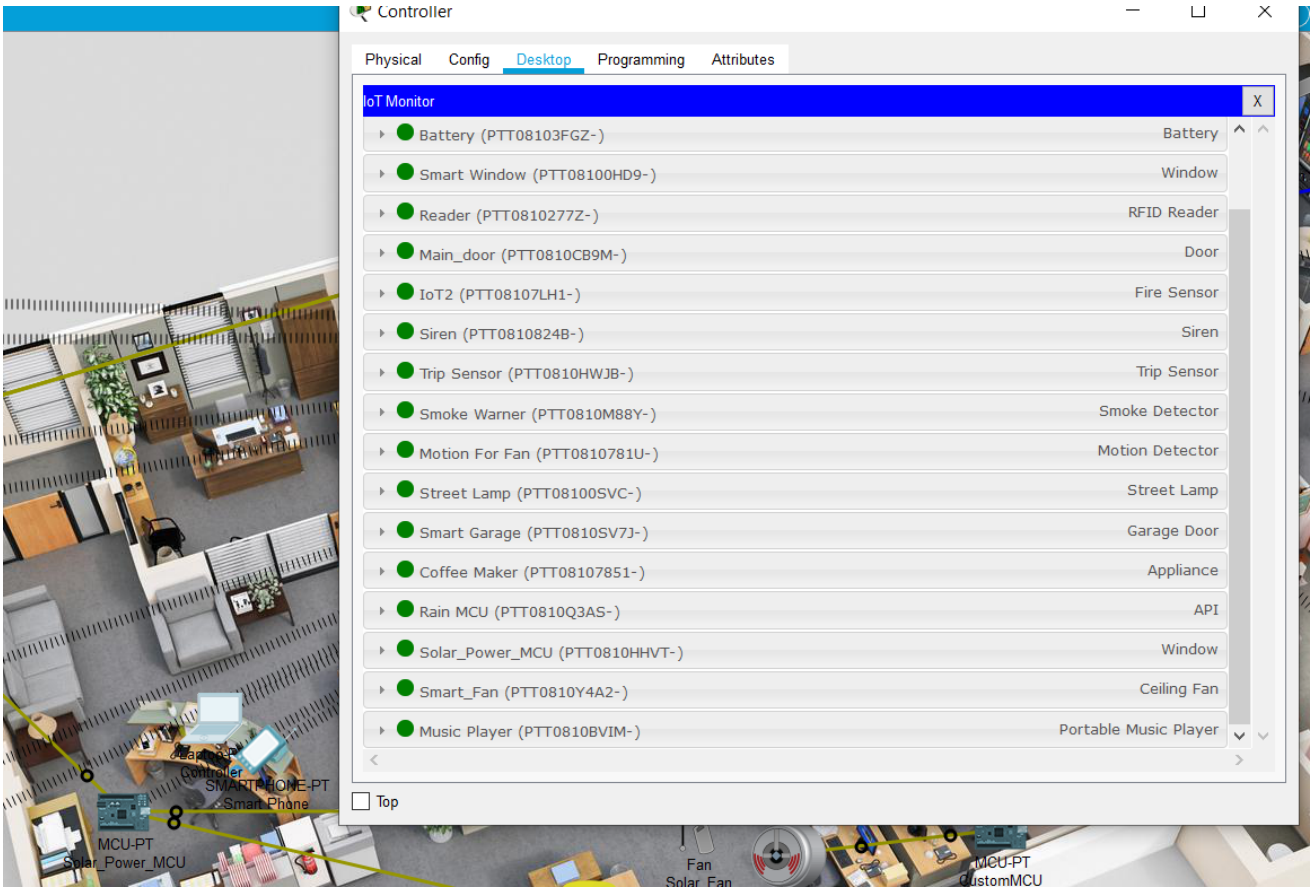
1. The office has a WRT300N router that is connected to all other IoT devices.
2. The WRT300N router is itself connected to a modem that is connected to a larger cluster or server.
3. A laptop or a mobile is sufficient to keep track of all IoT devices used. This fact is also demonstrated.

The project can be accessed at:
https://drive.google.com/drive/folders/1KpVy5LYZ5qjc3XXHVDGYekPVhim5pTbb?usp=sharing

The office setup is shown here:

The sensors maintain a record of about 20 environment variables.


Environments
Simulation Time Scale: 1 Second(s) is equal to 30 simulated Minute(s)
Keyframe Graph
Advanced
Values
98
91
84
77
70
63
56
49
42
35
28
21
14
7
0
00:00
01:00
02:00
03:00
04:00
05:00
06:00
07:00
08:00
09:00
10:00
11:00
12:00
13:00
14:00
15:00
16:00
17:00
18:00
19:00
20:00
21:00
22:00
23:00
00:00
Time
Alpha
Ambient Temperature
Argon
Atmospheric Pressure
Beta
CO
CO2
Clouds
Compaction
Composition Hardness
Electromagnetic Radiation
Elevation
Fire
Gamma
Gravity
Heat
Helium
Humidity
Hydrogen
Infrared
Ionization



All the environment variables and the IoT devices can be accessed at a common laptop/mobile/computer available with the office manager.

5. Software Implementation

Cisco Packet Tracer

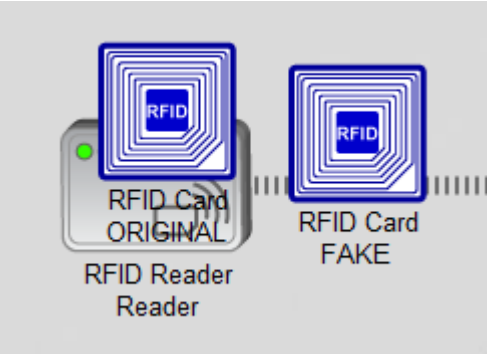
The project was implemented using Cisco Packet Tracer because:

1. Free license;
2. Easy to use;
3. Offers a large library of tools;
4. Offers customisation options like programmable computers and devices; and
5. Offers high scalability

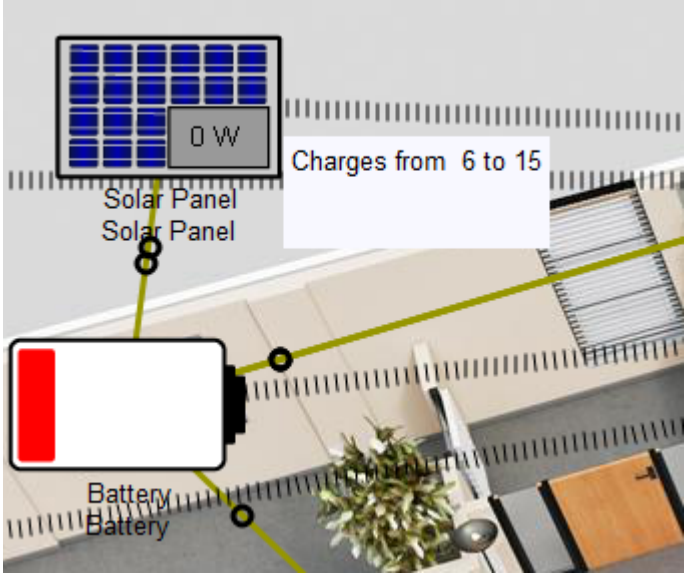
The project can be accessed at this link:
https://drive.google.com/drive/folders/1KpVy5LYZ5qjc3XXHVDGYekPVhim5pTbb?usp=sharing

Snapshot

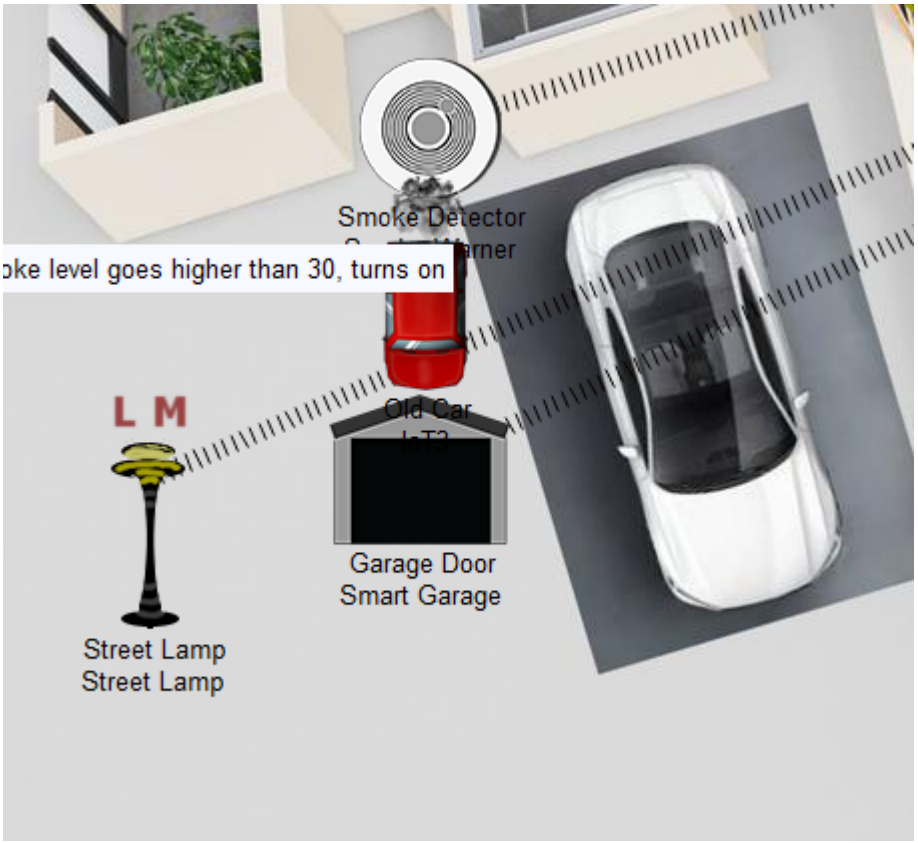
Here are some snips from our project.



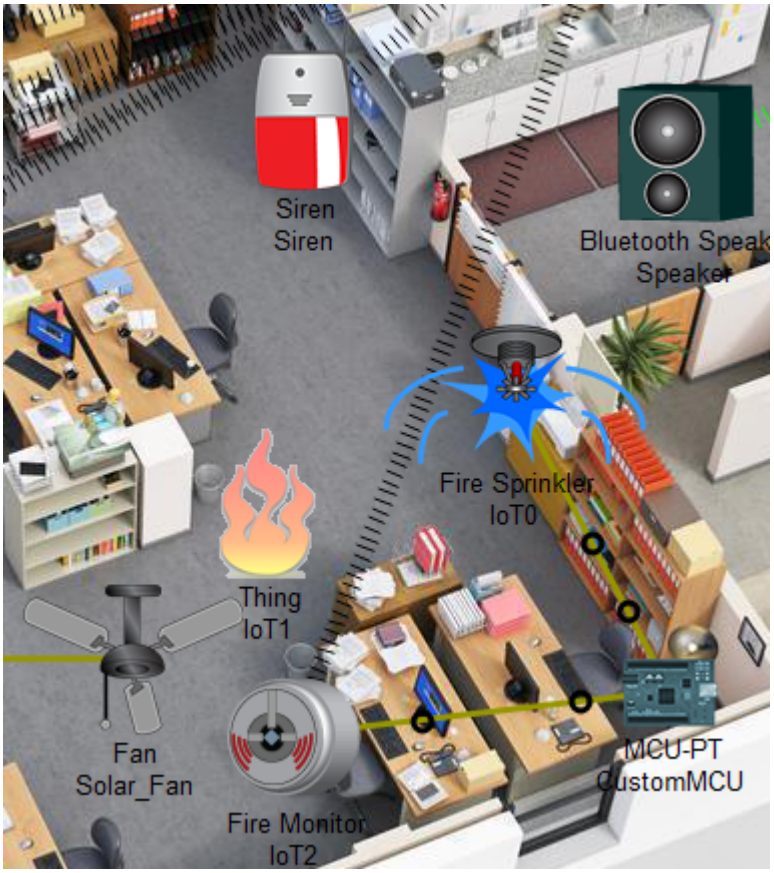
RFID CARD and READER in action



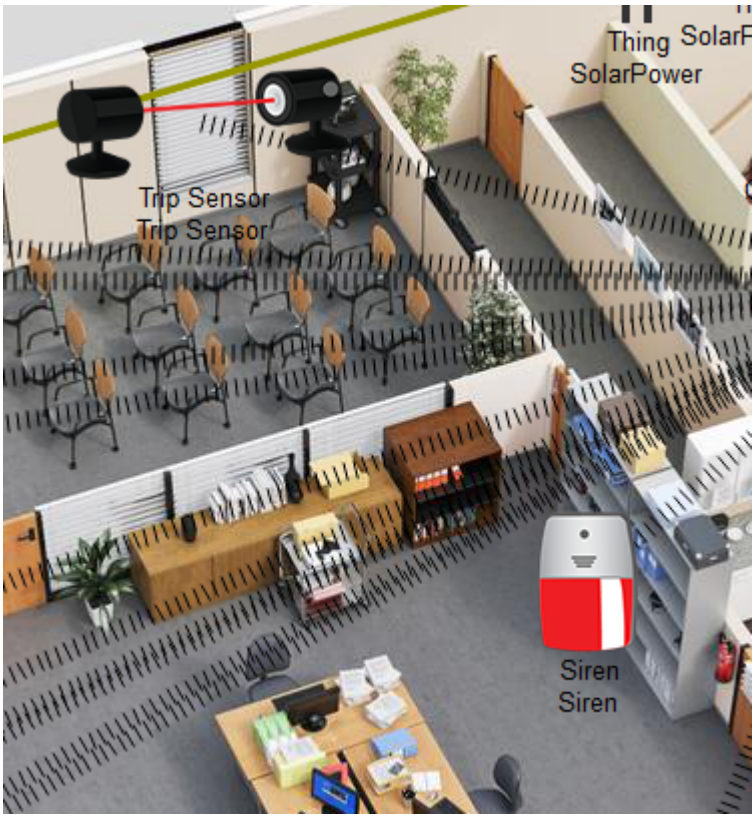
The solar powered battery in charge



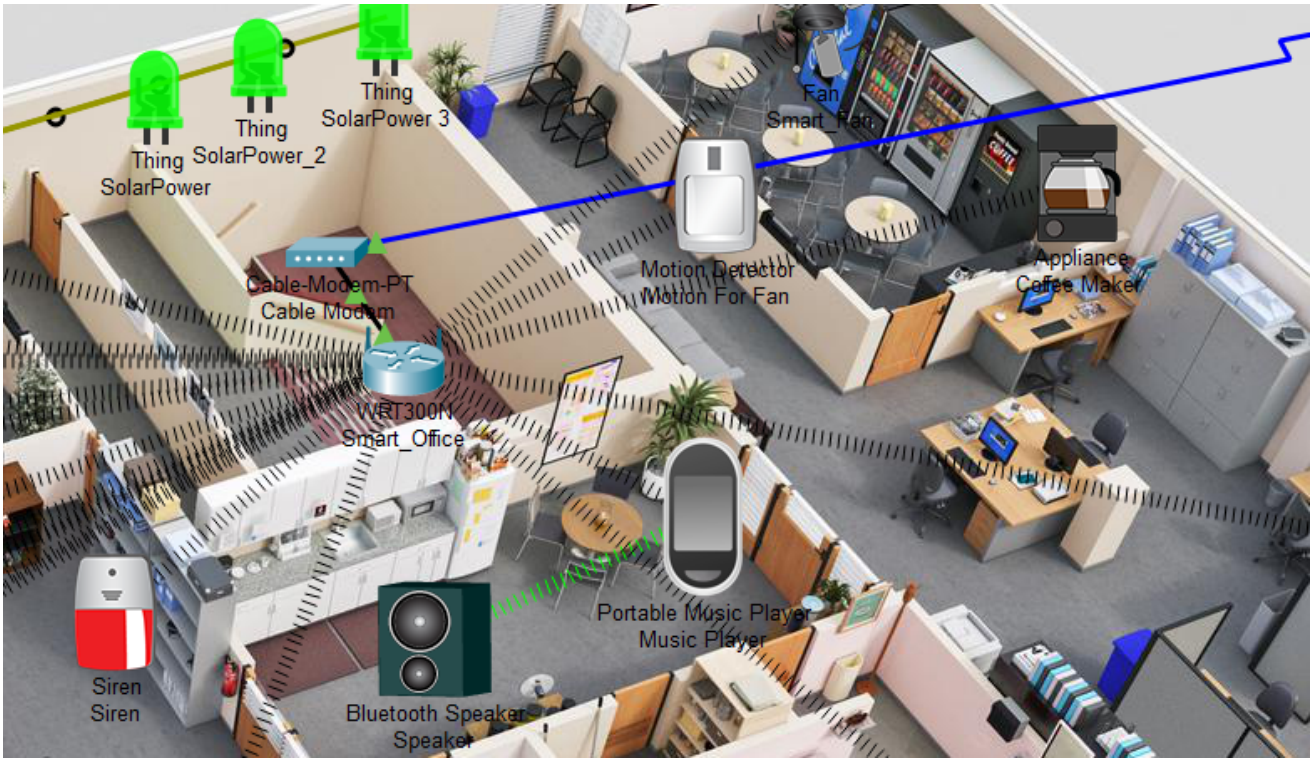
Smart Garage in action. The door is open and the car emits smoke. (CISCO packet tracer clearly offers a great number of tools)



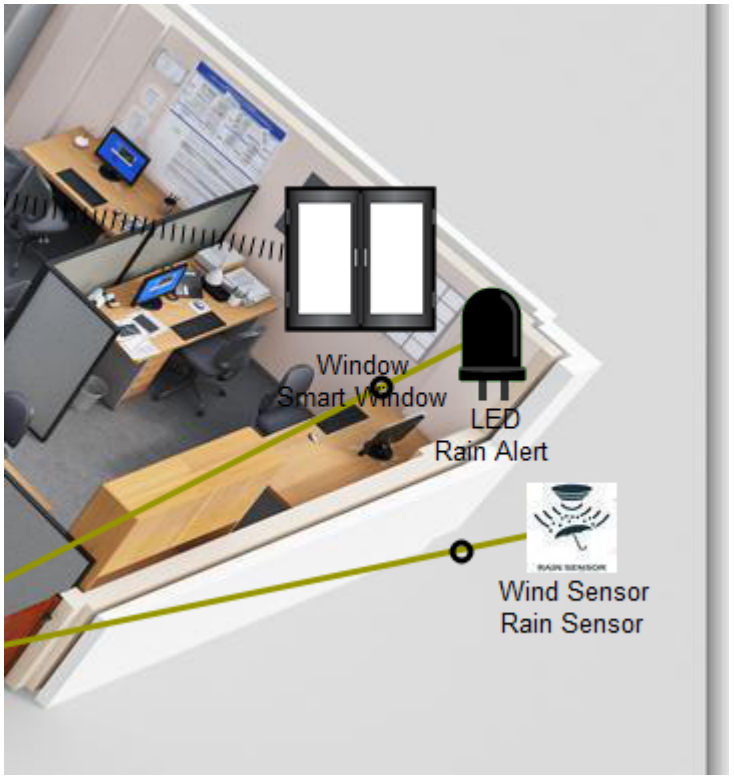
Motion sensor and fire alarm in action



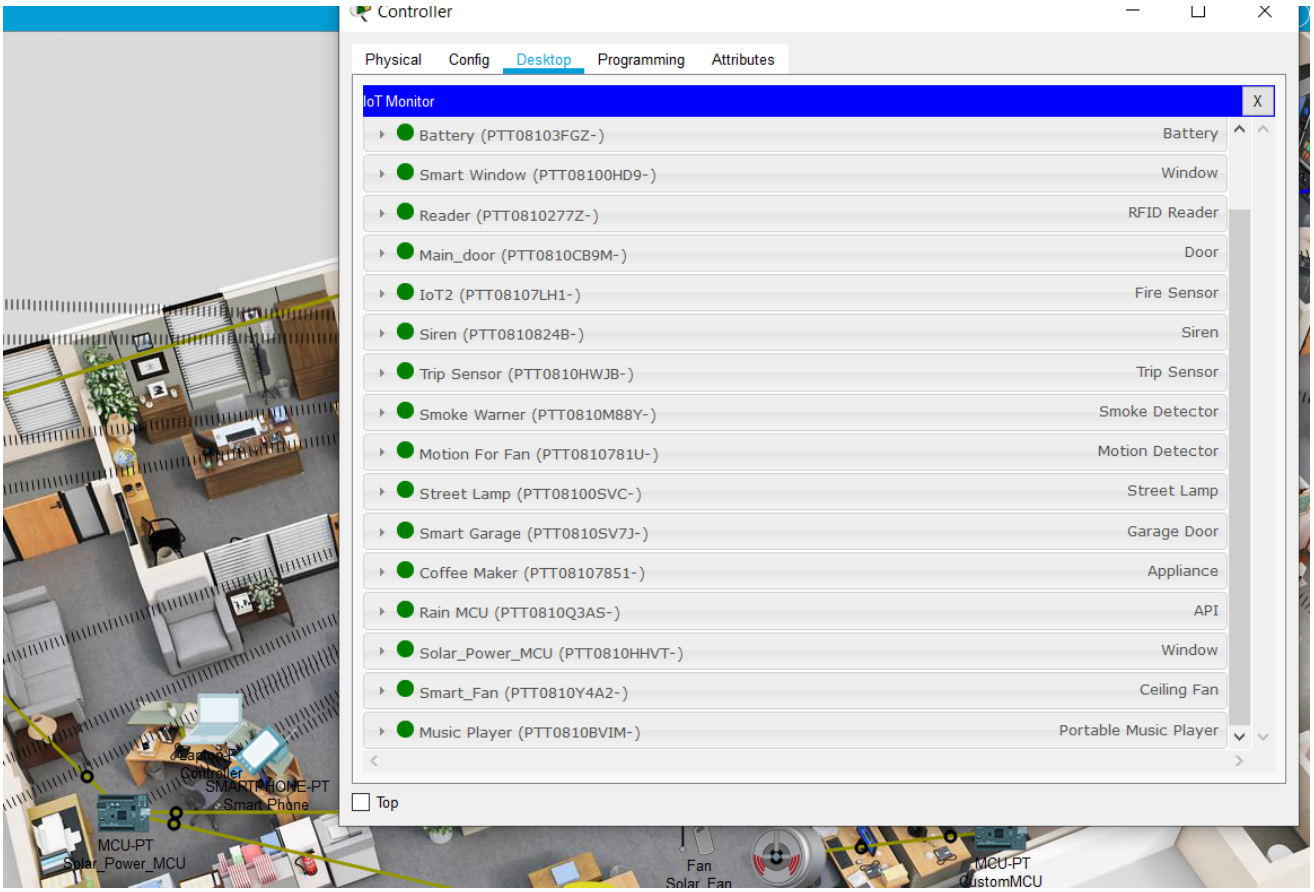
The trip sensor i.e. the theft detection module in action



The music speaker



The smart Window module



A laptop or a mobile can be used to detect the state and signal of IoT devices.

6. Estimated cost

One of the main objectives of the project was to develop a synergy between the economy of the project while also maintaining the required norms to develop a handsfree office.

Component and maintenance Cost

The following should summarise the cost of building and maintaining of the model -

Components Used	Purchase cost / Subsidy (if any)	Maintenance Cost (yearly)
RFID	About 10,000 INR. This has to be spent only once.	Battery lasts for an average of 4 years. And a general mechanic So, on an average, the maintenance cost is around 200 rupees per year.
Rain Sensor	150 INR*4	2 years lifetime with minimum maintenance requirement.
Photo sensor	1000 INR * 2	2 years lifetime with minimum maintenance requirement.
Solar Panels	2 lakhs INR (with 60% subsidy)	No maintenance needed for about 20-25 years.
Solar battery	18000 INR (base) * 4 (number)	No maintenance needed for 5-7 years.
Active IR sensors	400 INR - 500 INR	2-3 years lifetime with minimum maintenance
Passive IR sensors	100 INR - 200 INR * 3	3 years lifetime with little or no maintenance
Fire Alarm Sensors	700 INR*5	Maintenance every 6 months. The cost

		involved is the charge of the mechanic.
Fire Water Sprinkler	1000 INR * 3	Maintenance every 6 months. The cost involved is the charge of the mechanic
Programmable MCU	300 INR	No maintenance needed for about 2-4 years
Bluetooth Speaker	1200 INR	No maintenance needed for about 12-18 months.
Routers	8000 INR	Maintenance once a year

Extra Installation Cost

These costs have to be borne only once.

Office Space Module	Installation Costs involved
Kitchen (requires Bluetooth speakers + music system)	0
Garage	About 14,000 INR
Coffee Vending + Fan	About 5000 INR
Street Lamp	About 8000 INR to construct the lamp
Theft Protection	About 2000 INR
Battery	About 2000 INR
Door Lock	About 10,000 INR for all the doors
Fire Alarm	About 5000 INR

Total cost of components and basic establishment is around 2,30,000 INR/office. These costs do not repeat themselves.

Finally, installing a cloud may cost around 4.5 lakhs INR per year, which can be scaled down to about 2.8 lakh per year using a premise based server.

However, since we are using a MQTT server, a limited server with even reduced costs may be used for the connections.

So, the total cost of installation of the components including their base cost adds up to about 2.3 lakhs with an optional expenditure of about 3 lakhs per year depending upon the scaling of cloud the organisation needs.

Comparison against real-time costs

As per research, the loss in productivity in Indian scenario is about 57% which is very high compared to only about 33% in the UK. Most of this is due to stress, anxiety and isolation. This also means that the costs involved in well being increase both on the balance sheet of the company as well as the employee.

So, it is pretty apparent that a smart office is an urgent necessity.

1. The solar panel saves about 18 lakhs INR in electricity costs every year, given the scenario of India being a country rich in sunlight. In Arizona, USA - the savings are less, around 10000 USD per year(around 8,00,000 INR).
2. Elimination of any office staff responsible for relaying and carrying messages and files by digitizing everything saves around 8.5 lakh INR per year (given the basic bay of office clerks being around 2,40,000 INR per year in India). The savings increase in case of countries like the USA and the EU where minimum wages are higher.
3. Fire damages can cost a company about 30-90% of all its hardware and intellectual resources. This could also mean that a company could face heavy losses in future to reestablish systems. A fire alarm would be a very small investment given the possible losses. Business Sprinkler Alliance computes fire related losses to cost around 230 million pounds per year (about 2000 crore INR) in the UK alone.

All this means that using the proposed model is way more cost efficient than a regular office set up with all the installation costs covered up in about 2-3 years. After that, the organisation shall actually make profit with the organisational set-up and the smart office model proposed.

Conclusion

1. We propose a smart office model that is profitable and safe to work in the midst of the COVID-19 crisis. The model would yield profits from about the 3rd year of installation. This is with the assumption that company earnings remain steady and other volatile factors are constant.
2. In the 1st and 2nd year, it shall serve as a reason for higher productivity, reduced mental anxiety at work place and shall thus aid in absolute profits from the 2nd year itself.
3. We discuss the setting cost, variables and sensors involved.
4. We also contribute in our part to the spirit of environment protection, by suggesting a profitable model based on renewable and non-polluting energy sources.

Appendix A: Protocols

The protocols used in the project are -

MQTT

Introduction:

Originally developed in 1999 to monitor oil and gas pipelines over remote satellite connections.

We have used the MQTT protocol because -

1. Message Queuing Telemetry Transport
2. Lightweight
3. Publish-subscribe messaging transport model
4. designed for the constrained devices and with low bandwidth,
5. easy for communication between multiple devices

IEEE 802.11N

Standard protocol for WiFi 4.0

Uses multiple antennas and multiple nodes to reduce the probability of any dead point. This makes it a cost effective protocol as compared to protocols that rely on stronger signals. So, IEEE802.11n fits perfectly with MQTT.

Bluetooth

Bluetooth is a wireless networking protocol that uses radio waves in the bandwidth 2.402 to 2.48 GHz. Typically has a maximum range of 10m.

Reference

[1] T F Prasetyo et al 2018, *"J. Phys.: Conf. Ser. 1013 012189 Prototype of smart office system using based security system"*

[2] Dony Susandi et al 2017, *"SMART PARKING SYSTEM PADA PROTOTYPE SMART OFFICE BERBASIS INTERNET OF THINGS"*

[3] Ping Shum et al 2018, *"Smart Office: A Voice-controlled Workplace for Everyone"*

[4] Arnau Erola et al 2015, *"Smart Insiders: Exploring the Threat from insiders using the Internet-of-Things"*

[5]Jianli Pan et al 2015, *"An Internet of Things Framework for Smart Energy in Buildings: Designs, Prototype, and Experiments"*