Design of remote monitoring system for interior environmental parameters of yacht

Xiaozhen Wang¹, Qijun Xiao³*, Lu Bai³, Pianhui Wu³ and Zhonghui Luo³

¹Guangdong Communication Polytechnic, Guangzhou, China
²School of Electronic and Electrical Engineering, Zhaoqing University, Zhaoqing, China
³School of Mechanical and Electronic, Guangdong Polytechnic Normal University, Guangzhou, China

*Corresponding author e-mail: shawqj@126.com

Abstract. Aiming at the yacht equipment and personal safety, as well as the yachtowner and water management departments should grasp the yacht related state in time, it is designed in this paper the remote monitoring system for yacht cabin environment parameters based on ZigBee and GPRS technology. The work mainly includes the structure of network system and the network topology design, as well as system hardware design, software design, and simulation experiment to realize the remote real-time data display, analysis and storage. The simulation test shows that the system can monitor the internal environment parameters of the yacht in real time. The system runs stably and has good expansion performance. The relative error of the system measurement is no more than 1.52%.

1. Introduction

Yacht leisure and entertainment is favored by rich classes as a healthy way of life in foreign countries. With the rapid development of China's economy, the consumption of the rich has become more and more diversified. Taking yacht to the sea for sightseeing, leisure, entertainment, and business reception has become a symbol of high-quality life, and yacht tourism has come into being. Some organizations, enterprises and middle and high earners become the main consumption group of yachts. Yacht price is expensive, medium and large recreational yacht cost a few million yuan to several hundred million yuan. However, yachtowner will hand the yacht to the yacht club on behalf of the management most of the time, therefore, no matter the yacht is in the navigation or docked, the owner want to know some key information of the yacht, such as the operation condition of the main equipment, whether the yacht cabin is in water or the liquid level of fuel tank and water tank, etc., thus to monitor the yacht to remind yacht service person in time. The infrastructure of China's yacht safety is still weak, and the safety monitoring work is not perfect. Therefore, it is urgent to research and develop the remote monitoring system of environmental parameters in the cabin of the yacht, so as to provide technical support for the safety guarantee.

ZigBee technology is characterized by low power consumption, short distance, low data rate, low cost and low complexity, while GPRS technology is mature and covers a wide range[1]. Based on a medium scale yacht as an object, using Zigbee to build a short distance Wireless Network and GPRS remote communication network to build a remote cabin environmental parameters monitoring system, the cabin main environment parameters are collected in real-time to provide technical support for
yacht safety operation and health maintenance, thus to promote the healthy development of yacht industry.

2. System Construction
Terminal system consists of four parts as sensor nodes, ZigBee network, GPRS network and monitoring center, in which the sensor nodes mainly include distributed temperature sensor, PM2.5 sensor, water level sensor, signal conditioning circuit and ZigBee terminal nodes. The sensor real-time acquisition of the yacht cabin environment parameters, the parameters of the acquisition signal are sent to ZigBee terminal node of A/D port through the signal conditioning circuit, the converted digital signal is connected to coordinator node through the ZigBee network and the coordinator node communicates with the GPRS module through the serial port, which transmits the signal to the remote monitoring center or the terminal mobile phone through the GPRS network. The monitoring center displays and saves the data of the environment parameters of the yacht cabin. According to the actual situation, the monitoring center or mobile phone terminal can send control instructions to the monitoring system to adjust certain parameters or implement emergency plan treatment to ensure safety. The system structure diagram is shown in Fig 1.

Because this system is applied to the yacht cabin, considering the general area of yacht is not very big now, we choose the simplest star network to form ZigBee network topology of the system, and its monitoring nodes around the coordinator to form a circle with a radius of about 100 meters, and it can completely covers the general scope of the yacht cabin, and it has low cost, easy networking, easy to extend and convenient management[2].

3. System Hardware Design
The remote monitoring system of environmental parameters in the cabin of the yacht, ZigBee local network node mainly includes two parts: terminal node design and coordinator node design. The terminal node in ZigBee network is responsible for the acquisition and wireless transmission of cabin environmental data, and the coordinator node is responsible for processing data and sending the data to the gateway[3]. The system hardware structure is shown in Fig.2.

System hardware design and type selection are as follows:
(1) Temperature and humidity sensor. The temperature and humidity data collection part uses DHT11 temperature and humidity sensor. DHT11 temperature and humidity sensor has the advantages of high measurement accuracy, fast response speed and strong anti-interference ability. Therefore, it has a unique advantage in temperature and humidity collection. It has built-in volume small powerful single chip microcomputer, direct serial communication and it is easy to use. Since the chip is highly
integrated, the chip is small and energy dissipation is relatively low, but the communication range is large. Communication can be realized within 20 meters, so it is widely used in various detection fields.

(2) Signal conditioning circuit is to adjust and amplify the 0-24mV voltage output signal of the temperature sensor to 0-5V voltage signal, so as to facilitate A/D conversion of ZigBee terminal nodes. The amplifier circuit is composed of the front amplifier and the secondary amplifier. The front amplifier is realized by the AD620 chip of American analog device company (ADI). The secondary amplifier circuit is designed from the LT1122 chip and powered by a power supply of plus or minus 15V.

(3) ZigBee terminal node. The main chip of terminal node is CC2530 chip.

(4) ZigBee coordinator. The hardware structure is the same as ZigBee terminal node, but with different functions. It communicates with GPRS module through serial port, collects the upstream information sent by ZigBee terminal nodes in each sensor node, and sends down control instructions that the monitoring center to issue downward.

(5) GPRS module. The remote communication node of GPRS is composed of microcontroller and GPRS module. The microcontroller is STC12C5A60S2 microcontroller produced by Hongjing Technology Company (STC). STC12C5A60S2 microcontroller has two serial ports, it communicate with coordinator and GPRS module through two serial ports. The GPRS module selects the CM3180EP module, which has the functions of SMS and GPRS[4,5].

4. System software design

4.1. Sensor node software design
The system software design adopts the modularization programming idea to design the three parts of sensor node, coordinator node and remote monitoring center. After the sensor node is energized, the initialization operation is carried out first. After the network is successfully linked, the coordinator node will assign a 16-bit network address for the sensor node, and the sensor node will send clock synchronization signal to the coordinator node to enter the low-power mode. After the remote monitoring center sends the start collection command, the sensor node is awakened for temperature data collection through timer interrupt, and then the collected data is sent to the coordinator node and finally transmitted to the monitoring center through GPRS network. If the data is sent successfully, the sensor node will go into sleep mode again until the next timer is interrupted, and then wake up the sensor node to collect and send data[3]. The sensor node workflow is shown in Fig. 3.

4.2. Coordinator node software design
The main work of coordinator software design is hardware initialization, network establishment and wireless communication with terminal nodes. After the initializing of the coordinator, it begins to scan the channel. After selecting the channel, it establishes the PAN network and sends the beacon periodically to the terminal node. After receiving the network request of the node, an unique PANID in the network will be assigned to the terminal node, waiting for the node to enter the network. Up to now, the build of network is finished.
4.3. Software design of remote monitoring center

The monitoring center is developed by Microsoft Visual Studio software, which mainly manages and monitors the system. In this paper, the software design of the monitoring center is completed by C# language in the platform of .net Framework. The monitoring center operates in an Internet environment with a fixed IP address or a fixed domain name for client access. The overall structure of the monitoring center mainly includes the front-end service interface, the back-end Windows service program and the back-end database. In the front-end service interface, users can monitor data in real time and query historical data of environmental information. The main function is to monitor the system in real time.

5. System experiment test

In order to test the performance of the system, two sensor nodes composed by temperature sensor and pressure sensor, one coordinator node, one GPRS module and two PCS are used to build a system test platform. Main test contents include ZigBee networking test, GPRS module and monitoring center software data transmission test, temperature and pressure signal acquisition test.

5.1 ZigBee networking test

After the completed ZigBee node program is compiled correctly in the IAR development environment, CoordinatorEB in the Workspace is selected and downloaded to the coordinator node through the CC2530 simulator. Similarly, select EndDeviceEB under Workspace to download the program to the sensor node. After each node is powered on, the coordinator node establishes the network firstly. At this time, the LED light is normally on, indicating that ZigBee networking is normal.

5.2 GPRS module and monitoring center software data transmission test

In order to test whether the GPRS module can meet the long-distance data transmission, 1 PC is selected as the server, and another PC connects to the server through remote desktop login to check the
data received by the server. The test finds that it takes about four seconds to establish a connection and communication of sending and receiving data.

5.3 Temperature signal acquisition and testing
After determining that the ZigBee networking, GPRS module and the monitoring center software test are all free of problems, the water is heated with a hot thermos and the temperature signal can be collected through temperature sensor and a thermometer. When start collecting button is on, sensor nodes will broadcast to the coordinator node at 1s interval sampling point set by procedure, then through the serial communication with GPRS module to send signals to the remote monitoring center software on the server eventually. This test tests 40°C, 45°C, 50°C, 60°C respectively. The maximum relative error between the temperature displayed by PC and the real temperature by thermometer is 1.52% to meet general industrial control requirements.

6. Conclusions
In this paper, a remote monitoring system based on ZigBee and GPRS is designed according to the safety test requirements of the internal environment parameters of the yacht, mainly including the hardware and software design and implementation of the system. The simulation test shows that the system can monitor the internal environment parameters of the yacht in real time, and the system runs stably and has good expansibility. The monitoring points can be added or deleted randomly according to the need of actual monitoring equipment or parameters. Based on this design, GPS technology and video image sensor can be added in the future, which can not only realize the positioning of the yacht, but also carry out video monitoring of the main area of the yacht. It has the feeling of being in its place. The yacht owner can control the state of the yacht in real time no matter when and where is he to ensure the safety of the yacht.

Acknowledgments
This work was supported by Science and Technology Project of Guangdong Provincial Transportation Department (Technology-2016-02-048): Yacht Intelligent Monitoring system based on Internet of things, the Natural Science Features Innovative Projects of Education Department of Guangdong Province (No.2015KTSCX157), and Guangzhou science and technology and Information Bureau (No. 201510010235).

References
[1] Jiang Wei. Design of Vegetable Greenhouse Monitoring System Based on ZigBee and GPRS. Master thesis of Shenyang University of Technology, June, 2018.
[2] CAI Changan, Design of Greenhouse Temperature and Humidity Monitoring System Based on the Internet of Things. Journal of Changsha University, 2016, 30(2):70-72
[3] WANG Xiaozhen, LIU Can, WU Hongliang. Design of remote mooringforce monitoring system for the deepsea cage based on ZigBee and GPRS, 2015, 42(1):24-27
[4] Chen Rui, DESIGN OF DISTRIBUTED PV PLANT WIRELESS DATA ACQUISITION SYSTEM BASED ON ZIGBEE AND GPRS. Master Degree Thesis for Southwest Jiaotong University, 2017.12
[5] LAI Shenggang. Design of Maloperation-proof Locking System for Subway Substation Based on ZigBee and GPRS. Research on Urban Rail Transit, 2018,(4):135-138