Implementation of a Greenhouse Crop Remote Monitoring System with IOT Technology

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ABSTRACT

To develop a surveillance system with remotely control method for a greenhouse crop is a fresh issue. In this report on the basis of IOT (Internet-of-Things) platform to implement an aperture previously reminded. The developed system, basically, is suitable for monitoring the parameters of plant growth environment. Accordingly, the gathered data and the results from the measurement system are not only helpful for designing the construction, but they can also be useful for recognizing the growth environments of the plants. Several of the devices, such as, a temperature meter, humidity meter and all other facilities are playing the roles of perception layer in the IOT configuration. Besides, the Zigbee wireless mesh is jointed with some sensor nodes to construct a semi-WSN (wireless sensor network).

Keywords: *IOT, plant growth environment, Zigbee wireless mesh, cloud technique.*

I. INTRODUCTION

Recently, global climate changing obviously, extreme weather variate clear, both brought frequently incremental in disasters of plants. The urgent work for setting up an automatic monitor system focuses on the aforementioned issues is necessary. There are a lot of issues addressed and based on IOT (Internet-of-Things) concept illustrated in [1]. In 2008, IBM@ Corporation proposed the 'Smart planet' vision and pointed out that IOT has become the indispensable role [2]. There are some cases of application, the medical care system, regional environmental observation and environmental education information system, the oriental fruit fly ecological monitoring and warning system, as well as the application of the IOT in innovative applications of plant factory, etc.. An automatic routing type for the WSN (Wireless Sensor Network) gateway device can be applied to integrate into a whole WSN. Furthermore, the above system's characteristic has automatic routing functions, and can be installed as one of WSN node device. However, when it is failure to link to a fault sensor node which is one of other sensor node devices and it can't pass the normal sensor measurement data back to the normal host. Simulation of WSN is to evaluate the performance of the system using several statistics reports. The monitoring system can be fully extended to several different types of application, such as, health care and environmental inspection [3]. Nowadays, only the intelligent environment control system applied in the greenhouse plant cultivation is in developing. To obtain high quality of crops which are depending on the plant environmental conditions, and greenhouse provides a closed and controlled environment. Such results can ensure that the stability of the plant growth during the whole year whether the weather and the environment is good or not. An integrated intelligent greenhouse, high production efficiency of land usage and environment of the controlled physical parameters, and appropriate management will help not only in better crop yields, but also the quality of crops can be improved.

In view of the above mentioned problems for farming cultivation managers and researchers, therefore, need to demand a remote monitoring system which can make them have not to attend and not come close to the field measurement. A convenient and efficient to observe and to collect the remote area of the farming culture of the workplace environment monitoring parameter data are generated by the aforementioned idea. In the role of the construction of ecological environment monitoring system, wireless sensor and front-end gateway device have become main components of the system. However, in the practical application of WSN, it is very likely due to the device fail or sensor node to link to an error one. Thus, not only other ones cannot send the normal sensor measurement data back to the host, but consequently it also affects the whole appropriation of the ecological environment monitoring system [4].

In this paper in the introduction to the whole article introduce briefly the research background and the architecture, in the second chapter ZigBee principle and description of each layer architecture, as well as the system uses ZigBee instrument (IP - Link2220 module) the protocol and the key technology of instruction; Monitoring system of greenhouse crops in the third chapter a statement, the layout of the architecture and illustrate the future combined with cloud the value of science and technology, and the fourth chapter, the system operation interface and the result of Zigbee message transmission, record and monitor the change of plant process observation and analysis. Finally, a brief conclusion will value the function of remote monitoring system of greenhouse crops do under control of the whole, as well as the future goes deep in the cloud technology in education study on deeper breakthrough.

II. KEY TECHNOLOGY AND ZIGBEE WIRELESS NETWORK

The difference of cable network and wireless network cable network application has certain limitations, and extension is not an easy installation, high maintenance costs, and wireless network faults is safety, interference. In order to

make up for the defect of cable network and wireless network, integration with a wired and wireless mixed network solution, this system use longitude engineering technology (Lon works technology) of the remote monitoring system integrated into IP network. System consists of data acquisition module and Zigbee wireless sensors to monitor temperature and relative humidity. Wireless sensor network was originally for military applications, is now more widely application field, including home automation, monitoring systems, environmental and health monitoring.

2.1 *Zigbee principle and each layer architecture*

Definition of Zigbee transceiver in IEEE 802.14 Wireless Personal Area networks (WPAN, Wireless Personal Area Network), its structure is divided into Physical layer (Physical, PHY) and media access Control layer (Medium Access Control, MAC) Low power Wireless Personal Area networks (Low Power Wireless Personal Area Network, LoWPAN) combined with the offset is in photograph frequency shift keying (O-QPSK) and Direct Sequence Spread Spectrum (Direct Sequence Spread Spectrum, DSSS). Zigbee specified (NWK) Network, Network layer and Application layer including Application Support (Application Support, APS) sub-layer, Zigbee setup purpose (Zigbee Device Object, ZDO), there are Application Framework (Application Framework, AF) and the safety of the Zigbee. Zigbee listens for multi-channel Access to avoid the use of Carrier (Carrier Sense Multiple Access with Collision Avoidance, CSMA/CA) Collision of media intervention, provides the mesh networks to ensure that the data packets, and specify the mutual operational application, as shown in Fig. 1. IEEE 802.14 transceiver work without having to rent the 2.4 GHz frequency band, with 16 communication channel theory data transfer rate of 250 KB/s, separating each channel to 5 MHZ. Zigbee network there are three types of nodes, including a Zigbee network Coordinator (Zigbee Coordinator, ZC), Zigbee Router (Zigbee Router, ZR), or Zigbee terminal equipment (Zigbee End Device, ZED). ZC and ZR are fully functional equipment, and ZED is hypo function. ZC is usually by the main power supply, is to start the Zigbee network a unique network ID, PAN ID selecting an operating a network of 16 channels [5].

Due to the low transmission rate and low consumption ZigBee electrical characteristics cause of Zigbee application mainly to play the role of in control. In the system using Zigbee (IP - Link2220 module), can be divided into fully transparent with a binary two modes. In transparent mode, the terminal unit would have been sent by Zigbee information to control, the control side but can't make a control of terminal unit, only the sound of data for processing. In Binary mode, control logic can do control of terminal unit, and only in the control side needed, able to do the data to the terminal unit for action. As mentioned in the introduction, when the Zigbee connected with some terminal device, can only do transfer in transparent mode, but as entrance guard monitoring or some such as I/O device without having to transfer has been the application of type, or control of the control or have some special needs to do to deliver messages, is not suitable for use in transparent mode.

So this system will be in binary mode, using Zigbee module provided by the communication format and instruction in the Zigbee message transmission and control, so it can be applied to case study this paper acquisition way of setting application parameters monitoring.

2.2 *IP-link 2220(2220H) module introduction*

Provided by Taiwan He Li d-link IP - 2220 series products are used in short distance wireless Link Machine to Machine (the Machine - to - the Machine) of communication products, in the hardware IP - 232/485 Link provides industrial standard RS - 2220 interface, and communications using an IEEE 802.15.4 way transmission, the RS - 232/485 to replace them by wireless cable, as shown in Fig. 2. Module through the Mesh (Mesh), Star (Star), Cluster (Cluster - tree), such as elastic network topology, improve network reliability, fully meet the needs of various short distance wireless applications. IP - link2220 (2220H) with Full Mesh architecture, the network design to take a Master node, the other is the Client side. Mesh networks provide backup communication paths, if one malfunction (including interference), the network will automatically through the standby path information. This extension increase the reliability of the entire network, at the same time on the new device or reconFig. the existing equipment is relatively easy. IP - link2220 (2220H), there are three kinds of mode allows users to use, respectively is a binary pattern (Binary Protocol Mode), transparent broadcasting mode (Transparent - Broadcast Mode) and transparent point-to-point mode (Transparent - P2P Mode). Among them, the transparent mode is a kind of communication way has nothing to do with the data packet format, the user only needs to transfer data directly to the serial port, the module will be on their own to deal with data, according to the pre-set target node address to transfer data to the module [6].

2.3 *He Li - general frame format*

In He Li (Helicomm) technology provided by the IP - Link series of Zigbee products, its protocol, there are four types of frames, respectively is order requests (command request), instruction reply (the command response), data request data request and data validation, data acknowledgement) four frames. They use the same frame structure, as shown in table 1.

I. column Header Control (Control Header) : length is 1 byte, Bit3 Bit0 ~ for the packet of ordinal number, 0 to 15 cycles (modulus 16), is used to distinguish different packet, adjacent to the packet sequence number must be different. Bit4 is retained. The default is 1. Bit5 ~ Bit7 said frame type, as shown in table 2.

II. Attachment Quality indicators (the Link Quality Indicator) bar: the length is 1 byte, said received packet connection Quality and value of 0 to 255, the higher the value of the said signal Quality, the better.

III. Objective status Address (Destination Address) bar: length of 2 byte, said the network Address of the Destination node. Including three addresses are reserved, respectively, said

the network host addresses 0x0000, table type radio address 0XFFFF and 0xfffe said the local node.

IV. Column Length of load (Payload Length) : Length is 1 byte, said load column data Length, the Length of the valid range is 0 to 97 byte.

V. Column load (Payload) : 0 ~ 97 byte variable length. This value is limited by IEEE802.15.4 MAC layer can travel at the maximum byte.

VI. OR Checksum bar: XOR Checksum will calculate all the sum of column, if the XOR Checksum failure, a frame will be automatically discarded.

III. A GREENHOUSE CROP MONITORING SYSTEM ARCHITECTURE

According to the research's report pointed out that global population will exceed 9 billion threshold in 2050. In the future, much lack of resources crisis may be caused by the policy of land usage or the project of energy crops. Originally, because of population expansion and the formation of the food crisis, to improve agricultural productivity is an important issue in the world. To reduce the mass utilization of harmful chemical pesticides and the huge of waste of food are also critical issues. At present, in the highest stage of development of facilities agriculture "plant factory", it seems to the advanced way to solve the problem. Based on the thinking of using high-tech technology in plant growth, and the IOT technology is one of worth actual development and application in this level. Development of greenhouse crop remote monitoring system, this paper is divided into three parts, as shown in Fig. 3. The application layer includes host computer (PC), Visual Basic developed program. The network layer includes Zigbee module (obstacle-free interference in the ideal state, the farthest distance is about 1 km), RS - 232 communication interface. Perception layer contains temperature sensors, humidity sensors, light measurement sensors. It can also be extended to contain different types of application of sensing elements, and the above narrative of every construction and complete system is shown in Table 1.

3.1 *Intelligent Cultivation Environment Monitor*

The plant production environment includes light, CO2, and cultivation liquid composed by environment status is closely related to the crop output results. Most of the status contains lots of information integration, automation monitoring and control requirements. However, in the past, most of the cultivation environment, more sensors are for individual requirement for artificial copy records, for example, temperature, humidity, scheduler etc., and the collection system monitoring couldn't be applied in such application. From the study of literature [7], shows that if the individual sensor through system integration, monitoring with IOT concept to each cultivation environment factors change, then it can be more effectively in some aspects, such as demand management, save the cost, and rapid response to cultivation.

3.2 *The Cloud Service Platform*

The cultivation environment monitor is one important issue for addressing. Besides, the cultivation of crops is for different planting formulas and growing environments. Uploading data through a mobile device or farm sensors storing relevant data to the cloud is the first phase. Gathered sensors, information and camera timing test temperature and humidity on the farm, field images and bright sunshine, the record of peasant household production, breeding, cultivation condition and crop growth information, will be collected every day and pass to the cloud database. The achieved production quality, information and the cost of information can be disclosed immediately. The second phase is addressing in whenever the unit can develop a new formula of crop planting, and how quickly the market began to provide and be engaged in the production operators, that is, how the system can provide new service opportunities. Currently, the concept of available through the cloud service platform and the formula stored in the cloud, different crops need whole factory output back plant factory, as long as the equipment can be connected to the cloud service can get the best way to plant [8]. In terms of consumer's point of view, food safety has become a very important event. There is the food industry of cloud service platform, the consumer can access it by smartphone or computer in anytime and provide inquire information about food that makes all the process operation too. Information transparency can not only ensure that the quality of the food, but also be to reassure consumers eat rest assured to buy.

IV. SYSTEM SIMULATION

1) In simulation, the results on indoor and outdoor environments are compared each other. In the process of measurements, mainly focus on plant growth environment parameters, for example, temperature, humidity, illumination. Those important environmental parameters are gathered for monitoring and analyzing for plant cultivation. The deployment of test and implementation of steps are described as follows, first step: there are light and temperature sensors, air hygroscope sensor. Three Zigbee modules are connected respectively through the router wireless transmission way, the data collected then sent back to receiver in the center of the computer monitoring and control system. The sampling time is assigned every half an hour and the getting data of environment parameter then passed back to monitoring system. There is an air-conditioning system usually priority to set to 23 degrees C and installed indoor environment. Moreover, the human body comfortable humidity is 40 ~ 58% in indoor temperature regulation and indoor illumination is about 30 ~ 60 Lux.. In the duration of outdoor suburban environment ventilation climate test time, the average daily illumination of the light during the day is about 2140 Lux. on contrast the quantity of illumination is almost 0 at night. The above two conditions, to make plants do not shrink because of the subjective environment condition, indoor and outdoor plants are for daily to appropriate water spraying. Because the previously obtained result is without

using the interior lighting, the illumination value will be zero approximately.

2) In addition, reviewing the simulation equipments in the process of establishing, Zigbee module packet error occurs immediately in the simulation of sensor used. It is caused if the provided voltage is lower than 7.5 Volts. If the battery sensor can increase power consumption when the signal to send information, we may master in numerical stability for sensors at any time. In this paper, a replaceable battery is standby at any time. A solution strategy adopted for this experimental simulation is supported with a switching power supply which stays at 8.2 Vol. for a long stable time.

3) When plants cultivated in outdoor, the light is from the sun due to seasonal periodic change of length. The monitoring location place belongs to the mountainside, and the temperature parameters collected change largely on day and night. Outdoor environment placed on the open window at 7F in college of engineering of Dayeh University in which is with a good ventilation and sunlight quantity is big. The temperature is usually around 20 to 23 degrees C. The humidity changes bigger from 60 to 90% in the morning and evening. The ambient light up to about 3200 Lux is helpful to plants absorbing water to carry out photosynthesis. The other, the illumination of the night was 0 Lux. Above the environmental conditions, we spray appropriate water on the plants daily. Because of outdoor ventilation with sunny, evaporating faster, the amount of spraying water is more than indoor.

4) Summary, in the four days of actual simulation environment parameters monitoring, we observed indoor and outdoor also affect the germination growth of the plant. The humidity also cannot be to ignore. The degree of space ventilation can affects the evaporation of water, so we must be timely provide for lifting the temperature, sun light, windproof way to make plants grow in one of the most suitable environment conditions which will improve quality and production rate. Relatively it is safeguard that the planting industry investment has been profitable.

V. CONCLUSION

The proposed intelligent agricultural system based on the IOT is still at the experimental stage. According to preliminary estimation, by means of fine-tune the environment control parameters, to reduce plant diseases, to insect pests, to save manual work time, reduce labor costs and increase production are all possible events. The development of this system, some controlled parameters can be applied in combination with the plants conditions to make grow completely. On the other hand, in order to make plants grow quickly, in the future the greenhouse can be added by using of a simulated sunlight LED lighting system. Thus, via increasing energy for saving system, the system connect to the remote monitoring center through the IOT can monitor and control plants to handle with any conditions. Since the Ad Hoc mesh has also been adopted in this system, it has many advantages. In system, point of view measure a wireless monitoring system, the advantages of adopting Zigbee technology in the monitoring of the physical environment and plants growth management can be summarized as low cost, low power consumption, network life for a long time, and then a designed stable and accurate monitoring and control system, as shown in Fig. 3. In the near future, the system hopes further to combine with a professional understanding of biological growth, interdisciplinary research, at the same time, to joint with the cloud service education teaching platform, which can create highly value of plant factory environment.

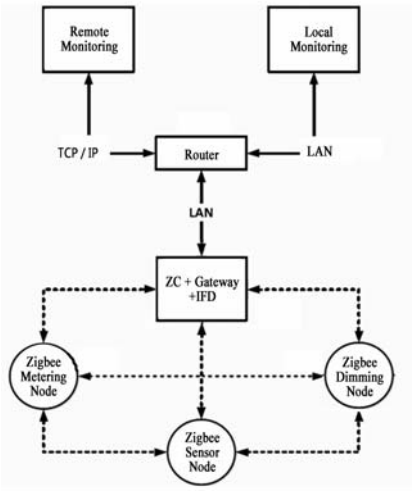


Figure 1. The zigbee system architecture diagram

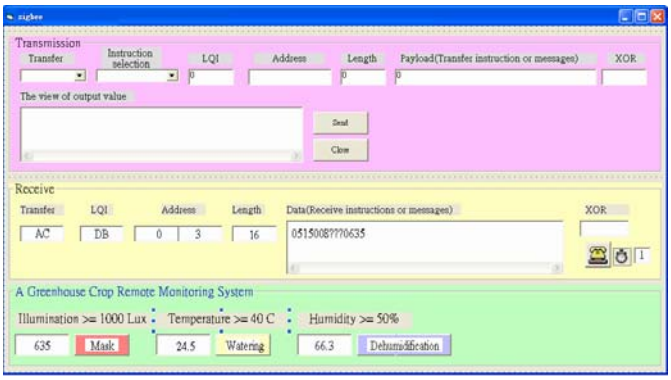
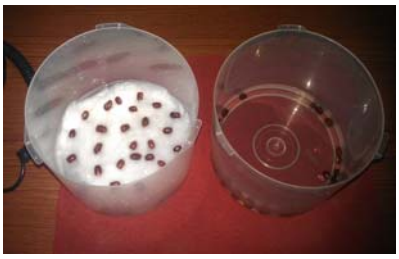
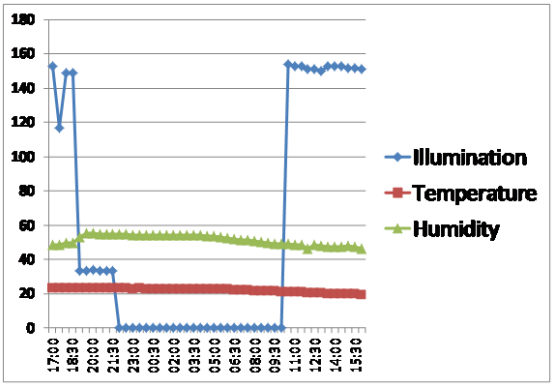


Figure 2. The sensor packet data receiving state

(a) zigbee module transmits live environment



(b) the red beans in the petri dish grew after two days



(c) Environment temperature, humidity, illumination change curve

Figure 3. The test results of indoor cultivation environment from the first to the second day

VI. REFERENCES

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