Sensors & Transducers, Vol. 160, Issue 12, December 2013, pp. 250-255

www.sensorsportal.com

Sensors & Transducers

© 2013 by IFSA

http://www.sensorsportal.com

Application of Wireless Sensor on Intelligent Monitoring in Logistics Refrigerator Car Transportation

Qi JINPING

Lanzhou Jiaotong University, P. O. box 95, Lanzhou, China, 730070

Tel.: 18693104867

E-mail: qjpskc@163.com

Received: 23 October 2013 /Accepted: 22 November 2013 /Published: 30 December 2013

Abstract: This paper introduces the wireless sensor network and its applications, analyzes the key technologies of its application in logistics. Such as: energy consumption, the node localization problem, topology control problem, the MAC protocol and routing protocol, etc. And it also analyzes the application of wireless sensor network in logistics warehouse environment monitoring, transporting supplies real-time monitoring, logistics management of dangerous goods and cold chain logistics management and designed an intelligent monitoring system based on Iot sensor technology. This paper expounds the use of Internet of things technology such as advanced radio frequency identification (RFID) technology, sensor technology and the wireless communication technology, and realizes intelligent identification of temperature and humidity monitoring of the goods in the refrigerator car and achieves real-time locating and tracking of refrigerator car position, and finally achieves the intelligent monitoring of the whole process of refrigerator car transportation. *Copyright © 2013 IFSA.*

Keywords: Wireless sensor technology, Intelligent monitoring system, Refrigerator car transportation, FPGA, Internet of Things technology.

1. Introduction

Wireless sensor network is made up of a large number of low-cost micro sensor nodes deployed in monitoring area. And it is a multiple hops self-organizing network system formed by wireless communication mode. Its purpose is collaboratively to perceive, collect and process perception object information in network coverage area and sent it to the observer. As wireless communication, embedded computing and sensor technology is increasingly mature, the research and application of WSN is becoming more and more widely.

The role of logistics in social and economic development is becoming increasingly prominent. Through a variety of advanced modern logistics technology to promote the development of logistics has very important practical significance. The WSN has application value in many fields of logistics, including equipment monitoring, warehouse environment monitoring, transportation vehicles in production logistics and tracking and monitoring of the goods, dangerous goods logistics management and the cold chain logistics management, etc. This paper discusses the key technology and application prospect of WSN applications in logistics and uses the advanced RFID technology, sensor technology, GPRS/GPS technology and the Internet to design a intelligent remote monitoring system for refrigerator car which can make real-time monitor of the temperature and humidity , door switch state, cargo information and position of the vehicle in the refrigerator car. Achieve full monitoring and traceability of the whole process of transportation.

2. Key Technologies of Wireless Sensor Network Application in the Logistics

2.1. Energy Management

Because sensor networks node distribution are numerous with large coverage and complex working environment, to replace the battery is not realistic most of the time. In the current research progress of the problem of energy conservation, dormancy mechanism is one of the most effective ways to save energy [1].

2.2. Node Location

No matter the sensor node is installed in the warehouse or in transport vehicle, the node localization is a key issue. Node localization refers to the determination of the relative position or absolute position of sensor nodes. At present there are mainly two types of node localization algorithm: localization algorithm based on distance measurement and localization algorithm which is not relates to distance measurement [2].

2.3. Mobile Control Problem

Motion control is responsible for the detection and control of mobile nodes and maintenance of routing to the rendezvous point and still makes the sensor nodes track its neighbors. Through topology control can automatically generates good network topology to improve the efficiency of routing protocol and MAC protocol, laying the foundation of data fusion, time synchronization, and the target location and many other aspects, to save energy of nodes to prolong the lifetime of the network[3].

2.4. MAC Protocol

MAC protocol has important influence on energy consumption of nodes because of its direct control of radio frequency module which is the biggest energy component in the node. Therefore, the energy efficiency is the main design goal of MAC protocol of wireless sensor network. At present, the methods for reducing power consumption of the MAC protocols are mainly the reduction of data traffic, increase of the RF module sleep time and conflict avoidance, etc [4].

2.5. Routing Protocol

The main task of the routing protocol is to establish a routing between sensor nodes and sink nodes and transfer data reliably. The first design principle is to save energy and prolong the network lifetime. Based on the above reasons, the protocol can't be too complicated and too much state information can't be saved in nodes, and it does not allow too many routing information exchange between nodes. At the same time sending redundant information should be avoid as much as possible and reduction of energy waste is required.

3. Prospect Analysis of Application of Wireless Sensor Network in Logistics

With the deepening of the research, many key technologies are handled well, which leads to the large-scale application of WSN in logistics. For example, (1) WSN can be used in warehouse environment monitoring, meet the demand of the distributed monitoring of environmental parameters such as temperature, humidity and air composition, realize the intellectualization of the storage environment. (2) Application of wireless sensor network (WSN) can realize real-time monitoring of the state of the dangerous goods and the container. And it can alarm in time once it is over the alert value which provides security for tracking, monitoring and management in the process of dangerous goods logistics. (3) If the wireless sensor network is applied in the cold chain logistics, temperature and humidity of all products can be monitored in a frozen environment, and temperature and humidity control can be achieved in time and the quality of the products is also guaranteed [5].

4. Design of Intelligent Sensor

In order to reduce the workload of system design, abstract away the data model of part of the widely used sensors, design software and hardware of the system according to the abstracted structure.

The current commonly used sensors can be abstracted as analog input and digital input, and reverse control can be abstracted as analog output and digital output. So the basic block diagram of the sensor can be drawn as Fig. 1.

4.1. Artificial Neural Network

The basic principle of neural network fusion technology is similar to the human brain process of synthesizing data or information. Fig. 2 is an artificial neural network fusion routing model. When routing is without application of neural network fusion technology, there exits many redundant information transmission between sensor nodes in the network. This increases the node's working intensity, time of data processing and frequency of communication.

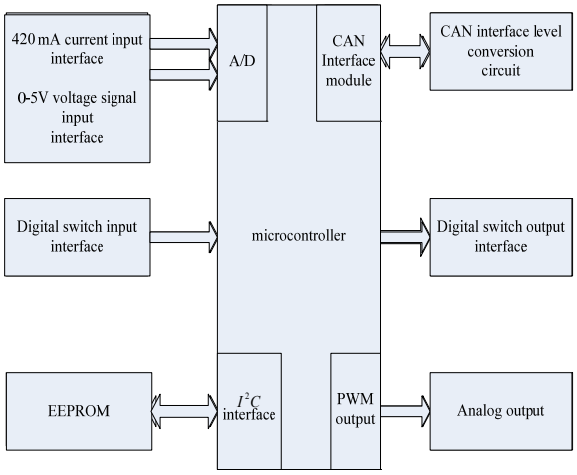

Fig. 1. Basic block diagram of sensor.

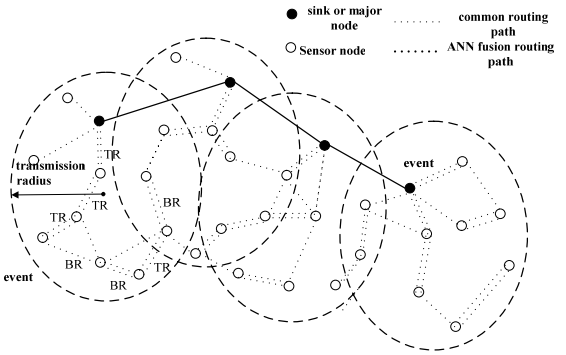

Fig. 2. Artificial neural network.

The application of neural network data fusion technology can greatly improve the intelligent level of sensor network applications, and reduce the node energy consumption and prolong the lifetime of sensor networks effectively.

4.2. SOM Algorithm

The basic goal of SOM algorithm is to provide an approximation for the original input space H through looking for a large collection of a smaller collection storage input vector $X \in H$ of prototype $W_j \in A$ [6].

Set up s as the total number of input samples in the network, and the p[th] input sample can be represented by vector as:

$$X^p = (x_1^p, x_2^p, ..., x_i^p, ..., x_n^p),$$

the output value of each output neurons denoted by

$$y_j, j = 1, 2, ..., m,$$

the weight vector connected with the jth output neuron denoted by

$$W_j = (w_{j1}, w_{j2}, ..., w_{ji}, ..., w_{jn})^T.$$

Its external input mode can be expressed by:

$$u_j = \sum_{i=1}^{n} w_{ij} x_j \tag{1}$$

The neuron adaptive process, in the case of continuous time variable can be expressed in the following equation:

$$\begin{cases} \frac{dW_i}{dt} = \eta (X - W_i) & i \in N_c(t) \\ \frac{dW_i}{dt} = 0 & i \in N_c(t) \end{cases} \tag{2}$$

In which, W_j is the weight vector, $W_j = (w_{j1}, w_{j2}, ..., w_{ji}, ..., w_{jn})$, η stands for learning efficiency, X is input vector, $X = (x_1, x_2, ..., x_i, ..., x_n)^T$, N_c is a field with c as its center.

SOM neural network is very effective for solving all kinds of type identification problems of nonlinear distribution whose characteristic is not obvious, with characteristic parameters interlaced and mixed. And SOM does not need the intended target, it can automatically divide data into groups. So the network omits the study time with high instantaneity and is more suitable for the selection of wireless sensor network routing.

4.3. Hardware Structure of Intelligent Sensor

The hardware structure diagram of intelligent sensor is shown in Fig. 3.

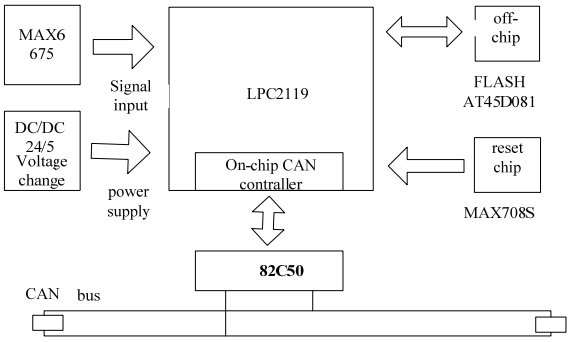

Fig. 3. Hardware structure diagram of intelligent sensor.

4.3.1. The Communication Principle and Hardware Connection of MAX6675 and LPC2119

Temperature acquisition chip MAX6675 adopts standard SPI serial peripheral bus and MUC connector, and MAX6675 can only be as slave unit.

The concrete circuit diagram of connection between LPCZ119 and MAX6675 is shown in Fig. 4.

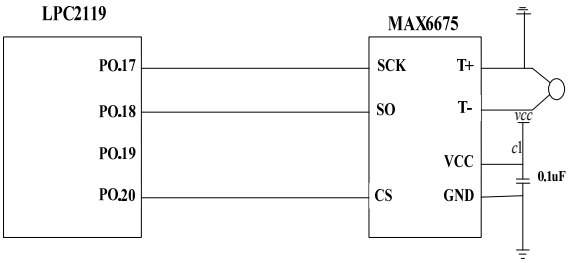

Fig. 4. Circuit diagram of connection between LPCZ119 and MAX6675.

4.3.2. Schematic Diagram of Data Storage AT45D081 and LPC2119

Schematic diagram of data storage AT45D081 and LPC2119 is shown in Fig. 5.

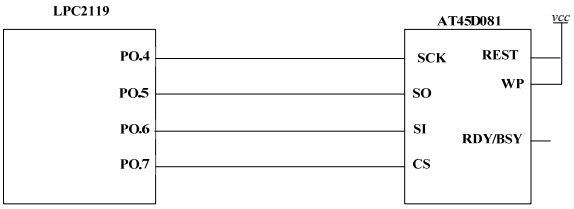

Fig. 5. Schematic diagram of data storage AT45D081 and LPC2119.

4.4. Software Structure of Intelligent Sensor

The main program flow of intelligent sensor is shown in Fig. 6, system initialization program is shown in Fig. 7.

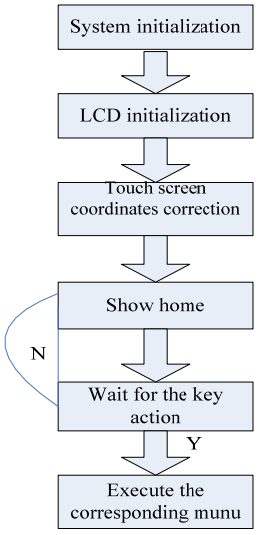

Fig. 6. Main program diagram of intelligent sensor.

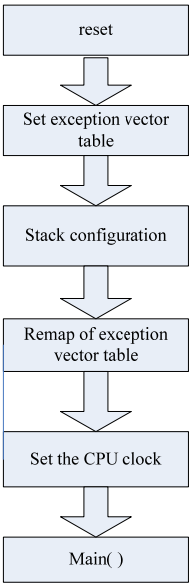

Fig. 7. System initialization program.

Start the program refers to an assembler executed by LPCZ119 before it enters the C language main() function and after power on reset or manually reset. This program is mainly to provide basic operation environment for the C language program, including set of exception vector table, dock configuration and so on. The system parameters set by the procedures directly affect the operation of the follow-up programs. So it is the basis and prerequisite of the software runs.

5. Intelligent Monitoring System Design for Refrigerator Car Based on Sensor Technology

5.1. Design Goal

Because of its wide scope of transportation of refrigerator cars with bad conditions of the road environment, which leads to management difficulties in the process of transportation. Since goods transported are mostly fresh meat, fruits, vegetables, dairy products, cold drinks and health food, it requires high environment standard in the car. Combining the above characteristics of transportation process of refrigerator cars, design a remote intelligent monitoring system for refrigerator cars based on the Internet of things technology, which can achieve a whole-process monitor of temperature and humidity of all the products in a frozen environment , realize the control of temperature and humidity in time, ensure the quality of the products.

5.2. The Make Up of Intelligent Monitoring System

System adopts building block design, and is made up of multipoint temperature and humidity

acquisition module, the door switch monitoring device, RFID module, vehicle monitoring module, GPRS/GPS module, wireless communication network and the remote monitoring center. System composition block diagram is shown in Fig. 8.

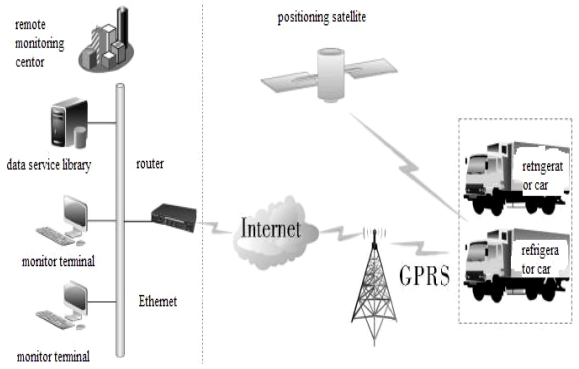

Fig. 8. Block diagram of system composition.

The system is based on the advanced Internet of things technology, combined with the existing sensor technology and wireless communication technology, to achieve the purpose of real-time accurate monitoring. Through temperature and humidity sensor with high performance, to constitute temperature and humidity acquisition module for real-time reading of temperature and humidity data in the car. To measure the distribution of temperature and humidity data, several temperature and humidity acquisition modules can be placed in the car according to actual needs.

5.2.1. Monitoring Center of Intelligent System

Multipoint temperature and humidity acquisition module, the door switch monitoring device, RFID reader, GPRS/GPS module and monitoring module in the car together can be seen as the monitoring center in the refrigerator car. The system chart is shown in Fig. 9.

5.2.2. Remote Monitoring Center Principle and Way of Data Transmission

The monitoring center in the car can connect to the remote monitoring center by wireless communication network and the Internet. And Remote monitoring center make real-time monitoring of the refrigerator car. The monitor terminal of remote monitoring center designs humanization monitoring interface using intelligent analysis software. Output the data on the interface and make real-time display, alarm, process, record and print of the data from every refrigerator car, to determine the location of each refrigerator car. Intelligent system data delivery is implemented by FPGA.

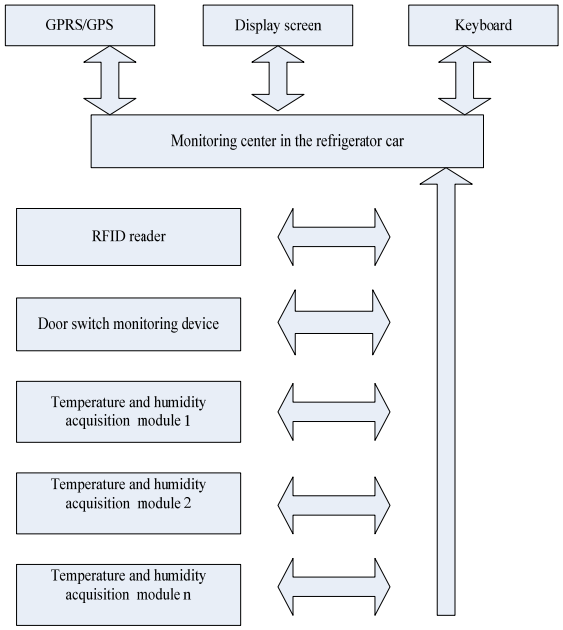

Fig. 9. Block diagram of the monitoring center.

5.2.3. The Design of Light Module Interface

Virtex - 5 Rocket lO GTP transceiver is an embedded hardcore in Xilinx FPGA device, with characteristics of universality, low power consumption and low cost etc. And it can support a variety of standard protocols, such as Aurora protocol, gigabit Ethernet, etc. Each GTP transceiver contains independent sending module and receiving module. When using the GTP to send and receive data, make universal instantiation of GTP by core generator of Xilinx according to the design requirements [7].

5.2.4. Hardware Verification of the System

Theoretically, maximum communication speed to control W5100 by single-chip microcomputer can be up to 25 MB/s. In the practical application, however, because of the network and the communication speed between CPU and W5100, network transmission speed of W5100 is far less than 25 MB/s. This design adopts FPGA to control W5100. After the test, speed of the sending end can be up to 64 MB/s maximum. Because the system is a one-way optical fiber transmission with no feedback, so there will be packet loss phenomenon due to the fast speed for receiving data of board 1 and slow speed for sending data of board 2. In the FPGA program for board 1 add certain idle loop to reduce the speed of receiving server data, at the same time add in the FPGA program for board 2 a certain size of storage space to

cache data received. After both ends do appropriate adjustments, packet loss phenomenon will not occur again.

6. Conclusion

In this paper, the intelligent monitoring system designed based on IOT sensor technology adopts the Internet of things technology such as advanced radio frequency identification (RFID) technology, sensor technology and wireless communication technology, realizes unidirectional fiber optic data communication method based on Ethernet by using FPGA to control W5100. This method occupies less logic resources inside the FPGA and its feasibility and reliability are proved through the video file transmission and real-time playing. Using FPGA to do data processing as well as Ethernet data communication, and provides a simple method for the verification of inspiration and inerrancy of the communication link.

The research and application of wireless sensor network is more and more widely. The first application of wireless sensor network (WSN) on several typical logistics areas are: storage environment monitoring, real-time tracking of the goods, dangerous goods logistics management and cold chain logistics management. As the key technologies such as energy management, node localization, topology control, MAC protocol and routing of the wireless sensor network become more and more mature, its developing prospect is predictable.

References

[1]. T. Derong, On multi-channel data acquisition and communication system design, *Communication Technology*, Vol. 43, Issue 02, 2010, pp. 95-97.

[2]. Z Liyi, B. Jidong, The application of optical fiber Ethernet technology in the metropolitan area network, *Study on Optical Communications*, Vol. 32, Issue 01, 2003, pp. 32-35.

[3]. S. Duwen, Z. Minbo, Data transmission scheme based on DSP technology and Ethernet card, *Communication Technology*, 2008, Vol. 41, Issue 07, 2008, pp. 98-100.

[4]. N. Knaian, A wireless sensor network for smart roadbeds and intelligent transportation systems, *Massachusetts Institute of Technology*, Boston, 2000.

[5]. M. Bogataj, L. Bogataj, R. Vodopivec, Stability of perishable goods in cold logistic chains, *International Journal of. Production of Economics*, Vol. 2, Issue 1, 2005, pp. 345- 356.

[6]. L. Jinlong, W. Li, G. Xiaorong, Multi-point temperature and humidity remote wireless monitoring system design, *Microcomputer Information*, Vol. 25, 2009, pp. 31-32.

[7]. D. Liangui, Z. Yong, The integrated application of RFID and GPS technology in logistics industry, *China Daily*, 2005.

2013 Copyright ©, International Frequency Sensor Association (IFSA). All rights reserved.
(http://www.sensorsportal.com)