Design for Wireless Sensor Network-Based Intelligent Public Transportation System

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***Abstract*—Intelligent public transportation system is an effective way to improve the quality of our country transportation. Wireless sensor network is a novel technology made by the convergence of sensor technology, micro electro mechanism technology, wireless telecommunication technology and network technology. It is suitable to transportation scenarios for the characteristic of rapidly deployed and self organized. An improved solution combined the wireless sensor network and internet technology is presented in the article. It effectively solves three critical problems of the wireless sensor network, including energy saving, localization and communication distance. By using the low cost and high stability microchip, a high reliability and low cost intelligent public transportation system based on wireless sensor network can be easily established.**

Keywords-intelligent public transportation system; wireless sensor network; location

I. INTRODUCTION

With the high-speed economic development and the rapid urbanization and the popularization of automobile, the urban traffic congestion is becoming more and more serious. Buses which are low cost and high carrier loading and coverage of lines can effectively relieve the transportation crowding and play positive action on the energy saving and emission reduction. Now most of bus announcement systems are designed for the passengers in the bus, not considering the passengers on the platform. If the weather is not good or the light is dark, the passengers on the platform usually can't distinguish the bus numbers. The buses' operating environment must be improved for the convenience of the passengers. A few of the bus systems adopt the GPS location system. However they are so costly that it is difficult to popularize them easily. So the research of a low cost, high effective intelligent public transportation system based on the wireless sensor network [1] has great practical meaning and market value.

II. OVERALL DESIGN SCHEME

The intelligence of the public transportation system is the effective combination of advanced information technology, sensor technology and communication technology. It accurately realizes the location, monitoring and dispatch of all the buses, and then supplies the dynamic information for the passengers. As the Fig. 1 illustrates, the intelligent public transportation system mainly contains scheduling center, vehicle system and station system. The scheduling center collects vehicles' location information from all the computers connected to the terminal stations and analyzes the information. The station system collects and publishes the vehicles' location information, then sends the location information to the scheduling center. The vehicle system mainly forecasts the coming platform according to the feedback message from the station system.

III. SCHEDULING CENTER

As the Fig. 2 illustrates, scheduling center established on the vehicles' location is a computerized dispatch system. The buses' location information are collected and sent to the dispatch center by the wireless technology and internet technology. The scheduling center analyzes the vehicles' real time location according to the information collected and achieves a most optimal dispatch to all the buses real timely and publishes the buses' real time location on the internet.

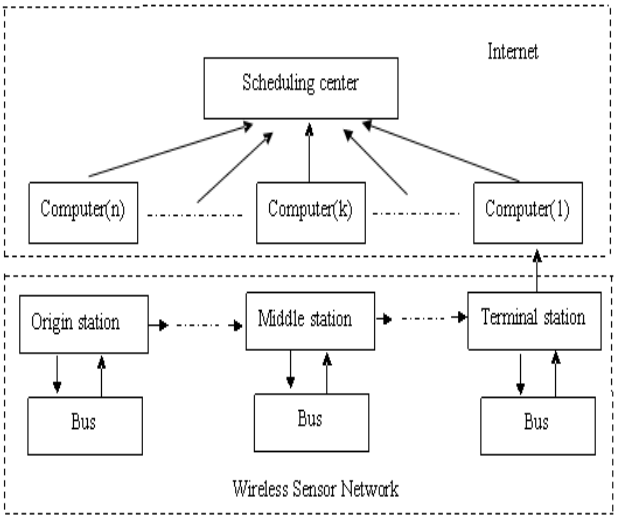

Figure 1. The overall structural diagram of the intelligence of the public transportation system

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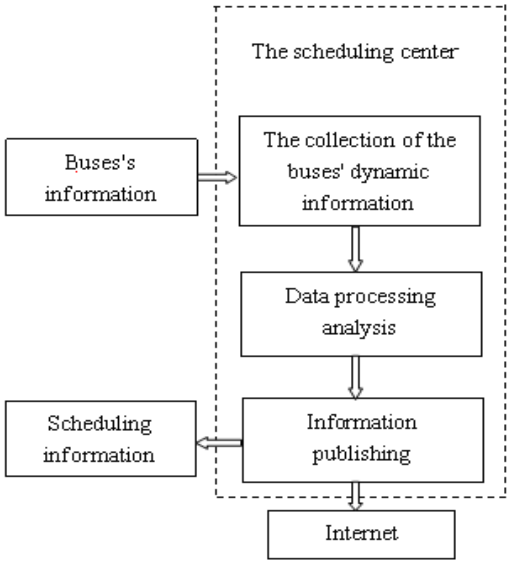

Figure 2. The scheduling center's structural diagram

IV. WIRELESS SENSOR NETWORK

Compared to traditional computer networks, the design and implementation of a wireless sensor network [2] require confluence of many fields, including sampling technology, signal processing, network, power management, embedded systems, information aggregation， distributed computing and many more. A wireless sensor network [3] is composed of a large number of sensor nodes which achieve some complicated tasks by cooperation with each other. Every sensor node usually has the functions of data collection, data processing and wireless transmission.

Many applications have been proposed for wireless sensor networks [4]. In some cases, field investigation and test have already been made and the experiences have been reported. These include habitat monitoring, active volcano sensing, structural health monitoring and underground mining. These applications clearly demonstrate the greater scope and usefulness sensor networks which are made up of several spatially distributed, low cost, light weight and smart sensor nodes with embedded software to fulfill complex tasks in a cooperating manner. And all these advantages represents in the wireless sensor network of this article.

But in the design of the wireless network [5], several problems exist, such as energy saving, location and communication distance.

A. Energy Saving

How to prolong the life cycle of the wireless sensor network is very important in the design of the wireless sensor network. Node's energy mainly supports the operation of the MCU, communication module. In this article, the mass adoption of low power MCU based on the dynamic power management and voltage scaling can reduces the power loss of the wireless sensor network to a great extent. Parts of the modules are at the state of dormancy when the sensor node doesn't receive any useful message. In a sensor node, the power loss of the communication module is in the most part. The emission module sends the code message every 100ms discontinuously and the receiving module is at the state of dormancy too if not activated.

B. Location Problem

Location has a decisive position in the intelligent bus system. In this article, different vehicles have various codes which represent their identities. The stations identify the vehicles by their various codes and send the vehicles' location information collected to the scheduling center. The system can distinguish accurately between which stations is the spot of the vehicle. This location accuracy could satisfy most of the passengers' requirements.

C. Communication Distance

Communication technique is one of the critical technologies in the wireless sensor network [6]. It mainly refers to the optimization of the communication distance, frequency and media. Further the distance is, the more power loss of the communication is. In this article, according to various requirements the choices of communicate distance are different.

V. VEHICLE SYSTEM AND STATION SYSTEM

The wireless sensor network [7] is composed of vehicle system and station system. The overall hardware design diagram of the station and vehicle is shown as Fig. 3 and Fig. 4 respectively.

A. Hardware Design

As Fig. 3 illustrates, the station system's hardware mainly contains main controlling MCU AT89C51, subsidiary MCU 8051, wireless transceiver and wireless emission module, bus location display circuit, LED display circuit and voice reminding circuit.

1) Main controlling MCU AT89C51

The main controlling MCU establishes the fundamental input-output port to realize the serial communication with the wireless transceiver and the parallel communication with the subsidiary MCU. It is the intelligent controlling center of the station system.

2) Wireless transceiver and wireless emission module

Under the control of the MCU AT89C51, they adopt the MCU CC1020 for ensuring the steady operation of the wireless transceiver and wireless emission module.

3) Bus location display circuit, LED display circuit and voice reminding circuit

They publish the vehicles' location information by voice and display for the passengers.

The terminal station needs to communicate with the scheduling center by a computer. It sends all the passing by this terminal station buses' location messages to the scheduling center through the internet.

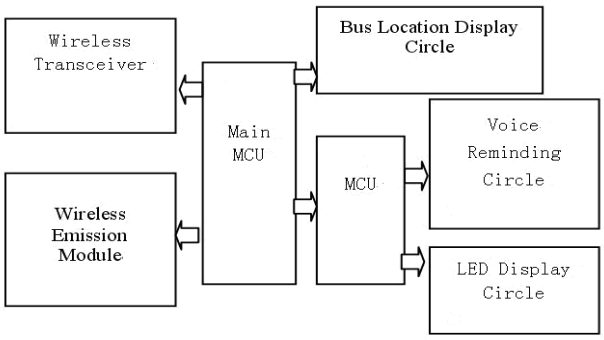

Figure 3. Station system

The vehicle's hardware consists of vehicle main controlling MCU AT89C51, wireless transceiver, subsidiary MCU 8051, voice reminding circuit, displaying circuit and transfer switch of uplink and downlink. Its design is similar to the station's as shown in Fig. 4, so not mention in details.

B. Software Design

1) The station system's software design

As the Fig. 5 illustrates, the station system's idiographic work flow is shown as follows: After the system is initialized, the wireless emission module is at the shielding state and the station system is at the state of receiving code message. The station system queries whether the receiving module receives the message. If the code message is received rightly, the system judges whether it is the vehicle's or the station's code message. If the message received is the vehicle's code message, which is defined as one byte, station system sends back a responsive message to the vehicle system, calculates the route codes received to get the bus's route right number, reads the route code message from the memory of code information database, and sends it to the station subsidiary MCU. Then the station subsidiary MCU activates the LED display and voice reminding circuit. If the message received is the station message(three bytes),station system calculates the route codes received, substitutes the destination address in the code by the following station address, activates the wireless emission coincided with the bus's location display circuit, and turns on the right bus's location indicator. The station wireless emission module must be shielded after finishing sending the code message.

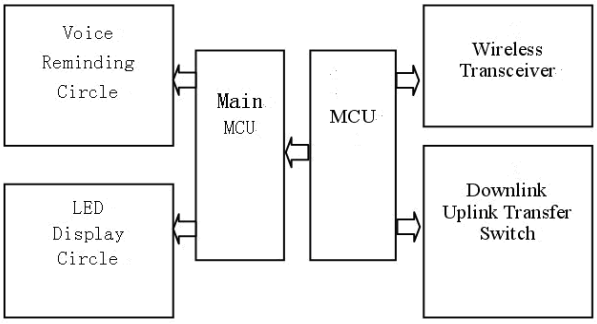

Figure 4. Vehicle system

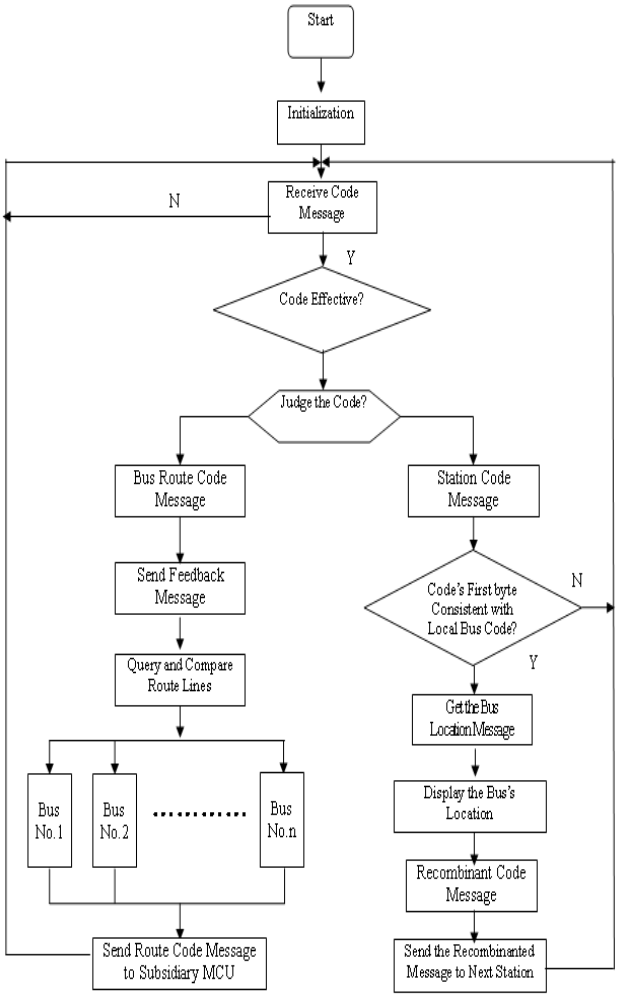

Figure 5. Idiographic software flow of the station system

2) The vehicle system's software design

As the Fig. 6 illustrates, the station system's idiographic work flow is shown as follows: The vehicle main controlling MCU AT89C51 storages the buses' line codes and changes the buses' line codes by turning the switch of uplink and downlink to distinguish the downlink or uplink. A timer is set for the main controlling MCU and the MCU can launch the message carrying specific route's codes through the wireless transceiver's antenna every 100ms. Then it queries whether the receiver module receives the station's feedback message before the next 100ms. If the receiver module doesn't receive any feedback message from station system, the MCU keeps sending the code message. If the vehicle system receives the feedback message of the station system, it continues to compare and judge whether the feedback message is correct. If the feedback message is right, the transceiver module in vehicle system stops sending the code message for 30s. At the same time, it begins to forecast the following station and displays the name of the station, and then turns to the initial state. If the feedback message is wrong, the vehicle system doesn't do anything and continues to send the code message.

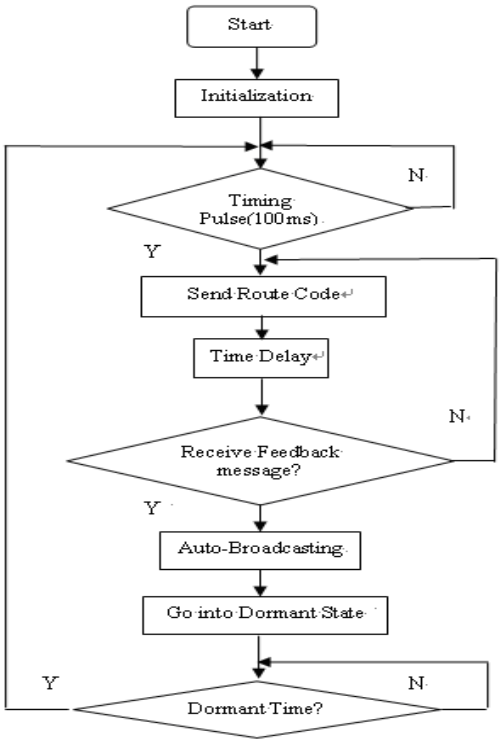

Figure 6. Idiographic software flow of the vehicle system

VI. SIMULATION EXPERIMENT

The object of simulation experiment is shown in Fig. 7. Its hardware and software are all achieved and it can work effectively. To reduce the research cost, the LED display screen is replaced by digitron . In the Fig. 7, one with digitron represents the station system; the other represents the vehicle system.

Fig. 7(1) shows that the bus No. 2 is coming to the bus station. For the convenience of demonstration, the vehicle system has three switches which are line transfer switch(1), transfer switch of downlink and uplink(2) and power switch.(3), and the station system has a power switch(4) only. If the line transfer switch(1) turns to No. 1, as the Fig. 7(2) illustrates, the station begins to forecast that the bus No. 1 is coming.

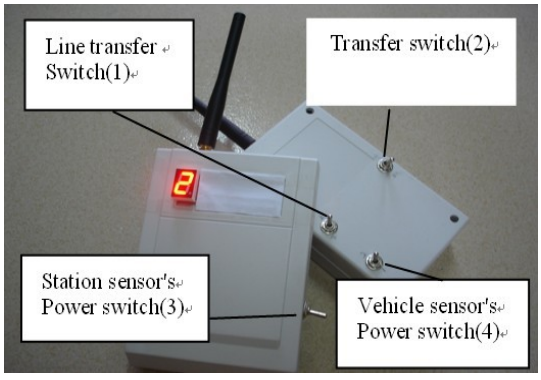

Figure 7(1). The object of simulation experiment

Figure 7(2). The object of simulation experiment

The object represented is two types of the sensor nodes in the whole sensor field and all the sensors are just as the two types. So it is easy to be extended to the whole sensor network.

- The wireless sensor network [8] in this article adopts the cheap and low power MCU based on the dynamic power management and dynamic voltage scaling. And communication module with dormancy mode is also the method to save energy.
- The self-organization of the wireless sensor network makes sure of the seamless access of the vehicles into network and it also improves the reliability of the data transmission.
- It can satisfy most of the passengers' requirements for the system designed to decide accurately between which stations the vehicle is.

The wireless sensor network based bus system which is low cost, high stability and high efficiency supplies a effective method for small urban to establish high effective intelligent public transportation system. This article mainly realizes the design and test of the two types of the sensor nodes. The next work's focal point is the extension of them to the whole sensor network.

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