Project Report

Smart Agriculture System Based on IoT

Carried out as a part of Online Internship under
IoT Application Developer
During June-July 2021
At

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CONTENT

1. Introduction

1.1 Overview

Agriculture plays a critical role in the entire life of a given economy. Agriculture is the key development in the rise of a sedentary human civilization. There are various issues that are hampering the development of the country. The possible solutions for the problems faced is to opt for modernized agriculture. Agriculture can be made smart by using Internet of Things (IoT) technologies. Smart Agriculture increases quality, quantity, sustainability and cost-effectiveness of crop production and also analyses the weather conditions. This paper proposes a system which is useful in monitoring the field data as well as controlling the field operations which provides the flexibility. The paper aims at making agriculture smart using automation and IoT technologies.

1.2 Purpose

The Smart Agriculture System is a hi-tech and effective system of doing cultivation and growing food in a sustainable way. It majorly depends on IoT thus eliminating the need of physical work of farmers and growers and thus increasing the productivity in every possible manner. IoT based Smart Agriculture System improves the entire Agriculture system by monitoring the field in real-time. Several great uses for agriculture IoT in this space:

- Sensing for soil moisture and nutrients.
- Controlling water usage for optimal plant growth.
- Reporting weather conditions.

With the help of sensors and interconnectivity, the IoT in Agriculture has not only saved the time of the farmers but also reduces the extravagant use of resources such as water and electricity. It keeps various factors like Humidity, Temperature, Soil Moisture etc. under check and gives a crystal-clear real-time observation.

2. Literature Survey

2.1 Existing Problem

Farmers are to be present at farm for its maintenance irrespective of the weather conditions. They have to ensure that the crops are well watered and the farm status is monitored by them physically. Farmer have to stay most of the time in field in order to get a good yield. In difficult times like in the presence of pandemic also they have to work hard in their fields risking their lives to provide food for the country.

2.2 Proposed Solution

In order to improve the farmer's working conditions and make them easier, we introduce IoT services to him in which we use cloud services and internet to enable farmer to continue his work remotely via internet. He can monitor the field parameters and control the devices in farm.

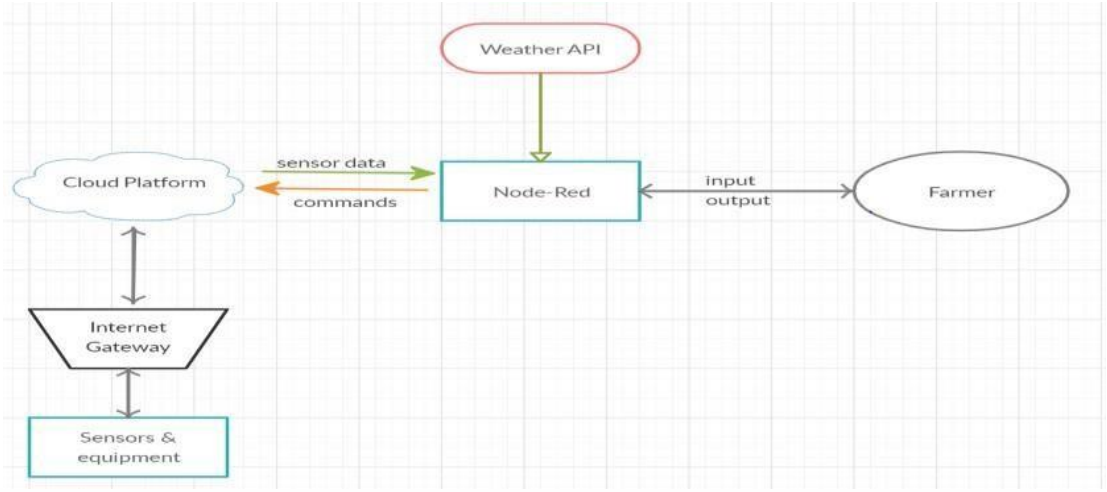
"SMART AGRICULTURE SYSTEM based on IoT" is regarded as the IoT gadget focusing on Live Monitoring of Environmental data in terms of Temperature, Moisture and Humidity of atmosphere and the plant/crop. The system provides the concept of "Plug and Sense" in which farmers can directly implement smart farming by such as putting the System on the field and getting Live Data feeds on various electronic devices using Web Application. Moreover, the data generated via sensors can be easily shared and viewed by agriculture consultants anywhere remotely via Cloud Computing technology integration. The system allows manually to turn the pumping motor ON and OFF on sensing the moisture content of the soil. The Farmer can also use "Run Motor for 30 minutes" button, where the Motor runs for 30 minutes and turns off automatically with Audio output of Motor turning ON, OFF and Run.

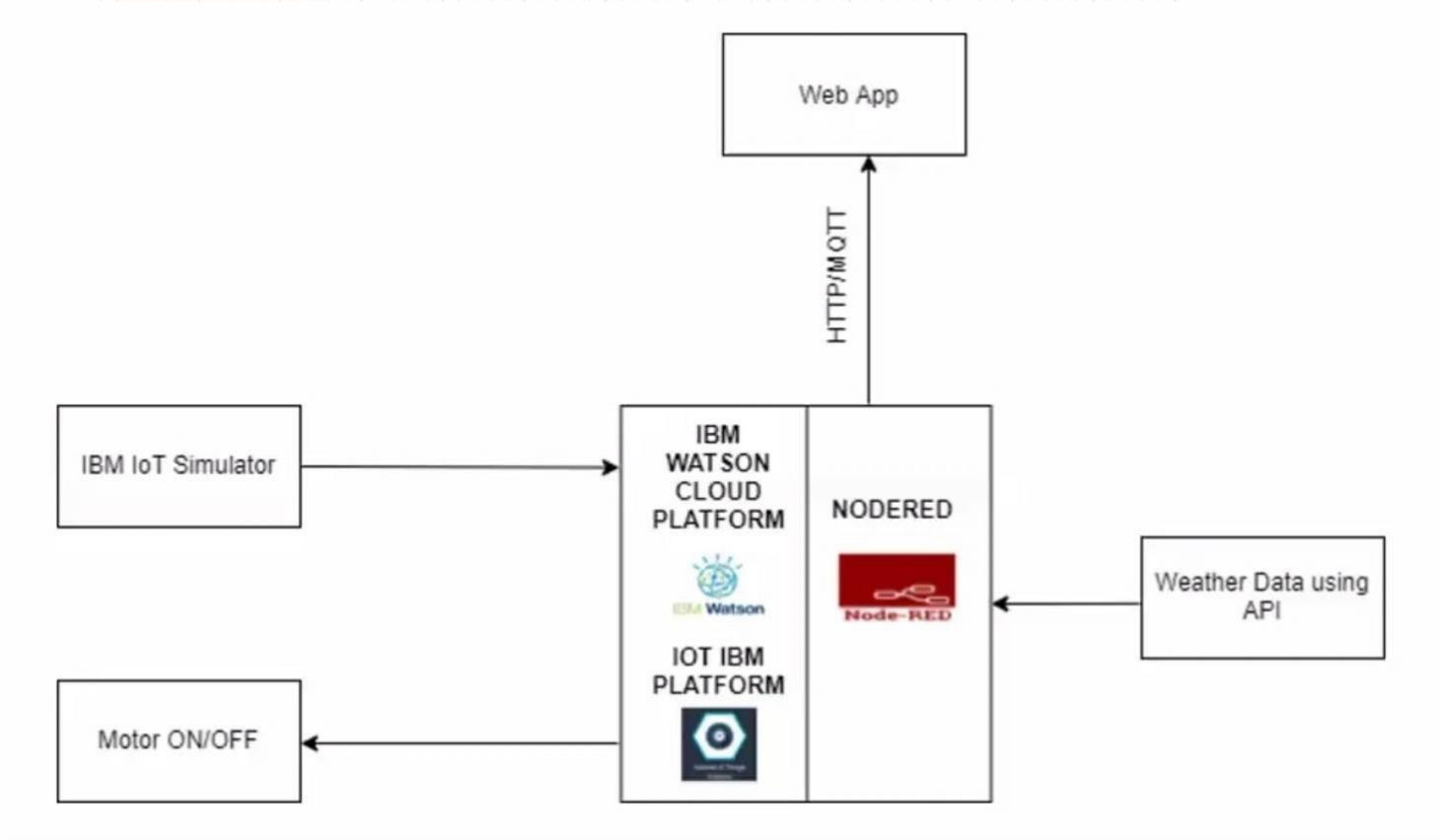
3.Theoretical Analysis

- **IBM Cloud** is a set of cloud computing services for business offered by the information technology company IBM. Here, IBM platform acts as an interface to control the electronic devices in real time through Watson IoT platform.
- **The Watson IOT platform** is used when the projects contain hardware such as sensors, electronic devices. It acts as an interface between devices and IBM Cloud by retrieving data from the devices and sending it to cloud and vice-versa.
- The simulated data is sent from **IBM IOT simulator** to IBM Watson cloud platform and then presented in **web interface using http/mqtt web protocols**.
- To know the real time data of any agricultural farm, we use **Open weather API** (Application Program Interface), which has some predefined APIs.
- Once the data is received, it is sent to the cloud via **Node-red platform**.
- The data is monitored continuously (here temperature, humidity and soil temperature) from a web interface.
- In case of watering crops **motor** can be turned on or off through the web interface controlled through internet.

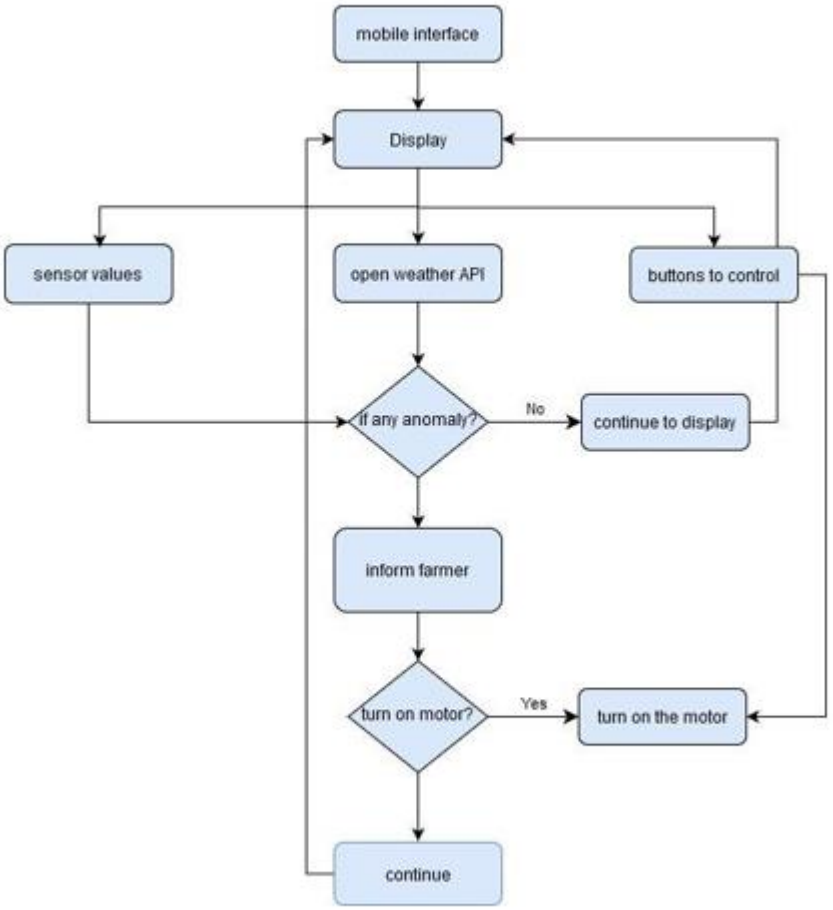
3.1 Block Diagram

In order to implement the solution, the following approach as shown in the block diagrams is used.





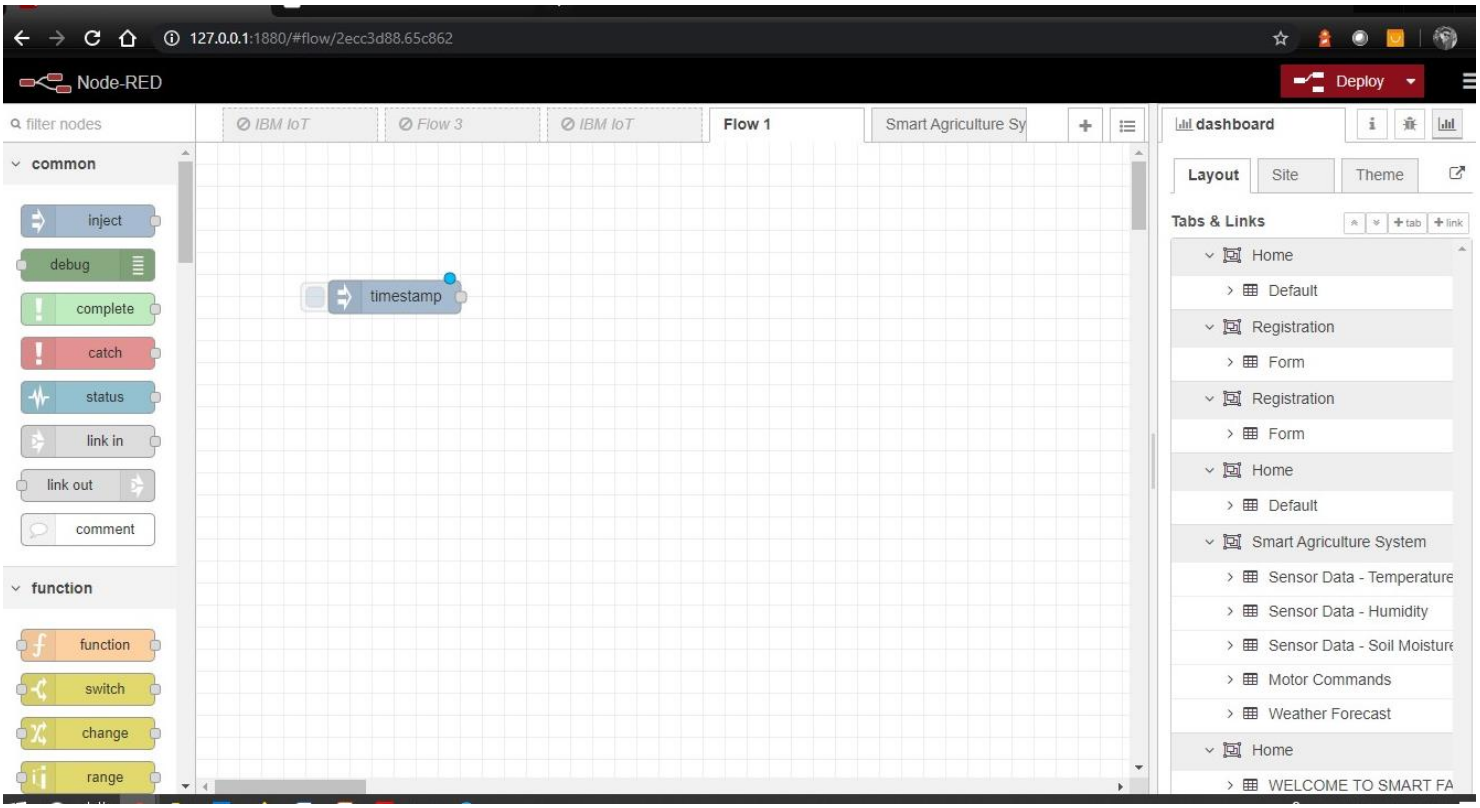
Flowchart:


mobile interface
Display
sensor values
open weather API
buttons to control
if any anomaly?
No
continue to display
inform farmer
turn on motor?
Yes
turn on the motor
continue

3.2 Required Software Installation

3.2. a Node-Red

Node-RED is a flow-based development tool for visual programming developed originally by IBM for wiring together hardware devices, APIs and online services as part of the Internet of Things.
Node-RED provides a web browser-based flow editor, which can be used to create JavaScript functions.

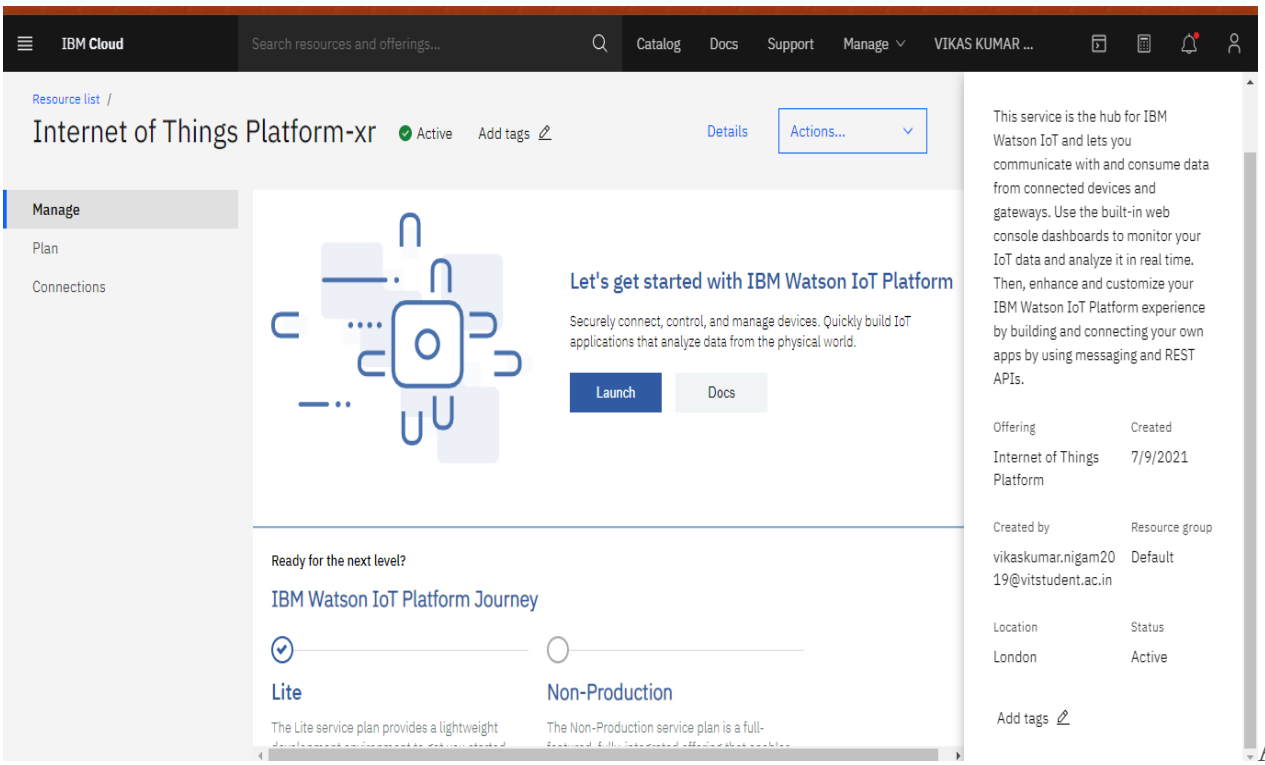


Installation of IBM IoT and Dashboard nodes for Node-Red

In order to connect to IBM Watson IoT platform and create the Web App UI these nodes are required

1. IBM IoT node
2. Dashboard node

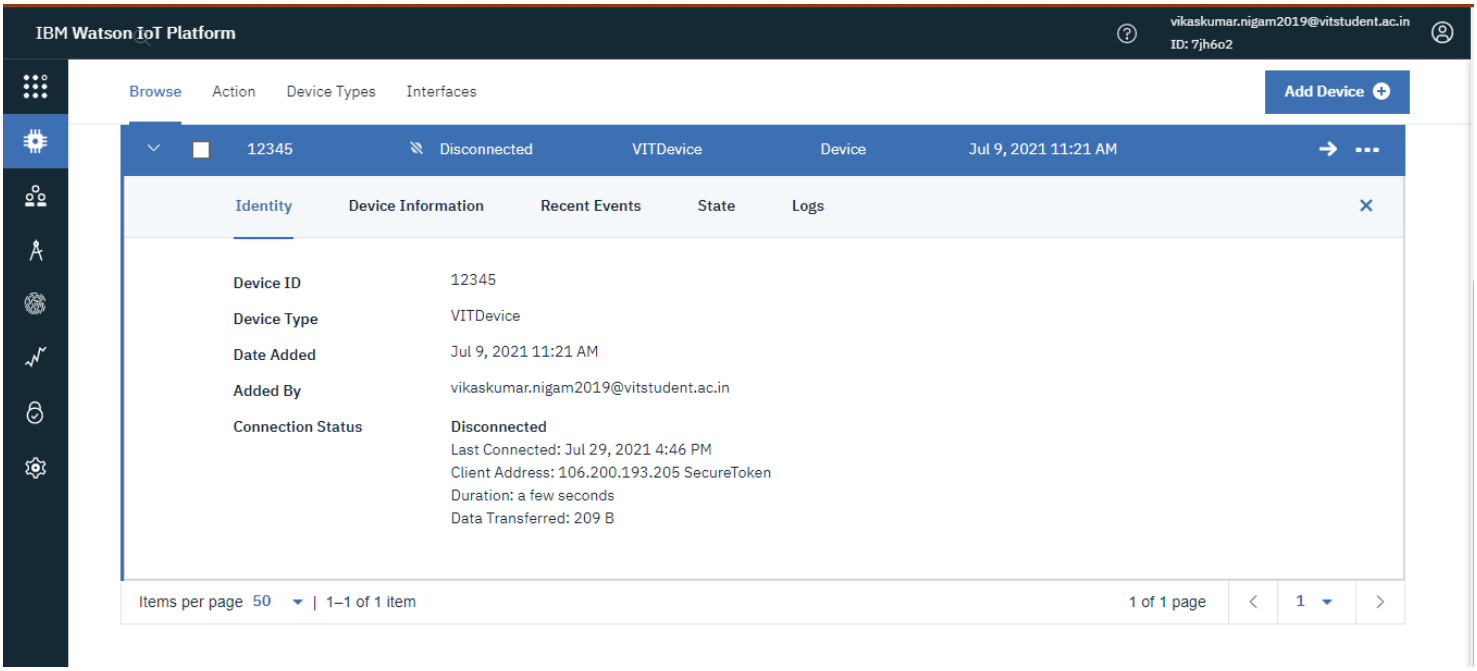
3.2.b IBM Watson IoT Platform



A fully managed, cloud-hosted service with capabilities for device registration, connectivity, control, rapid visualization and data storage. IBM Watson IoT Platform is a managed, cloud-hosted service designed to make it simple to derive value from your IoT devices.

Steps to configure:

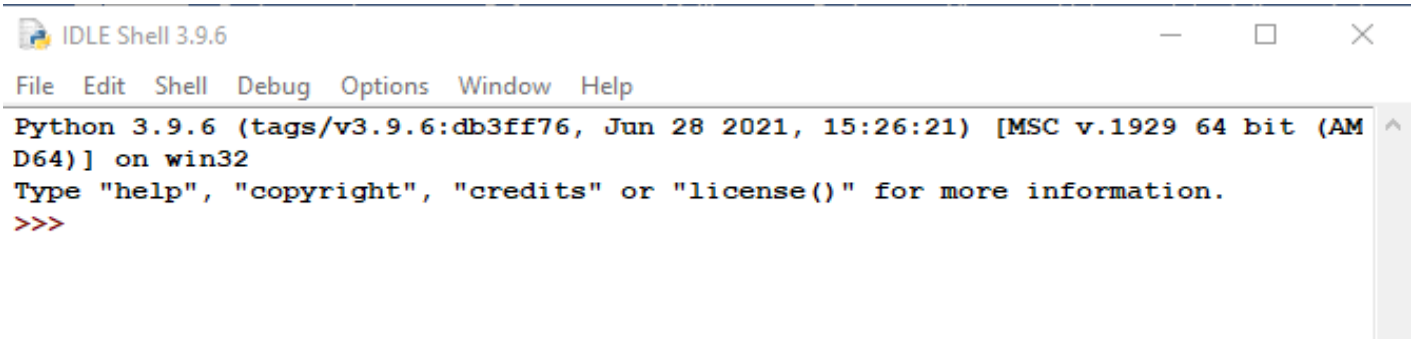
- Create an account in IBM cloud using your email ID
- Create IBM Watson Platform in services in your IBM cloud account
- Launch the IBM Watson IoT Platform
- Create a new device
- Give credentials like device type, device ID, Auth. Token
- Create API key and store API key and token elsewhere.



3.2. c Python IDE

Install Python3 compiler

Install any python IDE to execute python scripts, in my case I used python 3.9.6 shell to execute the code.



3.3 IoT Simulator

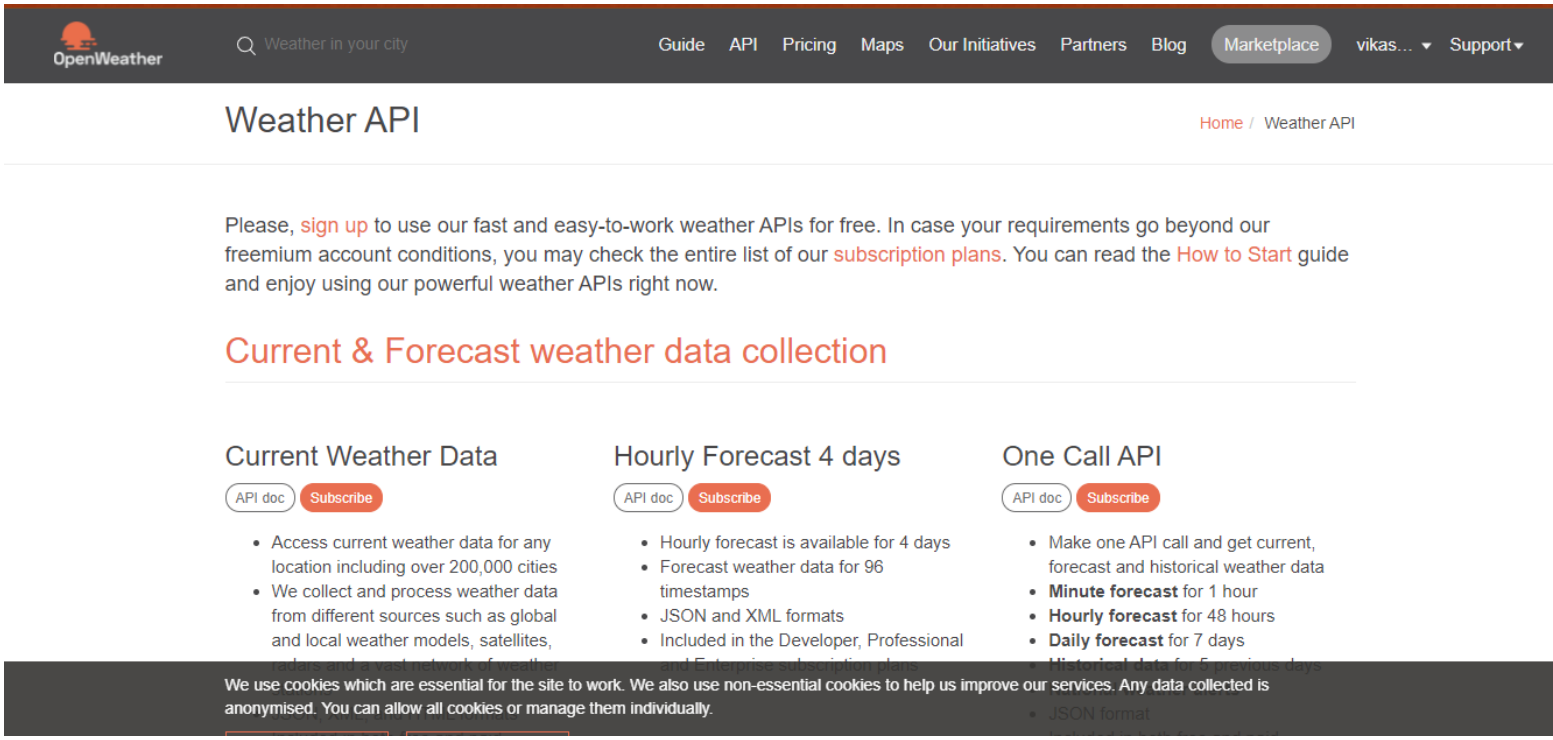
In our project in the place of sensors we are going to use IoT sensor simulator which give random readings to the connected cloud.
The link to simulator: https://watson-iot-sensor-simulator.mybluemix.net/
We need to give the credentials of the created device in IBM Watson IoT Platform to connect cloud to simulator.

3.4 Open Weather API

OpenWeatherMap is an online service that provides weather data. It provides current weather data, forecasts and historical data to more than 2 million customers.

Website link: https://openweathermap.org/guide

Steps to configure:



- Create account in OpenWeather
- Find the name of your city by searching
- Create API key to your account
- Replace “city name” and “your api key” with your city and API key in below red text.

api.openweathermap.org/data/2.5/weather?q={city name}&appid={your api key}

Link that’s been used in the project:

URL : api.openweathermap.org/data/2.5/weather?q=Chennai, IN&units=metric&appid=a0bfd7e12cd43d39a44c301354137ea5

4. Building Project

4.1 Connecting IoT Simulator to IBM Watson IoT Platform

From the Web UI go to “Connect to Watson IoT Simulator” TAB

Give the credentials of your device in IBM Watson IoT

Platform Click on connect

My credentials given to simulator are:

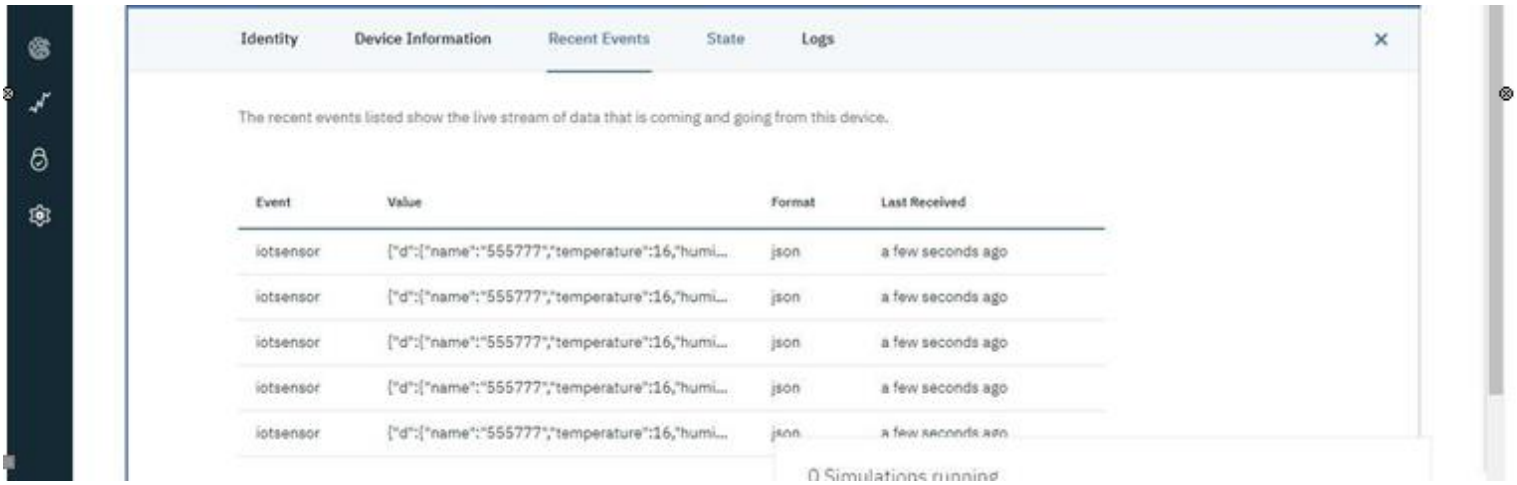
Organization ID : 7jh6o2

Device Type : VITDevice

Device ID : 12345

API Key : a-7jh6o2-dzuixifgmn

Authentication Token : &m9FkAtga+v7sEF?f



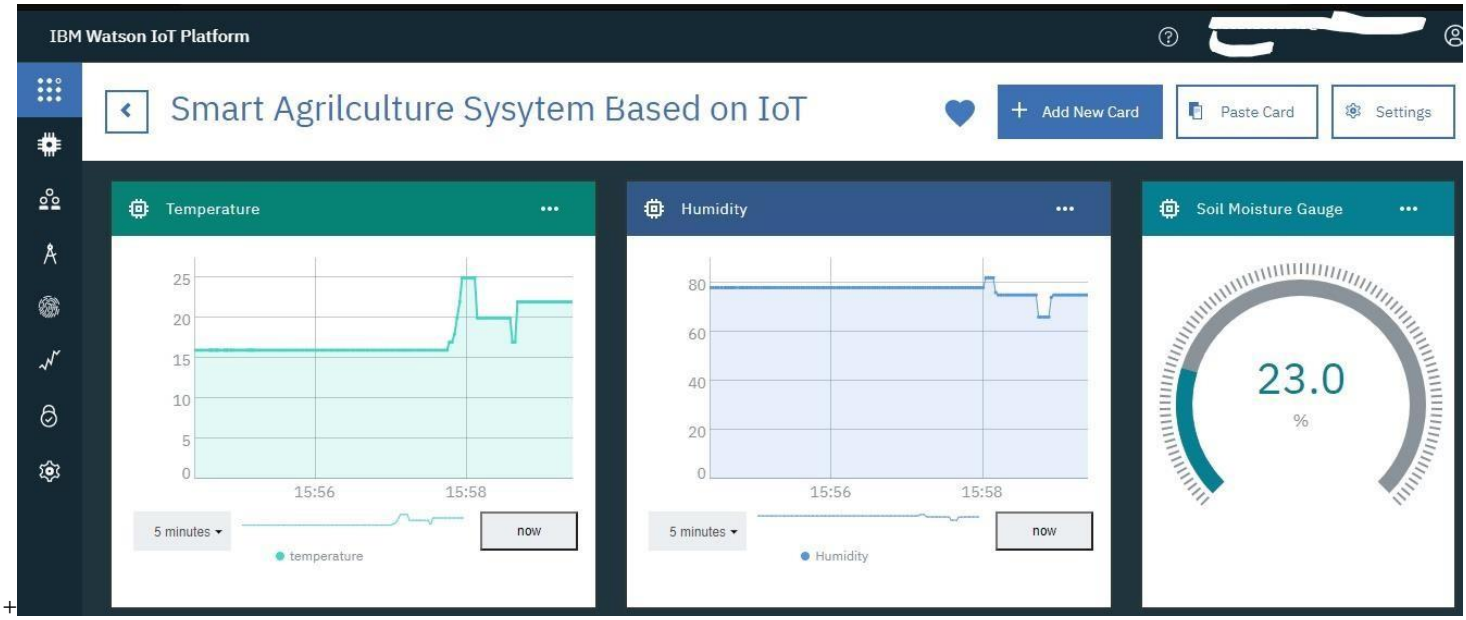
Watson IoT Sensor Simulator

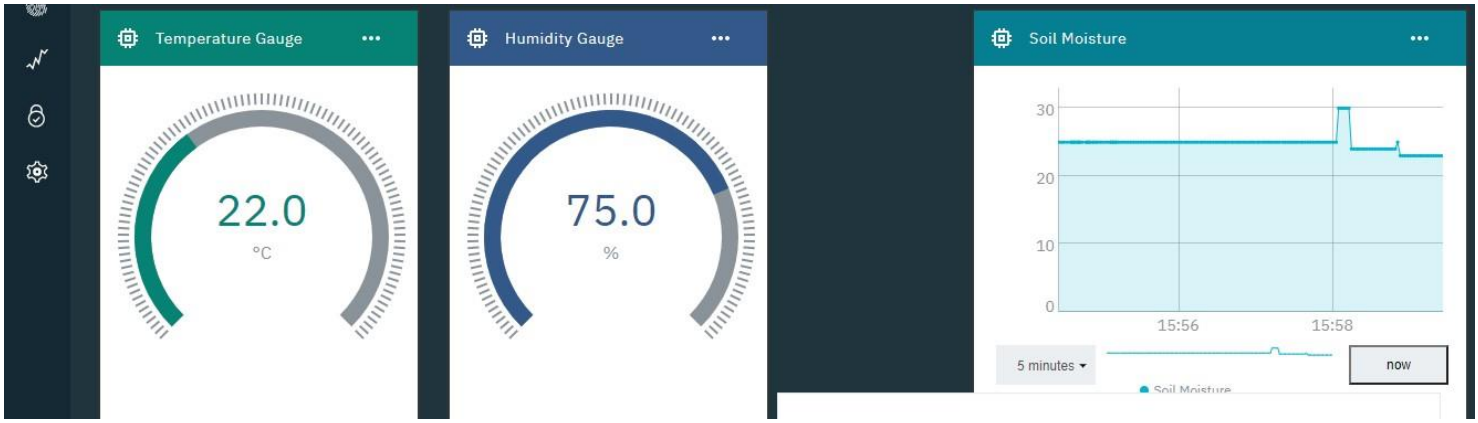
- You will receive the simulator data in cloud
- You can see the received data in Recent Events under your device
- Data received in this format(json)

```
{
    "d": {
        "name": "Nodemcu",
        "temperature": 16,
        "humidity": 78,
        "objectTemp": 25
    }
```

}

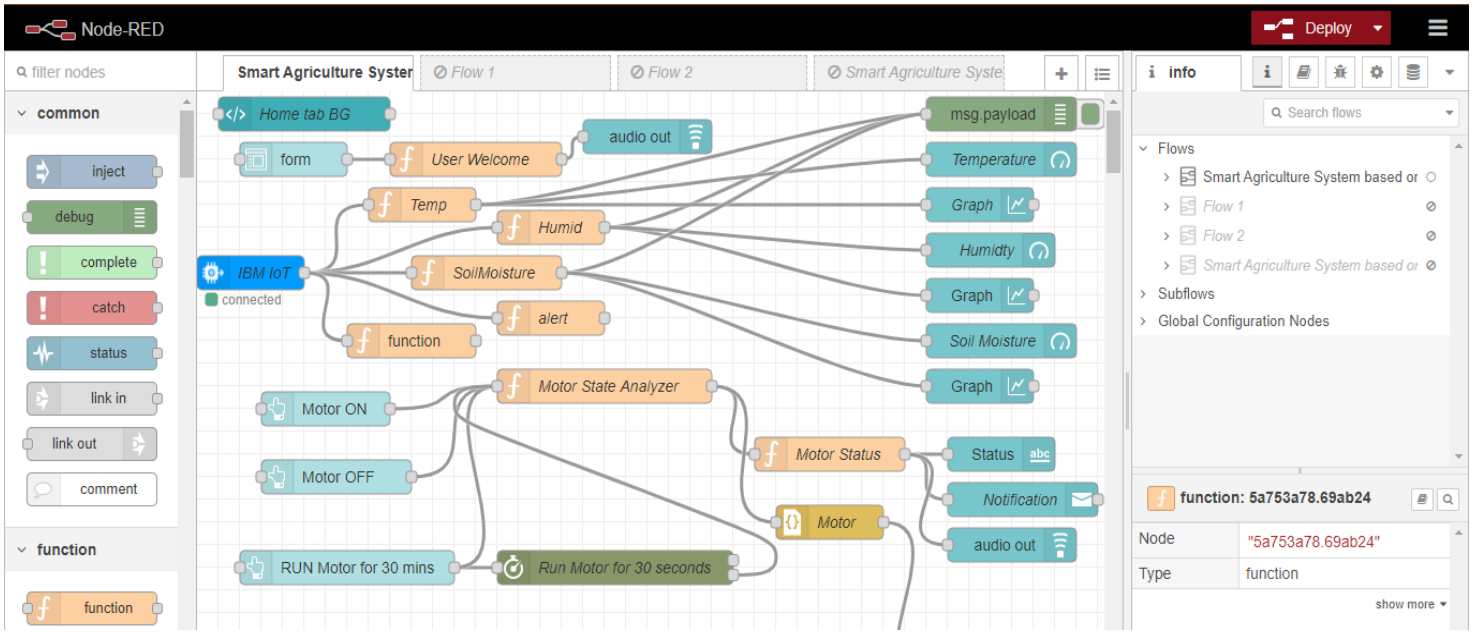
You can see the received data in graphs by creating cards in Boards tab.

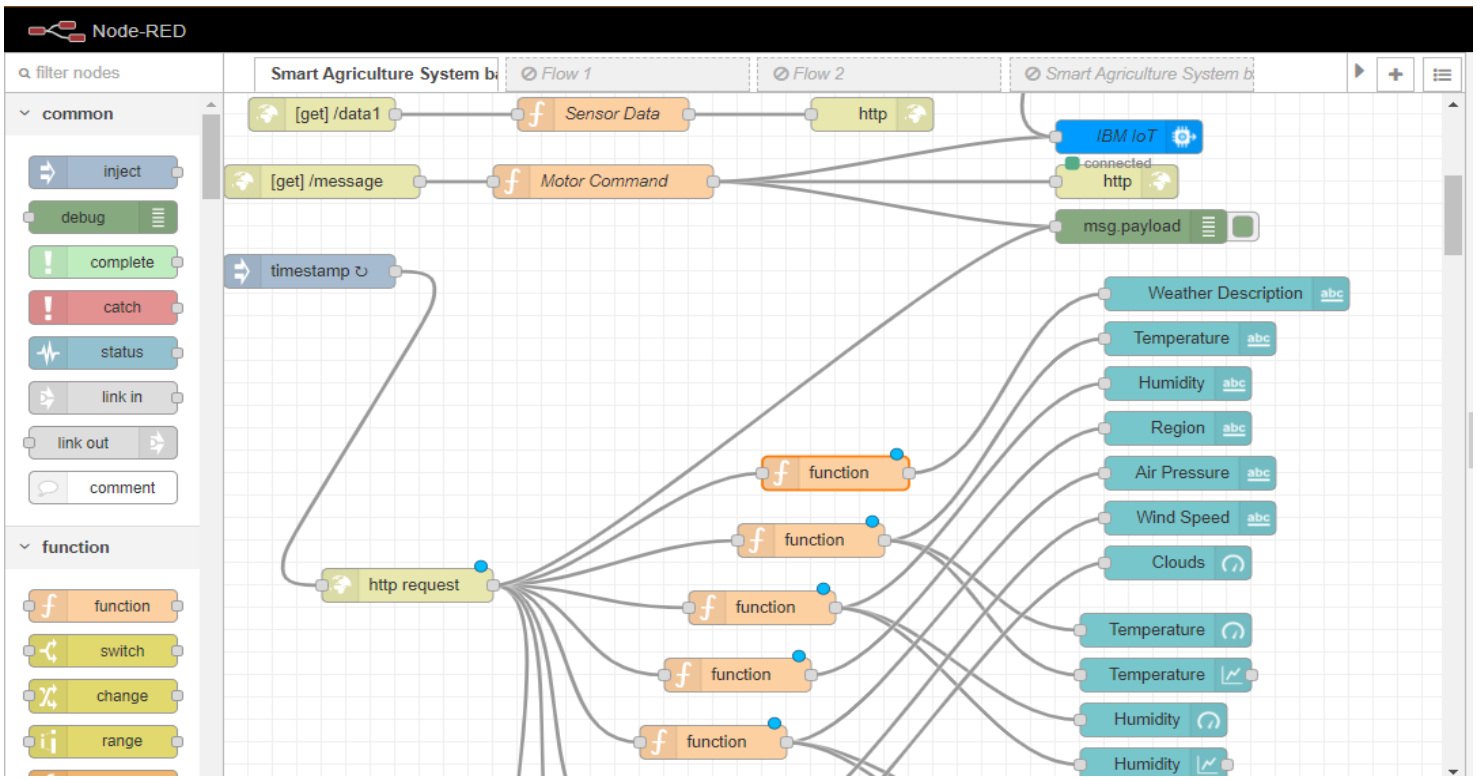


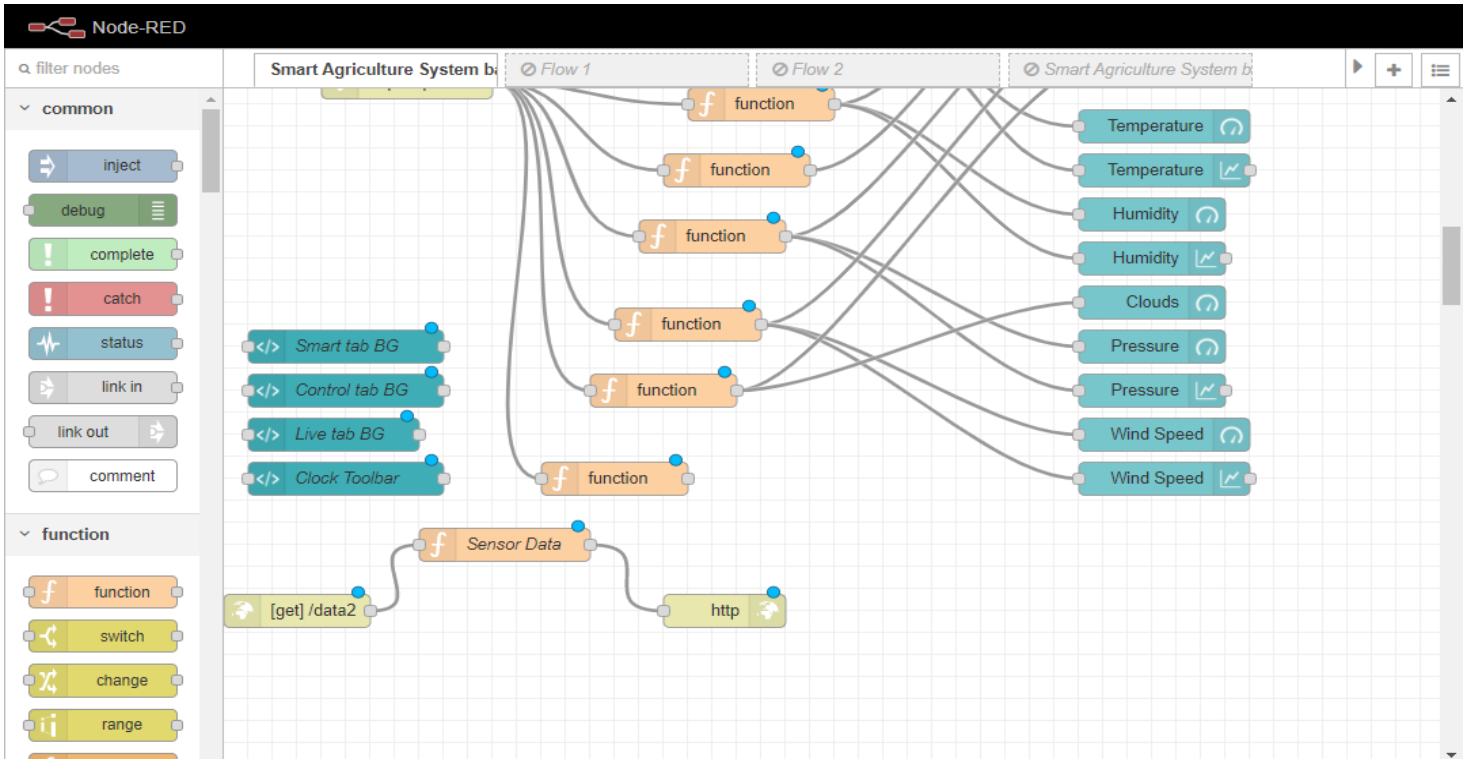


4.2 Configuration of Node-Red to collect IBM cloud data

The node IBM IoT App In is added to Node-Red workflow. Then the appropriate device credentials obtained earlier are entered into the node to connect and fetch device telemetry to Node-Red


Node-RED
Deploy
filter nodes
Smart Agriculture Syster
Flow 1
Flow 2
Smart Agriculture Syste
info
common
inject
debug
complete
catch
status
link in
link out
comment
function
Home tab BG
form
User Welcome
audio out
Temp
Humid
IBM IoT
connected
SoilMoisture
alert
function
Motor State Analyzer
Motor ON
Motor OFF
RUN Motor for 30 mins
Run Motor for 30 seconds
Motor Status
Motor
Status
Notification
audio out
msg.payload
Temperature
Graph
Humidty
Graph
Soil Moisture
Graph
Search flows
Flows
Smart Agriculture System based or
Flow 1
Flow 2
Smart Agriculture System based or
Subflows
Global Configuration Nodes
function: 5a753a78.69ab24
Node
"5a753a78.69ab24"
Type
function
show more

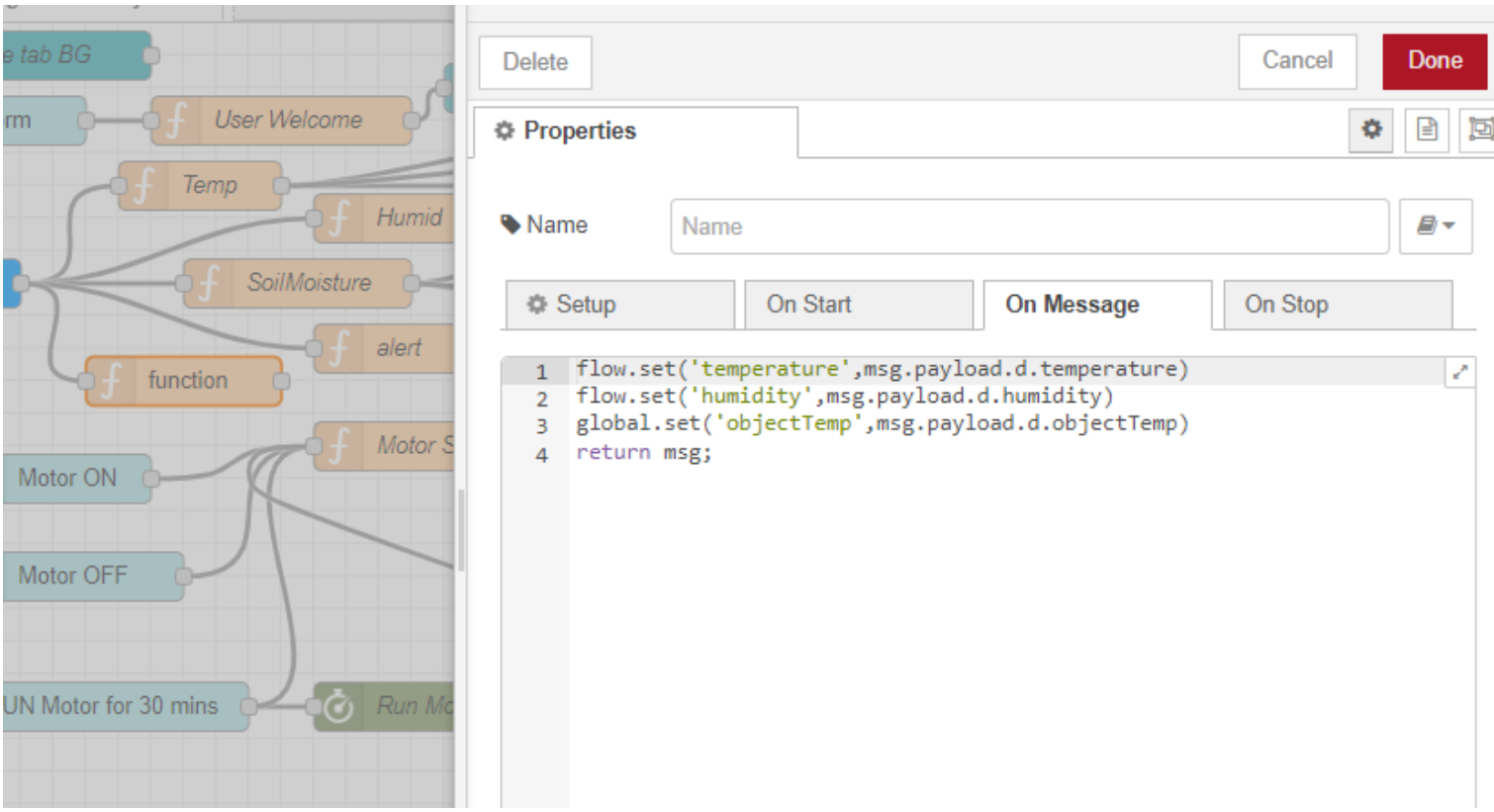

Node-RED
filter nodes
Smart Agriculture System b
Flow 1
Flow 2
Smart Agriculture System b
common
inject
debug
complete
catch
status
link in
link out
comment
function
function
switch
change
range
[get] /data1
Sensor Data
http
[get] /message
Motor Command
timestamp
http request
function
function
function
function
function
IBM IoT
connected
http
msg.payload
Weather Description
Temperature
Humidity
Region
Air Pressure
Wind Speed
Clouds
Temperature
Temperature
Humidity
Humidity


Node-RED
filter nodes
Smart Agriculture System b
Flow 1
Flow 2
Smart Agriculture System b
common
inject
debug
complete
catch
status
link in
link out
comment
function
function
switch
change
range
function
function
function
function
function
function
Smart tab BG
Control tab BG
Live tab BG
Clock Toolbar
Sensor Data
[get] /data2
http
Temperature
Temperature
Humidity
Humidity
Clouds
Pressure
Pressure
Wind Speed
Wind Speed

- Once it is connected Node-Red receives data from the device
  display the data using debug node for verification
- Connect function node and write the Java script code to get each reading
  separately. The Java script code for the function node is:

```
msg.payload=msg.payload.d.temperature
return msg;
```

  - Finally connect Gauge nodes from dashboard to see the data in
    UI Nodes connected in following manner to get each reading
    separately



This is the Java script code I written for the function node to get Temperature separately.

4.3 Configuration of Node-Red to collect data from OpenWeather

The Node-Red also receive data from the OpenWeather API by HTTP GET request. An inject trigger is added to perform HTTP request for every certain interval.

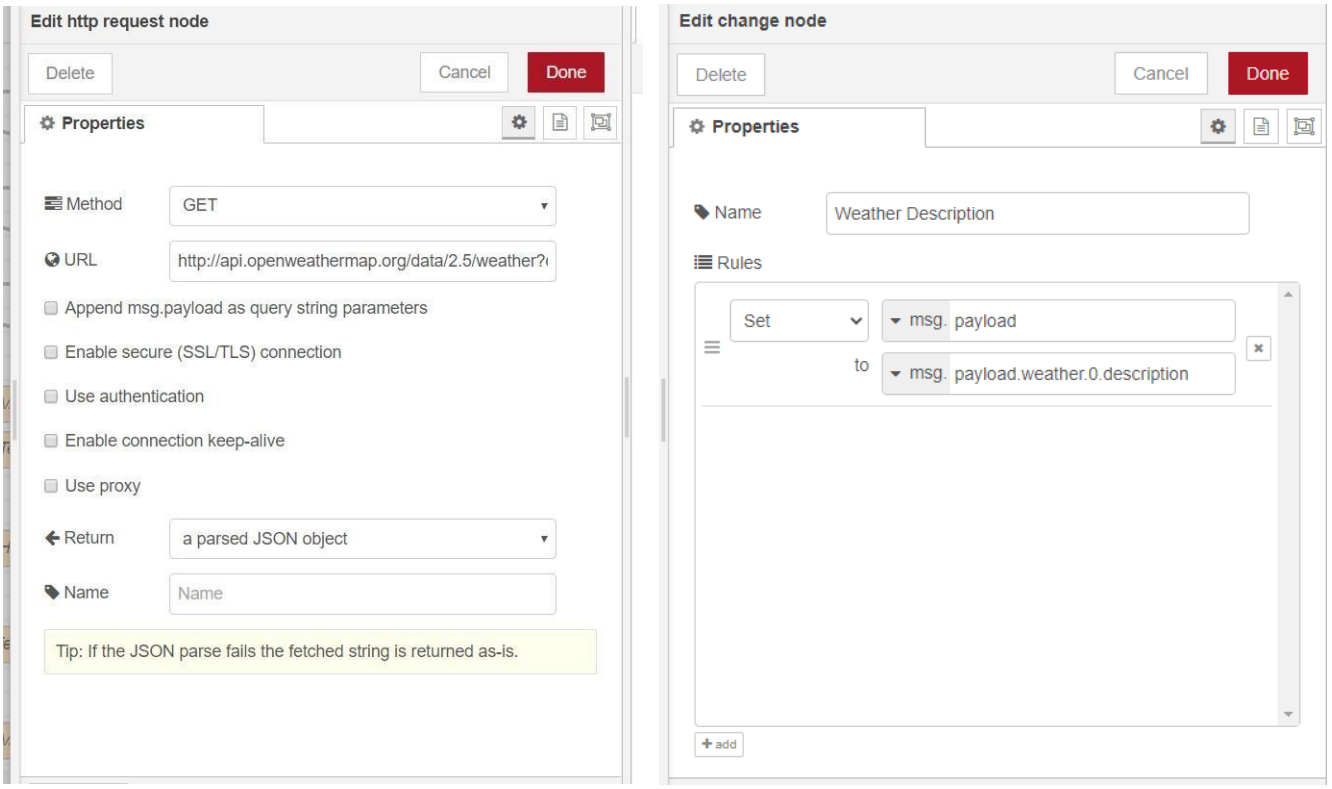
HTTP request node is configured with URL we saved before in section 4.4

The data we receive from OpenWeather after request is in below JSON format:

{"coord":{"lon":76.65,"lat":12.31},"weather":[{"id":803,"main":"Clouds","description":"broken clouds","icon":"04d"}],"base":"stations","main":{"temp":27,"feels_like":26.75,"temp_min":27,"temp_max":27,"pressure":1009,"humidity":69},"visibility":8000,"wind":{"speed":6.2,"deg":270},"clouds":{"all":75},"dt":1592387772,"sys":{"type":1,"id":9212,"country":"IN","sunrise":1592353739,"sunset":1592399985},"timezone":19800,"id":1262321,"name":"Chennai","cod":200}

- The above image has the program flow for receiving data from OpenWeather

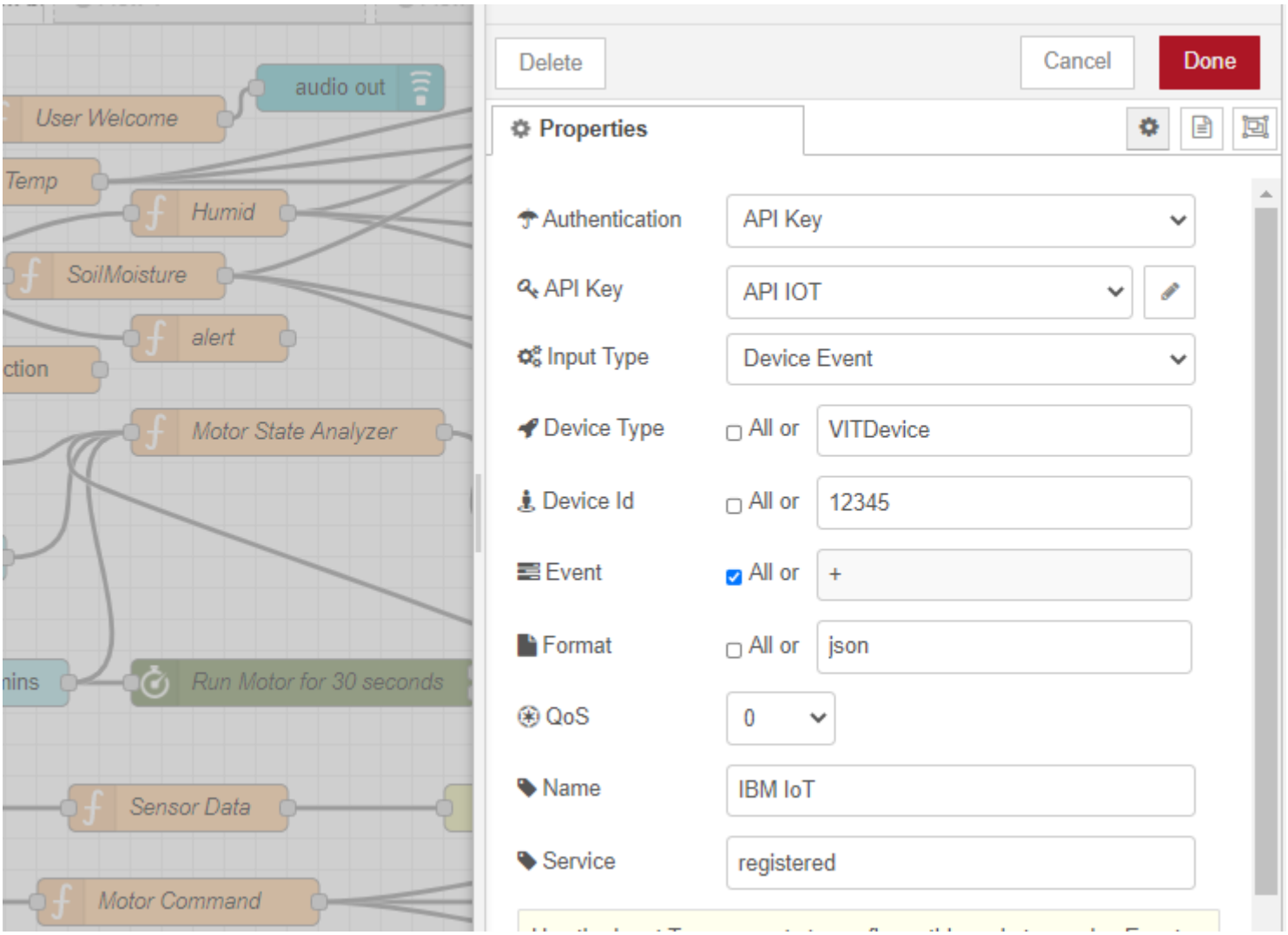
- Then we add Gauge and text nodes to represent data visually in UI



The above two images contain http request and function node data that needs to be filled.

4.4 Configuration of Node-Red to send commands to IBM cloud

Ibmiot out node is used to send data from Node-Red to IBM Watson device. So, after adding it to the flow we need to configure it with credentials of our Watson device.


audio out
User Welcome
Temp
Humid
SoilMoisture
alert
ction
Motor State Analyzer
nins
Run Motor for 30 seconds
Sensor Data
Motor Command
Delete
Cancel
Done
Properties
Authentication
API Key
API Key
API IOT
Input Type
Device Event
Device Type
All or
VITDevice
Device Id
All or
12345
Event
All or
+
Format
All or
json
QoS
0
Name
IBM IoT
Service
registered

- Here we add three buttons in UI which each sends a number 0,1 and 2.

  0 -> for motor off

  1 -> for motor on

  2 -> for running motor continuously 30 minutes

  We used a function node to analyse the data received and assign command to each number.

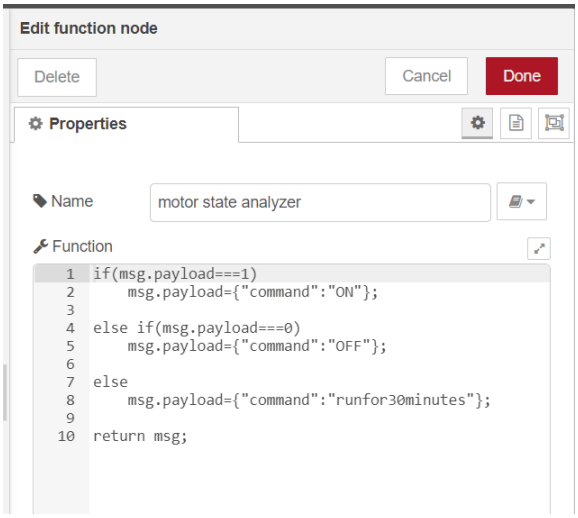
- The Java script code for the analyser is:

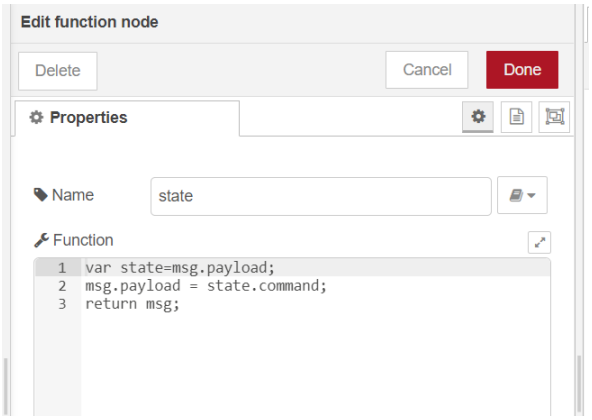
```
if(msg.payload===1)
msg.payload={"command":"ON"};
else if(msg.payload===0)
msg.payload={"command":"OFF"};
else
msg.payload={"command":"runfor30minutes"};
return msg;
```

- Then we use another function node to parse the data and get the command and represent it visually with text node.

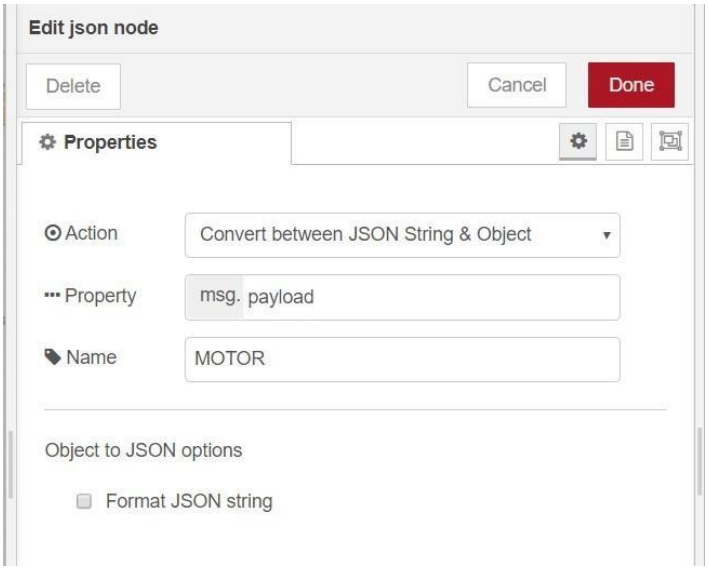
- The Java script code for that function node is:

```
var state=msg.payload; msg.payload = state.command;
return msg;
```





  - The above images show the java script codes of analyser and state function nodes.
  - Then we add edit Json node to the conversion between JSON string & object and finally connect it to IBM IoT Out.

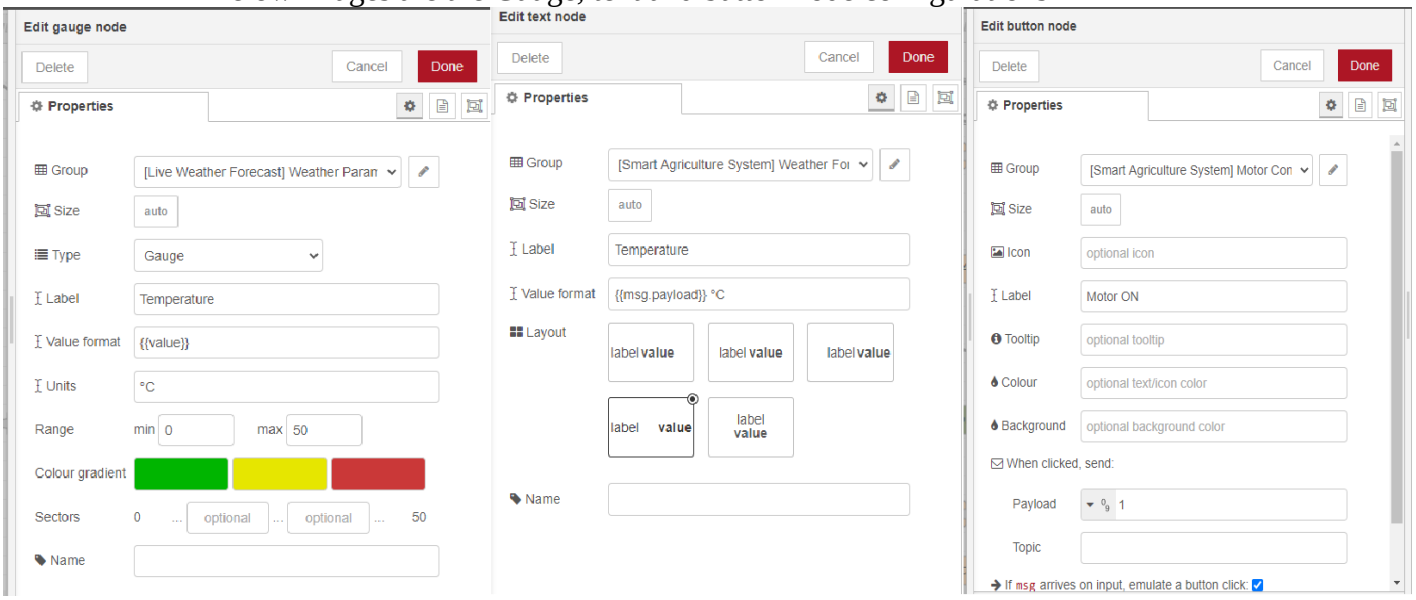


- Edit JSON node needs to be configured in this way.

- This is the program flow for sending commands to IBM cloud.

4.5 Adjusting User Interface

- In order to display the parsed JSON data a Node-Red dashboard is created
- Here we are using Gauges, text and button nodes to display in the UI and helps to monitor the parameters and control the farm equipment.
- Below images are the Gauge, text and button node configurations

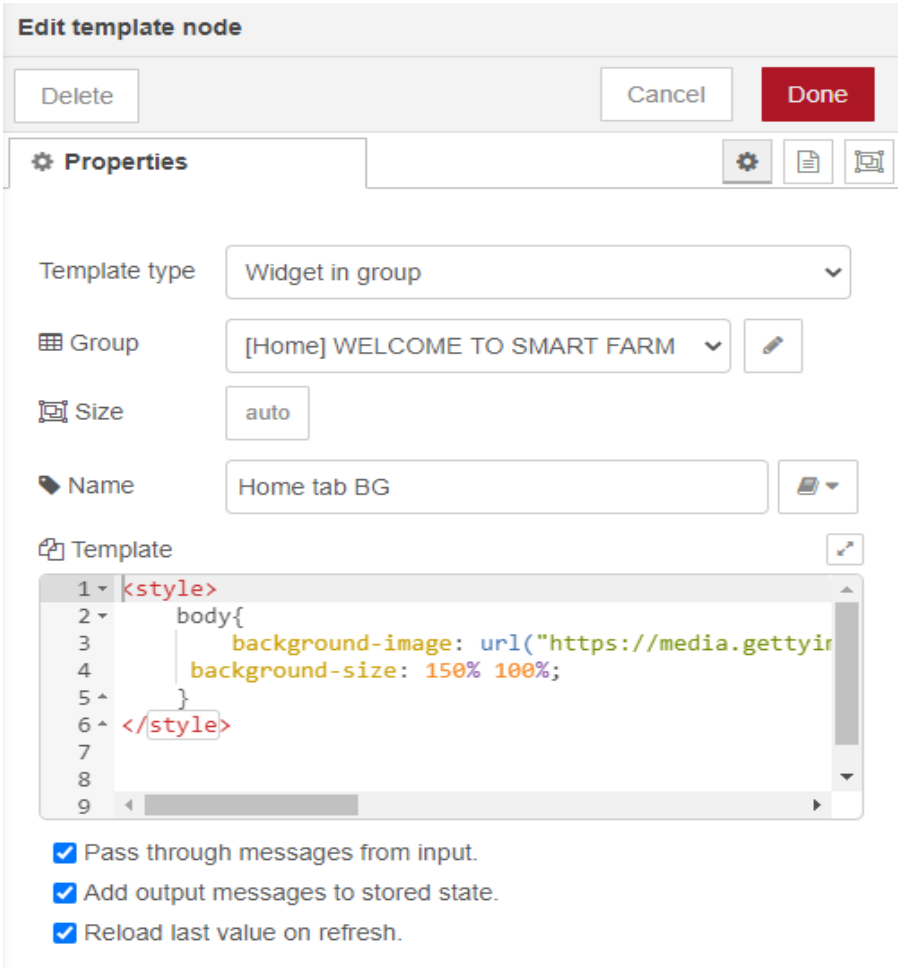


Adding Background image to the UI

- To add the background image we are going to add template node and configure it with below HTML code

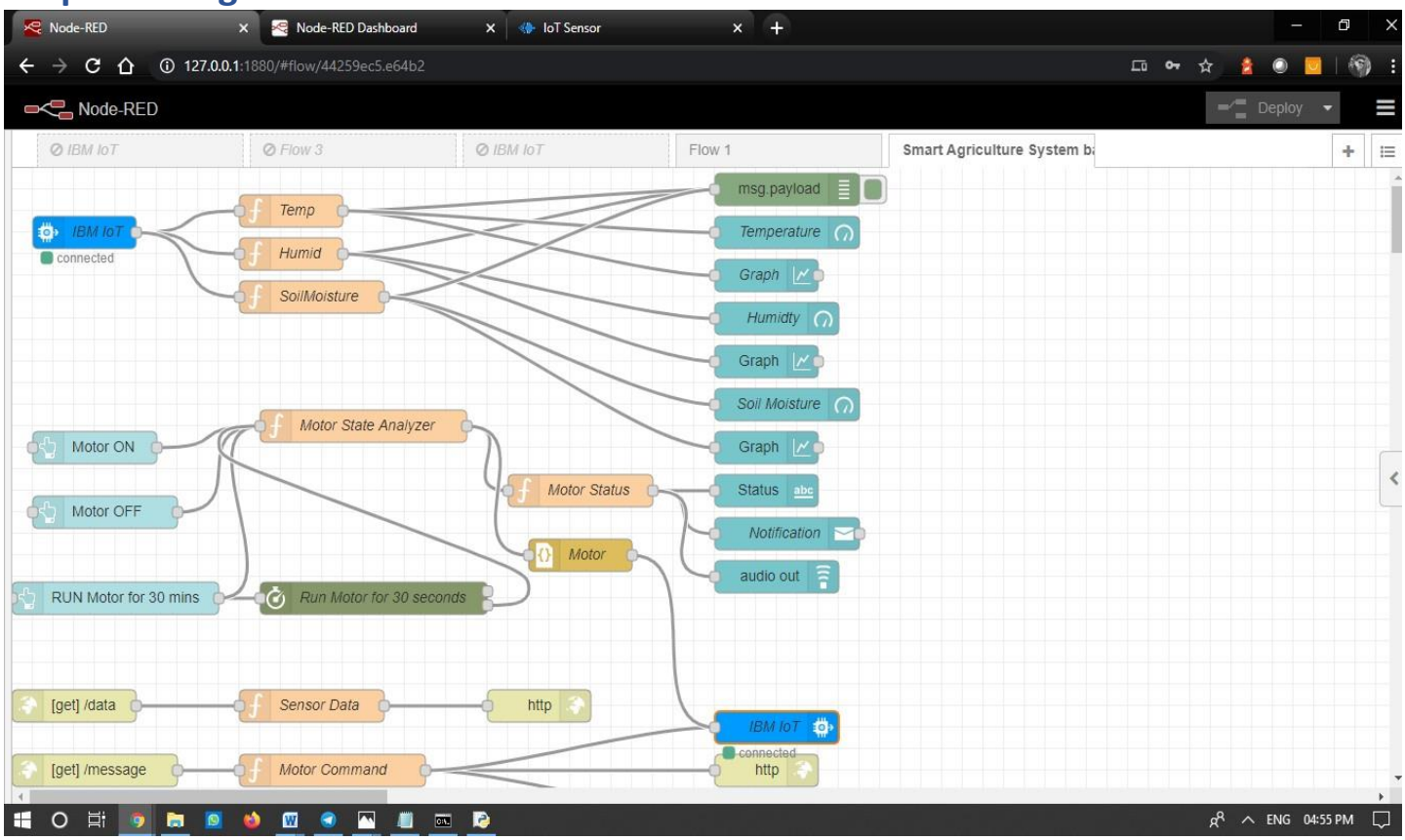
```
<style>     body
            {       background-image: url("https://media.gettyimages.com/photos/crops-grow-on-fertile-
                    farm-land-panoramic-before-harvest-picture-id937010674?s=2048x2048");
                        background-size: 150% 100%;



            }
</style>
```

We add URL of image that need to be displayed

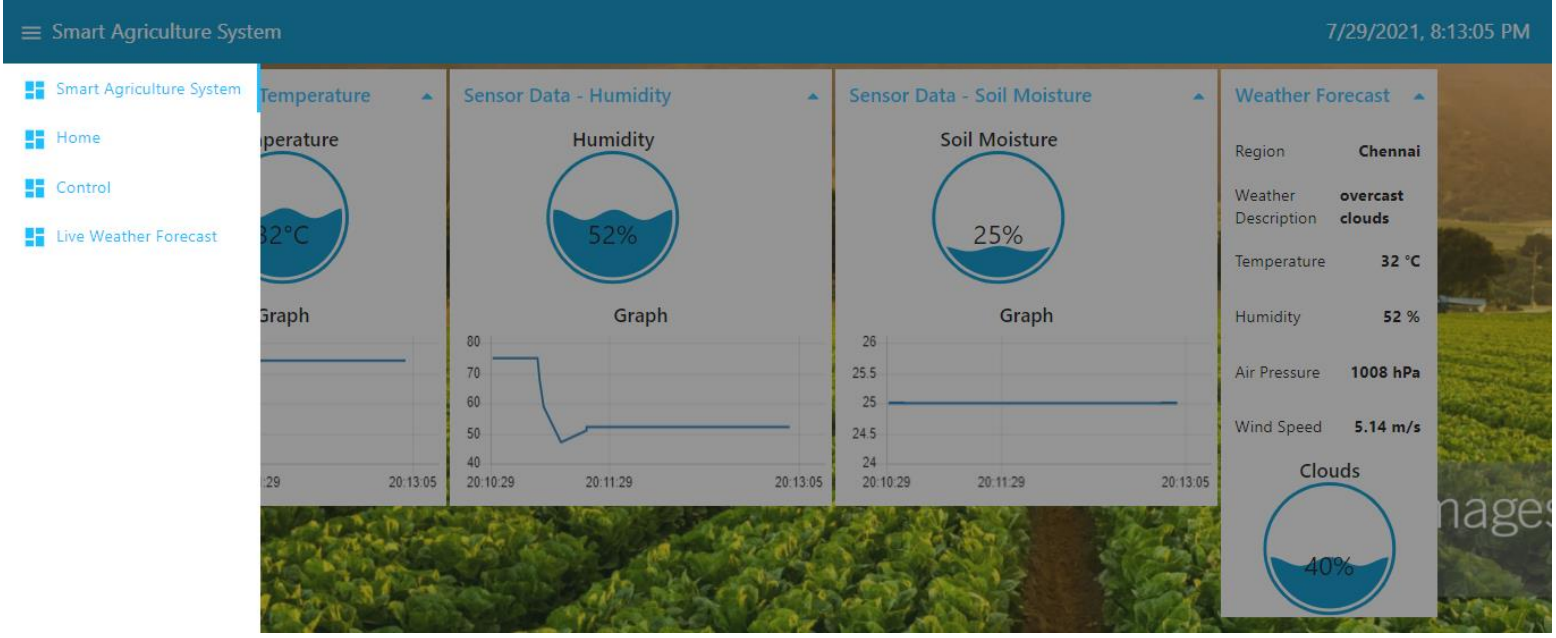


- Configuration is shown in the above image

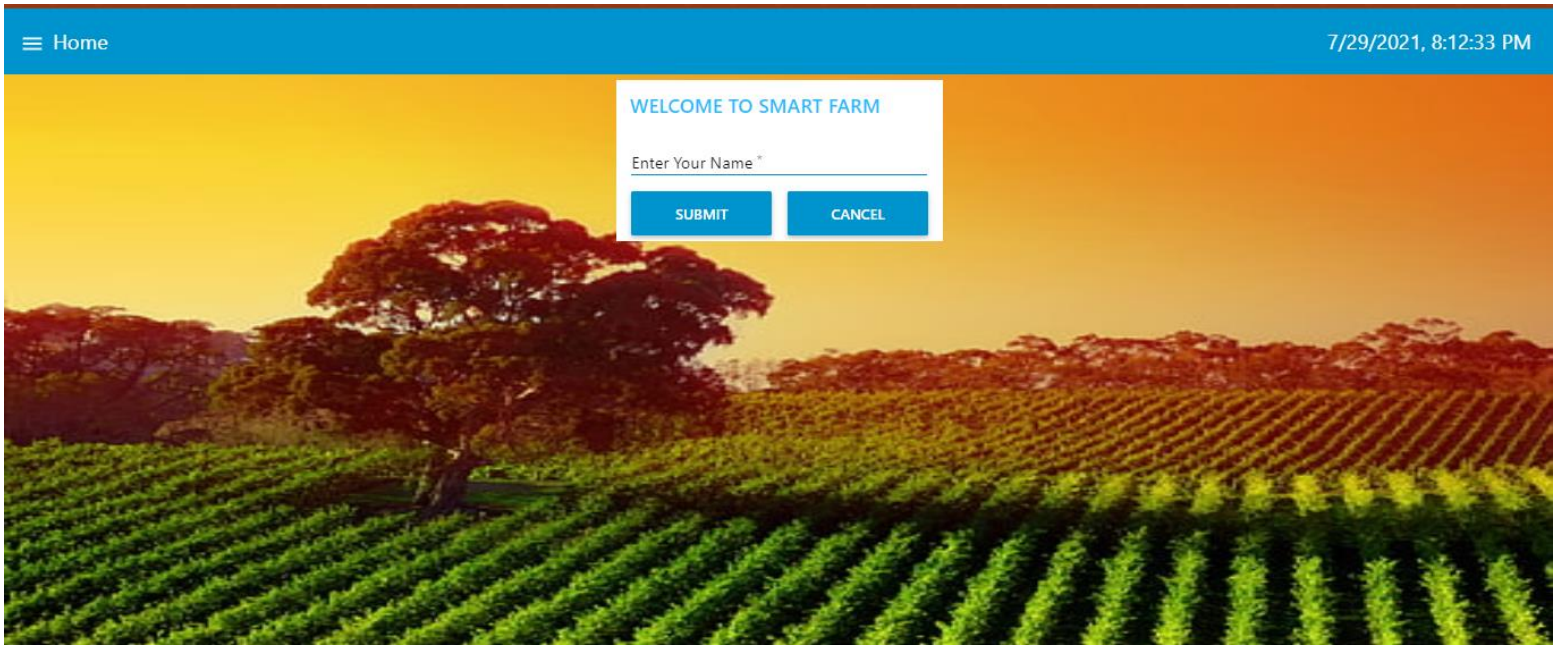
Complete Program Flow



Side View Tab



Home Tab



4.6 Receiving commands from IBM cloud using Python program

This is the Python code to receive commands from cloud to any device like Raspberry Pi in the farm:

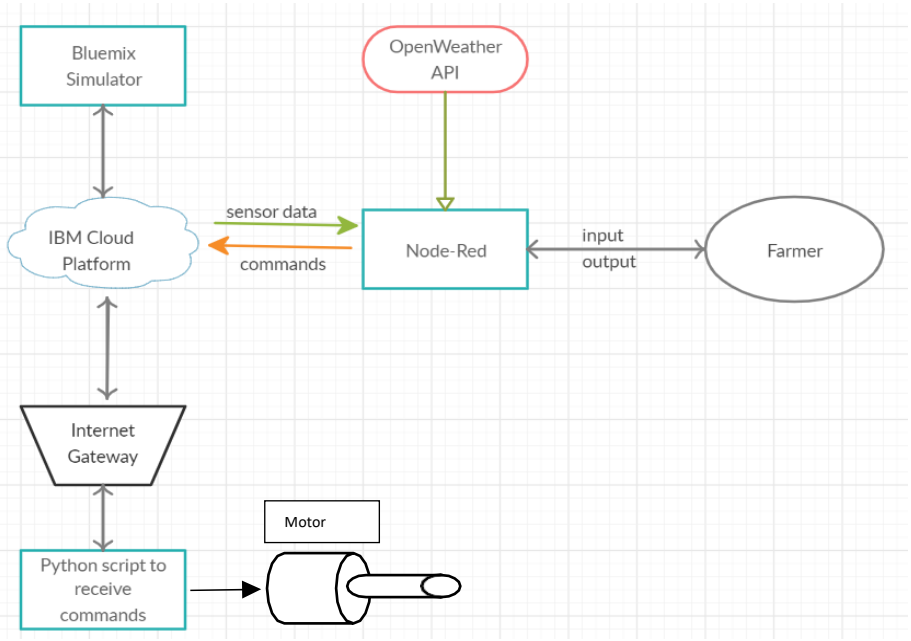
```
import time
import sys
import ibmiotf.application # to install pip install ibmiotf
import ibmiotf.device

#Provide your IBM Watson Device Credentials
organization = "mrcy9i" #replace the ORG ID
deviceType = "MOTOR"#replace the Device type wi
```

```
deviceId = "77777"#replace Device ID
authMethod = "token"
authToken = "-+H)NtqOd!6ac2s!YC" #Replace the authtoken

def myCommandCallback(cmd): # function for Callback
        print("Command received: %s" % cmd.data)
        if cmd.data['command']=='Motor turned ON':
                print("MOTOR ON IS RECEIVED")

        elif cmd.data['command']=='Motor turned OFF':
                print("MOTOR OFF IS RECEIVED")

        elif cmd.data['command']=='Running Motor for 30 minutes':
                print("MOTOR ON FOR 30 MINUTES IS RECEIVED")

        if cmd.command == "setInterval":

                if 'interval' not in cmd.data:
                        print("Error - command is missing required information: 'interval'")
                else:
                        interval = cmd.data['interval']
        elif cmd.command == "print":
                if 'message' not in cmd.data:
                        print("Error - command is missing required information: 'message'")
                else:
                        output=cmd.data['message']
                        print(output)

try:
    deviceOptions = {"org": organization, "type": deviceType, "id": deviceId, "auth-method": authMethod, "auth-
token": authToken}
    deviceCli = ibmiotf.device.Client(deviceOptions)
    #.....................................

except Exception as e:
    print("Caught exception connecting device: %s" % str(e))
    sys.exit()

# Connect and send a datapoint "hello" with value "world" into the cloud as an event of type "greeting" 10 times
deviceCli.connect()

while True:

        deviceCli.commandCallback = myCommandCallback

# Disconnect the device and application from the cloud
deviceCli.disconnect()
```

Device Commands are received by the local host through IBM Watson Cloud Platfrom

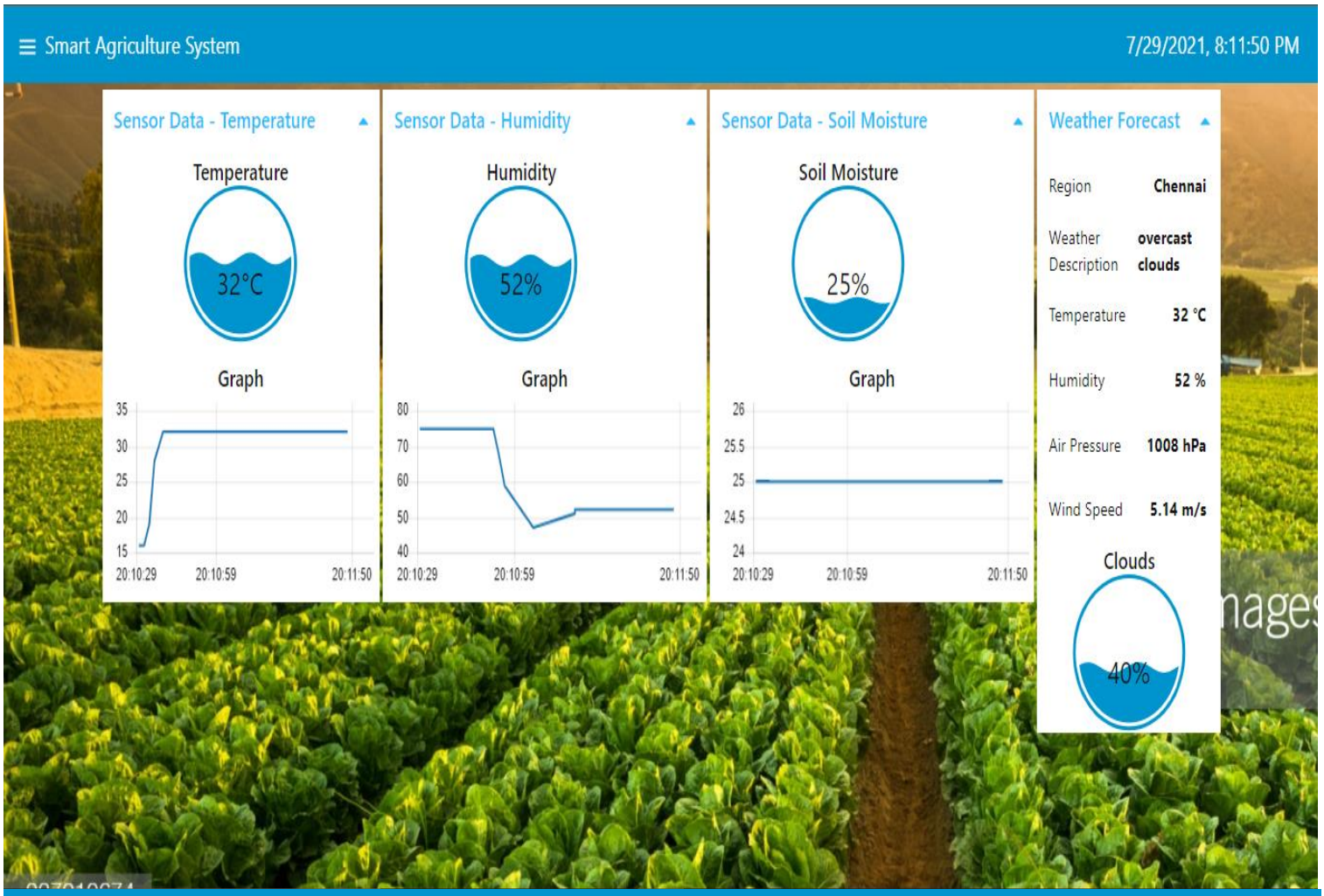
```
*IDLE Shell 3.9.6*
File  Edit  Shell  Debug  Options  Window  Help
Python 3.9.6 (tags/v3.9.6:db3ff76, Jun 28 2021, 15:26:21) [MSC v.1929 64 bit (AM
D64)] on win32
Type "help", "copyright", "credits" or "license()" for more information.
>>>
========== RESTART: C:\Users\HP\OneDrive\Desktop\ibm-project\project.py ==========
2021-07-29 20:29:16,837   ibmiotf.device.Client      INFO    Connected successfu
lly: d:7jh6o2:VITDevice:12345
Command received: {'command': 'Motor turned ON'}
Command received: {'command': 'Motor turned OFF'}
Command received: {'command': 'Running Motor for 30 minutes'}
Command received: {'command': 'Motor turned ON'}
Command received: {'command': 'Running Motor for 30 minutes'}
Command received: {'command': 'Motor turned OFF'}
```

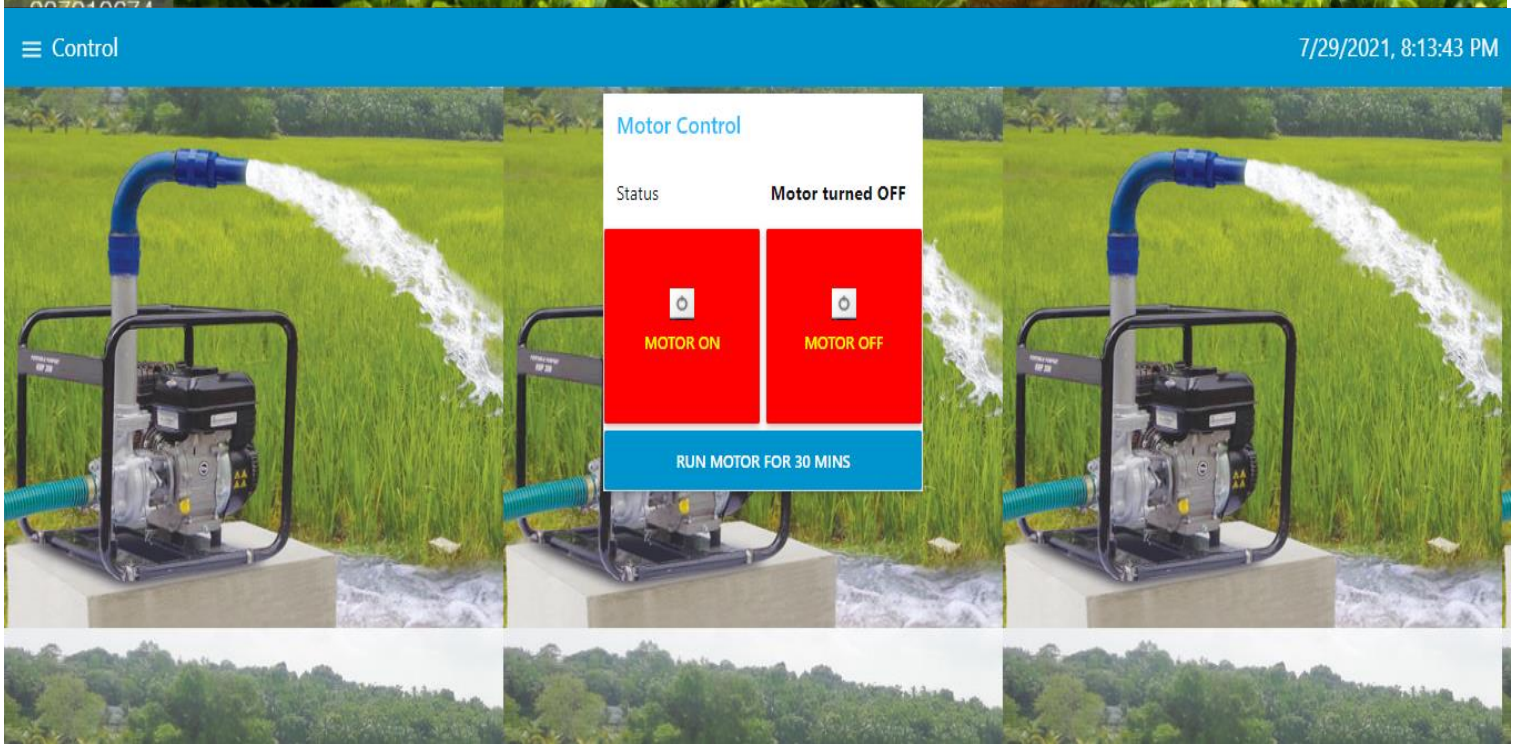
5. Flow Chart

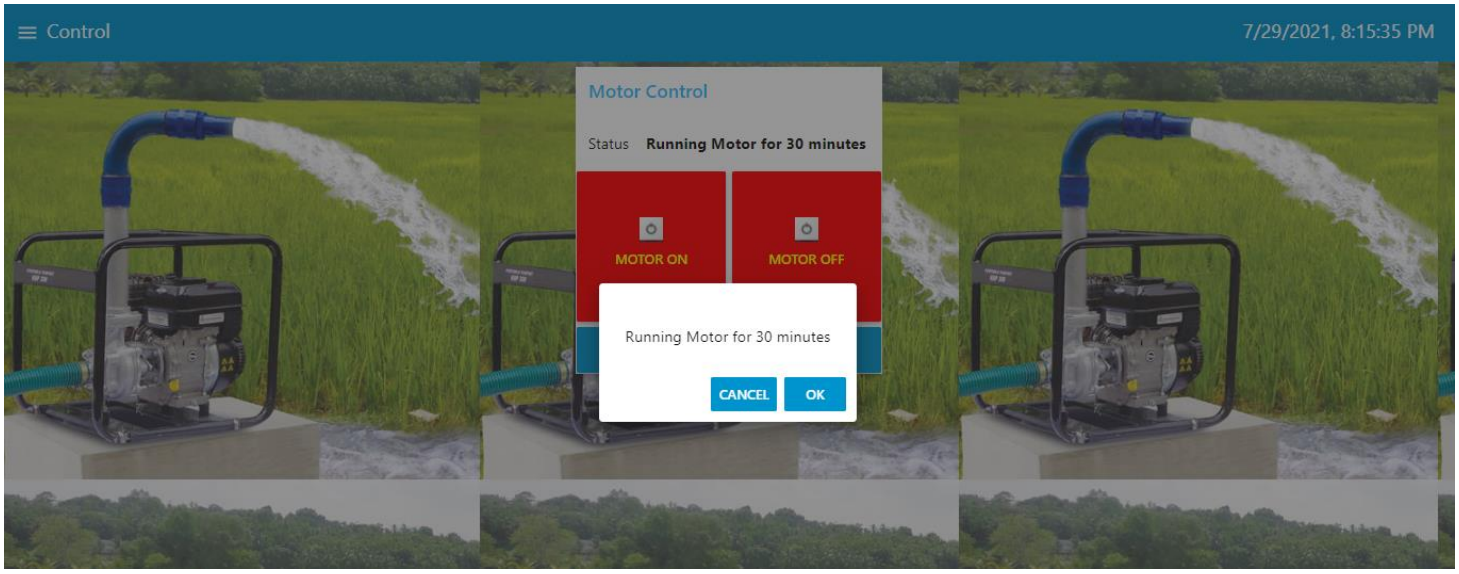


6. Observations & Results

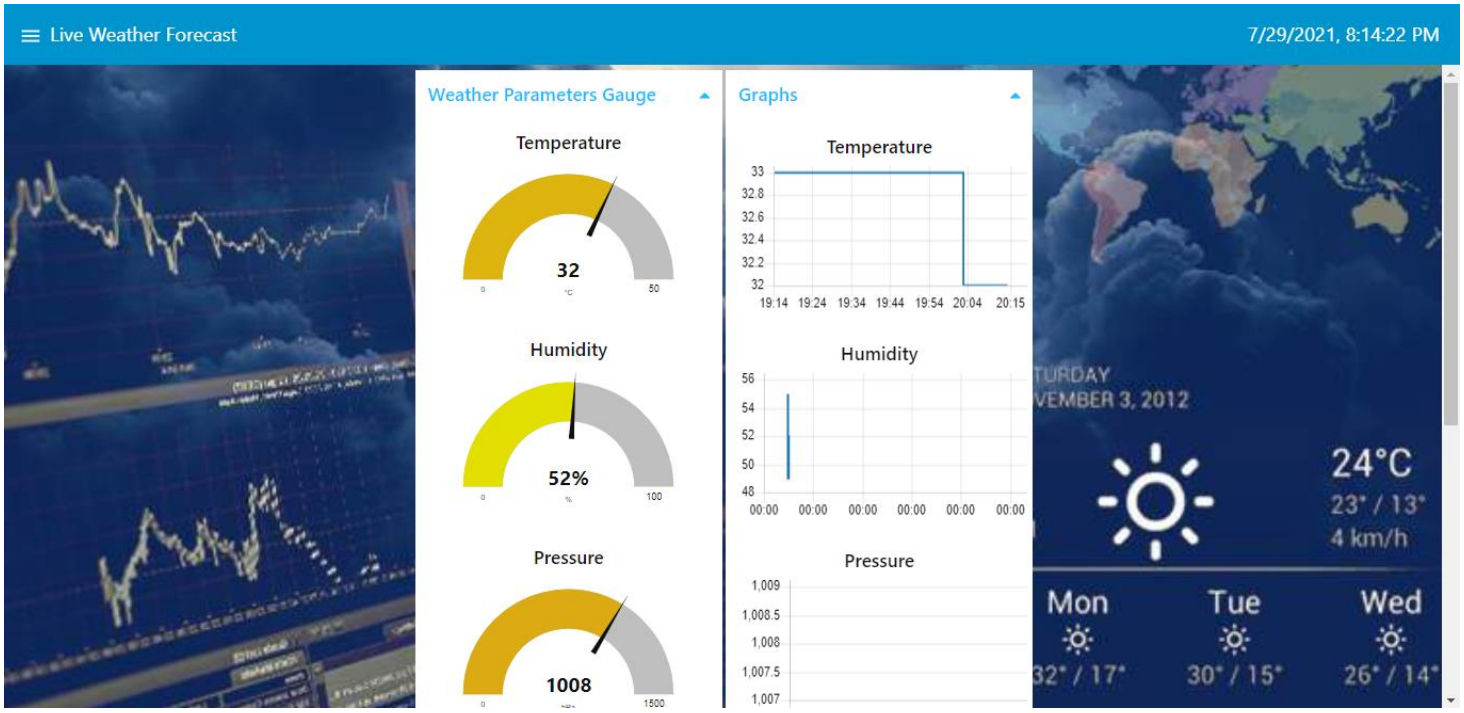
Simulator Data is received as shown in gauge and graph

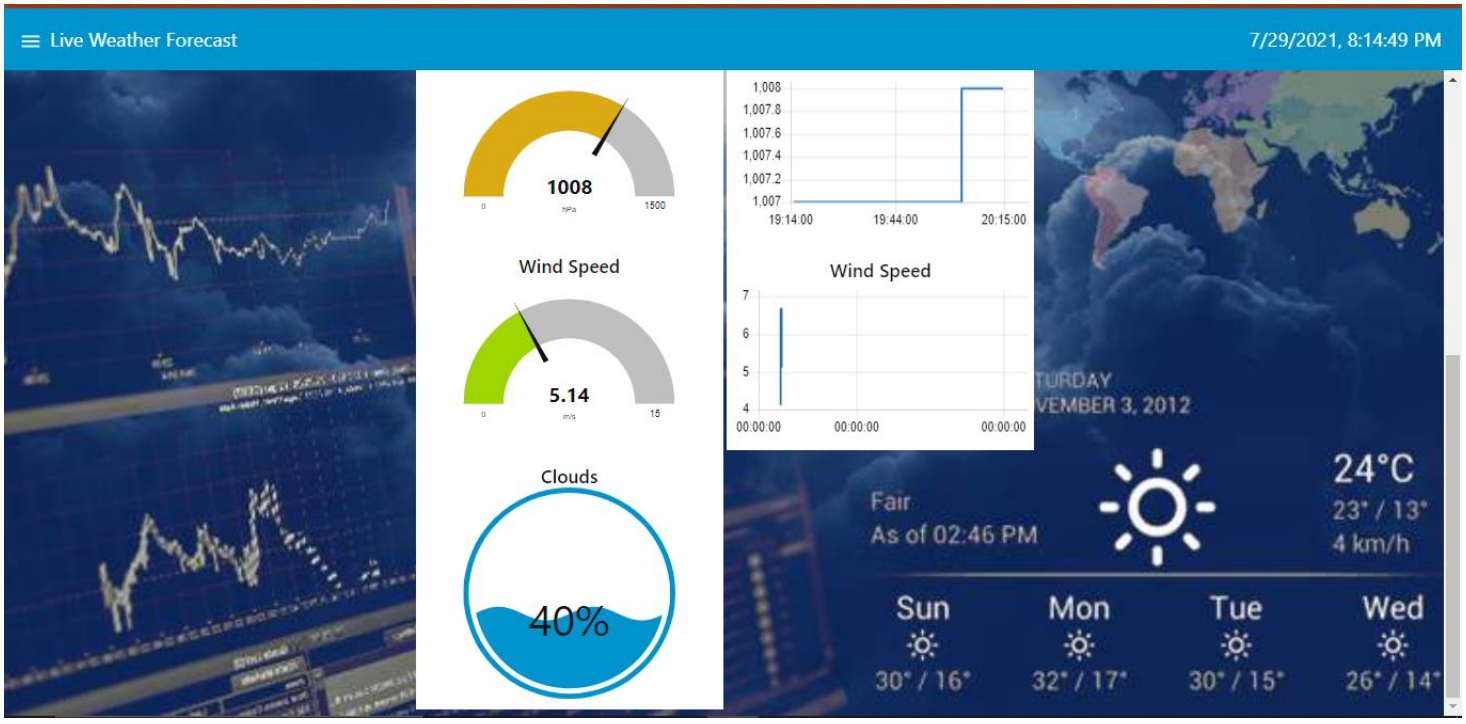




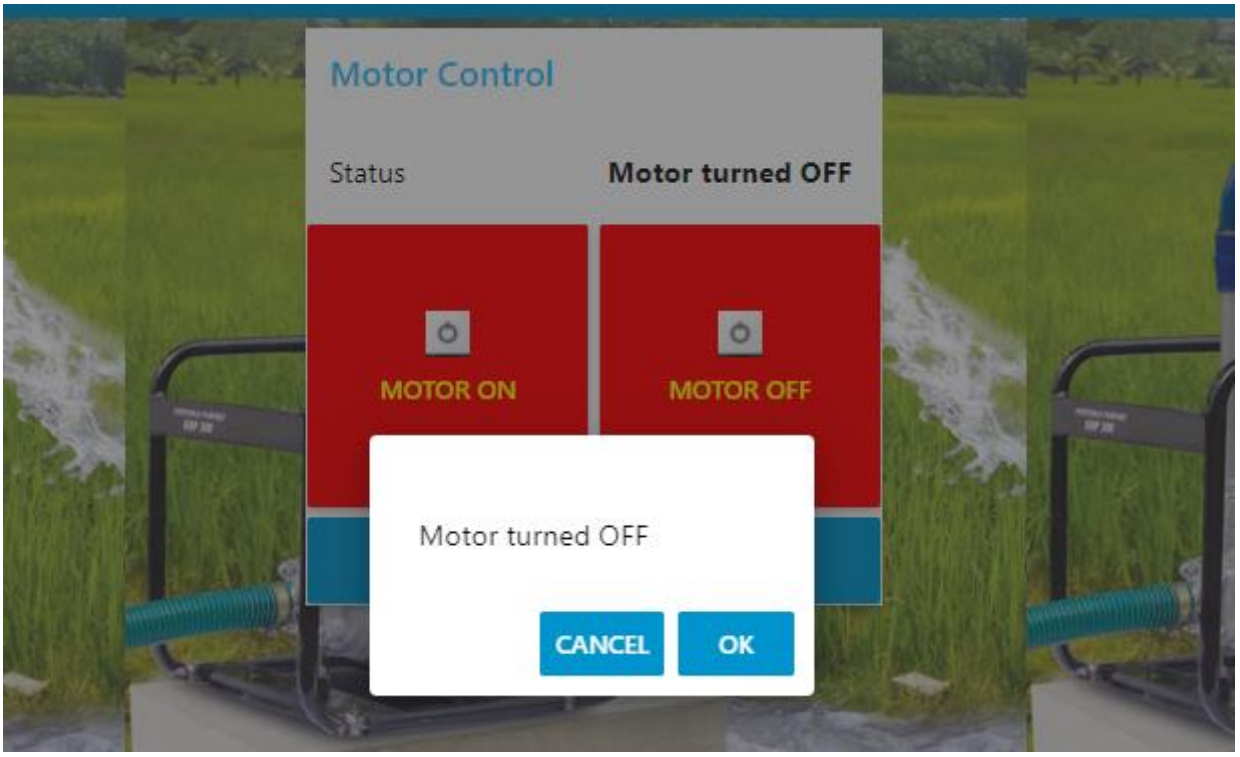

Control
7/29/2021, 8:15:35 PM
Motor Control
Status Running Motor for 30 minutes
MOTOR ON
MOTOR OFF
Running Motor for 30 minutes
CANCEL
OK

Live weather Forecast Data is Received as shown below

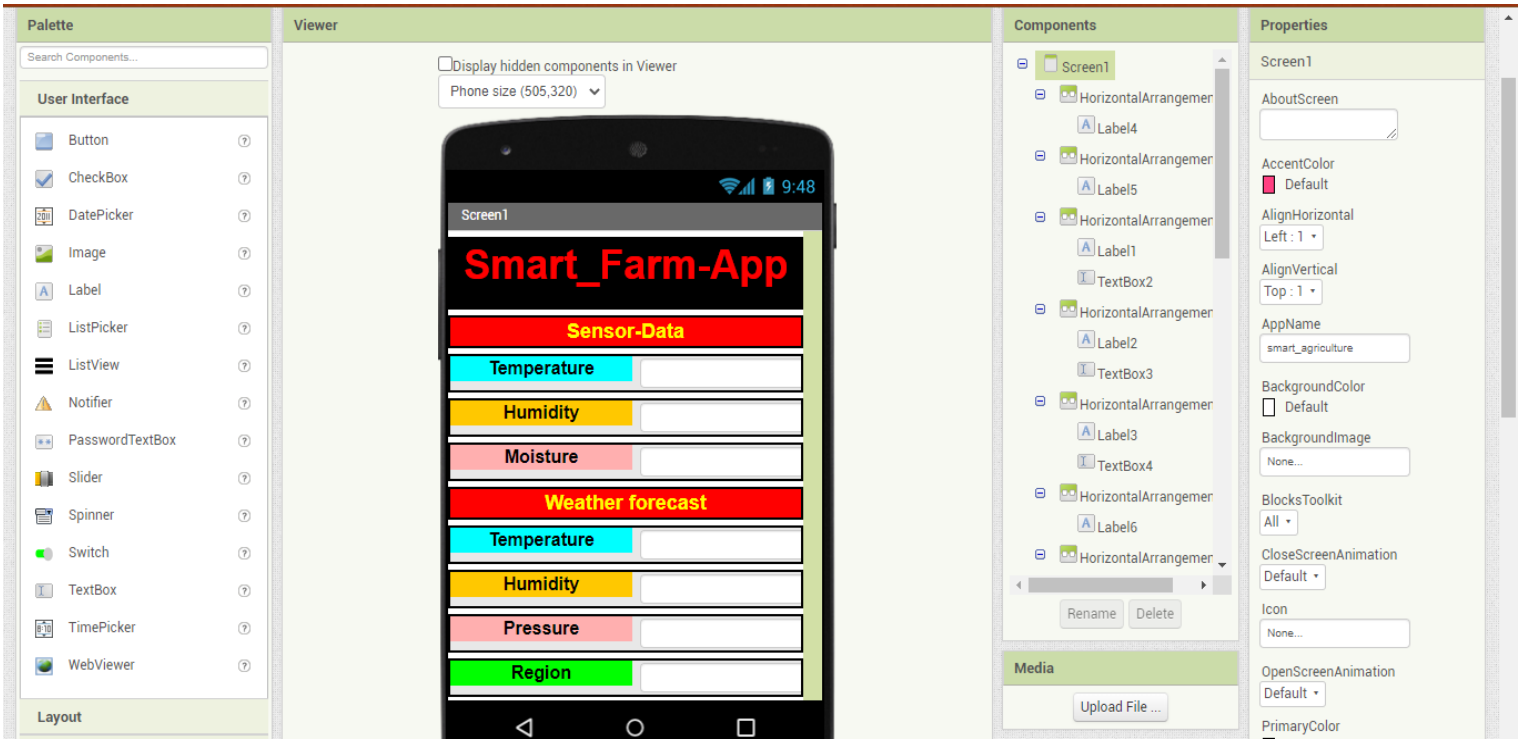


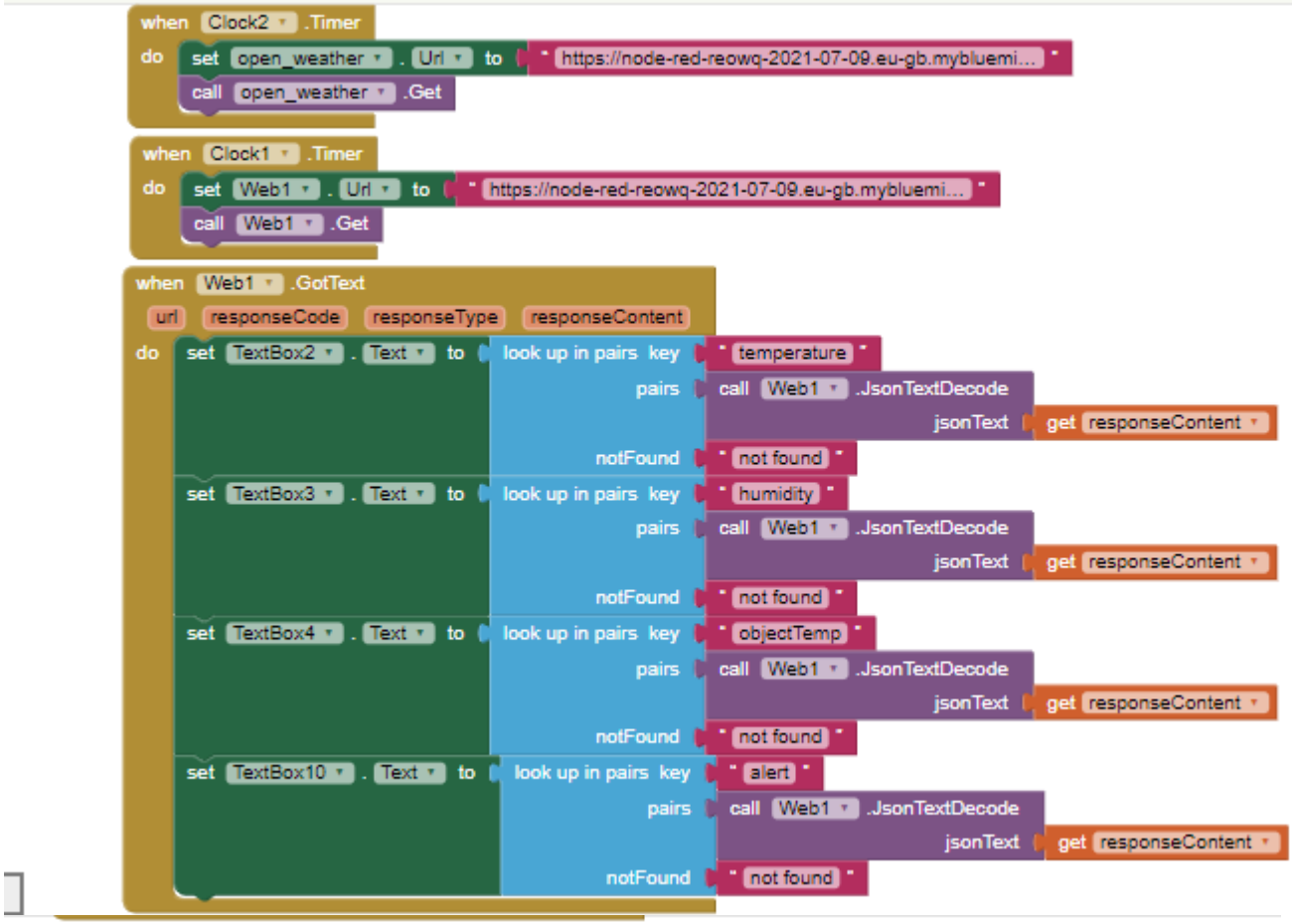


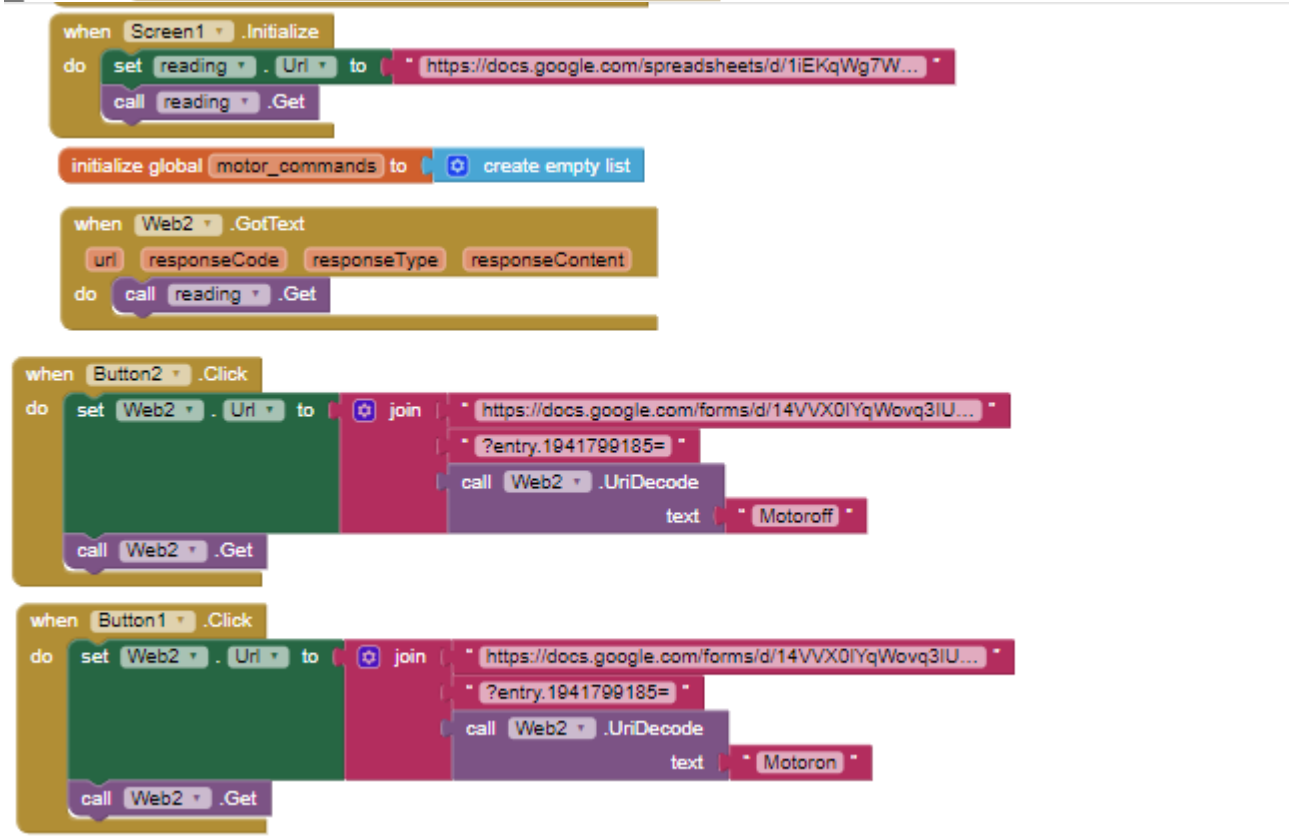
Motor Commands

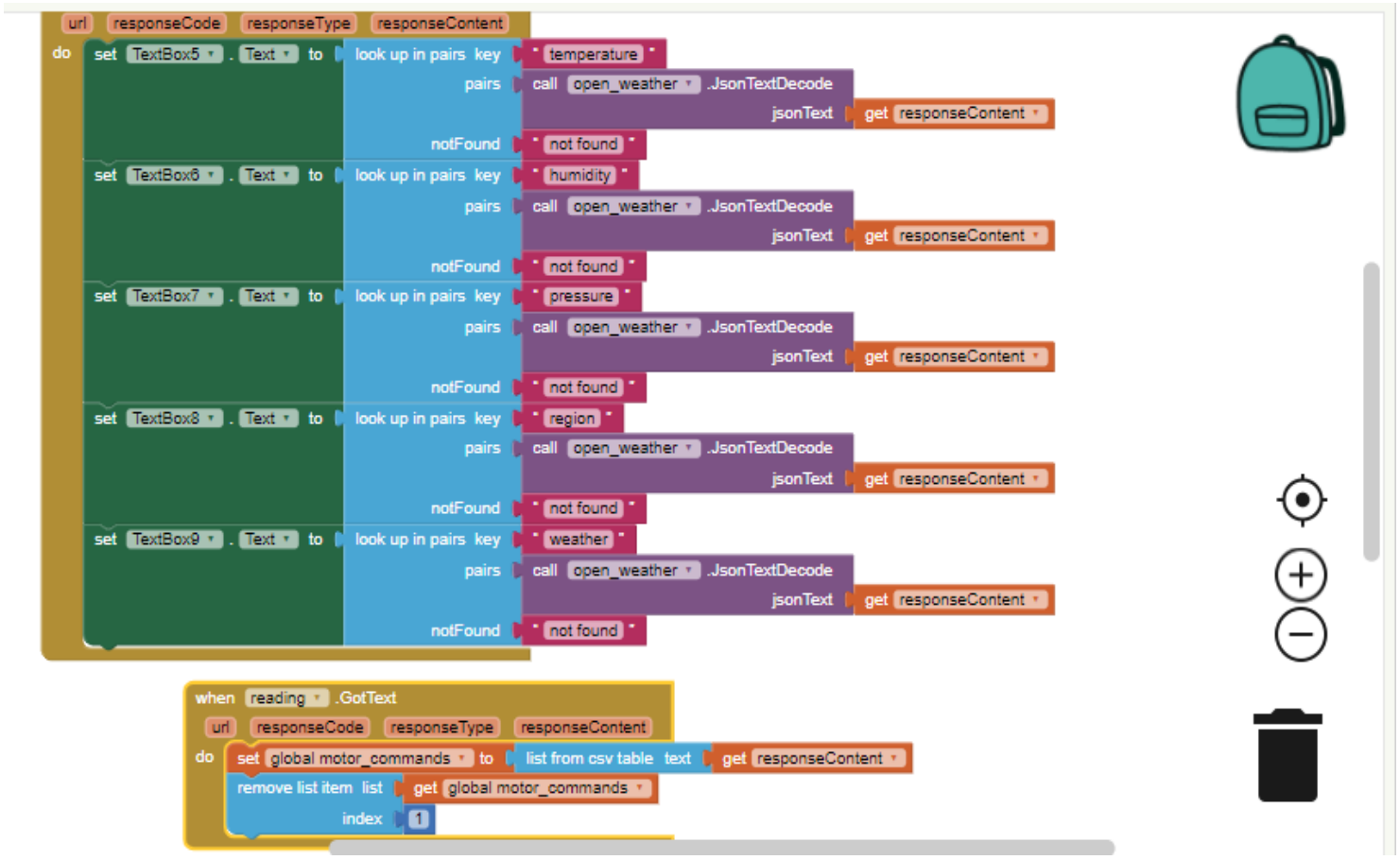


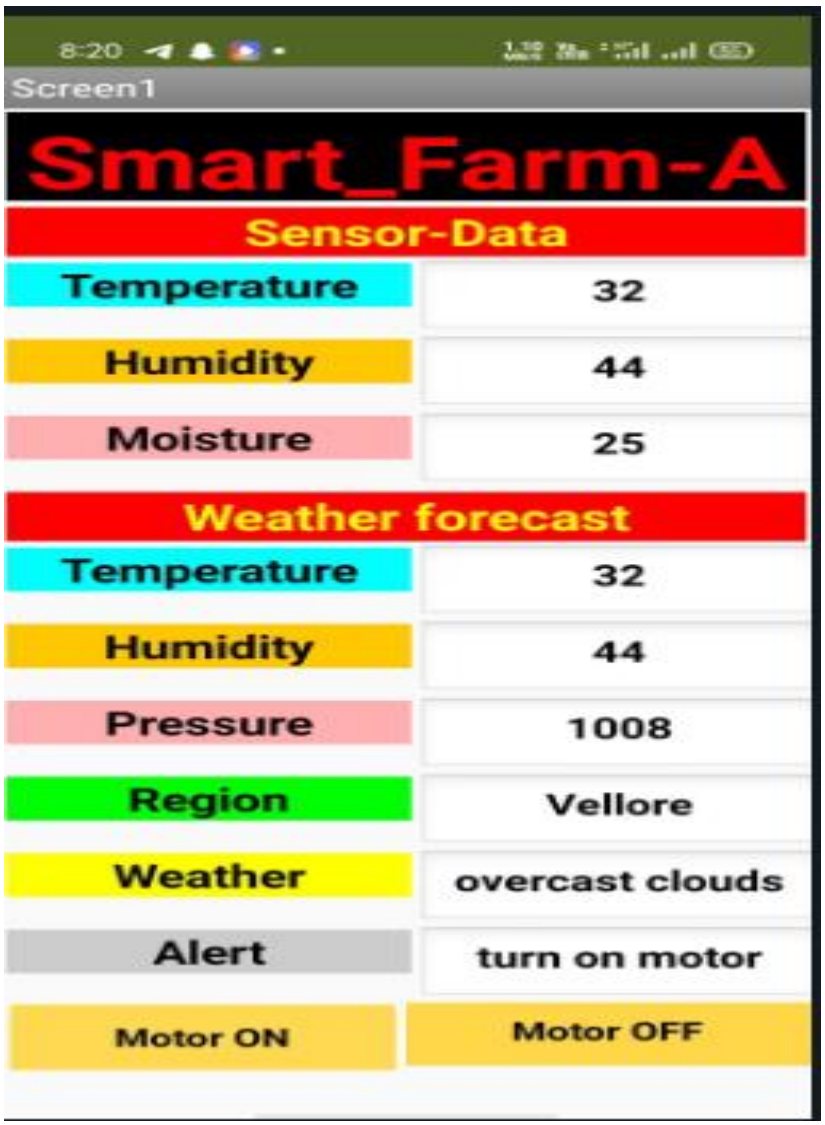
SMART _FARM APP




when Clock2 .Timer
do set open_weather . Url to " https://node-red-reowq-2021-07-09.eu-gb.mybluemi... "
call open_weather .Get
when Clock1 .Timer
do set Web1 . Url to " https://node-red-reowq-2021-07-09.eu-gb.mybluemi... "
call Web1 .Get
when Web1 .GotText
url responseCode responseType responseContent
do set TextBox2 . Text to look up in pairs key " temperature "
pairs call Web1 .JsonTextDecode
jsonText get responseContent
notFound " not found "
set TextBox3 . Text to look up in pairs key " humidity "
pairs call Web1 .JsonTextDecode
jsonText get responseContent
notFound " not found "
set TextBox4 . Text to look up in pairs key " objectTemp "
pairs call Web1 .JsonTextDecode
jsonText get responseContent
notFound " not found "
set TextBox10 . Text to look up in pairs key " alert "
pairs call Web1 .JsonTextDecode
jsonText get responseContent
notFound " not found "

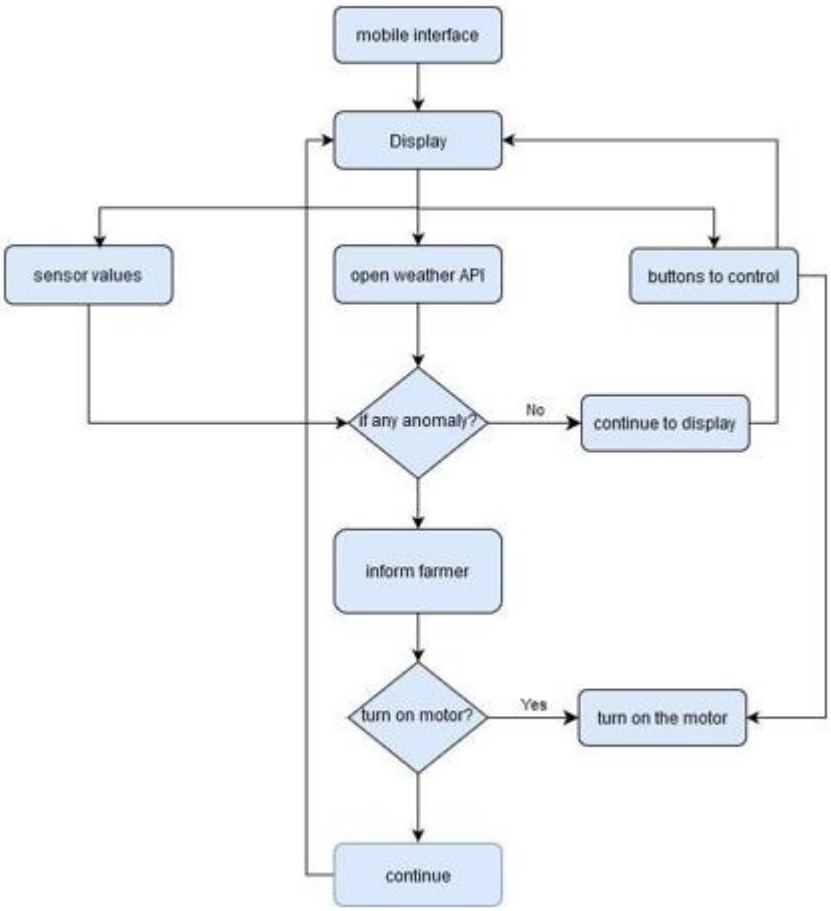

when Screen1 .Initialize
do set reading . Url to " https://docs.google.com/spreadsheets/d/1iEKqWg7W... "
call reading .Get
initialize global motor_commands to create empty list
when Web2 .GotText
url responseCode responseType responseContent
do call reading .Get
when Button2 .Click
do set Web2 . Url to join " https://docs.google.com/forms/d/14VVX0lYqWovq3IU... "
" ?entry.1941799185= "
call Web2 .UriDecode
text " Motoroff "
call Web2 .Get
when Button1 .Click
do set Web2 . Url to join " https://docs.google.com/forms/d/14VVX0lYqWovq3IU... "
" ?entry.1941799185= "
call Web2 .UriDecode
text " Motoron "
call Web2 .Get


url responseCode responseType responseContent
do set TextBox5 . Text to look up in pairs key " temperature "
pairs call open_weather .JsonTextDecode
jsonText get responseContent
notFound " not found "
set TextBox6 . Text to look up in pairs key " humidity "
pairs call open_weather .JsonTextDecode
jsonText get responseContent
notFound " not found "
set TextBox7 . Text to look up in pairs key " pressure "
pairs call open_weather .JsonTextDecode
jsonText get responseContent
notFound " not found "
set TextBox8 . Text to look up in pairs key " region "
pairs call open_weather .JsonTextDecode
jsonText get responseContent
notFound " not found "
set TextBox9 . Text to look up in pairs key " weather "
pairs call open_weather .JsonTextDecode
jsonText get responseContent
notFound " not found "
when reading .GotText
url responseCode responseType responseContent
do set global motor_commands to list from csv table text get responseContent
remove list item list get global motor_commands
index 1


8:20
Screen1
Smart_Farm-A
Sensor-Data
Temperature
32
Humidity
44
Moisture
25
Weather forecast
Temperature
32
Humidity
44
Pressure
1008
Region
Vellore
Weather
overcast clouds
Alert
turn on motor
Motor ON
Motor OFF

FLOW CHART

Flowchart:



7. Advantages & Disadvantages

Advantages:

- Farms can be monitored and controlled remotely.
- Increase in convenience to farmers.
- Lowered labor and operating cost.
- Better standards of living.
- Water Conservation.

Disadvantages:

- Lack of internet/connectivity issues.
- Added cost of internet and internet gateway infrastructure.
- Farmers wanted to adapt the use of WebApp.

8. Applications

The common applications of the Smart Agriculture are:

1. Sensor based systems for monitoring crops, soil, fields, livestock, storage facilities, or basically any important factor that influences the production.
2. Smart agriculture vehicles, drones, autonomous robots and actuators.
3. Connected agriculture spaces such as smart greenhouse or hydroponics.
4. Data analytics, visualization and management systems.
5. Crop water management.
6. Pest management and control works.
7. Precision agriculture.
8. Food production and safety, etc.

9. Conclusion

IoT enabled agriculture has helped implement modern technological solutions to time tested knowledge. This has helped bridge the gap between production and quality and quantity yield. Data Ingested by obtaining and importing information from the multiple sensors for real time use or storage in a database ensures swift action and less damage to the crops. With seamless end to end intelligent operations and improved business process execution, produce gets processed faster and reaches supermarkets in fastest time possible. Thus the objective of the project to implement an IoT system in order to help farmers to control and monitor their farms has been implemented successfully.

10. Future scope

Future development will be focused more on increasing sensors on this system to fetch more live data regard to pest control, food production, etc. also by integrating with the GPS to enhance the Agriculture IoT technology to full fill Agriculture Precision ready product. We can use it as a home automation controller. We can remotely operate or perform the jobs. Also combining with solar panels to conserve power. So the entire system is going to be eco-friendly.

11. Bibliography

IBM cloud reference: https://cloud.ibm.com/

Python code reference: https://github.com/rachuriharish23/ibmsubscribe

IoT simulator : https://watson-iot-sensor-simulator.mybluemix.net/

OpenWeather : https://openweathermap.org/