CASA0014

Connected Environment Blog post

In this blog, I will introduce my plant monitor and my opinion on the role of IoT in Connected Environments.

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Brief

In the book of the little prince, the little prince owns a delicate rose. She needs to water it every day, use a screen to block the wind, and use a glass cover to keep away insects. When you have a plant, You become responsible, forever, for what you have tamed.

IoT technology is the network of devices such as vehicles, and home appliances that contain electronics, software, sensors, actuators, and connectivity which allows these things to connect, interact and exchange data. can help users take better care of their plants by obtaining information about the environment where the plants are located (Kevin Ashton, 1999).

In this project, I will present my plant monitor prototype design and how it works. It is based on Arduino and Rpi to get soil data and visualize data. This is my plant, Eve. Eve is a peace lily, and I need to water it when the top inch soil feels dry.

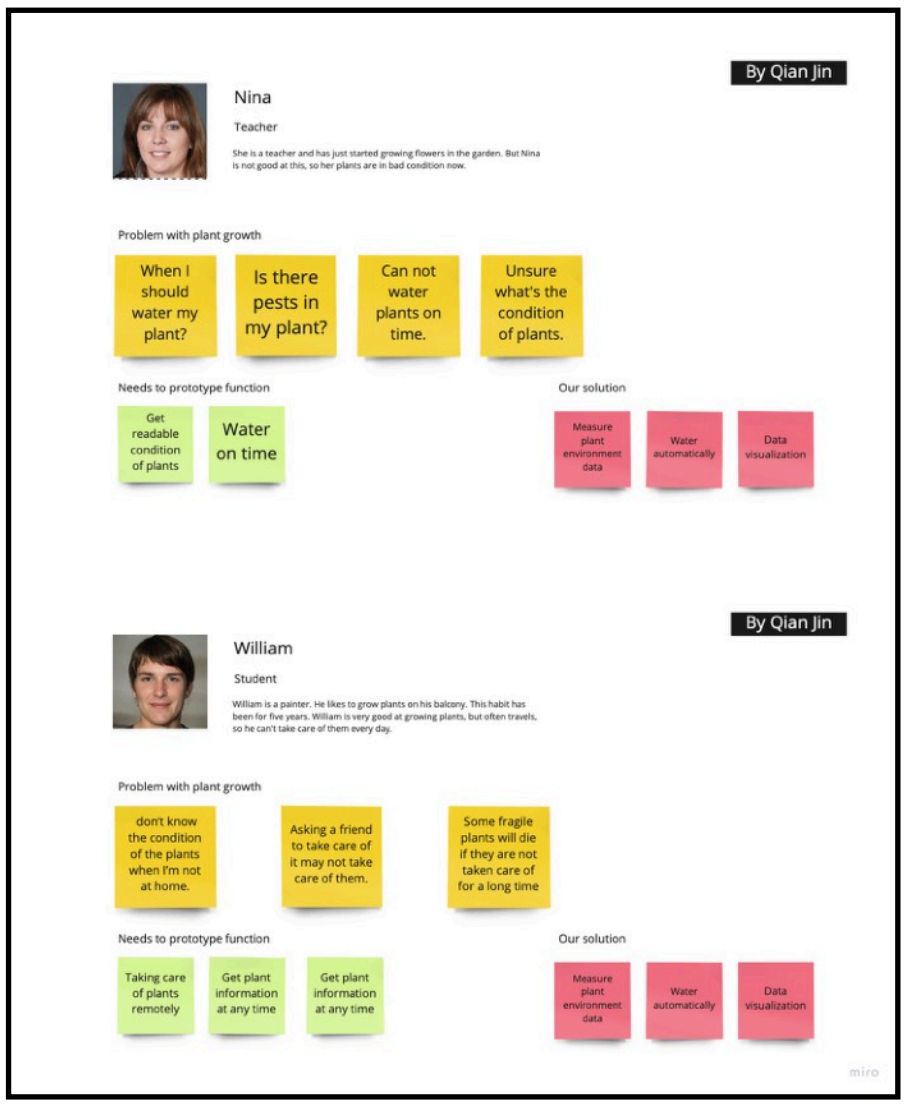
Plant monitoring is just a small application of IoT in the connected environment. IoT can also monitor more environmental data to help us. However, the application of these technologies also faces issues such as data credibility, data security, and sensor quality.

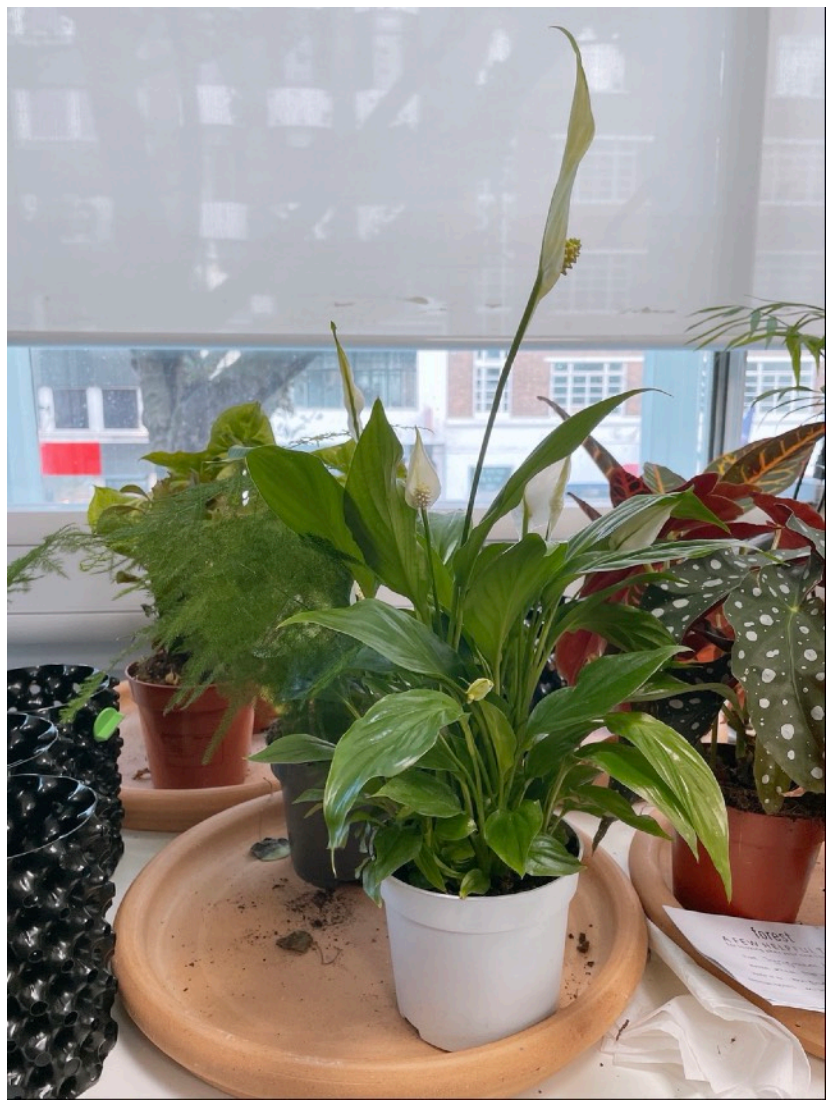
Chapter 1 : User and Goals

In this part, I analysis two users. One of them is a novice and the other is an expert in planting plants. Their characteristics cover most plant growers. This is the problem they face when growing plants and the achievable solution. Beside them, tutors gave me a plant. This is my plant, Eve. Eve is a peace lily, and I need to water it when the top inch soil feels dry.

To solve their problems, the plant monitor sensor design has these goals:

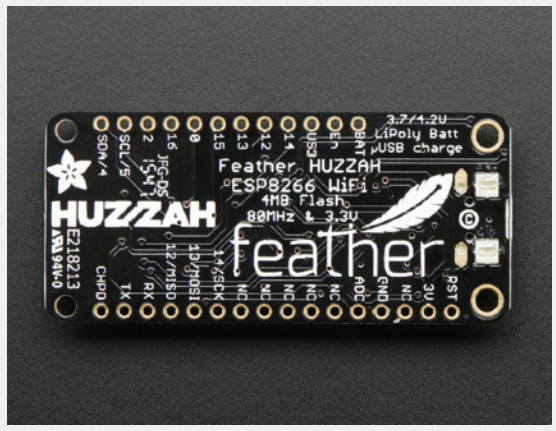
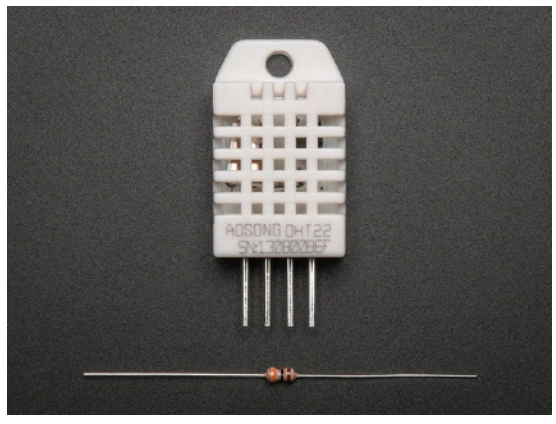
- Monitor the plant data(temperature, humidity, and soil moisture levels)
- Store data on a Rpi gateway
- Visualise collected data
- Water Automatically





Chapter 2 : Hardware and Software

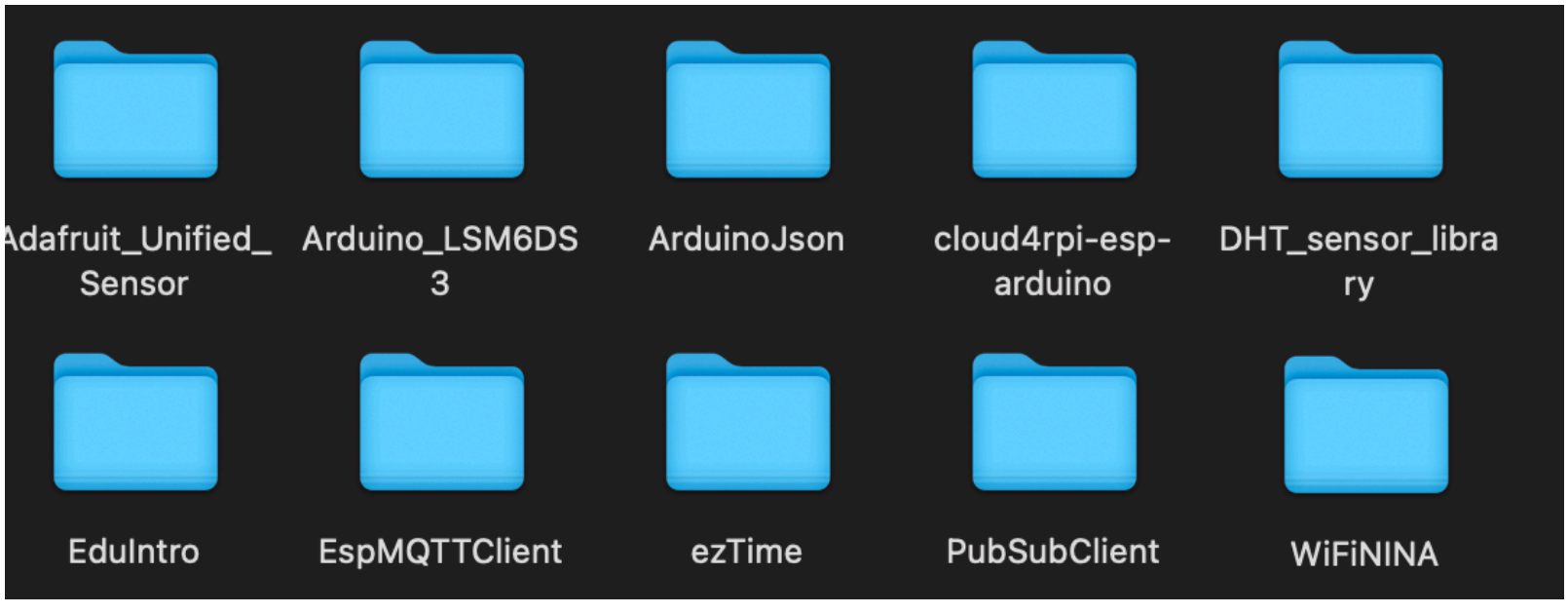
Hardware List

Name	Introduce	Picture
• Huzzah Board with ESP8266 Wifi	• Measures 2.0" x 0.9" x 0.28" (51mm x 23mm x 8mm) without headers soldered in • Light as a (large?) feather - 9.7 grams • ESP8266 @ 80MHz with 3.3V logic/power • 4MB of FLASH (32 MBit) • Built in WiFi 802.11 b/g/n • 3.3V regulator with 500mA peak current output • CP2104 USB-Serial converter onboard with 921600 max baudrate for uploading • Auto-reset support for getting into bootload mode before firmware upload • 9 x GPIO pins - can also be used as I2C and SPI • 1 x analog inputs 1.0V max • Built in 100mA LiPoly charger with charging status indicator LED, can also cut a trace to disable the charger • Pin #0 red LED for general purpose blinking. Pin #2 blue LED for bootloading debug & general purpose blinking	
• DHT22 sensor	• Low cost • 3 to 5V power and I/O • 2.5mA max current use during conversion (while requesting data) • Good for 0-100% humidity readings with 2-5% accuracy • Good for -40 to 80°C temperature readings ±0.5°C accuracy • No more than 0.5 Hz sampling rate (once every 2 seconds) • Body size 27mm x 59mm x 13.5mm (1.05" x 2.32" x 0.53") • 4 pins, 0.1" spacing • Weight (just the DHT22): 2.4g	
• Raspberry Pi	This incredible new Raspberry Pi 4 boasts amazing new features and improvements including: • 1.5GHz 64-bit quad-core CPU • Up to 8GB RAM (select model above) • Dual 4K displays (2x micro-HDMI ports up to 4kp60) • 2.4 GHz and 5.0 GHz IEEE 802.11ac wireless • Bluetooth 5.0, BLE • Gigabit Ethernet • 2x USB 3.0 ports and 2x USB 2.0 ports	
• 2 nails	To test the soil moisture by resistance between two nails.	

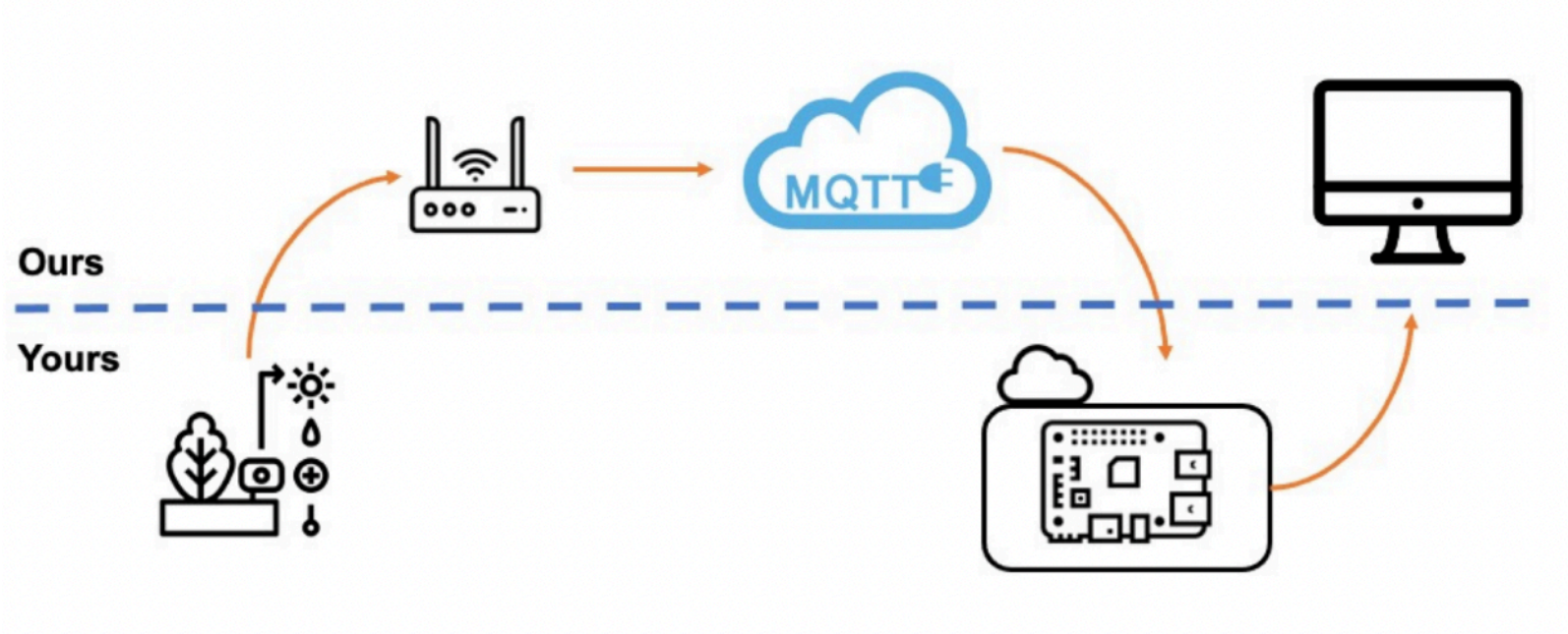
Source:https://thepihut.com/

Software List	
Name	Introduce
• Arduino IDE	The open-source Arduino Software (IDE) makes it easy to write code and upload it to the board. This software can be used with any Arduino board.
• MQTT Explorer	MQTT Explorer is a comprehensive MQTT client that provides a structured overview of your MQTT topics and makes working with devices/services on your broker dead-simple.
• Raspberry Pi Imager	From industries large and small, to the kitchen table tinkerer, to the classroom coder, we make computing accessible and affordable for everybody.
• Grafana	Query, visualize, alert on, and understand your data no matter where it's stored. With Grafana you can create, explore and share all of your data through beautiful, flexible dashboards.

MQTT Library List



Chapter 3 : Process



Source: CASA0014-Connected Environment

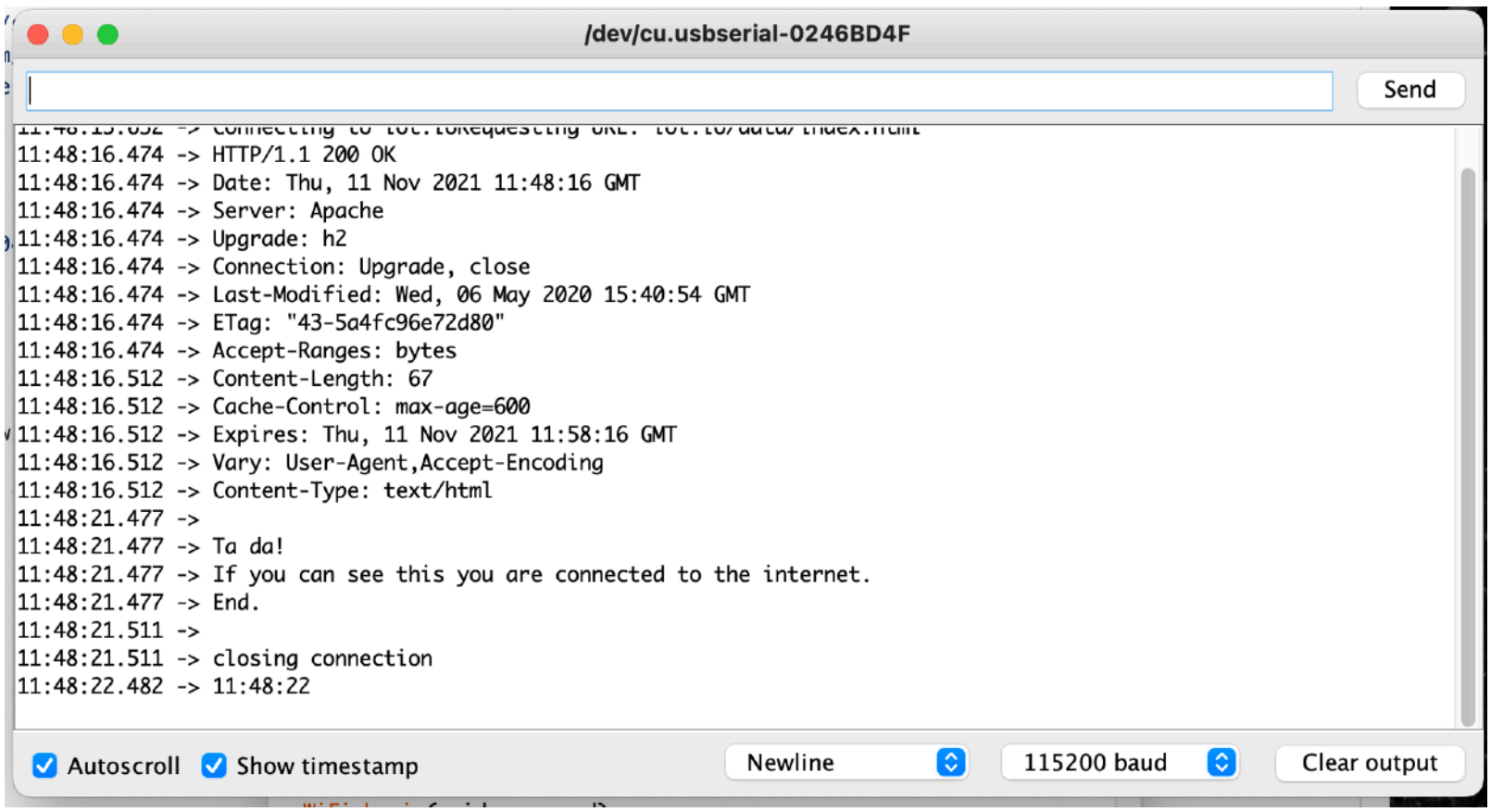
Step1 Connect to Wifi and Get Time

This step makes the Arduino board having wifi function. Copy the script (wifi.ino) as a new Arduino sketch.

The SSID and password need to be modified for the network connection.

```
const char* ssid     = "SSID here";
const char* password = "password here";
const char* host = "iot.io";
```

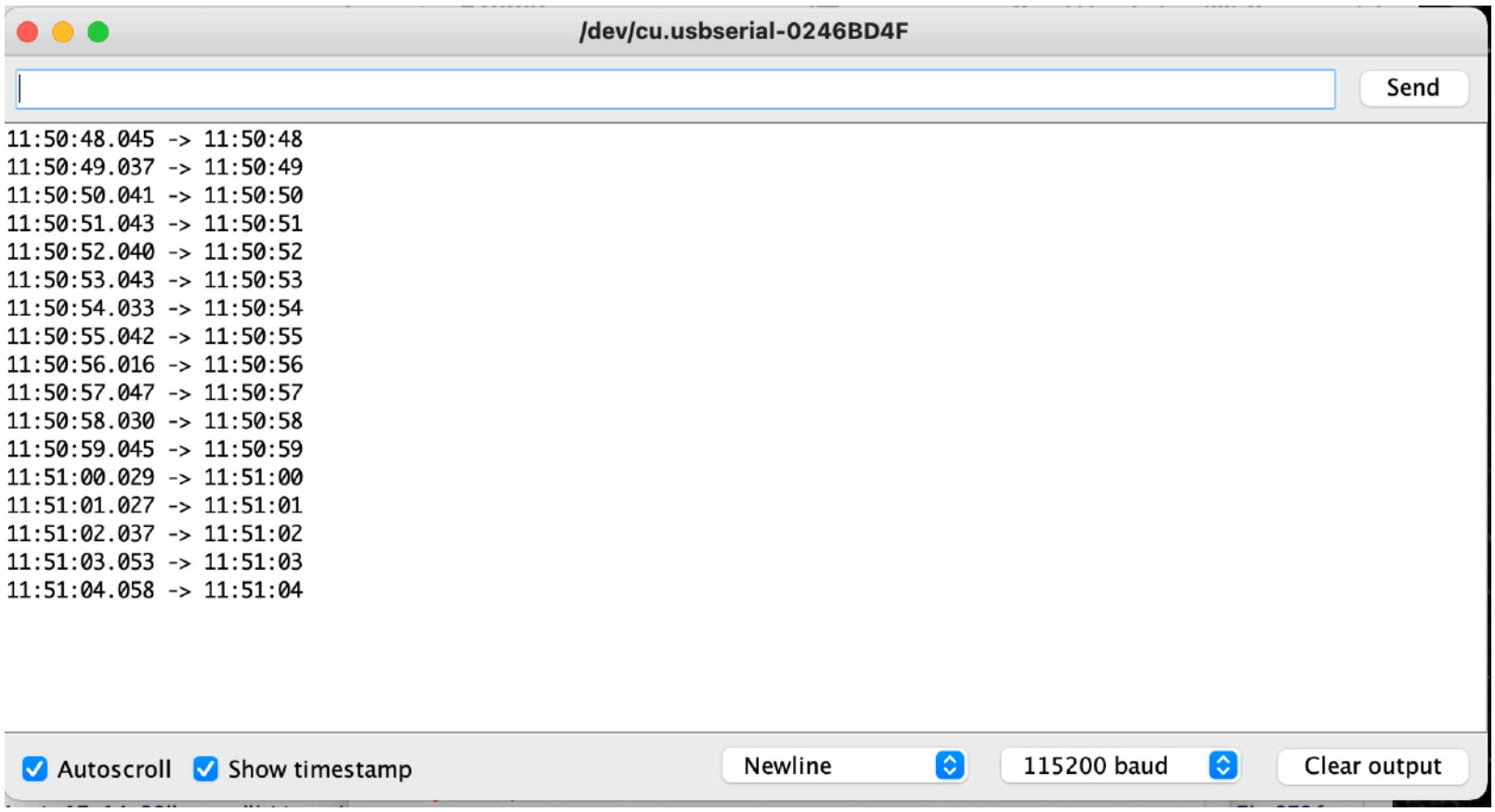
Then upload this script to the board, and it get the wifi signal.



This step uses ezTime library to make the Arduino get to know the time. Copy the script (Getting the time.ino) into the Arduino sketch.

```
const char* ssid     = "ssid here";
const char* password = "your password here";
Timezone GB;
```

Then upload the script to the board. The board could get the London time(timezone:GB).



Step2 Publish Data to an MQTT Sever

1.As did in step 1 and 2, connect to wifi and get the time. If you want to protect your wifi ssid and password. The secrets.h should be used to protect your privacy content.

2.Initialise the builtin LED, and MQTT Explorer can turn on and off the LED.

3.Use function sendmqtt() to view information saved in MQTT Explorer.

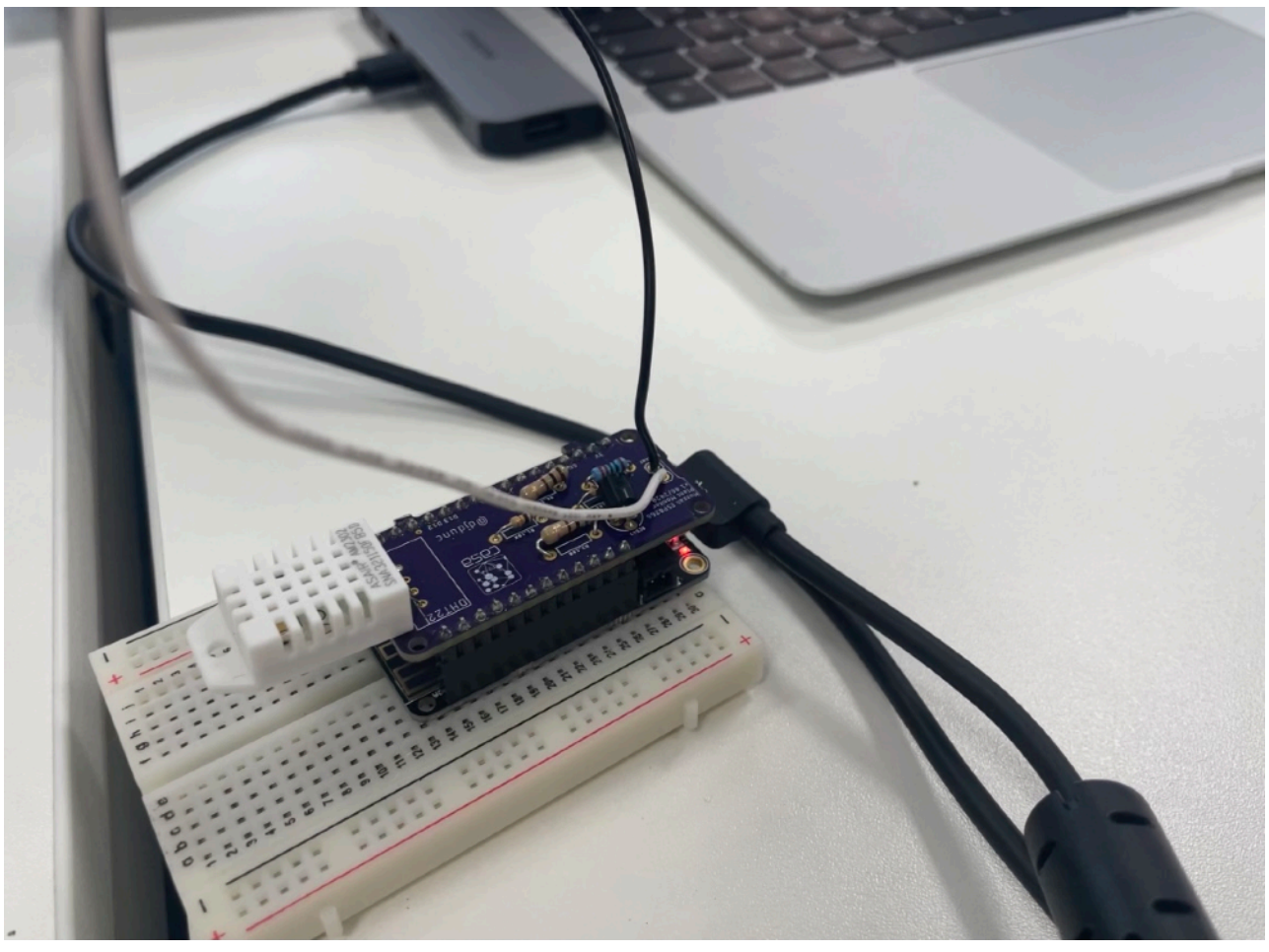
```
void sendMQTT() {

  if (!client.connected()) {
    reconnect();
  }
  client.loop();
  ++value;
  snprintf (msg, 50, "hello world #%ld", value);
  Serial.print("Publish message: ");
  Serial.println(msg);
  client.publish("student/CASA0014/plant/ucjnqji", msg);
}
```

4.Use function reconnect to repeat the loop until the client is connected.

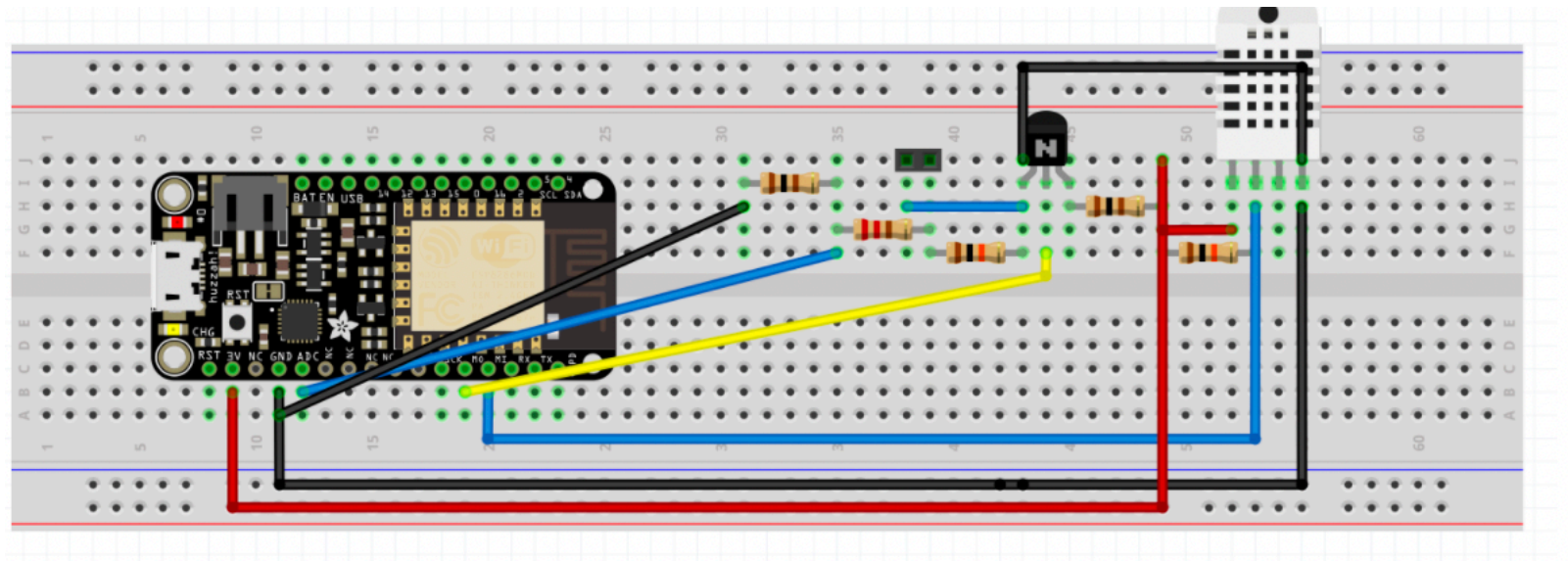
```
void reconnect() {
  // Loop until we're reconnected
  while (!client.connected()) {    // while not (!) connected....
    Serial.print("Attempting MQTT connection...");
    // Create a random client ID
    String clientId = "ESP8266Client-";
    clientId += String(random(0xffff), HEX);

    // Attempt to connect
    if (client.connect(clientId.c_str(), mqttuser, mqttpass)) {
      Serial.println("connected");
      // ... and subscribe to messages on broker
      client.subscribe("student/CASA0014/plant/ucfnqji/inTopic");
    } else {
      Serial.print("failed, rc=");
      Serial.print(client.state());
      Serial.println(" try again in 5 seconds");
      // Wait 5 seconds before retrying
      delay(5000);
    }
  }
}
```

5.Use callback function holds the code to process messages that have been subscribed to by the sketch.

6.Use the MQTT to turn on or out LED. Publish "1" (or “0”)to student/CASA0014/plant/ucfnqji/inTopic.



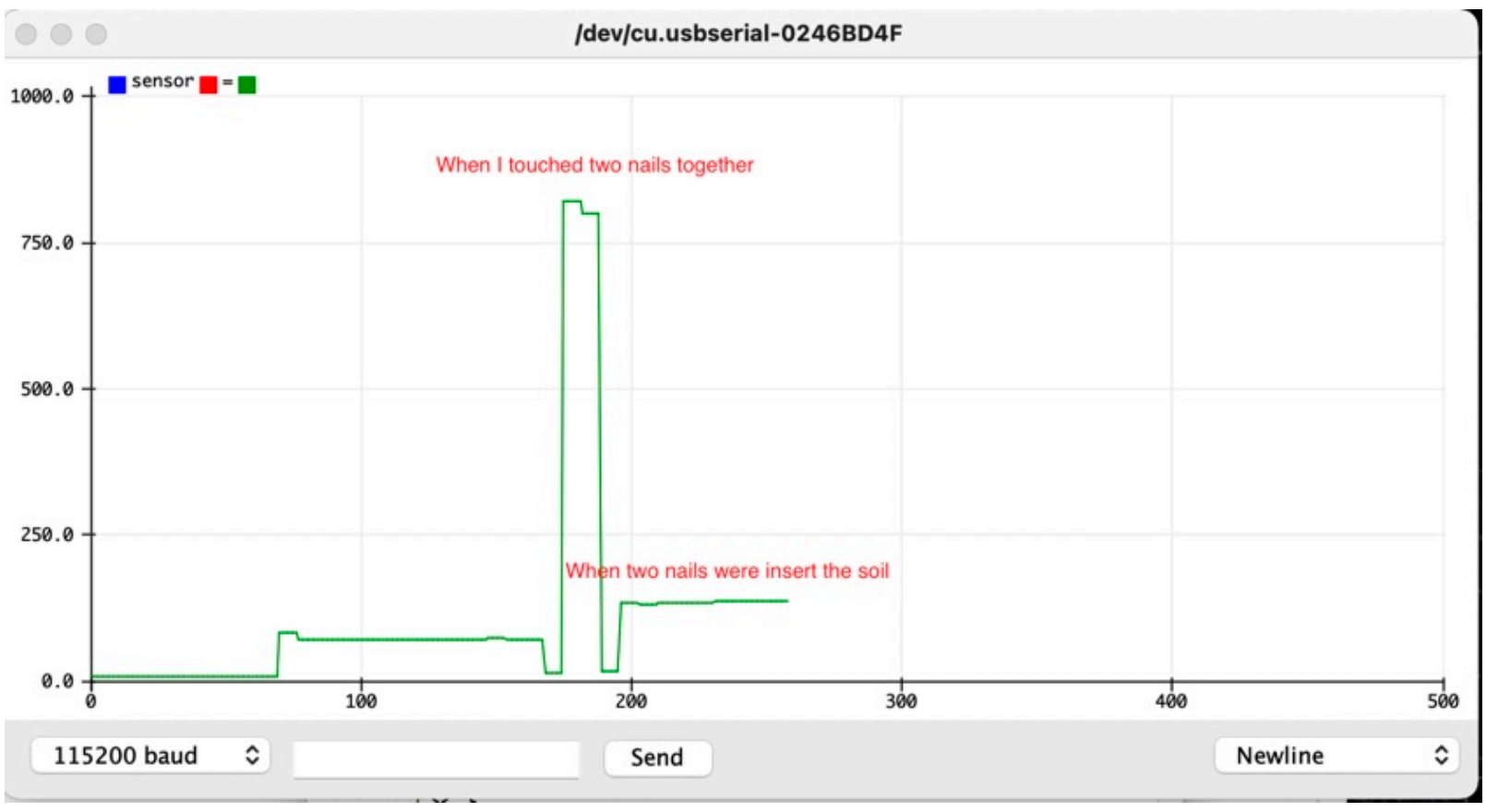
Step3 Monitor soil data and sent to MQTT



Following the fritzing diagram, I connected the DHT22 sensor(temperature / humidity sensor) and two nails(test the soil moisture).

Then I upload and run the testMoisture script(provided by Duncan) and DHT(Arduino>Files>Examples) to test sensors.

Finally, we used a CASA Plant Monitor shield which makes the packaging a little tidier.

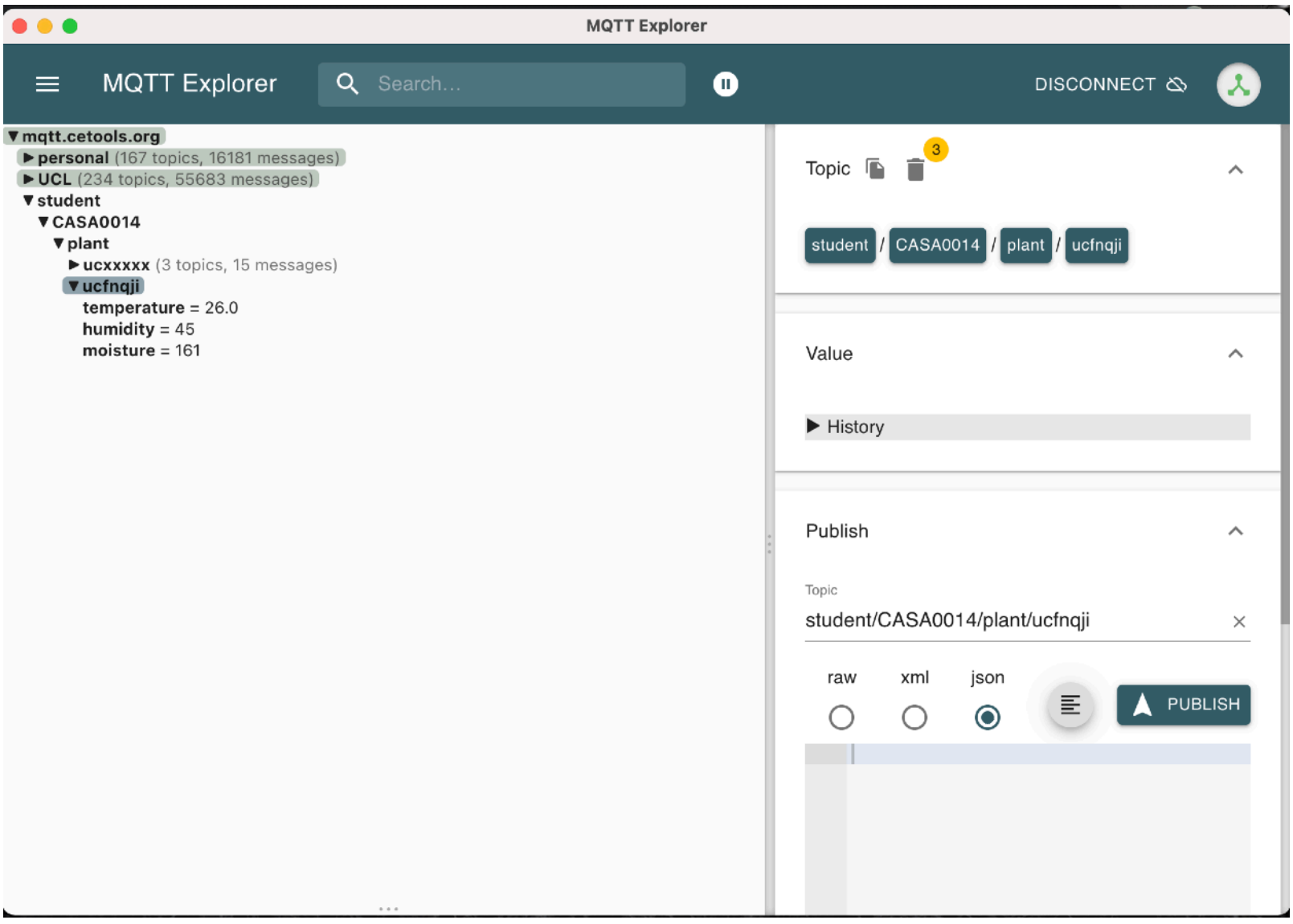


Publish the sensor data to my topic name— "ucfnqji" and get the temperature, humidity and soil moisture information.

In this step, I used the 'sendMQTT' fuction, and 'reconnect' fuction to get the data(like step2).

```
void sendMQTT() {

  if (!client.connected()) {
    reconnect();
  }
  client.loop();

  Temperature = dht.readTemperature(); // Gets the values of the temperature
  snprintf (msg, 50, "%.1f", Temperature);
  Serial.print("Publish message for t: ");
  Serial.println(msg);
  client.publish("student/CASA0014/plant/ucfnqji/temperature", msg);

  Humidity = dht.readHumidity(); // Gets the values of the humidity
  snprintf (msg, 50, "%.0f", Humidity);
  Serial.print("Publish message for h: ");
  Serial.println(msg);
  client.publish("student/CASA0014/plant/ucfnqji/humidity", msg);

  //Moisture = analogRead(soilPin);   // moisture read by readMoisture function
  snprintf (msg, 50, "%.0i", Moisture);
  Serial.print("Publish message for m: ");
  Serial.println(msg);
  client.publish("student/CASA0014/plant/ucfnqji/moisture", msg);

}
```

Now, the plant environment data is showed in MQTT. It means I can get plants' condition remotely.

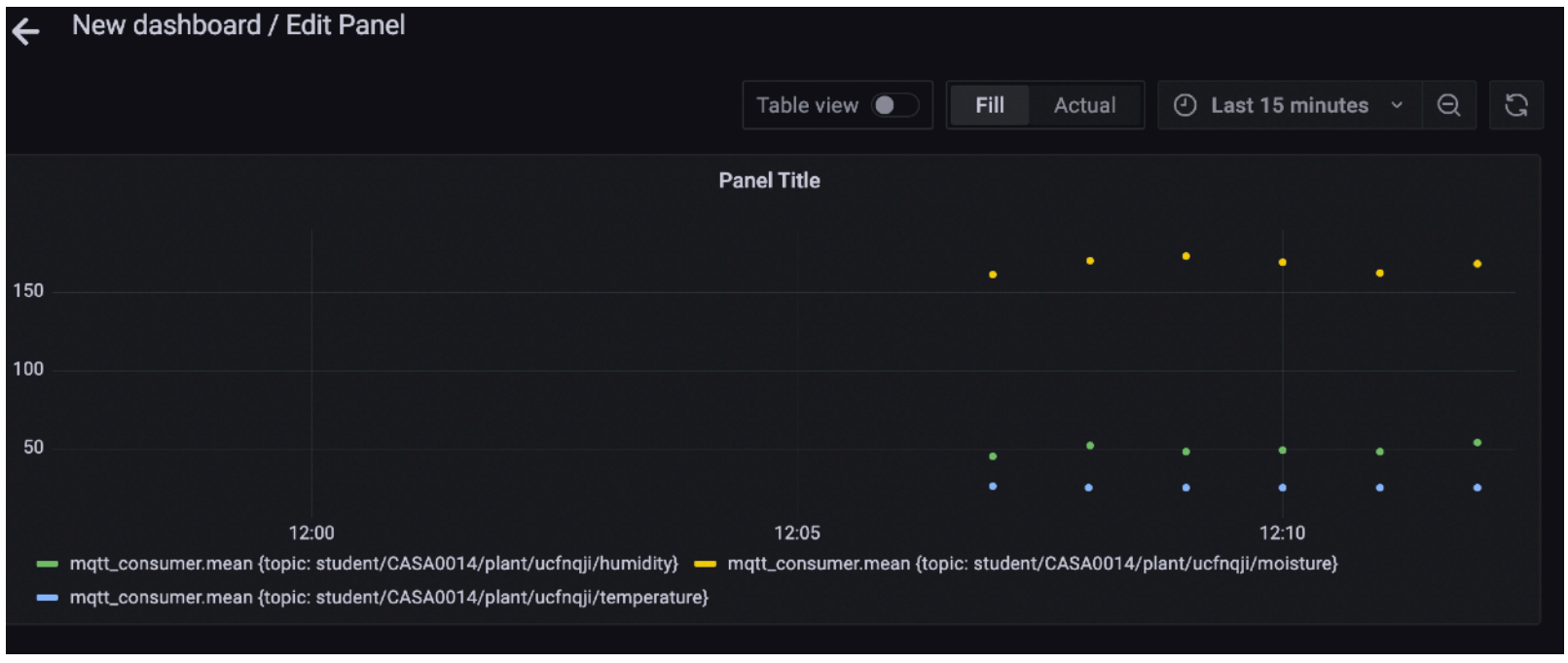


Step4 Store data by Raspberry Pi and Visualise Data

1. Assemble Paspberry Pi box.
2. Install Raspberry Pi software and login.
3. Change the device hostname.
4. Repeat for hosts file.
5. Quick update / upgrade
6. Installing InfluxDB on RPi

7. Based on the Grafana, I got the beautiful chart shows the Eve's environmental information.

Now, I can know whether Eve is healthy and take care her better.



Chapter 4 : Improvement

Commercial plant Monitor Analysis

Smart Garden 9

Benefits

- Automatic watering
- Perfect amount of light thanks to pro-grow lights
- Perfect amount of nutrients and oxygen at root level
- Grow 365 days a year
- Companion app to become a plant expert

Submitted by Qian Jin(Ashley)

YurDoca Soil Meter

Step 1	Step 2	Step 3
Insert the probe into the soil about 2-4 inches	Swich to PH/ Light/ Moisture position according to demand	Check the PH/ Light/ Moisture of the dial after 10 minutes

- Measure soil moisture
- Measure PH Value
- Measure sunlight intensity

Submitted by Qian Jin(Ashley)

BalenaPlant

- This is a Raspberry Pi balenaCloud starter project to measure temperature, humidity, and soil moisture levels
- Automate the watering of plants
- Software:balenaCloud, balenaEtcher,balenaCLI
- Hardware:Raspberry Pi ZeroWH/3B/4,A 32GB+ SD card,Pimoroni Automation HAT, DHT22 temperature and humidity sensor,Capacitive soil moisture sensor,Float switch,5V peristaltic pump

Submitted by Qian Jin(Ashley)

Shortage of this prototype

1. The final result is showed on the website. But I want to know Eve's condition whenever and wherever, so a mobile phone page is more user-friendly.
2. We use two nails to monitor the soil moisture. But it is not accurate and reliable.
3. We just monitor and visualise the plant environment data instead of taking advantage of data to come true some functions to grow plants better.

Improvement of this prototype

1. Develop an app to show Eve's environmental information.
2. Use the specific sensor to detect the soil moisture. Just like this

Description

Traditional soil moisture sensors are prone to corrosion with a limited lifespan regardless of measures taken.

This capacitive soil moisture sensor features no exposed plating and uses capacitive sensing to detect soil moisture. The result is a much more robust sensor without the usual corrosion worries!

The sensor has a built-in voltage regulator that supports 3.3V, meaning it can work with a 3.3V development board as well as 5V. To use this with the Raspberry Pi, an ADC (analogue to digital convertor) will need to be used (such as an ADC HAT) to convert the analogue signal from the sensor.

- Sensor type: Analogue
- Operating voltage: 3.3 VDC
- Output voltage: 0-3.0 VDC
- Interface: PH2.54 3-pin
- Size: 98 x 23mm

Source:https://thepihut.com/

3. Design a beautiful house for Eve and her friends.(Use 3dmax to build the model and 3D print technology to make it).

4. Achieve the watering automatically based on the soil moisture. When the soil moisture is lower than a value.

5. Visualising data by browser still need computer or other devices, using a screen to display soil environment data is better.

Chapter 5 : Extra Work

As analysing three mature cases(Chapter 5), I added some extra function to my plant monitor prototype.

Soil moisture sensor

Because measure the soil moisture by two nails is not accurate, I use the soil moisture sensor to replace them.

Water automatically based on soil moisture

Water automatically is a user-friendly function to people who do not know when they should water plants and who do not have free time to take care their plants. When the soil moisture is lower than 50% (Baleni, 2020).

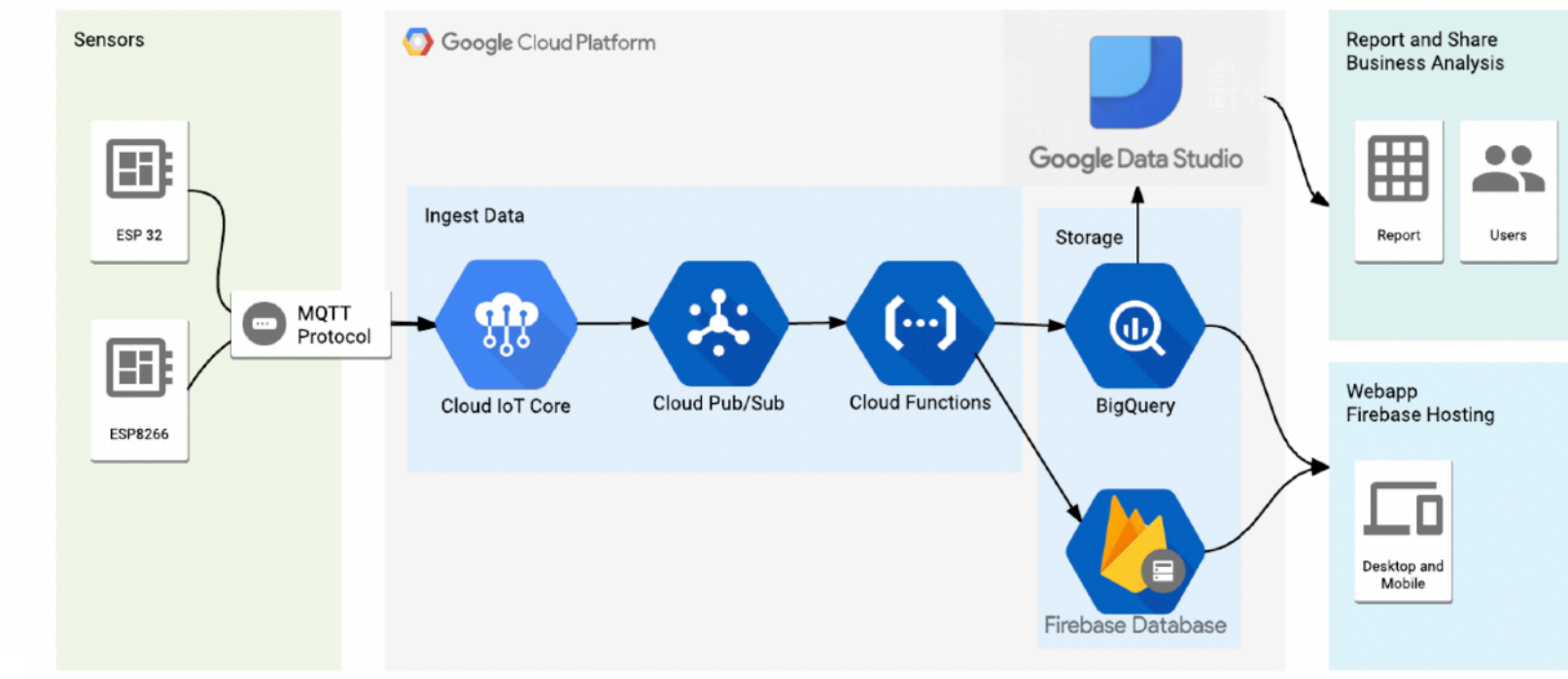
Visualise data by screen sensor

From our Arduino kit package, I find a screen sensor, and it could be used to display the sensor measured by other sensors. So, I can know Eve' condition when I shut down my computer.

Chapter 6 : Storyboard

The storyboard illustrates how a user who is not good at caring for plants uses this smart devices to help plants grow.

Chapter 7 : IoT and Connected Environments



Source:https://medium.com/google-cloud/build-a-weather-station-using-google-cloud-iot-core-and-mongooseos-7a78b69822c5

IoT technology get data from sensors , ingest data by IoT core, visualise data in desktop and mobile. Then the result of learnings pass through gateway device to sensors and make helpful changes to our environment.

However, most useful thing is expensive. The cost of cloud computing is not cheap.

	AWS	Google	Azure
Small compute (per hour)	$0.07	$0.04	$0.06
Storage (HDD / SSD) (GB per month)	$0.03 / $0.10	$0.04 / $0.17	$0.05 / $0.10
Data Ingress (In) (per GB)	Free	Free	Free
Data Egress (Out) (per GB)	$0.09	$0.085	$0.087
One User Transfers 10TB of Data to local drive	$900	$1,200	$870

Source:CASA0014-09, Duncan

Use cloud computing to get data back and analysis it is a big cost, it means some people who do not have enough budget can not make use of it.

Chapter 8 : Risks of IoT

When I turned on my light in the board, I find I can publish topic to a classmate's board in MQTT. It means I can control others' devices without password. What a dangerous phenomenon this is!

Then I checked the information about IoT security. Found that many IoT devices have been hacked. There are mainly the following forms:

Encryption of information transmission

Many IoT devices do not encrypt messages when sending messages over the network.

The best practice to ensure secure communication is to use transport encryption and use standards such as TLS. Isolating devices by using different networks also helps to create secure private communications, so that the transmitted data remains safe and confidential.

Use default password

Most Internet devices use a unified default password when they are put into use. The product manufacturer did not prompt the user to change the password. Therefore, these devices that use the default password are easily hacked.

My god, the wifi password in my house is still the default password, and it is printed on the router.

Remote access

The document released by WikiLeaks mentions that the Central Intelligence Agency (CIA) has been hacking IoT devices and turning on the camera/microphone without the owner's knowledge. Attackers may enter your device and steal all kinds of information without the user's knowledge.

References

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4. https://www.influxdata.com/

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