2018 Sixteenth International Conference on ICT and Knowledge Engineering

Smart Farm Monitoring via the Blynk IoT Platform

Case Study: Humidity Monitoring and Data Recording

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***Abstract*— The Internet of Things is a network of smart sensors that can control and monitor things from anywhere over the Internet. This smart system can be used to improve the productivity and quality of modern farming. Therefore, the present research aimed to propose a smart farming application powered by the Internet of Things. In this research, the prototype of a smart capsule was developed to measure the humidity in paddy bags stored in various locations within a warehouse. This smart capsule used Node MCU ESP8266 microcontroller and the SHT21 humidity sensor to send data to the Blynk server over a Wi-Fi network. Arduino IDE was used to write a C++ code for the microcontroller. The Blynk mobile application was used to monitor and display real-time humidity data through the digital dashboard. The collected humidity data were further analyzed and used to develop a paddy storage system for the future. In addition, when the smart capsule lost contact with the Blynk server, a notification was sent to responsible persons in a timely manner. The research results indicated that the developed smart capsules and Blynk application can effectively work together and are deemed suitable for use in smart farming.**

***Keywords*— *Smart Farm, Internet of Things, Blynk, Mobile Application, SHT21, Node MCU ESP8266*.**

I. INTRODUCTION

Thailand is classified as a developing country. Since its terrain mostly consists of lowlands suitable for agriculture, Thailand can produce a great number of agricultural products for domestic consumption and export to foreign countries. Particularly, rice is the country's main agricultural product and has been exported to many countries around the world. In 2017, Thailand's rice cultivation area increased by 9 million tons (12.7%) to 79 million tons, compared to 70 million tons in 2016. This shows that the country has the capacity to produce large amounts of rice each year. Thailand has exported an average of 10 million tons of rice annually, which can generate an income of more than 100,000 million baht per year [1]. After the process of harvesting, the paddy will be stored in a warehouse, as shown in Figure 1.

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Figure 1. Paddy bags stored in a warehouse [1].

Then the humidity of the paddy will be randomly measured by inserting a digital humidity meter (shown in Figure 2) into selected paddy bags. As there are many paddy bags that are stacked on each other, it is difficult to thoroughly measure the humidity in every paddy bag.

Figure 2. Digital grain moisture meter.

The Internet of Things (IoT) is a technology that connects people with things and enables real-time communication and data exchange. It is used to record, analyze, and evaluate data important for decision-making or achieving target conditions. Currently, the Internet of Things technology has been widely applied in various fields, such as measuring the amount of sunlight, temperature, and humidity suitable for agriculture [2], turning home appliances on and off with a smart home mobile application through the Internet [3], monitoring the amount of water and biogas as well as activating fire alarms in animal farms [4], providing flood warnings [5], and recording cardiac rhythms with an ECG measuring sensor [6]. Moreover, the Internet of Things can be compatibly combined with smartphones, making them more and more popular. There are mobile applications that are easy to use and support the Internet of Things such as Blynk, NETPIE, and Line Notify. In 2016, there were 31.7 million smartphone users, accounting for 50.5 % of the total population [7]. Figure 3 shows that the global number of devices connected to the Internet of Things and communication technology has steadily increased.

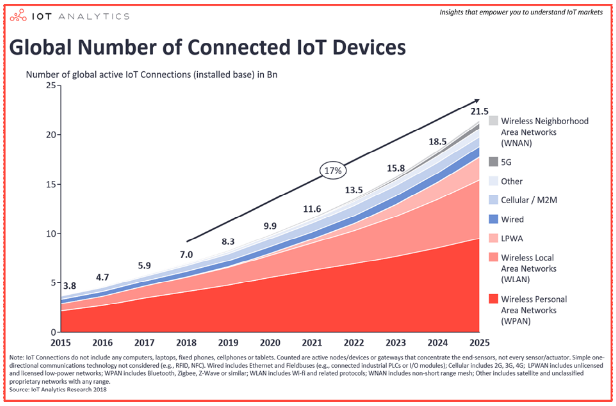

Figure 3. Global numbers of connected IoT devices [13].

From the above information, it can be seen that the humidity of the paddy has an effect on the process of humidity control and paddy storage before selling. Thus, the present research aimed to develop a smart capsule to measure and record the humidity of paddy stored in jute bags. The Blynk mobile application was used to monitor the real-time changes in the humidity of the paddy. The collected data can be used to analyze and determine effective paddy storage management plans. This experimental research mainly focuses on practical applications for the agricultural sector.

II. LITERATURE REVIEW

A. *Internet of Things*

The Internet of Things (IoT) is a network of physical devices. Kevin Ashton (1999) from the Massachusetts Institute of Technology proposed this concept and defined it as a network of things, including computers, mobile phones, refrigerators, doors, and cars that connect to each other and share data over the Internet. There are similar technologies that are closely related to IoT such as Machine-to-Machine (M2M), the Internet of Everything (IoE), ubiquitous computing, and embedded Internet systems. Physical things must contain microcontrollers and sensors in order to smartly connect with each other. These microcontrollers and sensors will send data to an IoT cloud server that functions as a hub for data exchange. The IoT has been extensively applied in various fields, as shown in Figure 4. In farms, the IoT is used to monitor the environment of mushroom cultivation houses [8]. It is estimated that by 2020 there will be more than 50 million things connected to the Internet [9]. The IoT wireless communication technologies that are widely used include the IEEE 802.11 wireless local area network (WLAN), the Low-Power Wide-Area Network (LPWAN), the narrow band Internet of Things (NB-IoT), and Sigfox. The IoT network protocols that are broadly known are MQTT and CoAP.

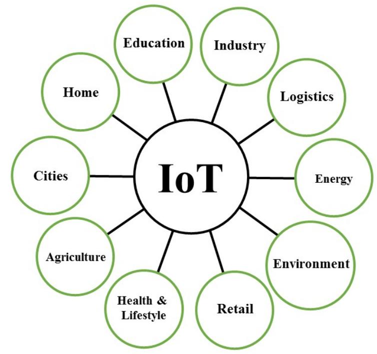

Figure 4. Applications of Internet of Things.

B. *Blynk*

Blynk is an IoT platform that supports both iOS and Android. It can compatibly work with many types of microcontrollers such as Node MCU ESP8266, Arduino, Rasberry Pi, and ESP32 over the Internet. It consists of three major components: 1) the Blynk application, which is used to control a device and display data on widgets; 2) the Blynk server, which is a cloud service responsible for all communications between smartphones and things; and 3) Blynk libraries, which include various widgets such as control buttons, display formats, notifications, and time management that enable a device to send data obtained from a sensor to be displayed on a mobile application in an effective and convenient way. The details are shown in Figure 5.

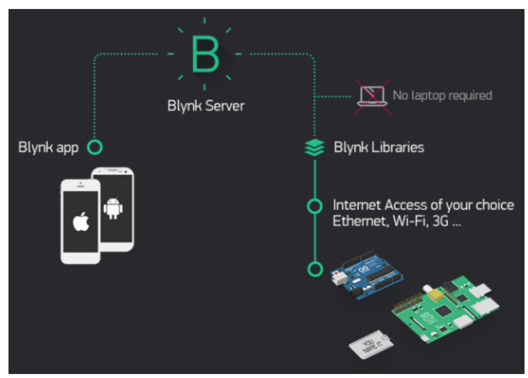

Figure 5. Blynk App working diagram [10].

C. *Node MCU ESP 8266*

The Node MCU is an opensource for the IoT platform that was invented in 2014. ESP8266 is a microcontroller [11] with a 160 MHz single-core CPU, a 32-bit reduced instruction set computer (RISC), IEEE802.11b/g/n 2.4 GHz Wi-Fi, and +19.5 dBm output at the antenna. The key characteristic of its real-time operating system (RTOS), which has been developed and produced by Espressif systems, is the power-saving architecture that features three modes of operation: active mode, sleep mode, and deep sleep mode. The sleep current is less than 20 µA. It is designed to work in many fields such as industrial, agricultural, and educational areas as well as smart homes. In addition, it can also operate in a wide temperature range of -40 Celsius to 125 Celsius. The chip dimension is 18 x 23 x 3 mm. The researcher selected to use ESP8266-12E in this research. Figure 6 shows the pin diagram of Node MCU

ESP8266. The general purpose input output (GPIO) pins were used to communicate with a sensor input: 16 GPIO pins, power: 3.3 volt, direct current. The advantages of Node MCU are that it can be connected to Wi-Fi, it is compatible with libraries that support a variety of sensors, and it is affordable. Therefore, it is suitable for use in the agricultural sector.

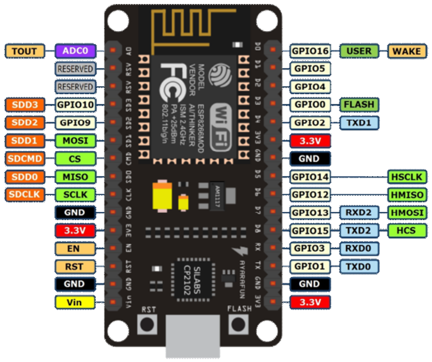

Figure 6. Node MCU ESP8266 pin diagram [12].

D. *Sensor*

SHT21 is a digital temperature and humidity sensor with a 12C interface and Hysteresis ±3 %RH. It is an affordable and easy to use sensor with high precision. The supply voltage ranges from 2.1 to 3.6. The package size is 3 x 3 x 1.1 mm. Figure 7 this sensor was selected to be used in the present research.

Figure 7. SHT21 temperature and humidity sensor.

E. *Programming*

The Arduino Integrated Development Environment (IDE) is an open-source application software that is used to write programming codes for microcontrollers in the Arduino family. The C/C++ programming language was used in this research.

III. SYSTEM DESIGN AND IMPLEMENTATION

A. *Concept diagram*

Figure 8 shows the conceptual process of smart farm monitoring. Humidity data are sent from the SHT21 sensor to the Node MCU ESP8266 microcontroller before being forwarded to and stored in the Blynk server through wireless communication. When users want to view the data they need, they just need to open the Blynk on their mobile phone.

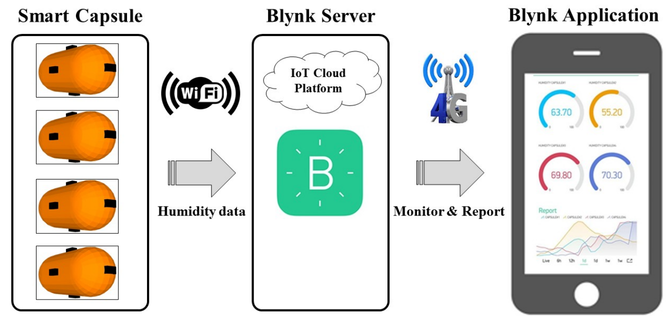

Figure 8. Architecture of smart farm monitoring.

B. *Smart Capsule Prototype*

A prototype design is the process of simulating a 3D smart capsule according to the predetermined color, dimension, and installing location of the microcontroller and sensor with the use of a computer program. The smart capsule prototype shown in Figure 9 can be clearly seen from every angle, allowing the researcher to modify or add necessary details before creating a real one.

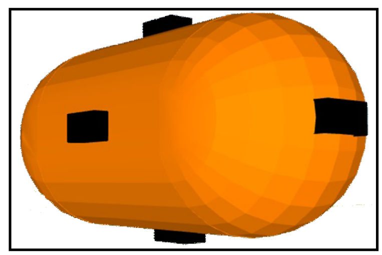

Figure 9. Smart capsule design prototype.

C. *Circuit design*

It was essential to design a circuit diagram of a microcontroller, sensor, and battery using the Fritzing program, as shown in Figure 10, because faulty electric wiring could cause damage to related devices.

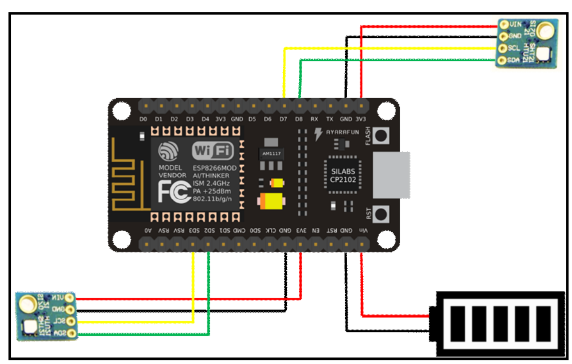

Figure 10. Circuit design from Fritzing software.

D. *Phototype Implementation*

A smart capsule was designed in a cylinder shape similar to a medicine capsule so that it could be easily inserted into a paddy bag. The external surface was made of reflective orange plastic in order to make it easily noticeable. The smart capsule size was 26 x 9.5 x 19 cm. The microcontroller, sensor, and battery were placed in each capsule.

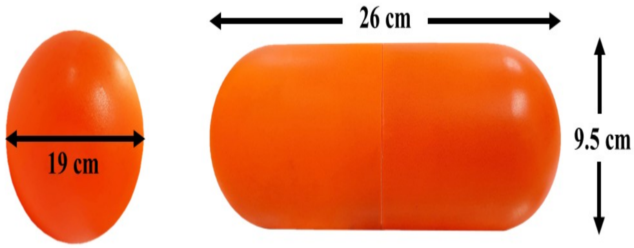

Figure 11. Smart Capsule.

E. *Microcontroller*

The Node MCU ESP8266 was mounted on a printed circuit board (PCB) while the sensor and battery were attached to the back of the PCB with a wire.

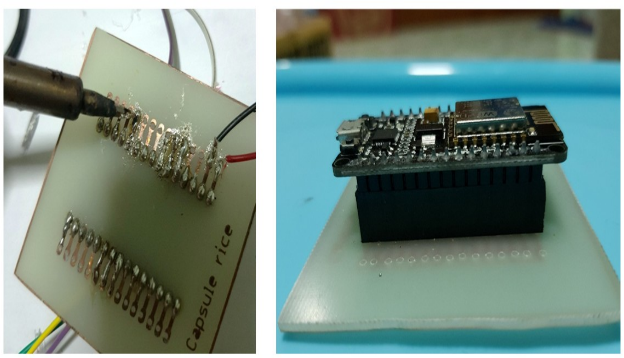

Figure 12. PCB soldering.

F. *Blynk Digital Dashboard*

A Digital dashboard is a graphic interface that is created by selecting, dragging, and dropping widgets from the widget box. Every widget needs some energy to operate. When each Blynk account is created, a user will be receive 2,000 energy. The energy balance will decrease once a widget is used as the details in Figure 13 indicate. The 3 widgets used in the present research were as follows.

- Gauge widget for viewing real-time data.
- Super chart widget for viewing graphical data and comparing the humidity data in each period.
- Notification widget for sending an alert when abnormal data are detected or when the microcontroller cannot be contacted due to a power shortage.

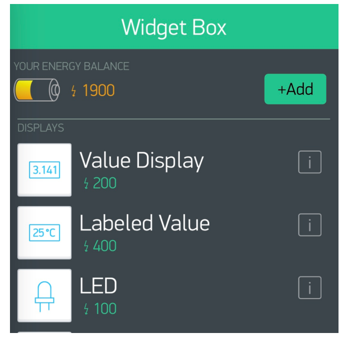

Figure 13. Screenshots of widget box.

G. *Experiment*

After all of the smart capsules were completely developed and activated, they were installed in the middle of paddy bags so that they could accurately measure the humidity of the paddy. The humidity data obtained from the smart capsules were displayed in the Blynk on a real-time basis.

Figure 14. Smart capsule in paddy bag.

IV. RESUALTS

As excessive humidity can negatively affect the quality of paddy, this experimental research used the IoT technology to measure and monitor its humidity. The developed real-time monitoring system can measure the humidity of paddy at any time, especially in inaccessible areas where many paddy bags are stacked on each other. Once the paddy bags stored in certain locations within a warehouse are reported to have high humidity, a responsible person can be alerted and solve the problem in a timely manner. The results of this research are described in greater detail as follows.

A. *Smart Farm Monitoring*

The paddy humidity data can be displayed on a smartphone through the use of the Blynk mobile application. The digital dashboard was created to show the humidity data obtained from the smart capsules. The smart capsules were able to measure and monitor the humidity of the paddy bags in the 4 storage locations within the warehouse. The gauge widget was used to display the data in real time, whereas the super chart widget was used to compare the humidity of paddy in the 4 different locations in form of graphical data, as shown in Figure 15. In this way, the responsible person could track and monitor the humidity of the paddy at any time and from any location.

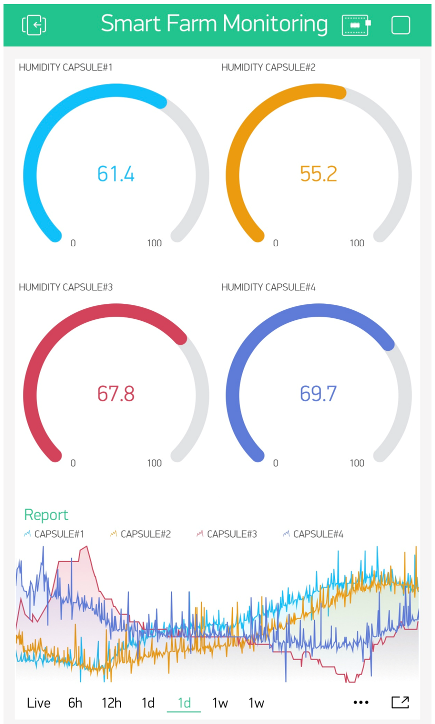

Figure 15. Screenshots of the humidity data from all capsules.

B. *Super Chart Widget*

Figure 16 shows the humidity data on an hourly basis. The data obtained from the 4 smart capsules were displayed in the form of a multiple-line graph in order to easily compare and monitor the changes in the humidity data on a real-time basis, hourly, every 6 months, or on a daily basis. The historical data could also be viewed on the dashboard. In addition, the data stored in the database could be exported into a CSV file for analysis purposes.

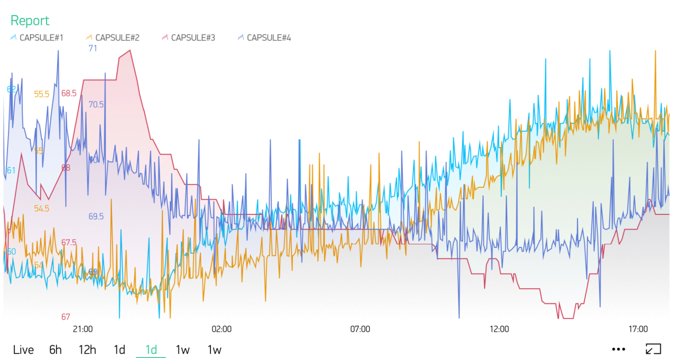

Figure 16. Real-time data shown on the super chart widget.

C. *Database*

The paddy humidity data displayed on the super chart widget were collected in the database in order to create a report. The report would be sent to the specified email address in the form of a comma-separated values (CSV) file, as shown in Figure 17. The date and time when the humidity data were recorded were clearly shown, making it easier to identify the changes in humidity levels. The obtained data could be further analyzed using the Microsoft Excel program in order to improve the paddy storage system in the future. The humidity data retrieved from the Blynk IoT server that stored all of the data sent from the sensor.

Humidity	Date	Time(GMT)
68.9	3 ตุลาคม 2561	10:50:00 AM
87.55	3 ตุลาคม 2561	10:51:00 AM
61.96666667	3 ตุลาคม 2561	10:52:00 AM
59.75	3 ตุลาคม 2561	10:54:00 AM
61.06666667	3 ตุลาคม 2561	10:55:00 AM
61.3	3 ตุลาคม 2561	10:56:00 AM
61.73333333	3 ตุลาคม 2561	10:59:00 AM
61.8	3 ตุลาคม 2561	11:00:00 AM
61.7	3 ตุลาคม 2561	11:01:00 AM
61.9	3 ตุลาคม 2561	11:02:00 AM
62	3 ตุลาคม 2561	11:03:00 AM
62.05	3 ตุลาคม 2561	11:04:00 AM
62.1	3 ตุลาคม 2561	11:05:00 AM
62.1	3 ตุลาคม 2561	11:06:00 AM
62.225	3 ตุลาคม 2561	11:07:00 AM
62	3 ตุลาคม 2561	11:08:00 AM
62.375	3 ตุลาคม 2561	11:09:00 AM
62.2	3 ตุลาคม 2561	11:10:00 AM

Figure 17. CSV file from Blynk server.

D. *Smart Capsule System Status*

The Blynk mobile application was able to monitor the status of each IoT device as shown in Figure 19. The "online" status showed that the device could work normally while the "offline" status indicated that the device encountered some problems, such as running out of battery or losing Internet connection. Once one of the capsules was offline, the system administrator would be immediately notified in order to check the problem and fix the device in a timely manner.

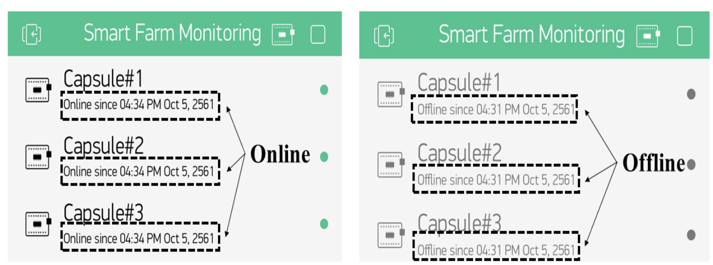

Figure 18. Online/offline status of the smart capsules.

E. *Blynk Notification*

A notification would be sent in case any device was disconnected from the system. Once there was an offline device, the Blynk application would send an alert message to the system administrator's smartphone, as shown in Figure 20. The notification widget allowed the system administrator to set the format of the notification message and specify the target email addresses on his/her own. Thus, when a device was offline, the system administrator would be alerted and be able to solve the problem in time.

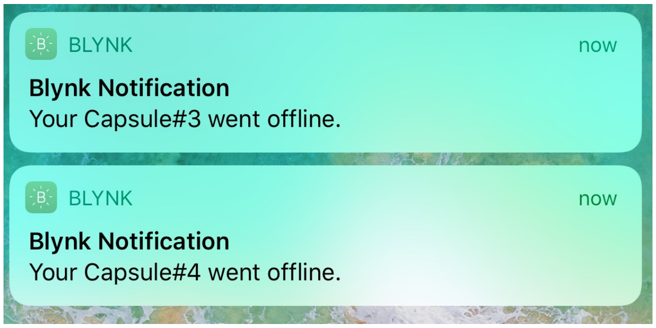

Figure 19. Blynk notification alert on the mobile screen.

V. Conclusion

The present research focused on applying the IoT technology to monitor the humidity of paddy bags stored in a warehouse using smart capsules. According to the research results, the Blynk mobile application could work well on Android and iOS. Blynk users can use basic widgets for free. However, an additional payment is required in case they want to use a lot of widgets. In the present research, the researcher spent about 300 USD to create the hardware. The results suggested that the Blynk server could systematically store the humidity data sent by the sensor installed within each paddy bag. Moreover, the Blynk application was able to effectively display all of the related data, including the humidity sensed by each smart capsule, the status of each device, and the multiple-line graph comparing the humidity data from the 4 smart capsules at each specific time, on a real-time basis. This indicated that the developed system was suitable for monitoring the humidity of paddy in order to prevent excessive humidity, which is the main cause of paddy rotting.

VI. Future work

Future research should be conducted to improve the shortcomings of the present study, for example, reducing the size of smart capsules so as to increase space for paddy storage, installing a humidity meter outside a paddy bag for easier installation and removal, and applying communication technologies that are more compatible with IoT, such as LoRa and NB-IoT.

ACKNOWLEDGEMENT

The authors would like to thank Department of Information Technology, Faculty of Industrial Technology and Management, King Mongkut's University of Technology North Bangkok for financial support.

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