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# The Architecture of the Smart Flowerpot by using the Internet of Things (IoT)

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***Abstract***: ***Smart Flowerpot was a plant pot that helped growers reduced care time and watering for the plants, because the plant pot offered by the researcher had a soil humidity sensor that measured the soil moisture and sent the soil moisture to the processor using NodeMCU ESP8266. If the humidity level of the soil was lowered to the specified value, NodeMCU sent a signal to the relay module, to allow the water pump to water the plants and there was an ultrasonic sensor module to measure the water level that was put in for watering the plants. If the water supply had almost run out, the NodeMCU would send a notification message to the Line Notify of the owner of the smart flowerpot to refill the water and, in addition, the smart flowerpot was equipped with an RGB LED Module to show the soil moisture status. If the LED was green, it meant high humidity, yellow was moderate humidity, red was low, and users could also use the mobile application to manage and display sensor values in order to let them know the status of the smart flowerpots. The researcher designed the Architecture of Smart Flowerpot by using the Internet of Things and brought it to five Information Technology and Computer Science experts to assess the suitability. Overall evaluation, the average 4.55 SD 0.63, was suitable at the highest level.***

***Keywords*** : ***smart flowerpot, Internet of Things, sensor.***

## I. INTRODUCTION

Planting ornamental plants is very popular in Thailand, planting trees for beauty and helping to relax the body because the colors of the various trees make the atmosphere look calm, help concentration, and could also purify the air. There is no need to rely on an air purifier alone, as trees could help filter the air, and some ornamental plants were also rare [1] and strengthened feng shui on the desk for the comfort of the grower, and not too difficult to grow. Also, there are ornamental or small plants suitable for planting in different angles of the room. [2]. The ornamental plants do not need flowers, might only have leaves that stand out, look good and have beautiful colors that attract the eyes of the growers and the general public. Planting trees on a desk or in a workplace was a problem causing some of the plants to die due to not watering the plants on Saturdays, Sundays or on other days off. There might also be watering problems such as water can overflow and spill on to the desk. There can also be other problems such as giving the plants too little or too much water, causing the soil to have moisture that was not suitable for the type of plants. From the above problems, the researcher proposed Smart flowerpots where the plants could be watered automatically by a soil moisture sensor, the microcontroller taking the reading from the sensor and then deciding to order the water pump to work There are also water level sensors to alert users via Line Notify and with an RGB LED showing the soil moisture status. In addition, there is also a mobile application for managing and viewing data from the sensors of the smart flowerpot.

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## II. OBJECTIVES

1. To design the Architecture of the Smart Flowerpot by using the Internet of Things.
2. To assess the suitability of the Architecture of the Smart Flowerpot by Using the Internet of Things.

## III. LITERATURE REVIEW

Kaminsin (2014) [3] created an iOS project: Controlling Watering Plants with the following objectives: 1. To study and develop an application for the iPhone. 2. To study and develop the application of the Arduino board to be useful in agriculture. 3. To enable farmers to be able to use it. 4. In order for those who studied the project to be able to expand further with the technology applied to watering plants by using watering controls with a Microcontroller, which used the Arduino board together with the Arduino Ethernet Shield, which was a device used to connect to the internet and had a Soil Moisture Sensor. A solenoid valve would be used so that users could order watering via the internet or automatic watering could be done as well. This would also help to reduce problems if farmers could not do the watering themselves. Thongpan and Thiangpak (2016) [4] established the Automatic Watering Systems via Wireless Sensor Network project with the following objectives: 1. To develop automatic watering systems via wireless sensor networks. 2. To study the experimental results of automatic watering systems via a wireless sensor network in an experimental field for farmers. 3. To study the satisfaction of farmers with automatic watering systems through wireless sensor networks. There was a work process for the development of wireless network systems, including soil moisture sensor systems which sent commands to the processor to check the moisture level in the soil in order to send commands to the electric water valve to switch it on/off according to the sensor humidity monitoring, to enable plants to obtain the right amount of water and to save water, as well as saving watering time, allowing farmers to reduce watering times in different plots and to have more time to care for other plants.

The automatic watering system, via the wireless sensor network, consisted of connecting the X-Bee to the computer to send the data to the X-Bee connected to the Arduino Uno, then the Arduino Uno would send data to switch on-off the electric water valve. Before the program would run, it had first to enable the program, then select the electric ON-OFF switch to the water valve, which, when it stopped working, disabled the program in order to enable the system to work automatically. The system was given to ten farmers; the results showed that the farmers were mostly satisfied with the automatic watering systems via wireless sensor networks.

Meethongjan and Kongsong (2019) [5] conducted research on the Aquarium Fish Smart Farming on the Internet of Things (IoT) and the Mobile Application Technology, in which this research presented a mobile application system that worked with IoT and the Android Application in order to control the aquarium water system. The development of the system in this study used Android studio, Java, C, Arduino IDE, SQL and Firebase software. For the control system, based on the NodeMCU ESP28266 V.2 board, Wemos-D1 boards and module ultrasonic hardware. This system was tested in a small fish tank in a house and data gathered to find the system performance. The assessment of the system's performance using Black Box testing was done by users and experts. Evaluation results and SD values were average. Evaluation results of users and experts were as follows: 4.21, 4.15 and 0.74, 0.72 respectively. Therefore, this system could be used as a tool for helping users and was a model for other Smart farmers.

Zhang et al. (2018) [6] conducted research on a novel and smart automatic light-seeking flowerpot for monitoring the flower growth environment. This study aimed to design a smart flowerpot by using microcontrollers. The entire system consisted of three parts: information collection layer, automatic control layer and data transmission layer. The first layer was a data collection process and used an algorithm in order to improve data collection accuracy. The second layer was for accurate control decisions to automate watering as needed and the third layer was a comparative analysis of the local light intensity, which was used to obtain the light-seeking and light-supplementing. The results showed that the Smart flowerpot had high anti-jamming efficiency. For data collection, proper soil humidity for flowers should be maintained at 65%, and the flowers should be well-distributed on the stems, with the error angle of light-supplementing between -3 degrees to 3 degrees.

Awakami, Tsukada, Kambara and Siio (2011) [7] conducted research on PotPet: a pet-like Flowerpot Robot, presented as a robot flower pot. The flowerpot-type robot was called PotPet, which helped users to grow crops more efficiently. PotPet performed automated activities like a pet. It would move to a sunny location or approach people when it needed to use water automatically. Basically PotPet consisted of a plant pot and many sensors to monitor the status of the plants. The robot would have wheels for movement and used a Microcontroller in order to control the device.

## IV. RESEARCH METHODS

1. For the design of the Architecture of Smart Flowerpot by using the Internet of Things, the researcher researched relevant documents and conducted studies on the NodeMCU ESP8266 Microcontroller and soil humidity sensor, RGB LED Module, Ultrasonic sensor module application, Relay module and Water pump, Smart flowerpot design and designed all of them into the Architecture of Smart Flowerpot by using the Internet of Things.
2. The suitability of The Architecture of Smart Flowerpot by using the Internet of Things was assessed by five experts in Information Technology and Computer Science. The statistics used in this research were mean and standard deviation.

## V. RESULTS

The design of the Architecture of Smart Flowerpot by using the Internet of Things: the whole system of Smart Flowerpot consisted of four parts: 1. Plant pot combined with

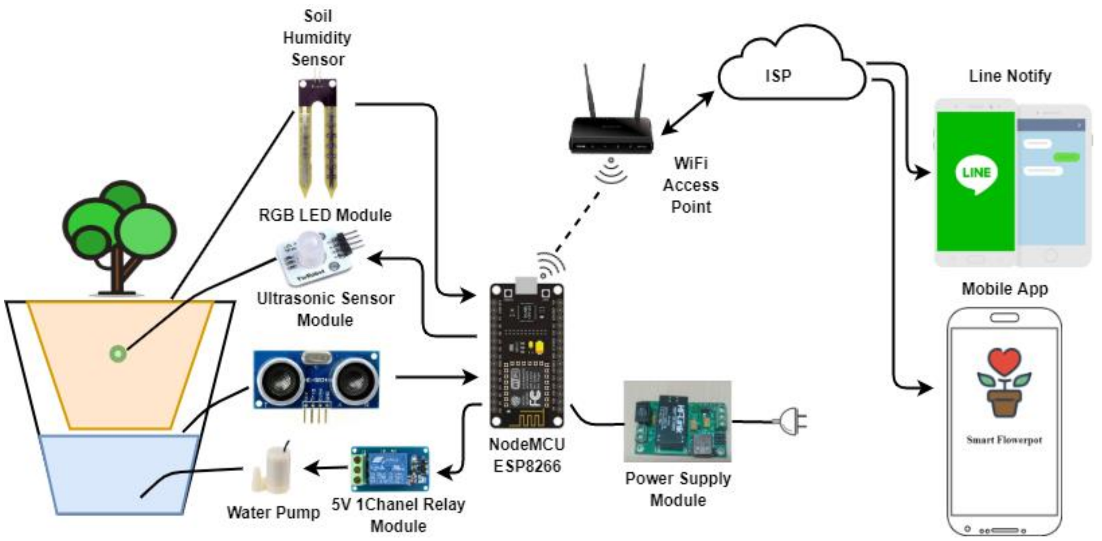


**Fig. 1.The Architecture of Smart Flowerpot by Using the Internet of Things.**

control. 2. Wi-Fi Access Point. 3. Line Notify and 4. Mobile App as in Figure1.

With details of each section as follows

### A. Flowerpot part combined with integrated control part

- Flowerpot part

  Flowerpots were 2-layer pots, the outer was a large pot, closed, no holes to contain water, the inner pot had holes to drain when watering the plants, if there was too much water then water would flow down, go to the bottom, ready when needed to continue watering the plants.

- Control part

The control was to make the flowerpot, a Smart Flowerpot, which had a Soil Humidity Sensor, to send the soil moisture to the control, which used NodeMCU. ESP8266. If the soil moisture was low, NodeMCU would send a command to the relay module for the water pump to operate and pump water to the plants. When watering the plants for a set amount of time, NodeMCU would send it to the relay module to shut down. The work caused the water pump to stop working and, in addition, the plant had an RGB LED Module installed as a lamp, to indicate the soil moisture status. If the lamp was green, this indicated that the soil had high humidity, if the lamp was yellow, the soil had medium humidity and, if the lamp was red, this indicated that the soil had low moisture. It had an Ultrasonic Module to measure the water level, to send the water level to NodeMCU, if the water level had continued to decrease, NodeMCU would send a warning message to Line Notify to notify the Smart flowerpot owner to allow them to continue to refill the water, installation of the devices as in Figure 2.

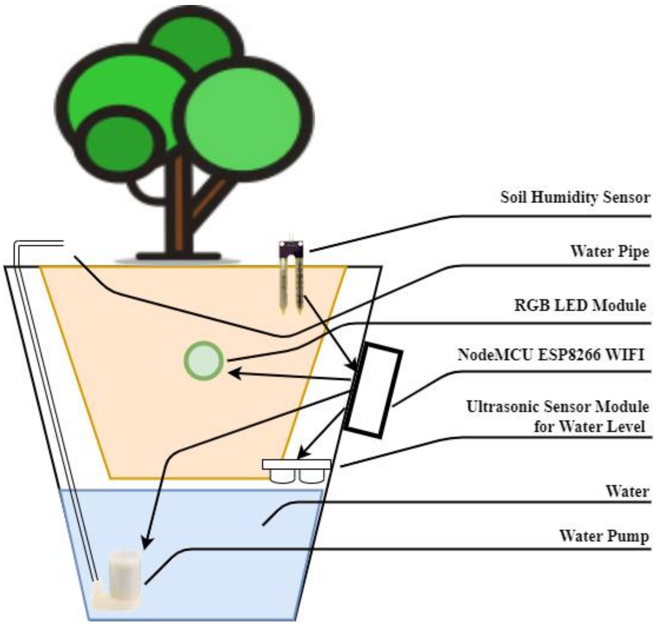


**Fig. 2. Installation of Smart Flowerpot**

The control consisted of a NodeMCU Microcontroller, equipment and various sensors as follows:

- NodeMCU Microcontroller

NodeMCU microcontrollers were open-sourced using the ESP8266 WIFI chip, a search on the ESP8266 chip would be developed in conjunction with the NodeMCU Development Board, and NodeMCU would include an ESP8266 chip that supported Wi-Fi.

The NodeMCU had Arduino features such as Analog (for example A0) and Digital (D0-D8). There were pins on the board. It supported commonly used communication methods, for example, UART, SPI, I2C and others. For the internet, the NodeMCU could use I2C to connect to the empowered LCD show, Magnetometer HMC5883, MPU-6050 Gyro meter, Accelerometer, RTC chips, GPS modules, contact screen shows, SD cards and so forth. The Node MCU Development board was a board that combined Wi-Fi, pins and interfaces for connecting to other devices, allowing us to apply various applications on the NodeMCU. [8] The characteristics of the NodeMCU are shown in Figure 3

**Fig. 3. NodeMCU Version 2 (ESP8266-12E) [9]**

- Soil Humidity Sensor

The Soil Humidity Sensor used a soil moisture sensor. The Soil Moisture Sensor was used to measure the soil moisture, or as a water sensor, it could be used with a microcontroller by using analog input to read the humidity, or choose to use digital signals sent from the module. It could adjust the sensitivity by adjusting Trimpot. The PCB had to be plugged into the ground in order for the voltage divider to work fully, then a voltage comparison circuit using IC op-amps LM393 was used to measure the pressure comparing the pressure measured from the soil moisture to the pressure that could be measured from the voltage divider circuit. Using Trimpot, the value was adjusted. If the pressure measured from the soil moisture was greater, it caused the circuit to release logic 1 to pin D0, but if the soil strength was small, logic 0 would be released to pin D0, pin A0 was the pin that connected directly to the circuit that used the moisture band in the earth, which provided a voltage from 0 - 5V which was the ideal. If the soil moisture was greater, the pressure was released, it could be less as well, in the form of a variable return, [10],[11]. The appearance of the soil humidity sensor is as Figure 4.

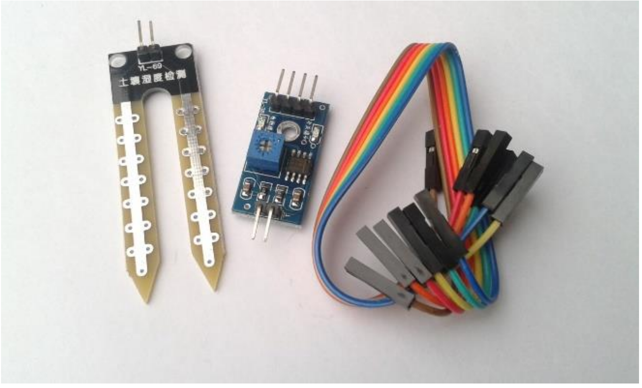

Fig. 4. Soil Humidity Sensor [10]

The values read from the soil humidity sensor were between 0-1023 as shown in Table 1.

**Table-1: Values readings from the soil humidity sensor**

| Read value | Meaning |
|---|---|
| < 200 | High humidity |
| 200 – 500 | Medium humidity |
| 500- 600 | Less moisture |
| > 600 | Very little humidity |

- RGB LED Module

The 10mm RGB LED tube display module could display colors; red, green and blue in the same lamp. It was a primary color light. When mixed together, it could be displayed in different colors, it could use the Arduino to show colors at 256 levels. When combined, it could display up to 256 x 256 x 256 or 16 million colors, as it was able to adjust the voltage of the three primary colors (red/green/blue) to get a full mixed color [12]. The characteristics of the RGB LED Module are shown in Figure 5.


Fig. 5. RGB LED Module [12]

- Ultrasonic Sensor Module

The Ultrasonic Sensor used the HC-SR04 Ultrasonic Module as a distance measurement module that used an ultrasonic wave range. It was a distance measurement that used non-contact measurement principles. The HC-SR04 module measured distances between 20 millimeters to 4000 millimeters, with a resolution of 3 millimeters using the +5V power. The module consisted of Ultrasonic transmitters, receivers and control circuits. The basic principles of operation of modules are with the following steps:

- Prepared HC-SR04 for measurement by sending the signal from NodeMCU to Trigger input pin with a high level not less than 10 us.
- The NodeMCU waited to receive a response signal from the HC-SR04 module (the module would automatically send 8 Plus signals at 40 Khz)
- The NodeMCU captured the amplitude of the echo signal from the HC-SR04 (high time signal channel, time from the ultrasonic signal transmission and received the signal back) [13]

The Smart Flowerpot used the HC-SR04 module installed inside the flowerpot, so the module was 2 cm above the water level. The purpose of using the HC-SR04 module was to use ultrasonic measurement. The level of water in the pot, whether it was full or empty, was a measure of the level of the water which was 3 millimeters, which was enough to measure. Characteristics of the Ultrasonic sensor module are shown in Figure 6.

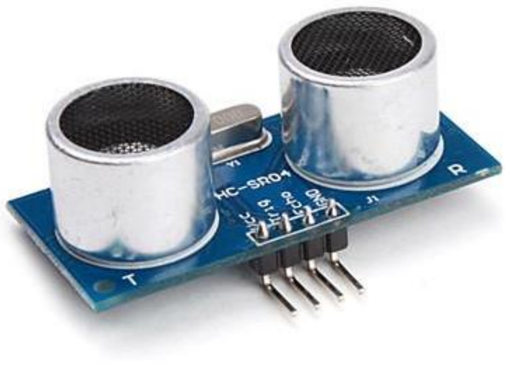


Fig. 6. Ultrasonic Sensor Module [14]

- Relay Module and Water Pump

- Relay Module is a digital switch to enable microcontrollers to work with high voltage devices. Relay modules can receive currents up to 10 A, can use both DC and alternating current, receive 5V level voltage directly from NodeMCU and are designed to protect the control circuit from the power side, by using an optocoupler in all the relays, widely used to build smart home projects [15]. These factors remove used water for an on-off water pump for watering plants. Relay modules as in Figure 7.


Fig. 7. Relay Module [15]

- The water pump was a small submersible which used a voltage of between 3 and 5 V, with a motor inside which pumped water in through the bottom hole and pumped it out the side. For general use, such as watering plants, it was easy with this pump. It was just placed in a water tank and opened to spray water out of the spout. [16], [17] Water Pump as in Figure 8.

Fig. 8. Water pump [16]

### B. Wi-Fi Access Point

The Wi-Fi Access Point was a device that was responsible for the wireless signal transmission. It was one basic device that could create a wireless network from the Lan network as easily as possible. The access point was to distribute the signal to the client in the radius of the surrounding signal, but the characteristics of the access point would be different, depending on what the manufacturer had designed. However, whoever designed it, it had only one LAN cable, which was the channel that received the internet signal or connected to the network from the network LAN, with clients who connected wirelessly. The operation of the access point was to work under the standard of IEEE802.11, so the device with this standard could use the access point to the full efficiency, the connection of the NodeMCU had to be with the access point that could access the internet by using SSID and a password. The characteristics of Wi-Fi Access Point are shown in Figure 9.

Fig. 9. Wi-Fi Access Point [18]

### C. LINE Notify

The LINE Notify was a LINE notification service that could send notification messages to an account or any of the existing groups via the API provided by LINE. The LINE Notify was free. The LINE Notify supported event notifications from Mackerel: Server Monitoring Platform for Engineers; GitHub: shared web services for software development projects; IFTTT: web services that allowed users to link other web services together and other services that could connect to the LINE Notify API [19]. In this research, when the NodeMCU had various activities, the LINE Notify would be called to work as well. For example, when the following occurred: soil moisture: 520, water pump: ON, soil moisture: 200, water pump: OFF as shown in Figure 10.

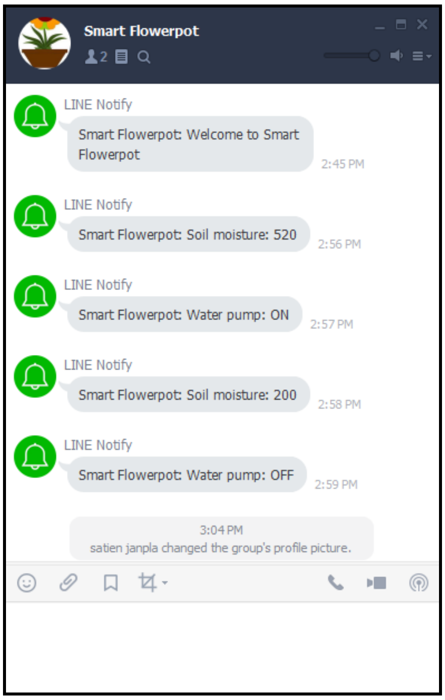


Fig. 10. Smart Flowerpot Line Notify

### D. Mobile Application

The Mobile Application was a tool that allowed the Smart Flowerpot owners to manage planted trees such as Login, installing a watering program, displaying system status. (The amount of water remaining, turning on-off the water pump, soil moisture level), watering settings (automatic, manual), turning on-off the water pump, etc. as shown in Figure 11.

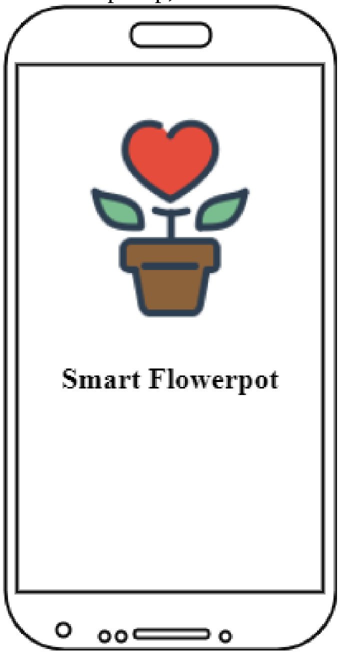


Fig. 11. Mobile Application

### Hardware Design of the Smart Flowerpot Using Internet of Things

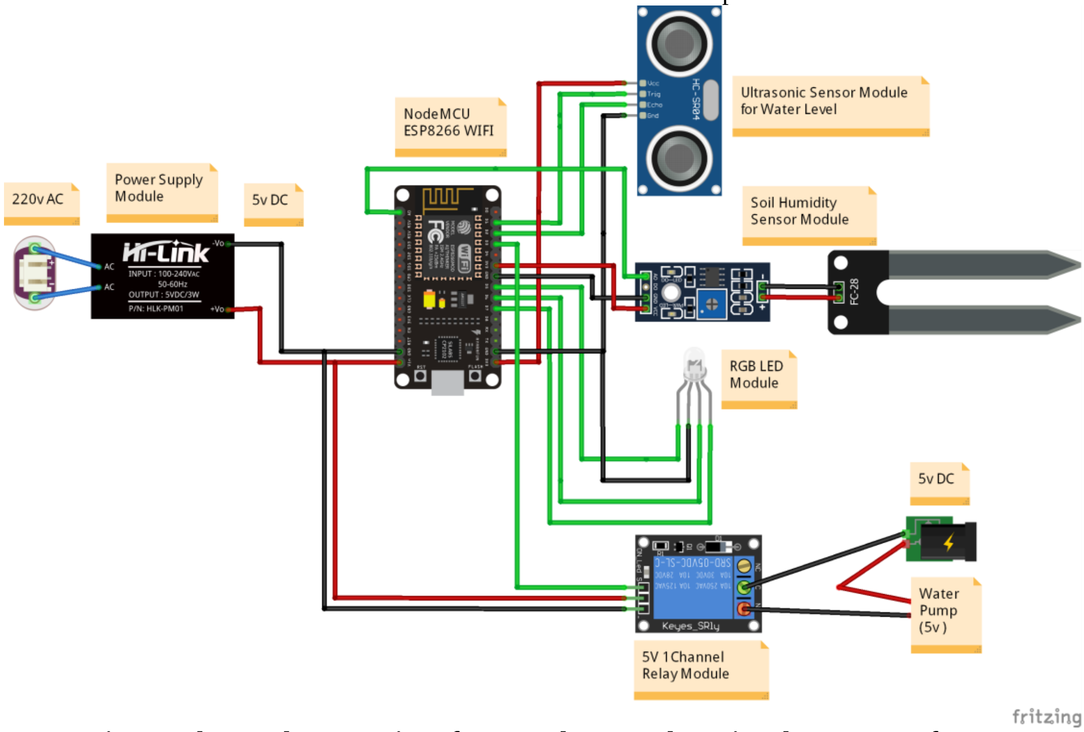


**Fig. 12. The Hardware Design of Smart Flowerpot by Using the Internet of Things**

In the hardware design, the system center would be the NodeMCU ESP8266 Wi-Fi and would connect the devices to the following NodeMCU.

- The Ultrasonic Sensor Module connected to pins D1, D2 and VCC, GND
- The Soil Humidity Sensor Module connected to pins A0 and VCC, GND
- The RGB LED Module connected to pins D5, D6, D7 and GND.
- The 5V 1Channel Relay Module connected to pins D3 and VCC, GND
- The Power Supply Module connected to the pin VCC, GND and the other side connected to 220VAC home power.
- The soil moisture sensor was connected to the soil moisture sensor probe with 2 wires to be + and –
- The water pump was connected to the Relay Module and connected to the 5V power supply pin.

All connections were shown in Figure 12.

**The Evaluation of the suitability of the Architecture of the Smart Flowerpot by using the Internet of Things.**

The analysis of the suitability of the Architecture of Smart Flowerpot by using the Internet of Things was carried out using descriptive statistics such as Mean and Standard Division. Defining criteria for evaluating suitability as a Rating Scale, which had criteria for determining the weight of the assessment to 5 levels, according to the model of the link (Linkert's Scale) [20] with the following criteria:

5 means most suitable
4 means very suitable
3 means medium suitability
2 means less suitable
1 means the least suitable

The Interpretation Criteria were used in order to classify the average score, the experts had the following scoring criteria at each level.

| | | |
|---|---|---|
| The Mean 4.50-5.00 | means | the most suitable |
| The Mean 3.50-4.49 | means | it is very suitable |
| The Mean 2.50-3.49 | means | moderate suitability |
| The Mean 1.50-2.49 | means | less suitable |
| The Mean 1.00-1.49 | means | the least suitable |

The assessment of the suitability of Information Technology and Computer Science experts on the Architecture of the Smart Flowerpot by using the Internet of Things, five people, evaluated the suitability which is shown in Table 2.

**Table-II: The assessment of the suitability of the Architecture of Smart Flowerpot by using the Internet of Things.**

| Description | Result | | Rating |
|---|---|---|---|
| | $\bar{X}$ | S.D. | |
| 1. Flowerpot integrated Control part | 4.80 | 0.45 | The most suitable |
| 1.1 Flowerpot part | 4.20 | 0.84 | It is very suitable |
| 1.2 Control part | 4.60 | 0.55 | The most suitable |
| 1.2.1 NodeMCU Microcontroller | 5.00 | 0.00 | The most suitable |
| 1.2.2 Soil Humidity Sensor | 4.40 | 0.55 | It is very suitable |
| 1.2.3 RGB LED Module | 4.80 | 0.45 | The most suitable |
| 1.2.4 Ultrasonic Sensor Module | 4.60 | 0.55 | The most suitable |
| 1.2.5 Relay Module and Water Pump | 4.00 | 0.71 | It is very suitable |
| 2. Wi-Fi Access Point | 4.40 | 0.89 | It is very suitable |
| 3. LINE Notify | 5.00 | 0.00 | The most suitable |

| | | | |
|---|---|---|---|
| 4. Mobile Application | 4.20 | 0.84 | It is very suitable |
| **Overall Score** | **4.55** | **0.63** | **The most suitable** |

According to Table 2, the results of the evaluation of the Architecture of Smart Flowerpot by using the Internet of Things were generally appropriate, at the highest level, with a mean of 4.55 and a standard deviation equal to 0.63, which was in the range of 0 to 1. Therefore, it could be considered reliable information and it could be concluded that the experts had relatively similar opinions, with the highest level of suitability.

## VI. CONCLUSION

This research was a document research, the research method was in two phases, namely, the design of the Architecture of the Smart Flowerpot by using the Internet of Things, data analysis by using the Content Analysis techniques and the results were:

1. The Architecture of the Smart Flowerpot by using the Internet of Things consisted of four parts which were: 1. Flowerpots combined with the Control part, this section consisted of 2-layer flowerpots, the outside was large that could contain water, the inner layer for planting trees was smaller. The control and sensor part consisted of a Soil moisture Sensor, which would send the soil moisture to the NodeMCU processor. If the soil moisture decreased to the set value, it would send to the relay module to allow the water pump to pump water to the tree. When the soil moisture increased to the set value, it would order the relay module to stop working, and the soil moisture level would also be displayed on the RGB LED Module, which would show in green, which meant the soil had high humidity, yellow; soil had medium humidity, red; soil had low humidity. There was a sensor to measure the level of water in the pot. If the water in the pot was out, it would alert the user to add water. 2. The Wi-Fi Access Point used for the Smart flowerpot connected to the internet, because the controller of the pot used the NodeMCU with a Wi-Fi connection. 3. Line Notify: the Smart flowerpot had a controller that sent the working situation of the Smart flowerpot to Line Notify such as sending soil moisture levels, water pump: ON/OFF, etc. and 4. The Mobile App was a section for users who owned the Smart flowerpot for controlling and displaying the sensor status and water level of the Smart flowerpot.

2. The evaluation of the suitability of the Architecture of the Smart Flowerpot by using the Internet of Things was by five experts in Information Technology and Computer Science. The statistics used in this research were the mean and standard deviation. The results showed that the developed architecture was the most appropriate, with an average of 4.55 and a standard deviation of 0.63. The use of NodeMCU was the control and processing of the Smart flowerpot, the experts commented that it was the most suitable with an average of 5.00, because the NodeMCU was a board that was compact and could connect to the internet via Wi-Fi. It was also a board that could process data at high speed. For the Line Notify the experts commented that it was very appropriate with an average of 5.00 as well. Using the Line Notify was more convenient for users because the Line had a good notification system and it was a system with which users were already familiar.

## ACKNOWLEDGMENT

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