Development of Temperature and Humidity Control System in Straw Mushroom Growing Farms with the Concept of Internet of Things (IoT)

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Keywords: Control system, Temperature, Humidity, Straw mushroom growing farms, Internet of Things (IOT).

Abstract: The objectives of this research were to develop electronic temperature and humidity sensor and to develop the application to control temperature and humidity in the straw mushroom growing farms by connecting to electronic devices to check for the straw mushroom farms to have the right temperature and humidity, reduce workflows of the operation in the aspects of temperature and humidity and to improve the yield of straw mushrooms to have quality and save labor and time. This is done by using the Internet system coupled with software development tools under the concept of Internet of Things (IoT). In this study, the researcher developed a sensor for managing temperature and humidity through a web application to turn on and off the water system, lighting and ventilation fan to control the temperature in the straw mushroom growing farms. Tools and applications used in this study were Node MCU ESP8266 board development set, temperature-humidity Sensor, relay equipment, water and lamp system, wires, and PCBs. All devices were developed to be integrated with Arduino software. C / C ++ and PHP were used for the development. The methods of study and system development was started by studying the information about straw mushrooms and straw mushroom area to collect information from the operator. All data was analyzed to be a guideline for the development, planning, designing development of equipment and software systems, preparing the development tools. The control scope was defined in system design. After the system has been developed, the equipment and software were tested in straw mushroom growing farms. The system performance and problems encountered by system testing were analyzed. The system was also updated from problems encountered. The system performance was also summarized the before being used as a model for further development in the future.

1 INTRODUCTION

"Straw Mushroom" is an agricultural product and one of industries that has driven the country's economy. It is a popular consumable agricultural product. It is highly nutritious, delicious, inexpensive, and can be processed into a variety of food. (Autrakul, 1997) The market demand is high. It is an economic mushroom that grows on a stack of moist rice straw. It is a fungus that grows starting with the fibers of the fungus grouping within a few hours in an appropriate environment. The increasing demand in the market makes straw mushroom cultivation becoming more and more popular. There is a need for internal straw mushroom farms management to control temperature by using thermometer in each mushroom farms with staffs to periodically walk and check the temperature. If the temperature is high, water would be turned on to lower the temperature. If the temperature is low, it is necessary to turn on the bulb to warm up the temperature in the mushroom farms. This is the background of the problem with the growth of mushrooms and the need to use labor to maintain and control the temperature and regularity of mushroom farms at all times. This would cause labor and time. (Chang and Philip,2004)

From the basic information, the researcher collected the data and analyzed the problem from the operator of The muchroom farm. The process was carefully supervised at every step to control the temperature of the mushroom farms.

It was found that the cost of cultivating 1 mushroom is 2,500 baht, revenue from harvesting mushroom is approximately 5,000 baht or profit

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about 2,500 baht per farm. Mushroom investing can be done twice in 1 month. The average yield is 30-50 kg. 1 kg of mushrooms can be sold in the market at the price of roughly 75-80 baht. From the problems encountered, if the temperature and humidity in the mushroom farm is high or too low, it will result in mushrooms do not flower, low production or damage. This results in mushrooms not being of desire standard size and sold at low prices.(Chang,1980) The appropriate temperature for straw mushroom flowering is fibrous mushroom that is approximately 32-40 degrees and the humidity in straw mushroom flowering is at 80-90% and the temperature is good for the flowering of the mushrooms are at 28-32 degrees and good humidity in flowering will be 70 - 80 % (Chang 1974;Chang,1996) From the information, it is important to know that the temperature and humidity control of mushroom cultivation is an important factor so responsive application would be developed by being connected to the electronic device developed by Internet of Things (IOT) concept (Vermesan and Peter,2013) to develop a temperature and humidity management system to turn the water, lighting, and ventilation fan system on and off in order to control the temperature and humidity in mushroom farms through an application by the functionality of the Internet coupled with technological devices. This would be done by using temperature and humidity sensors in mushroom growing farms instead of using only thermometer.

2 OBJECTIVE

1. To develop an electronic device to detect and control temperature and humidity in mushroom growing farms.
2. To develop application systems to control temperature and humidity in mushroom growing farms by being connected to the electronic equipment to monitor each stage within mushroom farms for achieving the appropriate temperature and humidity.

3 EXPECTED BENEFITS

1. The system reduces the operation of the mushroom farm operators in the aspects of temperature and humidity control.
2. The system helps to save labor costs and time to work.
3. The system will improve the straw mushroom output rate and quality standards in production.

4 MATERIALS AND METHODS

4.1 Tools and Equipment Used

1. Node MCU ESP8266 board
2. DHT22 temperature and humidity sensor
3. Relay turning on and off the water and light bolt
4. Jumper
5. PCB board
6. Arduino program
7. C/C++and PHP languages of Programming

5 LITERATURE REVIEW

5.1 Theory and Factors Affecting Straw Mushroom Growth

Straw mushroom life cycle mushroom is a low class plant. Seed spore falling on relative good humidity, temperature, and food, will grow into mushrooms. It grows to a fin and a flower. When factors affecting the growth of mushroom were studies, it was found that besides, the materials used, factors affecting growth were also appropriate acidity, light, temperature, humidity, climate and environment. The size of each straw mushroom farm is 4x5 m, which is divided into two sides, there were 3 layers on each side. Each layer is 80 cm high, with a distance of no longer 1 m from the wall of the farm. The temperature has a direct impact on the growth of each mushroom species starting from spore growing, the growth of the fiber to the point of being mushroom right temperature in each range. Material humidity and relative humidity in the air must be taken into account, which means the amount of water vapor in the air at that time. The relative humidity of mushrooms is 60%. The relative humidity creation in the air is done spraying the water system or fog system to increase the relative humidity. Additionally, the light is something is needed to be controlled especially light from the sun because it will directly affect the temperature and humidity. However, mushrooms need light to act as a catalyst for the fusion and develop into a complete mushroom. (See at Figure 1.)

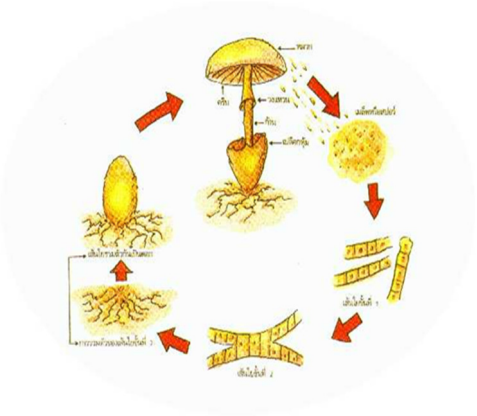


Figure 1. Life Cycle of the Mushroom

Weather is another factor that enables mushrooms to grow well and Oxygen is needed for mushroom to breathe. Good ventilation will effectively help the growth of the fiber and the development of mushroom. (Stamets,1993) This is because of the accumulation of carbon dioxide can cause fibers to suddenly stop growing causing mushroom to be rotten. Wind is another factor that impacts the humidity temperature of the seeding material, air humidity, and mushroom pests.

5.2 Internet of Thing (IoT) Concept

The Internet of things (IoT) is the network of physical devices, vehicles, home appliances and other items embedded with electronics, software, sensors, actuators, and network connectivity which enables these objects to connect and exchange data (Brown, 2016) Each thing is uniquely identifiable through its embedded computing system but is able to inter-operate within the existing Internet infrastructure.

The IoT allows objects to be sensed or controlled remotely across existing network infrastructure,[6] creating opportunities for more direct integration of the physical world into computer-based systems, and resulting in improved efficiency, accuracy and economic benefit in addition to reduced human intervention. (Vermesan and Peter ,2013). When the IoT is augmented with sensors and actuators, the technology becomes an instance of the more general class of cyber-physical systems, which also encompasses technologies such as smart grids, virtual power plants, smart homes, intelligent transportation and smart cities. Santucci, Gérald, 2016) "Things", in the IoT sense, can refer to a wide variety of devices such as heart monitoring implants, biochip transponders on farm animals, cameras streaming live feeds of wild animals in coastal waters, automobiles with built-in sensors.Legal scholars suggest regarding "things" as an "inextricable mixture of hardware, software, data and service" (Wigmore, 2014).

5.3 Electronic Equipment Used for System Development NodeMCU ESP8266 Board Development

NodeMCU is a platform that helps build the Internet of Things (IoT) project consisting of a development kit comprised of a circuit board. The circuit board that is open source software can be developed manually with the Lau language, making it easier to use. It comes with Wi-Fi ESP 8266 module. This is the key to the Internet connection. NodeMCU is similar to Arduino with built-in input-output port to be able to program controlling input / output devices without having to go through any other device. C / C ++ programming language can be used.

5.4 Node MCU Development Kit

Studies were conducted on the operation of the temperature and humidity control system by using Node MCU ESP8266 to control the sensors and hardware used for the Mushroom farms' climate control system by developing the Node MCU kit, or Node MCU Devkit. This kit is based on the Wi-Fi module named ESP 8266 With GPIO PWM, I 2 C, 1-Wire and ADC to be coupled on one board with a built-in USB-TTL. There is no need to be separately purchased similar to using ESP. it usually makes it easier to be used with PCB antenna for wireless transmission. The researcher used a micro-USB connector for power supply voltage or the equivalent +5 V. and for downloading the firmware.

5.5 DHT22 Temperature & Relative Humidity Sensor Module

It is a device that can be applied to the various embedded system design such as temperature and humidity measurements, room temperature, and humidity recorders. These devices vary by manufacturer, price, accuracy, measurement details, digital or analog values, etc. The experiment on the cheap DHT22 AM 2302 module provides a digital value and uses a single digital pin to be connected to Serial Data, Bi-Rirectional by connecting it to the Arduino to read from the DHT22 AM sensor device. (See at Figure2.)

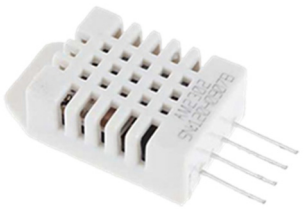


Figure 2. DHT22 AM sensor

5.6 Wireless Sensor Network

It is using a number of small sensor devices to measure environmental characteristics and the information was processed to create new knowledge about the environment around us or automatically respond to changes in the environment. Examples of the use of this wireless sensor network are the insertion of sensors into certain rare birds to detect the temperature changes that affect the relocation of these birds, the installation of sensors in large chemical mixers or chemical pipelines in industrial plants for chemical leakage, using many movement sensor devices to detect the abnormalities of those instruments so the abnormalities can take care of it before it causes damage. Sensors are installed around the airport to detect intruders in unauthorized areas. From these examples, it can be seen that using a number of different types of wireless sensor networks is a very small sensor called a mote, developed by Intel and University of California (UC) at Berkeley. The mote is a small computer for measuring humidity and temperature or other environment. It works by using conventional batteries and communicating with other nearby mote by adhoc wireless network for data to be transmitted between the motes until it reaches the destination that may be a computer or other instruments that is used for measured data collection. The wireless network causes a new computing paradigm to be created called “proactive computing”, which replaces the usual computer waiting for human instruction but proactive computing will forecast the environment that is needed by human needs and the environment is able to operate in advance of human. If necessary, proactive computing can occur due to the wireless sensor enables the computer to thoroughly and quickly receive information from the real world without the need for human input. Therefore, humans can proactively program the computer to operate as soon as the environment is as forecasted without having to wait for the instruction from the computer similar to an interactive system.

5.7 Research Related to the Development of Electronic Device for Automatic Control

Kittisak Saengprasit, et.al. (2017) has conducted a study and developed automatic control system for Angel mushroom farms with the water level sensor to control water level by using the resistance, high, and low value to indicate the amount of water. The measured values are then sent to the control board and processed to send signals to the pump control for controlling the water turning on – off in mushroom farm. Additionally, humidity control with humidity sensor then would send the value to the control board and the signal is also sent to control the fog builder to create the humidity. The information obtained from the control board would be displayed on the LCD screen. The dominant point of the system is it can be used to automatically water level control and humidity control. However, there are also disadvantages in the aspect of the display system would be the information being displayed on the LCD monitor only. Additionally, the research conducted by Kittiphong Niamnok, et al. (2009), has developed a climate control system to be used inside straw mushroom farm. The system would be able to automatically control temperature and humidity and ventilation. There is also system controlling water turning on and off the water pump to reduce the temperature inside the greenhouse.

Piyada Thonsungnoen (2017) Majoring in Medical Devices, King Mongkut's University of Technology North Bangkok has developed temperature testing and sensor device that is able to set the temperature through monitor and LCD monitor. The displayed is on the LCD monitor. The temperature is measured and stored in the SD memory card with alarm being through light signaling when the temperature inside the medicine cabinet is abnormal.

Sirodom Ramang (2011), a student in Business Information Technology Faculty of Information and Communication Technology, Silpakorn University has developed a climate control system with a case study on Ban Het Sung Men by designing the system to be able display the temperature and humidity through the systemí display alerts when temperature and humidity changes. The system can control the operation of mushroom greenhouse equipment such as ventilation fan, and water sprayer or turn off and on the device to stop or work to control temperature and humidity. The annual temperature and humidity reports can be viewed daily in the form of comparative graphs. Moreover, Thirayot Wangthong

and Prayun Chongchan (2015), Electrical Engineering Program, Faculty of Engineering, Mahanakorn University has developed an automatic humidity control system in a closed mushroom farm to control temperature and humidity inside the farm with the LCD to display the results such as date, time, temperature, humidity on the control board. Additionally, temperature in the farm can be controlled in the high or low range as set. The temperature and humidity is also stored such as the date, time, temperature, and humidity on the control box to have temperature and humidity inside the farm to be in the set range. The temperature and humidity can be stored as desired such as every minute, every 10 minutes, every hour, etc.

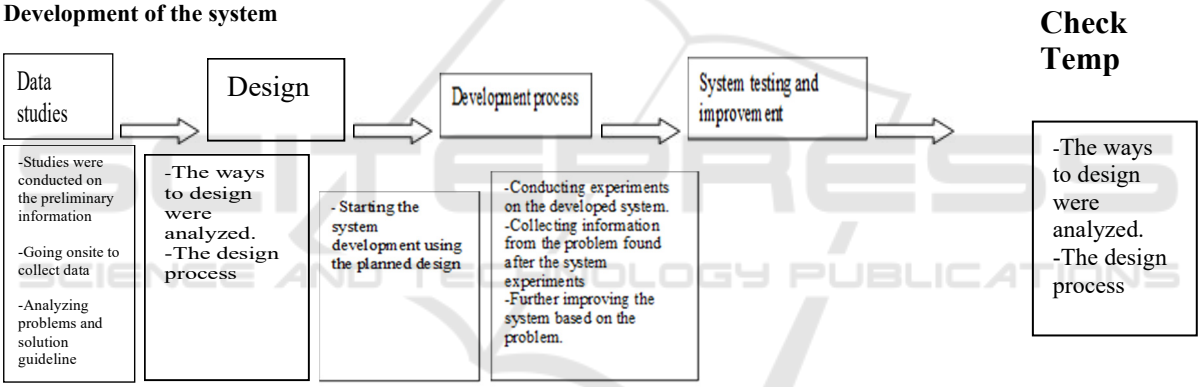
The system is able to record temperature and humidity values. There were temperature and a port board instructing the fan to work inside to automatically function control box .Ventilation works automatically when the temperature is high in the greenhouse.

5.8 System Process and Development

The researcher has conducted studies on the development of the system according to the schedule and the operational plan to achieve the set scope and objectives as follows:

1) Study on mushrooms and going onsite to mushroom growing areas to collect data and prepare a plan for the design of the equipment
2) Data collection and analysis to guide the Development of the system
3) Defining the scope of system control
4) The system design and analysis
5) Preparing the system development tools
6) Starting the system development
7) The system was tested after the system development and improvement.
8) The performance of the system was then summarized
9) Documents and manuals were prepared

Development of the system



6 SAMPLING

This research were use the sampling for collecting data from The 2 Muchroom Farms:-

1. Straw Muchroom Cottage Farm, Bangbuathong District Nonthaburi Province, Thailand.
2. Khunyi Straw muchroom Farm, Cholburi Province, Thailand.

6.1 Analysis and Systems Design Process

Analysis and design were conducted by the developer to demonstrate patterns and procedures to develop a system composing of:

6.1.1 System Flowchart

Designing flowchart system by controlling temperature and humidity system. There are users involved in the system, such as the administrator, who will oversee and manage the temperature control system of mushroom farms and request see the results of the system in The Muchroom Cottage Farm and Khunyi straw mushroom farm. After collocating data from the operator.

The Researcher can be to designing a System flowchart (see figure 3.), Flowchart of User system (see figure 4.) Flowchart Alert System and Temperature Control (see figure 5.) and ER-Diagram (see figure 6.)

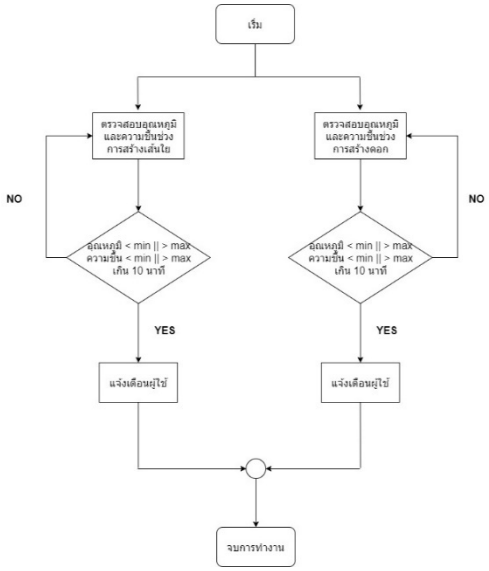


Figure 3. System Flowchart

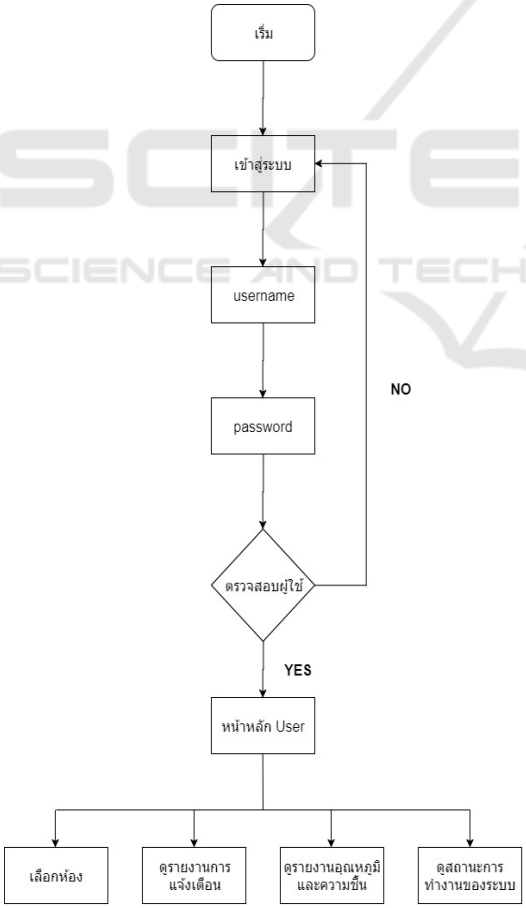


Figure 4. Flowchart of Users system

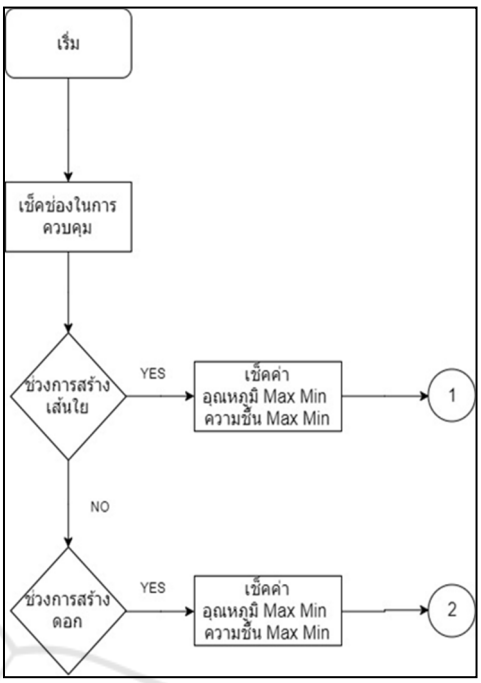


Figure 5. Flowchart Alert System and Temperature Control

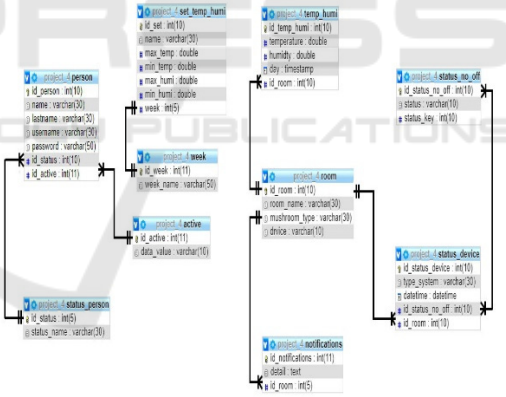


Figure 6. ER Diagram

7 RESULTS AND DISCUSSION

The electronic temperature and humidity sensor were connect with the application to control temperature and humidity in the straw mushroom growing farms by connecting to electronic devices to check for the straw mushroom farms to have the right temperature and humidity. This is done by using the Internet system coupled with software development tools under the concept of Internet of Things (IoT). In this study, the researcher developed a sensor for

managing temperature and humidity through a web application to turn on and off the water system, lighting and ventilation fan to control the temperature in the straw mushroom growing farms. All devices were developed to be integrated with Arduino software. C / C ++ and PHP were used for the development.

After to design and developed the system function process results of the temperature and humidity control system would be divided into two phases: (See the model at Figure 7)

The first phase is to control the temperature and humidity for mushrooms formation with control on turning on and off the light in this period. This is because during this period, the fiber of the mushroom will grow well in light blue lighting.#In the second phase, the temperature and humidity would be controlled for the mushroom formation. In this period, if the temperature is too high, the mushroom will form. However, users can turn on the system or automatically activate the water system to reduce the temperature or increase moisture in the mushroom farm through the web application. This included light bulbs or ventilation.

Additionally, temperature and humidity everywhere can be monitored or controlled without having to walk around each mushroom farm. This will save labor costs and time. It will also increase productivity, and contributes to increasing revenue for mushroom growers.#

7.1 The Operation of the System

1. DHT22sensor can be used to monitor the temperature and humidity of the mushroom farm.
2. Temperature and humidity can be displayed in real time through web application.
3. Water, lamps and fans can be turned on and off through the relay device.

7.2 The System User Operation

1. Temperature and moisture can be displayed in real time through web application.
2. Water, lamps and fans can be turned on and off through web application.
3. Past temperature, humidity and the system working condition can be monitored through the system.

Figure7. The temperature and humidity control system model.

After the system has been developed, the equipment and software were tested in sampling (The Muchroom Cottage Farm and Khunyi straw mushroom farm) The straw mushroom growing farms. The system performance and problems encountered by system testing were analyzed. The system was also updated from problems encountered. The system performance was also summarized the before being used as a model for further development in the future.

REFERENCES

Autrakul A : *A Straw Muchroom guide book*. Sangtawee Printing Co.ltd, Thailand. (1997)

Brown, Eric (13 September 2016). "Who Needs the Internet of Things?". Linux.com. Retrieved 23 October 2016.

Brown, Eric (20 September 2016). "21 Open Source Projects for IoT". Linux.com. Retrieved 23 October 2016.

Chang,shu-ting.and Philip G. *Mushroom:cultivation, nutritional value,medicinal effect andenvironmental impact*. 2nd ed.Boca Raton,Fla.:CRC press. (2004)

Chang ST. *Production of the straw mushroom* (*Volvariella volvacea*) from cotton wastes. Mushroom J 21: 348–354. (1974)

Chang ST .*Mushroom research and development - equality and mutual benefit*. Royse DJ, editor, Mushroom biology and mushroom products.University Park, PA: Pennsylvania State University.pp. 1–10. (1996)

Chang ST. *Cultivation of Volvariella mushroom in Southeast Asia*. Mushroom Newsletter for the Topics 1: 5–13. (1980)

Kittisak Saengprasit, Komyuth Chaiyawong and Siwakorn Kaewrat. *The System of automatic Contro lfor angel*

muchroom Farm. Faculty of Industrial Technology Loei Rajabhat University.(2017)

Kittiphong Niamnok, Noppadol Thongklat and Montri Wichiensan.*The automatically system for control temperature and humidity and ventilation*. Rajamangala University of Technology Lanna Tak (2009).

Piyada Thonsungnoen *The temperature testing and sensor device.*KingMongkut's University of Technology North Bangkok (2017)

Santucci, Gérald. *The Internet of Things: Between thezz Revolution of the Internet and the Metamorphosis of Objects*. European Commission Community Research and Development Information Service. Retrieved 23 October 2016.

Sirodom Ramang *A climate control system with a case study on Ban Het Sung Men*. ,Faculty of Information and Communication Technology, Silpakorn University (2011)

Stamets, P: *Growing Gourmet and Medicinal Mushroom*. Ten SpeedPress.Berekley,California. (1993)

Thirayot Wangthong and Prayun Chongchan. *The automatic humidity control system in a closed mushroom farm.* Faculty of Engineering, Mahanakorn University (2015)

Vermesan, Ovidiu; Friess, Peter. Internet of Things: Converging Technologies for Smart Environments and Integrated Ecosystems. Aalborg, Denmark: River Publishers. (2013).

Wigmore,I. "Internet of Things (IoT)". TechTarget. (2014).