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Development and Application of Real-time Monitoring System for Dangerous Chemicals Transport Vehicles Based on Internet +

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Vehicle transportation accounts for 80% of the dangerous chemicals transport volume in China, and it is of great significance to ensure safe transportation of dangerous chemicals. Based on the idea of "Internet +", this paper establishes a real-time monitoring system to realize all-round network management of vehicle information, driving status and security risks. This study designs a radio frequency identification (RFID) system to collect real-time data of dangerous chemicals transport vehicles, using a vehicle information concentrator to collect vehicle data and transmit it through mobile network; based on hardware design, it uses TOMCAT as the application server, Java as the system development language, and MYSQL as the database to develop a background management system for dangerous chemicals transport vehicles, and this system has a vehicle information management platform and a real-time vehicle monitoring platform. The application of the real-time monitoring system shows that the system can collect vehicle information, driver information, etc.; as well as locate the vehicles in real time and realize the danger warning of dangerous chemicals.

1. Introduction

As a pillar industry of China's economy, the chemical industry plays an important role in the development of the national economy. Due to the wide distribution of chemical products and chemical enterprises in China, most of the chemicals need to be transported. Among them, road transportation is the most flexible and convenient transportation method, and it is the main method for the transportation of dangerous chemicals. Therefore, road transportation safety of dangerous chemicals is of great significance to the healthy development of the entire chemical industry (Weike et al., 2017). As the transportation volume of chemical industry increases year by year and the number of transport vehicles increases substantially, dangerous chemicals accidents become more frequent, and scientific and effective management modes are urgently needed to improve the safety of dangerous chemicals transport vehicles (Wang et al., 2017).

The application of sensor technology, mobile communication technology, GIS (Geographic Information System), satellite positioning, Internet and other technologies in the road transportation industry of dangerous chemicals has provided a technical basis for the safety supervision (Kara and Verter, 2004). The Dutch government has established an emergency rescue network system for dangerous chemicals warehouses to achieve dual guarantees for monitoring and rescue. The United States and Japan have carried out hardware upgrades such as rollover warning and leak detection for dangerous chemicals transport vehicles; With the strengthening of the awareness of safe transportation of dangerous chemicals, domestic transportation enterprises and functional units have improved the safety supervision and dynamic monitoring of transport vehicles. Theoretical research has also achieved some preliminary results, but the development and application of integrated monitoring system for dangerous chemicals is still blank (Chen et al., 1997).

This paper first briefly introduces the hardware design of the real-time monitoring system for dangerous chemicals transport vehicles, then it devises in detail the system architecture and technical route of the monitoring system, and displays the various functional interfaces of the system. Based on the "Internet+" real-time monitoring platform, it can grasp the safety information related to transportation risks in real applications,

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realize real-time information sharing and effective data archiving, and provide important security for the transportation of dangerous chemicals.

2. Hardware design of monitoring system for dangerous chemicals transport vehicles

2.1 Overall system design

Using information communication technology and internet platforms to perform deep integration of internet technologies with traditional industries so as to achieve improvement in innovation and productivity is an interpretation of "Internet +" under the new form of economic development (Ng and Goetz, 2017). By combining Internet+ technology with supervision of dangerous chemicals transport vehicles, we can achieve comprehensive and real-time monitoring of dangerous chemicals transport vehicle information, safety protection equipment identification, dangerous area access control, real-time vehicle positioning, and surrounding environmen status monitoring.

The overall design scheme of the system is shown in Figure 1. The system can be divided into three parts according to its functional division: radio frequency identification (RFID), data concentrator, back-end database and management system (Sarma, 2001).

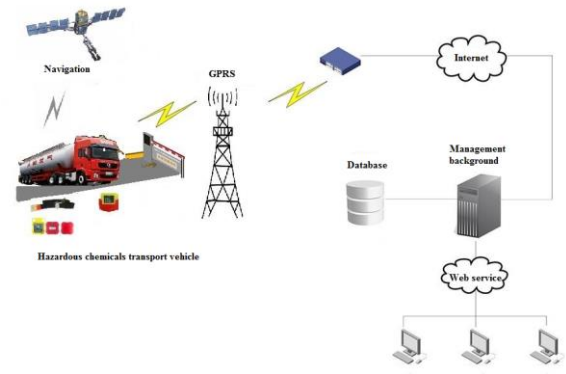

Figure1: Internet+ based intelligent vehicle management system diagram

Figure 2: Concentrator backplane and motherboard

2.2 System hardware design

2.2.1 RFID

The essence of RFID is to achieve wireless sensing with ultra-low energy consumption, which concentrates various types of safety information of the transport vehicles (Hirvonen et al., 2004).

For wireless RF communication, the communication frequency of currently used RF has two center frequency points of 2.4 GHz and 433 MHz. In this project design application, the frequency 433 MHz has a greater advantage than 2.4 GHz. The calculation formula for the loss of radio frequency communication signals propagating in air is as follow:

$$Los=32.44+20\lg d+20\lg f \quad (1)$$

In the formula Los means the transmission loss, unit is dB, *d* means the propagation distance, unit is kilometers; *f* means the operating frequency of the RF signal, unit is MHz.
According to the loss rate of the signal, 433MHz was selected as the communication scheme and the Freescale's FXTH8700xD series chip was adopted as the main chip for active transmission. The chip has a built-in 315/434MHz RF transmitter, a built-in 125kHz low frequency receiver, a built-in ULPWU (Ultra Low-Power Wake-Up), and a built-in integrated chip temperature and pressure sensor (Bonter and Bridge, 2015). Besides module chip, the RFID also includes a battery module, a program download circuit, a low frequency write circuit, and a signal transmission circuit. In the source tag, the 125K low frequency writer is used to input the host computer code to collect information of dangerous chemicals transport vehicles, categories of vehicle transport dangerous chemicals, and the safety protection equipment (Talarico et al., 2015).

2.2.2 Concentrator design

The main function of the concentrator is to concentrate the information and safety positioning information of the dangerous chemicals transport vehicles identified by the RFID and send it to the back-end server through the wireless communication module.
The concentrator is the identity information management which applicable to the vehicle safety protection equipment. It receives the data information sent by the RFID on the vehicle safety protection equipment through 433MHz wireless communication frequency, so as to realizing the real-time monitoring of the validity period, surrounding environmental of the RFID (Temperature and Pressure information).
Figure 2 shows the hardware diagram of the concentrator. The concentrator mainly includes the RFID card reader module, signal transmitting module, power module, GPRS information transmitting module, LCD module, main chip, and TF memory card (Planas et al., 2008).
The main program of the concentrator is designed to perform the most important tasks according to task priorities through UCOS-III real-time kernel initialization. In addition, in order to facilitate the inspection of dangerous chemicals vehicles in dangerous places, the transport vehicles are equipped with gate controllers (Du et al., 2017).

3. Design of monitoring system for dangerous chemicals transport vehicles

3.1 System design plan and system structure

After a brief introduction to the hardware foundation of the vehicle real-time monitoring system in the previous section, this section expands the detailed design of the system.
The platform of dangerous chemicals transport vehicle monitoring system is mainly divided into vehicle information management platform and background monitoring platform system: vehicle information management system records the license plate number, vehicle model, vehicle color, engine number, purchase time, operation license number, annual review status, etc., at the same time record the driver's name, age, residential address and other basic information; the background monitoring platform has the three functions of positioning query, map display and early warning management based on the vehicle system hardware measurement information for hazardous chemicals transport vehicles.

3.1.1 System design principles and system requirements

(1) System design principles
To ensure the sustainable development and applicability of the system, the system design follows the unified design principle, advanced principle, safety principle, standardization principle, and large capacity principle. These design principles can guarantee the uniformity of the application system construction structure and data model, it can ensure the system meet international, national, and industry standards, so that the safety and reliability of system design and operation can be improved, and the system capacity can ensure the system has strong scalability and data storage capacity (Bula et al., 2016).
(2) System requirements
System requirements include system application requirements and system function requirements: system application requirements request the system has stabilize structure, high adaptability and continuous working ability; The main requirement of the system function requirements is that it should be able to perform real-time transmission and storage of the dangerous chemical vehicles information collected by the hardware system, and be able to locate the vehicles and sound safety alarm (Marbach, 2003).
As shown in Figure 3, the network topology of the real-time monitoring system for dangerous chemicals transport vehicles is divided into three levels according to system requirements: vehicle built-in system, cloud platform system, and intelligent control platform (Keenan et al., 2010).

3.1.2 System topology

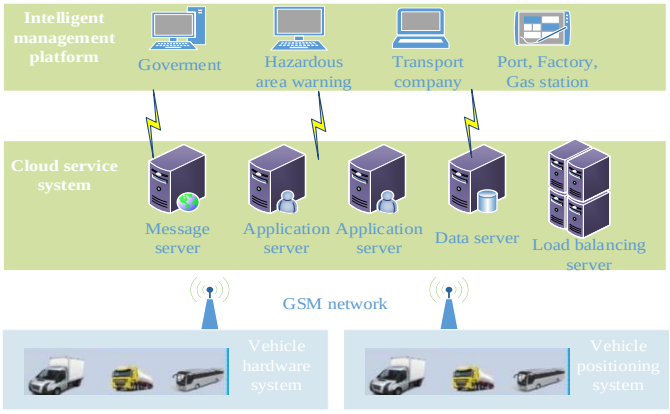

Figure 3: System structure topology

3.1.3 System server hardware and software platform

The server hardware selects a 2.5GHZ CPU, 8G memory, 2M bandwidth network card, 80G hard disk capacity, and the server operating system selects the window R2 which is secure and has a friendly human-machine interface (HMI) (Dusserre et al., 1995).

The application server selects TOMCAT. In order to improve the information query and extraction speed and the running fluency of the whole system, MySQL database is selected. The specific software environment technical platform is shown in Table 1:

Table 1: Software technical environment

Software classification	Specific applications
Server platform	Alibaba Cloud
Operation system	Windows server 2008R2
System develop language	Java
Database	MySQL
Data transmission method	TCP/IP
Data transmission format	JSON

3.2 System platform detailed design

The system platform interface is mainly divided into a menu area, a work area, and a status area. It is mainly divided into user login module, vehicle terminal module, transportation positioning module and danger warning module. Figure 4 shows the main interface of the monitoring system.

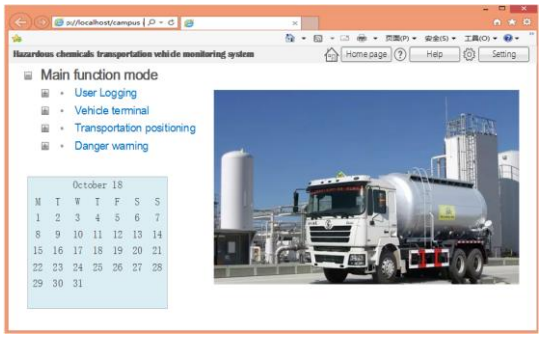

Figure 4: Main interface of the monitoring system

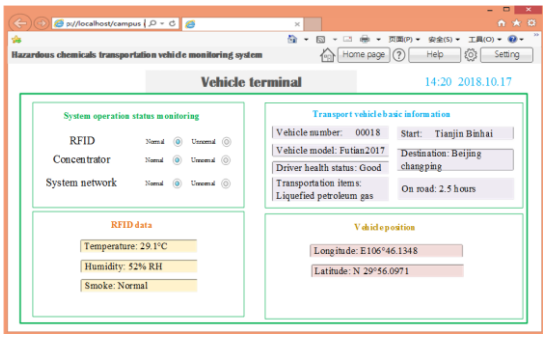

Figure 5: Vehicle terminal interface

Figure 5 shows the recorded data of the vehicle terminal, from system inspection modeling, we can clearly master the basic information of transport vehicles and their transport positioning.

The system also has a vehicle location information map, its display interface can intuitively and dynamically track the position changes of different numbered vehicles in the map. In addition, the maintenance interface of danger warning module allows the vehicle real-time monitoring system to sound danger alarms during the transportation process of dangerous chemicals when the surrounding environment status parameters exceed the danger warning range. The warning levels are as follows.

Table 2: Warning level description

Warning level	Warning condition	Warning description
First level	Compartment temperature is greater than 35° C	Compartment temperature does not meet the requirements
	Compartment humidity is greater than 35 ° C	Compartment humidity does not meet the requirements
	Body vibration exceeds 1g	Vehicle vibration is severe
Second level	Compartment temperature is greater than 50° C	Compartment temperature is not normal, hazardous chemicals react easily with air contact
	Body vibration exceeds 3g	The body vibration is severe and it is easy to roll over.
Third level	Compartment temperature is greater than 90° C	Hazardous chemicals in the car have reacted

It can be seen from the table that the higher the warning level, the more dangerous the dangerous chemicals transport vehicles. Under normal circumstances, the driver needs to stop and check the dangerous chemicals to ensure the safety of transportation. When the warning level reaches the third level, it indicates that the dangerous chemicals may be exploding and leaking. The background supervisory department should immediately instruct the driver to properly park the vehicle, at the same time inform relevant emergency departments to take corresponding measures.

The danger warning module of the vehicle real-time monitoring system can automatically classify the detected data and display the warning information directly in the background control system, and the vehicle terminal also receives the information synchronously. The driver can automatically adjust the driving status of the vehicle according to the emergency level, or can be operated according to the guidance of background personnel.

The monitoring system of dangerous chemicals transport vehicles will save dynamic data into MySQL database during the transportation process of different numbered vehicles. These data provide an effective guidance for the analysis of dangerous chemicals transportation safety. And the data in the monitoring system database can provide effective scientific evidence for dangerous chemicals transport companies, dangerous location management personnel and relevant government functional departments to deal with dangerous chemicals transportation accidents.

4. Conclusion

Transportation safety of dangerous chemicals is double risks to people and property, which is of great significance to the healthy operation of the chemical industry. In order to cope with insufficient supervision of dangerous chemicals transport vehicles in China and reduce the transportation accidents of dangerous chemicals, this paper carried out research on the real-time monitoring system of dangerous chemicals transport vehicles based on relevant research at home and abroad. According to the idea of Internet +, the related technologies of internet and communication fields were applied to the inspection of dangerous chemicals, and the hardware and software development and application of the system were realized. The main contents and significance of this paper are as follows:

(1) This paper achieved introduction and design of dangerous chemicals vehicle RFID, data concentrator, back-end database and management system hardware.

(2) Based on the Internet+, a real-time monitoring system was designed, and the main function modules of the system were introduced and explained.

(3) The research in this paper can be promoted in the practice of dangerous chemicals transportation, it can provide guidance for the transportation safety of dangerous chemicals vehicles, and provide effective safety data for relevant enterprises and departments.

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