ReTeSoil: A Temperature, Relative Humidity, and Soil Moisture Monitoring System Using GSM With Blynk

Sittie Alyzza M. Garcia, Ariel James T. Abarquez , and Cristina P. Dadula

***Abstract*—This monitoring system was developed based on the temperature, relative humidity, and soil moisture content of a plant to minimize the occurrence of excessive and irregular irrigation that leads to certain problems like shortage in soil nutritive elements and decrease in productivity. The system is composed of two nodes: the sensor node and the base node, and BLYNK mobile application program. The sensor node consists of sensors and a transmitter for the sending of data to base node. The base node is responsible for accepting data from the sensor node and it consists of a receiver and a Global System for Mobile communication (GSM) module to relay the received data to the *BLYNK* cloud. The system used RF communication for sensor to base node data transmission and Global Packet Radio Service (GPRS) for base node to BLYNK cloud data transmission. The BLYNK application program is used to monitor and display the data from the sensors, and sends email notification when the measured value of at least one of the sensors is below or above the set limit. All functionalities of the application program were working. The maximum operating distance for the RF module was 35 m when both receiver and transmitter modules have antenna installed. In addition, it was observed that GPRS communication was not stable, a noticeable time delay was experienced in displaying sensor data to the application. Hence, the use of more stable communication like Wi-Fi is highly recommended to avoid some communication issues.**

***Keywords:* monitoring temperature, relative humidity, and soil moisture; GSM, GPRS, RF communications, Wi-Fi, wireless sensor network.**

Sittie Alyzza M. Garcia, Ariel James T. Abarquez , and Cristina P. Dadula, Mindanao State University, General Santos City, Philippines (e-mail: garciasittie21@gmail.com, ajs.abarquez97@gmail.com, cris_dadula@yahoo.com)

I. Introduction

Excessive and irregular irrigation is not good for both plants and soil. This will result to some serious problems like shortage in soil nutritive elements, decreased productivity, or increase in salinity. Thus, causing the soil nutrients to be submerged and remain in the subsoil while the groundwater comes up to the surface, the groundwater undergoes evaporation and forms salts on the soil [1]. This leads to decrease in quality and productivity of the soil. To avoid these problems, some systems were designed to remotely monitor the humidity of the soil. Whenever the humidity reached a certain level, a motor pump is turned on to deliver the required water [2]. There is also a monitoring system designed for precision agriculture implemented using wireless sensor nodes. These sensors are spread through the field to periodically collect and relay soil data to the processing centers [3]. Gerard Rudolph Mendez et al. [4] have performed temperature and soil humidity monitoring by using Wi-Fi communication; for sensor node, they used the WSN802G module. Sensor measurements are collected and stored in the server for further analysis. Kishore Babu and Saggam Divyasri [5] have made a similar system which used GPRS for transmitting data instead of WiFi. Nurul Fahmi et al. [6] also implemented a wireless sensor network for the monitoring of a precision agriculture system. They made a simple prototype that used temperature, humidity, pressure, and soil moisture sensors. This prototype can monitor environment status through a website and even on smartphone. In 2013, H.A. Mansour et al. [7] have studied the effect of automatic control on closed circuit drip irrigation system as a modified irrigation system on yellow corn crop vegetative and yield parameters.

This research aims to develop a microcontroller-based system for monitoring of essential plant growth factors that can be remotely accessed by the user wirelessly through an application program. The objectives of the study are: 1) to develop a system prototype that uses two main sensors (DHT11 humidity and temperature sensor, and soil moisture sensor), microcontroller, RF module and

GSM module, 2) to use BLYNK to build an application for displaying data, 3) to transmit data from the sensor node to the base node using RF communication, 4) to transmit data from the base node to the BLYNK cloud using GPRS, and lastly 5) to test the functionality of the RF communication range, stability of connection of the GSM module, and BLYNK cloud data transmission.

II. Agricultural Monitoring and Control Systems using Wireless Sensor Network (WSN)

The study discussed in [3] demonstrate the design and development of a Wi-Fi-based WSN capable of intelligent monitoring of agricultural environment conditions using a pre-programmed control and management system that can be updated as required. The WSN has three components which are the sensor nodes, access point, and central station. The sensor node is capable of data collection of parameters such as relative humidity, air pressure, temperature, soil moisture, presence of light, and nutrient levels. On the other hand, the study conducted in [4] used WSN to aid farmers for real-time monitoring of different agricultural areas. A simple prototype for precision agriculture was developed that monitors humidity, soil moisture, temperature, and atmospheric pressure. The study discussed in [5] shows the effect of automatic control closed circuits drip irrigation system on yellow corn crop. This was conducted in the Al-Hasa region of Saudi Arabia. A microcontroller-based irrigation system was discussed in [6]. The researcher wants to develop a system that can work constantly in a remote location, even under abnormal conditions. The system monitors the soil humidity and delivers water whenever the humidity reaches a certain level. The study discussed in [7], developed a distributed wireless sensor network which is powered by photovoltaic panels. Soil moisture and temperature sensors are placed in the plant's roots to gather information. Sensor measurements are sent into a gateway to display values in a web application. These measurements are also used to trigger actuators for control of some system variables, such as water quantity. The system also used a communication link that used cellular-Internet interface for data transmission that allows for remote inspection and irrigation scheduling.

III. Methodology

This section presents the design and development of both the software and hardware components of the system. For the software application, BLYNK was used to develop a user interface and mobile application to display the data coming from the sensor node. It is an Internet of Things (IoT) platform suitable only for smartphones [8]. Meanwhile, Arduino IDE was used for the development of algorithm needed by the hardware component of the system. Arduino IDE is an open-source software that is compatible with the application and board used in the system [9]. This allows for the hardware component to interact with the user application.

The system has two circuits: the base node and sensor node, as shown in Figure 1. The sensor node is composed of an Arduino Uno board, sensors (namely, DHT11, the temperature and humidity sensor, and the soil moisture sensor), and RF transmitter module to send the data to the base node. This base node is composed of an Arduino Uno board, a GSM module, and an RF receiver module. Sensor node will send data to the base node through RF communication using a TX/RX RF module. Moreover, the data received by the base node will also be sent to the BLYNK cloud by the GSM module so that the developed application can access the data anytime and anywhere.

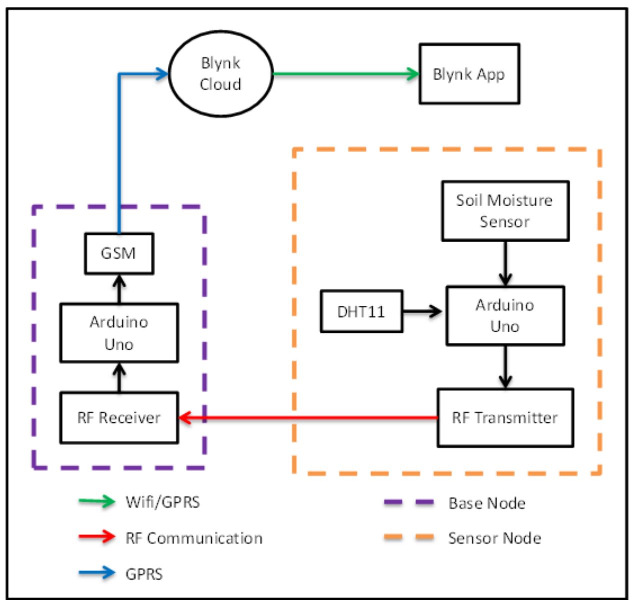

Fig. 1. Conceptual system framework.

A. Hardware Development

The project's hardware development consists of two circuitries: the sensor node and the base node construction.

Sensor Node

Sensor node is responsible for remote measurements and transmission of data [10]. It consists of Arduino Uno, RF transmitter module, DHT11, soil moisture sensor, and a 9V battery. The DHT11 sensor will gather the data for the temperature and relative humidity. It can also determine the soil's moisture using soil moisture sensor. Once all the data are gathered, the RF transmitter will transmit all the data to the base node. Figure 2 shows the schematic diagram of the sensor node.

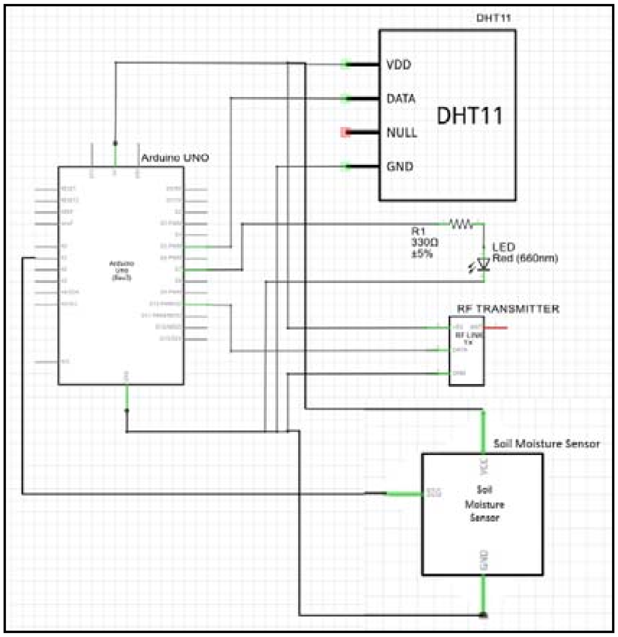

Fig. 2. Sensor node schematic diagram.

Base Node

The transmitted data coming from the sensor node will be received by the base node. It consists of Arduino Uno, GSM module, RF receiver module, and a 9V battery. When the data are transmitted from sensor node to the RF receiver module, the data will be forwarded to the BLYNK cloud by the GSM module so that the developed application can access the data anytime and anywhere.

The RF module that was used in the system operates in 433 MHz frequency band. This means that the RF transmitter and receiver will operate at the same frequency [11]. RF modules are commonly used in wireless communication because of their stability and wide coverage but is very prone to multipath fading and other error sources [12]. Another module that was used is the GSM sim900a module [13]. This module is capable of data communications between the base node and the BLYNK server. Figure 3 shows the schemtic diagram of the base node.

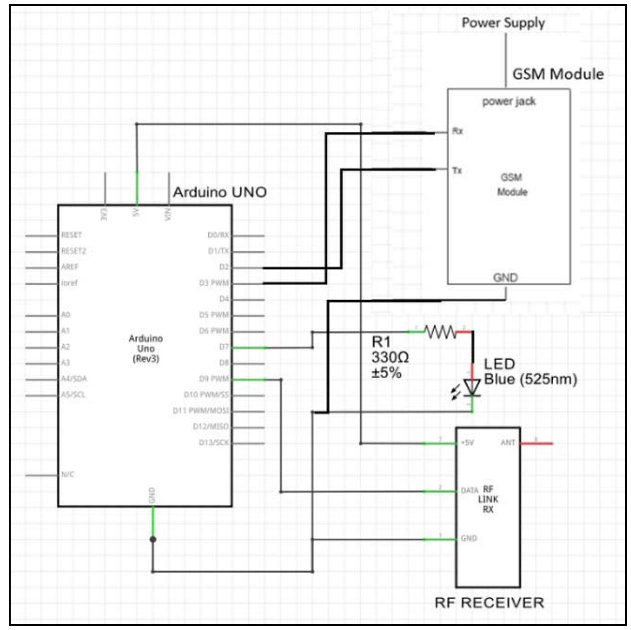

Fig. 3. Base node schematic diagram.

B. Software Application Development using BLYNK

BLYNK application was used in the software development. This application has the necessary functions in developing the system. Figure 4 shows how Blynk will be setup. It used a drag-and-drop feature in building the application and can communicate with Arduino IDE just by installing the needed libraries. The functions include the monitoring of the following sensors: (1) soil moisture, (2) temperature, (3) humidity, and (4) the *Timeline* for the real-time data of the sensors. With these in mind, the main layout of the BLYNK application should contain three gauges for every data of the sensors, SuperChart for the timeline of real-time data, and a notification and email widget. The notification function is used if sensor readings are above the set limit. However, to be able to monitor the sensors with these gauges and the SuperChart, it is then necessary for the BLYNK application to be able to communicate with the Arduino UNO board via the GSM Sim900a module. To do so, the GSM Sim900a module must have a data connection to access the BLYNK server, to monitor the data from the sensors which will be displayed by the BLYNK application. The codes are modified to make sure that the gauge and SuperChart can get the data from the sensors to monitor the soil moisture temperature, and relative humidity. The codes include the communication between the application and the Arduino. Figure 5 shows the layout of the BLYNK application.

Fig. **4.** BLYNK setup [14].

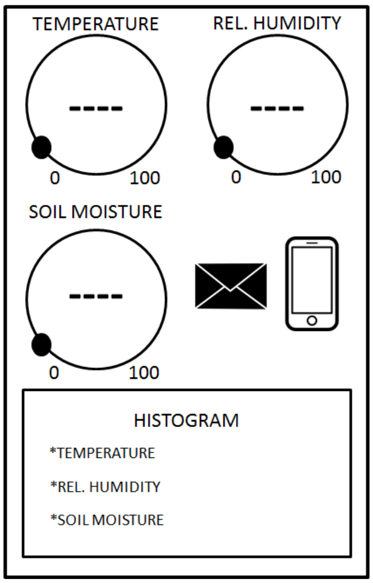

Figure 5. Application layout.

C. Hardware and Software Integration

After the necessary codes are finalized, testing whether the current codes are suitable to complete the anticipated functionalities of the hardware takes place. The researchers used the Arduino IDE Serial Monitor to check the initialization and connectivity of the GSM module and the BLYNK cloud, as shown in Figure 6. This initialization of the GSM module takes time depending on signal strength and where the node is being set up. Figure 7 shows that the BLYNK application is already connected to the Arduino IDE. It also displays the data from the sensors.

D. Distance Test

The transmission of data from the sensor node to base node was also tested for different distances (from 0 to 45 m) with the presence or absence of the antenna of the transmitter module and receiver module.

```
Initializing modem...
[15335]
    ___  __          __
   / _ )/ /_ _____  / /__
  / _  / / // / _ \/  '_/
 /____/_/\_, /_//_/_/\_\
        /___/ v0.5.2 on Arduino Uno

[15342] Modem init...
[16247] Connecting to network...
[16559] Network: Globe Telecom-PH
[16559] Connecting to internet.globe.com.ph ...
[23806] Connected to GPRS
[24086] Connecting to blynk-cloud.com:80
[27984] Ready (ping: 836ms).
[60425] Connecting to blynk-cloud.com:80
[62874] Ready (ping: 852ms).
[96156] Connecting to blynk-cloud.com:80
```

Fig. 6. The initialization of the GSM module, network connection, Access Point Name (APN), Global Packet Radio System (GPRS) status, and BLYNK cloud connection.

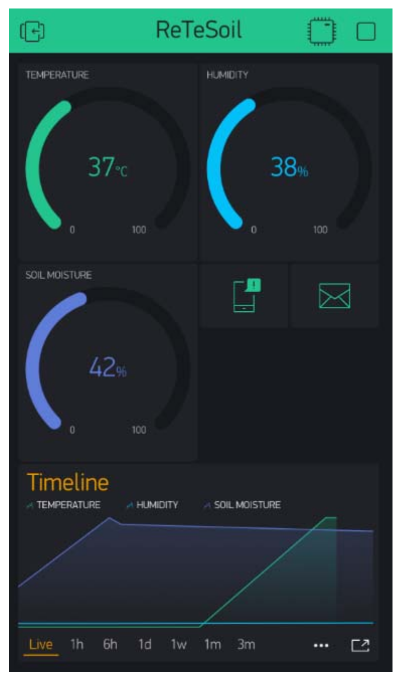

Fig. 7. Displaying of data using BLYNK application.

IV. Results and Discussion

Figure 8 shows the final version of the BLYNK application, which has an interface that allows the user to monitor sensor data, through the GSM module connection.

A. Final Version of the BLYNK Application

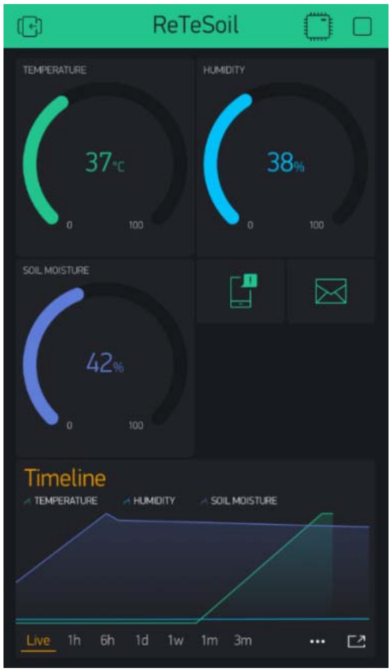

Fig. 8. BLYNK application main interface.

To monitor the data from the sensor node, the three gauges display the numeric data of the sensors, which are the DHT11 sensor (temperature and relative humidity sensor) and soil moisture sensor. The SuperChart shows the live and historical data of the sensors. The email widget allows the user to send email from the hardware to any email address if the sensor readings are above the set limit. The push notification widget allows the user to send push notification from the hardware to the user's device in case the hardware went offline and when the data from the sensors are above the set limit [15].

B. Initializing the GSM Modem

This section shows the results in the Arduino IDE serial monitor when the GSM module is being initialized, as shown in Figure 9. The initialization of the GSM module to connect to the data services of the network takes a bit longer depending upon the signal strength or the area where the base node is being set up. After the initialization, establishment of connectivity between the application and the module was initiated. Some problems encountered about the initialization of the GSM module include: 1) there were times that the module did not initialize properly and proceeded on restarting to re-initialize the module, and 2) there were also times that the researchers need to unplug the power supply and then plug it again.

```
Initializing modem...
[15335]
    ___  __          __
   / _ )/ /_ _____  / /__
  / _  / / // / _ \/  '_/
 /____/_/\_, /_//_/_/\_\
        /___/ v0.5.2 on Arduino Uno

[15342] Modem init...
[16247] Connecting to network...
[16559] Network: Globe Telecom-PH
[16559] Connecting to internet.globe.com.ph ...
[23806] Connected to GPRS
[24086] Connecting to blynk-cloud.com:80
[27984] Ready (ping: 836ms).
[60425] Connecting to blynk-cloud.com:80
[62874] Ready (ping: 852ms).
[96156] Connecting to blynk-cloud.com:80
```

Fig. 9. Arduino IDE Serial Monitor—GSM modem initializing.

C. Establishment of Connection between the BLYNK Application and the GSM Module

This section shows the application when the GSM module is connected to the BLYNK application. Figure 10 shows the Arduino's response to establish the connection.

```
Initializing modem...
[15335]
    ___  __          __
   / _ )/ /_ _____  / /__
  / _  / / // / _ \/  '_/
 /____/_/\_, /_//_/_/\_\
        /___/ v0.5.2 on Arduino Uno

[15342] Modem init...
[16247] Connecting to network...
[16559] Network: Globe Telecom-PH
[16559] Connecting to internet.globe.com.ph ...
[23806] Connected to GPRS
[24086] Connecting to blynk-cloud.com:80
[27984] Ready (ping: 836ms).
[60425] Connecting to blynk-cloud.com:80
[62874] Ready (ping: 852ms).
[96156] Connecting to blynk-cloud.com:80
```

Fig. 10. BLYNK is connected to the GSM module.

The researchers encountered some stability problems with the establishment of connection between the application and the GSM module. Figure 10 shows how the connection was established for a couple of seconds, and then it will be disconnected, and connected again afterwards.

D. Distance Test for RF Communication

Table 1 shows the summary of all the processes that can be performed by the RF module as mentioned above. Note that this evaluation was done while performing a distance test. As such, the table below shows the results for a distance test of up to 45 m.

Table 1
RF Communication Range Testing Summary

Distance	TX With Antenna	RX With Antenna	Remarks
0 m	NO	NO	Transmit data
5 m	NO	NO	Failed
5 m	YES	NO	Transmit data
10 m	YES	NO	Transmit data
15 m	YES	NO	Failed
15 m	YES	YES	Transmit data
20 m	YES	YES	Transmit data
25 m	YES	YES	Transmit data
30 m	YES	YES	Transmit data
35 m	YES	YES	Transmit data
40 m	YES	YES	Failed
45 m	YES	YES	Failed

During testing, the transmission stability was poor when the distance was about on its limit (40 m). The base node, most of the time, can receive data as long as the receiver antenna was installed. Otherwise, the connection was not stable, causing it to poorly receive the arriving data. With the antenna installed, the transmission was successful up to 35 m.

E. Displaying of Data using BLYNK Application

The application successfully established the necessary hardware-to-hardware communication, hardware-to-software communication, hence it successfully displayed the data coming from the sensor node as shown in Figure 11. The researchers set the threshold value of each gauges, as shown in Table 2. So if the reading value of the temperature, for example, is above the threshold value, notification will appear, as shown in Figure 12.

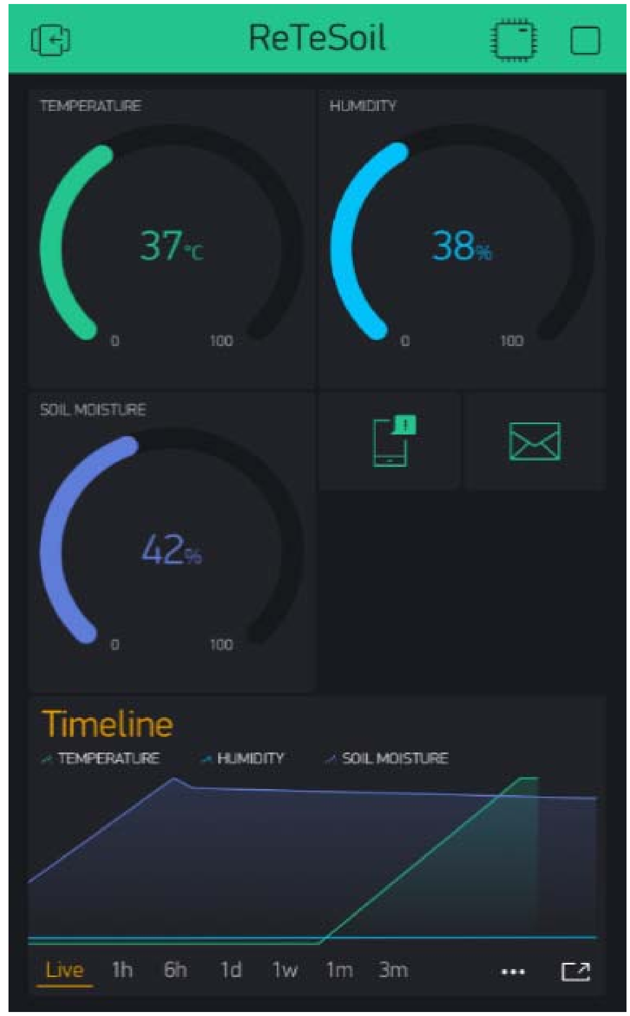

Fig. 11. Gauges reading.

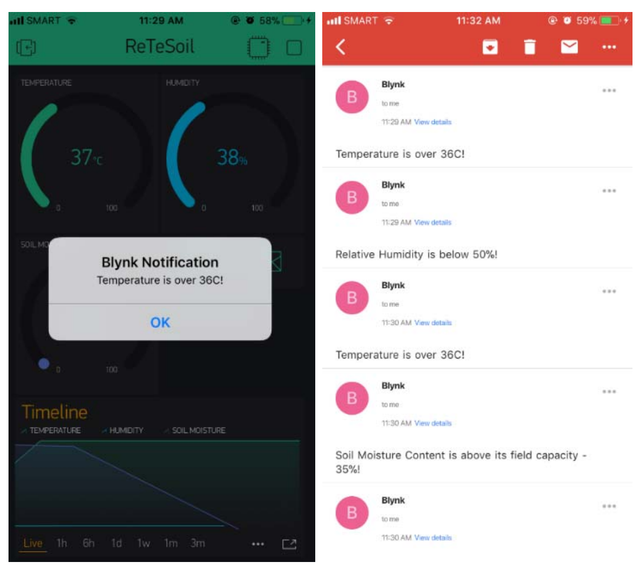

Fig. 12. Push and email notification.

Table 2
Threshold Summary

	Threshold Value
Temperature	36°C
Relative Humidity	50%
Soil Moisture	30% and 70%

The threshold value can be altered by changing the values in the source code. Once the values are set and the prototype is ready, it cannot be changed since the microcontroller was enclosed in a box.

V. Conclusion and Recommendations

The researchers implemented a wireless monitoring system using BLYNK that can monitor temperature, relative humidity, and soil moisture content of the plant. With this, the sensors' data coming from the sensor node are displayed in the application with push notification and push email that allow users to remotely monitor the environment conditions in an area, if the threshold values are above or below the set limit. The researchers observed that the RF communication used in the base node connection has a maximum operating distance of 35 meters when both modules have antenna. Within this operating distance, data can be transmitted to the base node without any issues except when the distance is about its maximum limit (35 m). The initialization of GSM modem and connection to GPRS for base node and the BLYNK application communication was not stable. Delay was observed, it took a couple of seconds or minutes depending upon the signal strength of the network.

Future works may consider the improvement of the stability of data transmission from base node to BLYNK cloud by using Wi-Fi and/or other more stable communication. The use of a higher frequency operating RF modules can also be considered for wider range compare to 433-MHz RF modules that covers only 35 m, as well as, improving the hardware for both base node and sensor node. The use of 5-12 volts of power source with at least 1 Ampere rating to power up the Arduino board and GSM modem for the base node is highly recommended. This is also applicable for the sensor node since RF transmitting module consumes a lot of power when transmitting data remotely. Lastly, the use of a high-quality module and sensors can also be considered to avoid too much calibration.

References

[1] "Excessive and Irregular Irrigation Has the Following Effects," [Online]. Available: http://www.biologydiscussion.com/articles/excessive-and-irregular-irrigation-has-the-following-effects/2403. [Accessed 4 January 2018].

[2] S. R. Kumbhar and A. P. Ghatule, "Microcontroller based Controlled Irrigation System for Plantation," p. 4, 2013.

[3] H. Sahota, R. Kumar and A. Kamal, "A Wireless Sensor Network for Precision Agriculture and its Performance," p. 18, 2011.

[4] G. R. Mendez, "A WiFi based Smart Wireless Sensor Network for an Agriculture Environment," Palmerston North, 2012.

[5] S. Divyasri, and K. Babu, "Automated Irrigation System using a Wireless Sensor Network and GPRS Module," *International Journal of Innovative Technologies,* pp. 1307-1317, 2015.

[6] N. Fhami, S. Huda, E. Prayitno, M. Rasyid, M. C. Roziqin and M. U. Pamenang, "A Prototype of Monitoring Precison Agriculture System Based on WSN," p. 6, 2017.

[7] H. Mansour and Y. El-Melhem, "Impact the Automatic Control of Closed Circuits Drip Irrigation Systems on Yellow Corn Growth and Yield," p. 10, 2013.

[8] M. S. Shah, U. A. Shaikh, and H. S. Doshi, "Internet of Things (IoT): Integration of Blynk for Domestic Usability," *Vishwakarma Journal of Engineering Research,* pp. 149-157, 2017.

[9] Arduino, [Online]. Available: http://arduino.cc. [Accessed 6 May 2018].

[10] A. Terzis, A. Szalay, and Q. Wang, "A Novel Soil Measuring Wireless Sensor Network," in *IEEE Instrumentation and Measurement Technology Conference Proceedings*, Austin, 2010.

[11] S. M. A. Alim, M. S. Islam, K. B. R. Kawshik, F. Amid and S. Islam, "433 MHz (Wireless RF) Communication between Two Arduino UNO," *American Journal of Engineering Research,* pp. 358-362, 2016.

[12] M. Maroti and A. Ledeczi, "Wireless Sensor Node Localization," 2011.

[13] M. N. Jivani, "GSM Based Home Automation System Using App Inventor," *International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering,* pp. 12121-12128, 2014.

[14] "Kickstarter," [Online]. Available: http://create.arduino.cc/projecthub/vijayvikram11844/first-project-arduino-blynk-a5a297.

[15] Blynk, [Online]. Available: http://docs.blynk.cc/. [Accessed 6 May 2018].