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A Bus Management System Based on ZigBee and GSM/GPRS

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***Abstract*—This paper introduces a system design about bus management system based on ZigBee and GSM/GPRS, which implemented the basic functions of the intelligent public transport management system, such as monitoring the time of bus arrival , departing from the bus station and reporting stations name automatically. This system can ensure punctuality of vehicles to run, improve the automation level of reporting stations and quality of public transport service. The management system has low cost and thus it is more feasible.**

Keywords- ZigBee; GSM/GPRS; public transport system;

I. INTRODUCTION

Public transportation is provided by the Government as a public service, and its service quality directly impacts on the travel convenience of the public. As a result, punctual arrival stations of the buses and accurate reporting stations name are important tasks. At present, punctuality of buses can be guaranteed because some employee monitor the states of buses operating and adjust the departure time of buses rationally at the bus start station and bus terminal. But it is difficult to monitor the punctuality of buses via the intermediate stations.

To solve the question mentioned above, we shoud obtain the arrival time of buses at intermediate stations in time. However, these bus stations are distributed in whole city, vehicles are moving from one place to another ceaselessly, the buses arrival time at intermediate stations are stochastic.

Consequently, the wireless technology should be applied in the intelligent public transport management system in order to monitoring the buses operation states. Recently, a method is to use GPS system to monitor the movement of buses, and then use SMS to send the vehicle location information to the monitoring center. However, it is difficult to apply the technology in large scale because of the higher the cost of GPS systems. In fact, we need not to care about the movement process of buses, but concentrate on the buses arrival time or the departure time at stations. In addition, the bus driver report station name by pressing a button at present that may misguide passengers when a mistake occurred. Thereby we develop a bus management system based on ZigBee and GSM/GPRS in order to slove those questions.

II. OPERATION OF SYSTEM

ZigBee is a wireless technology developed as an open global standard to address the unique needs of short distance communication, low data rate, low-cost, low power consumption wireless networks in recent years. The ZigBee standard operates on the IEEE 802.15.4 physical radio specification and operates in unlicensed bands including 2.4 GHz and 868/915 MHz. It utilizes direct-sequence spread spectrum modulation and operates on a fixed channel. A total of 27 channels numbered 0 to 26 are available per channel page. As a result, the flexibility of ZigBee application can be improved greatly because several different ZigBee networks in the same area can coexist with each other by selecting different channels. Comparing with other network technology, the protocol stack of ZigBee network is more simple and only 32KB flash memory consumption. ZigBee technology is more suitable for the low cost application, especially for the operation of MCU with limited computation and low storage capacity.Thus, ZigBee neiwork can provide reliable delivery of data between remote devices and its infrastructure is more flexible. A coordinator in ZigBee network can be used to initiate, terminate, or route communication around the network. The coordinator is the primary controller of the network. ZigBee devices can also apply to join or leave the network. Physical layer provide the information of link quality which can determine the distance between a receiver and a sender. The communication distance is usally about tens of meters.

To monitoring the runing of buses and improving the punctuality of buses at intermediate stations, we shoud obtain the accurate arrival time, and send this information to the company's monitoring center. Note that, our concern here is the time of the bus arriving the stations, we are not interesting in their position and their travel time between stations. So, we need not to use the expensive GPS sytem to positioning their locations. Here, we combine the technology of ZigBee with GSM/GPRS to monitor the arrival or departure time of buses at stations and report bus stations automatically.

The system we designed comprises of the electronic boards at stations, the wireless identifier installated in buses and the monitoring software operated in PC. The electronic board of each bus station consists of a station monitor, GPRS communication module and the LED display. Here, the station monitor is a ZigBee coordinator which can accept the request from other ZigBee devices to join the network, and can identify every device configured with ID. At the same time, we install the wireless identifier device in every bus. When the system is operating, the station monitor transmit beacon frame continuously. The wireless identifier in buses can receive the beacon frame which include relevant

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information about this bus station, when buses approach the station. Then the bus can report the station name automatically. Meanwhile, it send itself information to the station monitor, and the monitor obtain the information about bus ID, arrival time and the license plate number of bus. Those information can be transmitted back the company's monitoring center by GSM/GPRS system. After the bus depart from the station, the station monitor also transmit the message-----"XX bus has left the station" to the center. At the same time, the center send this message to next station's electronic board and display "XX bus has left YY station, arriving this station after ZZ minutes" on the LED. That can provide convenience for passengers waiting. The monitoring center can be in control of the operation of each bus accurately to guarantee its punctuality. ZigBee's effective operating range is only tens of meters, and it can estimate the distance between the vehicle and the platform according to the signal strength. As a result, the monitor can be aware of the bus arrival only when the bus near the station. In addition, the system can also operate smoothly when many buses approach the same station, because a ZigBee coordinator allow ZigBee devices to connect with it.

The whole system's cost is very low because it has a few of station monitors and low cost wireless identifiers. The Figure 1 shows the system structure and its operation:

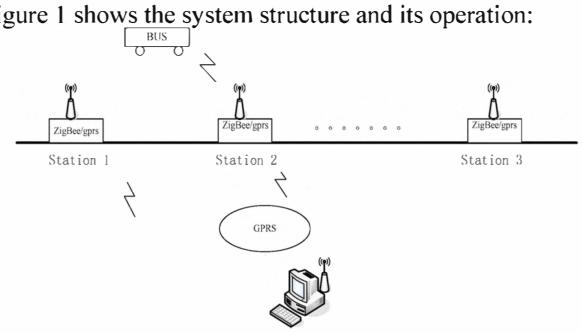

Figure 1. Structure of The System

III. THE HARDWARE DESIGN

This management system comprises of the station monitor, the wireless identifier equipped in buses and the monitoring center. In this paper, we mainly focus on software and hardware design of the station monitor and the wireless identifier.

At present, many manufacturers developed the design platform for ZigBee technology. But, considering the competitive ZigBee solution by CC2430 provided, we select the design platform of TI corporation to develop our system. The CC2430 combines the excellent performance of the leading CC2420 RF transceiver with an industry-standard enhanced 8051 MCU, 32/64/128 KB flash memory, 8 KB RAM and many other powerful features. Combined with the industry leading ZigBee protocol stack (Z-Stack), the CC2430 provides the market's most competitive ZigBee solution. Transceiver of CC2430 realize the fuction of ZigBee PHY, and it can operate in 2.4GHz. Its key features are as follows:

a) High performance and low power 8051 microcontroller core.

b) 2.4 GHz IEEE 802.15.4 compliant RF transceiver (industry leading CC2420 radio core).

c) CSMA/CA hardware support..

d) Wide supply voltage range (2.0V – 3.6V)

e) Less than 0.6μA current consumption in standby mode, where external interrupts can wake up the system.

f) Digital RSSI / LQI support.

g) Powerful DMA functionality.

h) 32-128 KB in-system programmable flash, 8 KB RAM.

i) Battery monitor and temperature sensor.

j) 14 bits ADC.

k) 21 general I/O pins, two with 20mA sink/source capability.

l) Two powerful USARTs with support for several serial protocols..

Few external components are required for the operation of CC2430. A typical application circuit is shown in Figure 2. Monopole antennas are resonant antennas with a length corresponding to one quarter of the electrical wavelength (λ/4). They are very easy to design and can be implemented simply as a "piece of wire" or even integrated into the PCB. Though the antenna gain is low, it is enough to satisfy the requirements in most cases.

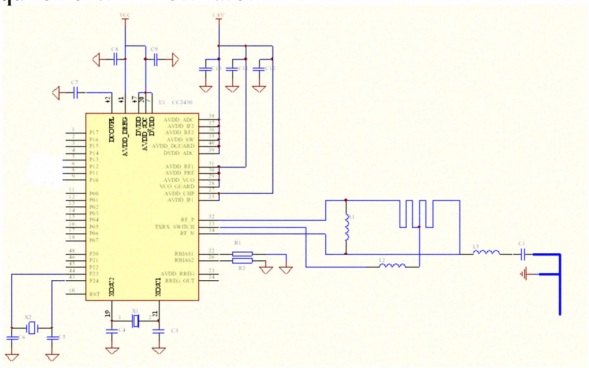

Figure 2. Typical Application Circuit of CC2430

The structure of station monitor is shown in Figure 3. In this circuit, a GSM module's UART is connected with CC2430. One I/O pin of CC2430 is use to control the GSM module ON or OFF. A 8-bit DIP switch are connected with P1 of CC2430. Here, the GSM module communicates with the monitoring center using GPRS technology. A ID of station is set by the 8-bit DIP switch. As a ZigBee coordinator, it may occupy some resource when it communicate with other devices. But the coordinator establish the number of connections would not be too much, and need not to support the application of network layer, thereby the resource of CC2430 is enough to satisfy the normal requirements. There is no problem for power supply because the monitor installated in station. However, in case

of power supply failed, we should take the capacity of rechargeable battery into account carefully, since GSM/GPRS module would consume energy a lot. In addition, we should solve the problem of the RF interference between GPRS module and ZigBee device in the hardware. The structure of wireless identifier circuit equipped in bus is really simple.

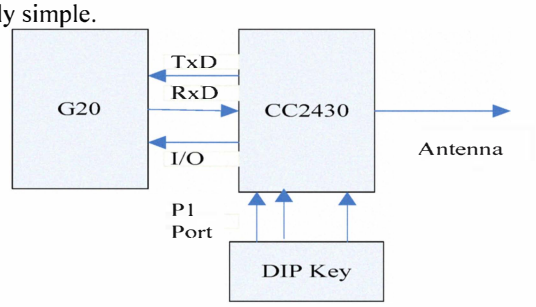

Figure 3. Circuit of Station Monitor

IV. THE SOFTWARE DESIGN

The system software includes the application software and the ZigBee protocol software. Two development methods are provided by TI corporation. One is only a simple application which takes advantage of MAC layer operation supported by IEEE802.15.4 hardware. Another is a complete ZigBee implementation which includes the function of network layer and application layer. The API functions of physical layer and MAC layer are provided by those schemes. We only call those functions when implemente the ZigBee protocol stack. TI corporation offer some design examples in datasheet which can help to implement our application design. Details can be found in datasheet provided by TI.

TI's CC2430 provides the software that can run on a simple multi-tasking operating systems, various tasks are scheduled by the operating system to complete the specific application. Each task has two C language function, one is the initialization function, another is the event handle fuction. Most applications can be extended by modifying source code of these examples. There are two modification methods, adding a new task or increasing an event in the existing task. In order to avoiding the collision between an existing event and a new event, we should think before doing that carefully. In addition, this operating system is non-preemptive but order scheduling, so the time of handling an event should not be taken up too much. We implement our design by increasing a new event in a task.

The station monitor itself is a ZigBee network coordinator which configured with a GSM / GPRS module. When we turn on the device power supply, the GSM/GPRS module and ZigBee protocol stack would be initialized by MCU. Then the station monitor can use a channel scan to measure the energy on the channel. Before starting a new network, the results of a channel scan can be used to select an appropriate logical channel and channel page, as well as the network identifier that is not being used by any other network in the area. The superframe is bounded by network beacons sent by the ZigBee coordinator and then waiting for the connection requestes from ZigBee devices. The coordinator should first confirm their validity when it receives the connection requestes from ZigBee devices to join the network, and then send the connection permission command. Once the connection established, the station monitor can obtain the device identifier and register it in the list. At the same time, the monitor send the message "XX bus YY clock arrive ZZ station" to monitoring center. Of course, the station monitor allow a lot of devices to connect with it at one time and register them in the list. When monitor receives the disconnection request from a bus, it delete the bus information from the list, and then send the message "XX bus leave YY station". The Flow chart of the system is as follows:

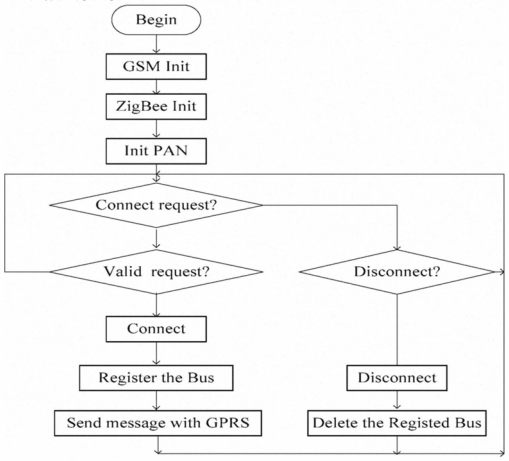

Figure 4. Flow Chart of Station Mnitor

The wireless identifier installed in the bus is a ZigBee device too. When power supply is on, the ZigBee protocol stack is initialized, then the wireless idetifier begin to scan channel and look for a ZigBee coordinator. After detecting the superframe which is transmitted by the coordinator, the identifier requestes to communicate with the coordinator. When the connection is established, it would obtain the information about the station monitor. Meanwhile, it can report the name of the bus station automatically. Once the bus depart from the station, the signal strength is low than a certain level, the bus send the disconnection request to the station monitor. The Flow chart of wireless idetifier is as follows:

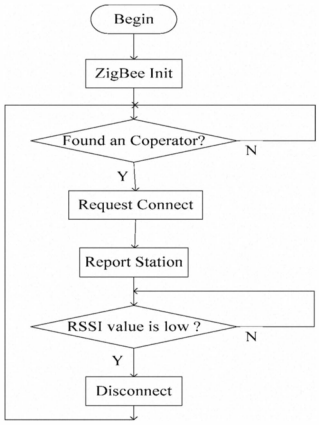

Figure 5. Flow Chart of Wireless Identifier

V. CONCLUSION

In accordance with the situation of the public transport management system at present, we design a new intelligent bus monitor and management system by using ZigBee technology and GSM/GPRS technology. It can improve the quality of the public transport service effectively. Its low cost is easy to accept by many public transport Corporation.

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