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Faculty of Information and Communication Technology (FICT)

UCCN2513 Mini Project

Individual Project – June 2022 trimester

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Tutorial Group: T3

Items	**Marks**
Motivation and problem statement (5%)	
Objective (5%)	
Project scope (4%)	
Contribution to the project (4%)	
Design (3%)	
Implementation (3%)	
Performance Study (3%)	
Conclusion (3%)	
Total (30%)	

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Motivation and problem statement

Problem Statement:

According to the United Nations, the process of digitalization has yet expanded at a phenomenal rate that no one has ever expected before, involving 50% of the world's population in just two decades. Undeniably, the Internet of Things (IoT) is powerful and full of potential that could shape the future. With the rise of the 5G network, massive connectivity and high network speed could be the game changer that unlocks the full potential of IoT systems. High speed and simultaneous data transfer allow data to be transferred and processed on the go hence providing a much more responsive and efficient system. IoT solutions could be applied in various fields, including industries, healthcare, workplace, etc to boost performance, maximizes efficiency and provides better products or service to the end-users. In this paper, the issues that exist in offices will be discussed and solutions will be proposed to tackle the problems.

The first problem that exists among offices is inefficient energy consumption in offices. According to Condeco, companies usually overspend on their office buildings' electricity bills. Two major components that are causing the high energy consumption are the Heating, Ventilation, and Air Conditioning (HVAC) and the lighting in the building. The lack of IoT sensors causes false conditions in the workplace could not be detected and no effective precautionary steps to be taken immediately. As a result, a huge amount of energy could be wasted for nothing. For example, the light in the office remains switched on when there are no people in the room, or the air conditioning unit keeps on running when the temperature is already adequate. Both of the examples stated above will contribute a huge number to the electricity costs as well as increase the overall carbon footprints of a building.

The second problem is the low efficiency and productivity in typical offices. For instance, the smart IoT sensor could sense and detect the concurrent conditions in the offices. After that, the data could be uploaded and to be processed in an automated system. However, there will a lot of hassle without the smart office monitoring system. When an employee encountered a problem, they have to waste plenty of time troubleshooting the problem. During the troubleshooting process, a lot of time will be wasted in finding the main issues that caused the problem. Besides, without the real-time monitoring IoT sensors, the environmental data or readings of the office are harder to obtain. Staffs have to undergo a manual complicated

workflow to solve a particular problem step by step. During the process, a lot of manpower and time will be wasted hence resulting in low efficiency and productivity.

Motivation:

IoT and office automation could reduce operating costs. Smart office IoT solutions are making it possible for businesses to decrease costs across the board. Sensors could record occupancy in real time to reduce energy usage. By doing this, problems such as overheating, inadequate heating, excessive lighting, and other inefficient behaviours are resolved. Additionally, occupancy data assists businesses in making the most of their space to increase office capacity while lowering rental expenses. With the use of sensors and predictive maintenance, organisations can plan fixes for the best periods to prevent downtime. On the other hand, smart offices and automation are also more environmentally friendly when compared with typical offices. IoT sensors can be used to optimise how much energy is used in buildings. Hence, optimizing the energy consumption of the office at an efficient level and also minimizing the carbon emissions and the impacts on the environment.

Smart IoT for office monitoring could also boost performance and productivity, as well as provide convenience and comfort to staff. This is because, with the aid of IoT smart office systems, the systems help to automate many processes. For example, turning off the lights and the air conditioning unit automatically when it is unnecessary. The automation process could reduce barriers and limitations that hamper productivity. Smart office automation could scale processes such as administrative tasks, delivery, etc. This improves the overall efficiency and productivity at all levels. Besides that, the smart office could also make the workspace more customizable and comfortable. This allows staff to control the aspects of their working environment, such as temperature control and office environment. As a result, providing much more comfortable for the staff, hence boosting their productivity.

Project scope

This IoT for Office Monitoring project aims to deliver a real-time office environmental data monitoring system in the workplace. This system is expected to be deployed in an indoor place, such as an office. The system can detect concurrent environmental data (E.g., temperature, pressure, humidity values) from IoT sensors. Besides that, the system will implement cryptographic protocol (AES-256) and MQTT protocol for wireless data passing, which is energy-efficient and easy to deploy and supports unreliable networks. MQTT panel also will display the statistics of the environmental data in MQTT panel, which is accessible from mobile devices. The environmental data that are coming from the MQTT broker will be stored in a database (InfluxDB). The environmental data will be processed and displayed on a dashboard that will show the statistics of the environment data in figures and charts. In fact, if the values of a particular environment data exceed a certain threshold, a warning indicator will show on a LED and a warning notification will be sent to Telegram. On the other hand, a wireless switch to control LEDs through a mobile device will also be implemented.

Project Objectives

The objective of the project is stated as below:

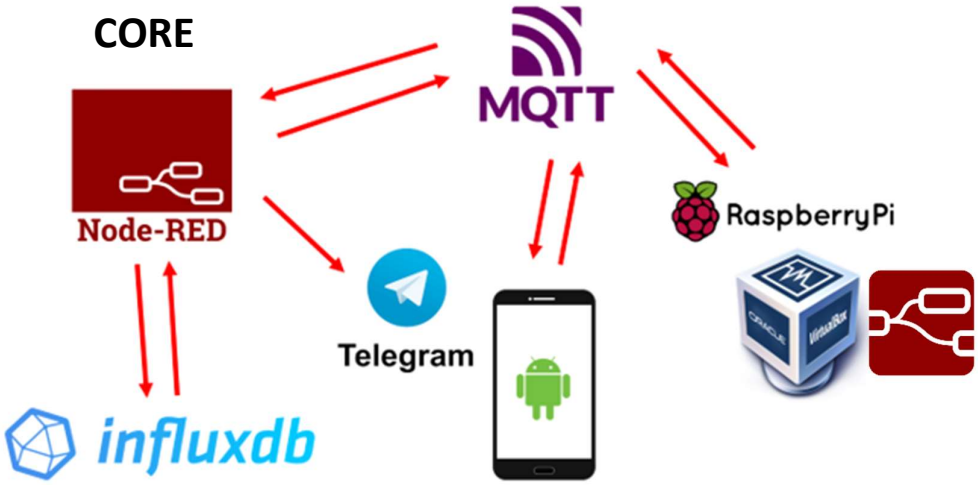
- Creates a system that could monitor the real-time environmental data from IoT sensors.
- Gives warnings indicator and warning messages if the environmental data exceeds a certain threshold.
- Implements wireless switch for LEDs and provides environmental data statistics on mobile devices.
- Implements data encryption/decryption for security purposes.
- Provides a dashboard that shows the statistics of the real-time environmental data in dynamic figures and charts.
- Provides commands to control the system through Telegram.

Contribution of the project

This project involves the collection of environmental data from the office. The collected data could contribute to a lot of functions. For instance, after the temperature is collected, an event could be triggered if the temperature value exceeds a certain value. The outcome can be modified to suit the needs of the system. For example, a LED will be lighted up if the temperature value is very high. Besides that, this system will also show warning indicators and send warning messages to notify the users that the value of specific parameters has exceeded the normal value. For example: if the temperature is normal, green colour LED will be displayed; else, if the temperature is abnormal, a red colour LED will be displayed instead. A warning message will also be sent to Telegram to notify the users that something is wrong. On the other hand, a simple and clean UI called a dashboard will show the statistics of the environmental data on a screen. Users can monitor and obtain the latest environmental data through an appealing UI, instead of the raw data displayed in the console. Furthermore, users can control the switch LED wirelessly through their mobile devices. Through the MQTT panel, users can switch on or off the LED effortlessly just by pressing the button on their mobile devices. Last but not least, this project will also provide responsive telegram messaging, where users could obtain the latest environmental data and more (Today covid-19 cases, weather, etc.) through typing commands in Telegram chat to obtain the relevant data.

Design

Architectural diagram:



This system consists of 5 major components.

- Raspberry Pi: acts as a virtual IoT sensor to collect environmental data
- MQTT: acts as a broker to allow collected data to be transferred wirelessly
- Node-RED: The core component of the system. Includes the flow and configurations of the whole system.
- InfluxDB: acts as the database to store environmental data.
- Smartphone: Works with MQTT and telegram to send commands and instructions to Node-RED and Raspberry Pi through MQTT.

The flow of the systems is stated as below:

1. Node-RED (Raspberry Pi) collects environmental data from Sense HAT Emulator.
2. Encrypts the data and sends it to MQTT
3. Node-RED (Core) receive the data from MQTT and decrypts the data.
4. Node-RED (Core) deposits the data into the database (InfluxDB)

After that, a few actions could be performed:

- Node-RED query the data from the database and display the environmental data's statistics on a dashboard
- Node-RED sends a warning message to a smartphone through Telegram if the environmental value exceeds a certain threshold.
- Node-RED display warning: red colour LED if the environmental value exceeds a certain threshold.
- The smartphone acts as a wireless switch to control the on/off of the light on LED Panel in Raspberry Pi.
- MQTT will display the environmental data statistics on the smartphone MQTT panel.

Implementation

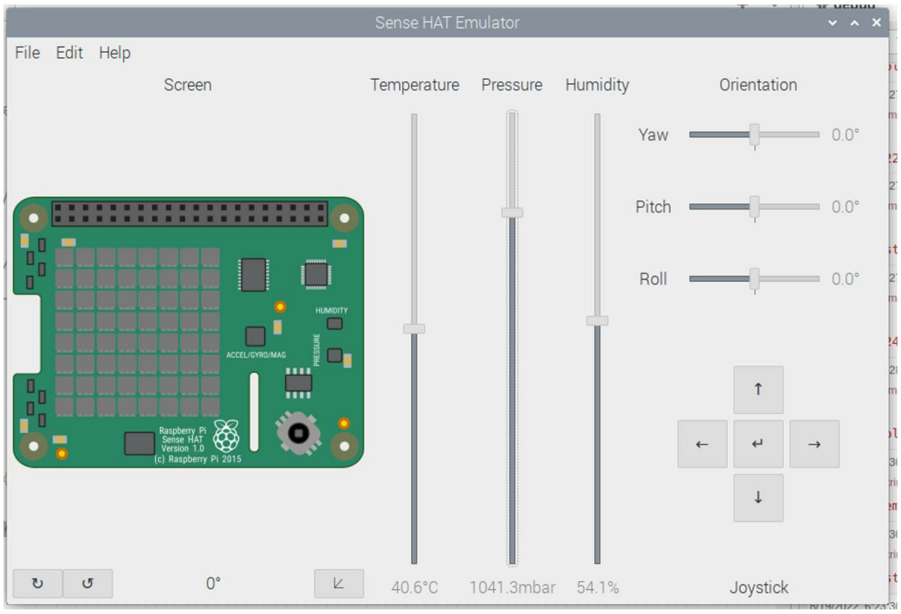
Prerequisite:

- Installed Node-Red on Raspberry Pi and Windows machine
- Installed InfluxDB on Windows machine
- Installed IoTMQTTPanel in smartphone
- Installed Telegram on smartphone

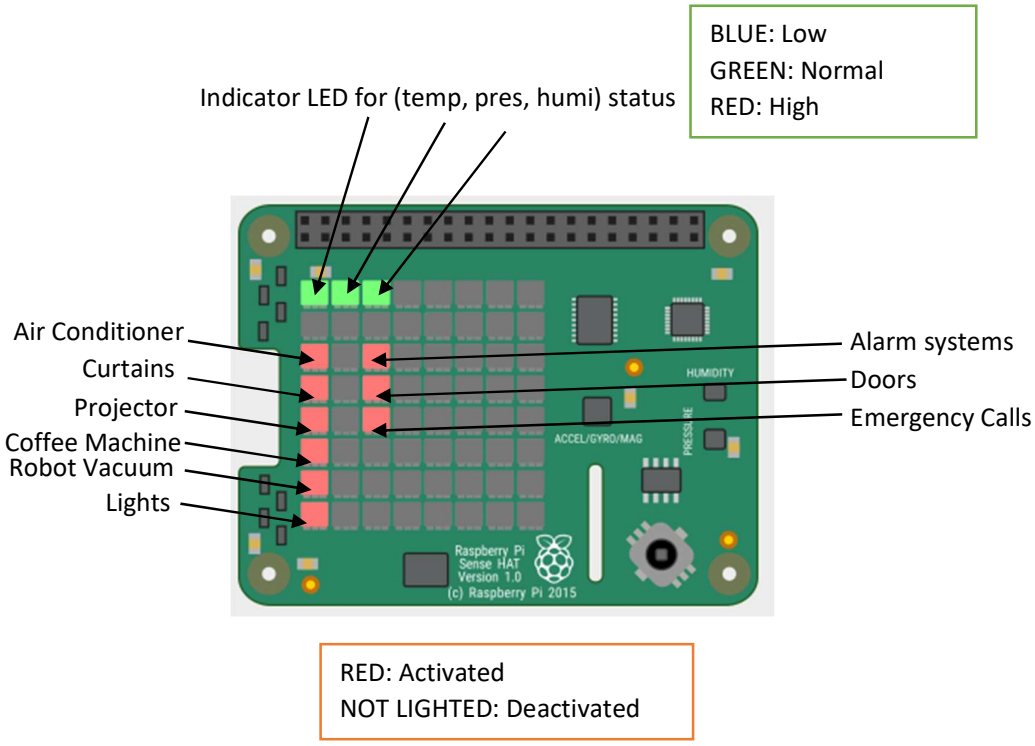
The implementation of this system consists of 5 parts:

1. Obtain environmental data, display LED warning, sends encrypted data to MQTT
2. MQTT Switch
3. Obtaining environmental data from MQTT, decrypting data and pass into InfluxDB
4. Dashboard
5. Telegram

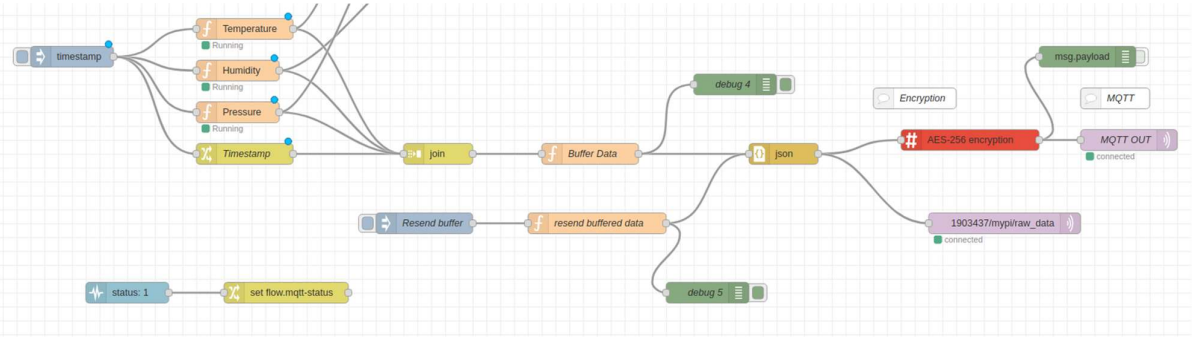
Sense HAT Emulator is used to simulate the IoT devices in real life. The correspond IoT devices and sensor is specified in the diagram below.



The environmental data (Temperature, Pressure, Humidity) in the Sense Hat Emulator acts as the virtual IoT sensors to give data to Node-RED.



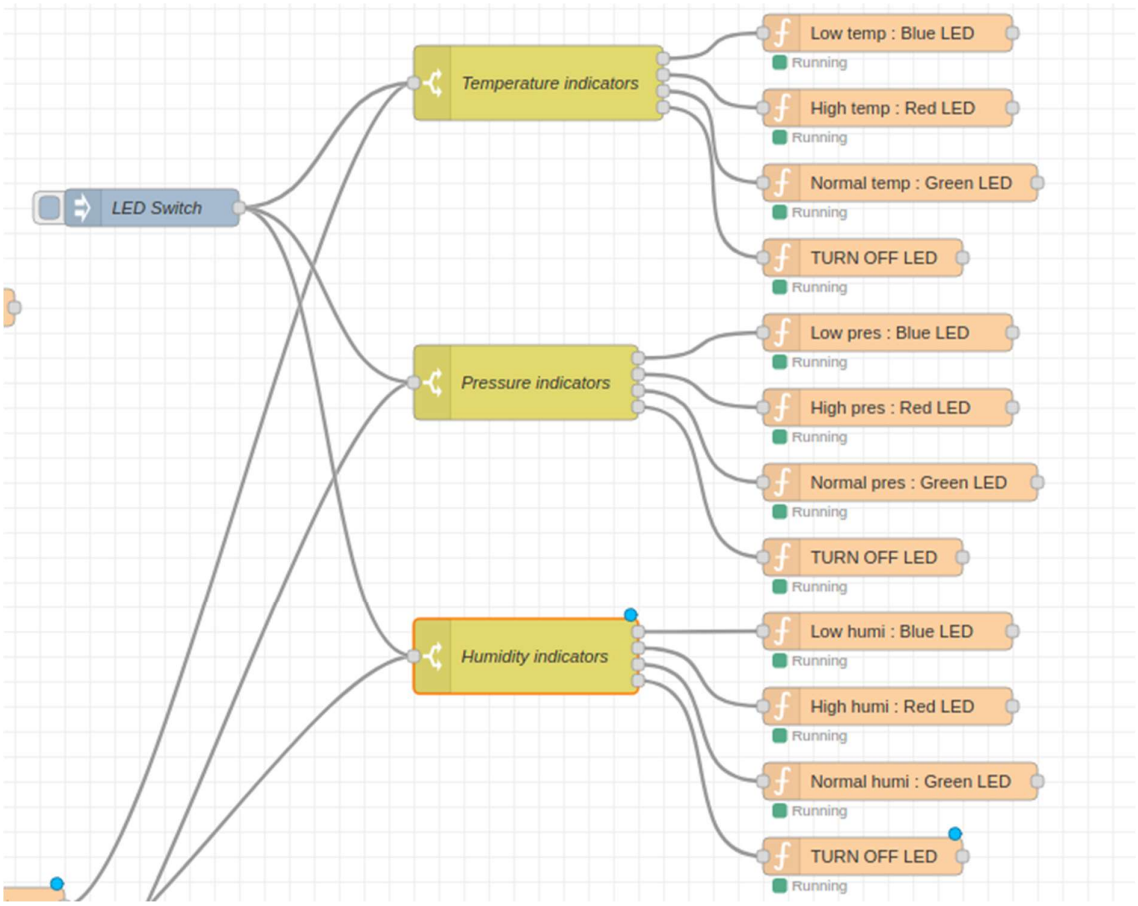
1. Obtain environmental data, display LED warning, sends data to MQTT



Retrieve data (temperature, humidity, pressure) from Sense HAT Emulator. Status is used to checks the condition of MQTT OUT. If the MQTT OUT is unavailable, data will be stored in buffer. Resend the buffer to MQTT OUT again if the MQTT broker is back online. Encryption will be performed on the outgoing data.

The data will be stored in buffer if the MQTT broker is unavailable.

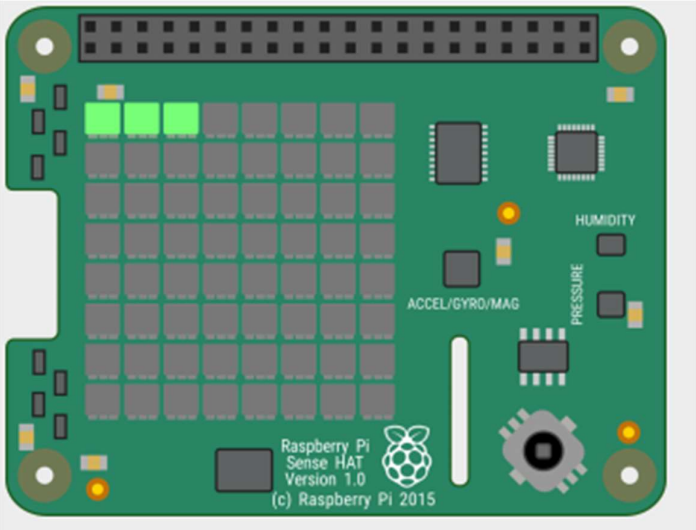
Checks for the environmental data and display the status in LED.



Blue LED: Low value

Green LED: Normal Value

RED LED: High Value



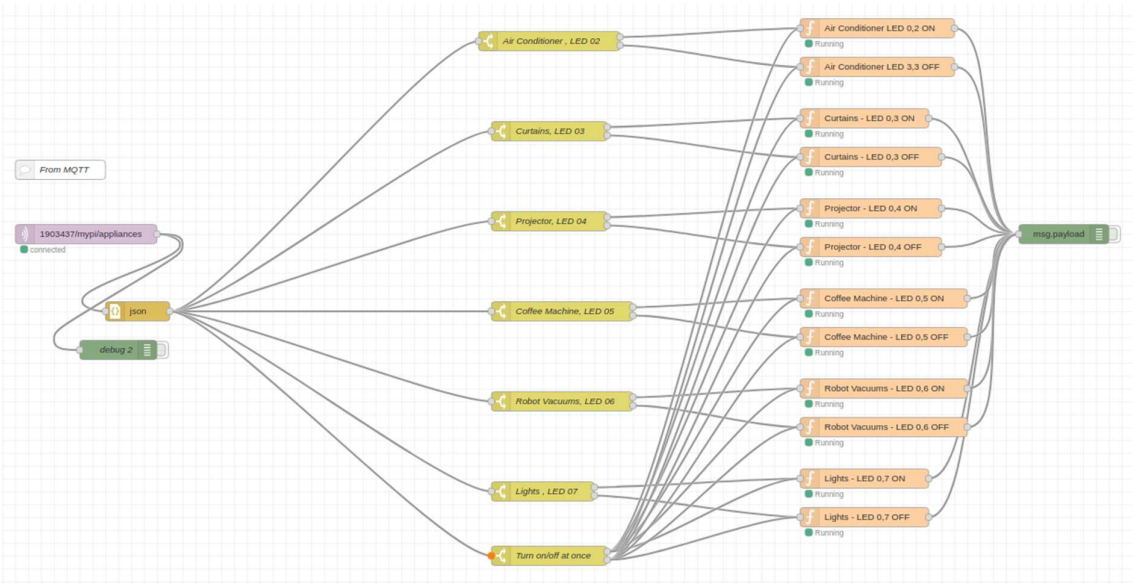
After the data has been converted into JSON String. The method AES-256 encryption will be called to encrypt the data for security before passing it into MQTT OUT.

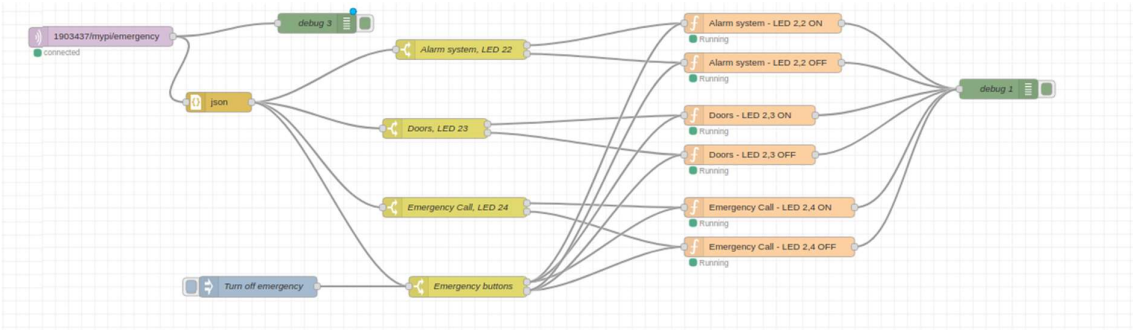
User can use their preferred crypto password while encrypting and decrypting the data.

The unencrypted and encrypted messages are shown below:

MQTT LED Switch

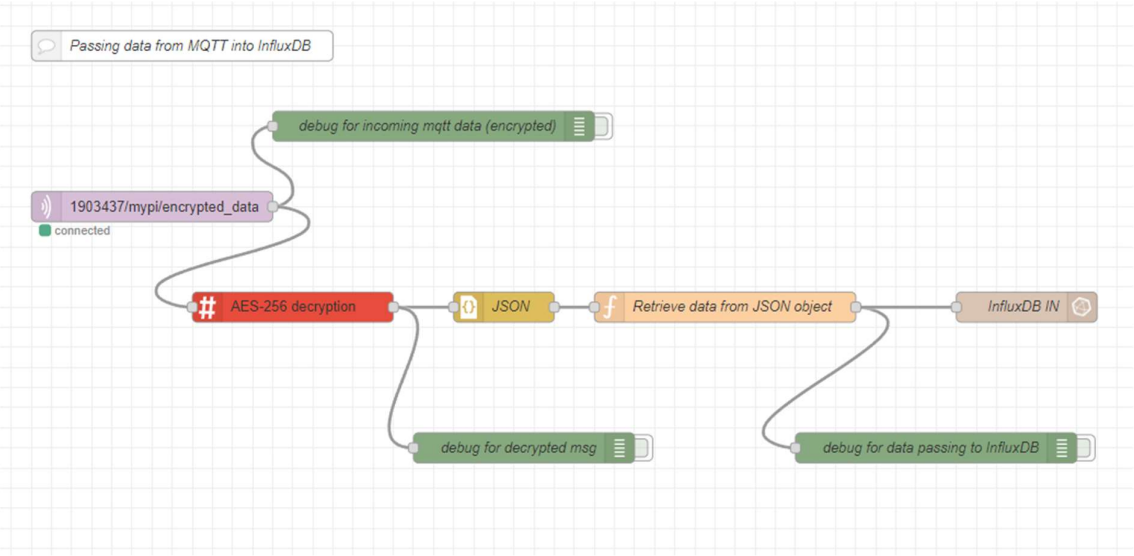
Using MQTT Broker to perform wireless control of IoT devices through IoT MQTT Panel, Node-RED Dashboard, and Telegram commands



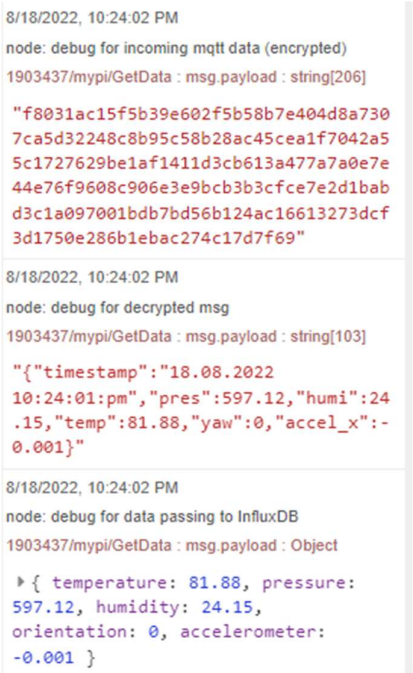


3. Obtaining environmental data from MQTT, decrypting data and pass into InfluxDB

In this part, the encrypted data will be retrieved from MQTT, a decryption process will decrypt the data. After that, it will be passed over a JSON method to convert the data into JavaScript Object. A function will be used to get all the data and finally, the data will be passed into InfluxDB.



In order to decrypt the message, the encryption crypto password must be the same as the decryption crypto password to decrypt the data successfully. The figures below show the data before decryption, after decryption and after the JSON method.



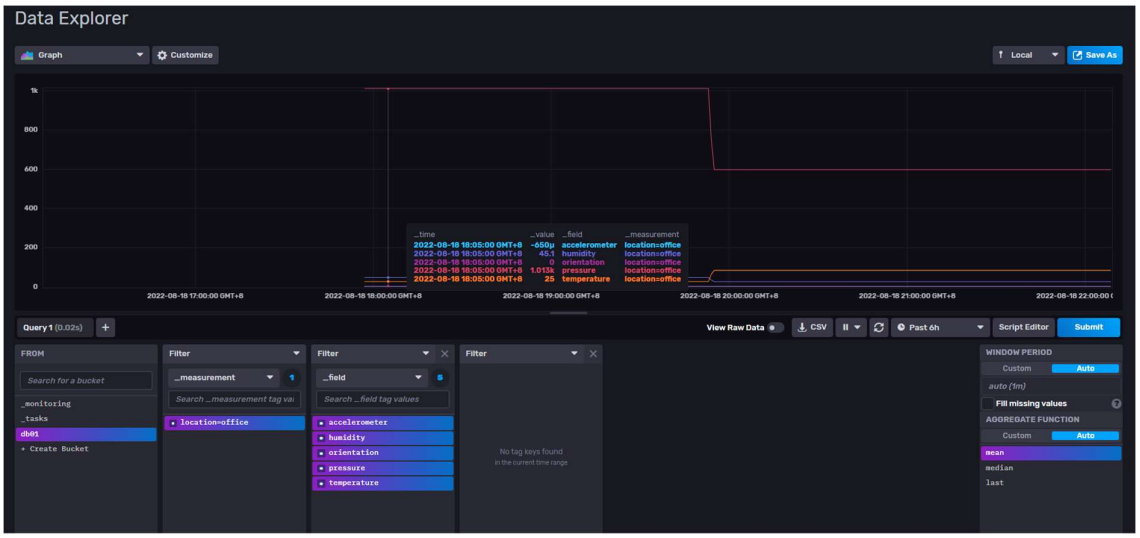
Before decryption

After decryption

After JSON method, converted into JavaScript Object

After that, the data will be passed into InfluxDB, specify the server, organization, bucket, and the measurement of the data

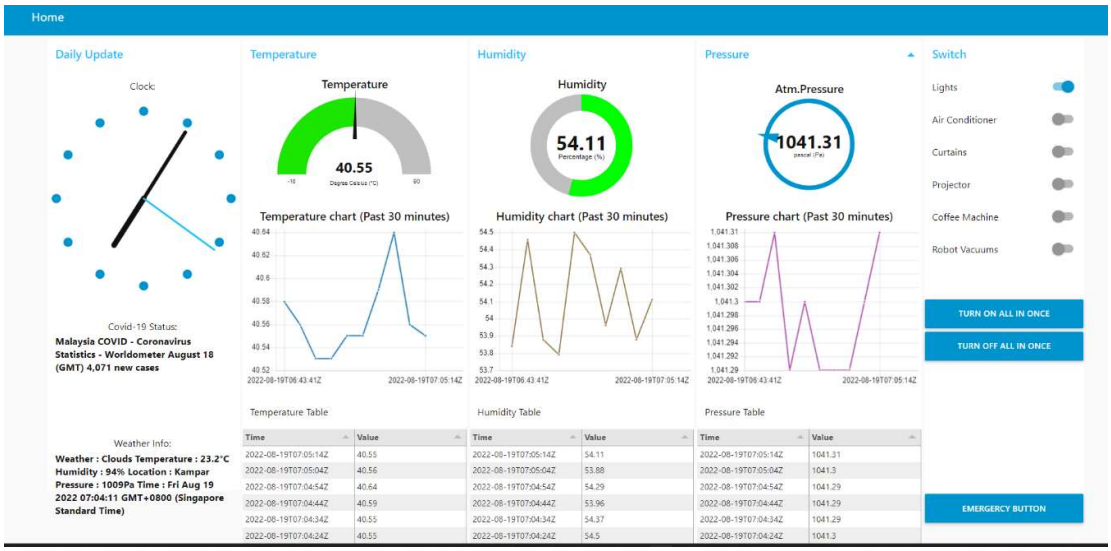
In the Influx Database, the data will be stored with respect to the timestamp.



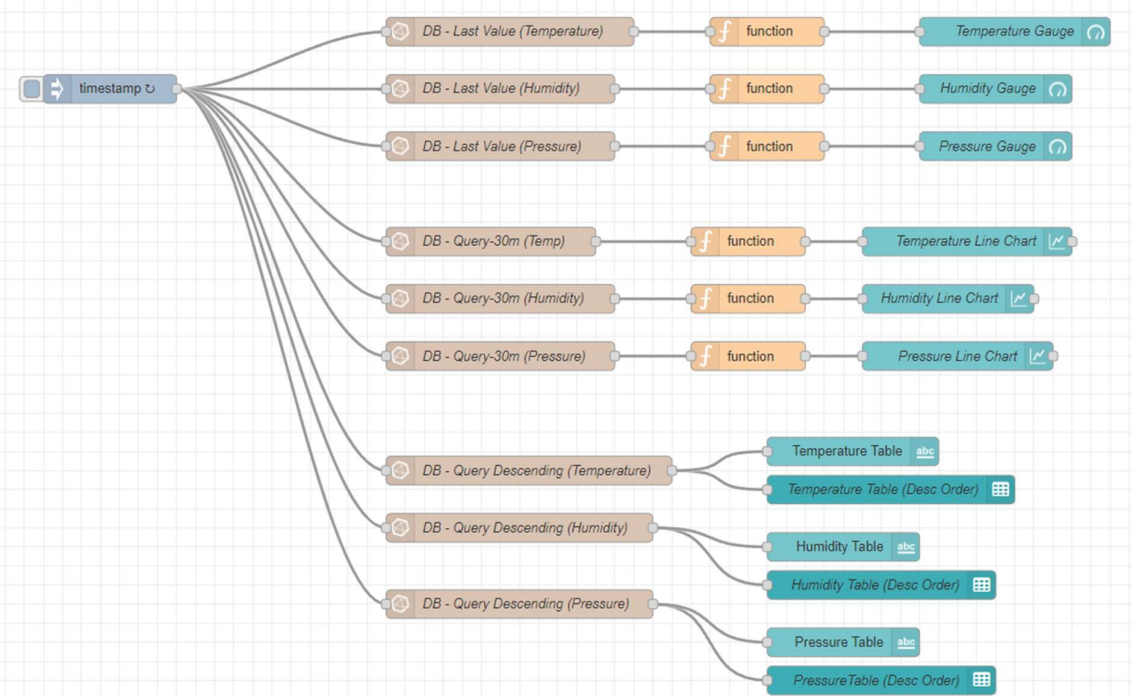
Influx Database

4. Dashboard

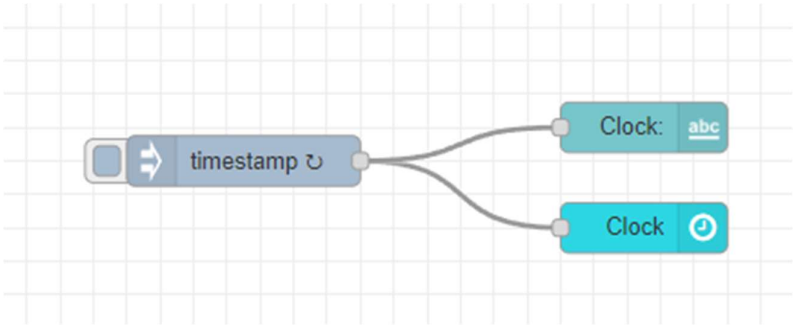
Display an interactive dashboard to the users:



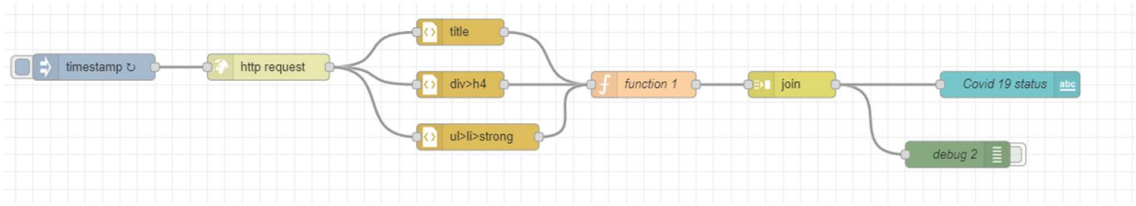
Extract data from database and display it in Node-RED dashboard:



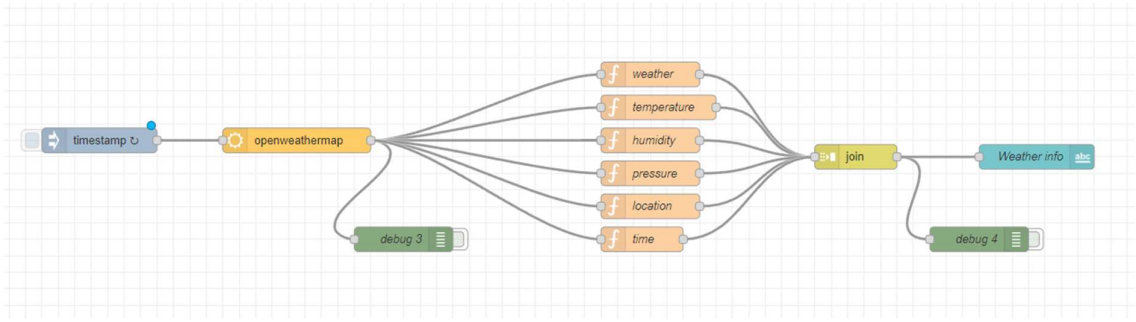
Display Clock:



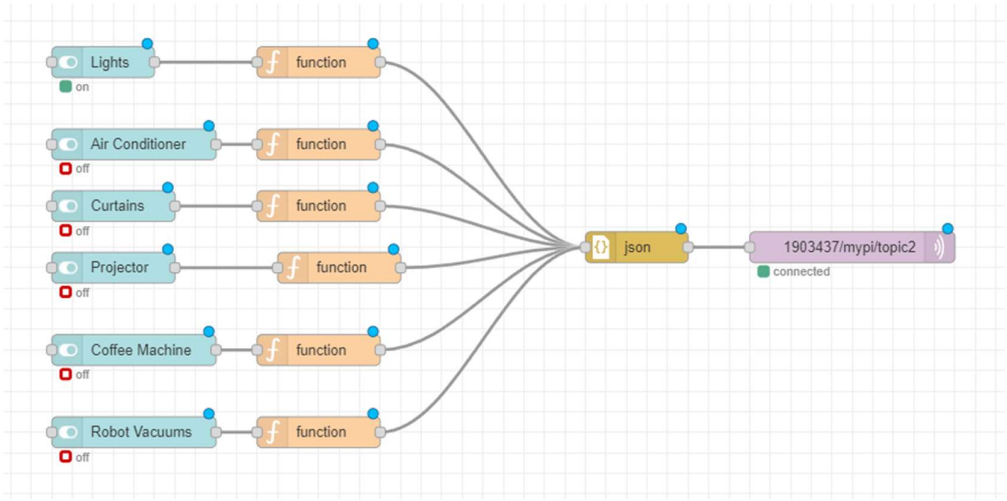
Display Covid-19 Status:



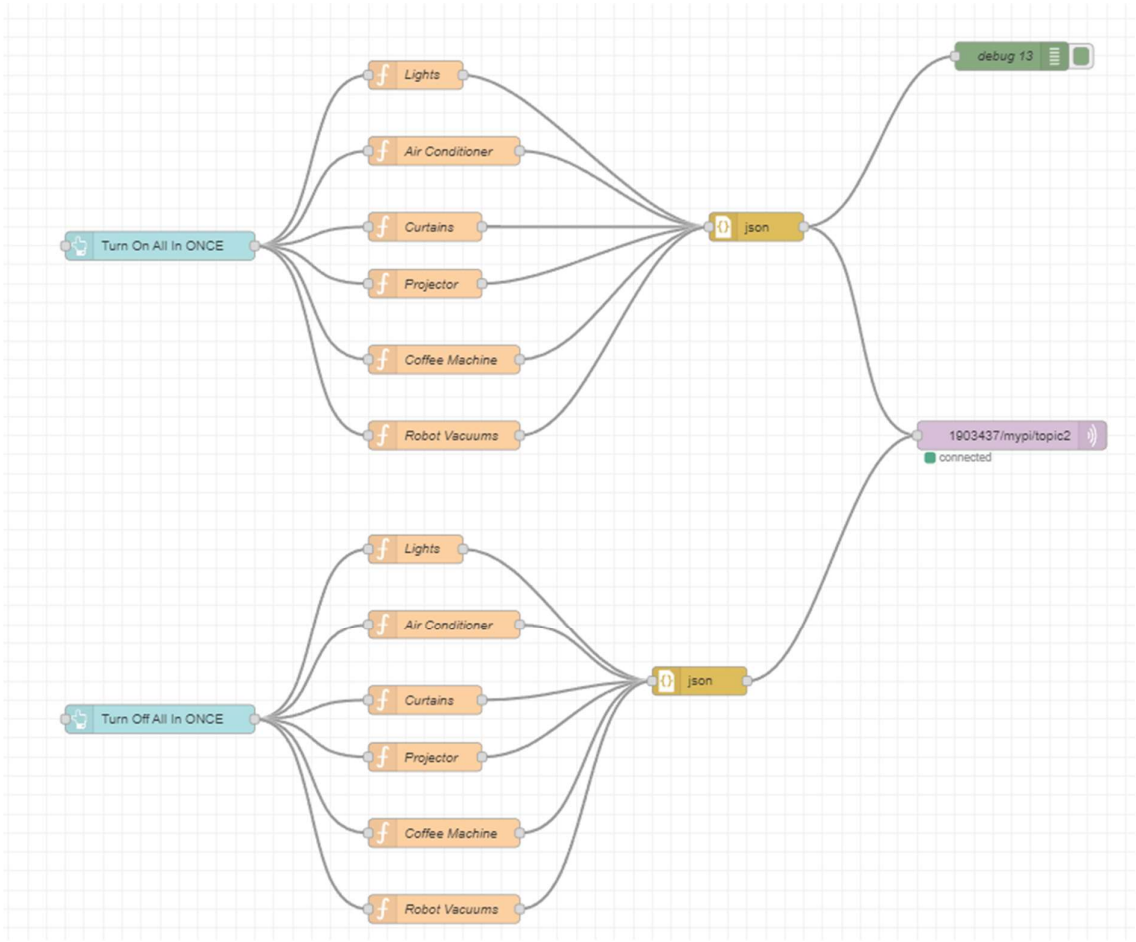
Display Weather through OpenWeatherMap API:



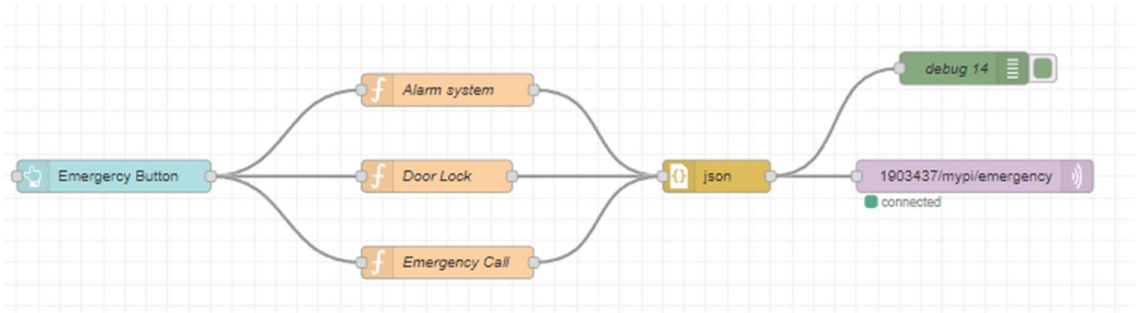
Provides interactive switch for user to control IoT devices with MQTT:



Provides turn on/off all at once switch for user:

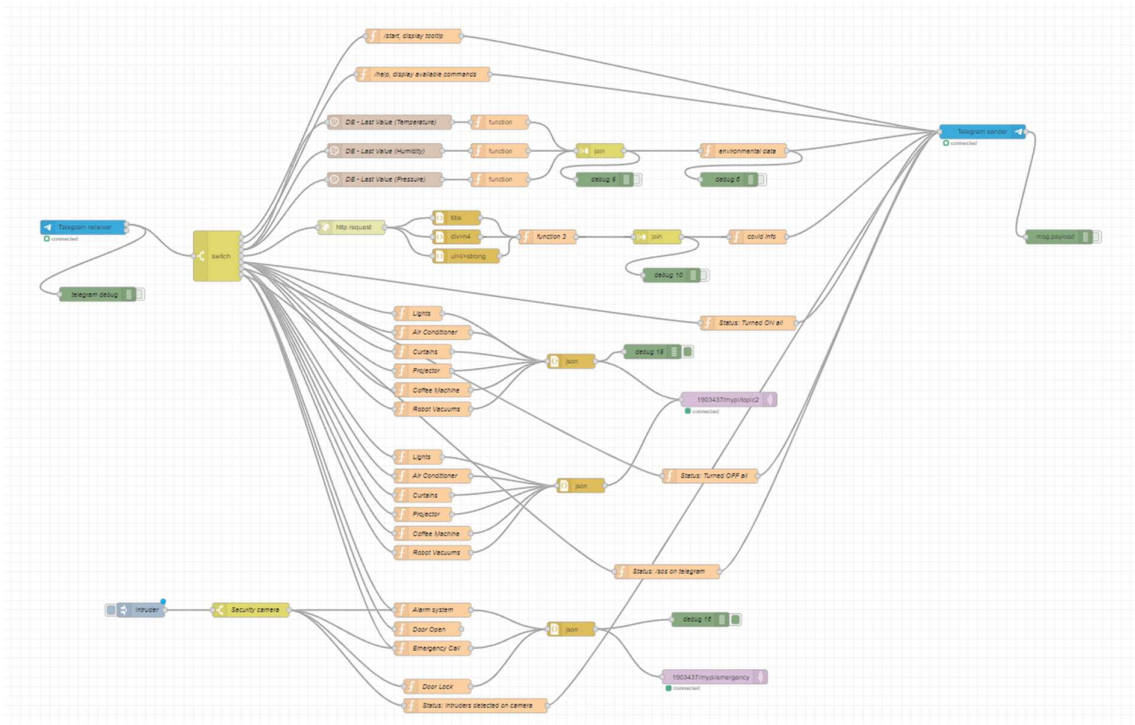


Provides emergency button for user to trigger emergency events:

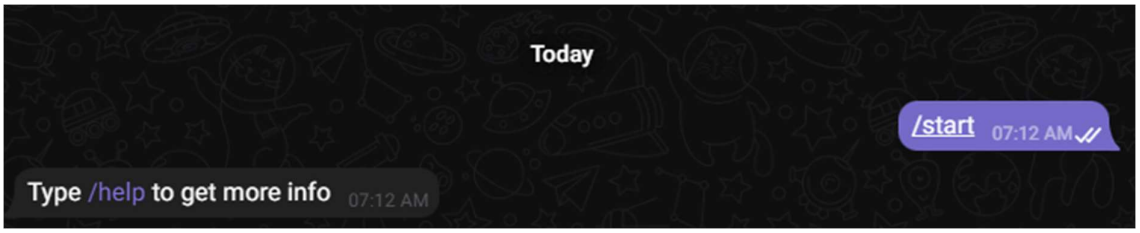


5. Telegram

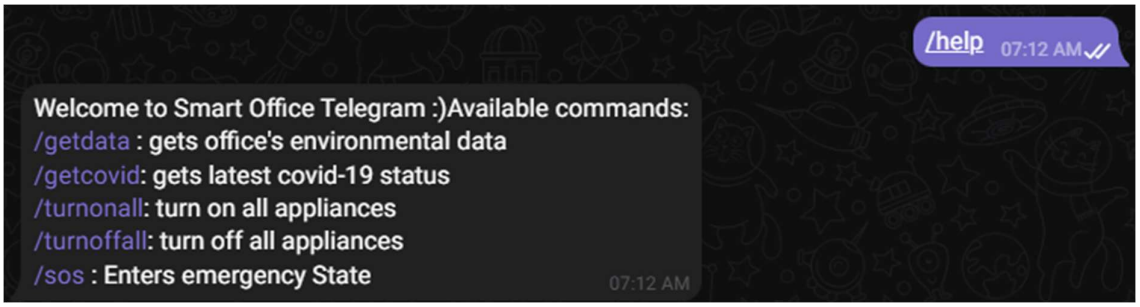
Uses Telegram sender/receiver and MQTT to send out commands:



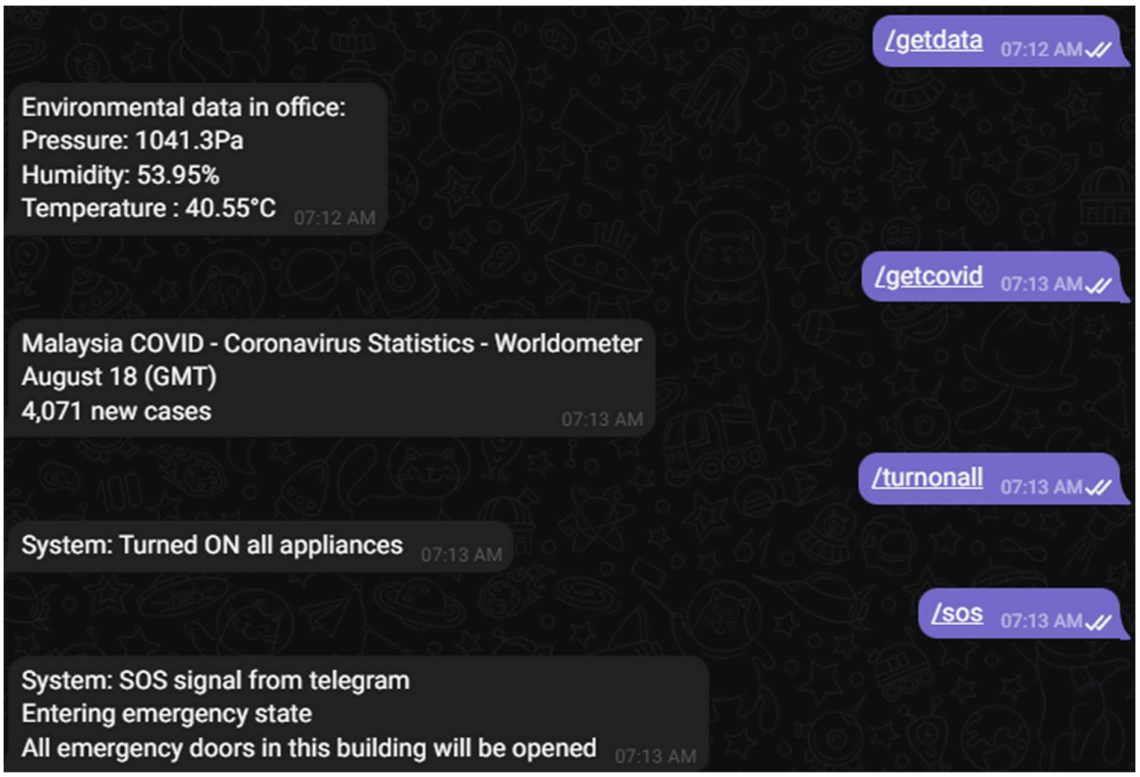
Demonstration of the Telegram bot.



/start function



/help function



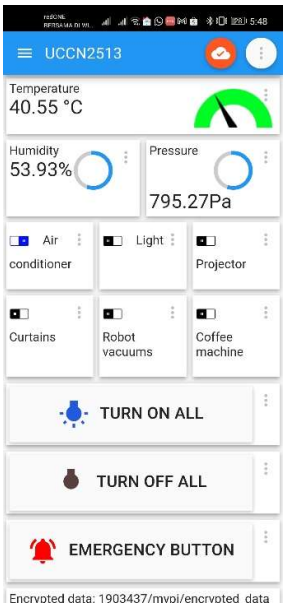
Multiple Available commands.

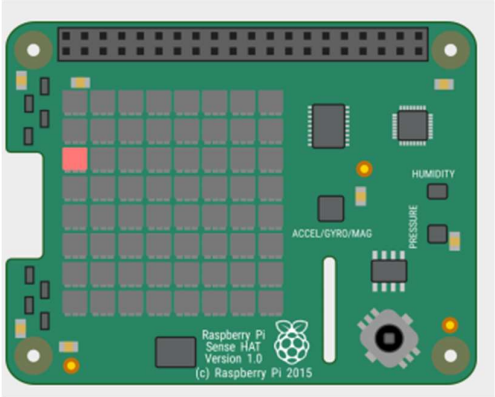
Performance Study

In this section, the scalability of adding new IoT device will be tested. Every IoT device scenario will be tested 10 times. Finally, the performance will be analysed.

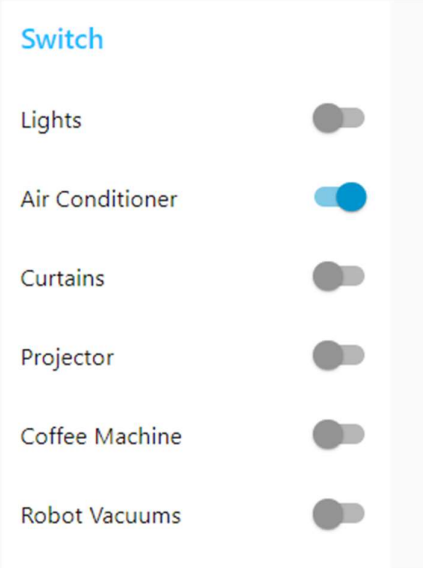
1. Testing the Air Conditioner

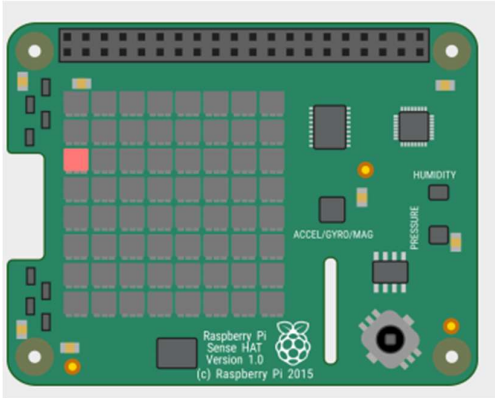
- Switch on/off through IoT MQTT PANEL





-Switch on/off through Node-RED dashboard

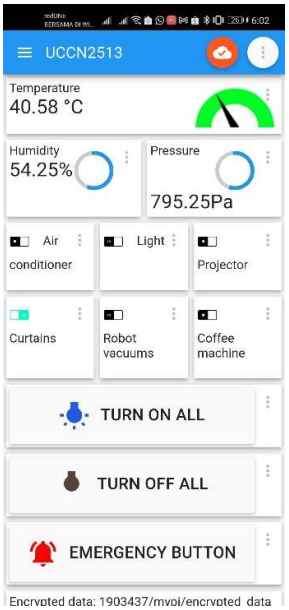


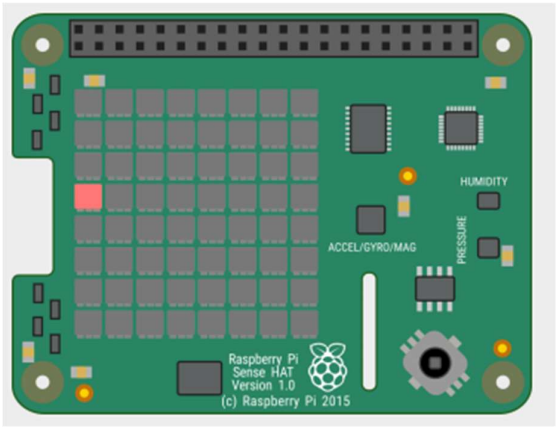


No.	*Node-RED dashboard Switch*	*IoT MQTT Panel Switch*	*Sense HAT Emulator (LED)*	*Accuracy*	*Outcome*
1.	Off	Off	OFF	100%	Successful
2	Off	Off	OFF	100%	Successful
3.	Off	Off	OFF	100%	Successful
4.	Off	Off	OFF	100%	Successful
5.	Off	Off	OFF	100%	Successful
6.	On	On	ON	100%	Successful
7.	On	On	ON	100%	Successful
8.	On	On	ON	100%	Successful
9.	On	On	ON	100%	Successful
10.	On	On	ON	100%	Successful
11.	-	Off	OFF	100%	Successful
12.	-	Off	OFF	100%	Successful
13.	-	Off	OFF	100%	Successful
14.	-	Off	OFF	100%	Successful
15.	-	Off	OFF	100%	Successful
16.	-	On	ON	100%	Successful
17.	-	On	ON	100%	Successful
18.	-	On	ON	100%	Successful
19.	-	On	ON	100%	Successful
20.	-	On	ON	100%	Successful

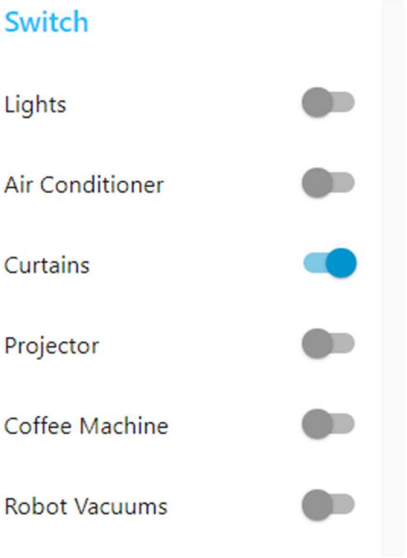
2. Testing the curtains

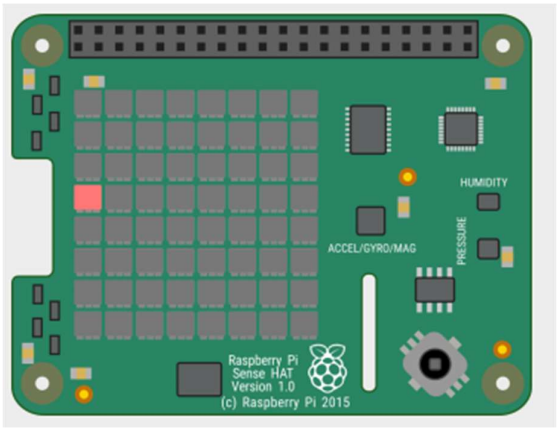
- Switch on/off through IoT MQTT PANEL





-Switch on/off through Node-RED dashboard

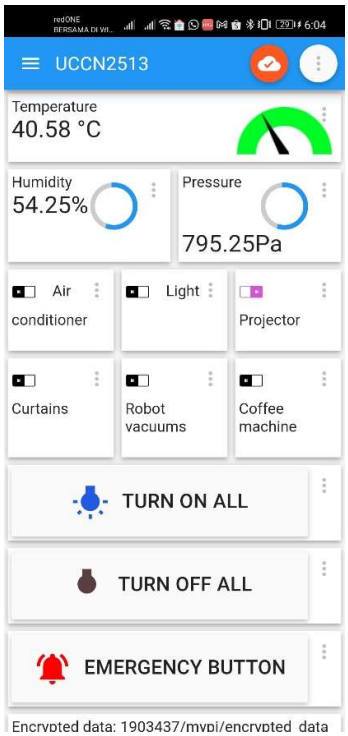


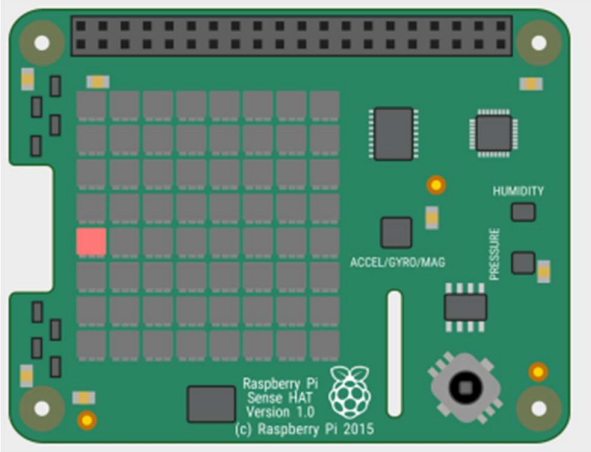


No.	*Node-RED dashboard Switch*	*IoT MQTT Panel Switch*	*Sense HAT Emulator (LED)*	*Accuracy*	*Outcome*
1.	Off	Off	OFF	100%	Successful
2	Off	Off	OFF	100%	Successful
3.	Off	Off	OFF	100%	Successful
4.	Off	Off	OFF	100%	Successful
5.	Off	Off	OFF	100%	Successful
6.	On	On	ON	100%	Successful
7.	On	On	ON	100%	Successful
8.	On	On	ON	100%	Successful
9.	On	On	ON	100%	Successful
10.	On	On	ON	100%	Successful
11.	-	Off	OFF	100%	Successful
12.	-	Off	OFF	100%	Successful
13.	-	Off	OFF	100%	Successful
14.	-	Off	OFF	100%	Successful
15.	-	Off	OFF	100%	Successful
16.	-	On	ON	100%	Successful
17.	-	On	ON	100%	Successful
18.	-	On	ON	100%	Successful
19.	-	On	ON	100%	Successful
20.	-	On	ON	100%	Successful

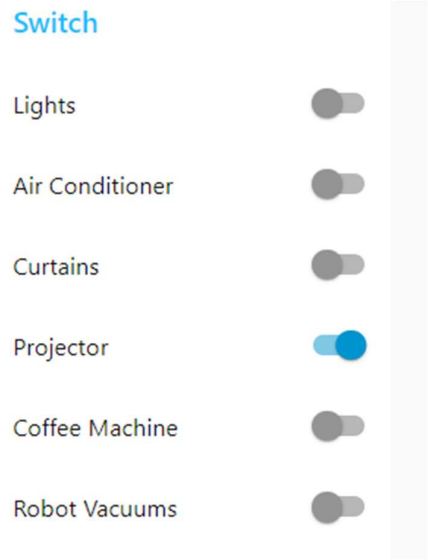
3. Testing the projectors

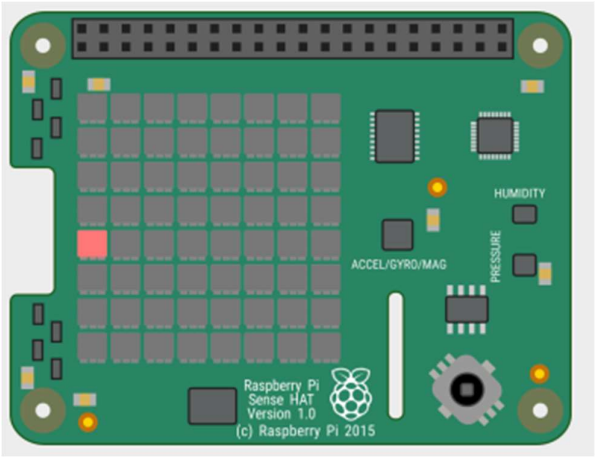
- Switch on/off through IoT MQTT PANEL





-Switch on/off through Node-RED dashboard

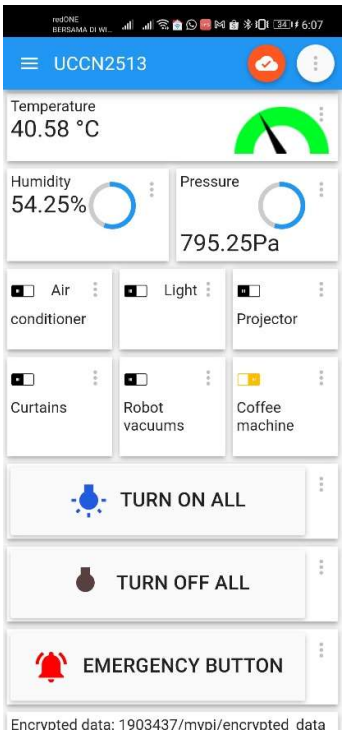


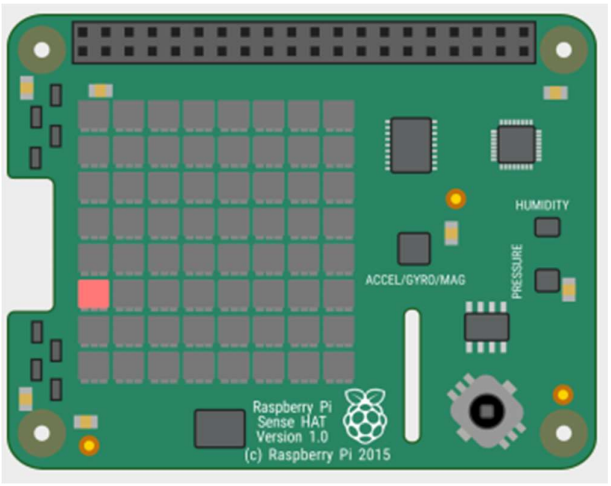


No.	*Node-RED dashboard Switch*	*IoT MQTT Panel Switch*	*Sense HAT Emulator (LED)*	*Accuracy*	*Outcome*
1.	Off	Off	OFF	100%	Successful
2	Off	Off	OFF	100%	Successful
3.	Off	Off	OFF	100%	Successful
4.	Off	Off	OFF	100%	Successful
5.	Off	Off	OFF	100%	Successful
6.	On	On	ON	100%	Successful
7.	On	On	ON	100%	Successful
8.	On	On	ON	100%	Successful
9.	On	On	ON	100%	Successful
10.	On	On	ON	100%	Successful
11.	-	Off	OFF	100%	Successful
12.	-	Off	OFF	100%	Successful
13.	-	Off	OFF	100%	Successful
14.	-	Off	OFF	100%	Successful
15.	-	Off	OFF	100%	Successful
16.	-	On	ON	100%	Successful
17.	-	On	ON	100%	Successful
18.	-	On	ON	100%	Successful
19.	-	On	ON	100%	Successful
20.	-	On	ON	100%	Successful

4. Testing the Coffee Machine

- Switch on/off through IoT MQTT PANEL





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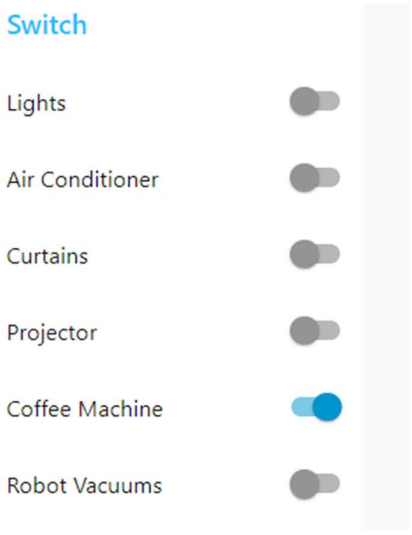
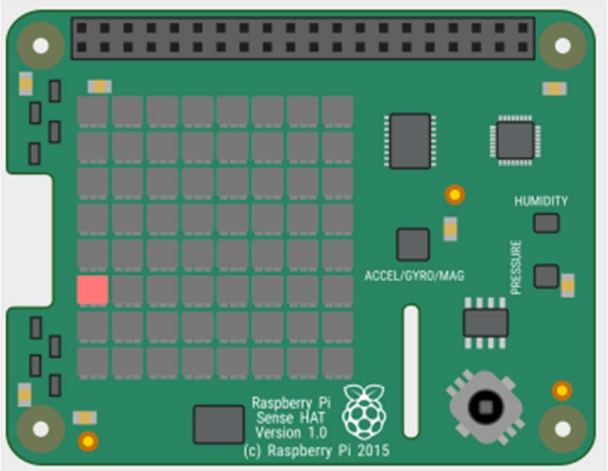
Switch on/off through Node-RED dashboard

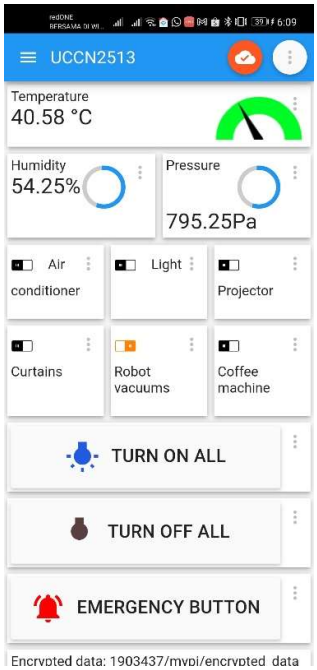


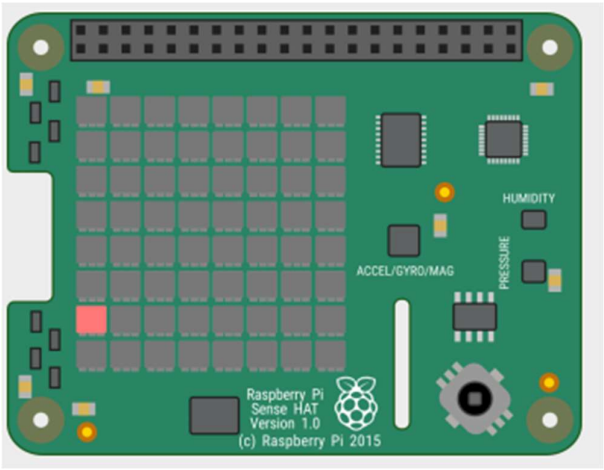


No.	*Node-RED dashboard Switch*	*IoT MQTT Panel Switch*	*Sense HAT Emulator (LED)*	*Accuracy*	*Outcome*
1.	Off	Off	OFF	100%	Successful
2	Off	Off	OFF	100%	Successful
3.	Off	Off	OFF	100%	Successful
4.	Off	Off	OFF	100%	Successful
5.	Off	Off	OFF	100%	Successful
6.	On	On	ON	100%	Successful
7.	On	On	ON	100%	Successful
8.	On	On	ON	100%	Successful
9.	On	On	ON	100%	Successful
10.	On	On	ON	100%	Successful
11.	-	Off	OFF	100%	Successful
12.	-	Off	OFF	100%	Successful
13.	-	Off	OFF	100%	Successful
14.	-	Off	OFF	100%	Successful
15.	-	Off	OFF	100%	Successful
16.	-	On	ON	100%	Successful
17.	-	On	ON	100%	Successful
18.	-	On	ON	100%	Successful
19.	-	On	ON	100%	Successful
20.	-	On	ON	100%	Successful

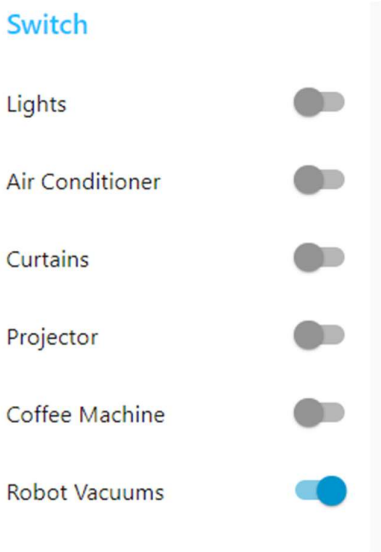
5. Testing the Robot Vacuums

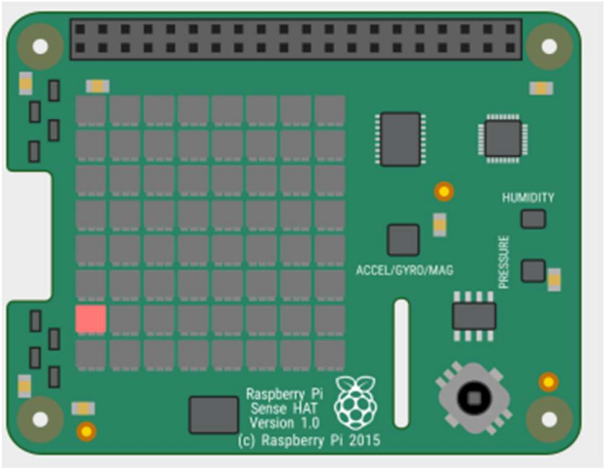
Switch on/off through IoT MQTT PANEL





Switch on/off through Node-RED dashboard

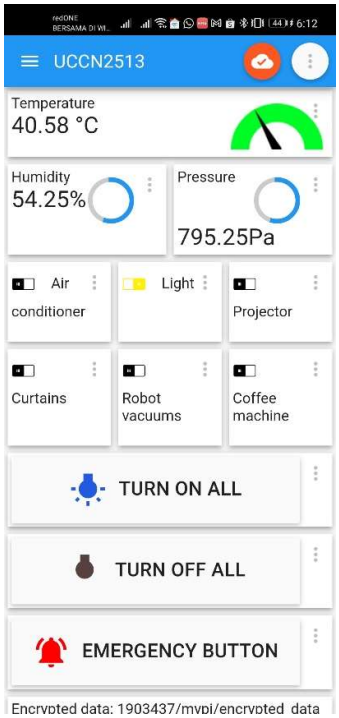


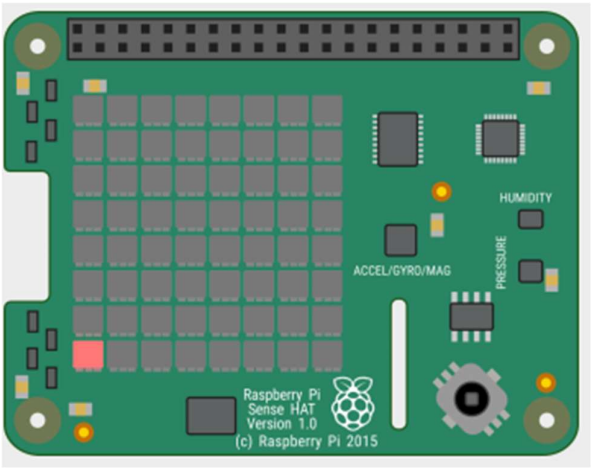


No.	*Node-RED dashboard Switch*	*IoT MQTT Panel Switch*	*Sense HAT Emulator (LED)*	*Accuracy*	*Outcome*
1.	Off	Off	OFF	100%	Successful
2	Off	Off	OFF	100%	Successful
3.	Off	Off	OFF	100%	Successful
4.	Off	Off	OFF	100%	Successful
5.	Off	Off	OFF	100%	Successful
6.	On	On	ON	100%	Successful
7.	On	On	ON	100%	Successful
8.	On	On	ON	100%	Successful
9.	On	On	ON	100%	Successful
10.	On	On	ON	100%	Successful
11.	-	Off	OFF	100%	Successful
12.	-	Off	OFF	100%	Successful
13.	-	Off	OFF	100%	Successful
14.	-	Off	OFF	100%	Successful
15.	-	Off	OFF	100%	Successful
16.	-	On	ON	100%	Successful
17.	-	On	ON	100%	Successful
18.	-	On	ON	100%	Successful
19.	-	On	ON	100%	Successful
20.	-	On	ON	100%	Successful

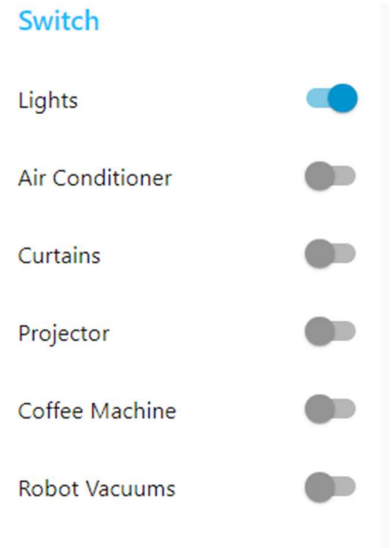
6. Testing the Lights

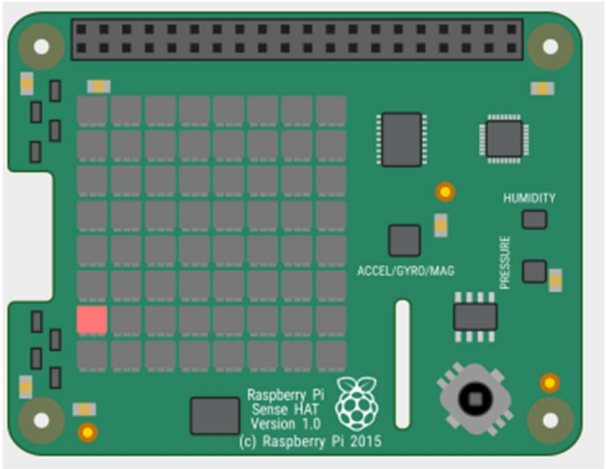
Switch on/off through IoT MQTT PANEL





Switch on/off through Node-RED dashboard

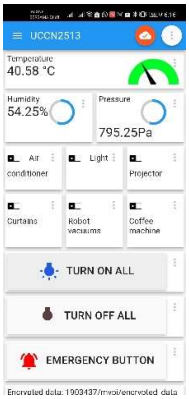


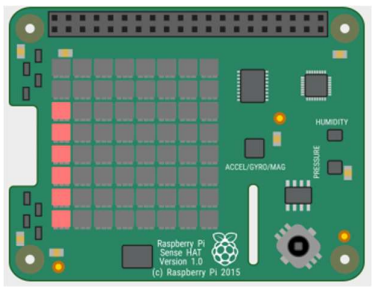


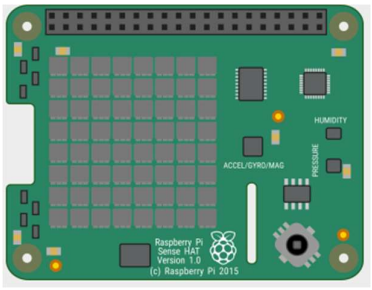
No.	*Node-RED dashboard Switch*	*IoT MQTT Panel Switch*	*Sense HAT Emulator (LED)*	*Accuracy*	*Outcome*
1.	Off	Off	OFF	100%	Successful
2	Off	Off	OFF	100%	Successful
3.	Off	Off	OFF	100%	Successful
4.	Off	Off	OFF	100%	Successful
5.	Off	Off	OFF	100%	Successful
6.	On	On	ON	100%	Successful
7.	On	On	ON	100%	Successful
8.	On	On	ON	100%	Successful
9.	On	On	ON	100%	Successful
10.	On	On	ON	100%	Successful
11.	-	Off	OFF	100%	Successful
12.	-	Off	OFF	100%	Successful
13.	-	Off	OFF	100%	Successful
14.	-	Off	OFF	100%	Successful
15.	-	Off	OFF	100%	Successful
16.	-	On	ON	100%	Successful
17.	-	On	ON	100%	Successful
18.	-	On	ON	100%	Successful
19.	-	On	ON	100%	Successful
20.	-	On	ON	100%	Successful

7. Testing the Turn on/off at once button

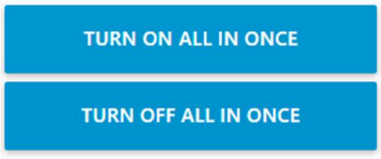
Press on/off button through IoT MQTT PANEL

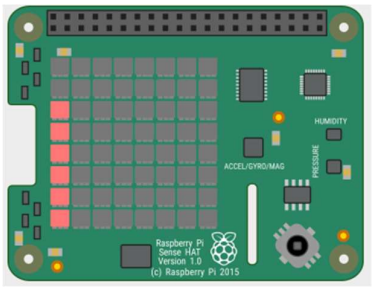


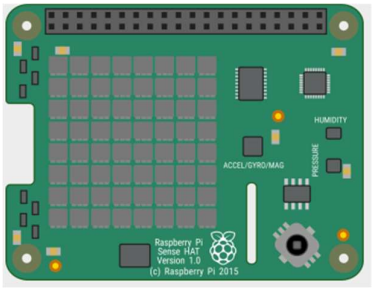




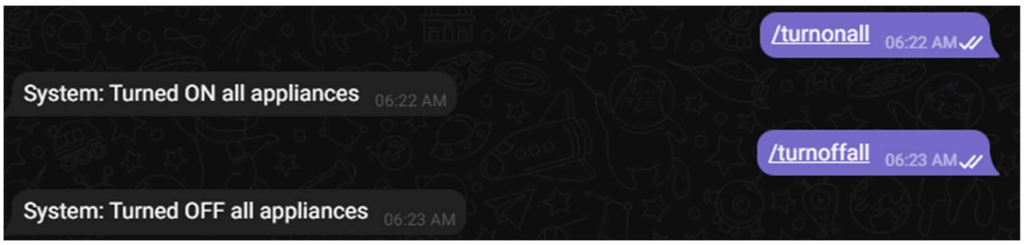
Press on/off button through Node-RED dashboard

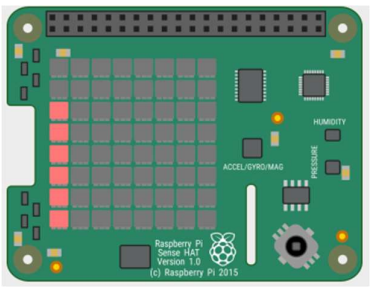


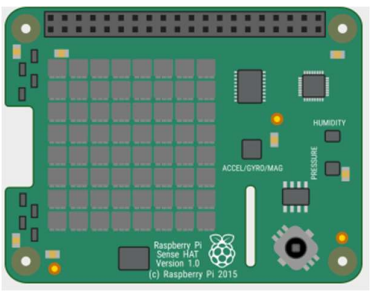




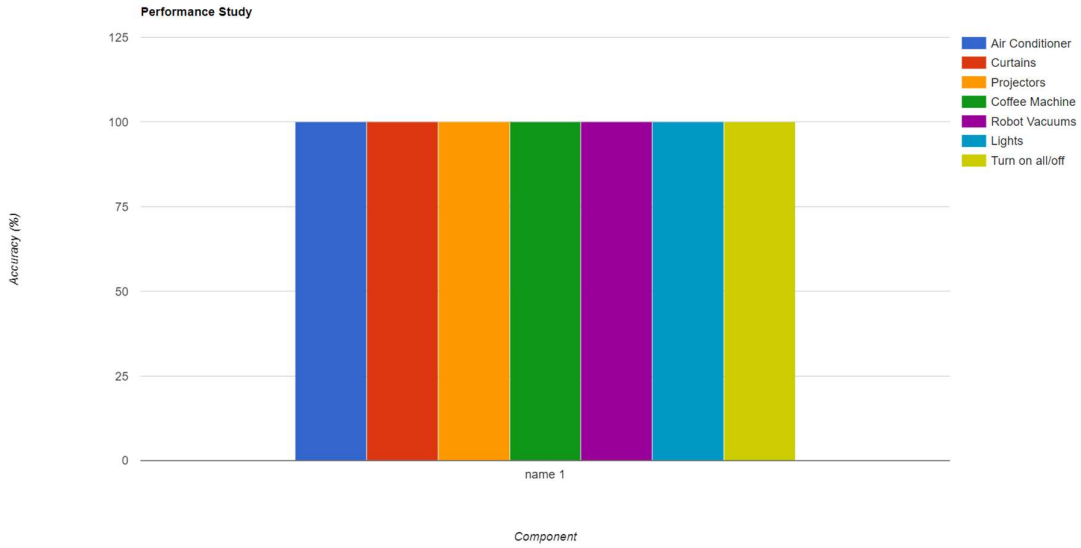
/turnonall , /turnoffall command in Telegram







No.	*Telegram Bot Command*	*Node-RED dashboard Button*	*IoT MQTT Button*	*Sense HAT Emulator (LED)*	*Accuracy*	*Outcome*
1.	/turnoffall	0	0	OFF	100%	Successful
2	/turnoffall	0	0	OFF	100%	Successful
3.	/turnoffall	0	0	OFF	100%	Successful
4.	/turnoffall	0	0	OFF	100%	Successful
5.	/turnoffall	0	0	OFF	100%	Successful
6.	/turnonall	1	1	ON	100%	Successful
7.	/turnonall	1	1	ON	100%	Successful
8.	/turnonall	1	1	ON	100%	Successful
9.	/turnonall	1	1	ON	100%	Successful
10.	/turnonall	1	1	ON	100%	Successful
11.	-	0	0	OFF	100%	Successful
12.	-	0	0	OFF	100%	Successful
13.	-	0	0	OFF	100%	Successful
14.	-	0	0	OFF	100%	Successful
15.	-	0	0	OFF	100%	Successful
16.	-	1	1	ON	100%	Successful
17.	-	1	1	ON	100%	Successful
18.	-	1	1	ON	100%	Successful
19.	-	1	1	ON	100%	Successful
20.	-	1	1	ON	100%	Successful
21.	-	-	0	OFF	100%	Successful
22.	-	-	0	OFF	100%	Successful
23.	-	-	0	OFF	100%	Successful
24.	-	-	0	OFF	100%	Successful
25.	-	-	0	OFF	100%	Successful
26.	-	-	1	ON	100%	Successful
27.	-	-	1	ON	100%	Successful
28.	-	-	1	ON	100%	Successful
29.	-	-	1	ON	100%	Successful
30.	-	-	1	ON	100%	Successful



After testing all the IoT components, the performance of the system is very promising, with 100 percent accuracy among all of the IoT components. Hence, the scalability of this system is very good as adding new IoT devices will not affect the accuracy of another IoT device.

Conclusion

In conclusion, this project aims to deliver an IoT office monitoring system that offers users the ability to monitor and control IoT devices in the workplace. Besides that, the system is also fully automated that could monitor real-time environmental data and give warnings to the users if the value is abnormal. On the other hand, with the implementation of MQTT, the devices in the workplace could be controlled remotely and all of the devices could be activated with just one button. Ultimately, the goal of this project is to provide an efficient system in the workplace where the environmental data can be monitored, and further steps could be applied such as turning off the air conditioner and lights automatically to save energy and prevents energy wastage. Employees could also have a better workplace where they can observe the real-time environmental data on the dashboard and can control the IoT devices around them, hence boosting the overall productivity and efficiency in the workplace.