Internet of Things: Agriculture Precision Monitoring System based on Low Power Wide Area Network

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Abstract: - Nowadays, many people around the world depend mostly on agriculture for their livelihood. In the majority of countries around the world, it is the most significant occupation for many families. Unfortunately, farmers, particularly in oil palm plantations, continue to rely on age-old practices. One of the key elements in achieving high and long-term oil palm production on peat is the adoption of efficient precision water management. In essence, this means maintaining the water table at the necessary depth. Because of the peat's persistently low water table, oil palm productivity has sharply decreased. In this work, an Internet of Things (IoT) for precision agriculture monitoring is developed using a long-range wide area network (LoRaWAN) algorithm. Based on an approach point of view, a LoRaWAN is a long-range, low-power, low-bitrate wireless telecommunications system meant to be used as part of the Internet of Things architecture. The end devices link to gateways through a single wireless hop using LoRaWAN. These gateways function as transparent bridges, relaying messages from the end devices to a central network server. The ultimate result is the creation of a precision water management assistance algorithm employing LoRaWAN and IoT that is both affordable and effective.

Key-Words: - IoT; LoRAWAN, Wireless Communication, Sensors Networks, Topology, Water Management, Water Table, Oil Palms.

Received: April 16, 2023. Revised: February 7, 2024. Accepted: March 8, 2023. Published: April 22, 2024.

1 Introduction

The quick development of Internet of Things (IoT) technology and its applications has accelerated research in various areas of industries such as autonomous vehicles, smart cities, smart homes, and so on. One of the most popular IoT applications is precision agriculture.

It is predicted that there will be 9.7 billion people on the planet by 2050, leading to a substantial increase in the demand for food, [1]. To address this rising need, the implementation of IoT technology coupled with data analytics (DA) is poised to enhance operational efficiency, productivity, financial viability, and environmental sustainability, [2], [3]. Precision agriculture harnesses IoT technology as a vital tool for farm management, ensuring that crop and soil data are precisely tailored to boost productivity and meet desired outcomes.

Traditional farming manages the crop yields based on time-proven techniques as well as historical regional conditions, [4], [5]. This type of method usually causes a lot of waste such as water and deteriorates soil quality by using significant amounts of agrochemicals such as pesticides. This wastage and deterioration of soil have caused a negative impact on the profitability and the environment. Therefore, sensor-based agriculture was considered to reduce the impacts of traditional farming.

Precision agriculture relies on sensors to access the data such as temperature, soil moisture, leaf wetness, humidity, groundwater level and so on, [6], [7], [8]. All these sensors will be located at a strategic location to provide the most accurate data for analysis. The sensors use wireless connectivity to send the environmental data to the internet cloud for data processing and analysis. The collected data can be used to analyze the significant patterns and trends which will be very helpful make in making decisions for irrigation, fertilization, pesticides, and so on.

The sensors in IoT precision agriculture are equipped to transmit data to the cloud, with wireless connectivity emerging as the optimal choice, [9], [10]. Various types of wireless technologies are available for IoT applications, including Wi-Fi, 4G/5G, SigFox, LoRaWAN, ZigBee, and more. Among these options, LoRaWAN stands out as one of the most popular wireless technologies for IoT precision agriculture due to its ability to offer long-range communication spanning up to 20 kilometers while maintaining low energy consumption. Typically, it operates efficiently with just AA batteries or Lithium-Ion batteries, providing an extended operational lifespan, [11].

The water table represents a crucial parameter in agriculture, as fluctuations in the water table affect crop yields, [12]. Essentially, the water table marks the upper boundary of the saturated zone, where the pores and fractures within the ground contain water. This surface coincides with the point where the water's pressure head equals atmospheric pressure, denoting a gauge pressure of 0. In essence, it serves as the "surface" of the subsurface materials saturated with groundwater in a specific area. Groundwater can originate from precipitation or the inflow of groundwater into the aquifer, both contributing to fluctuations in the water table.

In regions with ample precipitation, water seeps through soil pore spaces, traversing the unsaturated zone. As it descends, water progressively occupies more of the soil's pore spaces until it reaches the saturation zone, also known as the phreatic zone. Within this zone, permeable rock layers that yield groundwater are referred to as aquifers. In soils with lower permeability, like compacted bedrock formations or historic lakebed deposits, delineating the water table can be more challenging. Numerous research studies have investigated the influence of water depth on various crops, underscoring the importance of monitoring water table fluctuations in agriculture, [13], [14], [15], [16], [17].

In general, the water table observation wells are located in remote areas, therefore the on-site data collection is very time-consuming and high manhours consumption which will lead to high cost. In addition, due to the on-site data collection, there is no real-time data available and decisions will not be able to be taken immediately. The following research questions were formed and described the aim of this work.

- How can a LoRaWAN-based IoT node that can measure the liquid level and visualize the data be designed and implemented?
- How can the node be able to monitor the battery life so that the battery can be recharged or replaced before it runs flats?
- How to visualize the data of water level information and battery life at the IoT platform/dashboard?

Therefore, we considered a LoRaWAN gateway, IoT sensor node, internet, and Blynk IoT platform to measure the water level of a particular crop using the water sensor and its battery level. Smartphones are used to verify the water level and battery level of a sensor remotely with the smartphone and based on the water level, we can control the water pump for half an hour.

The rest of the paper is organized as follows: section 2 provides the literature survey, section 3 gives the scope of the work, section 4, and explains the proposed methodology. Results, discussions, and conclusions are drawn in sections 5, 6, and 7 respectively.

2 Literature Review

Nowadays, agriculture serves as the primary livelihood for countless individuals across various regions of the world. Thanks to remarkable advancements in technology, farming has gained greater popularity and significance. A diverse array of tools and techniques are readily accessible for the advancement of agriculture. According to the United Nations Food and Agriculture Organization, the world needs to produce 70% more food by 2050 than it did in 2006 to sustain the rising global population, [18]. In response to this demand, farmers and agricultural enterprises are increasingly turning to the Internet of Things (IoT) for enhanced analytics and increased production capabilities.

The IoT is a network of interconnected devices used to communicate required data efficiently without the need for direct human intervention. This is more efficient because globally it can link a large number of devices, requires less human intervention, is quickly accessible, saves time, and facilitates simplified communication. Nowadays, many sectors are utilizing IoT technology. In the field of agriculture, IoT devices increase production by knowing the major parameters such as soil moisture, temperature, and water level.

Hence, the agricultural sector is using IoT technology for smart farming to improve productivity, reach a wider audience, and cut down on expenses, time, and human interaction. However, monitoring of oil palms in Malaysia is one of the major issues. In [19], Gartner analysis claims that by the end of 2016, there were 30% more connected devices than there were at the end of 2015. By 2020, this number is expected to increase to 26 billion devices.

IoT sensors provide accurate information on the crop yields, rainfall patterns, pest infestations, and soil nutrition to the farmers. Farmers can improve their farming methods with the help of this essential knowledge. The real-time, accurate, and shared characteristics of the Internet of Things make it a promising technology that could bring about major changes to the agricultural supply chain. It is an essential piece of technology for creating an efficient agricultural logistics flow, [20].

Adopting IoT in agriculture provides several benefits. Initially, water waste can be reduced with the use of a water sensor, next, it permits ongoing land surveillance, which permits the implementation of preventative actions early on. Thirdly, IoT improves farming operation’s efficiency and increases productivity. Fourthly, it makes crop monitoring easier while offering information on crop progress. Fifth, IoT helps manage soil by determining important factors like moisture content and pH levels for the best possible seed selection. Furthermore, plant and crop diseases can be identified with the help of sensors and RFID chips. RFID tags share information online and transfer it to readers. Farmers and scientists can remotely access this data, allowing for prompt crop disease prevention, [21]. Farmers can also know the global market prices of the crop with the use of smart devices and increase their crop sales.

In a separate investigation documented in [22], IoT demonstrates its versatility across various agricultural domains, encompassing applications such as intelligent irrigation management systems, pest and disease control, water quality monitoring, tracking cattle movements, dairy management, greenhouse environmental monitoring, soil condition assessment, and precision agriculture employing Unmanned Aerial Vehicles (UAVs). The cloud-based smart forming system facilitates the early detection of borer insects in tomato crops, [23]. This issue was effectively addressed through the convergence of cloud computing and IoT technologies.

Furthermore, within the scope of the paper [24], a comprehensive architecture for monitoring soil moisture, temperature, and humidity levels on small-scale farms is presented. The primary impetus behind this research is to curtail water consumption while concurrently enhancing productivity on modest agricultural holdings and ensuring precision in their operations. In the paper [25], the proposed approach leverages a fusion of LoRa technology and cloud computing to accelerate the advancement of agricultural modernization. This innovative combination facilitates the creation of smart agricultural solutions, effectively addressing the challenges faced by farmers even in remote locations.

Furthermore, in a separate study documented in [26], cutting-edge communication architectures are implemented, showcasing the integration of foundational sensing technologies and communication mechanisms for IoT. Additionally, the paper delves into recent strides made in the theory and application of wireless underground communication. It also sheds light on the significant hurdles inherent in IoT design and implementation. In [27], LoRaWAN network utilization is highlighted. This protocol offers long-distance communication with exceptionally low energy consumption, aligning with the growing demands and requirements of modern farmers for enhanced accessibility and facilities.

In [28], authors have built a prototype to collect the air temperature, humidity, leaf wetness, and soil moisture reading from sensors and forward the sensed data to the things network (TTN) by using LoRaWAN, which consists of one executor node and three collector nodes. These nodes work together to gather data, which is subsequently analyzed to determine whether the irrigation system should be activated or deactivated. The author has skillfully engineered a system that offers both flexibility and scalability, allowing for the seamless addition of new services and integration with various other IoT platforms.

In [29], authors have built a IoT sensor node by using an Arduino Uno board. The sensor node comprises 3 different types of sensors and they are soil moisture sensor, rain sensor, and temperature with humidity sensor. The sensor node collected the environmental data and sent it to the Thingspeak IoT platform via Wi-Fi. The collected data were able to be visualized in the Thingspeak IoT platform. The data can be made available from smartphones which allows the user to access the data everywhere.

In [30], authors set up an IoT system that consists of a network and application server, sensor node, and LoRa Gateway. The sensor node collects temperature and humidity data and sends it to the network server via the LoRa gateway. Network servers receive the data from the LoRa gateway and arrange the data set before sending it to the application server for visualization. In the research, the author has conducted an assessment about the data transmission delay. The result shows that the distance has an impact on the network connection request, the longer the distance, the connection request will take a longer time which causes delay.

In [31], authors have conducted experimental research about the soybean water use, growth, and yield parameters within the climate-controlled greenhouse. The research was conducted under 4 different water table depths, they are 30, 50, 70, and 90 cm. The optimal depth of soybean was determined as 70 and 90 cm.

In [32], authors developed a IoT-based Soil Health Monitoring Unit (SHMU) with LoRaWAN as a wireless communication medium between the SHMU with the gateway. The node consists of a micro-controller board, LoRa radio, soil sensors, Li-ion battery, solar panel, and battery charger. There are two main sensors in the SHMU and they are commercially available soil sensors that are capable of measuring soil EC (Electrical Conductivity), temperature, and moisture while another sensor is used for measuring the soil CO_2 concentration. The SHMU also has a GPS module which allows the user to use the node GPS coordinates and mark the sampling point on a map. Author used a personal computer as an IoT server which consisted of several open-source software such as ChirpStack, Mosquitto and PostgreSQL. This software was used for data/message processing, data storage, and visualization. The research has shown a promising result in which all the data were able to be collected for visualization and storage.

In the literature, various models and methods are considered for monitoring crop irrigation. The authors considered sensors for monitoring the soil moisture, temperature and humidity, co2 concentration, leaf wetness, pest infections, rainfall patterns, and so on. In this paper, we considered a pressure-based liquid level sensor for identifying the water level in the ground surface, and one more sensor is used to detect the battery level of the network system. This battery information is one of the major parameters we consider along with the water level. With this device, we can control crop irrigation without any issues like power failures and water reduction. This provides an enhanced remote monitoring crop irrigation system.

3 Scope of Work

The basic aim of the paper is to build a liquid-level sensor IoT node which is used to monitor the water table fluctuation. The battery-driven sensor node contains a pressure-based liquid level sensor, which is intended to measure water level with a defined interval. Apart from the liquid level monitoring, the sensor can monitor battery status. The collected liquid level data and battery status will be sent to the gateway by using LoRaWAN wireless communication technology. Blynk IoT platform will be used for data storage and visualization. Other than using a PC to access the data, smartphones can also be used to view the data from everywhere and anytime.

4 Methodology

In the literature, many authors worked on soil moisture sensing using various sensors and enhanced crop irrigation. In this paper, a precision monitoring agricultural system is considered and it consists of sensors, a microcontroller, LORaWAN, and current to voltage converter. Every component is having its advantages. The proposed system network topology, its component specifications, and working are explained clearly in this section.

4.1 Network Topology

The proposed system's network topology is depicted in Figure 1, which consists of four primary components within the network architecture: the sensor node, the LoRaWAN gateway, the internet, and the IoT platform. Each component has its importance in controlling the water level. Initially, the sensor node detects the water level, next the same data is forwarded to the LoRaWAN gateway, and through the internet the sensed information is forwarded to the Blynk IoT platform for storage and visualization.

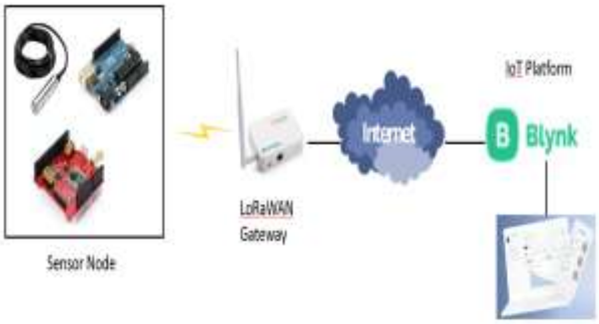

Fig. 1: Network Topology

4.2 Sensor Node

The sensor node is the basic element of an IoT network topology. This node includes a 12V DC battery, pressure-based liquid level sensor, LoRaWAN wireless module, microcontroller, and current to voltage converter. The water pressure will be detected by the pressure-based liquid sensor and the same is forwarded to the IoT platform using the wireless module and LoRaWAN gateway. This plays a very important role in controlling the water level in the irrigation system.

4.3 Keyestudio Uno R3

The Keyestudio Uno R3 is a microcontroller board based on the ATmega328, offering complete compatibility with the Arduino Uno R3, which is shown in Figure 2. It features a comprehensive set of hardware components, including 14 digital input/output pins (with 6 capable of functioning as PWM outputs), 6 analog inputs, a 16 MHz quartz crystal, a power jack, USB connectivity, and a reset button, which are listed in Table 1.

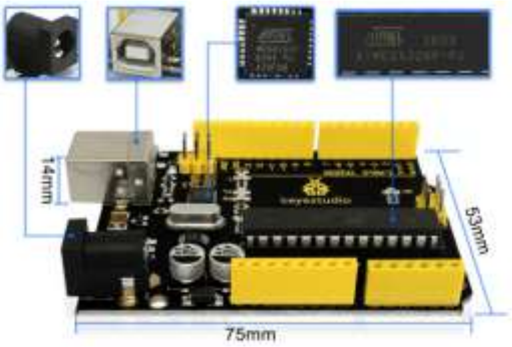

Fig. 2: Keyestudio Uno R3

Given its full compatibility with the Arduino Uno R3, the Keyestudio Uno R3 can be effortlessly programmed using the Arduino IDE. The microcontroller helps in controlling the water level of the proposed system. It transfers the sensed water level to the IoT platform and also to the smartphone. The former can verify the water level and the pipe will be controlled based on the water level.

4.4 LoRaWAN Shield

The LoRa shield is a wireless transceiver module designed for long-range communication with Arduino microcontroller boards, which is shown in Figure 3. This shield enables the transmission of data over extended distances while maintaining low data rates. It harnesses spread spectrum communication technology, known for its remarkable interference resistance and energy efficiency.

Table 1. KEYESTUDIO UNO R3 Specifications

S. No	Parameter	Specifications
1	Controller	ATmega 328P-PU
2	Input Voltage	7-12V
3	Digital Input/Output Pins	14 (of which 6 provide PWM output)
4	PWM Pins	6 (D3, D5, D6, D9, D10, D11)
5	Analog Input Pins	6 (A0-A5)
6	DC Current per I/O Pin	20 mA
7	Flash Memory	32 KB
8	SRAM	2 KB
9	EEPROM	1 KB
10	Clock Speed	16 MHz
11	LED_BUILTIN	D13

The LoRa shield is powered by the Semtech SX1276/SX1278 chip, well-suited for wireless sensor network applications like precision agriculture, smart cities, and building automation. It achieves exceptional sensitivity, surpassing -148 dBm, thanks to a cost-effective crystal and materials. Furthermore, it incorporates a built-in +20 dBm power amplifier, significantly enhancing the link budget for any application requiring extended range or robust connectivity, which are listed in Table 2. In comparison to conventional systems, the LoRa shield offers notable advantages in terms of blocking, selectivity, interference resilience, and power efficiency.

Fig. 3: LoRaWAN Shield

Table 2. LoRaWAN Specifications

S. No	Parameter	Specifications
1	Max. Link budget	168 dB
2	RF Output	+20 dBm at 100mW
3	PA efficiency	14dBm
4	Bit rate	300Kbps
5	Max. Sensitivity	Down to -148dBm
6	RSSI	127

4.5 Analog Current to Voltage Converter

Typically, industrial sensors and devices generate a current signal output ranging from 420 MA. 25 mA current signal is converted into a 0~3V voltage signal by using this analog converter, making it effortless for the main control board to receive input from the sensor.

In fault diagnosis, current signals lower than 4 mA are commonly employed, while signals exceeding 20 mA are utilized for overrun detection. Consequently, this converter is meticulously engineered with a detection range spanning from 0~25 mA, catering to both fault detection and overrun detection applications. This converter incorporates a high-precision 0.1% sense resistor and an ultra-low-noise rail-to-rail zero-drift operational amplifier, ensuring remarkable accuracy without the need for calibration, which is shown in Figure 4. It offers the convenience of operating on a wide voltage power supply, ranging from 3.3V to 5.5V, and produces a 0 to 3V voltage signal output. This compatibility extends to a wide range of microcontroller boards and makes it adaptable to a diverse array of applications. Its specifications are listed in Table 3.

Fig. 4: Analog Current to Voltage Converter

Table 3. Analog Current to Voltage Converter Specifications

S. No	Parameter	Specifications
1	Voltage	3.3-5.5 V
2	Detection Range	0-25 mA DC
3	Accuracy	±0.5% F.S. @ 16-bit ADC, ±2% F.S. @ 10-bit ADC
4	Termination Resistance	120Ω
5	Connector	PH2.0-3P

4.6 Pressure-based Liquid Level Sensor

The sensor is a submersible liquid level sensor that incorporates a high-performance pressure-sensing chip, sophisticated processing circuitry, and temperature compensation technology, which is shown in Figure 5. This sensor is designed to detect varying pressures at different liquid depths or levels, converting these pressure signals into a current output signal. The resulting current output signal, ranging from 4 to 20mA, is subsequently transformed into a voltage signal using an analog current-to-voltage converter before being inputted into the microcontroller board.

Crafted from stainless steel and fortified with anti-corrosion materials, the sensor boasts an IP68 protection rating. It is versatile, and capable of functioning effectively with a wide range of liquids, including water, oil, and high-viscosity substances. The sensor consistently delivers reliable performance across diverse measurement scenarios, spanning from rivers, reservoirs, and groundwater to water tanks. The pressure-based liquid sensor specifications are listed in Table 4.

Fig. 5: Pressure-based Liquid Level Sensor

Table 4. Pressure-based Liquid Sensor Specifications

S. No	Parameter	Specifications
1	Cable Length	5m
2	Measure Range	0-5m
3	Overall Accuracy	0.5%
4	Output Signal	4-20mA
5	Operating Voltage	12-36V
6	Operating Temperature	-20℃-70℃
7	Overload Capacity	300%

4.7 Measurement Principle

The liquid level sensor node was developed with the primary purpose of monitoring fluctuations in the water table. However, due to certain limitations, such as the availability of water table observation wells, the system underwent testing within a controlled laboratory environment. To simulate the absence of a water table observation well, a 2-meter-long, 4-inch PVC pipe was utilized. This pipe was filled with water to a specific height, and the sensor was positioned at the pipe's base. A water release valve was installed at the pipe's bottom to regulate the controlled release and replenishment of water, effectively simulating water level fluctuations.

The water level measurement setup is shown in Figure 6. The sensor employed in this setup is a hydrostatic pressure sensor capable of measuring the pressure of stationary fluids. Hydrostatic pressure is the result of the gravitational force acting on a static liquid at a measurement point. Irrespective of the shape or volume of the well or pipe, the hydrostatic pressure at the measuring point within the pipe or well remains directly proportional to the liquid's height. The formula for calculating the liquid level is as follows:

$$D = P_2 / (\rho * g) \tag{1}$$

P_2: Pressure of the liquid upon the sensor
ρ: Liquid density
g: Local gravity acceleration
P_1: Atmospheric pressure on liquid surface
D: Depth between the sensor and the liquid surface

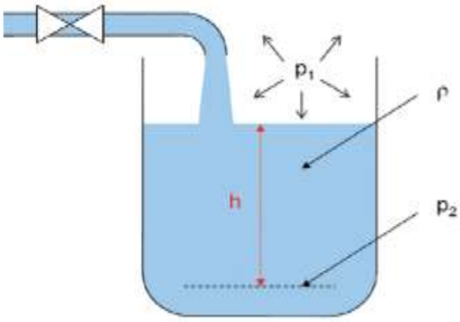

Fig. 6: Measurement of Water Level in an Open and Vented Pipe

In an open or vented pipe, there is a continuous equalization of pressure between the surrounding air and the gas phase above the liquid. The ambient pressure, which exerts an additional "force" on the medium, mirrors the ambient pressure affecting the entire system, including the level sensor. When using a relative pressure sensor that is already compensated for ambient pressure, it inherently corrects for the influence of this ambient pressure on the level measurement. In essence, a relative pressure sensor in a vented pipe effectively nullifies the ambient pressure above the liquid, allowing the hydrostatic pressure to solely represent the liquid's depth. Once the liquid pressure has been captured by the liquid level sensor, the signal is then amplified and adjusted by the circuit, and subsequently output as a standard 4 to 20 mA analog current signal. The relationship between the output current of the liquid level transmitter, the output voltage of the current-to-voltage module, and the depth is depicted below in Figure 7. It shows the relationship between the analog current ranging from 4 to 20 mA and voltage. The analog current will be converted to voltage signals ranging from 0.48 V to 2.4 V which represent liquid depth of 0 to 5 meters.

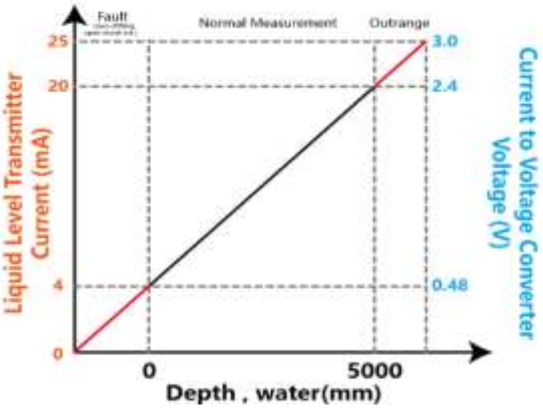

Fig. 7: Relationship of Output Current to Voltage

4.8 Blynk IoT Platform

Following the collection of liquid-level data by the sensor, the information is transmitted to an IoT platform known as Blynk. Blynk provides a comprehensive suite of software tools suitable for prototyping, deploying, and remotely managing connected devices, whether for personal IoT projects or scaling up to serve millions of commercially connected products.

Users can seamlessly connect their IoT devices to the cloud and construct iOS, Android, and web applications without the need for coding. These applications enable real-time or historical data analysis from the information sent by IoT devices. The platform additionally empowers users to remotely control their devices from anywhere across the globe and receive critical notifications, among other functionalities. Blynk streamlines the management of multiple devices performing identical functions through the use of Device Templates. Essentially, a Device Template comprises a collection of configurations. Once a template is created, IoT devices can be generated from it, inheriting all associated configurations. A crucial component within the template is the template ID, serving as a unique identifier for each template, which must be incorporated into the code on the IoT device.

Blynk can accept both raw and processed data originating from any sensor or actuator linked to the MCU board. A data stream serves as a conduit that informs Blynk about the nature of the data it carries. When data is transmitted to Blynk, it traverses a data stream using the Blynk protocol. Each incoming data point is automatically timestamped and archived within the Blynk Cloud database.

Virtual Pins play a pivotal role in Blynk, facilitating the exchange of data between IoT devices and the Blynk platform. These pins enable data to be dispatched from the Blynk App, processed on the microcontroller, and subsequently relayed back to the smartphone. Blynk can be harnessed to trigger functions, access I2C devices, perform value conversions, control servos, DC motors, and much more. Virtual pins also offer the flexibility to implement customized interface functionality and interface with external libraries like Servo, LCD, and others. When it comes to sending and storing data, it can be preserved in its original form or averaged into one-minute intervals. Averaging entails consolidating multiple values sent within a minute into a single value stored by Blynk. However, real-time data remains visible on the dashboard.

Blynk excels at visualizing data, enabling users to present it in the form of charts or graphs. Dashboards are constructed using building blocks referred to as Widgets. These user interface layouts are an integral component of the Device Template, ensuring that when the template's layout is updated, the user interface across all devices is also automatically updated. Blynk has some standard Widgets which are ready to use. Users can build their own dashboard based on their preferences. Besides, some function buttons can be created on the dashboard for example buttons to set the data collection time interval.

5 Results

In this section, IoT devices like Uno R3 microcontroller, LoRaWAN gateway, pressure-based liquid level sensor, and Blynk IoT platform are used to monitor the water level in an agriculture sector. The pressure sensor detects the water level and sends the same to the microcontroller. The microcontroller verifies the received sensed data with the threshold value. If the received data is greater than the threshold, then the valve will be in an off position and the pipe will not spill the water. If it is less than the threshold, then the valve will be on and the pipe will spill the water.

As previously mentioned, a 2-meter PVC pipe serves as a simulation for water table observation. The pipe is filled with water, reaching a height of approximately 1.7 meters. Subsequently, the sensor is positioned at the base of the pipe to gauge the pressure at its lowest point. The pressure measurements are then converted into liquid height, as elaborated in the previous section.

From the setup, the water level is measured and is transferred to the Blynk, an IoT platform. Figure 8 shows the data visualized in a line chart from Blynk using a web browser. The sensor measures the liquid level every 30 minutes for a total duration of 22 hours. The pipe has been fixed with a valve to release water with an appropriate flow rate. The reason for this release valve is to simulate the water level fluctuation to verify the sensor can detect and measure the changes in the water level.

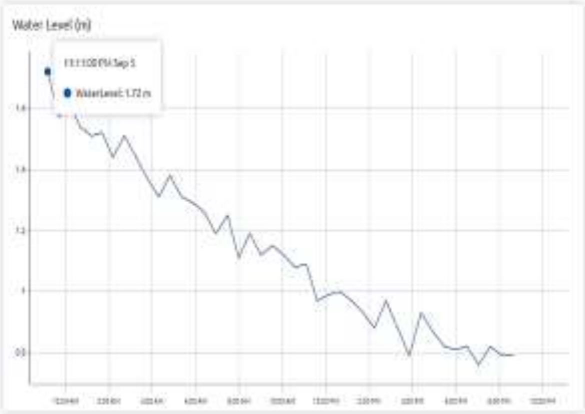

Fig. 8: Water Level Line Chart from Web Browser

Referring to Figure 8, the sensor measured the highest level which is at 1.72 meters. The water level was measured every 30 mins, the water level showed a reduction over time until approximately 0.8 meters in height.

Interval(s)
1802

Update Interval
OFF

Fig. 9: Water Level and Battery Life Information from Smartphone Apps

The sensed data is stored in the web browser and the same is forwarded to the smart devices. Apart from viewing the data from a web browser. Blynk also provides Apps for the user to view the data from a smartphone. Figure 9 shows the water level and battery life from the IoT node. Users can configure the update interval by using the customize update button in the Apps. The update interval is configured as 1802 seconds which is approximately 30 mins. The data also can be plotted in Blynk Apps. Figure 10 shows the water level line chart in auto-scale

Fig. 10: Water Level Data Line Chart in Blynk Apps

Continuous monitoring of sensed data i.e., water level monitoring and battery monitoring is stored in the web browser and also forwarded to the smartphone, which helps the farmer to monitor the agriculture fields and to enhance the crop yields.

6 Discussions

In this paper, a water monitoring system is designed with a low power wide area network and IoT devices. The major component is a pressure-based liquid level sensor. It detects the water level and forwards the same to the LoRaWAN gateway. With the internet, the sensed data is forwarded to the Blynk IoT platform. The water level is measured for every half an hour and the reduction rate of water is identified. As the time increases the water level reduces which is shown in Figure 9. As the water level reduces below the precision level then the PVC pipe will spill the water by opening the valve.

Along with the water level, the proposed network detects the battery level. It will help in continuous detection of the water level without system shutdown. This continuous detection and sharing of sensed data through smartphones helps the farmers to verify the crop growth and yield remotely. Agriculture precision monitoring systems help farmers to enhance their crop yield.

7 Conclusions

In this paper, the development and use of LoRaWAN-based IoT systems for monitoring water level fluctuation is considered. Initially, the prototype for measuring the water level has been designed, then coded, and finally tested successfully. The pressure-based liquid level sensor in the prototype measured the data and the same data was forwarded to the Blynk IoT platform by using LoRaWAN wireless communication technology. Besides, the IoT sensor node is capable of monitoring the battery status so that the battery can be charged or replaced before it runs flat to avoid any downtime. The battery life and water level data were able to be visualized in the Blynk IoT platform. The water level has been plotted in a line chart and the data is accessible either using a web browser from a PC or Blynk Apps via a smartphone.

Future work in the area of LoRaWAN-based IoT systems includes code optimization to maximize the battery life. Besides, the node can be added with more sensors that are capable of collecting different types of environmental data such as moisture sensors, rain sensors, etc., which will help to optimize the cost.

Acknowledgement:
This work was supported and funded by Leave a Nest Grant, MMUE/220070.

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Contribution of Individual Authors to the Creation of a Scientific Article (Ghostwriting Policy)

The authors equally contributed in the present research, at all stages from the formulation of the problem to the final findings and solution.

Sources of Funding for Research Presented in a Scientific Article or Scientific Article Itself

This work was funded by Leave a Nest Grant, MMUE/220070.

Conflict of Interest

The authors have no conflicts of interest to declare.

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