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A Clownfish Farming Monitoring System Based on the Internet of Things

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Abstract. *Aquarium fish has a large commercial market, but it requires a great deal of labor force during the farming process; among fish types, the clownfish is considered high in economy value. This study implements the Internet of Things technology in the cultivation and monitoring of clownfish farming in order to reduce labor costs and improve the mortality rate in clownfish because performing diagnosis using sensor values prevents loss from human errors. In the proposed system, the Internet of Things technology is utilized to design and develop a clownfish farming monitoring system that focuses on reducing farmers labor time. The system uses a ZigBee development board as a platform for data transmission and connection between sensors where all sensor data are transmitted to servers for storage via zigbee. The system also provides a monitoring webpage platform. Every ZigBee conducts diagnosis on the sensor data; such as an abnormal sensor value is detected and then relevant equipment is triggered. By adding intelligent diagnosis, the system enhances farming success rates. The simulation results show the good stability and reliability of the proposed system.*
Keywords: Internet of Things, Aquaculture Automation, Remote Terminal Unit, Real-time Data Analytic

1. **Introduction.** Nowadays, the Internet of Things (IoT) has become a key target in high-tech industries around the world. Sensor data are processed or transmitted via wireless networks. The IoT technology has reduced labor necessity and provided better operation methods, thus the IoT has been widely applied to a variety of industries, such as the Internet of Vehicles, Industry 4.0, and smart cities. Beside, the IoT can also be applied to aquaculture. Fish farming demands heavy manpower, and such labor costs raise the overall farming costs; meanwhile, climate changes directly or indirectly cause losses. Climate change factors mentioned in Reference [1] include climate and environmental changes in fish tanks, which both affect mortality rate of the fish. Different fish species adapt to different temperatures; additionally, a fish tanks level of acidification also affects fish growth and mortality. Reference [2] suggests that both the internal and external environments of a fish tank are crucial. Therefore, not only does establishing a monitoring system based on the IoT technology reduce labor costs, when monitoring the internal and external environments, related equipment can aid in minimize impact from natural disasters while reducing loss caused by human errors.

Reference [3] illustrates the statistics for the year 2010 from Executive Yuans Council of Agriculture. The aquarium fish market boasts high demands and is estimated to generate 2.3 trillion New Taiwan dollars in gross output. In Taiwan, it yields around 1.5 billion New Taiwan dollars annually. For indoor saltwater fish farmers, clownfish has high of economic value and being a major target of development. However, in clownfish farming, water quality and other factors may lead to farming failure; for instance, climate changes and abnormalities, dramatic temperature changes, water temperature, pH level, and salinity all influence how the clownfish grows. As a result, it requires heavy manpower for 24-hour monitoring of the clownfishs living environment [4]. Moreover, since expected labor shortage and raised wages in the future will increase farming costs, factors such as labor will become a burden for fish farmers. Given the above, we propose utilizing the IoT to monitor the clownfishs environmental factors, such as water salinity, temperature, and pH level, and utilize existing sensors to examine internal and external environmental factors. Besides, all the while using ZigBee to conduct data diagnosis and transmit data to the server for storage to relieve the servers computational burden. The proposed system includes three parts: (1) An IoT sensor detects internal and external environments; (2) Environmental sensor data diagnosis triggers relevant equipment; and (3) A fish farm security surveillance system prevents incidents such as clownfish theft.

The main goal of this research is to propose a clownfish farming monitoring system based on the IoT that resolves labor cost issues. The study focuses on indoor farming environments. The system consists of five sensors [5] a PIR sensor, temperature sensor, illuminance intensity sensor, water level sensor, and salinity sensor and ZigBee to diagnose an indoor farming environment. ZigBee collects sensor data and performs intelligent diagnosis to trigger relevant equipment, such as stepper motors, heating rods, light modulators, and water pumps; it then transmits the data to the server and the server stores keeps the data in storage. This study provides the fish farmers with a website that allows them to monitor farm conditions at all times. Furthermore, in case of anomaly, the system notifies the fish farmer with a mail so that they are updated of all new developments from their devices. The experimental results show feasibility of the proposed system.

2. **Related Works.** Reference [6] discusses monitoring aquaculture environments, including the monitoring of concentration of dissolved oxygen in water, temperature, and electricity usage. When the main power source shuts down, solar batteries can be triggered to prevent fish kill from tank oxygen depletion. This studys system applies remote

monitoring and uses ZigBee to wirelessly transmit data to a remote server. This study also uses an optimal value calculator to obtain optimal parameters.

Reference [7] focuses on designing an Internet-of-Things aquaculture monitoring alarm system. Most farming systems only detect a single factor; however, in order to monitor dissolved oxygen concentration, this study wishes to detect soil temperature, humidity, atmospheric pressure, and carbon dioxide concentration at an interval of three minutes. Thus, the Internet of Things is applied for detecting multiple environmental factors for further analysis.

Reference [8] establishes an automated monitoring fishery that uses the ZigBee wireless sensor network to transmit data back to a remote server while monitoring and controlling the tanks environmental data. This includes temperature, dissolved oxygen, pH level, and water level sensor module monitoring system. In addition, each sensor is equipped with a solar device for power maintenance. The system relies on the Internet of Things to integrate different sensors, which also enhances its expandability.

Reference [9] focuses on establishing an aquaponic system. Fish waste can serve as nutrients for plants while plants serve as biofilters. The system utilizes the Internet of Things to establish an automatic control system for fish tanks, storing all data via cloud storage while regularly detecting water environment statistics and ensuring water circulation to achieve ecological balance.

Reference [10] proposes IoT problems that need solving, such as data transmission management, resource management, and sharing existing wireless networks. The study suggests an IoT self-learning mechanisms that allows IoTs to self-adapt to dynamic environments and adjust performance parameters, a learning process utilizing information collected from users and other IoT equipment that optimizes the systems overall performance. An ideal design would enhance the overall network performance while satisfying QoS requirements.

Given the energy limitations of wireless sensors, Reference [11] takes into account the issue of reducing energy waster. The study proposes an effective routing technique; sensor routing is designed either as static or dynamic, and integrates heterogeneous network in its network communication.

Based on the aforementioned literature, we can anticipate marine resource shortage in the future, and we will rely on fish farming to satisfy market demands. Fishery will rely on IoT systems to reduce labor costs and maintain farming quality; however, related studies have focused on monitoring the water environment. This studys system, on the other hand, provides a monitoring and intelligent diagnostic system that reduces labor force while elevating farming quality.

3. **Background.** This section introduces the hardware as well as Internet protocols used in this study, which can be divided into two parts: the first part briefly introduces ZigBee while the second part introduces the IEEE 802.15.4.

3.1. **ZigBee: An Introduction.** This study employs ZigBee for transmitting sensor data and conducting further diagnosis of anomalies. The ZigBee development board used in this study carries the CC2530 system on chip (SOP) developed by Texas Instruments. CC2530 follows the IEEE 802.15.4 protocol; it is small-sized, low-power, cheap, and adopts a protocol that conforms to international standards. This studys zigbee module boasts a COM port that supports communication between any microprocessor and computer.

In ZigBees specification, both the physical layer (lowest layer) and the data link layer (second layer) strictly follow IEEE 802.15.4s related specifications and standards. In order to enhance hardware stability, facilitate I/O connections, as well as facilitate connections using JTAG (Joint Test Action Group) lines for debugging, programming codes, or minimizing module size, ZigBee provides a stack app library named Z-Stack, which is an open-source protocol.

3.2. **The IEEE 802.15.4 Communication Protocol.** This study follows the IEEE 802.15.4 communication standards. IEEE 802.15.4 defines the operations of low-rate wireless personal area networks; it has a communication range of 10 meters with a transfer rate of 250KB/s at its highest. It was established as a response to more and more electronic designers demanding applicability towards schemes that have low complexity, have low data rate, and require only battery for power. Main features include low rate, low cost, low electricity consumption, abundant network nodes, and easy establishment. Thus, it is also suitable for application towards intelligent home automation, industrial automation, agricultural monitoring, electricity monitoring, and security alarm systems.

3.3. **Device Types in Network Topology.** The IEEE 802.15.4 communication standard defines two device types in network topology: the full-function device (FDD) and the reduced-function device (RFD). FFD plays three different roles; it can serve as the networks only personal area network coordinator (PAN coordinator), as a coordinator, or simply as the end device. An DFF can talk to any other FDD or RFD, but an RFD can only talk to one FFD. Therefore, by definition, an RFD is usually a device with simpler functions, such as a light switch or a sensor. An RFD does not usually transmit large amount of data, and it only connects to one FFD at a time; as a result, an RFD only requires minimal storage space and resources (Reference [12]).

4. **The Proposed Scheme.** This section aims at illustrating the proposed schemes structure, network detection, and functions. The section is divided into two parts: the first part concerns reception and diagnosis of sensor data; the second part discusses a B/S cross-platform application.

4.1. **The Actuator Module.** The actuator principles applied in this study are illustrated in Figure 1. Left sides P3 includes, from top to bottom, VCC, IN, and GND; VCC connects to +5V voltage while IN connects to ZB500s I/O port, so that ZB500 can gain control of the actuator module. This circuit employs the optical coupler (OC) EL817, leading to this circuits good electricity insulation and interference immunity, greatly enhancing its reliability. The transistor at the far end is responsible for amplifying the common emitter, the goal of which is to raise the photocurrent from optical coupling to in turn raise this signaling relays excitation ability (Reference [13]). The completed device is shown in Figure 2.

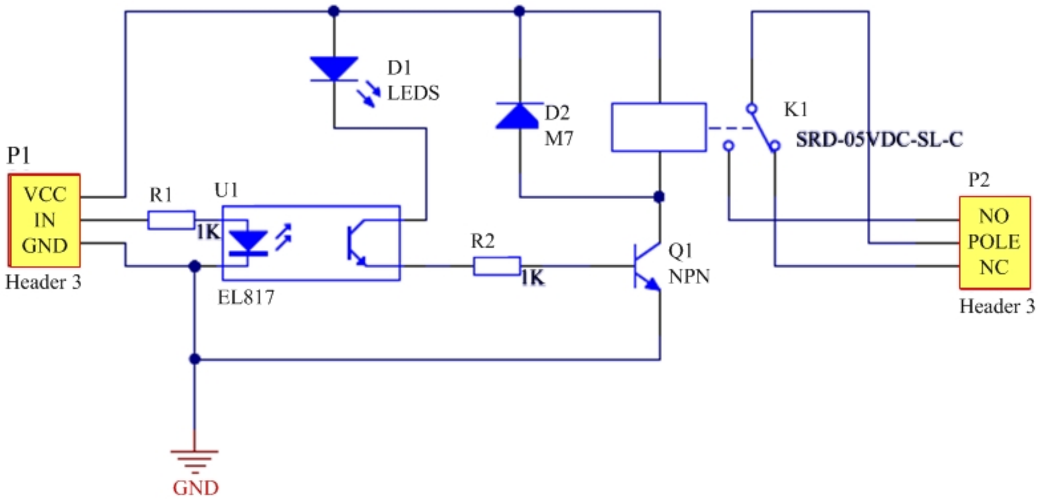

Figure 1. Actuator Module and Circuit

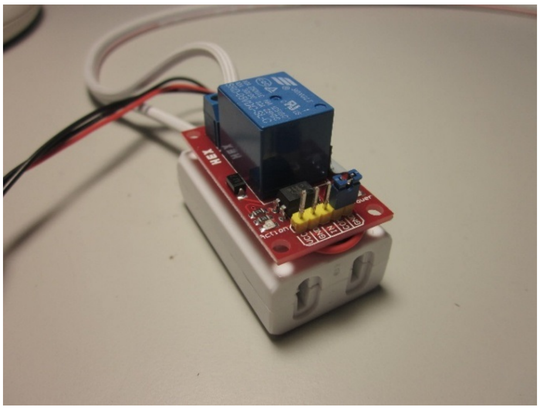

Figure 2. Actual Example of the Actuator Module

4.2. **Temperature Sensor Module.** This study employs the DS18B20 temperature sensor, a product by Maxim Integrated, U.S.A, shown in Figure 3. It converts temperature physical quantity into digital signal, and each DS18B20 comes with its unique serial number, thus enabling it to perform multipoint measuring. One can connect multiple DS18B20s using the same DQ line to read and write. Its measuring range falls within -55 +125C; its measuring accuracy at -10 +85C can reach 0.5C (References [14] and [15]).

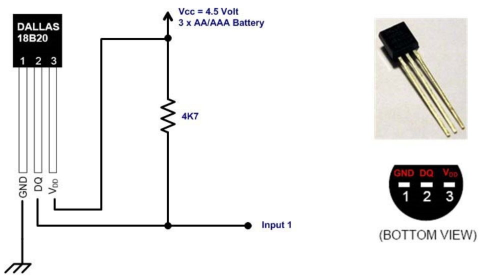

Figure 3. DS18B20s Circuit Connection

4.3. **Infrared Detector Module.** The HC-SR501 module employed in this study is a pyroelectric infrared detector (PIR), as shown in Figure 4, mainly used in human detection. The detection method involves adding an optical filter to the sensors receiving path: given that optical filters are selective in the wavelength it allows for penetration and human temperature, at 36.5C, gives off infrared rays of 10um in wavelength while optical filters bear transmittance of above 70% at wavelength of 7 14um, it is ideal for human detection. Additionally, HC-SR501s sensing range is 100 cone angle at its front and 3 7 meters in distance, adjustable. It is a passive infrared sensor composes of BISS0001 as its signal processor, paired with the DSN-FIR800 pyroelectric infrared detector and a few external components.

FIGURE 4. HC-SR501 Human Detection Infrared Ray Sensor

4.4. **Stepper Motors.** In order to accurately control the cameras rotating direction, stepper motors are chosen for operation. Stepper motors are electrical machines that convert digital signals to mechanical energy. Printers, hard disk drives, and optical disk drives all employ stepper motors for its power. This study uses a two-phase bipolar stepper motor with a step angle of 1.8 degress. Thus, an input of 200 pulse signals yields a full rotation ($200*1.8^o=360^o$). Since the stepper motors rotation angle is directly proportional to the pulse input, controlling the pulse input allows for precise control of the motors rotation angle. In order to control the stepper motors rotation, we mst rely on the electromagnetic principle of creating magnetism with electricity. The coil wrapped around the stator attracts the rotor to rotate; this method of flowing direct current through the stator coil to create a magnetic field is called excitation. To achieve correct positioning and control, we must follow a certain order when performing excitation on the coils; such method of stepper motor coil excitation can be classified into: (1) single-phase excitation, (2) two-phase excitation, and (3) 1-2 phase excitation. Here we have decided to apply two-phase excitation, the principle of which is to perform excitation by simultaneously using two sets of stator coil, as shown in Figure 5. The moment of force is greater than that of single-phase excitation, enough to carry the weight of the camera.

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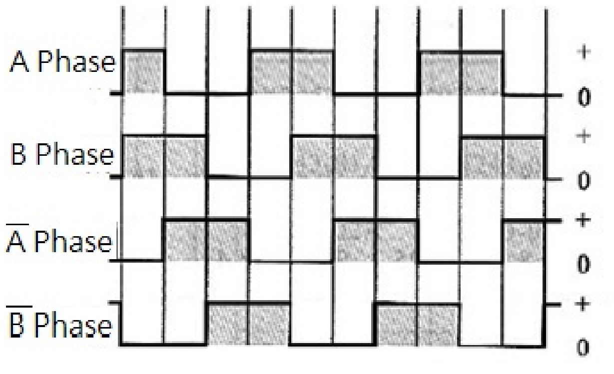

Figure 5. The Excitation Order in Stepper Motors Two-Phase Excitation

As shown in Figure 6, the cone on the ZB500 on the right side is the HC0SR501 human detection infrared ray sensor. When human motion is detected, CC2530 outputs signal via two-phase excitation order, triggering the motor to rotate. However, in case of high state signal output, the current is insufficient to trigger rotation in inductive stepper motors. Therefore, as shown on the bottom left corner of Figure 6, one circuit board underwent Darlington amplification, which is a type of direct coupling amplifier. The transistors are directly connected, without use of any coupling elements. The biggest advantages of such design are high current gain (2) and voltage gain of slightly under 1.

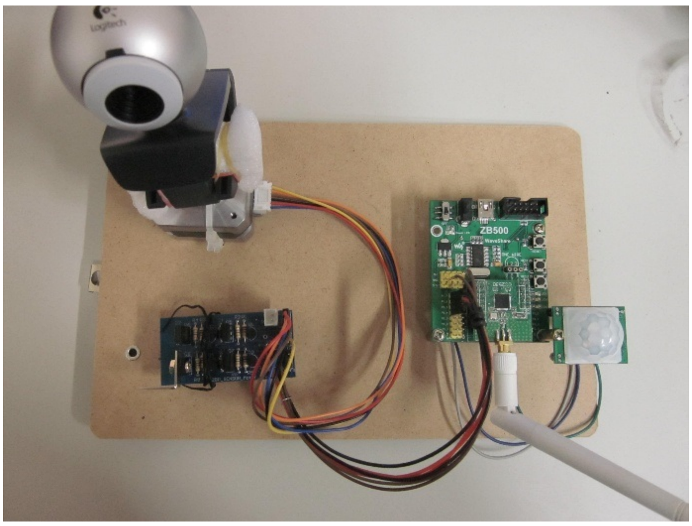

Figure 6. Finished Product of Infrared Ray and Stepper Motor

4.5. **Illuminance Module.** This study employs KPS-3227, an NPN silicon phototransistor, as shown in Figure 7. It is often applied in backlit displays and is very energy-efficient. This device is highly sensitive to visible lights; the collectors photocurrent and illuminance are almost directly proportional in terms of linearity. We can see from this study that the incident rays energy and the transistors IC electric current are directly proportional, and changes in ICs electric current affect RCs voltage; as a result, the VCE voltage also changes accordingly. Therefore, by measuring the voltage of RC or VCE, we can learn what the current quantity of illumination is.

FIGURE 7. The KPS-3227 Illuminance Sensor

4.6. **Light Modulator Design.** When actually testing out hardware functions, we first decided to build the modulator using the 555 chip and X9511WP digital variable resistor. The use of the 555 chip yields high-frequency PWM signals and the LED light source is free from flickering; this method yields satisfactory results, and is currently a very common approach. I traditional approaches, an ordinary variable resistor is used for adjusting the duty cycle; nevertheless, this entails that manual adjustment is required. Thus, we can pair the modulator with X9511WP to build a programme-controllable light modulator. Based on the above, we have, as illustrated in Figure 8, designed a circuit that utilizes X9511WP to adjust LED brightness. The finished product is shown in Figure 9.

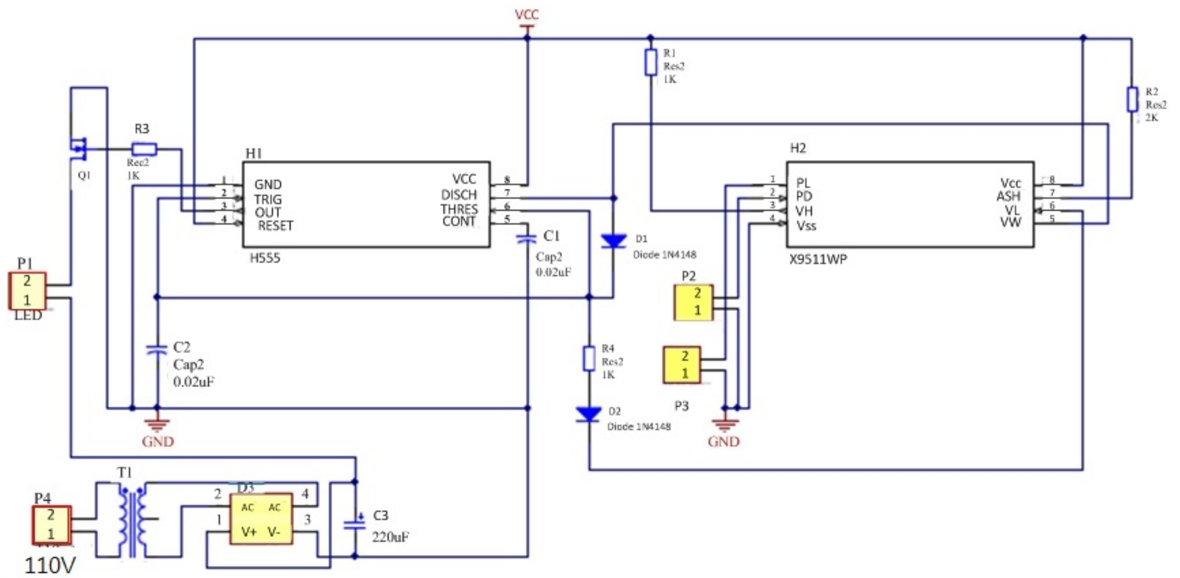

FIGURE 8. A Self-Designed LED Light Modulating Circuit

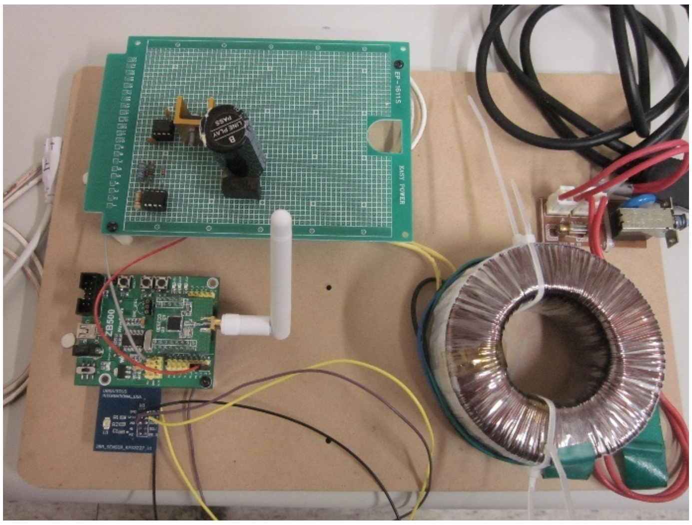

FIGURE 9. The Assembled Illuminance Sensor and Light Modulating Circuit

4.7. **Water Level Sensor Design.** This ultrasonic module (USM) chosen for this study is HC-SR04, a fairly common, user-friendly, low-cost untrasonic module with an accuracy of 3mm. It is based on the physics principle that all waves reflect upon contact with an object and the mathematical relationship between sound speed and time to calculate distance, as illustrated in Equation 1. We know that sound travels at 340m/s, and by multiplying that number to the sound waves bounce time measured by this module, we can obtain the objects distance. The finished product is shown in Figure 3-20; the board beneath ZB500 is HC-SR04, which is used to detect water level and trigger corresponding relay. This is shown in Figure 10; one is for adding water while the other one is for pumping it.

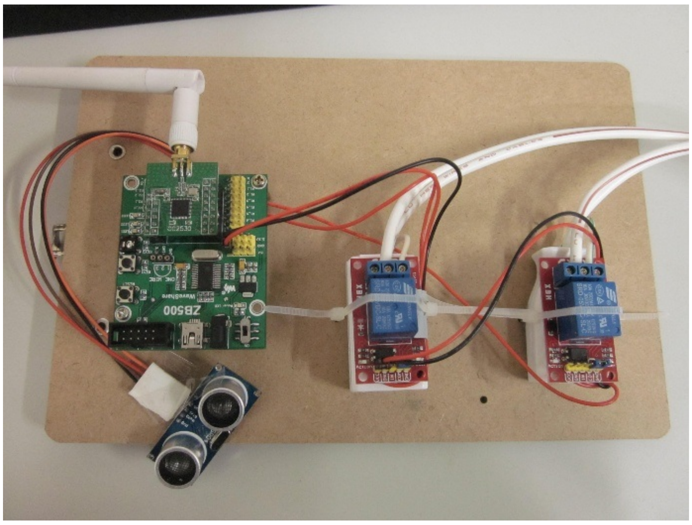

FIGURE 10. A Finished Product of Ultrasonic Water Level Sensor

In practice, we measure the waiting time between the ultrasonic waves launch until its reflection, which is a very short interval of usually a few s, and then multiply it by 34,000 cm; the result is the distance between test objects, as illustrated in Equation 2. It is worth noting that given that CC2530 is a microcontroller of a variable type that does not apply floating-point numbers, which means that it does not use decimal points, we transposed s 10 to the negative 6th power term to the speed side and performed the division at the very end. Also, because we measured the total addition of time of launch and reception, we must adjust the final value: we should either divide the waiting time by 2 or multiply the speed by 2. Because microcontrollers perform multiplications faster, we chose to multiply the speed by 2, as shown in Equation 3.

$$Displacement = Time * Velocity \tag{1}$$

$$Displacement = WaitingTimes * 34000cm \tag{2}$$

$$Displacement = WaitingTime * 68000/1000000 \tag{3}$$

We used CC2530 to directly simulate this modules communications protocol, as shown in Figure 11. It isnt harder to use than a light modulators PWM; the digital signals all follow the standard TTL (transistor-transistor logic) levels. First, we send out a high state signal of 10 s in length, and the HC-SR04 module, after successful reception, sends back an array of eight consecutive pulses to signify that the module has been successfully turned on and is ready to measure distances. When we once again receive high state signals from the HC-SR04, CC2530s internal timer is triggered; when HC-SR04 is finished with measuring, its signals become low level and the timer is turned off.

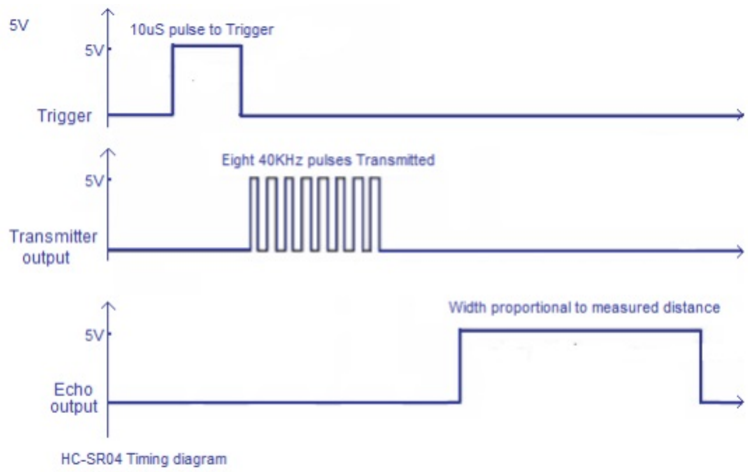

FIGURE 11. The Operation Sequence of the HC-SR04 Ultrasonic Module

4.8. **Salinity Sensor.** The clownfish are a type of tropical fish that inhabit the ocean; while water temperature is crucial, water salinity is just as important. This study designed a salinity sensor based on electric conductivity, the principles of which are illustrated in Figure 12. It can be divided into four parts: a Wien bridge oscillator, a non-inverting amplifier, a voltage divider circuit, and a full wave bride rectifier. The non-inverting amplifier in the second part utilizes electrodes to measure water resistivity. When salinity increases or decreaes, resitivity also increases or decreases accordingly; meanwhile, it also affects the non-inverting amplifiers amplification, and the sine wave amplitude measured in output also changes accordingly. The third part consists of a simple voltage divider circuit, the aim of which is to reduce the output voltage because ADC can only accept as much as 3.3 volts; it it exceeds this number, it will burn out CC2530. The fourth part involves a full wave bridge oscillator. We must be extra cautious with the subsequent filtering; in this application, the aim of filtering isnt to reduce ripples in the power source, so there is no need to maintain the voltage at the wave crest. In order to enable the direct current to swiftly change following changes in water resitivity, we used a capacitor with a small capacitance of 0.1 uF and connected it in parallel with a variable resistor to correct the capacitors time constant during electric discharge. When performing correction, we simply need to ensure that the time constant is smaller than the sine waves wave period.

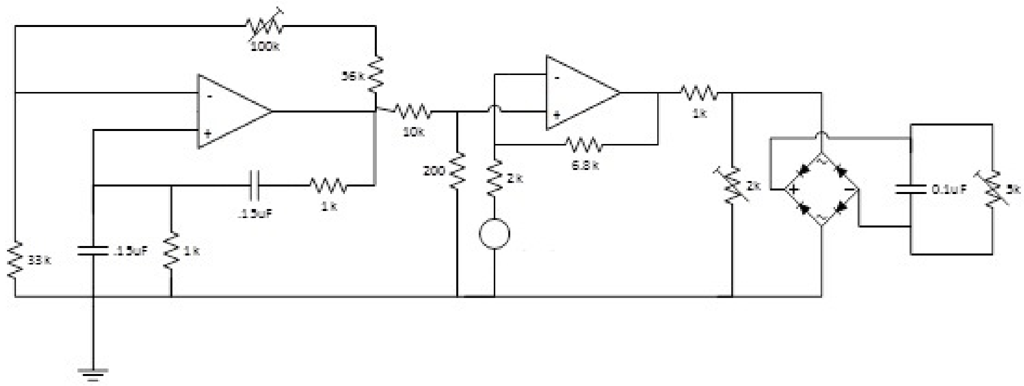

FIGURE 12. The Salinity Sensors Circuit Map

The LM324 4-in-1 operational amplifier in this circuit follows the same steps and rules, which is why there is a 9-0-9 transformer on the left side in Figure 13, serving as a double DC power supply of +12 and -12 volts for LM324. We acquired some seawater used in farming clownfish from the fish farming department and soaked the electrode in the output volate, as shown in Figure 14(a). We can see that the output voltage is roughly 0.19 volts; with this voltage as a base standard, any voltage that exceeds it signifies that the salinity is too high. We also mixed another 200 grams of freshwater with 30 grams of salt to simulate high salinity and soaked the electrode in the output voltage, as shown in Figure 14(b). We can see that the output voltage increased to around 0.204 volts. Therefore, by utilizing CC2530s built-in ADC to receive this signal, we can monitor the farming tanks salinity in real time to actuate the relay and add frewhwater to reduce water salinity.

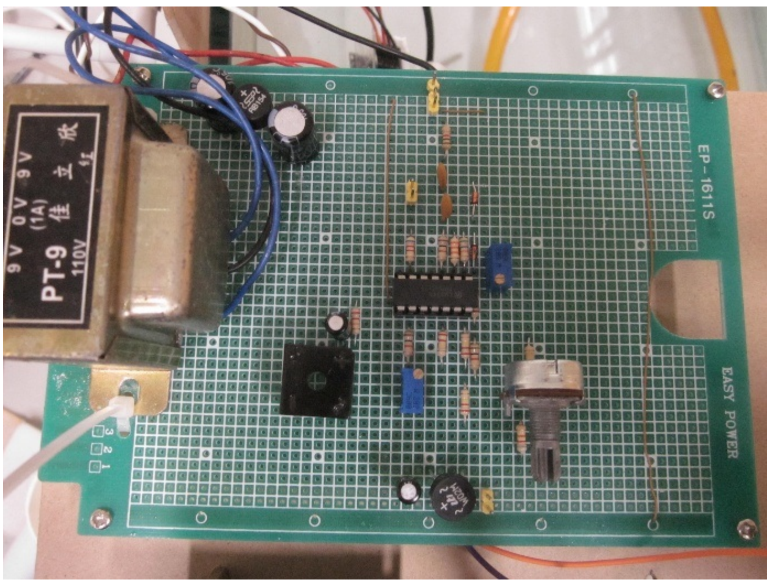

FIGURE 13. A Finished Product of Salinity Sensor

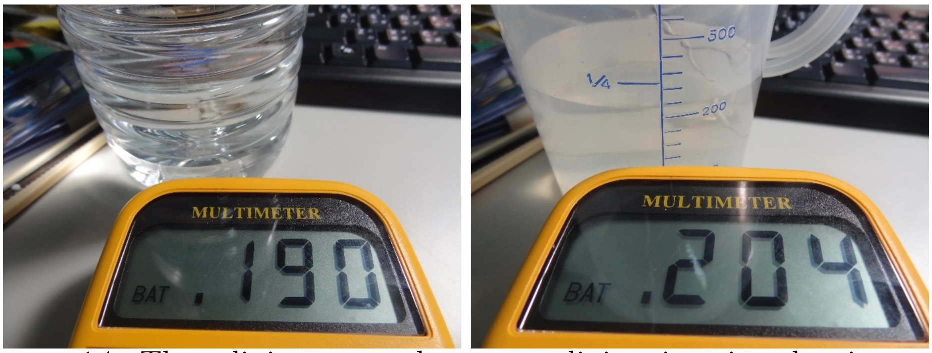

Figure 14. The salinity sensor detects a salinity situation that is normal and another that is too high. (a)Salinity is Normal, (b) Salinity is Too High

Clownfish are farmed in regular seawater; seawater has an average salinity of 34.72% and varies within the range of 33 37%. Based on our salinity sensors measurements, normal seawater salinity bears 0.19 volts, and if we look at the number 0.19 volts as the base for the average seawater salinity 34.72%, and input this voltage to ADC for detection, then we obtain the value of 440. As mentioned above, the DC voltage detected at the beginning using digital electric meter was 0.19 and 0.204 volts, which might be indiscriminative for humans; however, for an exceptional ADC, it makes a huge difference, as illustrated in Equation 4. CC2530 has a built-in ADC of 12-bit, and we set the reference voltage at 1.8 volts; by such we learn that the resolution can be as small as 0.00043956043 volts, meaning that any nuance can be accurately detected. Consequently, we used the value 440, obtained from measuring the seawater used in farming clownfish, to establish a normal salinity determination range of 400 460. As shown in Figure 15, when the value exceeds 460, the salinity is diagnosed as too high, and P1_1 is set as high state to trigger the pump to draw water into the fish tank.

$$0.00043956043 = 1.8/212 - 1 \tag{4}$$

```
If (val_num<=460 && val_num>=400)
{
        P1_1=0; // normal
}
Else if(val_num<400)
{
        // Low salinity
}
Else
{
        P1_1=1; // High salinity
}
```

Figure 15. Range for Determining Whether Water Salinity is Normal

4.9. **B/S Cross-Platform Application Service.** This study has developed a cross-platform webpage application service based on the concept of B/S. This concept bears subtle difference compared to past concepts of client/server (C/S). The structure of C/S is shown in Figure 16; it is generally built on a dedicated network, usually a small-range network environment in a business enterprise. It provides conneciton and data exchange services directly in the local area network via dedicated servers. Generally speaking, every client is expected to have a certain level of computation ability to execute different software associated with different clients. If a client uses a Windows OS, they must install Windows software; if a client uses the Linux OS, then they should install Linux software. However, this approach leaves clients exhausted and developers troubled, because developers have to develop a variety of software of different programming language but identical functions (Reference [16]). On the other hand, the structure of B/S is illustrated in Figure 17; it is built on a wide area network instead of a dedicated network environment, and has a better adaptation range than C/S. Normally, it requires only an operating system and a browder for execution.

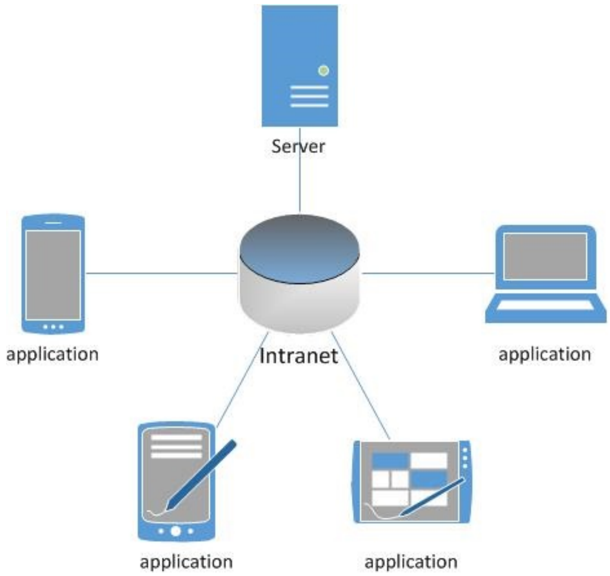

Figure 16. The Structure of C/S

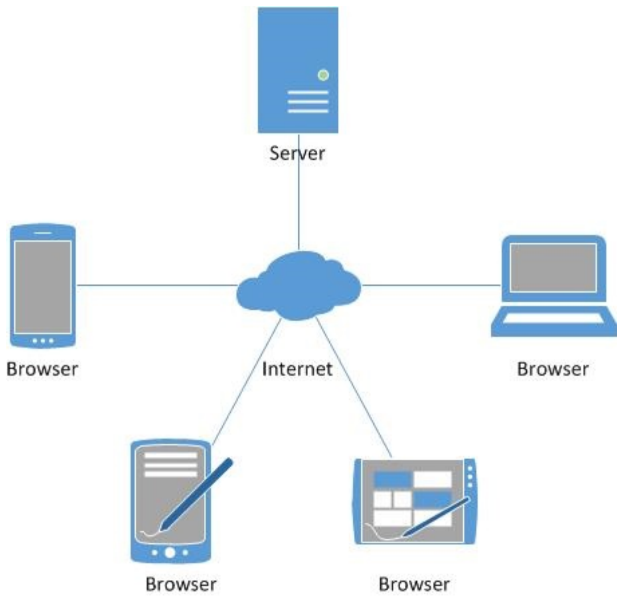

Figure 17. The Structure of B/S

5. **Performance Analysis.** This section introduces this studys hardware circuit implementation results and the softwares human-machine interface as well as simulation of the clownfish farming monitoring system. The study performed a series of simulation experiements to test for feasibility, and conducted analysis based on the experiement results. We have proposed an intelligent IoT system that utilizes a variety of sensors, actuators, and the ZB500 module to enable users to conveniently monitor remotely. The systems sensor nodes include temperature, illuminance, human infrared ray, ultrasonic water level, and salinity sensor. In the following, we will present figures to prove this studys experiment results.

Figure 18 illustrates a simulation of water temperature diagnosis while the heating rod is on; Figure 19 shows a simulation of water temperature diagnosis while the heating rod is off. Figure 20 illustrates environmental illuminance diagnosis; if it exceeds 300 Lux, then the system slightly dims the LED tubes brightness. In Figure 21, when human motion is detected, given that currently the sensor rotates at a fixed angle of 45 degrees, it is impossible to locate the human location and turn towards a specific direction. Once it becomes capable of turning frontwards, it will be able to send an e-mail to alarm security or directly retrieve and store the image and then send out to the security personnels cell phone via multimedia messaging; all the above are goals to achieve in the future. Figure 22 is a water level diagnosis simulation. When farming any type of fish, water level is always crucial; too high or too low of a water level can cause fish to dehydrate and no be able to breathe. Therefore, we applied the HC-SR04 ultrasonic module to detect water level; when it is too low, it actuates the pump that adds seawater to swiftly return the water level to normal height. Figure 23 shows water salinity diagnosis simulation. Clownfish are saltwater fish, so salinity in the fish tank is essential and must be kept within seawater salinity range. The salinity sensors output is connected to CC2530s internal ADC to conduct continuous monitoring of water salinity. When CC2530 detects and diagnoses that the salinity is too high, it turns Port1_1 to high state so that the motor can obtain enough power to begin fuctioning. We applied two key techniques jQuery Mobile and AJAX so that our application service can be used perfectly across platforms. When users visit the site on different devices, it automatically loads different webpages, all the while supporting the original applications operating methods, as shown in Figure 24.

We conducted system variation comparison against References [7, 8, 9]. For our IoT fish farming system, aside from monitoring the coefficients within the fish farm, we must also enable users to remotely monitor those numbers from afar. Additionally, the system must be capable of conducting coefficient anomaly detection; when anomalies occur, the system should trigger relevant equipments, such as a water pump, and notify the user at the same time. After comparing our study against other literature, we confirmed that our approach satisfies all the above requirements, and the system was successfully implemented.

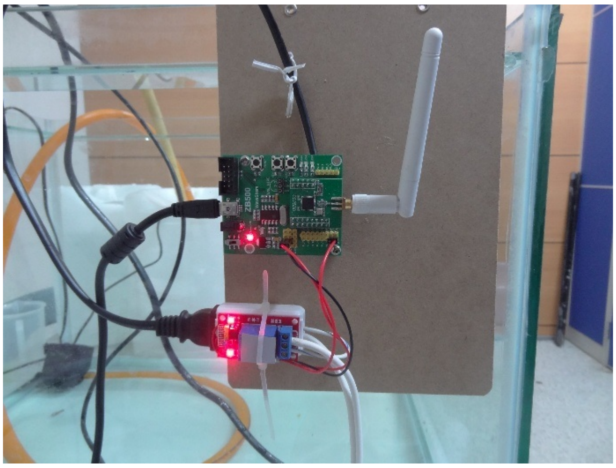

Figure 18. Heating rod being turned on

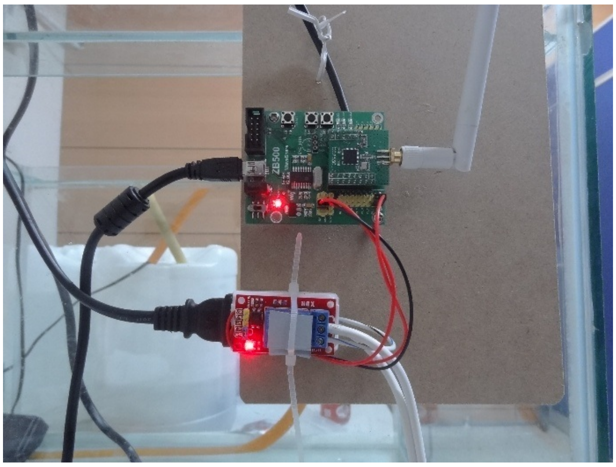

Figure 19. Heating rod being turned off

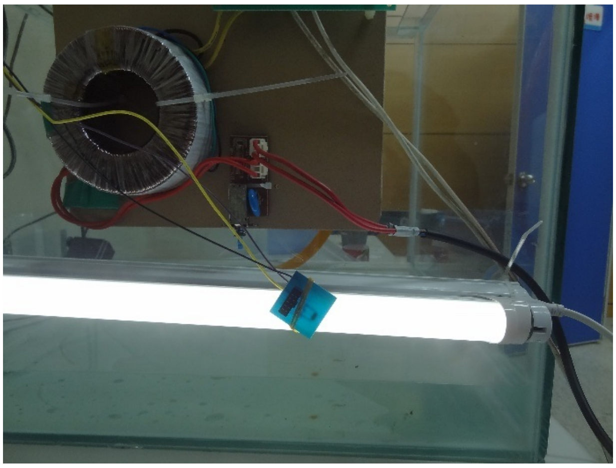

Figure 20. A dimmed LED tube

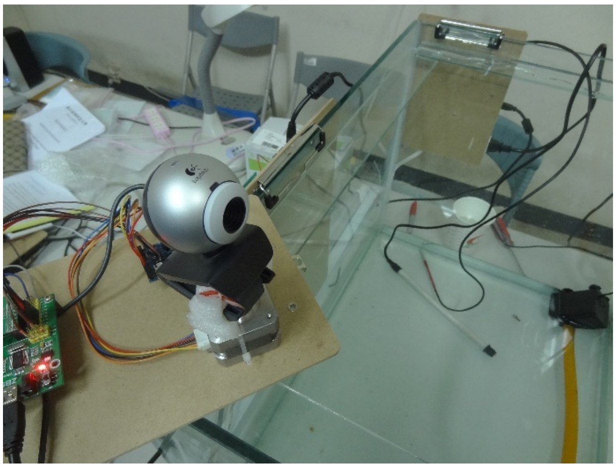

Figure 21. Human motion is detected, so it is facing frontwards

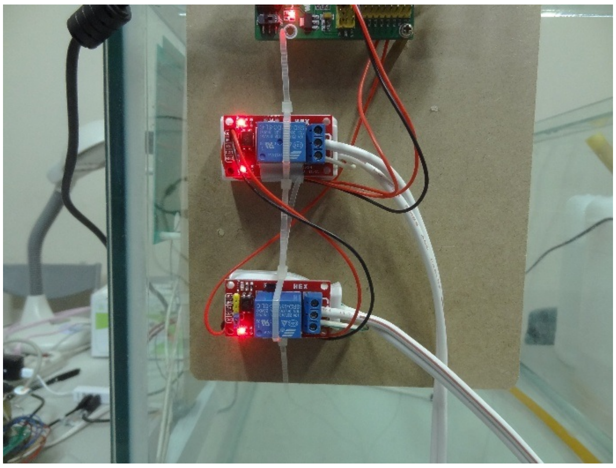

Figure 22. Water leverl is too low, so seawater is being added

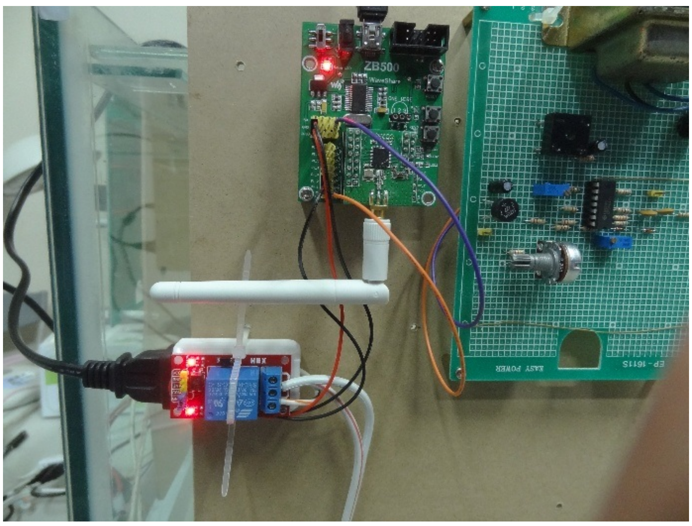

Figure 23. Water salinity is too high, so freshwater is being added

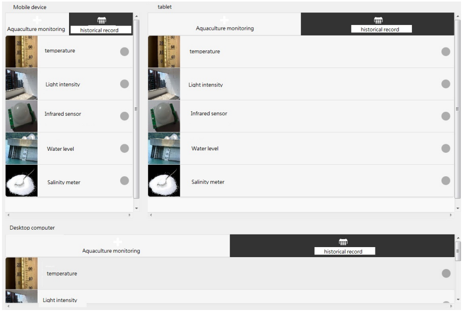

FIGURE 24. Different devices display different webpage services

TABLE 1. Comparison of proposed system and three state-of-the-art systems

Property \ Method	[7]	[8]	[9]	Proposed system
The system provides remote monitoring.	YES	YES	YES	YES
The system has a wireless network feature.	YES	YES	YES	YES
The system conducts data anomly detection.	YES	YES	NO	YES
The system triggers relevant equipment if anomaly is detected.	YES	YES	NO	YES
The system has an emergency data notification feature.	NO	NO	NO	YES

6. **Conclusions.** This study has explored various problems that might arise from applying variegated sensors to clownfish farming; it has also defined many object rules to establish an Internet of Things. Meanwhile, in order to reduce the need for 24-hour monitoring on the farmers end, the study has proposed a clownfish farming monitoring system based on the Internet of Things to resolve issues, plan out and establish a monitoring system that simulates clownfish farming, and relieve farmers burdens. We developed an Internet of Things structure based on WSN. There are variegated sensors and actuators; when each sensor and actuator are capable of communicating with each other while performing automated operations based on defined rules, they become an intelligent IoT in which all objects are connected. The simulation results show that the proposed system has the good performance.

REFERENCES

[1] Xie Hengyi, Chen Gaosong, Zeng Zhende, Xi Yile, Cai Wansheng, How the Penghu Aquaculture Industry Deal With Frost Injuries in Wintering Sea Areas, *FRI Newsletter*, issue 40, 2012.

[2] Fisheries Research Institute, Council of Agriculture, Executive Yuan, Marine Science and Technology Development Plans Sustainable Management in Aquaculture, *Fishery Research Institute Special Edition*, issue 19, 2015.

[3] Council of Agriculture, Executive Yuan, Council of Agriculture Aquarium Fish Key Industry Research Teams Mid-Term Plans, *The Farmers' Academy*, 2010.

[4] Rui Teng, Huan-Bang Li, Bing Zhan and Ryu Miura, Differentiation Presentation for Sustaining Internet Access in a Disaster-Resilient Homogeneous Wireless Infrastructure, *Digital Object Identifier 10.1109/ACCESS.2016.2519244*, 2015.

[5] ZigBee Specification Version 1.0, ZigBee Alliance, 2005.

[6] Wen-Tsai Sung*, Jui-Ho Chen, Da-Chiun Huang and Yi-Hao Ju, Multisensors Realtime Data Fusion Optimization for IOT Systems, *2014 IEEE International Conference on Systems*, Cybernetics October 5-8, 2014.

[7] ShaoHua Hu, Dynamic Monitoring Based On Wireless Sensor Networks of IoT, *IEEE Conference*, 2015.

[8] Jui-Ho Chen, Wen-Tsai Sung* and Guo-Yan Lin , Automated Monitoring System for the Fish Farm Aquaculture Environment, *2015 IEEE International Conference on Systems*, Man, and Cybernetics, 2015.

[9] N Hari Kumar, Sandhya Baskaran, Sanjana Hariraj and Vaishali Krishnan, An Autonomous Aquaponics System using 6LoWPAN based WSN, *2016 4th International Conference on Future Internet of Things and Cloud Workshops*, 2016.

[10] Taehyeun Park, Nof Abuzainab and Walid Saad, Learning How to Communicate in the Internet of Things: Finite Resources and Heterogeneity, *Special Section on Optimization For Emerging Wireless Networks*, 2016.

[11] Jingjing Yan, Mengchu Zhou and Zhijun Ding, Recent Advances in Energy-Efficient Routing Protocols for Wireless Sensor Networks, *Digital Object Identifier 10.1109/ACCESS.2016.2598719*, 2016.

[12] IEEE Standard for Part 15.4: Wireless Medium Access Control (MAC) and Physical Layer (PHY) specifications for Low-Rate Wireless Personal Area Networks (LR-WPANs), 2003.

[13] Wang Haoyuan, Power Source Plug Socket with Low Stand-By Dissipation Power, *graduate student at the in-service education program of Department of Electrical Engineering*, Fu Jen Catholic University, 2009.

[14] Tu Jiayu, A Research on Application of ZigBee-Integrated Temperature Sensors at Nursing Homes, M.A. thesis, Department of Computer Science and Information Engineering, Asia University.

[15] Yang Zhezhang, Shi Boyu, Dong Ying, and Chen Kunhan, Application of Wireless Sensor Networks in Establishing Environmental Temperature and Humidity Monitoring System, *Gerontechnology Research Center, Yuan Ze University*, 2008.

[16] Zhong Zixian, Developing Remote Monitoring Systems Based on Z-Stack, *M.A. thesis, Department of Electrical and Electronic Engineering, Chung Cheng Institute of Technology*, National Defense University, 2011.