IOT for Smart Farm: A case study of the Lingzhi Mushroom Farm at Maejo University

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***Abstract* --This research aims to prototype a smart Lingzhi mushroom farm. This research applied the use of IOT with a sensor to measure and monitors the humidity in the Lingzhi mushroom farm. The humidity data processed through NETPIE was developed and provided by NECTEC as a free service for IOT. Humidity data was stored into a NET FEED (a sub service from NETPIE) and displayed on mobile devices and computers through NET FREEBOARD (another sub service of NETPIE). This research also controlled sprinkler and fog pumps automatically and the functional status (switching on and off for periods of time) pushes notifications through LINE API on the LINE Application. The equipment and tools used in this research were NodeMCU, humidity sensor, RTC (real time clock), relay module, sprinkler and fog pumps. C++ and Node.JS were used as programming. The services and protocol used were NETPIE (Network Platform for internet of everything) with subservices such as NETPIE FEED, NETPIE FREEBOARD, and NETPIE REST API. The results of the research showed that using IOT with the sensor enhanced the prototype of smart farming.**

Keywords : IOT ,NETPIE, LINE API

I. INTRODUCTION

A. Background

The Thai government would like to promote Thailand 4.0 to use a new technology for Thai agriculture. Therefore, Maejo University Chiangmai, has a concept to develop a prototype of a smart Lingzhi mushroom farm by using current information technology to control the environment. The reason for developing the smart Lingzhi mushroom farm is to promote a new modern agriculture to Thai farmers. Controlling the environment of mushroom light, temperature, humidity and air flow are all needed, [1] however research done by Maejo University showed that humidity was the most important factor for the growth of the spores and leaves of the Lingzhi mushroom. This research applied the use of IOT with the humidity sensor to measure and monitor the humidity in the Lingzhi mushroom farm as well as control the irrigation automatically.

B. Research objective

This research aims to develop a prototype of a smart farm using technology IOT, NET and LINE API to measure and monitor the humidity of the Lingzhi mushroom farm and control the sprinkler and fog pumps automatically.

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II. Literature review

Internet of Things is an internet application which involves three kinds of technologies, that is 1) perception, 2) transmission and 3) intelligent processing [2]. Internet of Things combines sensor technology, communication networks, internet technology and intelligent computing technology to achieve reliable intelligent processing [3]. The protocol commonly used for the internet of things is MQTT. MQTT (Message Queuing Telemetry Transport) is a broken-based publishing/subscribing, instant messaging protocol. It's designed to be open, simple, lightweight, and easy to implement. The advantage of the MQTT protocol is that it solves the problem of instantly pushing various messages from the server to the mobile devices.

NETPIE is a cloud-based platform service that facilitates interconnecting IOT devices (things) together in the most seamless and transparent manner. This is made possible by pushing the complexity of connecting IOT devices from the hands of application developers or device manufacturers to the cloud. NETPIE also provides micro-gear libraries, firmware or SDKs that facilitate communication channels and other functionalities between things and the NETPIE platform. Micro-gear is open-source. NETPIE is not managed by MQTT brokers. NETPIE creates our own publish-subscribe communication model that allows instant messaging among IOT devices (things). This communication model can support both the MQTT protocol and the HTTP REST protocol. To make things communicate over the MQTT protocol, it uses the KEY and SECRET which we (these researchers) have created on the NETPIE web for authentication [4].

LINE API provides a service called LINE Notify that can send messages or notices to the LINE Application. The service used is a common HTTP POST. Access Token is applied as a code when using LINE API [5]. In this research NodeMCU sends messages of the functional status when switching on and off from the sprinkler and fog pumps to the API service. Notifications are then sent to the LINE Application.

NodeMCU is an open source IOT platform. It includes firmware which runs on the ESP8266 WI-FI SoC (System-on-chip) from Espressif Systems Company (from Shanghai, China). It is a 32 bit Microcontroller. In this research NodeMCU used an ESP-12 module or NodeMCU version 2. NodeMCU is similar to the Arduino which has built in input and output ports. NodeMCU is compatible with Arduino IDE where programming C++ can be written. For compiling and flashing programming codes, it can be done using microB-USB. NodeMCU has advantages on Arduino where it is smaller and can connect to WIFI [6].

Previous research

Previous research [7] was applied using IOT with RFID to find the best practice of logistic management for the Electricity Generation Authority of Thailand (EGAT) Mae Mao Mining, Lampang. Their research applied the use of RFID for lignite coal trucks and data from the RFID process automatically through a server and was stored into a private cloud computer. The equipment and tools used in their research was an RFID reader, UHF passive RFID tags, Arduino Mega 2560 + Ethernet Shield, PHP, Jason, Node.JS, and Maria DB as a database system. The protocol used was MQTT. The results of the research showed that officers who worked for related systems were satisfied. The system enhanced the best practice of lignite coal mining logistics in terms of information checking.

In this research, the authors would apply the concept from previous research using IOT technology. NETPIE services developed by NECTEC was also applied into their current research to process data via the internet and stored in a cloud computer. This was able to be displayed on computers and mobile devices. In addition, LINE API was also included as a functional status to send notifications on the LINE Application. For hardware selection, NodeMCU was selected, instead of using Arduino Mega 2560 + Ethernet Shield that was suggested by Chieochan, Saokaew and Boonchieng.

III. RESEARCH METHODOLOGY

Following the waterfall model of the system development life cycle (SDLC), there are 5 steps in this research. These steps are the requirement and feasibility study, system analysis and design, implementation, system validation, and maintenance.

A Requirement and Feasibility study

The requirement of this research was to prototype a smart Lingzhi mushroom farm. The humidity was the most important environmental aspect that needed to be controlled in the Lingzhi mushroom farm. Automatically switching on and off the water sprinkler and the fog was required. The period of time of the watering was dependent on the humidity of the Lingzhi mushroom farm. The suitable humidity needed by the Lingzhi mushroom farm is between 90-95%. Moreover, the system should be cost effective and requires simple maintenance. Humidity data was sent to cloud computing (using NETPIE services) and was shown on computers and mobile devices. The status of watering was noticed on computers and mobile devices.

For this research, we selected IOT as smart technology for the smart Lingzhi mushroom farming. The tools, software and protocol used are shown in fig. 1 and table 1-3.

TABLE I: Hardware and purposes of the use

Hardware	Purposes of use
NodeMCU V2 (ESP8266 -12E)	Control devices and send data into internet via WIFI connection
Sensor DHT22 / AM2302	Temperature and humidity sensor
RTC I2C Module DS1307 (Real time clock)	Time stamp
Relay Module 2 channel 5 V	Control (switch on and off) sprinkler pump and fog pump
Sprinkler pump AC 220V 370W Q.Max 1.5m/h	Sprinkler irrigation
Fog pump 3.0 Lpm 12 BAR 24 VDC 2.5A	Fog irrigation
LCD 20X4 with I2C interface	Display functional status

TABLE II: Software and purposes of the use

Software	Purposes of use
C++ on Arduino IDE	Programming language on Node MCU
Node.JS	Information retrieval into JSON formatted on NETPIE REST API and information conversion into CSV formatted

TABLE III: Service and Protocol and purposes of the use

Service and Protocol	Purposes of use
NETPIE (Network Platform for Internet of Everything)	Platform and service of IOT for humidity data management
NETPIE FEED	Store humidity and time data on cloud computing
NETPIE FREEBOARD	Display humidity and time data on mobile devices
Line API (Application Programming Interface)	Notify functional status of sprinkler and fog pumps on the LINE Application
NETPIE REST API (Representational State Transfer Application Programming)	Information retrieval interface

B. System Analysis and Design

The research was done during the winter season. The average daily temperature was 20 to 25 degree Celsius. It was considered suitable for the growth of the Lingzhi mushroom. [8] Therefore, the development of the IOT system was not designed to control and measure the temperature. However, a DTH22 was a bi-functional sensor measuring temperature and humidity at the same time. In this research, only humidity of the Lingzhi mushroom farm needed to be measured. Functional status of the sprinkler and fog pumps were needed to send notifications (switching on and off automatically). The average humidity should be 90-95%. The Lingzhi mushroom farm was also designed using local materials. Light, air flow and air ventilation were not considered in this research.

Concept diagram

In this research, IOT was applied with the humidity sensor, to measure the humidity of the Lingzhi mushroom farm. It also controlled the switching on and off of the water sprinkler and fog automatically. NodeMCU was applied as hardware with WIFI for the IOT to connect with the Maejo University access point. This allows it to be able to connect to the internet. A service used to send humidity data to an internet was NETPIE, and the sub service used was NETPIE Freeboard to real-time display humidity data and time stamp on smartphones and computers [9]. Another sub of NETPIE used was NETPIE Freed to record humidity data and the time stamp on cloud services [10]. The information retrieval used was Node.JS on NETPIE REST API [11]. LINE Notify was used to notice the functional status of water sprinkler and fog.

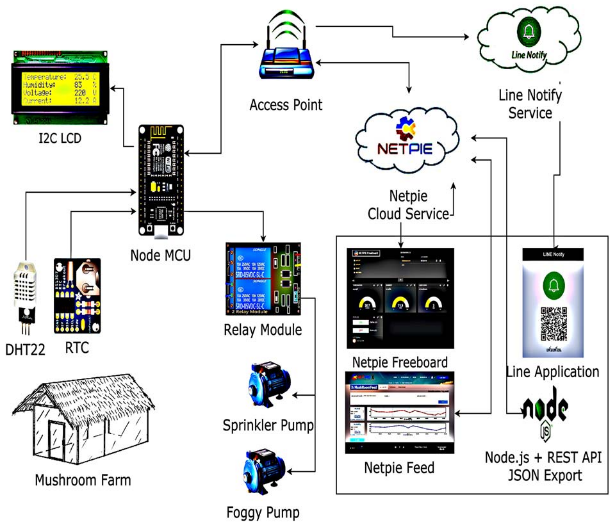

Figure 1. A conceptual diagram of the intergraded systems of smart Lingzhi mushroom farm monitoring and controlling using IOT, NETPIE and LINE API

The total time to cultivate the Lingzhi mushroom is between 90 to 120 days. The first 40 days is in a nursery farm. From days 40 to 120, it is cultivated in the Lingzhi mushroom farm for the purpose of spores and leaf collection. An irrigation of the water sprinkler is made in the first 20 days and water drops are needed on the Lingzhi mushroom leaves. This accelerates the process of increasing mushroom spores. The irrigation of the water sprinkler is three times a day (09.00, 13.00 and 15.00) and for five minutes long each time. For water fog, the moisture must be controlled and is needed throughout the Lingzhi mushroom cultivation. The condition of the watering fog is on the humidity between 90 to 95 percent.

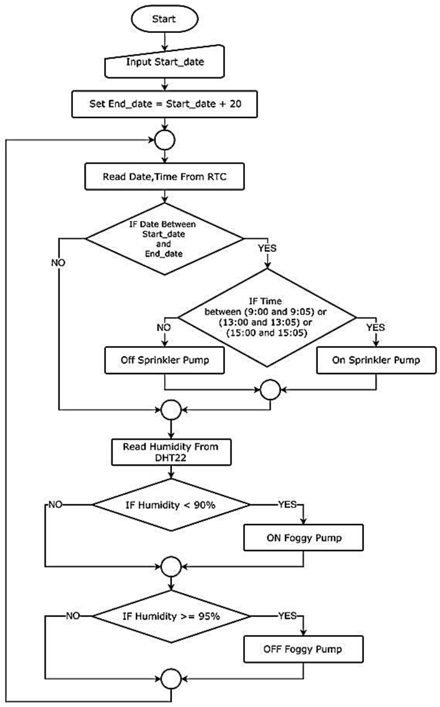

Figure 2. The flow chart of condition of watering the Lingzhi mushroom farm on sprinkler and fog systems

C. Implementation

All electronic devices are put in a waterproof control box. The installation of the control box is located at the front of the mushroom farm. Sprinkler and fog pumps were allocated at the back of the Lingzhi mushroom farm. There were 3,500 Lingzhi mushroom cultivated in the mushroom farm. The size of the mushroom farm was 4m. X 6m. X 3m. (width, length and height). Sensor DHT22 / AM2302 Temperature and humidity sensors were located in the middle of the mushroom farm.

Figure 3. Location to install IOT systems and sprinkler and fog pumps.

Figure 4. An IOT system in a control box

In this research, two watering systems to control the humidity of the Lingzhi mushroom farm were applied. The black tube was a sprinkler which was on the top. The white tube was a fog system which was below. The sprinkler system was to accelerate the process of increasing the Lingzhi mushroom spores. Water drop were needed to cover the Lingzhi mushroom leaves. The fog system was used to control the humidity of the Lingzhi mushroom farm between 90 to 95 percent of humidity, which was suitable for the growth of the Lingzhi mushroom.

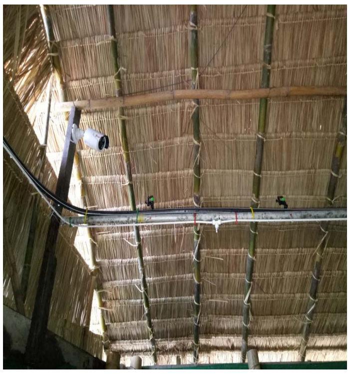

Figure 5. Sprinkler and fog systems

In order to connect WIFI, NodeMCU supports WIFI standard IEEE 802.11b/g/n. In this research, Fixed IP address mode was taken.

Figure 6. NodeMCU connecting WIFI

D. System Validation and Maintenance

In order to make sure the humidity sensor and IOT system cloud measured the humidity correctly, the wet bulb and dry bulb thermometers were used for validation.

The comparison of the results of humidity read by IOT and wet bulb and dry bulb thermometer (manual read) were taken into account. The humidity data in the fig. 7 showed that humidity data read by IOT system and human went the same direction. However, humidity data read by IOT was more detailed as the digits were in decimals.

In addition, fig. 5 CCTV (closed-circuit television) was installed to monitor the status of the watering system. This made sure the pumps were working.

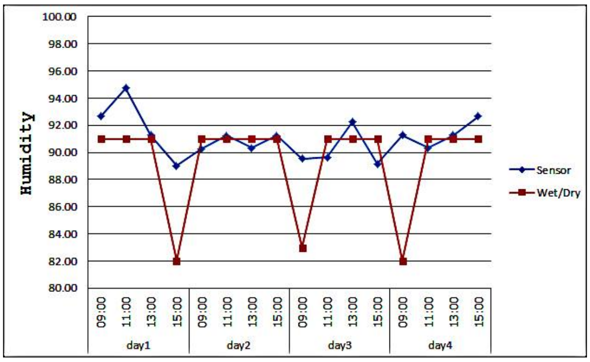

Figure 7. A comparison between humidity data measured by IOT system and human (manual)

Figure 8. IOT system and wet bulb and dry bulb thermometer measuring and monitoring the humidity of the Lingzhi mushroom farm

IV. Results

Humidity data read from DHT22 sensor can be displayed in many ways. It can be shown on the LCD where it's located in front of the control box. It can also be shown on mobile devices. NETPIE services with sub services such as NETPIE FREEBOARD and NETPIE FEED were implemented in this stage. The functional status of sprinkler and fog pumps (switching on and off) and time stamp can be noticed via LINE Application.

Figure 9. Humidity, temperature and time stamp were shown on LCD screen

NETPIE FREEBOARD (IOT Dashboard) was a web application provided by NECTEC. MJU smart Lingzhi mushroom farm was a private freeboard then key and secret were also needed and they were generated by NETPIE. It was an open-source with real time updates and it was considered stable and reliable. It was supported by Google chrome, Firefox, Safari, but Internet Explore was not supported. In this research, a service of NETPIE FREEBOARD can display humidity data read from DHT22 every 5 minutes. Information consists of time stamp, status of sprinkler and fog pumps.

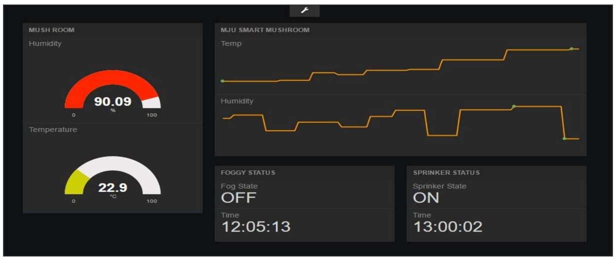

Figure 10. Real time humidity data of Lingzhi mushroom farm was shown on NETPIE FREEBOARD

Humidity data read from DHT22 was stored into a cloud computing service by NETPIEFEED. Information could be displayed in a time series graph to monitor the change of humidity of the Lingzhi mushroom farm. Historical information of the humidity of the Lingzhi mushroom farm also could be retrieved.

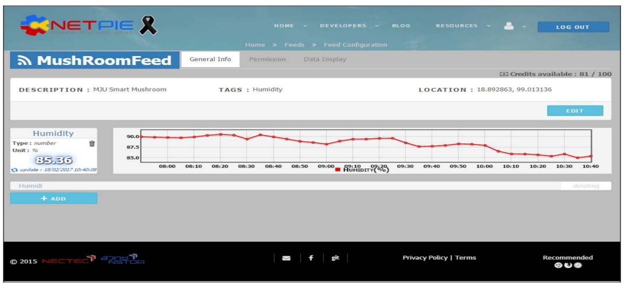

Figure 11. The graph of humidity data of the Lingzhi mushroom farm was shown on NETPIE FEED

The LINE Application sent notifications when the status of the sprinkler and fog pumps were turned on and off. Members in a LINE group were informed.

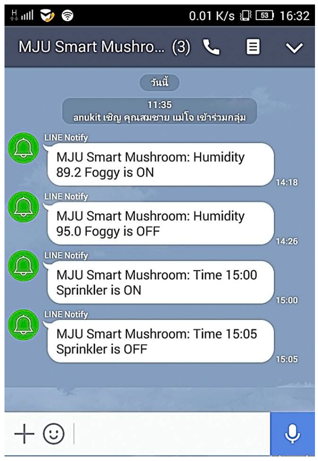

Figure 12. Functional Status of the sprinkler and Fog pumps were notified on LINE Application

Historical humidity data was stored in a service by NETPIE FEED which could be retrieved using REST API via the GET method and the result would be in JSON format. Node.JS was applied to retrieve the humidity data into JSON format. The time was shown as GMT UNIX Timestamp (milliseconds). As a Thailand time, UTC + 7 was needed to add. From the fig. 13, UNIX Stamps was 1487390706069 and converted to human readable date was 18 February 2017.


```
{
    "feedid":"mushroomfeed",
    "description":"MJU Smart Mushroom",
    "since":[1,"months"],
    "granularity":[1,"hours"],
    "data":[
        {
            "attr":"Humidity",
            "unit":"%",
            "values":[
                [1487379005698,89.92500000000001],
                [1487379605844,89.79166666666669],
                [1487383206795,88.7030769230769],
                [1487386805660,85.85083333333334],
                [1487390405855,82.735]
            ]
        }
    ],
    "lastest_data":[
        {
            "attr":"Humidity",
            "values":[[1487390706069,82.2]]
        }
    ]
}
```


Figure 13. JSON format retrieved from NETPIE FEED

V. Discussion

There were 2 points to discuss in this research. One was on economic perspective using IOT system being worth the investment. Second was on the limitation of using NETPIE FEED service from NETPIE.

Firstly, for economic perspective, a new developed IOT system was considered worth the investment. The electronic equipment cost approximately 2,000 Baht including

NodeMCU V2 (ESP8266 -12E), Sensor DHT22 / AM2302, Relay Module 2 channel 5 V, LCD 20X4 with I2C interface and some electric lines (excluding sprinkler and fog pump).

It is assumed that IOT is a computer. If one computer operated for one month for 24 hours a day, the electricity bill would be 420 Baht [12]. The Lingzhi mushroom farm cultivated for 4 months. The electricity bill would be 420X4= 1,680 Baht.

The labor cost in Thailand is 300 baht per 8 hour working day. It would cost 9,000 x 4 months = 36,000 Baht to employ laborers to measure the humidity and switch the sprinkler and fog pumps on and off.

It would be approximately 10 times cheaper to use the IOT systems over manpower to do the same job.

Secondly, NETPIE FEED is available free for users. It is developed and provides services by NECTEC. IT needs to share resources appropriately. FEED rate is limited to writing the API key to four times in about 60 seconds or 15 seconds on average to be written in one spot. To be noted that NETPIE FEED allows data to be stored for one year. Reading data from NETPIE FEED is limited to 5 times in 4 seconds [4].

VI. Conclusion

IOT Technology was applied for the smart Lingzhi mushroom farm. The development of the IOT system was used for 4 months throughout the Lingzhi mushroom cultivation period. The developed IOT system was considered stable. Humidity data was considered reliable and accurate (if compared to the information done manually). The functional status of sprinkler and fog pumps were done correctly. The project leaders of smart Lingzhi mushroom farm from Maejo University, ChiangMai were satisfied.

VII. Future research

Future research could be done for the improvement of the IOT system. Firstly, Solar cell should be applied to integrate into a current IOT system. It should be portable and easy to use for farmers in the isolate area. Secondly, Linkit One with GSM should be applied to replace NoeMCU, in case the Lingzhi mushroom farm has no WIFI, GSM would be an option. For Maejo University, the comparison of the growth of the Lingzhi mushroom between the farm using the IOT system and using traditional manual is taken.

VIII. Acknowledgments

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