Design and Implementation of Information System Based on ZIGBEE and RFID

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***Abstracts* - In this paper we combine processor instruction practices together with enterprise information systems based on ZIGBEE and RFID technology to design and implement a general purpose communication module with a wide application potential. Radio Frequency Identification, RFID, uses radio frequency signals through space coupling (alternating magnetic or electromagnetic field) to achieve non contact transmission of information through messages for the purpose of automatic identification technology. Our results show that the system achieved all the basic functions of an enterprise information communication system. Our proposed RFID-ZIGBEE enterprise information system enhances communications between staff and managements, e.g. in unfamiliar situations new staff may ask questions to learn and gain information at any time in the daily course of carrying out their duties.**

Keywords - ARM Processor, AT89S52 Micro-controller, RFID, ZIGBEE

I. INTRODUCTION

A. What is Zigbee?

ZigBee [1] is an IEEE 802.15.4-based specification for a suite of high-level communication protocols used to create personal area networks with small, low-power digital radios, such as for home automation, medical device data collection, and other low-power low-bandwidth needs, designed for small scale projects which need wireless connection.

The technology defined by the ZigBee specification is intended to be simpler and less expensive than other wireless personal area networks (WPANs), such as Bluetooth or Wi-Fi. Applications include wireless light switches, electrical meters with in-home-displays, traffic management systems, and other consumer and industrial equipment that requires short-range low-rate wireless data transfer.

Its low power consumption limits transmission distances to 10–100 meters line-of-sight, depending on power output and environmental characteristics.[2] ZigBee devices can transmit data over long distances by passing data through a mesh network of intermediate devices to reach more distant ones. ZigBee is typically used in low data rate applications that require long battery life and secure networking (ZigBee networks are secured by 128 bit symmetric encryption keys.) ZigBee has a defined rate of 250 kbit/s, best suited for intermittent data transmissions from a sensor or input device.

ZigBee was conceived in 1998, standardized in 2003, and revised in 2006. The name refers to the waggle dance of honey bees after their return to the beehive.

B. Design and Implementation

Wireless sensor network is an integrated intelligent information system that assembles, information transmission, information processing, it has the characteristics of low cost, energy consumption, low data rate, self-organizing networks. The ZIGBEE technology is the standard wireless network protocol stack for low-rate sensor and control network design, is the suitable standard for wireless sensor network. ZIGBEE wireless sensor network is base on the ZIGBEE technology. It has great application potential. Radio Frequency Identification, RFID is the use of radio frequency signals through space coupling (alternating magnetic field or electromagnetic field) to achieve non-contact transmission of information through the message to the purpose of automatic identification technology.

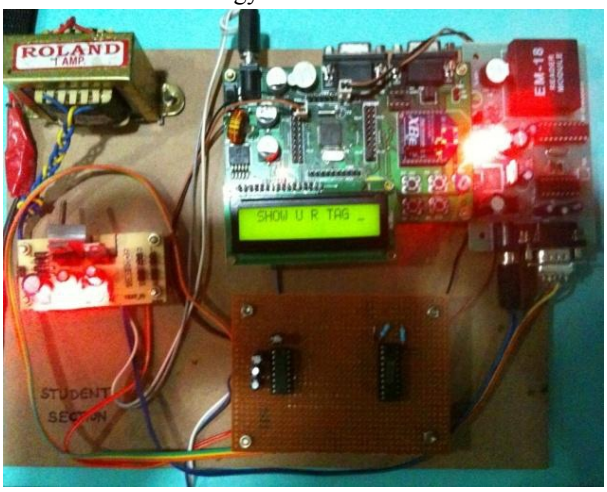

Fig. 1 Central Monitor unit

In recent years, RFID technology in the logistics field has been widely adopted, it is recognized as one of the industry's most important industry and application technology in this century. The unique function of RFID is to mark anything or person of the real world, in the virtual

world of network, it have three functions as "tag", "address number" and "sensing".

In this system, RFID and ZIGBEE combination, use RFID data for wireless interactive communication, to achieve the information between Staffs and managements, such questions, answers, voting, attendance, assessment and other functions. This system consists of two units one is management monitoring unit and another is Staff data collecting unit. Staff unit consists of controller, RFID module, ZIGBEE, LCD, yes or no buttons. Staffs attendance is taken by RFID reader and the data is passed to management through ZIGBEE module, if Staff present status led will glow.Shown in fig 1.

Then management asks questions from monitoring unit which is interfaced with ZIGBEE and the questions are displayed in the LCD at Staff side. Staff will reply yes or no through buttons. And the information is passed back to the management through ZIGBEE. Wireless sensor network is an integrated intelligent information system that assembles information acquisition, information transmission, and information processing; it has the characteristics of low cost, energy consumption, low data rate, self-organizing networks. The ZIGBEE technology is the standard wireless network protocol stack for low-rate sensor and control network design, is the suitable standard for wireless sensor network. ZIGBEE wireless sensor network is based on the ZIGBEE technology.

II. RFID

RFID technology uses radio frequency non-contact way of two-way data transmission between the reader and the RF card to achieve the objectives of target identification and data exchange. The work-flow of RFID Read-write device is: Read-write device sent a certain frequency RF signals through the transmitting antenna, When RF card goes into the transmitting antenna work area, resulting in induced current, the RF card obtains energy, is activated. Then the RF card, sends out owns code and other information through the card built-in antenna. Read-write device's receiving antenna received carrier signals from the RF card, the carrier signals then transmitted by the antenna regulator to the RF card; Read-write device demodulates and decodes received signals. The coupling (inductive-electromagnetic), communication processes (FDX, HDX, SEQ), from RF card to reader device from, the method of data transmission (load modulation, backscatter, high harmonic), and the frequency range, etc, different methods of non-contact transmission are fundamentally different. However, all reader devices from the functional principle to the resulting design structures are very similar; all reader devices can be simplified into two basic modules as High-frequency interface and control unit. High frequency interface contains the transmitter and receiver, its features include: produce high frequency transmission power, activate RF card, and provide energy, modulate the transmitted signal, convey data to the RF card; receive and demodulate the high frequency signal from the RF card. Control unit functions include: communicate with the application system software, and implement commands sent from application software; control of the communication process with the RF card (master-slave principle); encode and decode signal systems, execute anti-collision algorithm, encrypt and decrypt data transported between RF card and reader device, As well as authenticate between the RF card and reader device and other additional features.

III. ZIGBEE WIRELESS SENSOR

A. Software Architecture

The software on the ZigBee wireless sensor network devices is mainly composed of embedded operating system software, ZigBee protocol stack and application program, embedded operating system kernel provides a simple and efficient task transfers, interrupt handling and time queue management, also includes all the underlying hardware driver. Applications program include serial communications, RF communications, and signal strength detection. It uses modular design protocol stack, makes the whole System-level clear, good scalability, conducive to the secondary development of ZigBee technology.

B. Stack Design

ZigBee protocol stack is to ensure that wireless devices are low-cost, low power and low speed network interoperable. ZigBee protocol stack of different layers communicate through the service access point, most layer has two interfaces: data entity interface and management entity interface. Data entity interface goal is to provide top service routine data. Management entity interface goal is to provide the mechanisms including access to the upper inside layer parameters, configuration and data management. ZigBee technology has defined the standard specification of the physical layer, link layer and network layer, therefore, the realization of these three layers are usually similar. Wireless sensor network's different applications are composed from the basic application, such as join the network, break away the network, send data, etc. This article uses the IAR Embedded Workbench for 8051 software to program the physical layer, media link layer and network layer code of the system platform, each of the header file defines each layer of the support of the services and application program interface. Meanwhile, the platform also provides a number of application interface, for example aplFormNetwork ( ), plJoinNetwork ( ), aplSendMSG ( ), etc. Users can call these functions to achieve their development and application.Shown in fig 2.

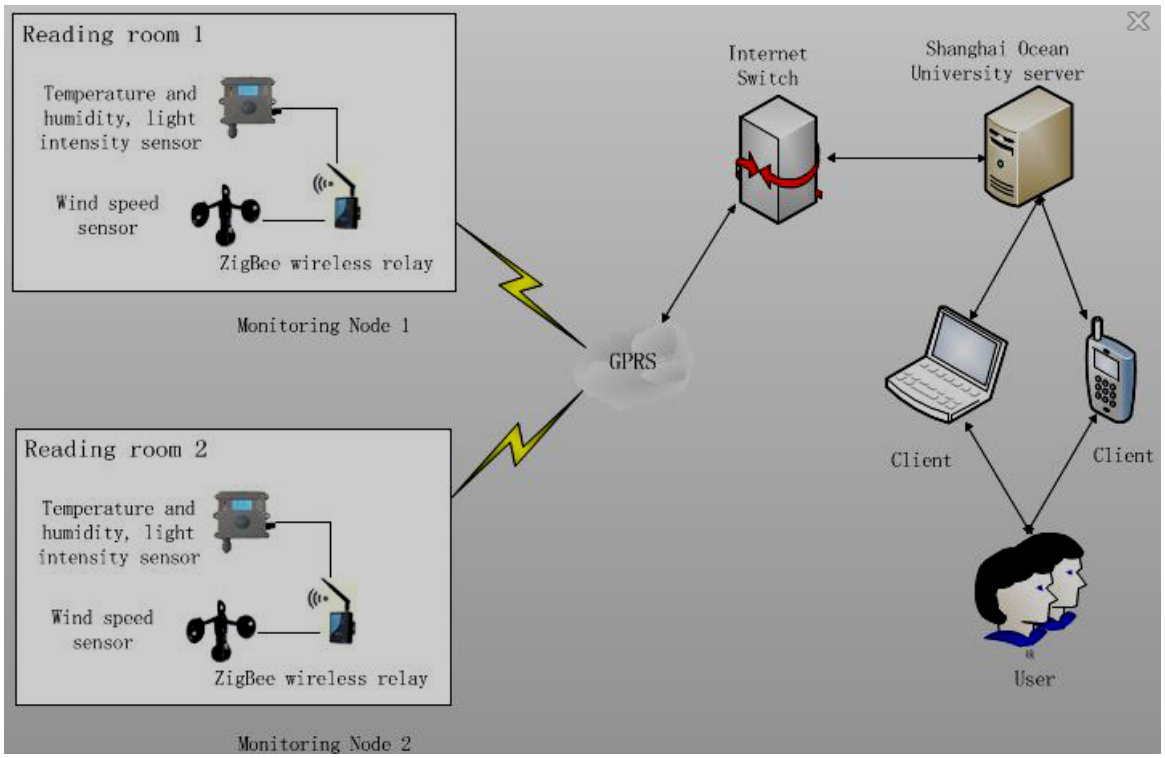

Fig2. The structure of library environment monitoring system

C. Overall System Function

The enterprise information system consists of RFID systems with ZigBee subsystems, can enhance the learning information between Staffs and managements, also can effectively manage Staffs in class attendance and Staff learning outcomes and the progress to absorb knowledge. managements can keep abreast of the progress of Staffs and enhance the Staffs less familiar course content. Staffs may also rely on this system to effectively communicate and interact with managements, to unfamiliar places for learning and ask questions at any time, to avoid face to face embarrassing questions or omission may be key. In this paper, RFID and ZigBee combination, use RFID data for wireless interactive communication, to achieve the information between Staffs and managements, such as questions, answers, voting, attendance, assessment and other functions. Each elective course Staffs are assigned to a Staff tag, every seat in the class room table with a simple reader (Reader) subsystem, after Staffs enter the classroom, the table reader subsystem can automatically sense and read the Staff tag, then the reader will send the information via ZigBee wireless to the podium of the main system, through the main system, managements can know how many Staffs school, attendance records of Staffs, and make statistics. Staffs subsystem is equipped with 3 buttons and LEDs, Staffs can push the yes or no button on the subsystem, (to know or do not know) to answer managements questions, by ZIGBEE wireless, the answer back to the main system on the podium, the main system with a display subsystem to display the corresponding keyboard keys and control, Staff status and location can be displayed through the display, managements can monitor the Staffs' real-time understanding of the course and to grasp the situation, give supplement according to the situation, through the button, to call a Staff(each subsystem (for example: A ~ Z) corresponds to the buttons on the main system A ~ Z). The subsystem table lamp (LED) of the Staffs called will light up or flash, until the Staff presses the yes button. Low power consumption. In the low-power standby mode, two AA size batteries can support one node to work 6 to 24 months, if use lithium batteries, such as L71 and other industrial batteries, the capacity can be achieved 3AH, its use of time up to 10 years. By dramatically simplifying protocol, reducing the requirements for communication controller, 8051 8-bit micro-controller to measure, sub function nodes as small as 4KB code, and the ZIGBEE protocol is a royalty free. Low rates. ZIGBEE communication work in the rate of 250kbps, can meet the application requirements of low-rate data transmission. Short distance transmission range is generally between (open range) 10 ~ 100m, after the increase in RF transmit power can also be increased to (open range) 100 km. This refers to the distance between adjacent nodes. If the communication between nodes and routing by relay, the transmission distance can be further. It can fully meet the requirements of working efficiency system. The ZIGBEE is fast response, In general, from

sleep into the work state needs just 15ms, and nodes connect into the network needs only 30ms, further save energy. High capacity. This ZIGBEE network using star network topology, Manage 254 sub nodes through the master node; at the same time, the master node can be managed by upper layer network node, composed of up to 65,000 node network. High security ZIGBEE provides a three-tier security model, Including non security settings, use the access control list (ACL) to prevent illegal access to data and the use of Advanced Encryption Standard (AES128) for symmetric encryption, to ensure its security attributes with flexibility. License free frequency bands. Direct subsequent spread spectrum in the industrial scientific medical 2.4GHz (global) (ISM) license-free frequency bands.

IV. PERFORMANCE ANALYSIS

Generally, sensor nodes' transmit power can be divided into more than 30 levels, RIHA only makes use of the highest and lowest transmit power, and filters are used at the receiving end, which is sufficient to distinguish RFID value. Therefore, the rate of packet loss is the greatest impact factor for receive hidden information correctly. Assume the number of continuously received signal in the same strength section is N_{RSSI} , the repetition number of each hidden information code is T_N , the number of encoding message in the same section I_R is:

$$I_R = \left\lceil \frac{N_{RSSI}}{T_N} \right\rceil \tag{1}$$

The number of continuously send hidden information in the same section is I_S , network packet loss rate is $Loss$, to ensure $I_s = I_R$, then
$I_S * T_N * Loss < T_N$

$$I_S < 1/Loss \tag{2}$$

Thus, to ensure receiving hidden information correctly, the number of continuous hidden information coding in the same section should less than the reciprocal of packet loss rate.

The hidden information transmission delay relates to the hidden information code number and time of iteration. The hidden information transmission delay is $I_S * T_N$. Visibly, increasing the repetitions of hidden information coding improves reliability, but also increases transmission delay. We should regulate the repetition time according to the environment and data's importance degree.

In addition, the amount of hidden information associates with the coding rules, simple coding rule's information hiding ability is limited, coding rules with large information hiding capacity often more complex in computation. It should consider the requirement of information hiding and design rational encoding rules.

V. EXPERIMENTAL ANALYSES

RIHA's reliability and validity is verified by simulation experiments. This section mainly analyzes two aspects of its performance: hiding information acquisition ratio and energy consumption.

We set the distance between the nodes is 80*m*, the maximum transmission power is 0*dBm*, energy consumption is 17.4*nW*, the minimum transmission power is -24*dBm*, energy consumption in transmission process is 8.5*nW*, the transmission frequency is 2400*MHz*, path attenuation index is 2.5, random Gauss noise from environment is 5 in the simulation. Assuming the hidden information is: 0011 0101 0110 0111 1110 1010 1011 1111.

RFID without repeat hidden information code transmission is shown Figure 3. The horizontal axis is the number of received packet, and the vertical axis is the RFID correspond with the packet. From the figure we can see the change of RFID clearly. The upper limit of RFID is 170 and the lower limit of RFID is 160. Thus the RFID higher than 170 is 1, and less than 160 is 0, we can obtain the hidden information for this group RFID is: 0011 0101 0110 0111 1110 1010 1011 1111, which is the same as the hidden information is sent.

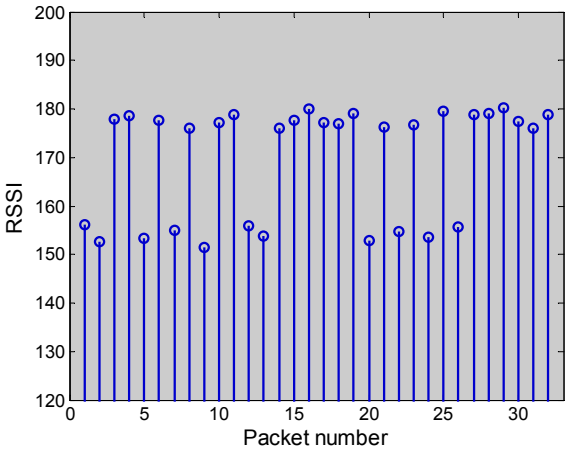

Fig 3. RFID without repeat hidden information code transmission

In Figure 4, each hidden information code transmits 3 times. The source node uses each hidden information code corresponded transmit power 3 times. The destination node uses filtering algorithm to process the obtained RFID, and obtains the hidden information. The mean filter algorithm is used in the simulation that is average every three RFID, the value higher than 170 is 1, less than 160 is 0. We obtain the hidden information 0011 0101 0110 0111 1110 1010 1011 1111, which is the same as without redundant hidden information code.

In these experiments, the hidden information acquisition rate is 100%. When the packet transmission correctly, the receiver can extract the hidden information completely. The simulation results prove the correctness of RIHA. Packet loss did not occur in the simulation, in actual situation the data may lose due to conflict or other reasons. The efficient filtering algorithm and reasonable data processing technology are used. The receiver can recover the hidden information through redundancy checking and correct errors in transmission to improve the accuracy of hidden information acquisition further.

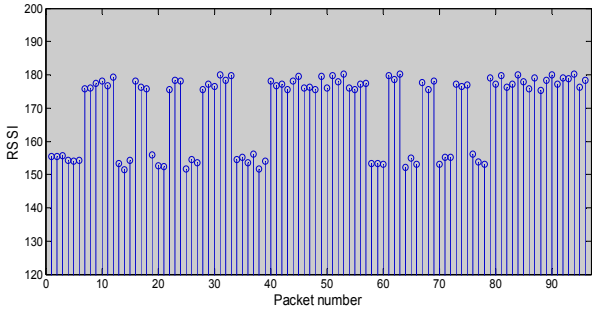

Fig 4. RFID with 3 repeat hidden information code transmission

Next, we analyse the energy consumption of RIHA. Figure 5 compares the energy consumption of nodes with or without hidden information. The horizontal axis is the packet number, and the vertical axis is the energy consumption. The blue dashed line represents the energy consumption without hidden information transmission, in which the sender selects transmission power randomly. The red solid line represents the energy consumption with hidden information transmission.

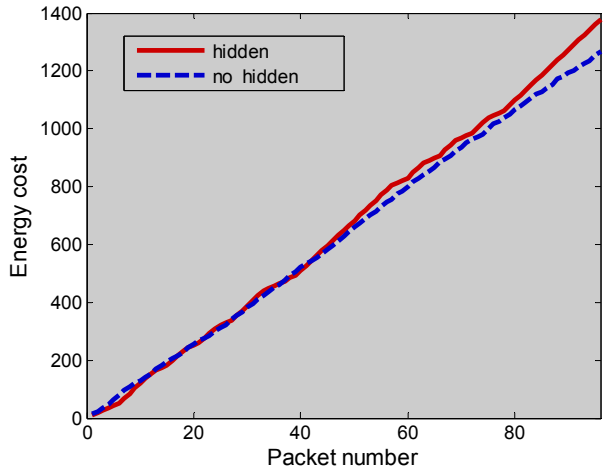

Fig 5.Comparison of energy consumption

As can be seen from the figure, energy consumption of hidden information transmission almost the same as no hidden information transmission in the first half, and increases in the last half slightly. It related to the encoding rule and data to be transmitted. In this simulation, the middle part and the last part of hidden information have several 1 multiply, so that the node has to transmit information with maximum power continuously, which leads the increase of energy consumption. Sending more 0 in hidden information will make its energy consumption lower than no hidden information transmission. That is to say the network energy consumption depends on the original data, whether transmission hidden information has little effect on it.

VI. CONCLUSION

In this system, the combination of RFID and ZIGBEE aims to achieve an information communication system between staff and managements. RFID technology used for data acquisition and transmission, ZIGBEE wireless transmission module uses a star network topology to achieve the data from staff end to managements end nodes for wireless transmission. We chose low-power hardware equipment and transport protocol, and add a node sleep mechanism, so that the system has low energy consumption, large communication range and high stability characteristics. Using the enterprise information platform, can realize the application of practical working efficiency. The results show that, the system can implement the basic functions of staff-management information system. The system combines ZIGBEE wireless sensor networks and RFID radio frequency identification technology, and has modular design, with the characteristics of scalability. With minor modification, the application can be ported to other systems.

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