CS5453: INTERNET OF THINGS

PROJECT REPORT

SMART INTERNET OF THINGS (IoT) GARDEN

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CHAPTER 1
INTRODUCTION

1.1 GENERAL

In recent years, the demand of building automation system increases especially in offices and households. Generally, it is because automation helps reducing consumption of electricity, decreases the wastage, uses less manpower, and helps in energy saving. Automation system that is implemented at home is known as home automation. The home automation term is referred to the automation system that can integrate household activities which include sensors to read input condition and centralized the control of electrical appliances. The examples of implementation of automation system at home include home surveillance system, watering plant system, domestic robot, pet feeding system, and other household activities.

This report focuses on building smart garden which will automate the irrigation system. The purpose of this project is to monitor and control the plant growth in home garden/ farm area based on environmental factors, like weather and soil moisture. This technology creates suitable conditions for growing plants such as flowers and vegetables which prevents bad effects that are caused by weather change. Most mini gardens in residential area are not covered with house roof and it will be exposed to weather change such as heavy rain or a superhot day. This various environmental conditions may affect the plant growth in the garden. This mini garden should be monitored by home owner frequently to ensure the plants are growing healthily. However, it might be difficult for the home owner who are away for a long time to monitor their plants. One system should be built to monitor and control the system that can irrigate their plant from other places.

1.2 EXISTING SYSTEM

At present, the farms/ small gardens are being taken care by the home/ farm owner. They physically visit the farm/ garden and based on condition of soil they water the plants. Sometimes during hot scorching summer, the farm owner has to stand in his agriculture land and to monitor watering of plants. And during night time, they sleep in their farms to protect the corps from being destroyed by anyone. Thus various environmental conditions may affect the plant growth.

1.3 PROPOSED SYSTEM

In this project, we propose to use moisture, humidity, temperature, ultrasonic and rain sensor to automate the irrigation activity. All the mentioned sensors will be connected to Raspberry Pi 3 and which in turn is integrated with Amazon Web Server (AWS) IoT core for enabling cloud computation. The system based on inputs from moisture and rain sensor turns on the water pump if the tank is full and farm is dry. In case the storage is empty the solenoid valve will be opened to allow ingress of water. Additionally, we have used another raspberry pi module integrated with camera to detect any unauthorised activity in the farm/ garden. switch. The proposed system design consists of three major steps:

(a) Development of the system hardware by using Raspberry Pi.

(b) Development of the program for taking the inputs and performing the desired action.

(c) Publish temperature, moisture and distance data to the AWS IoT Core.

(d) Integration with Motion Eye OS to enable email notification on detection of intrusion.

CHAPTER 2
COMPONENTS DESCRIPTION

2.1 BLOCK DIAGRAM

The project utilises a combination of hardware and software component which are connected using the below mentioned block diagram. Individual modules have been discussed in detail in subsequent paragraphs.

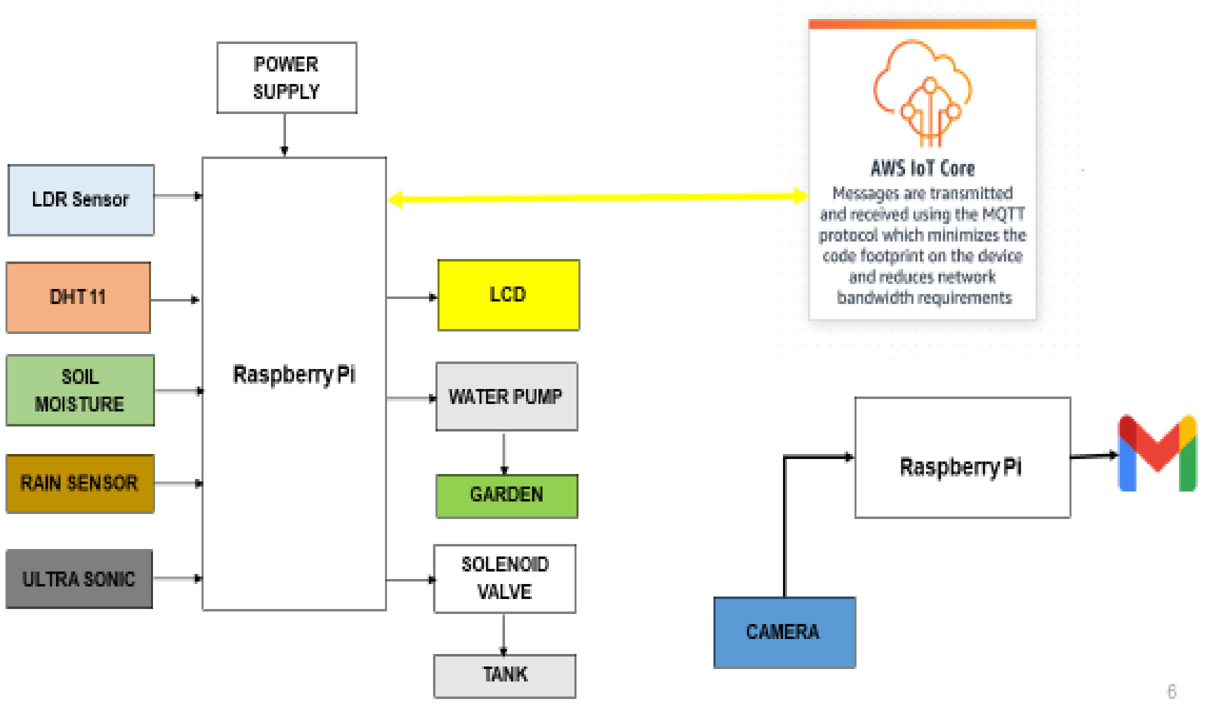

Figure 2.1 Block Diagram

2.1 HARDWARE COMPONENTS

2.1.1 RASPBERRY PI

The Raspberry Pi is a series of credit card–sized single-board computers developed in the United Kingdom by the Raspberry Pi Foundation with the intention of promoting the teaching of basic computer science in schools and developing countries. The original Raspberry Pi and Raspberry Pi 2 are manufactured in several board configurations through licensed manufacturing agreements with Newark element14 (Premier Farnell), RS Components. The hardware is the same across all manufacturers.

The Raspberry Pi 3 is equipped with a quad-core 64-bit Broadcom BCM2837 ARM Cortex-A53 SoC processor running at 1.2 GHz, making it about **50% more powerful than the Pi 2.** Which means the new Raspberry Pi 3 can be used for office applications and web browsing. The great innovation in this third version is undoubtedly the addition of a WiFi chip and Bluetooth Low Energy. This not only saves space (you no longer need to connect WiFi and Bluetooth dongles), but also frees up more USB ports for connecting other devices.

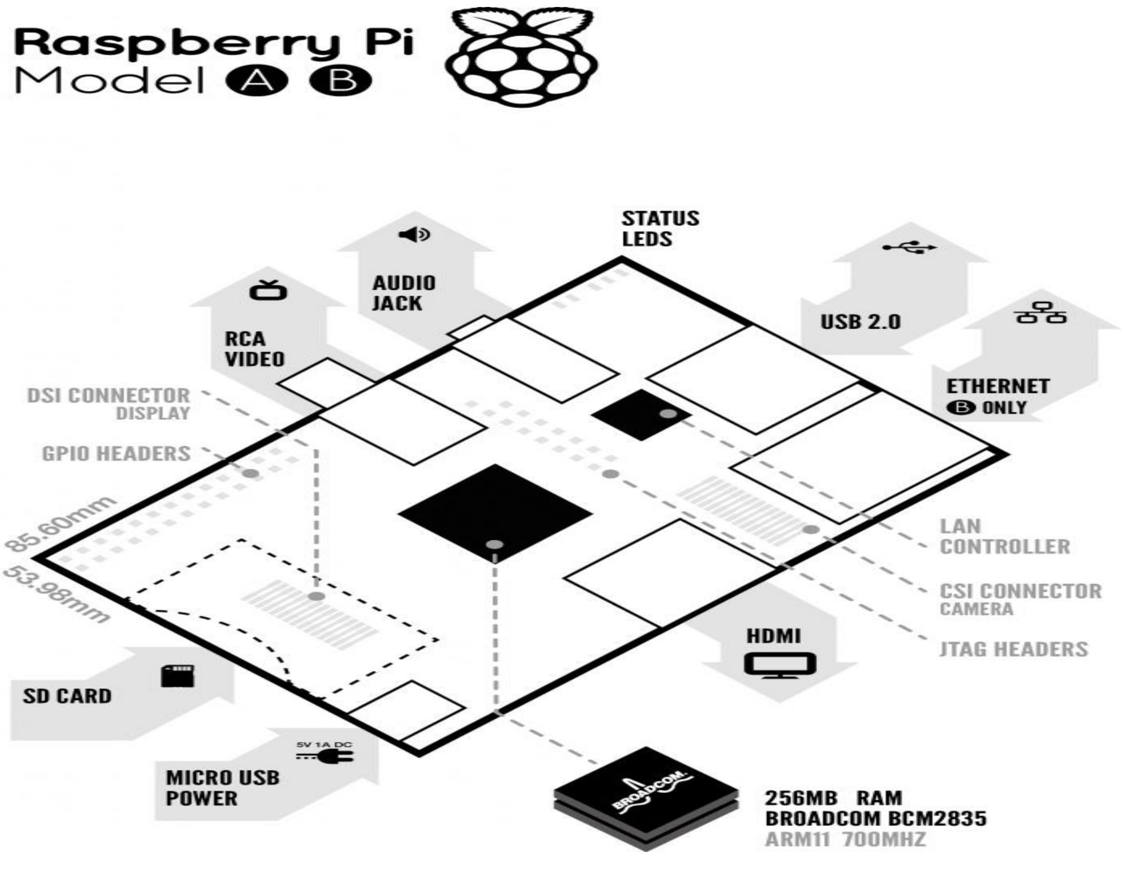

Figure 2.2 - Block Diagram of Raspberry Pi

2.1.2 LIQUID CRYSTAL DISPLAY (LCD)

LCD (Liquid Crystal Display) screen is an electronic display module and is used in a wide range of applications. A 16 x 2 LCD display is very basic module and is very commonly used in various devices and circuits. These modules are preferred over seven segments and other multi segment LEDs. The reasons being LCDs are economical, easily programmable, have no limitation of displaying special & even custom characters.

A **16x2 LCD** means it can display 16 characters per line and there are 2 such lines. In this LCD each character is displayed in 5x7 pixel matrix. This LCD has two registers, namely, Command and Data. The command register stores the command instructions given to the LCD. A command is an instruction given to LCD to do a predefined task like initializing it, clearing its screen, setting the cursor position, controlling display etc. The data register stores the data to be displayed on the LCD. The data is the ASCII value of the character to be displayed on the LCD.

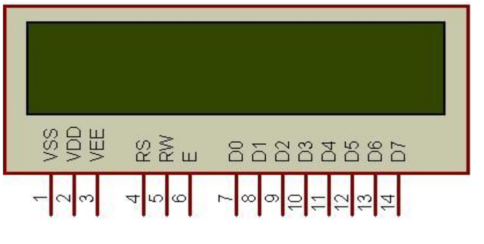

Figure 2.3 – Liquid Crystal Display (16 x 2)

Pin Number	Symbol	Function
1	Vss	Ground Terminal
2	Vcc	Positive Supply
3	Vdd	Contrast adjustment
4	RS	Register Select; 0→Instruction Register, 1→Data Register
5	R/W	Read/Write Signal; 1→Read, 0→ Write
6	E	Enable; Falling edge
7	DB0	Bi-directional data bus, data transfer is performed once, thru DB0 to DB7, in the case of interface data length is 8-bits; and twice, through DB4 to DB7 in the case of interface data length is 4-bits. Upper four bits first then lower four bits.
8	DB1	
9	DB2	
10	DB3	
11	DB4	
12	DB5	
13	DB6	
14	DB7	
15	LED-(K)	Back light LED cathode terminal
16	LED+(A)	Back Light LED anode terminal

Table 2.1 - Pin Description of LCD

2.1.3 DHT11 (HUMIDITY & TEMPERATURE SENSOR)

DHT11 Temperature & Humidity Sensor features a temperature & humidity sensor complex with a calibrated digital signal output. By using the exclusive digital-signal-acquisition technique and temperature & humidity sensing technology, it ensures high reliability and excellent long-term stability. This sensor includes a resistive-type humidity measurement component and an NTC temperature measurement component, and connects to a high-performance 8-bit microcontroller, offering excellent quality, fast response, anti-interference ability and cost-effectiveness.

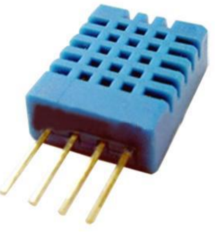

Figure 2.4 – DHT Sensor

Each DHT11 element is strictly calibrated in the laboratory that is extremely accurate on humidity calibration. The calibration coefficients are stored as programmes in the memory, which are used by the sensor's internal signal detecting process. The single-wire serial interface makes system integration quick and easy. Its small size, low power consumption and up-to-20 meter signal transmission making it the best choice for various applications, including those most demanding ones. The component is 4-pin single row pin package. It is convenient to connect and special packages can be provided according to users' request.

Item	Measurement Range	Humidity Accuracy	Temperature Accuracy	Resolution	Package
DHT11	20-90%RH 0-50 ℃	±5%RH	±2℃	1	4 Pin Single Row

Table 2.1 - Specifications of DHT 11

2.1.4 LIGHT DEPENDENT RESISTOR (LDR)

Light dependent resistor (LDR) is a resistor whose resistance decreases with increasing incident light intensity or vice versa. As the name suggests, LDR is a type of resistor whose working depends upon only on the light falling on it. The resistor behaves as per amount of light and its output directly varies with it. In general, LDR resistance is minimum (ideally zero) when it receives maximum amount of light and goes to maximum (ideally infinite) when there is no light falling on it. It's specifications are as follows:-

(a) Resistance : 400ohm to 400Kohm

(b) Sensitivity: about 3msec

(c) Voltage ratings: I used it on 3V,5V and 12V

2.1.5 MOISTURE SENSOR

The soil moisture sensor is a kind of sensor used to gauge the volumetric content of water within the soil. These sensors measure the volumetric water content. The relation among the calculated property as well as moisture of soil should be adjusted & may change based on ecological factors like temperature, type of soil, otherwise electric conductivity. The microwave emission which is reflected can be influenced by the moisture of soil as well as mainly used in agriculture and remote sensing within hydrology. The working of this sensor can be done by inserting this sensor into the earth and the status of the water content in the soil can be reported in the form of a percent.

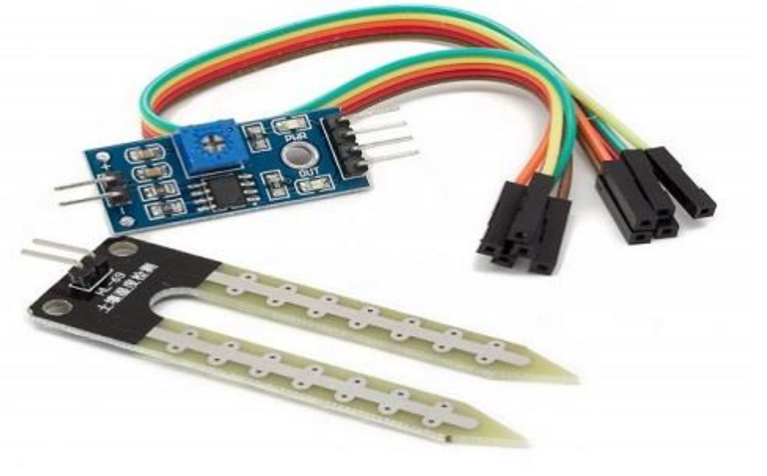

Figure 2.5 – Soil Sensor

This module has four pins which are described below:-

(a) VCC pin is used for power

(b) A0 pin is an analog output

(c) D0 pin is a digital output

(d) GND pin is a Ground

2.1.5 RAIN SENSOR

A rain sensor is one kind of switching device which is used to detect the rainfall. It works like a switch and the working principle of this sensor is, whenever there is rain, the switch will be normally closed. The rain sensor module/board is shown below. Basically, this board includes nickel coated lines and it works on the resistance principle. This sensor module permits to gauge moisture through analog output pins & it gives a digital output while moisture threshold surpasses. The pin configuration of this sensor is shown below. This sensor includes four pins which include the following.

(a) Pin1 (VCC): It is a 5V DC pin

(b) Pin2 (GND): it is a GND (ground) pin

(c) Pin3 (DO): It is a low/ high output pin

(d) Pin4 (AO): It is an analog output pin

Figure 2.6 – Rain Sensor

2.1.6 ULTRASONIC SENSOR

Ultrasonic sensors are industrial control devices that use sound waves above 20,000 Hz, beyond the range of human hearing, to measure and calculate distance from the sensor to a specified target object. Ultrasonic sensors use electrical energy and a ceramic transducer to emit and receive mechanical energy in the form of sound waves. Sound waves are essentially pressure waves that travel through solids, liquids and gases and can be used in industrial applications to measure distance or detect the presence or absence of targets

Ultrasonic sensors (also known as transceivers when they both send and receive) work on a principle similar to radar or sonar which evaluate attributes of a target by interpreting the echoes from radio or sound waves respectively. Ultrasonic sensors generate high frequency sound waves and evaluate the echo which is received back by the sensor. Sensors calculate the time interval between sending the signal and receiving the echo to determine the distance to an object.

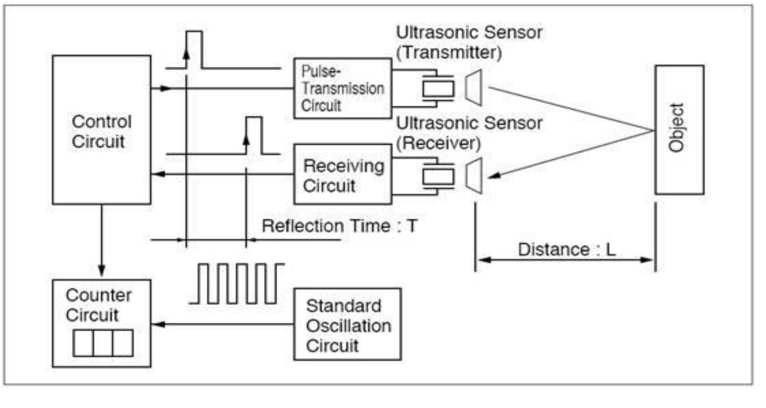

Figure 2.7 – Block Diagram of Ultrasonic Sensor

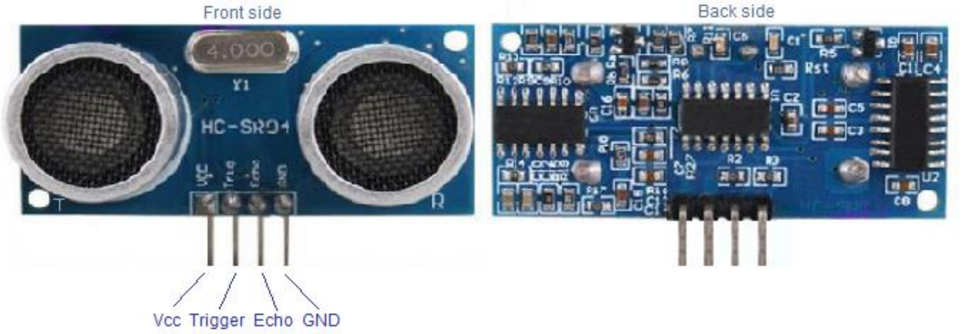

Figure 2.8 – Ultrasonic Sensor

Pin Description of the ultrasonic sensor is as follows :-

(a) **VCC** : 5V DC supply voltage is connected to this pin.

(b) **Trigger**: The trigger signal for starting the transmission is given to this pin. The trigger signal must be a pulse with 10uS high time. When the module receives a valid trigger signal it issues 8 pulses of 40KHz ultrasonic sound from the transmitter. The echo of this sound is picked by the receiver.

(c) **Echo**: At this pin, the module outputs a waveform with high time proportional to the distance.

(d) **GND**: Ground is connected to this pin.

2.1.7 SOLENOID VALVE

A solenoid valve is an electrically controlled valve. The valve features a solenoid, which is an electric coil with a movable ferromagnetic core (plunger) in its center. In the rest position, the plunger closes off a small orifice. An electric current through the coil creates a magnetic field. The magnetic field exerts an upwards force on the plunger opening the orifice. This is the basic principle that is used to open and close solenoid valves. Components of solenoid valve are coil (A), armature (B), shading ring (C), spring (D), plunger (E), seal (F) and valve (G).

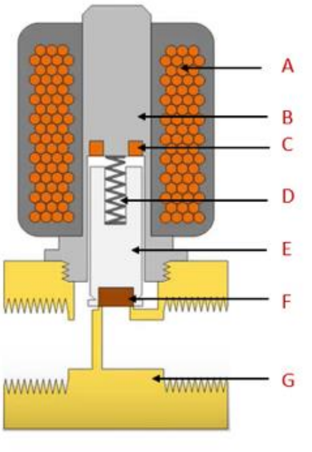

Figure 2.9 - Components of a solenoid valve

A solenoid valve consists of two main components: a solenoid and a valve body (G). Figure 2.8 shows the components. A solenoid has an electromagnetically inductive coil (A) around an iron core at the center called the plunger (E). At rest, it can be normally open (NO) or normally closed (NC). In the de-energized state, a normally open valve is open and a normally closed valve is closed. When current flows through the solenoid, the coil is energized and creates a magnetic field. This creates a magnetic attraction with the plunger, moving it and overcoming the spring (D) force. If the valve is normally closed, the plunger is lifted so that the seal (F) opens the orifice and allows the flow of the media through the valve. If the valve is normally open, the plunger moves downward so that the seal (F) blocks the orifice and stops the flow of the media through the valve. The shading ring (C) prevents vibration and humming in AC coils.

2.2 SOFTWARE COMPONENTS

2.2.1 SD CARD FORMATTER

The SD Memory Card Formatter formats SD Memory Card, SDHC Memory Card and SDXC Memory Card (respectively SD/SDHC/SDXC Cards) complying with the SD File System Specification created by the SD Association (SDA). It is strongly recommended to use the SD Memory Card Formatter to format SD/SDHC/SDXC Cards rather than using formatting tools provided with individual operating systems. In general, formatting tools provided with operating systems can format various storage media including SD/SDHC/SDXC Cards, but it may not be optimized for SD/SDHC/SDXC Cards and it may result in lower performance.

These Cards have a “Protected Area” for SD Card security purposes. The SD Memory Card Formatter does not format the protected area in the SD/SDHC/SDXC Cards. The protected area shall be formatted by an appropriate PC application or SD host devices that provide SD security function.

2.2.2 FILE ZILLA

FileZilla is a free and open-source, cross-platform FTP application, consisting of FileZilla Client and FileZilla Server. Clients are available for Windows, Linux, and macOS, servers are available for Windows only. Both server and client support FTP and FTPS (FTP over SSL/TLS), while the client can in addition connect to SFTP servers.

2.2.3 THONNY PYTHON IDE

Thonny is an integrated development environment for Python that is designed for beginners. It supports different ways of stepping through the code, step-by-step expression evaluation, detailed visualization of the call stack and a mode for explaining the concepts of references and heap.

2.2.4 RASPBERRY PI SOFTWARE

The Raspberry Pi primarily uses Linux kernel-based operating systems. The ARM11 is based on version 6 of the ARM which is no longer supported by several popular versions of Linux, including Ubuntu. The install manager for Raspberry Pi is NOOBS.

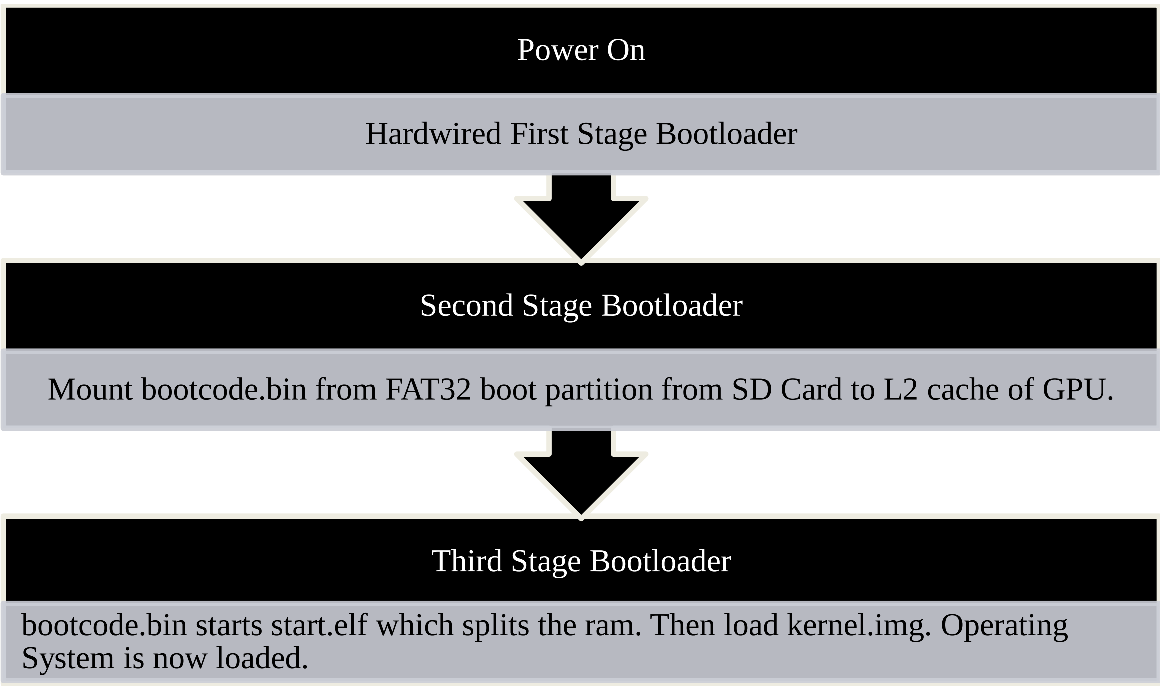

Figure 2.10 - Boot process of Raspberry Pi

2.2.5 NOOBS INSTALLER

The Raspberry Pi Raspberry Pi package only comes with the main board and nothing else. It does not come shipped with an operating system. Operating systems are loaded on a SD card from a computer and then the SD card is inserted in the Pi which becomes the primary boot device. Installing operating system can be easy for some enthusiasts, but for some beginners working with image files of operating systems can be difficult. So the Raspberry Pi foundation made a software called **NOOBS – New Out Of Box Software** which eases the process of installing an operating system on the Pi.

The NOOBS installer can be downloaded from the official website. A user only needs to connect a SD card with the computer and just run the setup file to install NOOBS on the SD card. Next, insert the card on the Raspberry Pi. On booting the first time, the NOOBS interface is loaded and the user can select from a list of operating systems to install. It is much convenient to install the operating system this way. Also once the operating system is installed on the card with the NOOBS installer, every time the Pi boots, a recovery mode provided by the NOOBS can be accessed by holding the shift key during boot. It also allows editing of the config.txt file for the operating system

2.2.5 MOTION EYE OS

MotionEyeOS is a free open-source application which allows you to turn a Raspberry Pi with a camera into a home video monitoring system, where the photos and videos can either stay on your device (and home network) or, if you choose, be uploaded automatically to a cloud-storage service such as Google Drive or Dropbox.

CHAPTER 3
IMPLEMENTAION DETAILS

3.1 ARCHITECTURE DIAGRAM

The circuit diagram to connect all the sensors with the Raspberry Pi module is as shown below: -

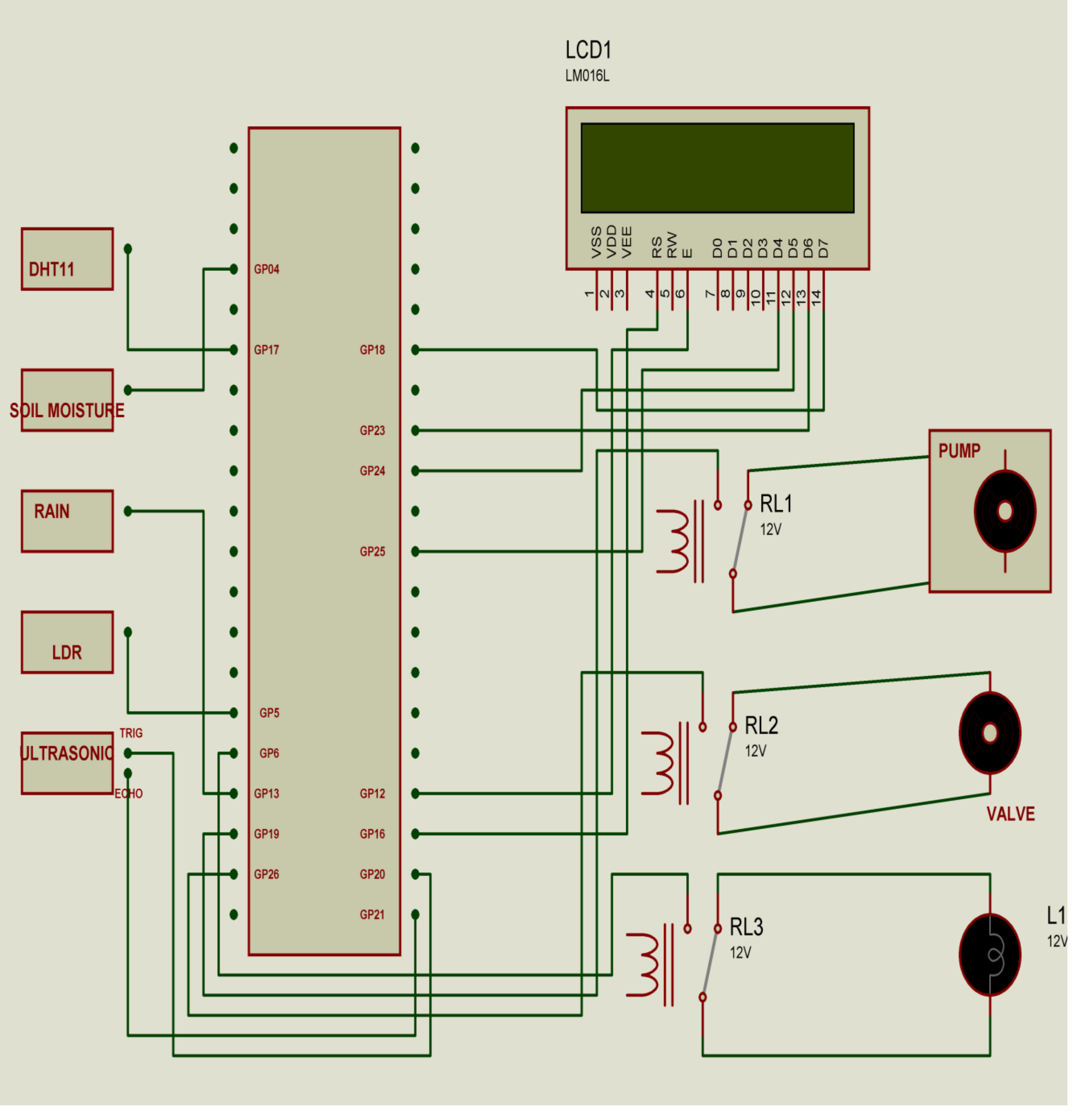

Figure 3.1 – Circuit Diagram

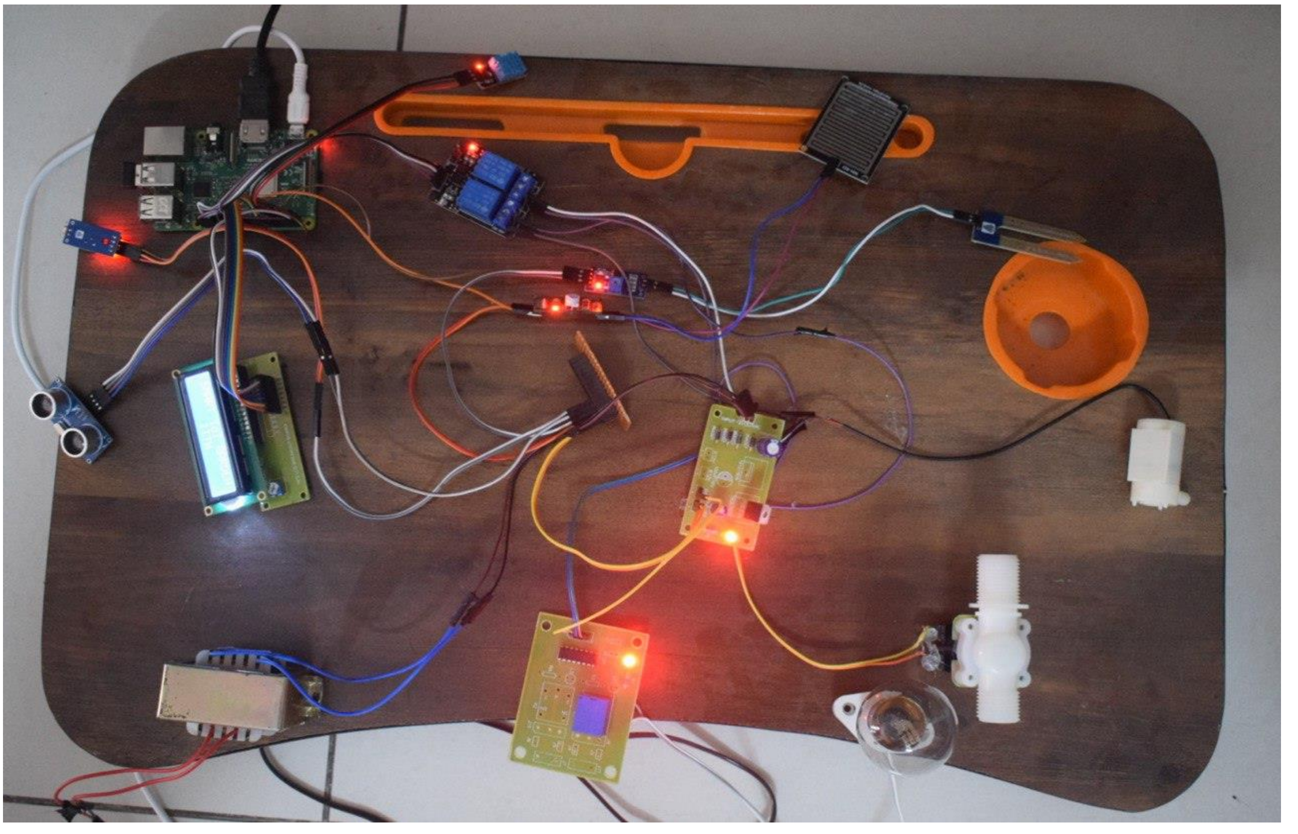

Figure 3.2 – Automatic Irrigation Implementation

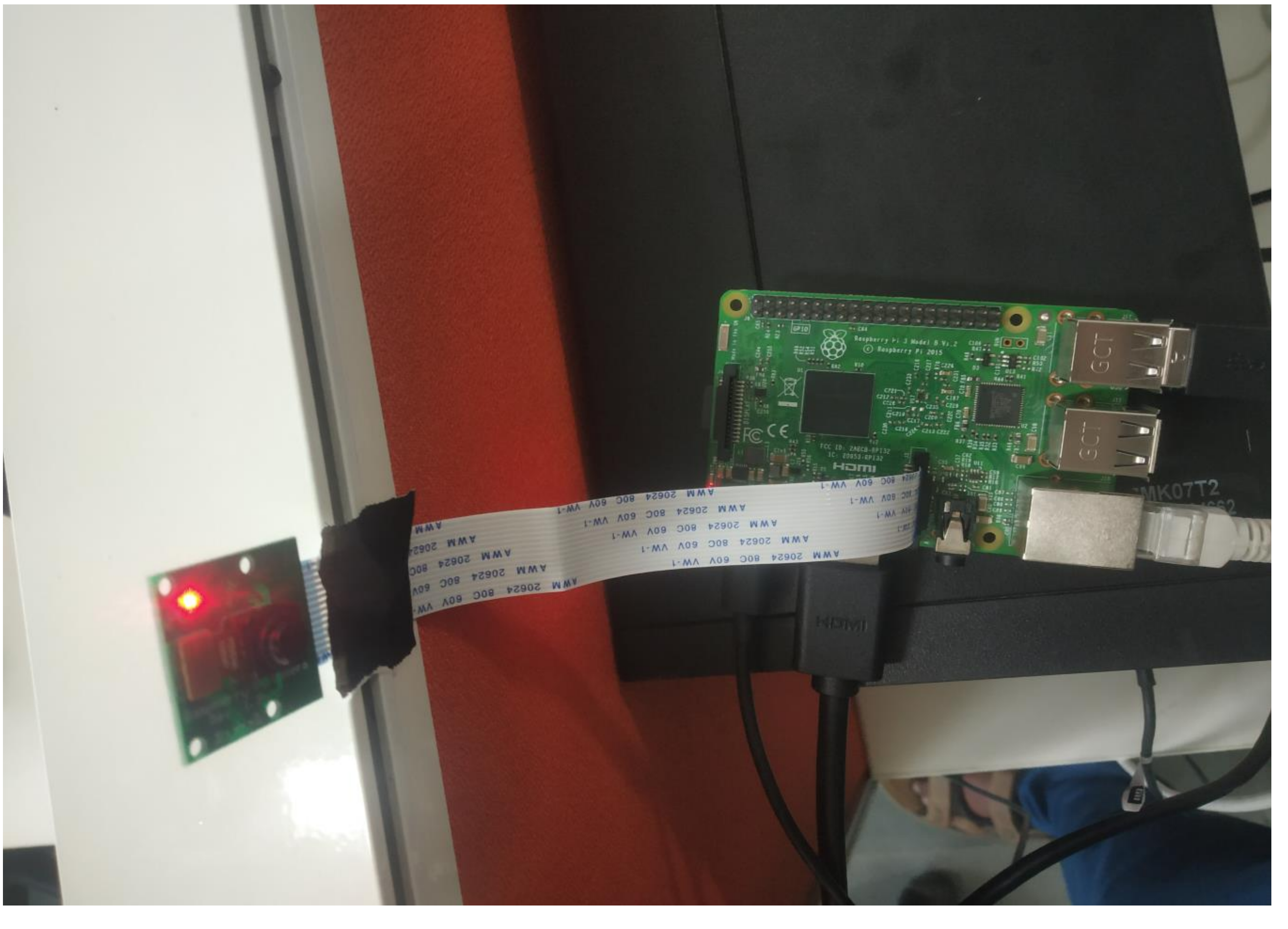

Figure 3.3 – Motion Eye OS

3.2 INTEGRATION OF RPI WITH AWS

Raspberry Pi can be integrated with AWS for enabling publish subscribe architecture using the following steps:-

(a) Create account in AWS.

(b) After signing in, then navigate to the “Services” dropdown and search for “IoT Core”

(c) In the IoT Core console, go to Secure > Policies and click “Create a policy”.

(d) Next, go to Manage > Things and press “Register a Thing”.

(e) On the next page you have the option to add a certificate for your thing.

(f) After you generate certificates, you should download all the created certificates to your Raspberry Pi device.

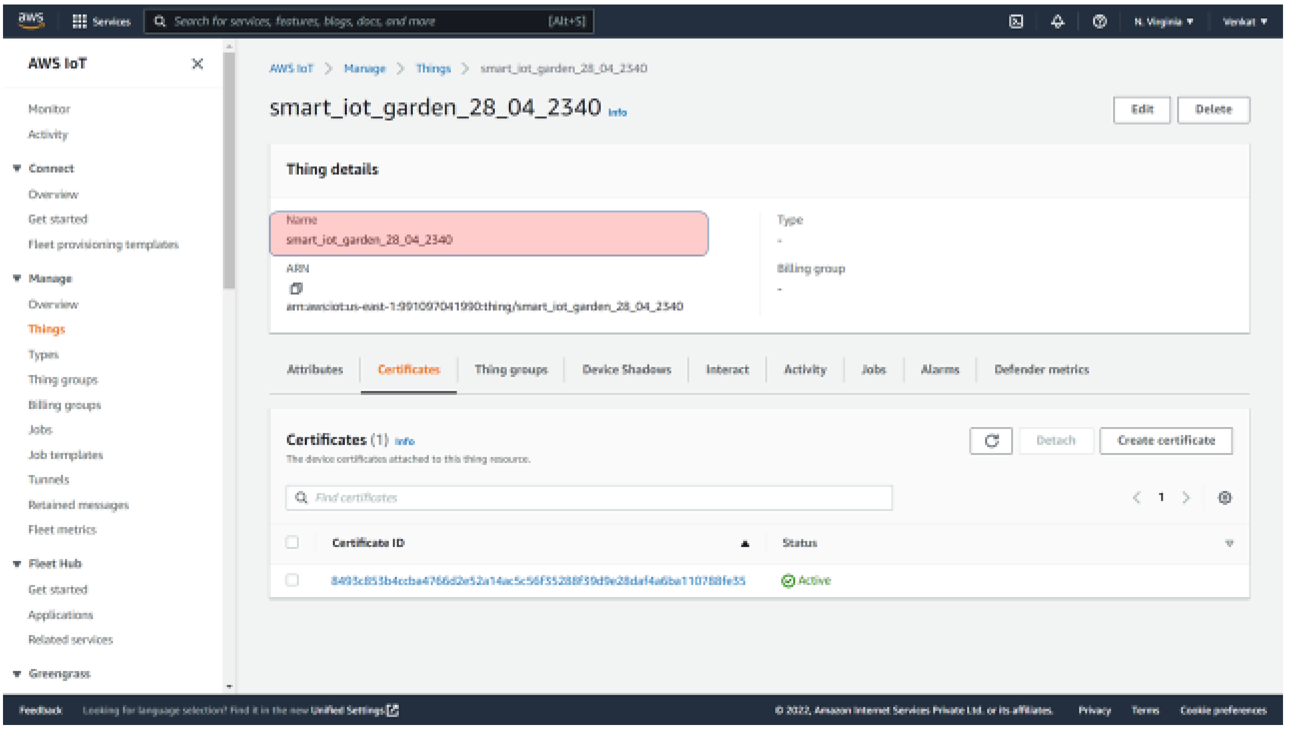

Figure 3.1 – AWS Thing

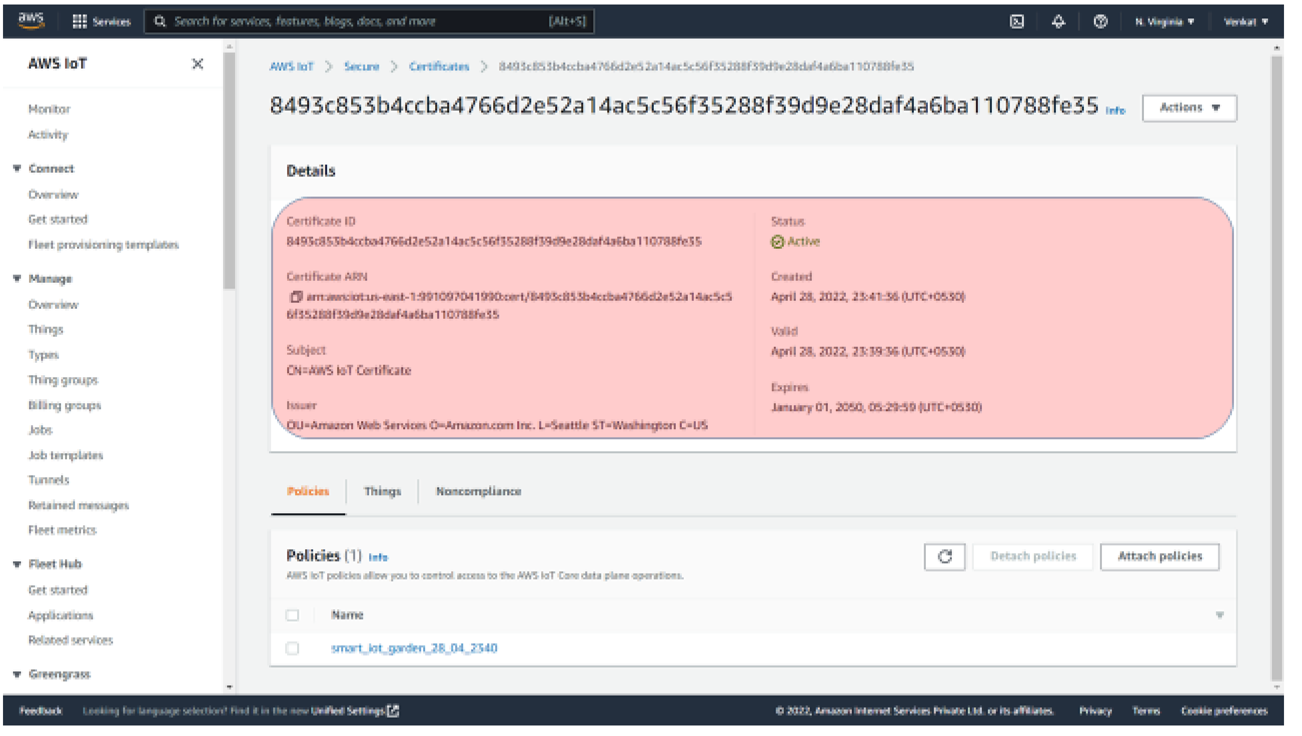

Figure 3.2 – Certificate Details

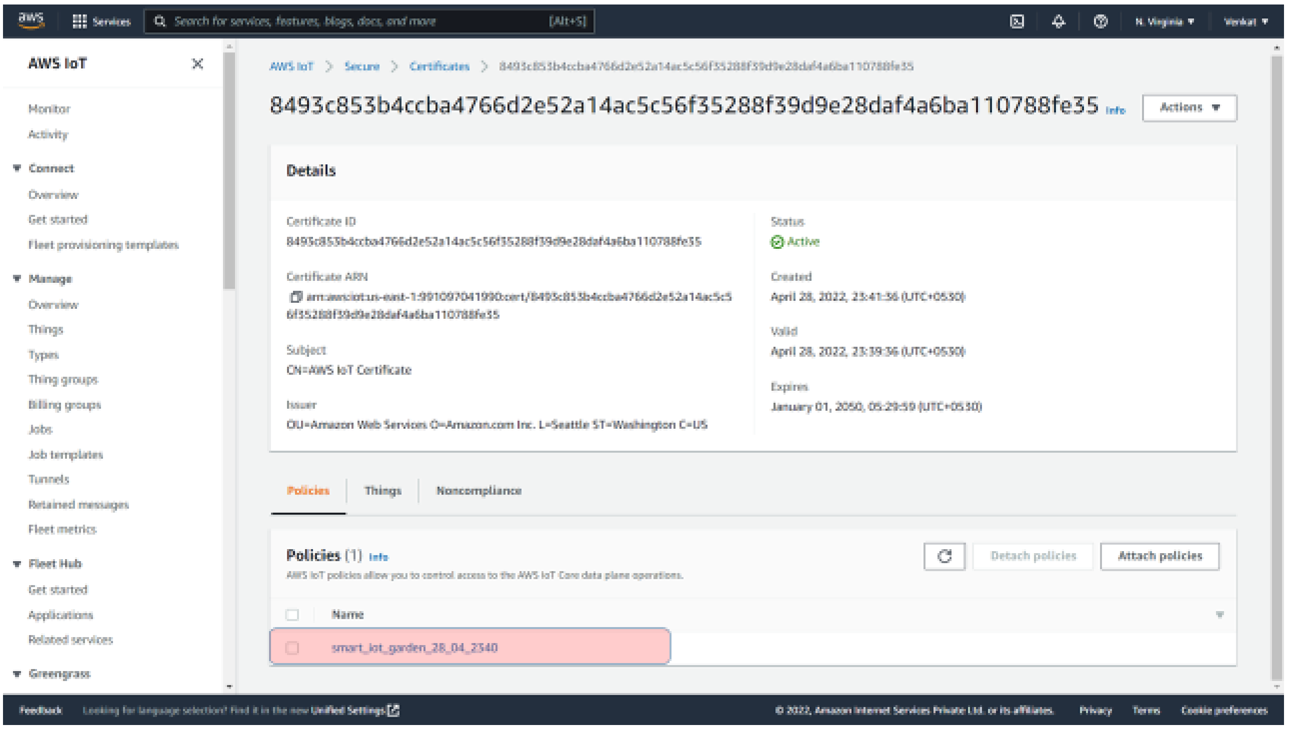

Figure 3.3 – Policy Details

3.3 CONFIGURATION IN MOTION EYE OS

Configuration of camera with motion eye operating software to enable sending mail can be achieved in following ways:-

(a) With your microSD card connected to your computer, open the SD card Formatter application and format your microSD card with the “overwrite format” option.

(b) Next, extract the motion-eye os image from the .zip folder. Then, you can use win32diskimager or Etcher to write the image onto the SD card.

(c) Insert the microSD card in the Raspberry Pi.

(d) Connect a camera. If you’re using the Raspberry Pi camera V2 module, make sure you’ve connected the camera in the right orientation.

(e) Open your browser and type the Raspberry Pi IP address. You’ll see the Motion-Eye login page.

(f) You can configure pretty much everything in your web user interface.

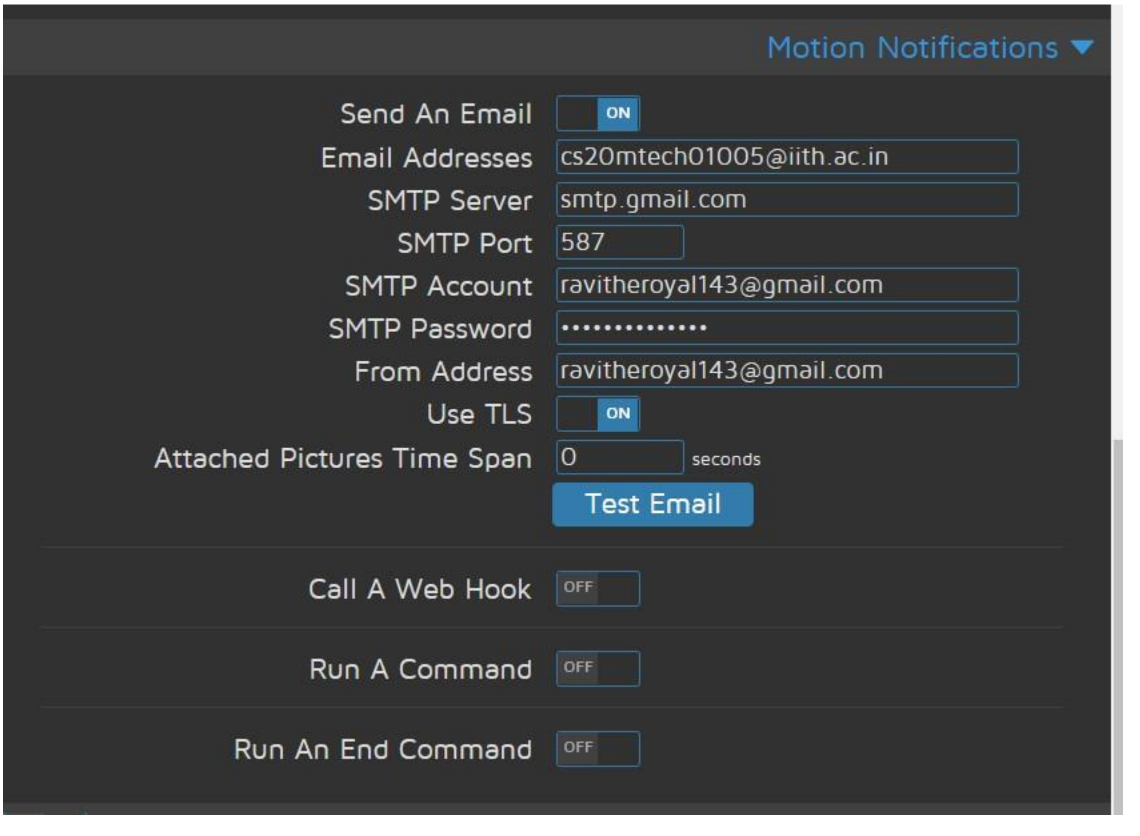

Figure 3.4 – Motion Settings

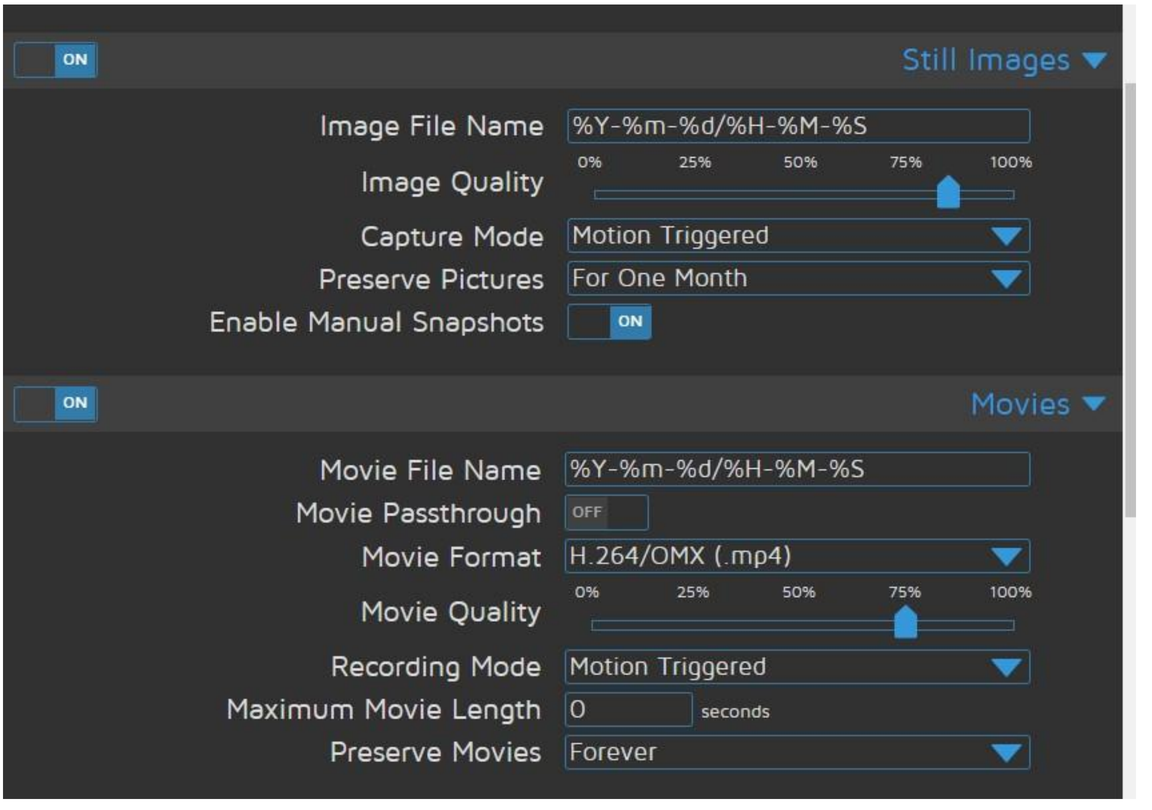

Figure 3.5 – Still Settings

3.4 SOURCE CODE

The code based on various conditions was written in python code and can be found at the **Github** location: https://github.com/kuldeeps1208/SmartIoTGarden.git

CHAPTER 4
TESTING RESULTS

4.1 SOURCE CODE OUTPUT

Upon running the code, messages were displayed on the output window. Some of the results have been captured and shown below detailed results are available at the **Github** mentioned link. https://github.com/kuldeeps1208/SmartIoTGarden.git

Figure 4.1 – Source Code Output

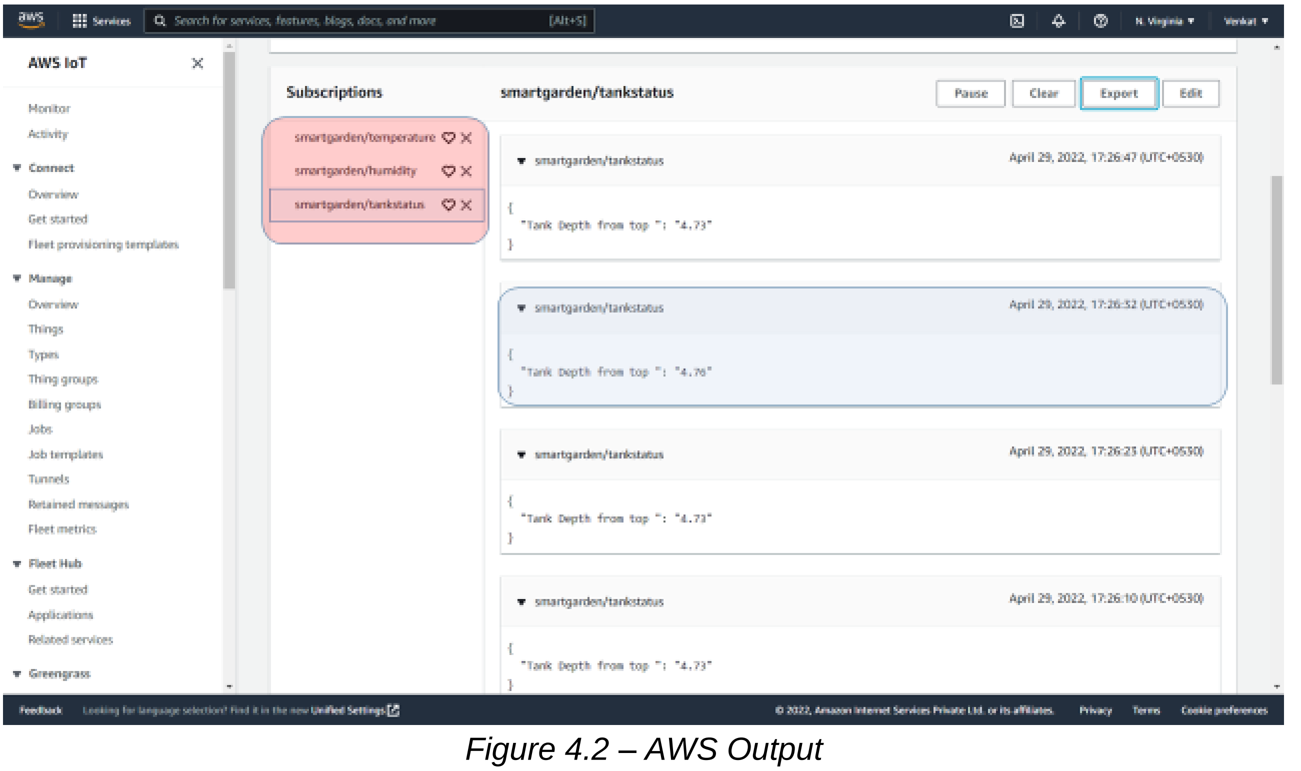

Figure 4.2 – AWS Output

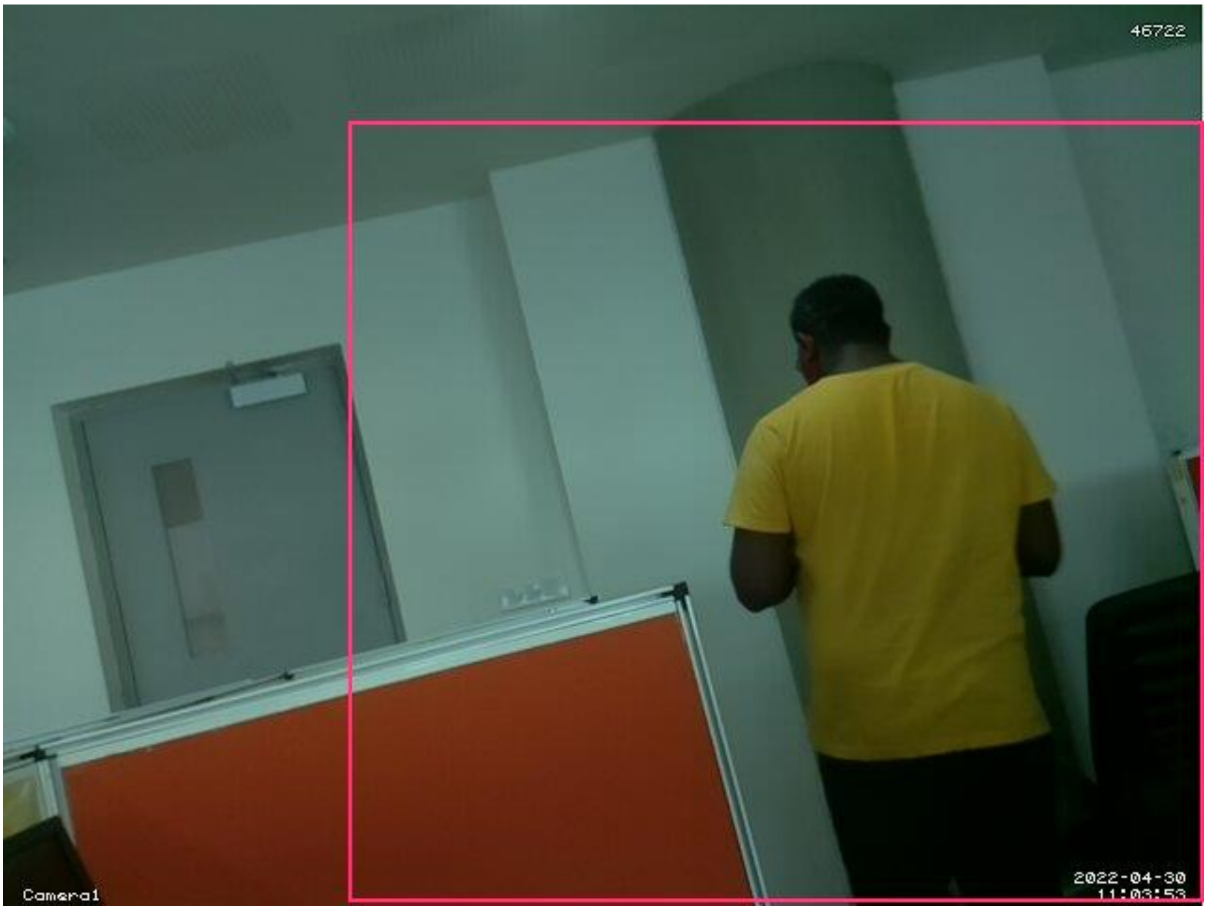

Figure 4.3 – Live Monitoring

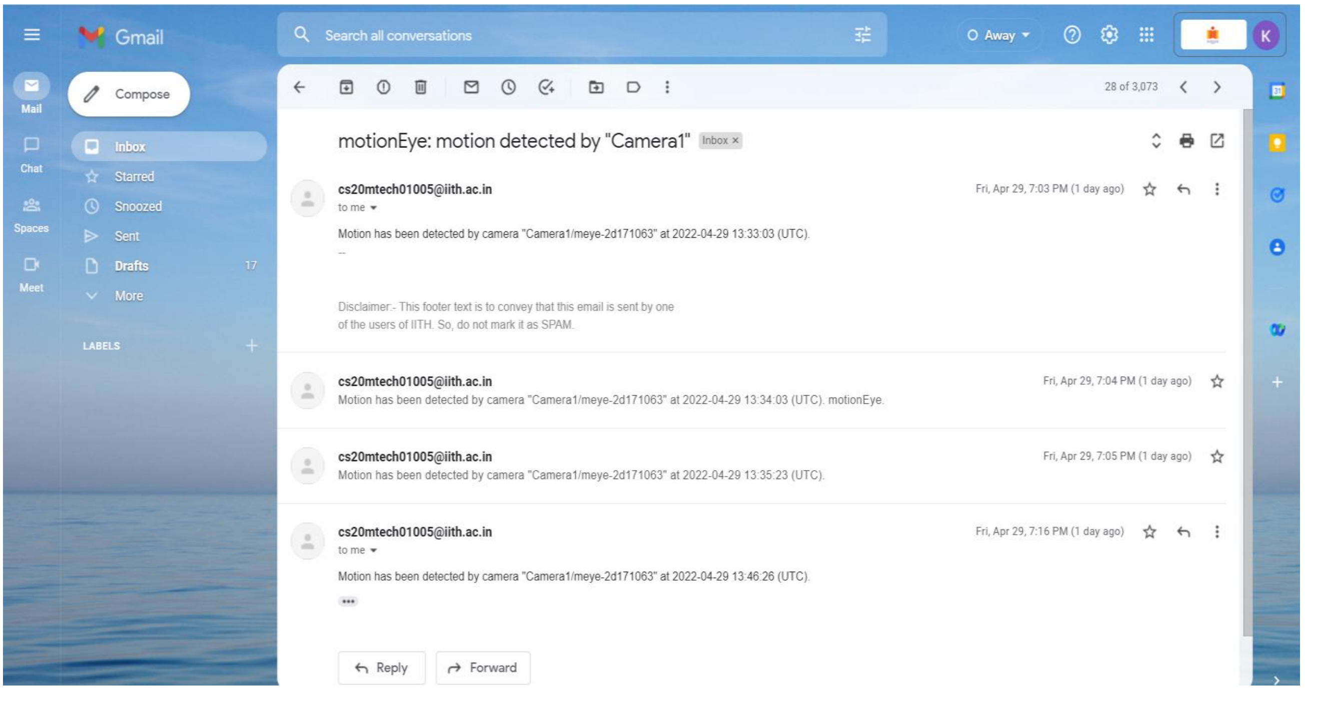

Figure 4.4 – Email Triggered

CHAPTER 5
CONCLUSION

Smart IoT Garden System has been successfully developed with Raspberry Pi by connecting it with light sensor, soil moisture sensor, ultrasonic sensor, rain sensor and a single relay module. All sensors have provided good measurement of parameters when carrying out the experimental cases. Raspberry Pi controls on and off of the relay. The system is feasible and cost effective for optimizing water resources in any small-scale agricultural sectors. By implementing Android interface apps in mobile (*future scope*), a user can manage to control the irrigation system remotely. Additionally, email is also sent to the user to give information about the intrusion. Therefore, the intervention of human is much reduced using this smart garden system.

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