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To cite this article: M F Mohammed *et al* 2018 *J. Phys.: Conf. Ser.* **1019** 012053

View the article online for updates and enhancements.

IOP Conf. Series: Journal of Physics: Conf. Series **1019** (2018) 012053 doi:10.1088/1742-6596/1019/1/012053

IoT based monitoring and environment control system for indoor cultivation of oyster mushroom

M F Mohammed[1], A Azmi[1], Z Zakaria[2], M F N Tajuddin[1], Z M Isa[1] and S A Azmi[1]

[1] Centre of Excellent of Renewable Energy (CERE), School of Electrical Systems Engineering, Universiti Malaysia Perlis (UniMAP), 02600 Pauh Putra, Perlis.
[2] Faculty of Engineering Technology, Universiti Malaysia Perlis (UniMAP), 02100 Padang Besar, Perlis, Malaysia

m.fayzul@unimap.edu.my

Abstract. This paper is presenting an implement of Internet of Things (IoT) monitoring and environment control for indoor cultivation of oyster mushroom. By using IoT based remote monitoring system not only the labor cost can be reduced with cover a bigger area, but can improve the productivity of the oyster mushroom by control the most suitable environment for mush room to grow. This paper discuss about the oyster mushroom, IoT system in general, the system implementation and results that obtained from the system. In conclusion based on the developed system, authors discussed the advantages and points need to be considered when working on the system.

1. Introduction

The need of food and limitation of space or land as an agro-economic activity make urban farming technology is becoming popular and has become one of promising solution for securing food supply. Apart from that, extreme weather changes and climates affect the production of crop, thus increasing their prices and lowering the quality of the crops produced [1]. Hence, this paper present an internet of things (IoT) based monitoring and environment control for indoor cultivation oyster mushroom, which is a smart urban farming system that requires less maintenance, less manpower and saves a lot of space [2]-[3]. Furthermore, this project is dedicated to improve and enhance the conventional plantation system in general. Using IoT platform will enhance the capability of current equipment for remote monitoring purpose and at the same time log the data for analysis and references [4]-[5].

1.1. Internet of Things (IoT)

Gartner Inc. defines the IoT is the network of physical objects that contain embedded technology to communicate and sense or interact with their internal state or the external environmental. Applications of IoT in agro-industrial are monitoring, control, prediction and logistic [1],[6]. Figure 1 shows a block diagram of basic IoT system. IoT device will receive a data from the attached sensor and sent the data to the database via internet connection. Most of popular IoT connection is via WiFi module. The data sent to server must follow the API format of the platform provider, and then data will store in the database accordingly. Data can be seen or retrieved by user through the browser application whether via smart phone or computer. The browser will request data from the server and server will sent it accordingly. The process for control also using a same path, it is start from user sent command data to the server and server will store it in the database. The device will keep monitor the changes of command storage data by request it accordingly. When the command data is received by IoT device, it will be executed accordingly as programmed by system developer.

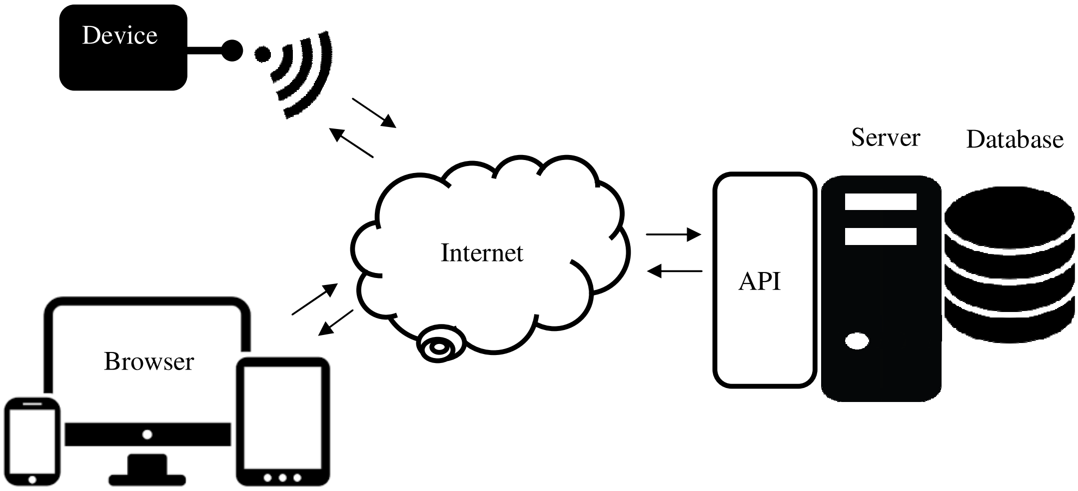

Figure 1. Basic topology of IoT system.

1.2. Indoor cultivation oyster mushroom

The indoor cultivation room was measured at 5.8 m in length, 4.57 m in wide and 2.74 m in height inside a concrete building located at Taman Pauh Indah, Arau, Perlis. The wall was made by bricks at one side and by gypsum board on the rest of the walls. The roof of the room was built up by also gypsum board under the main concrete roof. The room was installed with four rows of racks; each rack contained four iron bars distance by 15 cm from each other and 55 cm distance between the racks. Roof ventilation as 7.5 m^3/min ventilation rate (20CQT1 KDK, Malaysia), light as 10 watts for 648 lumens (E27 B22, Malaysia) and side ventilation as 2.8-3.3 m^3/min ventilation rate (P120×120×38, UK) was installed inside the room in order to facilitate fresh air and maintain proper light intensity respectively. The roof ventilations was installed with a top roof to bring air from inside to outside and the side ventilations was installed at bottom of the wall with a black filter to bring outside air to inside.

The bags were arranged horizontally through the racks by using nylon rope and made it tight by cable tie and hanged vertically. Twelve bags were arranged in one column of rope by 3 bags in together in 4 parts. The columns of rope were arranged at 25 cm distance from each other in every rack so that the air and humidity can easily flow through the spaces between the bags, preventing the temperature of the bags from increasing. Mushroom mycelia emitted heat during incubation, so the bags can be easily overheated if they touch each other [7]. The distance of the top end bag from the ceiling was 76 cm and the down end bag from the floor was 30 cm. The humidifiers as 4-5 L/hr in 2,700-2,900 rpm/min (TAY-RING TL-3600, Taiwan) were placed between the two columns of bags where the distance of humidifier from the 48 opening part of the bags (front view) was 25-30 cm, from the side view of bags was 20-25 cm and from the back view of bags was 10-15 cm. All the devices were fixed by an electrical digital timer (DG-1120, Malaysia). Instrumentations were installed at different positions inside the cultivation room to monitor temperature, humidity, light intensity and CO2 level during the experimental procedure.

The optimal value of temperature, light intensity and humidity for oyster mushroom planting is at 26-29 ^{o}C, 50-300 lux and 80-90% respectively. The temperature and humidity normally are by exhaust

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fan and humidifier [8]. Light intensity is provided by fluorescent lamps. The range of normal condition for oyster mushrooms indoor plantation is given in Table 1.

Table 1. Important parameters for oyster mushroom grow.

Parameters	Range	*Unit*	Controlled Equipment
Temperature	26-29	^{o}C	Fan
Light	50-300	lux	Lamp
Humidity	80-90	% RH	humidifier

2. Hardware Implementation

The illustrated diagram for the project is as shown in Figure 2. In the project, ATMega 2560 microcontroller is used as the main control board. The high performance, low power Microchip 8-bit AVR RISC-based microcontroller combines 256KB ISP flash memory, 8KB SRAM and 86 general I/0, 32 general purpose working registers, real time counter, six flexible timer/counter with compare modes, PWM, 4USARTs byte oriented 2-wire serial interface, 16channels 10-bit A/D converter and a JTAG interface for on chip debugging. This device operates between 4.5-5.5 V.

There are four inputs that are LCD, temperature and humidity sensor (H & C), light intensity sensor (L) and real time clock (RTC). For LCD the team use Nokia 5110 LCD screen. It is an 84x48 pixel monochrome LCD display. These displays are small, only about 1.5" diagonal, but very readable and come with a blue backlight. This display is made of 84x48 individual pixels, hence the application is used for graphics and text. These displays are inexpensive, easy to use, require only a few digital I/O pins and low power consumption. Temperature and humidity sensor (DHT 22) is a low cost humidity and temperature sensor with a single wire digital interface. The sensor is calibrated and does not require extra components so measuring relative humidity and temperature is simpler. This device operates at 3.3-6 V and the range is from 0-100% RH for humidity and -40 to 80 degrees C temperature range. For light intensity measurement, BH1730 sensor is been used. This device operates at 3-5.5 V and capable to measure light intensity in between 0-500 lux. DS1302Real Time Clock (RTC) has been used to get actual time. Three pins are needed specifically for the interface (CE,I/O, SCLK) and VCC2 should be connected to +5 V. For output parts, there were 6 outputs which are LEDs, Buzzer, ventilation fan (V1 & V2), Water pump (M1), lamps (L1 & L2) and humidifier unit (H1, H2, H3 & H4). Finally, ESP8266 WiFi module has been used for push data to cloud. The controller of the system have been fabricate as shows in Figure 3.

Table 2. Main equipment.

	Model
Controller Board	Arduino Mega
Humidity & temperature sensor	DHT22
Light sensor	BH1750
Relay circuit	10 A, 250 Vac and 5V dc, active low module
Wifi module	ESP8266-01
Display	Nokia 5110 graphic LCD

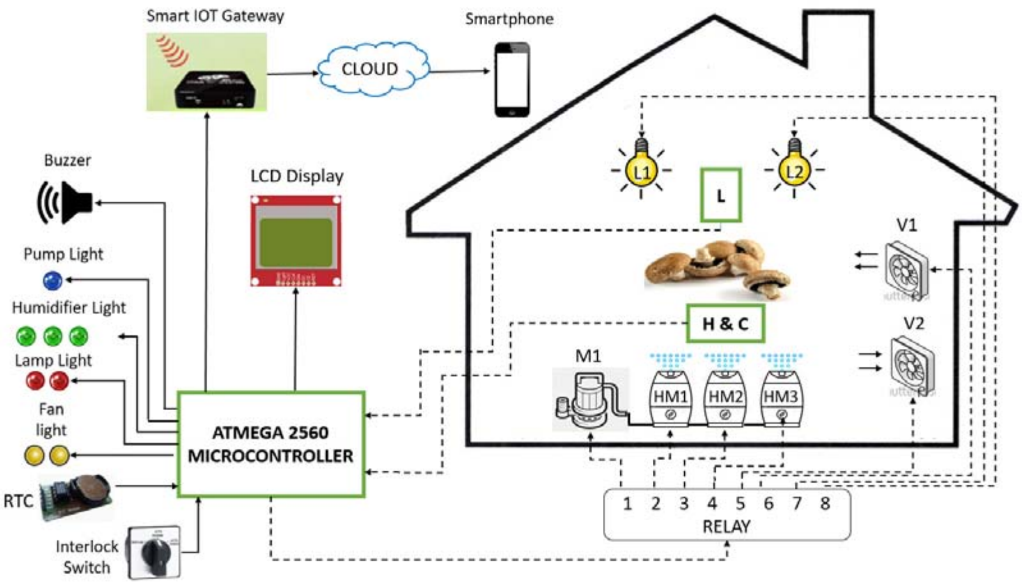

Figure 2. An Illustrated Diagram of Smart Agriculture System: Mushroom House Box

Figure 3. The controller and socket outlet for IoT Monitoring and environment control system for indoor cultivation oyster mushroom.

3. Software Implementation

In this project, Arduino Mega have been used as a controller to integrate data from sensor and sent the information to IoT platform through ESP8266-01 WiFi module. In this project, ThingSpeak have been uses as an IoT platform. The sensor reading has been recorded to the series of parameter needed by microcontroller through connection of analog or digital input of Arduino Mega, then passing this information data using serial communication to the ESP8266-01 WiFi module. This ESP8266-01 has been program to connect to available WIFI with internet connection located at the field area, receive the sensor data from Arduino Mega and send the sensor data to the specific channel to the ThingSpeak

IoT platform server using issuing provided HTTP API request format. The successful data submitted can be visualize at ThingSpeak IoT platform and available Android or IOS apps that linked to the same platform. Figure 4 and 5 show the algorithm data transfer by main controller and WiFi module respectively.

In order to retrieve the information on existing channel ThingSpeak server, the device such as mobile apps need to request the data on ThingSpeak server using determined HTTP API request format. The data received on mobile apps can be displayed in sensor value, graph in time domain for visualize on trend of data and can be used as a control parameter to the related device.

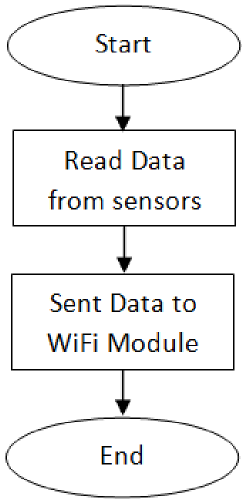

Figure 4. Algorithm for data transfer by main controller

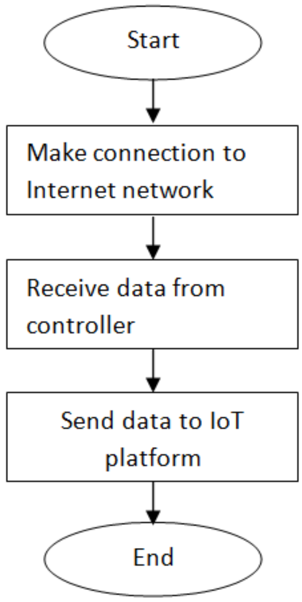

Figure 5. Algorithm for data transfer by WiFi module.

4. System monitoring Function Test

In this system, there are three parameters are monitored at a 5 minutes sampling rate; room temperature, relative humidity and light intensity. Figure 6-8 are show data with function of time that obtained from the IoT server platform. Besides using browser, the data can be duplicated and can be monitored by user via third party apps on android. This method gives flexibility to user to monitor their system. Figure 9 shows example of dashboard apps that have been used in the system.

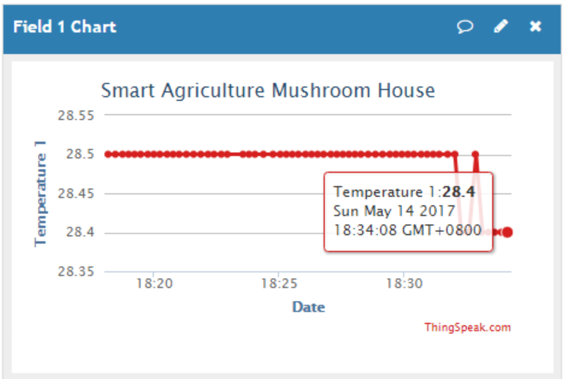

Figure 6. Room Temperature data.

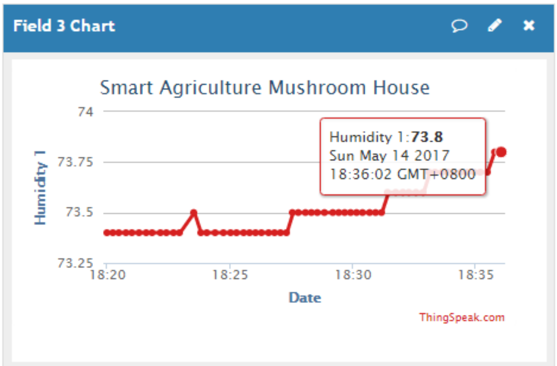

Figure 7. Room Humidity data.

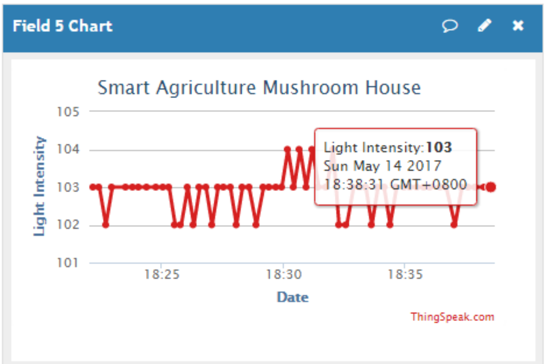

Figure 8. Room Light intensity data.

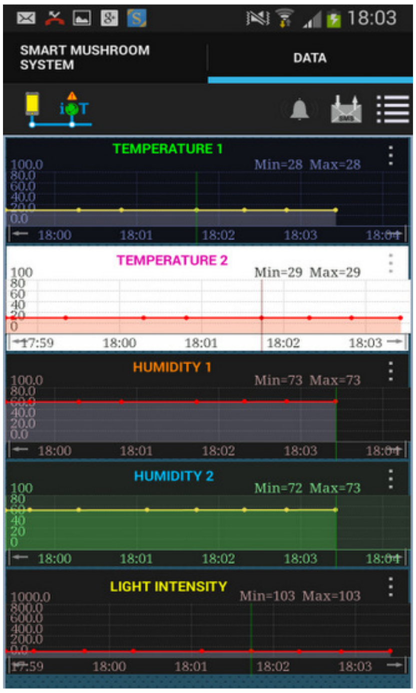

Figure 9. Apps dashboard for display real time data.

5. Conclusion

Monitoring and environment control for indoor cultivation of oyster mushroom has successful been implemented. IoT based monitoring system is promising technology to enhance the production of mushroom due to:

- Low cost in capital because of system framework is based on open source platform.
- Easy and user friendly. Data migration is easy to be done.
- Expandable. The system can be modular, easy to increase the number of data/sensor.

However, there are limitations on the system that need to be considered:

- Remote monitoring is relying on internet connection quality.
- Currently, system control via internet is not recommended because of quality of internet. However it can be done with proposed system.
- Beside the hardware and internet data cost, operation cost (mothly/yearly) of server cloud platform must be taken account. Many platforms are free only for personal or non-commercial used and have a limited access.
- A data security issue in IoT is not a confidential. If the system deals with highly sensitive data, data verification or encryption method maybe needs to apply which is required a complex algorithm at server and nodes.

References

[1] Jesús Martín Talavera, Luis Eduardo Tobón, Jairo Alejandro Gómez, María Alejandra Culman, Juan Manuel Aranda, Diana Teresa Parra, Luis Alfredo Quiroz, Adolfo Hoyos, Luis Ernesto Garreta, Review of IoT applications in agro-industrial and environmental fields, In Computers and Electronics in Agriculture, Volume 142, Part A, 2017, Pages 283-297, ISSN 0168-1699,
[2] A Mustafa Alper Akkaş, Radosveta Sokullu, An IoT-based greenhouse monitoring system with

Micaz motes, In Procedia Computer Science, Volume 113, 2017, Pages 603-608, ISSN 1877-0509

[3] Jiang Zhaohui, Xu Zhengrong . The remote monitoring of agricultural information system design and implementation of Journal of agricultural network information, 2010, (11): 40-43.

[4] Fernando Terroso-Saenz, Aurora González-Vidal, Alfonso P. Ramallo-González, Antonio F. Skarmeta, An open IoT platform for the management and analysis of energy data, In Future Generation Computer Systems, 2017.

[5] C. Cambra, S. Sendra, J. Lloret and L. Garcia, "An IoT service-oriented system for agriculture monitoring," *2017 IEEE International Conference on Communications (ICC)*, Paris, 2017, pp. 1-6.doi: 10.1109/ICC.2017.7996640

[6] K. R. S. R. Raju and G. H. K. Varma, "Knowledge Based Real Time Monitoring System for Aquaculture Using IoT," *2017 IEEE 7th International Advance Computing*

[7] Curvetto, N. R., Gonzalez Matute, R., Figlas, D., & Delmastro, S. (2004). *Oyster mushroom cultivation*. MushWorld.

[8] Md. Tariqul Islam, Zarina Zakaria, Nasrul Hamidin & Mohd Azlan Bin Mohd Ishak, "Characteristics of Indoor Mushroom Cultivation of Grey Oyster (Pleurotus pulmonarius) by Different Stages of Humidifying Treatment", World Applied Sciences Journal 34 (8): 1066-1075, 2016.