CHEMICAL ENGINEERING TRANSACTIONS
VOL. 71, 2018
A publication of AIDIC
The Italian Association of Chemical Engineering
Online at www.aidic.it/cet
Guest Editors: Xiantang Zhang, Songrong Qian, Jianmin Xu

ISBN 978-88-95608-68-6; **ISSN** 2283-9216
DOI: 10.3303/CET1871124

Remote Monitoring of Wireless Sensor Networks in the Transportation of Dangerous Chemicals

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With the acceleration of China's industrialization process, the production and transportation of hazardous chemicals have increased dramatically. The related safety management departments of government and enterprises have paid more attention to the safety issue in the process of hazardous chemicals logistics. However, the serious accidents in the field of hazardous chemicals logistics still occur frequently, bringing great threats to economic and social security and people's lives. Therefore, it has become the biggest challenge facing China's hazardous chemicals industry on how to safely monitor and transport hazardous chemicals. For this, this paper proposes a remote monitoring system for hazardous chemicals transport vehicles based on wireless sensor networks (WSN). In this system, the wireless sensor nodes are used to monitor the temperature of hazardous chemicals, vehicle attitude and tire pressure, and simulation of model car is made to realize the remote real-time monitoring of vehicle operating conditions.

1. Introduction

The frequent occurrence of hazardous chemicals logistics accidents mainly results from many problems in the supervision and operation of hazardous chemicals logistics activities (Rashid et al., 2016; Jamil et al., 2015). The supervision and management of hazardous chemicals logistics involves many departments, and there is a lack of effective policy linkage, and also standard and unified supervision and management mechanisms among various ministries/departments, so that no evidence can be truly followed in the process of supervision and operation of hazardous chemicals logistics (Yang et al., 2015). Due to the lack of a perfect dynamic tracking and monitoring system, the dynamic information of hazardous chemicals in the logistics process is difficult to grasp (Zhang et al., 2018). The WSN integrates sensors technology, embedded computing technology, modern network and wireless communication technology, distributed information processing technology, etc.; it can automatically monitor, sense and collect information of various environments or monitored objects in real time through various integrated micro sensors (Guo et al., 2017). The information is sent wirelessly and then transmitted to the user terminal in a self-organizing multi-hop network model, thereby realizing the connectivity of the physical world, the computing world, and the ternary world of human society.
Design of the overall plan of the remote monitoring system.
Therefore, according to the existing problems for industry, combined with the specific needs of the project, this paper designs a wireless sensor network based vehicle condition remote monitoring system for logistics, to real-time monitoring for working condition of vehicle logistics and gathering, and the working condition of vehicles were collected information sent to the remote monitoring center. The monitoring center manages hazardous chemical vehicles according to the received vehicle working condition information.

2. Design of the overall plan of the remote monitoring system

Dangerous goods are the general term for inflammable, explosive and highly corrosive articles. The transportation of dangerous goods is extremely dangerous. Any negligence may cause material loss or casualties. According to the causal investigation of these traffic accidents, there are two main reasons for causing dangerous goods transportation accidents, namely, traffic accidents caused by vehicle collisions, and rollovers etc.; the explosions, pollution, poisoning accidents due to leakage of dangerous goods (Huang et al.,

Please cite this article as: Li Y., 2018, Remote monitoring of wireless sensor networks in the transportation of dangerous chemicals, Chemical Engineering Transactions, 71, 739-744 DOI:10.3303/CET1871124

2017). Therefore, real-time monitoring of hazardous chemicals in logistics and transportation is very necessary.

In view of the current transportation situation and existing problems in the hazardous chemicals transportation industry, this chapter first conducts the functional requirement analysis of the working-condition monitoring system. Then it introduces the key technologies used in this system, and proposes to use the WSN for monitoring the vehicle condition information of hazardous chemicals. Finally, the model car was used to simulate the remote monitoring of the system during vehicle transportation.

2.1 Functional requirements analysis of remote monitoring system

In the system design, the wireless sensor network (WSN) was applied to monitor the working condition information of the vehicle in real time and obtain its working condition information. Table 1lists the functional requirements of the system.

Table 1: Functional requirements of remote monitoring systems

Vehicle condition monitoring function	Monitoring the working conditions of hazardous chemicals transport vehicles with wireless sensor nodes; The sensor node is arranged on the tank body, the vehicle body and the tire of the vehicle, and the temperature of the hazardous chemicals in the tank body, the posture of the vehicle and the tire pressure of the tire are monitored in real time;
Vehicle positioning function	The vehicle terminal communication module transmits the location information of the hazardous chemicals logistics vehicle to the remote monitoring center
Communication function	The system needs to send the monitored vehicle condition information and location information to the remote monitoring center via the network.
Status information record	The system needs to record and record some important status information. The remote monitoring center can query the historical status information of the vehicle.
Parameter configurable function	The system needs to be suitable for all kinds of hazardous chemicals transportation vehicles, so the system needs to have parameter configurable and adjustable functions.

2.2 Remote monitoring WSN design

In terms of the WSN structure and characteristics, this study uses wireless sensor nodes to monitor the temperature of hazardous chemicals, vehicle attitude and tire pressure in the vehicle tank of hazardous chemicals transportation vehicles (Li et al., 2017). The specific monitoring items are shown in the table. 2. In the system, the sensor nodes are arranged on the tank body, the vehicle body and the tire of the vehicle, to monitor its working condition information. Fig.1 shows the wireless sensor monitoring network.

Table 2: Specific monitoring items for wireless sensors

Item	Reason for monitoring
Temperature	Due to changes in environmental conditions and the friction between hazardous chemicals and tanks during the transportation of hazardous chemicals vehicles, the temperature of hazardous chemicals in the vehicle tank can be changed.
Vehicle attitude	Hazardous chemicals transportation vehicles generally have large volume, large mass and relatively narrow track, which is prone to rollover. The vibration of the vehicle body will have a serious impact on the transportation safety of the vehicle.
Tire tire pressure	When the tire tire pressure is too large, it may cause the tire to burst, which may cause the vehicle to roll over. Once the dangerous goods transport vehicles roll over, it will cause serious dangerous chemicals leakage accidents.

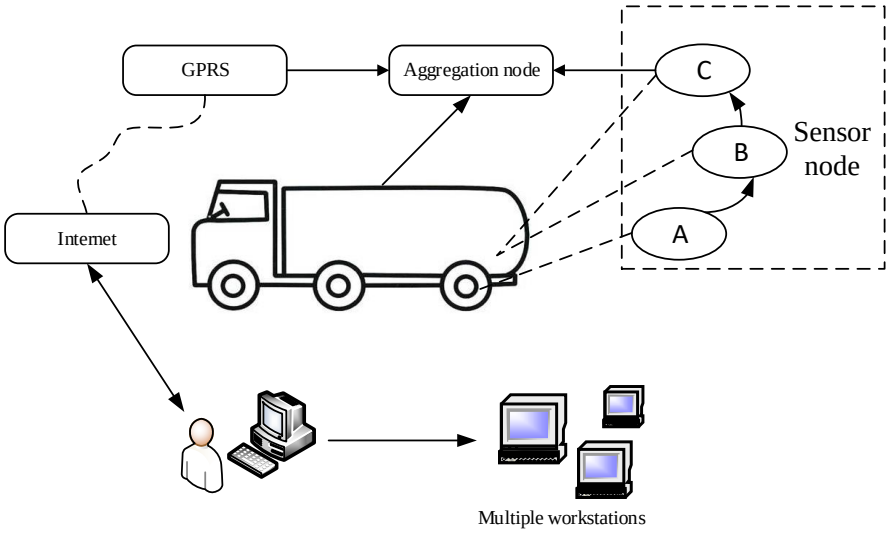

Figure 1: Wireless Sensor Monitoring Network

In WSNs, sensor nodes communicate using Zig Bee technology. In the sensor node design, the Zig Bee module DRF1600 by DTK Electronics was selected as the node's transmission module for communication between nodes.

In the working condition monitoring network, the vehicle terminal node acts as a coordination node of the Zig Bee network to complete node address allocation and data transceiving of the entire network. As a terminal node of the Zig Bee network, the working condition monitoring node is responsible for monitoring vehicle condition information and transmitting the monitored condition data to the vehicle terminal node (Ju et al., 2017). The communication module then transmits the vehicle condition information to the remote monitoring centre. The sensor network structure is shown in Fig.2.

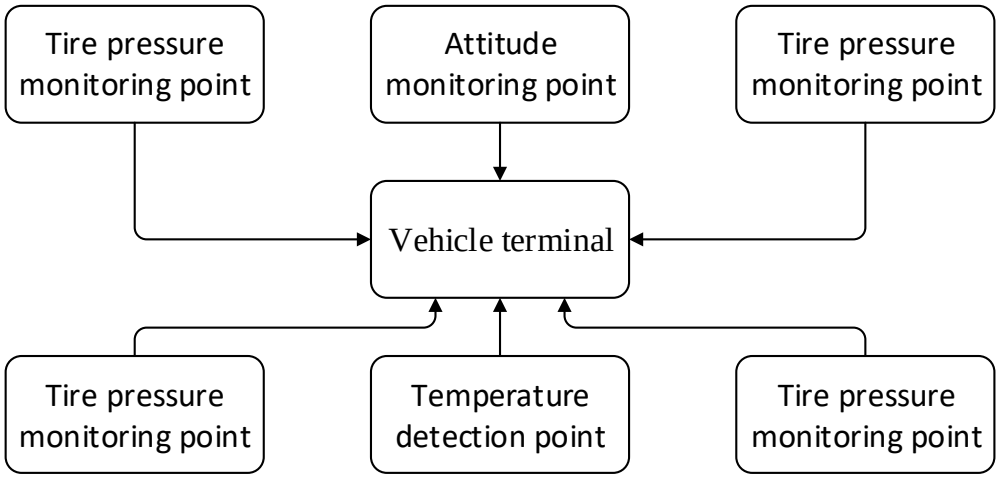

Figure 2: Structure of the sensor network

2.3 Establishment of wireless communication system in remote monitoring

By comparing the characteristics of various wireless communication technologies, and combining the specific needs of the project, GPRS technology is used for the communication between the vehicle-mounted terminal node and remote monitoring centre. Zig Bee technology is adopted for communication between sensor nodes. The wireless communication system is shown in Fig.3.

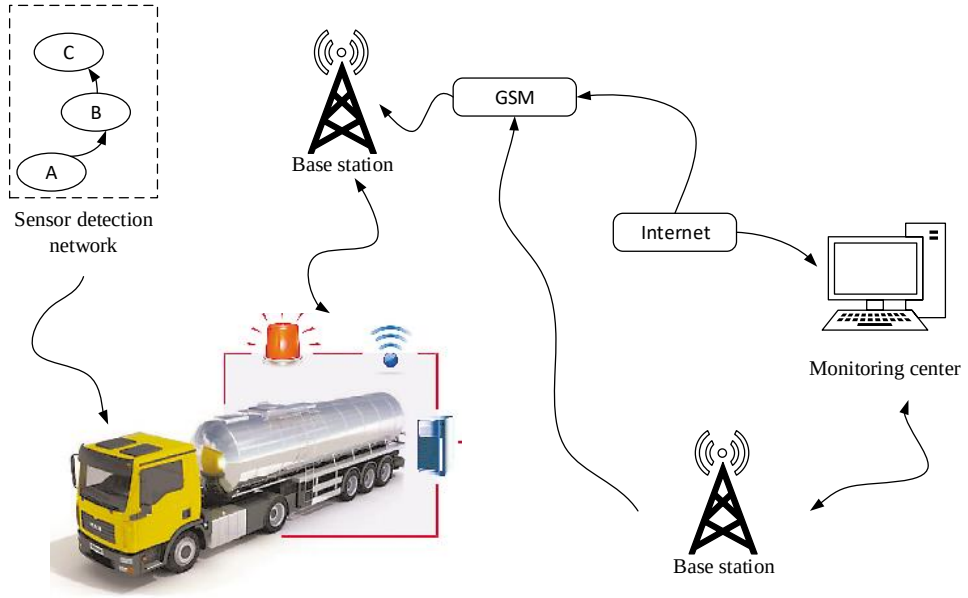

Figure 3: wireless communication system

2.4 Local computer software design

After the data is collected in the in-vehicle wireless sensor network, the original data needs to be analysed and processed in the on-board local computer. It mainly includes data acquisition, signal interception, signal analysis, filter, serial communication, and logic operation etc. The overall flow chart of the system is shown in Fig.4.

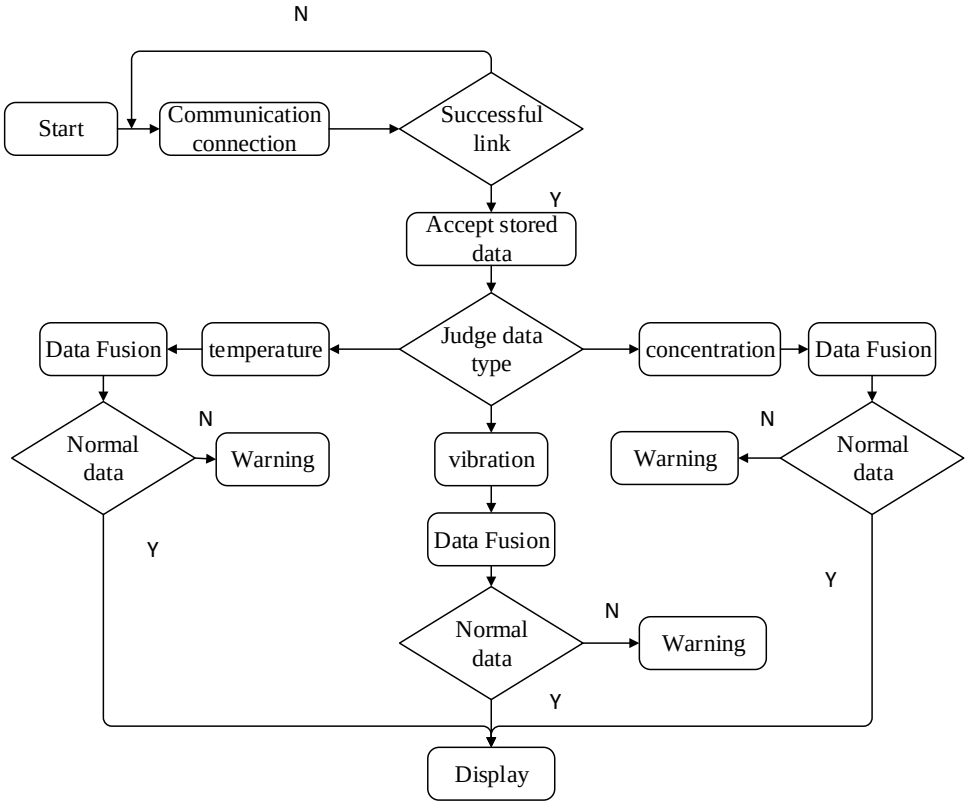

Figure 4: system overall flow chart

2.5 Overall design of remote monitoring system

The system needs to monitor the working condition of the hazardous chemicals transportation vehicle in real time, and also obtain the location information of the vehicle. The remote monitoring centre receives the working condition and location information of the vehicle. The system consists of four parts: vehicle terminal, wireless communication network, wireless sensor monitoring network, and remote monitoring centre. The vehicle terminal mainly collects the location information of the hazardous chemical logistics vehicle and receives the vehicle working condition data monitored by the wireless sensor network.
The wireless communication network completes communication between the vehicle terminal and the remote monitoring centre. The remote monitoring centre receives the working condition information of the vehicle. The overall structure of the system is shown in Fig.5.

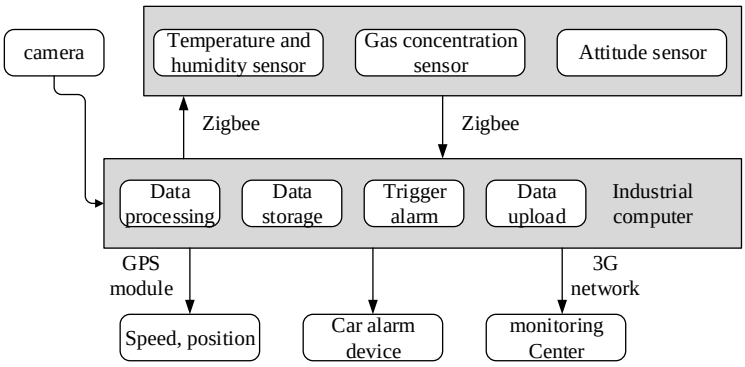

Figure 5: Overall block diagram of the system

3. Remote monitoring example in the process of transportation of hazardous chemicals based on wireless sensor network

This study uses the model car with vehicle terminal and sensor node to simulate the remote condition monitoring during the transportation process of hazardous chemicals. The simulation test was conducted mainly to observe the monitoring situation at computer end during the normal and abnormal operation of the model car. At the beginning of test, the remote monitoring system was started. After a while, when the information collected by the sensor was processed, it was transmitted to the computer via the wireless communication network. Fig.6 shows the computer monitoring.

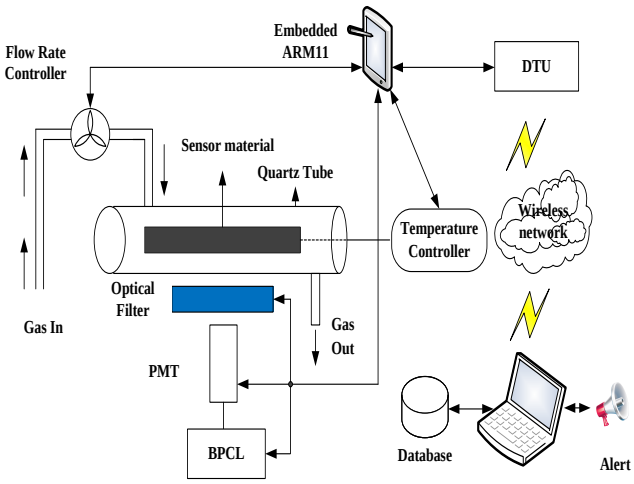

Figure 6: Monitoring of the computer segment of the model car under normal transportation conditions

Fig.6 shows the location of the model car, while the text on the right shows the model car running information, such as speed, temperature and humidity. In a safe operating mode, the middle text displays the materialized

information of the cargo being carried. When the model car crashes or rolls over, the system will alert and the text on the right will show rescue suggestions for the cargo (Fig.7).

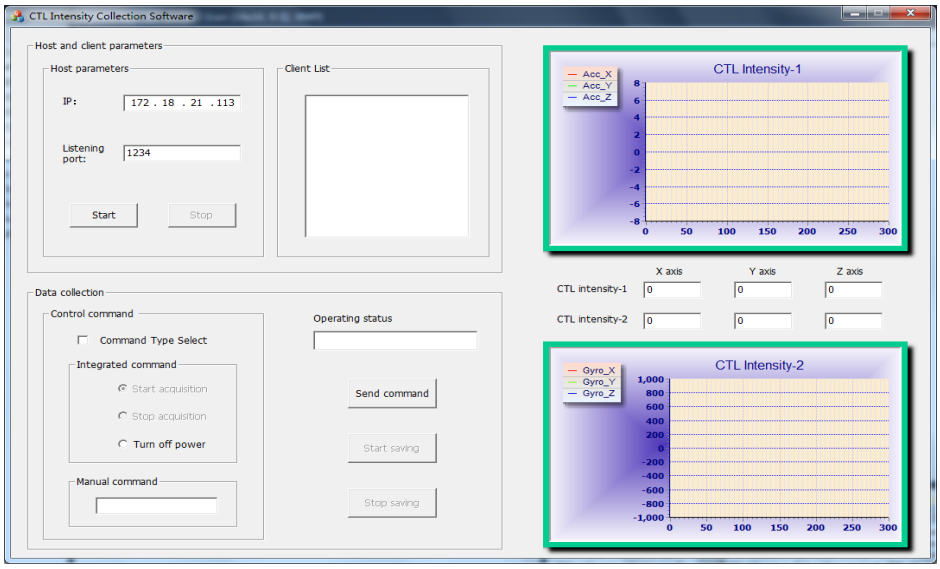

Figure 7: Monitoring of the computer segment of the model

4. Conclusion

This study based on the modern WSN technology, installs or inserts the real-time monitoring device on the transported items, so as to form a wireless LAN centred on the transport vehicle. It can monitor the transportation status of the goods at any time in the network, such as hazardous chemicals temperature, vehicles attitude and tire pressure, which solves the problem of real-time and timeliness in the traditional transportation model of hazardous chemicals. Besides, using the model car, GPRS means was adopted to report regularly or specifically report the status of the transport vehicle and the goods being transported, and to determine the special state of the hazardous chemicals in the real-time. Thus, it can provide certain remote monitoring and protection during the transportation of hazardous chemicals, to reduce the hidden dangers to social public safety during the transportation, thereby improving the safe transportation of hazardous chemicals.

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