An intelligent transportation system for hazardous materials based on the Internet of Things

Liming Cai[1,a*], Wu Xia[2,b], Peng Li[2,c], Long Zhang[2,d], Jing Liu[2,e]

[1]School of Physics and Information Engineering, Jianghan University, Wuhan, Hubei 430056, China

[2] Graduate faculty, Jianghan University, Wuhan, Hubei 430056, China

[a]cailm@aliyun.com,[b]xiawst@aliyun.com, [c]peng465675802@163.com, [d]dxxdragon163@163.com

[e]15871757905@163.com

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Abstract. Aiming at the lack of supervision and effective techniques in hazardous materials (Hazmat) transportation, in this paper, we use wireless sensor network (WSN), radio frequency identification (RFID), global positioning system (GPS), global system for mobile communication (GSM), geographic information system (GIS) and other modern information technologies to build an intelligent hazmat transportation system, which consists of parameters collection, information management, intelligent alerting and rescue dispatch. Apply Internet of Things (IoT) technology to hazmat transportation can improve transport safety and efficiency. It also has a certain practical value in reducing the negative impact on society and environment.

Introduction

Because the Hazmat transportation accidents take place frequently for the lack of supervision and effective techniques, the safety supervision department and the public have paid close attention to the Hazmat transportation for a long time [1]. Due to the inflammable, explosive and toxic ingredients of the Hazmat, the Hazmat transportation accident may result in leakage and explosion, which may carry a great negative impact on society and environment. Therefore, researching on Hazmat intelligent transportation system is of great significance to improve transport safety, protect the environment and promote further development of Hazmat transportation.

With the development of IOT, several scholars carried out study on this subject.

In 2000, Sergio et al. focused on the application of GIS in the management and control of major accident risk [2]; In 2005, Japanese scholars used GPS and GSM technology to realize the real-time monitoring of the vehicle; In 2009, Wang et al. used RFID/GPS/GPRS technology in Hazmat transportation, which improved the transport safety [3]; In 2014, Kuang et al. put forward to bringing monitoring of vehicle safety into the highway monitoring system [4].

These studies focus on the monitoring of vehicle, but the monitoring of Hazmat is lack of consideration. In China, however, the working center is shift to Hazmat leakage monitoring and rescue dispatch.

In order to address this problem, we use the key technology of IOT to build an intelligent hazmat transportation system, which consists of parameters collection, information management, intelligent alerting and rescue dispatch. Apply Internet of things (IOT) technology to hazmat transportation can improve system reliability and transport safety.

System Design

System Overview. In this paper, our system is composed of three subsystems: vehicle terminal system, wireless communication system and monitoring center system. Vehicle terminal system is responsible for data collection; Wireless communication system is responsible for packaging the data and sending the data to the monitoring center via TCP/IP protocol; Monitoring center system is responsible for information analysis and management, intelligent alerting and rescue dispatch. The architecture diagram of Hazmat intelligent transportation system is shown in fig.1.

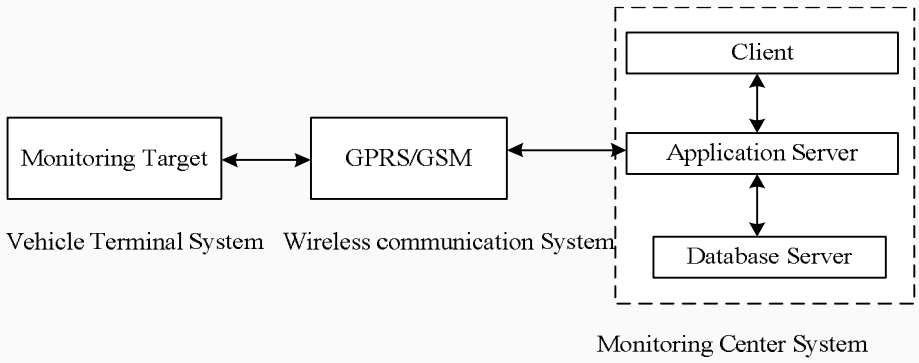

Fig. 1.Architecture diagram of Hazmat intelligent transportation system

The Vehicle Terminal System. The function of the vehicle terminal system is collecting information, sending information and implementing the command handed over by the monitoring center. GPS module is mainly responsible for collecting vehicle positioning information; ZigBee module is mainly responsible for collecting vehicle environmental information, Hazmat information, RFID information and sending the information to CPU module through the serial port. After CPU processing the information, the GPRS module will establish the TCP connection with the monitoring module to realize the information interaction. The hardware structure diagram of vehicle terminal system is shown in fig.2.

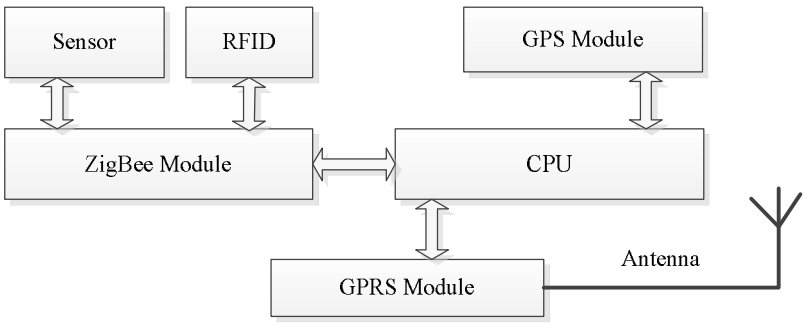

Fig. 2.Hardware structure diagram of vehicle terminal system

The GPS Module. Our system can realize vehicle tracking and scheduling through installing the GPS module on the vehicle. Considering the cost, positioning accuracy, power consumption, communication protocol of the system, the module we used in this system is NEO–6M-0-001. The work process of GPS module is shown in Fig.3.

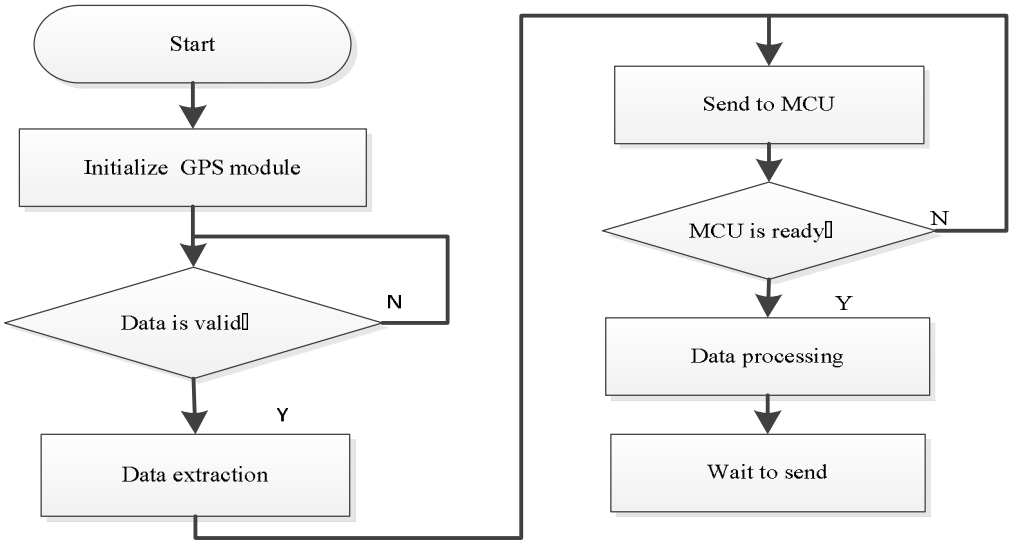

Fig. 3.The work process of GPS module

Firstly, initialize GPS module and make an analysis of data validation. Then send the valid data to MCU through the serial port. MCU will process and packet the data. Finally, the data will send to the server through GPRS module.

The Sensor Module. Due to the different categories of Hazmat, the parameter we need to monitor is different. In this paper, we choose liquefied petroleum gas (LPG) to conduct simulation experiment. Because LPG is sensitive to the environment, the collision of vehicle and the change of temperature and humidity may result in leakage and explosion. Thus temperature, humidity, gas concentration, smoke density and acceleration are necessary to monitor. Table 1 has shown the specific sensor selection and alarm value setting.

Table1. The sensor type and the alarm value

Parameter	Sensor type	The alarm value
Temperature	STH11	40℃
Humidity	STH11	50%
Gas Concentration	MQ-6	25%LTL
Smoke Density	MQ-2	0.06%
Acceleration	KXTE9-1026	1.5g

The Wireless Communication System. WSN is a kind of communication system, which includes the monitoring technique, control technique and the wireless communication technique. It has many characteristics, such as low cost, ad-hoc networking routing and dynamic topology. Sensor network system usually includes the sensor nodes and the sink nodes. The sensor node consist of the sensing unit, processing unit and communication unit, it not only can collect and send messages, but also become the routers of messages. The sink node is used to connect the sensor network and the external network. It sends the messages collected from the sensor network to external network. At the same time, it sends tasks transited from monitoring center to sensor nodes. In this system, the communication protocol is ZigBee. Fig.4 shows the network structure of the wireless

communication system.

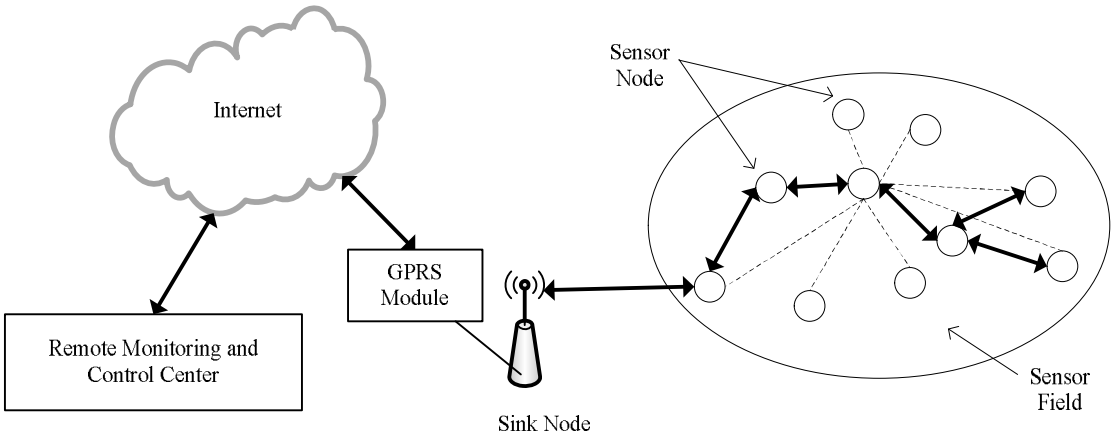

Fig. 4.The wireless communication system

The ZigBee Module. The core part of the ZigBee gateway node is the CC2530 processor, and it is the center of the network. The gateway will start the networking to set up a ZigBee wireless network after initialization. Then it sends beacon signals to handle the access requests of sensor nodes and assigns an only 16 bit short address for each node in this network. After successfully starting the networking, the system will receive the Hazmat and vehicle parameters uploaded by sensor nodes at regular time. On the one hand, the sink node will package the data and send the data to MCU through a serial port. On the other hand, the sink node will transmit the command handed over by MCU. After initializing, the sensor node sends the access request to the ZigBee gateway, and then sends the vehicle environment parameters regularly to the gateway.

The GPRS Module. The GPRS module used in this system is SIMCOM's SIM300. Firstly, we should initialize the SIM300. When gets the TCP command from MCU, the GPRS module will establish the TCP connection with the monitoring module in the monitoring center server system. Finally, it transmits the data, which is send from a serial port and packed by the communication protocol to the monitoring module.

Monitoring Management System. The monitoring center of the system is composed of the database server and the monitoring management system. Taking into account the scalability and maintainability of the system, we use B/S schema. Firstly, the vehicle terminal upload the data to the monitoring center, then the monitoring center store the data on the server. Finally, through analyzing, processing and displaying the data, the monitoring center can realize the remote monitoring of Hazmat and vehicle. The functional design for monitoring management center system is shown in Fig.5.

Conclusion

This paper provides a solution for solving the shortcomings of domestic Hazmat transportation. Installing the terminal on the vehicle, we can realize the collection of vehicle and Hazmat information in Hazmat transportation. On the one hand, CPU can process and display the parameters appropriately. On the other hand, the wireless communication module can establish the connection between the vehicle terminal and the monitoring center. Vehicle terminal is independent

of the monitoring center, which can enhance the fault tolerance of the system. The multiple-level interactive between the vehicle terminal and the monitoring center, as well as the storage of

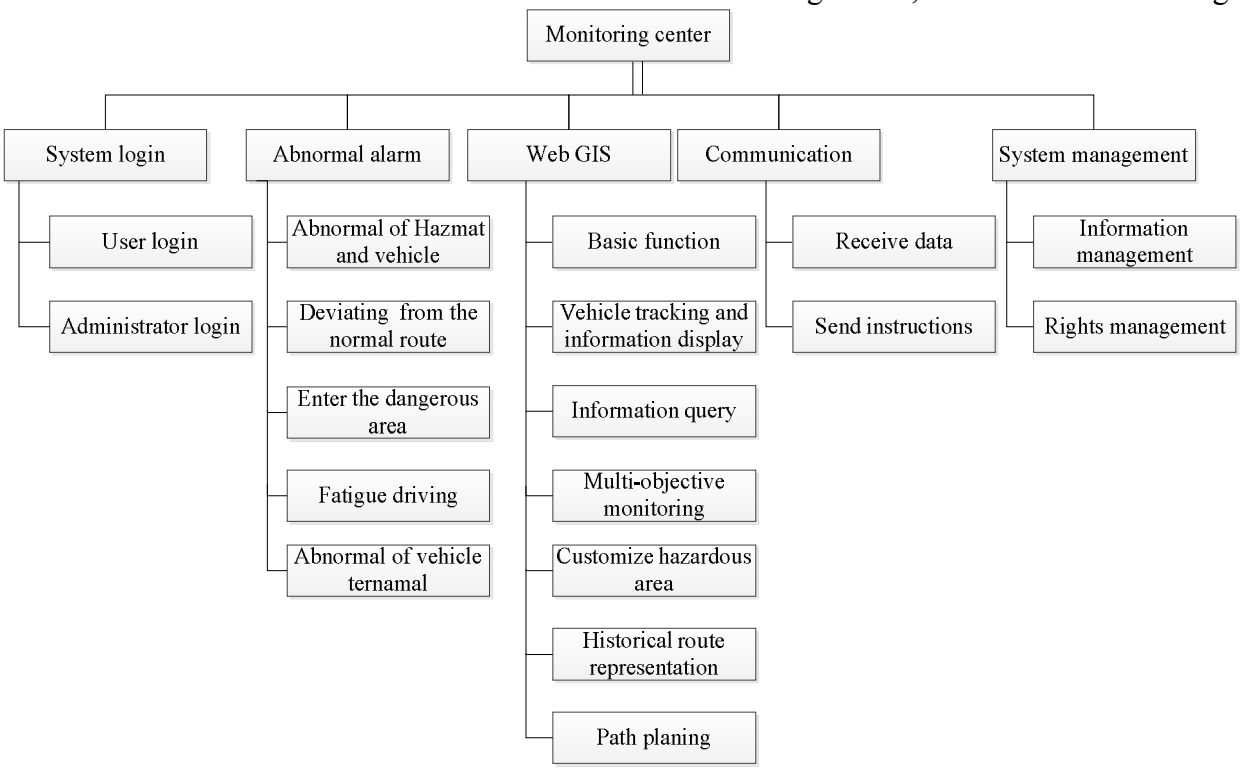

Fig. 5.Functional design for monitoring management center system

historical data can improve the reliability of the system. Apply IoT technology to Hazmat transportation can improve transport safety and efficiency. This intelligent transportation system also has a certain practical value in reducing the negative impact on society and environment.

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