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Research into a Wireless Smart Parking System

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In order to solve problems such as single function, poor real-time performance and low efficiency of the traditional parking lot, this paper designs an intelligent parking system based on a Zigbee wireless network, which is characterized by free license band, dynamic networking, and a self-multi hop network. On the basis of system design, according to the functional requirements of different nodes of the system, a reasonable hardware platform has been designed. The design of the software provides a detailed workflow. Practical testing shows that the system has high detection accuracy. It can fully meet the requirements of efficient management of an intelligent parking area.

1. Introduction

With the development of society, car usage has greatly increased. The boom in the automobile market has, however, triggered parking problems. Existing parking management cannot meet the growing demand for vehicles, and parking problems are becoming an obstacle that restricts the healthy development of the urban economy (Y.Y Qin and J.W. Zhang (2015)). Making full use of limited parking spaces to meet the demand for parking has become an urgent problem requiring solution. Therefore, it is of great significance to undertake research on intelligent parking management and practical solutions (H.Z. Liu et al. (2015)).
Compared with foreign countries, the use of intelligent parking based on a wireless network is still low in China. An intelligent parking system based on Zigbee can use the perception ability of sensor nodes to monitor and manage each parking space, provide special guidance services, manage parking and provide other functions.

2. System Compositions

The proposed parking system uses an ARM processor as the core, which is composed of a vehicle detector, a remote RFID reader, a LED display, a gate, and a parking lot. It is shown in figure 1.

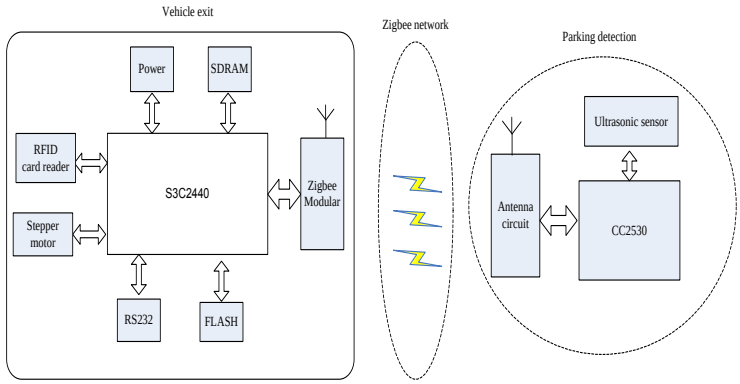

Figure 1: A structural diagram of the system

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A detector is responsible for checking whether vehicles pass. A microprocessor reads the data in the RFID card by an RFID reader. An LED screen displays the information for the remaining parking spaces. A gate controls vehicle access. The system will continue to monitor the vehicle; once a vehicle is detected, it immediately prepares an RFID card reading and writing process to read the information of the RFID card, and then the user's next action is decided. At the same time, an LED screen displays detailed information of the parking space to the user (E.J. Sun et al. (2015)). After all the actions are completed, the microprocessor sends a command to the gate control module, which permits the user to go in or out.

3. Hardware Design of the system

3.1 Core microprocessor

In the system， the MCU S3C2440 made by SAMSUNG CO is used. This product is designed to provide hand-held devices and general applications and is cost-effective, low-power, and uses a high-performance microcontroller solution in small die size. To reduce the total system cost, the S3C2440 includes the following components separately: 16KB Instruction and 16KB Data Cache, MMU to handle virtual memory management, 8-ch 10-bit ADC and Touch Screen Interface, and 2-ch SPI and PLL for clock generation. The S3C2440 was developed using an ARM920T core, 0.18um CMOS standard cells and a memory complier. Its low-power, simple, elegant and fully static design is particularly suitable for cost- and power-sensitive applications. It adopts a new bus architecture called Advanced Microcontroller Bus Architecture (AMBA).

3.2 ZigBee wireless module

In the parking lot, each parking space corresponds to a sensor, and the number of parking spaces in a large parking lot is generally more than one hundred, so the demand for security and transmission efficiency is high. Zigbee technology can be used to transmit controlling information. CC2530 in the Zigbee wireless transmission module has a very high level of integration, and works with an external crystal oscillator and reset circuit (X.T. Yang (2014)). The design of the RF part needs to be the impedance of the antenna plate load circuit. The design of the Zigbee wireless transmission circuit is shown in figure 2.

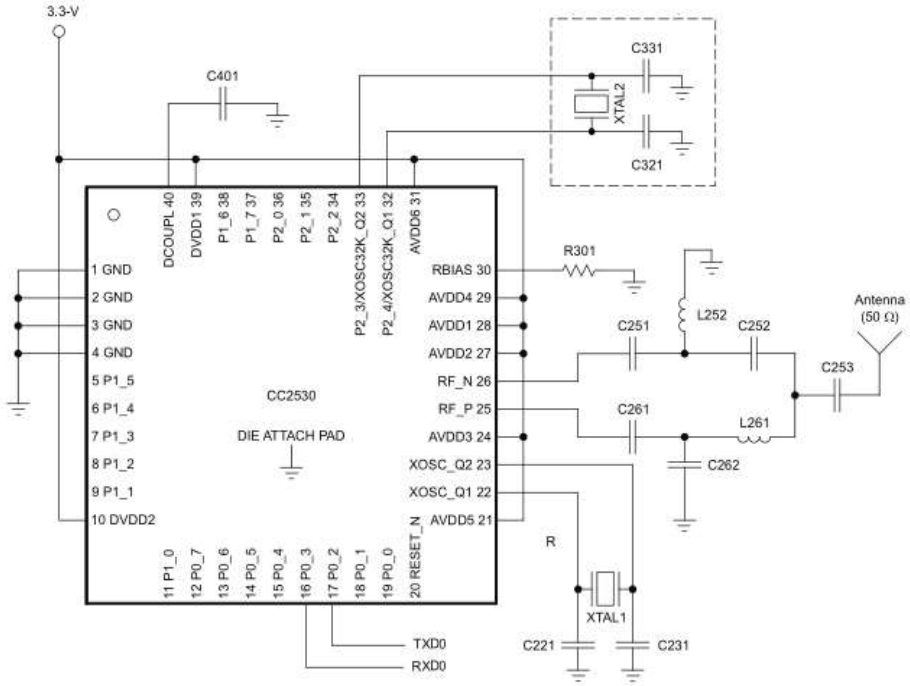

Figure 2: Design of the Zigbee circuit

The parking system is designed for the large intelligent management of hundreds of parking spaces. The wireless sensor terminal equipment based on a CC2530 module is installed at each parking space and each zone constitutes a ZigBee wireless sensor network. Each zone contains a ZigBee router and a plurality of wireless sensing terminal equipment with streamlined functions, and the whole area contains a ZigBee coordinator. Wireless transmission is used between ZigBee devices, and communication between the ZigBee coordinator and the host computer monitoring center are carried on by the serial.

3.3 The design of the parking detection circuit

The main types of space detectors available in China are a magneto-resistive sensor, ground sensor, video parking lot detector, ultrasonic sensors, and so on. But for various reasons, the use of space detectors is limited. For example, a magneto-resistive sensor needs to be buried about 30m underground, and it is difficult to replace the sensor and the ground sensor response. Video detection is easily influenced by weather conditions (Y.J. Zhang and S. Tian (2014)). The detection range of the ultrasonic sensor depends on the wavelength and frequency. The detection range of the compact sensor with millimeter wavelength is 300 mm~500 mm, and the wavelength is greater than 5 mm. The detection range of the sensor can reach 8m. Many factors can affect the accuracy of the ultrasonic sensor, the most important factor being the acoustic velocity with temperature. Thus many ultrasonic wave sensors have temperature compensation. This characteristic can make the analog output type ultrasonic sensor obtain the repetition accuracy of 0.6 mm within a wide temperature range.

Therefore this system selects the ultrasonic sensor. The sensor receiving and transmitting circuit of the ultrasonic sensor is shown in figure 3 and figure 4.

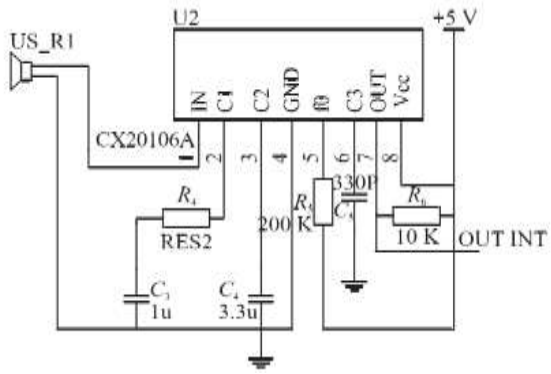

Figure 3: The ultrasonic receiving circuit

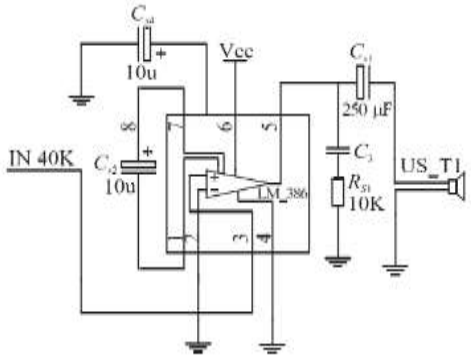

Figure 4: The ultrasonic transmitting circuit

4. The design of the system software

The system software mainly includes the Zigbee router node program, the Zigbee coordinator, parking detection and so on.

4.1 The design of the Zigbee router node

The design of the router node software is mainly responsible for the data acquisition and information fusion, and can also transmit the data as a secondary function, which allows the terminal acquisition node to be unrestricted by the location of the data collection node, and arranged in the required position. If it is far away, Zigbee routing nodes are just added in the middle for the data relay and forwarding. Then the integrated data is sent to the coordinator (D.Q. Yang and Y.J. Wang (2012)). It is shown in Figure 5.

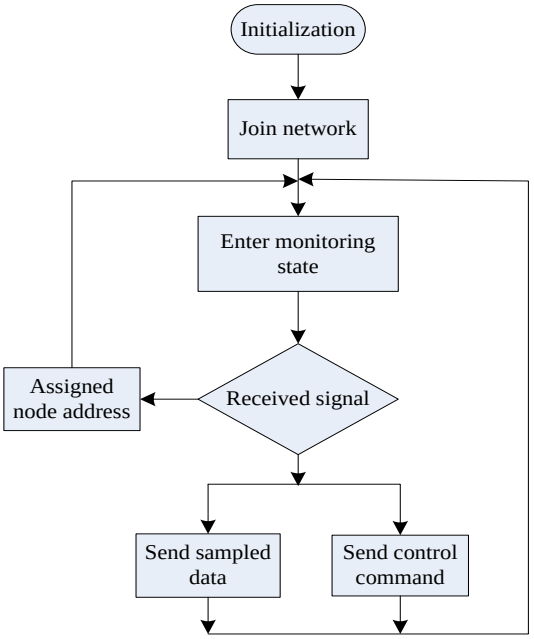

Figure 5: The flow chart of router node

4.2 The design of the Zigbee network coordinator

The Zigbee network coordinator is responsible for organization and coordination of the entire network and uses the fixed network address 0x0000, which makes it suitable to be the system for the data collection point. It is connected to the central controlling system by serial port RS232, and sends reported data to the central control system and stores data into a built-in or general database server. The network coordinator program is shown in figure 6.

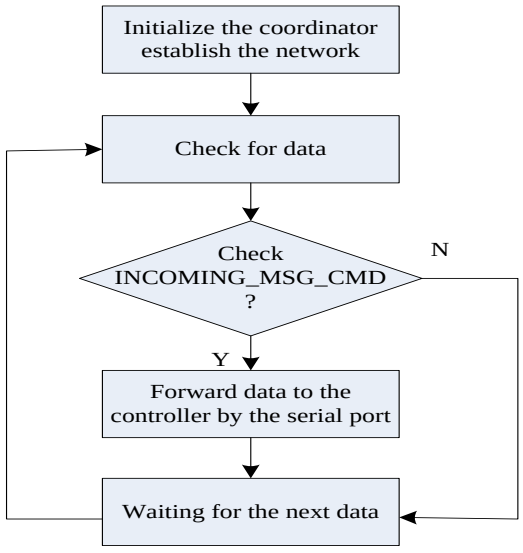

Figure 6: The flow chart of the coordinator

4.3 The design of the parking detection

Because of the limited energy of the terminal for parking detection, the following measures are taken to save energy:

The network parameters are saved to non-volatile memory after finding the network. In the next connection network, the program reads the saved network parameters first to reduce the time used for searching, and closes the wireless transceiver functions after each test or transmission. All the pins are set to a three floating

state and the MOS pipe of the infrared emission and receiving unit closes the pull-up resistor automatically, to enter a power-saving mode. To allow the energy-saving parameter to set its own sleep, the clock enters a low power sleep mode and waits for the next clock overflow as a wake-up event. The terminal parking detection node program is shown in figure 7.

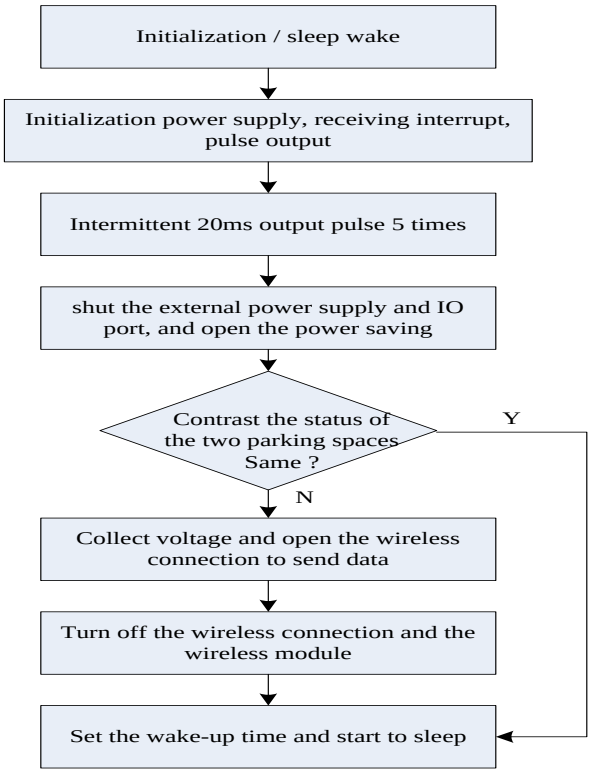

Figure 7: Parking detection flow chart

5. Experimental Results

During the test of the network data transmission, and the test of transmission between coordinator and the data concentrator, the gateway is connected to the data concentrator through the serial interface RS232 and to the computer by the data collector. The system has a coordinator node, two router nodes and four terminal nodes. The efficiency of test network data transmission is the efficiency of data receiving by [10] the data receiving end.

In the process of testing, 10 ms, 20 ms, 30 ms, 40 ms, 50 ms were used to test under different weather conditions. The rate of packet loss was 0 when the period of transmission was 50 ms. In order to record the packet sending and receiving, a serial port debugging program was used. The results are shown in table 1.

Table 1: Network data transmission test structure

Weather	Sending cycle (ms)	total number of sending (byte)	total number of receiving (byte)	Loss rate (%)
Sunny day	10	5867210	4083561	30.40
	20	6102548	4992034	18.19
	30	790568	662837	16.16
	40	2089452	2064358	1.20
	50	3068725	3068725	0
Cloudy day	10	5260533	3912709	25.62
	20	5926706	4832408	18.46
	30	790568	662837	16.15
	40	3105874	3026470	2.55
	50	4257906	4257906	0

6. Conclusions

This paper presents an intelligent parking system based on Zigbee technology, which can realize access without barriers, parking detection, parking guidance, and other functions. It can greatly improve the intelligent management of the parking lot. When vehicles enter or leave the parking lot, a low frequency stimulator wakes the HF RFID tags of their units, and the units remain in a dormant state when vehicles are away from the parking lot. Thereby it greatly reduces the power consumption of the vehicle mounted unit, and prolongs its service life. When the vehicle is parked, the vehicle location is combined with the CC2530, and the actual distribution within the parking lot is updated. The information is transmitted through the Zigbee backbone network to ensure two-way interaction of information. The system is low cost, has high reliability and high practicability, as indicated through the tests undertaken.

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