Project Report – Soil Moisture Detection System

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Abstract: This is the final report of CS244P project. In this project, a soil moisture detection system is implemented with Sparkfun ESP8266 board and soil moisture sensor as the key components. This system reads moisture data revealing the dryness of soil, and upload to cloud for easy and remote access. In addition, this system also reports 5-day weather forecast data. This system helps the user decide the best time of watering, and prevents the plants from being harmed by the potential weather changes such as frost or high temperature.

Introduction

Due to the intense daily schedule, it is common experience that the plants are left unattended. Lack of watering harms the plants, which is worsen by large amount of watering followed as compensation. Furthermore, owners may decide to water the plants based on empirical evidence (e.g. observe the soil for its dryness), which does not always give the best timing. All these problems call for precise and easy-to-access observation systems that can monitor the soil dryness quantitatively, and the rapid development of Internet of Things (IoT) may provide a solution.

IoT is the network of things, with device identification, embedded intelligence, and sensing and acting capabilities, connecting people and things over the Internet. Based on the problem requirement and function of IoT components, we determine the two aims of project: (1) detect soil moisture level and send data to readable terminals; (2) establish connection between detection system and cloud server so that the data can be accessed remotely by owners away from home. Summarization of system structure is given in Figure 1, and the procedures of implementation are described in the following sessions.

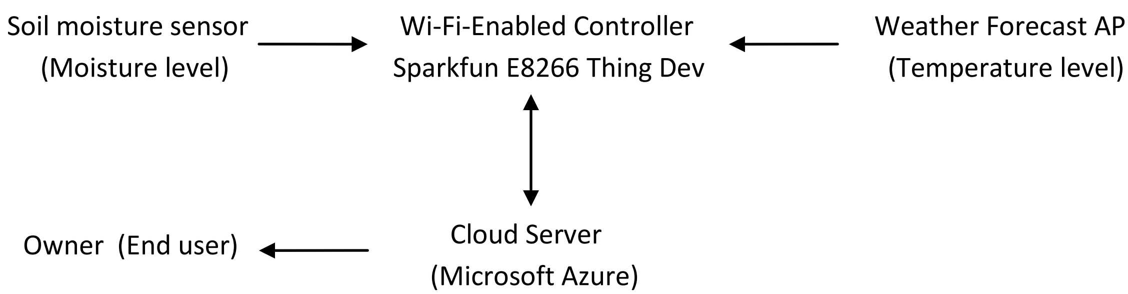


Figure 1 Structure of Soil Moisture Detection System

Materials

The two aims of project mentioned above require different IoT components. Measurement of soil moisture is executed by Sparkfun soil moisture sensor (SEN-13322, Figure 2A), which detects the soil moisture level and outputs it in absolute value between 0 to 1024, where 0 stands for driest condition. To establish cloud connection, Sparkfun ESP8266 Thing-Dev Board (WRL-13711, Figure 2B) is hereby used. As a very capable microcontroller, it can be programmed to monitor sensors connected and receive their output, then send the data to Internet via Wi-Fi.

A B

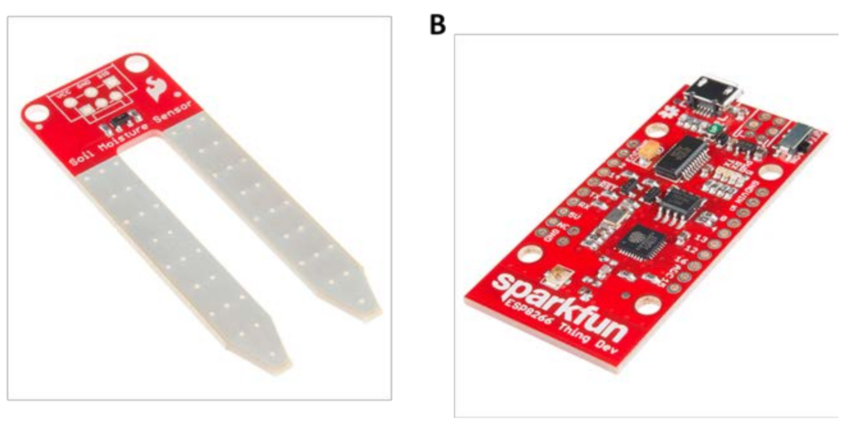


Figure 2 IoT components used in the project. Panel A: Sparkfun soil moisture sensor SEN-13322. Panel B: Sparkfun Thing-Dev Board ESP8266

For software, the ESP8266 board is programmed by Arduino 1.8.7. Connection to Microsoft Azure IoT Hub is established so that the data can be visualized in real-time using Azure app service and also the user can be notified for any critical situation.

Result

Soil Moisture Detection

The system is set up as Figure 3 shows.

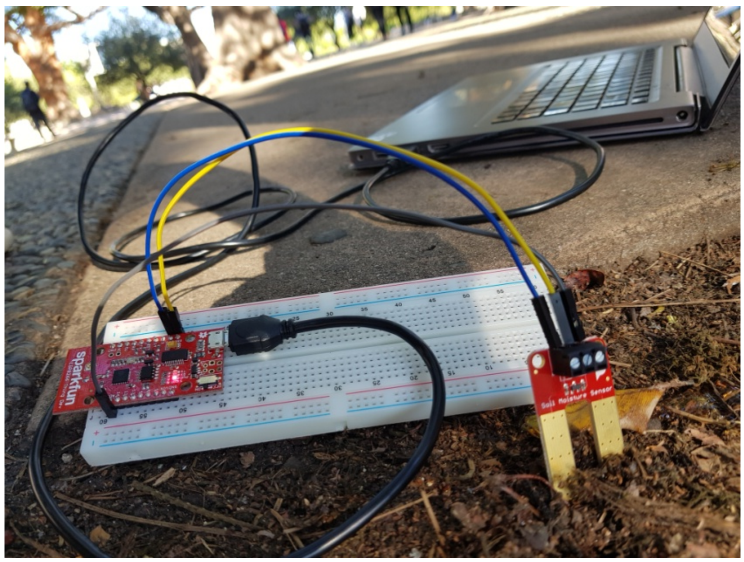


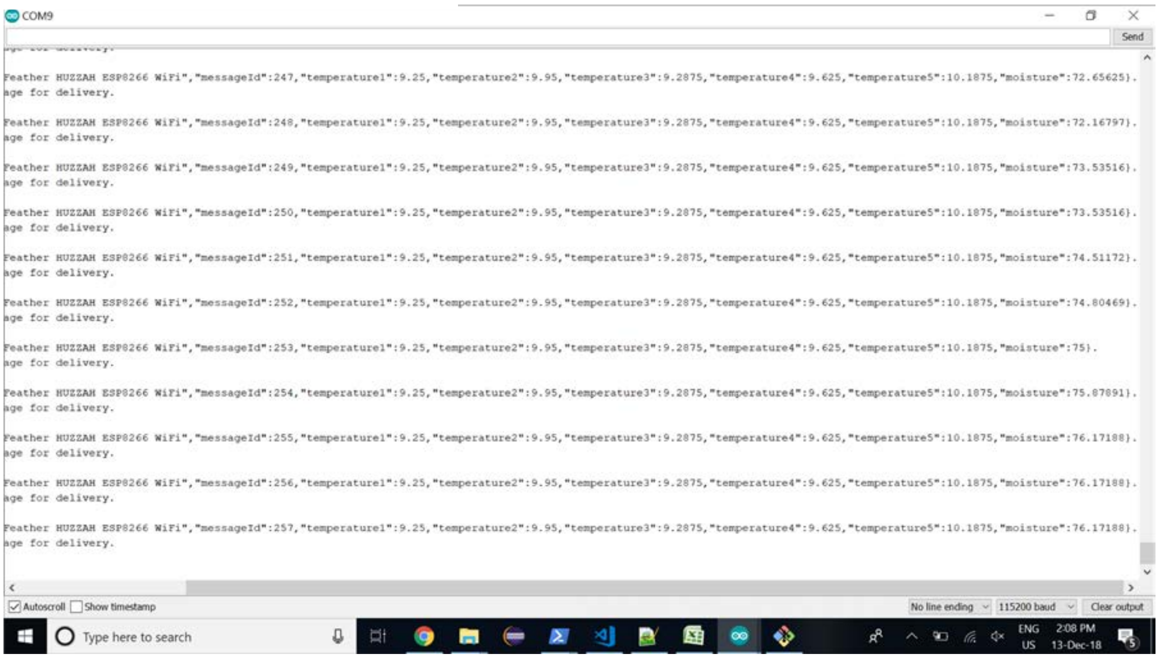
Figure 3 Soil Moisture Detection

On the side of plant, the moisture sensor continuously read the level of soil moisture in the frequency of 5 seconds, and the values in absolute values are converted by the program written into ESP8266 to percentage of saturation after division by 1024. Figure 4B describes the time curve of soil moisture increase after watering.

Cloud Server

The visualization in Figure 4B is implemented by Azure application service from original serial port output (Figure 4A). With the registration of ESP8266 device at server using connection key provided by our IoT hub, the local system is successfully connected with a remote server (Figure 5). Therefore, owners can monitor the fluctuation of soil moisture remotely by visiting the server.

A



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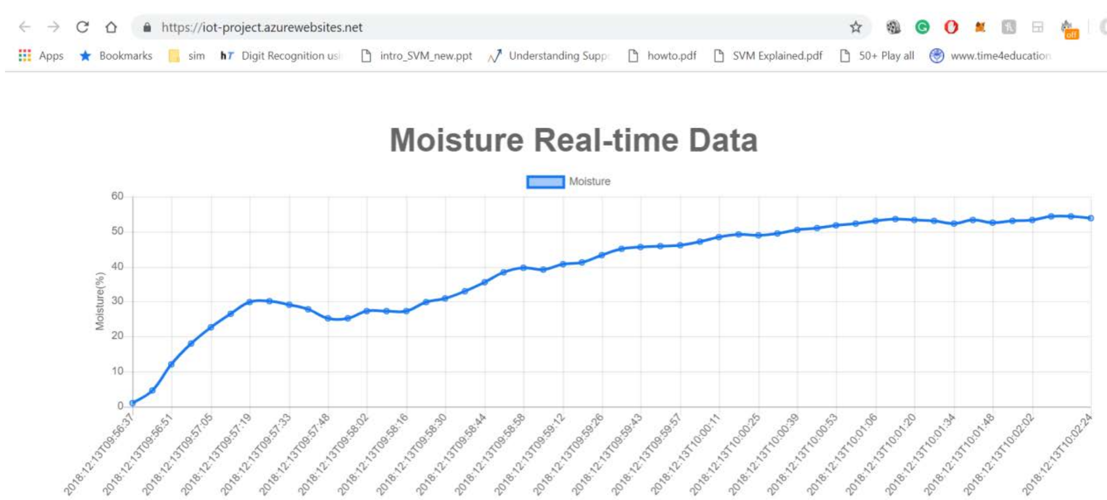

Figure 4 Output of soil moisture levels after watering (panel A, original output given by Arduino program; panel B, visualized output by Azure application services

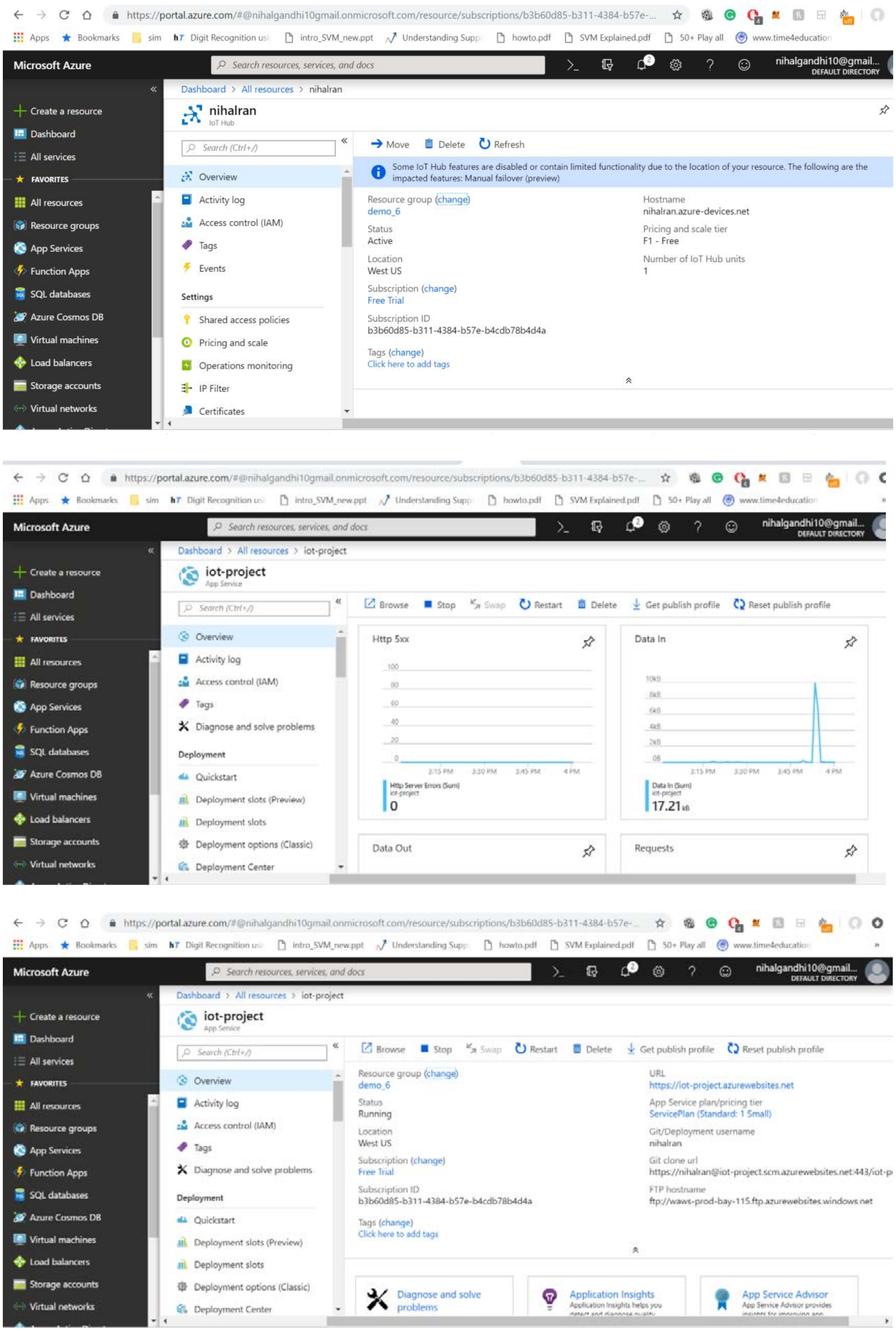

Figure 5 Microsoft Azure Setup

However, it is of note that watered plant may be vulnerable to adverse weather changes. For example, sharp temperature decrease (e.g. frost) may kill cells with more water uptake; on the other hand, plants that received more water supply have increased evaporation effect, which may be further enhanced by overheating and cause the plant lose even more water than original uptake. Therefore, the system also monitors temperature change to assist the user's decision. By exploiting the API to www.openweathermap.org, the system scrapes weather forecast information and exhibits temperatures of the next 5 days using Azure application service.

Furthermore, since the user may even miss checking the record of moisture levels, this system also sends email notification to the user when the soil moisture reaches critically low level. This feature greatly promotes the efficacy of management.

Also, we store that data in our Azure storage in BOLB containers and then use that data to predict the chances of rain. For this purpose, we use the machine learning weather forecast model already embedded as a service in Azure.

Owner's Decision

The owner can visit the target IoT hub at any time to find out the real-time change of soil moisture levels. The decision on watering is based on two parameters provided by the system: whether the soil is dry, and whether there are any fierce temperature changes in the next few days. The owner's dashboard is given in Figure 6.

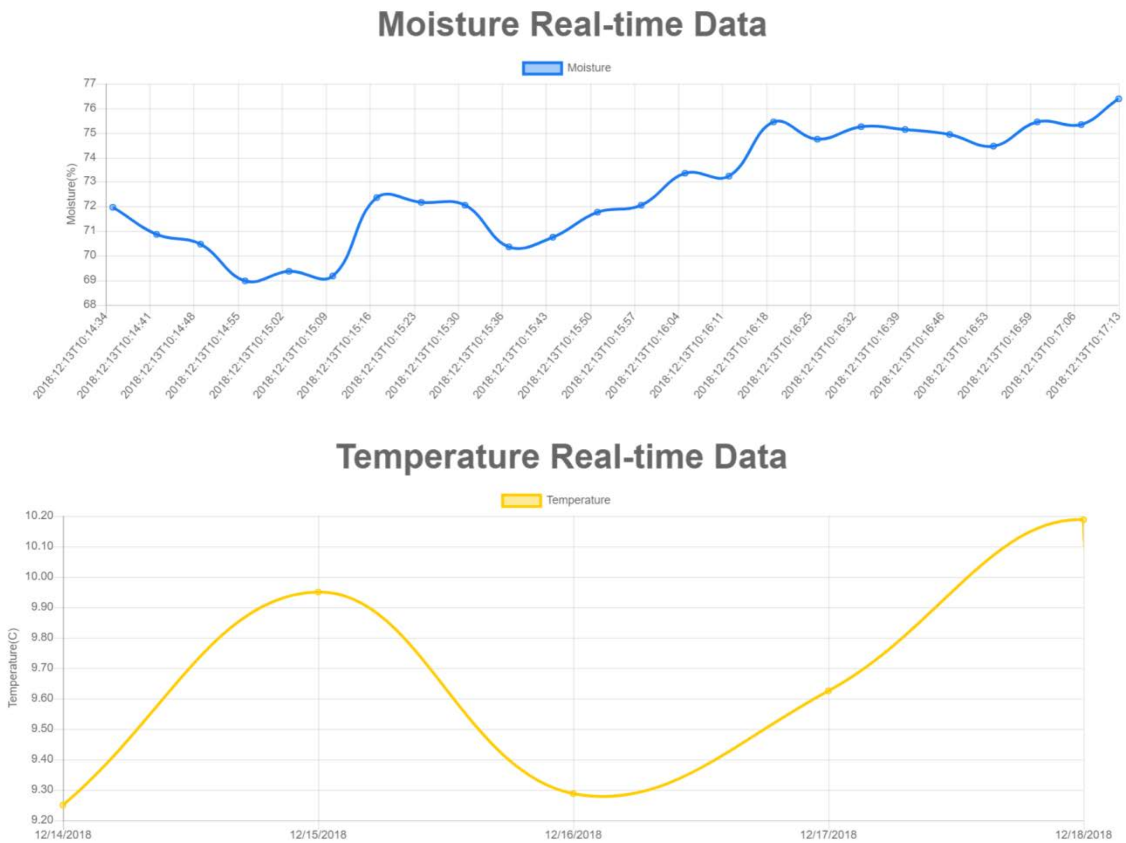

Figure 6 Dashboard of owner's side

When the level of soil moisture reaches threshold of alert, a reminding email will be sent to the user as shown in Figure 7. This guarantees the survival of plant.

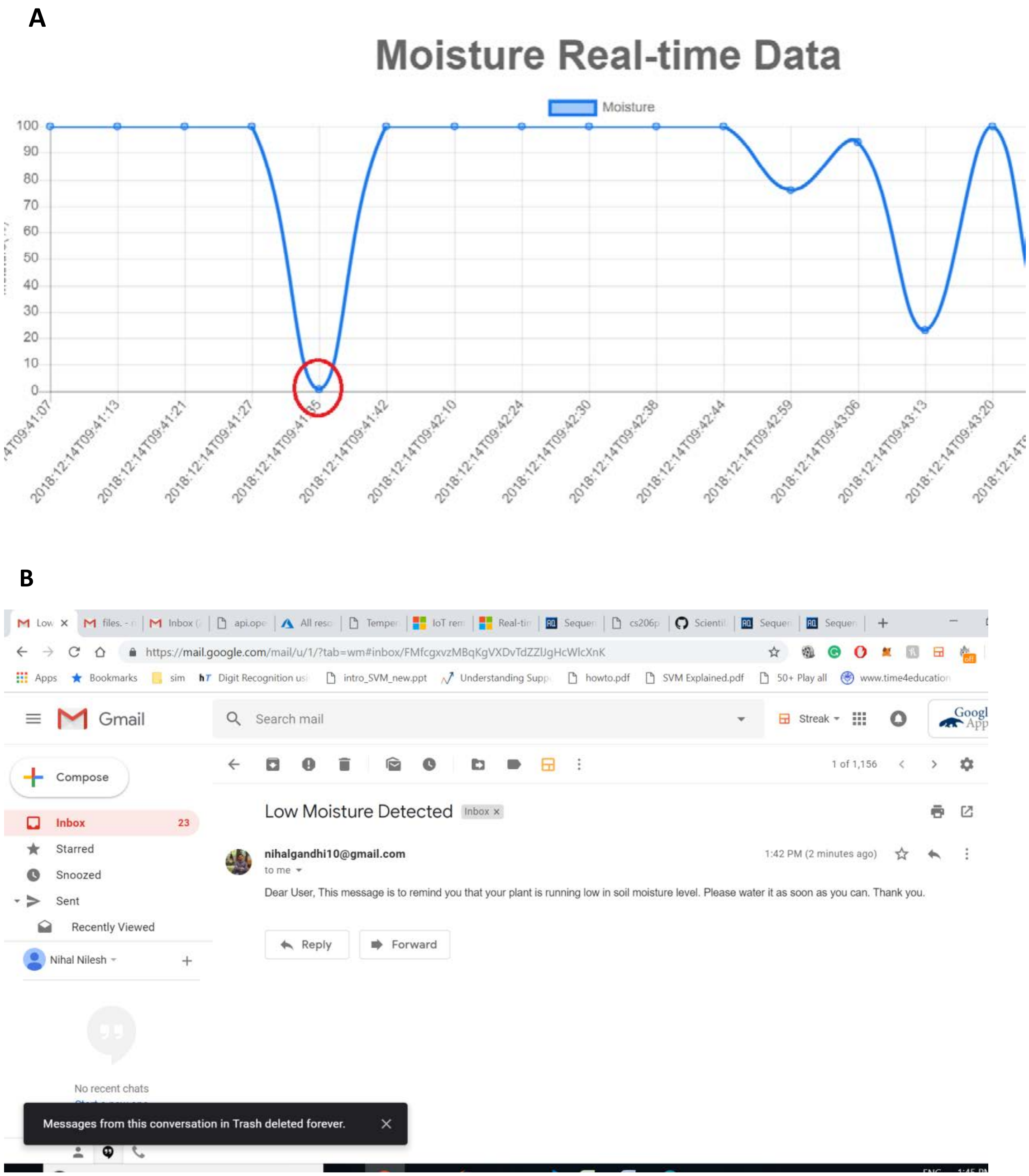

Figure 7 Email notification of low soil moisture level. Panel A: one time point reaches low moisture level. Panel B: an email is sent to the user to report this issue.

Conclusion

In this project we demonstrate a prototype of system that implements soil moisture content monitoring from remote locations. This report summarizes the system structure, protocol of data access and broadcast, as well as visualization. In addition, the alert system guarantees the active notification on severe dryness. Benefits of this system are not limited to smart management of backyard plants; actually, the application of such sensor network may provide solution to larger scale agricultural management.