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# Crop Prediction by Monitoring Temperature and Rainfall Using Decision Tree with Iot and Cloud Based System

P.Ganesh[1], K.Tamilselvi[2], P.Karthi[3]
*Assistant Professor, Department of Computer Science*
*Ayya Nadar Janaki Ammal College, Sivakasi-23, Tamil Nadu, India*
*Head, Department of Computer Science*
*SNMV College of Arts & Science, Malumachampatti, Coimbatore -50, Tamil Nadu, India*
*Assistant Professor, Department of Computer Technology*
*SNMV College of Arts & Science, Malumachampatti, Coimbatore -50, Tamil Nadu, India*

***Abstract:*** *Agriculture is the major source for the largest population in India to earn money and carry out their livelihood. Precision agriculture is already adopted in other countries, but we still need to involve IoT and cloud computing technologies for better production of crops. At present the climate differs in many areas around India due to various factors from human activities such as air pollution, deforestation, sewage and from natural changes such as distance of sea, wind direction, proximity to the equator. As per the changes in the climate, a farmer needs to predict which crop should be cultivated at which time. The dataset stores the details of the crop which should satisfy the requirements such as maximum and minimum temperature, maximum and minimum rainfall, soil type and location. The current temperature and rainfall range data can be collected by using DHT11 Temperature Sensor and Soil Moisture Sensor connected to Raspberry Pi. The collected data's (location, temperature value and rainfall range) are stored in AWS IoT. Connections with remote locations can easily achieved by using messaging protocol such as MQTT (Message Queue Telemetry Transport). The publish-subscribe pattern requires a message broker. The broker is responsible for distributing messages to interested clients based on the topic of a message. The Decision trees are versatile Machine Learning algorithm that can perform both classification and regression tasks in predicting the crop to be cultivated in a corresponding location as per the climatic changes. Amazon QuickSight helps to visualize the data by comparing with the trained data.*

***Keywords:*** *AWS, IoT, Raspberry Pi, DHT11, MQTT, Amazon Quick Sight*

## I. INTRODUCTION

Different devices and instruments can be integrated using IoT and its integrated platform. IoT plays very important role while controlling and monitoring traditional as well as general household objects [1]. In recent years, IoT has been attracting the attention of industrialists, researchers as well as government for deploying different services. By using internet, now a day it is possible to control and monitor all the things easily. Different things can communicate with each other, and can even make decisions by themselves with the help of internet [2]. Industry partners such as Amazon, Microsoft and IBM have introduced IOT based platforms such as AWS (Amazon Web Services) IoT and Microsoft Azure for effectively monitoring the remote applications.

As per the ABI Research [3], in 2014 wireless connected devices will increase to 16 billion, about 20% more than in 2013. According to Gartner, Inc. (a technology research and advisory corporation), there will be nearly 20.8 billion devices on the Internet of things by 2020[4].The IoT allows objects to be sensed or controlled remotely across existing network infrastructure, creating opportunities for more direct integration of the physical world into computer-based systems, and resulting in improved efficiency, accuracy and economic benefit in addition to reduced human intervention. When IoT is augmented with sensors and actuators, the technology becomes an instance of the more general class of cyber-physical systems, which also encompasses technologies such as smart grids, virtual power plants, smart homes, intelligent transportation and smart cities. With the help of sensors, environmental monitoring applications can be achieved such as environmental protection [5] by monitoring air or water quality [6], soil conditions [7], movements of wildlife and habitats can be monitored. Urban and rural infrastructures related operations like bridges, railway tracks; on- and offshorewind-farms can easily monitored as well as controlled using IOT [8]. IoT plays a key role in industrial applications and smart manufacturing like network control and management of manufacturing equipment, asset and situation management, or manufacturing process control.

In this paper, Raspberry Pi is used as gateway for remote monitoring purpose. Depending on the requirement any sensor can be interfaced with Raspberry pi for controlling the application. Gateway is synchronized with AWS (Amazon Web Services) IoT platform. MQTT acts as a messaging protocol for remote connections to distribute messages towards interested clients.

The organization of paper is as follows. In section 1 the DHT11 Temperature Sensor and Soil Moisture Sensor predicts the range of temperature and rainfall by interfacing with Raspberry pi. The section 2 defines proposed model of storing the collected data into AWS IoT using MQTT as a messaging protocol. The section 3 predicts the corresponding crop to cultivate in the respective location by sending the collected temperature and rainfall data towards the trained data using decision tree in AWS R tool. The section 4 defines implementation and visualization of temperature changes and crop to be cultivated using Amazon QuickSight.

## II. BACKGROUND AND RELATED WORK

The study of the relevant article available in literature reveals that most of the remote monitoring systems are designed using Arduino board and different electronics sensors for home automation and health monitoring. Very few were tried to develop remote monitoring systems using AWS IOT platform and Raspberry Pi. The IOT based available remote monitoring systems are briefly discussed in following section.

### A. IOT architecture

Many IOT- based healthcare applications [9], [10], [11] were introduced in the last decade. Most of the researchers worked on IOT implementations by taking the help of reference model. According to the different articles, there are three different key aspects that play very important role in IOT implementation: network, cloud and data. Each aspect can be designed by using different blocks, and each building block having correlation with one or more blocks. All the three aspects having very strong relation with each other and able to influence different IOT applications.

### B. Prerequisites for IOT Communication

The future is coming fast, connectivity is a commodity, and IOT is steadily taking shape, growing in popularity, and becoming a reality. So for IOT to truly become the next thing with all devices and users connected in and out of the home, we must take a look at the cost of connection, device type, and privacy. There are many network communication protocols which get operated at application layer for IOT devices such as MQTT [12] or CoAP [14], HTTP [13].

Depending on the application each and every protocol having its own advantage. After doing comparative analysis [15] researchers found that, MQTT is basically used in applications which demands QoS at different levels and multicasting of messages towards interested clients. CoAP is the best option to satisfy bandwidth requirement and round trip time (RTT). The future is changing drastically, and connectivity is acting like a commodity, and IoT is becoming a reality. The cost of connection, device type, and privacy plays very important role while deploying IOT concept for industry and commercial applications. To a large degree manufacturing organizations hereby become service organizations and end-to-end transparency is crucial. The insights gained with an integrated IoT approach from the customer side are also crucial and enable to offer better products, quality and services.

## III. DESIGN AND IMPLEMENTATION

In order to realize the crop prediction by monitoring temperature and rainfall system, the paper proposed an architecture which consists of AWS IOT platform and hardware components as shown in figure 1.

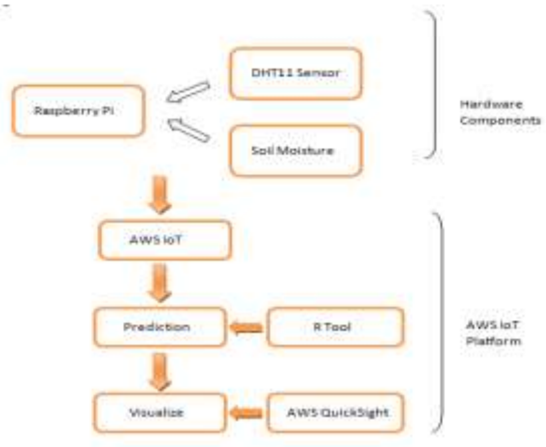



Fig 1. Working Architecture

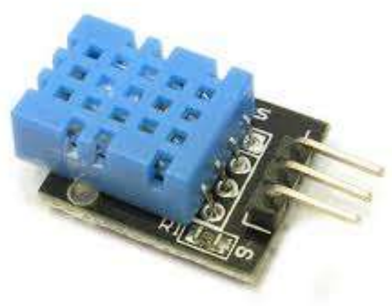
The AWS IOT platform act like a cloud server for exchanging the information in between end user and system. AWS cloud server provides the facility of interfacing any gateway device such as Raspberry Pi, and Arduino board for controlling any application.

A thing is created on AWS cloud server for establishing communication in between Raspberry Pi and server. For authentication purpose a certificate has to be created for that thing. Depending on the requirement a rule is created to evaluate messages sent by the thing and specify what to do when a message is received. An action is selected and configured for sending notifications towards a client related to messages. For publishing messages a topic has to be created. Subscription is created for a topic in which communication protocol as well as end point of the respective client is defined. After creating the subscription, messages can be easily sent towards a particular client. By using MQTT broker a topic can be subscribed as well as published for sending different messages.

The hardware components includes gateway device as Raspberry Pi, Ethernet cable or Wifi, computer/laptop, and DHT11, soil moisture sensors for monitoring temperature and rainfall range. Raspberry pi is connected with computer/laptop using Ethernet cable. A USB cable is used to power on the Raspberry Pi device. As per the application requirement, a sensor is interfaced with Raspberry Pi device for remote monitoring purpose.

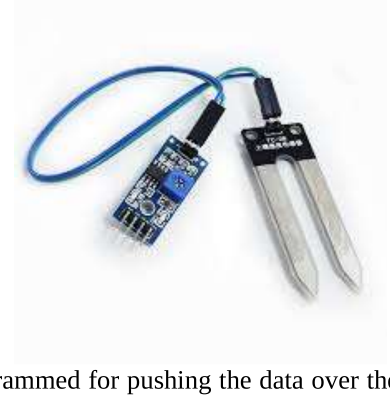
**DHT11 Temperature Sensor**

The DHT11 sensor is capable of measuring both temperature and relative humidity and provide fully calibrated digital outputs. Its temperature measuring range is from -40 to +125 degrees Celsius with +-0.5 degrees accuracy. The humidity measuring range, from 0 to 100% with 2-5% accuracy.



**Soil Moisture Sensor**

The Soil Moisture Sensor uses capacitance to measure dielectric permittivity of the surrounding medium. In soil, dielectric permittivity is a function of the water content. The sensor creates a voltage proportional to the dielectric permittivity, and therefore the water content of the soil. The sensor averages the water content over the entire length of the sensor. There is a 2 cm zone of influence with respect to the flat surface of the sensor, but it has little or no sensitivity at the extreme edges. The Soil Moisture Sensor is used to measure the loss of moisture over time due to evaporation and plant uptake, evaluate optimum soil moisture contents for various species of plants, monitor soil moisture content to control irrigation in greenhouses and enhance bottle biology experiments.



Raspberry Pi device is programmed for pushing the data over the AWS cloud server. Proposed system is implemented successfully by integrating AWS cloud server and Raspberry Pi device which is as shown in figure 2 and figure 3. As a prototype for remote monitoring, a DHT11 and soil moisture sensors are connected to

Raspberry Pi device. For interfacing Raspberry Pi with AWS cloud server a thing is created on server which is as shown in figure 3.

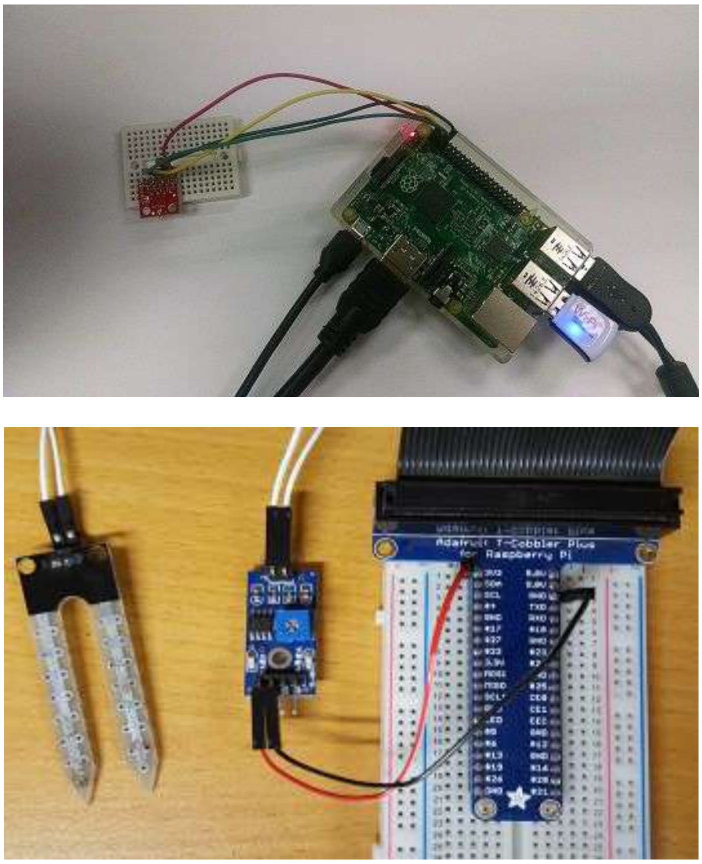



**Fig 2.** Prototype for implementation

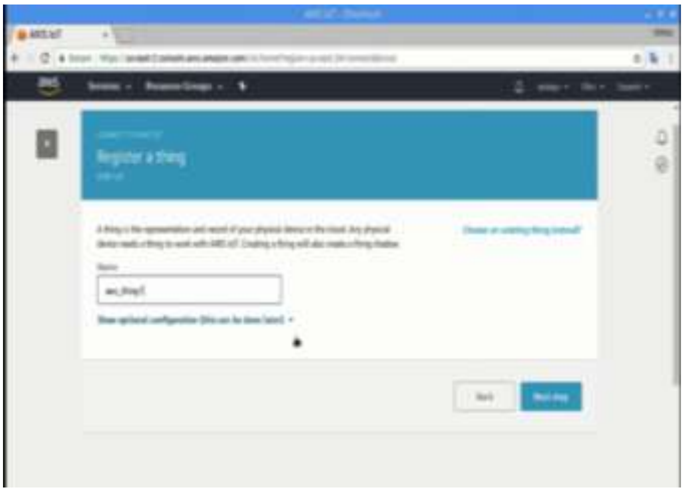



**Fig. 3** Creating a thing on AWS cloud server

Stepwise procedure for creating certificate, rule, topic and subscription is as shown in following figures

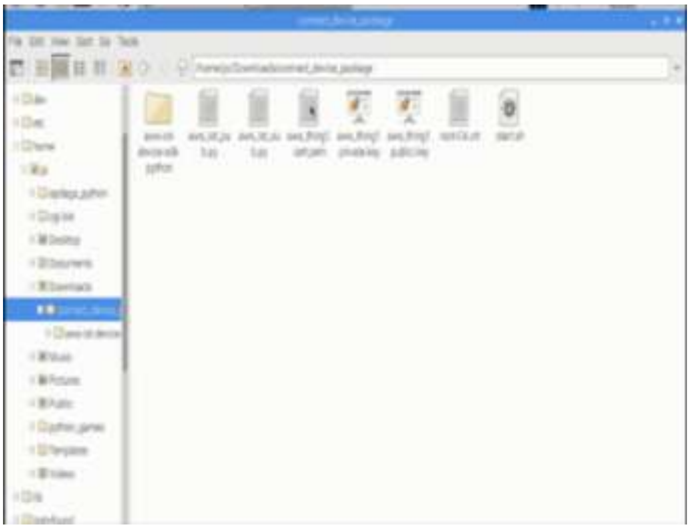


**Fig. 4** Download certificate to connect a device

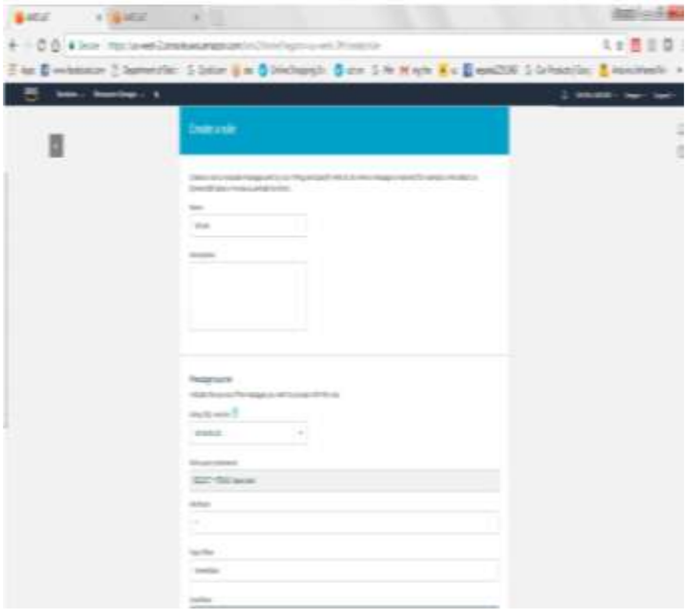


**Fig. 5** Create a rule

**Fig. 6** Get End Point to start publish

### 3.1 Programming Raspberry Pi

After interfacing DHT11 and soil moisture sensor with Raspberry Pi device next step is to programme Raspberry Pi device using python. Following is the sample program loaded to Raspberry Pi device for fetching the sensor data and store in AWS IoT.

```
import paho.mqtt.client as paho
import os
import socket
import ssl
from time import sleep
from random import uniform

connflag = False

def on_connect(client, userdata, flags, rc):
# func for making connection
    global connflag
    print "Connected to AWS"
    connflag = True
    print("Connection returned result: " + str(rc) )

def on_message(client, userdata, msg):
# Func for Sending msg
    print(msg.topic+" "+str(msg.payload))

#def on_log(client, userdata, level, buf):
#    print(msg.topic+" "+str(msg.payload))

mqttc = paho.Client()
  # mqttc object
mqttc.on_connect = on_connect
# assign on_connect func
mqttc.on_message = on_message
 # assign on_message func
#mqttc.on_log = on_log

awshost = "a1r7yoit83fln7.iot.us-east-2.amazonaws.com"
# Endpoint
awsport = 8883
# Port no.
clientId = "aws_thing1"
 # Thing_Name
thingName = "aws_thing1"
# Thing_Name
caPath = "root-CA.crt"
# Root_CA_Certificate_Name
certPath = "aws_thing1.cert.pem"
 # <Thing_Name>.cert.pem
keyPath = "aws_thing1.private.key"
# <Thing_Name>.private.key

mqttc.tls_set(caPath, certfile=certPath, keyfile=keyPath, cert_reqs=ssl.CERT_REQUIRED,
tls_version=ssl.PROTOCOL_TLSv1_2, ciphers=None)  # pass parameters

mqttc.connect(awshost, awsport, keepalive=60)              # connect to aws server

mqttc.loop_start()
  # Start the loop

while 1==1:
```

```
    sleep(5)
    if connflag == True:
        tempreading = uniform(20.0,25.0)
# Generating Temperature Readings
        mqttc.publish("temperature", tempreading, qos=1)
 # topic: temperature # Publishing Temperature values
        print("msg sent: temperature " + "%.2f" % tempreading ) # Print sent temperature msg on console
    else:
        print("waiting for connection...")
```

## IV. RESULTS

The implemented prototype is designed to predict the crop for cultivation as per the climatic condition and range of rainfall obtained. As per the changes in the climate, a farmer needs to predict which crop should be cultivated at which time. The dataset stores the details of the crop which should satisfy the requirements such as maximum and minimum temperature, maximum and minimum rainfall, soil type and location. The current temperature and rainfall range data can be collected by using DHT11 Temperature Sensor and Soil Moisture Sensor connected to Raspberry Pi. The Decision trees are versatile Machine Learning algorithm that can perform both classification and regression tasks in predicting the crop to be cultivated in a corresponding location as per the climatic changes. Amazon QuickSight helps to visualize the data by comparing with the trained data. For remotely monitoring the designed application we can effectively use AWS IoT platform as shown in figure7.

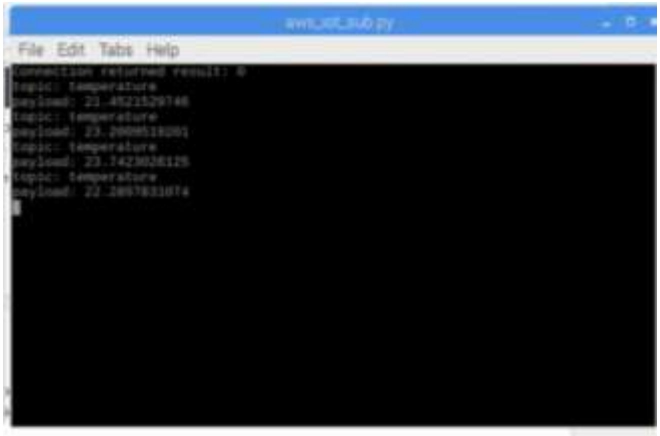



**Fig 7:** Output on Raspberry Pi terminal

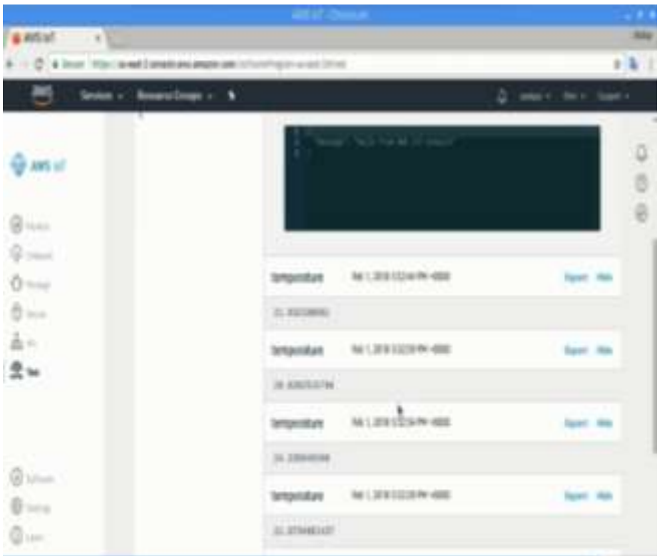


**Fig 8:** Subscribing and Publishing a topic using MQTT client

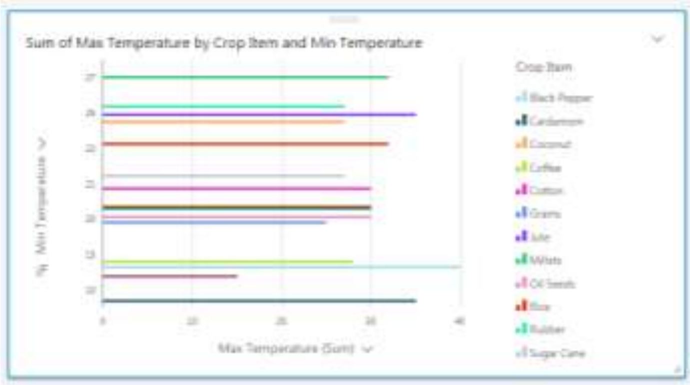



**Fig 9:** Visualize Temperature changes using AWS Quick Sight

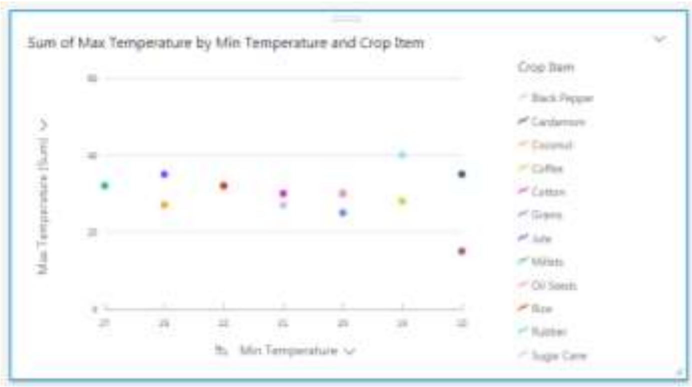



**Fig 10:** Locations for cultivating crop as per temperature changes

## V. CONCLUSION

AWS IoT platform plays an important role in collecting the temperature changes and rainfall received data from various location. The R studio in AWS platform helped in predicting the crop by analyzing the present collected data with the trained data set. The maximum and minimum temperature values will act a root for decision tree in predicting the crop for cultivation. The Amazon QuickSight in AWS platform helps in visualizing the temperature changes and location for cultivating the crops. The designed system is very economic and effective for monitoring any commercial as well as industrial application. By subscribing and publishing the topics, any notification related to climatic changes can be analyzed and crop for cultivation can be predicted. So, the designed smart sensing module is reliable and robust to work under any condition.

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## AUTHOR

[1]. Mr.P.GANESH has completed his M.C.A and pursuing M.Phil in SNMV College, Coimbatore, Bharathiyar University, Coimbatore and having teaching experience of 5 years in Ayya Nadar Janaki Ammal College, Sivakasi. His area of specialization is Internet of Things and Data Mining.
[2]. Mrs.K.TAMILSELVI has completed his MCA and M.Phil and having teaching experience of 17 years in SNMV College of Arts and Science. Her area of specialization is Network Security.
[3]. Mr.P.KARTHI has completed his M.Tech and M.Phil and having teaching experience of 6 years in SNMV College of Arts and Science. His area of specialization is Network Security and cryptography.