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Railway Safety Monitoring Architecture Based on Internet of Things

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Abstract. Based on the existing Internet of Things (IOT) technology, information systems and the application status of the IOT in domestic and international Railway Safety Monitoring and targeted at railway informationization and intelligentization, this paper comes up with the IOT architecture in the Railway Safety Monitoring of China, makes application designs in the multi-dimension of sense nodes of the IOT, reasonable signal path sharing and full fusion and sharing of induction information and analyses the effects and suggestions of the application of the IOT on passenger stations and freight stations/marshalling yards. This paper aims to accelerate the construction and improvement of railway security system and promote the safety foundation construction of railway.

Keywords: the Internet of Things • RFID • Railway Safety Monitoring

1. Introduction

The Internet of Things, a modern information industry, swept the whole world and drew extensive attention on a large number of people [1]. Now, the IOT technology in China has been applied to rail transportation, parking spaces recognition and so on. In February 2012, the Ministry of Industry and Information Technology Ministry official release of the Internet of things "twelfth five-year" development plan, which marks the completion of the top-level design of China's Internet of Things Industry. The IOT in the railway industry is mostly concentrated in the terminal network level, ignoring the overall architecture standards. Considering the status of China's railway safety

monitoring developments, to build the IOT application architecture in China's railway safety monitoring, has far-reaching significance.

2. Literature Review

The concept of the Internet of Things first appeared in the book "The Road Ahead" Bill Gates, published in 1995.So far, the academic community has not yet accurate definition of the concept of the IOT. On the basis of previous studies, this paper proposes the IOT is a network, which achieves intelligent identifying, locating, tracking, monitoring and managing through information sensing device, just as radio frequency identification (RFID), infrared sensors, global positioning systems, laser scanners, video identification system, according to the agreed protocol, any goods and connected to the Internet for information exchange and communication.

Judging from the objects and processes of the communication, the core of the IOT is the information exchange between Man to Machine and Machine to Machine. It should be emphasized that the IOT is not a new network. The overall perception of the IOT is based on a variety of existing information collection, from kinds of sensing devices and other information systems, to do better, richer and more complete information sharing. Complete reliable information exchange and sharing by the object access information network, relying on a variety of communication networks, no matter anytime or anywhere. Analyze and process mass perception of data and information with a variety of smart computing technology, in order to accomplish intelligent decision-making and control.

The development of science and technology continue to promote the development of the Internet of Things technology. At present, many scholars have explored the architecture of the Internet of Things and put forward different architectures, according to the different application points of view and research directions. The representative are the World Wide Web (Web of Things, WOT) system structure [2], EPC architecture, ITU architecture [3], as well as independent architecture [4] and M2M architecture. Currently, the more representative architectures of the IOT are EPC Global Internet of Things architecture supported by Europe and the United States and Ubiquitous ID (UID) of Things system supported by Japan [5]. China is also actively involved in the study of the architecture of the IOT, who is actively formulate standards and architecture of the actual situation of the social development of the IOT.

As can be seen from these IOT application system standard modes, the system architecture of the IOT is generally constituted by a three-tier system,

the sensing layer, network layer and application layer. Sensing layer , in the lower end of the whole system, the main role is the perception and object recognition, acquisition and capture information. The network layer is located in the middle position of the system as a whole, is universal service infrastructure of the IOT. The application layer is located in the top of the system, and the key is how to achieve social information sharing and protection of information security. It combines the IOT application architecture with industry-specific applications, achieving applications within the industry.

United States, Europe, Japan, South Korea and other countries with higher information technology capabilities and the higher level of informationization and intelligentization of the depth and breadth of the IOT application of the safety monitoring take the leading position in the world. Disaster prevention and safety monitoring system in Europe and Japan is in the leading position, which ensure the safety of the train travel effectively by the detection of the natural environment and equipment. The high-speed rail disaster prevention and safety monitoring system in Germany and France can achieve real-time monitoring of the environmental information of the train, snow storm and litter, to ensure traffic safety. In addition, Japan's high-speed rail disaster prevention and safety monitoring system can also be achieved earthquakes, floods, foreign body invasion limited to special locations such as tunnels, bridges and stations monitoring. And Spain carried out experimental application of optical fiber sensing technology in railway safety monitoring system for real-time monitoring of rail temperature, the speed of the train and train information.

What’s more the United States and Japan are in the experiments and applications of UAV technology. U.S. Department of Transportation exemplary UAV-based remote sensing systems will be applied to quickly obtain the image of the road transport network and information obtained for quick analysis. In Japan the use of unmanned aerial vehicles for post-disaster investigations, used in conjunction with the sensor base of scientific research data used to obtain the complex terrain.

China has attached great importance to railway security monitoring technology research and application. As early as in the 1970s, China had already begun the development work of the Infrared Hotbox Detection system. Since the 1980s, with the rapid development of modern control technology, communication technology and computer technology, security and surveillance technology are widely used to prevent train aggressive signal, bus fire, vehicle fuel-axis, line up rail off the rails, snow storm disasters, landslides and so on. China has developed and promoted the use of automatic train stop device, train

speed monitoring device, buses infrared Hotbox Detection device, rail flaw detector, track dynamic detection car. Through scientific and technological means, the security situation of China's railway traffic has been effectively improved.

In recent years, with the continuous improvement of passenger's train travel speed and travel quality requirements, a large number of state-of-the-art technology-based security monitoring equipment gradually come into the safety of the railway system. On the basis of infrared Hotbox monitoring, China has continued to develop the automatic monitoring system of the vehicle running state, realized the automatic monitoring for overloads and unbalanced load of freight trains, Part of the train wheels on the parameters and wheel fault. In the mountain railway, China has developed a forecast wind, rain, mudslides, landslides and other natural disasters Safety Monitoring Device. These advanced and reliable security monitoring equipments have become a means of protection of safety of the railway irreplaceable. Currently, the IOT technology has been applied in the field of railway safety monitoring in disaster prevention and safety monitoring, vehicle "5T" systems, comprehensive detection of high-speed railway trains and video surveillance and other aspects.

3. The IOT Hierarchy Architecture in the Railway Safety Monitoring

The IOT hierarchy architecture in the railway safety monitoring from the sensor, transmission, application angle, vertically divided according to the function can be divided into the application layer, the network layer and the sensing layer, as shown in the specific structure shown in Figure 1.

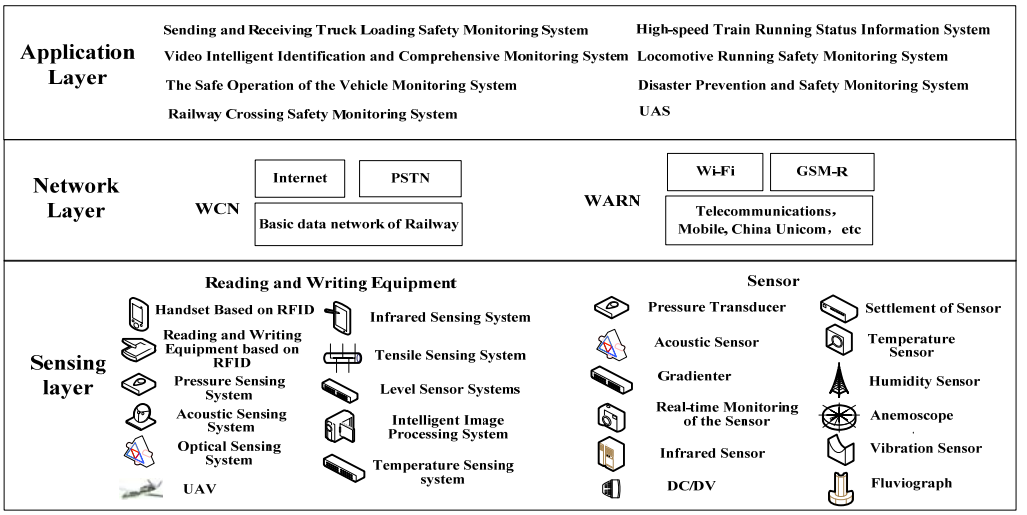

Fig. 1: The IOT Hierarchy Architecture in the railway safety monitoring

Sensing layer device, including various types of sensors, RFID tags and readers, IC card reader, mobile terminals, smart handheld machines, is mainly used in railway data collection, sending and receiving, automatic controlling and mobile data processing and controlling.

Network layer is divided into two components of a mobile communication network (MCN) and a wide area remote network (WARN).WARN is a basic data network for railway. MCN mainly uses the GSM-R. When the existing railway basic data network bandwidth is difficult to provide enough bandwidth, and then Telecom, China Netcom and other network should be used to achieve a private network for in the premise of railway data security. In some smaller areas of stations, Wi-Fi can also be used to build a wireless LAN in order to realize the transmission of sensor data. For some areas concentrated by a large number of sensors, it is allowed to build self-organizing network such as ZigBee to achieve the centralized transmission of sensor information.

The implementation and integration of information systems through the application layer will achieve the goal of creating "safe railway" and the establishment of the self-induced security road network.

4. The Effect of the IOT application

4.1. Passenger Station

The main task of the passenger station is to organize passengers safely,

accurately and conveniently to get on or off the train, and to organize trains safely, on-time arrival and departure, and to provide passengers with comfortable conditions of service. In addition to management factors, railway equipment, personnel and the environment are the three main factors affecting the safety of passenger station.

As shown in figure 2, to promote the application of video intelligent identification and comprehensive monitoring system in railway passenger station, improving and updating existing data reading and writing equipment and sensors is needed. When come into the station, rail IC card should be used to check in by Automatic Fare Collection System (AFC). In some stations face automatic identification equipment should be installed for law enforcement needs of the public security departments. Improve the application of the digital cameras, digital video, intelligent image monitoring system and intelligent video surveillance system in the identification of specific persons, dangerous section recognition. And foreign body contamination limit infrared sensor should be installed in the passenger stations near the railroad tracks to prevent pedestrian and foreign matter strayed into the railway track. At the same time, the information of the license plate number of Automatic Train Information System (ATIS), which is combined with Automatic Equipment Identification (AEI) and wheel detector, should be more shared with the other security monitoring system.

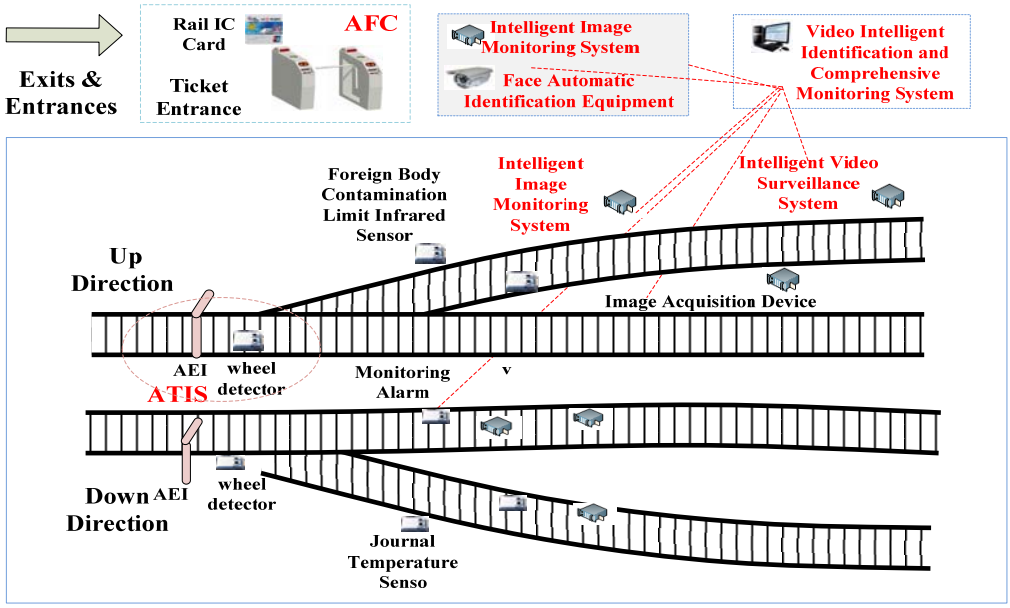

Fig. 2: The application in passage station

4.2. Freight Station/Marshalling Yards

Freight Station is the main railway stations in China. To enhance the quality of service of the freight station and improve freight service level is part of the informatization construction of Freight Station/marshalling yards.

As show in the figure 3, the application of the IOT technology in the freight station /marshalling yards is to adjust and optimize security monitoring, which mainly reflected in the application of integrated video intelligent identification and monitoring system and sending and receiving truck loading safety monitoring system. To promote the application of the IOT technology in the freight station/marshalling yards, the goal is to achieve security monitoring of the cargo inspection job. Through the integration of Overload and unbalanced load detection system, rail weighbridge, overrun detection system, Truck Performance Detection System (TPDS) and railway sending and receiving truck loading safety monitoring system, as well as four information system which are correct reporting system, vehicle management system, ATIS and Train Operation Dispatching Command System (TDCS), the freight station /marshalling yards will achieve seamless connection. Cargo screening handsets should be put into use in the goods inspection from the ground crew, and then the records of the problem-train will be uploaded to the secure centralized monitoring system for cargo inspection station. In some smaller areas of stations, Wi-Fi can also be used to build a wireless LAN in order to realize the transmission of sensor data. Eventually, we will achieve to monitor the whole process of cargo screening work.

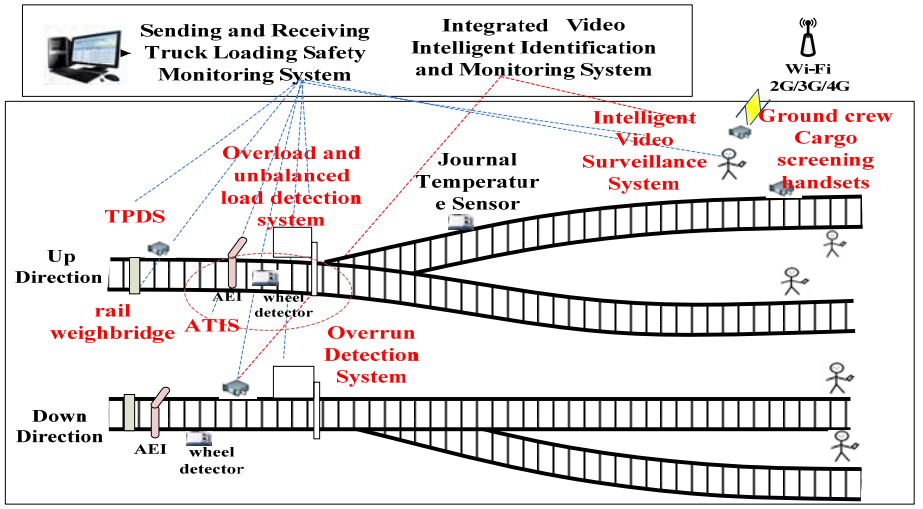

Fig. 3: The application in Freight Station/Marshalling Yards

4.3. Railway Line

The IOT applied in railway line is depicted as shown in figure4. In the propulsion of the application of railway security surveillance of the IOT, we need to gradually promote the integration of the IOT data acquisition and data transmission, so as to achieve security surveillance information system integration.

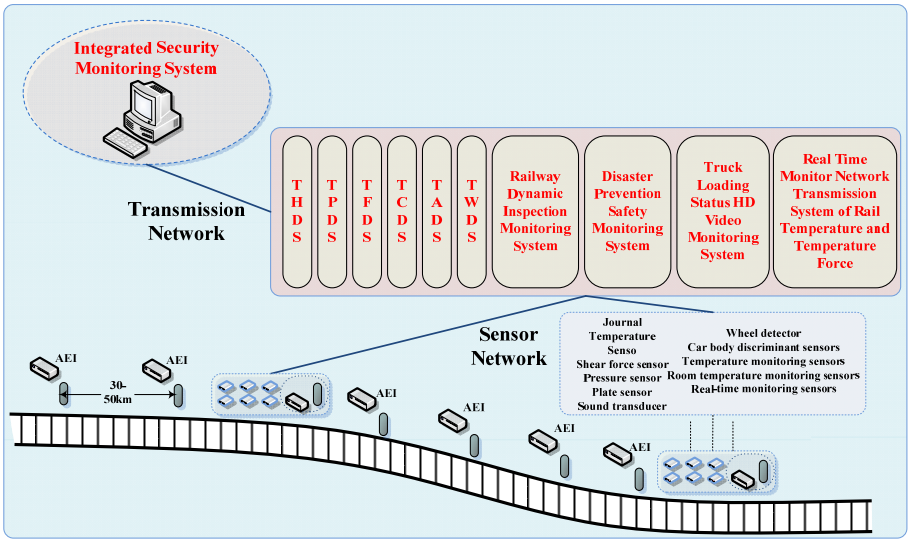

Fig.4: The application in railway line of the IOT Hierarchy Architecture in the railway safety monitoring

With the application of the IOT technology in the railway line, the following specific functions will be achieved. With High-speed train running status monitoring system , which helps to monitor and diagnose the security condition of the key parts, cars, rails, routes and grid of the EMUs, dispatchers and maintenance department can get information through Train-ground communication system timely. In this way, it will tracks the real-time status of high-speed trains and guarantees their safety, and at the same time, it can also provides data to the supervisors timely and reliably so that to help making decisions for matures like repairing and rescuing.

By Comprehensive monitoring system for the safe operation of the vehicle，we can get the early warning information of the integration of the locomotive safety monitoring and comprehensive analysis information. Integrate 5T system, and unify deployment of integrated trackside monitoring equipment to car safety, achieving information sharing and the seamless connection with Accurate

reporting information system, ATIS, TDCS .Establish a unified, complete safe operation of the vehicle alarm evaluation and treatment systems, for supporting the safety of vehicle operation vigilance and vehicle maintenance guidance.

With Railway Crossing safety monitoring system, which puts the IOT technology into use of railway level crossings, provides video surveillance and early warning function.

With the disaster prevention and safety monitoring system， focus on detection of real-time health and safety status of line, bridge, tunnel and station as well as the across the railway bridge, the fall from viaduct, the rockfall from tunnel. The system will provide Natural disasters information and foreign body contamination limit alarm message to Scheduling department and infrastructure maintenance department, which can improve the decision-making level in the case of disasters and emergency response capabilities. Railroad in adverse geological conditions and harsh climate areas, to increase automatically laid rainfall, snow, wind, landslides and other monitoring points. Take analysis of the real-time monitoring data in all-round and multi-angle way. And review with video surveillance system. At last, combined with Train control system and traction power supply system to form a linkage alarm and control output.

5. Conclusions

Railway safety monitoring and management plays an important role of railway development as well as national and social stability. The IOT technology applied in the railway safety monitoring can effectively resolve the status of railway safety decentralized monitoring. This paper describes with the application of the IOT technology to use data fusion, intelligent acquisition to get data in sensing layer, by rail proprietary and complementary line transmission, to achieve a comprehensive, integrated railway safety monitoring and management program at the application layer. However, let the IOT technology applied to every corner of the railway safety monitoring, we still have a long way to go.

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