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Research of Remote Fault Diagnosis System of Electric Locomotive Based on 4G Network

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Abstract. The paper presents a new type of remote fault diagnosis system of electric locomotive, which aiming at the problems and defects of traditional fault diagnosis technology of electric locomotive. The new system links electric locomotive host with ground repair center by using the mature 4G wireless communication technology, which can monitor and control the operation of electric locomotive remotely. As a result, it can alarm the locomotive fault in real time and guide the driver to eliminate it in time. The new system can greatly reduced the maintenance time of locomotive in railway depot, and improve the operation efficiency, which can ensure driving safety.

Introduction

In recent years, with the rapid development of railway technology in China, the scientific and technological content and complexity of electric locomotives are becoming higher and higher. As a result, the commonly used fault analysis, diagnosis and detection technology of electric locomotive will be difficult to meet the need of repair for the increasingly complex electric locomotives. In particular, after the "7.23 accident" on Yong-Wen line, the passengers have put forward higher requirements for the reliability and safety of railway operation. Therefore, how to detect the fault location of electric locomotive quickly and accurately and safely removing it in time is becoming the urgent problem for railway locomotive maintenance teams. Considering this need, this paper presents a new type of remote fault diagnosis system for electric locomotive based on 4G network. The system can remote fault diagnosis and analysis for electric locomotives running on the long-distance railway line by making full use of the rich experience and knowledge of electric locomotive industry experts, and using advanced locomotive fault diagnosis and reasoning method based on knowledge. Then, through the 4G network, the fault solutions are transmitted back to the control host of electric locomotive and real time show to the driver by the vehicle display. Based on this, the system can assist and guide the driver and locomotive maintenance teams for fault diagnosis and positioning, as a result, the fault is eliminated quickly.

Status of fault maintenance for electric locomotive

At present, the domestic fault maintenance of electric locomotive still stays in the mode of field diagnosis. That is, the maintenance into locomotive depot and drivers removing the slight faults online. The former is mainly for small or medium scale faults, while the latter is for slight faults. At the same time, it also depends on the experience and professional knowledge of the drivers, but the professional knowledge of the general drivers in the locomotive fault maintenance is usually short. On the other hand, for larger faults, the whole vehicle is usually returned to the locomotive factory, which takes a long time and wastes a lot of manpower, material and financial resources.

In addition, if you encounter bad weather conditions, the maintenance workers of electric locomotive in extremely harsh working conditions will be disturbed by external natural conditions, it's very possible to get a misjudgment of the locomotive fault point, which will directly cause serious consequences, even serious safety accidents. At the same time, there is not a set of practical fault warning system which can predict faults on line for the locomotive in operation. The remote fault

diagnosis system of electric locomotive researched in this paper can real-time collect, store and analyze the state data of electric locomotive in railway operation. According to the results of the analysis, the possible fault points of the electric locomotive are predicted in time. As a result, it can detect the hidden fault points in advance of locomotive operation, so as to send an alarm to the electric locomotive running on the line in time, and give corresponding fault handling plans to drivers.

System construction

In recent years, the 4G technology has been quite mature. It has obvious advantages in communication speed, transmission quality, network spectrum, costs of using and so on. It can combine all wireless services on the business, function and bandwidth, and can access the internet anywhere. It has comprehensive functions of satellite communication, positioning and timing, data collection, remote control and so on. Based on this, if the 4G network technology is combined with remote fault diagnosis system of electric locomotives, it will break through the bottleneck problems such as the bandwidth existing in remote fault diagnosis technology. As a result, the data transmission management and control of remote electric locomotive can be realized, and the quality of data transmission is improved. Moreover, combined with a powerful fault diagnosis expert system, the operation monitoring and fault location and processing of the remote electric locomotive can be accomplished in real time.

At present, the 4G network supports two standards of TD-LTE and FDD-LTE. Among them, FDD-LTE has the highest theoretical speed and wider base station coverage, and is suitable for wide area coverage of suburbs, highways and railways. The new constructed system adopts the FDD-LTE standard, which includes the vehicle terminal installed on the electric locomotive and the electric locomotive maintenance center, as shown in Fig. 1. The system can remotely connect the electric locomotive and the ground maintenance center, and transmits the data collected from the vehicle terminal to the ground maintenance center through the wireless network. The fault information data and state parameter data of the electric locomotive are stored in the system database, which can be used as the reference evidence for late analysis and diagnosis of the faults. At the same time, the information of the running state of electric locomotive is directly displayed on the monitoring screen of the maintenance center, so that the staff can monitor the running status of the electric locomotive in real time.

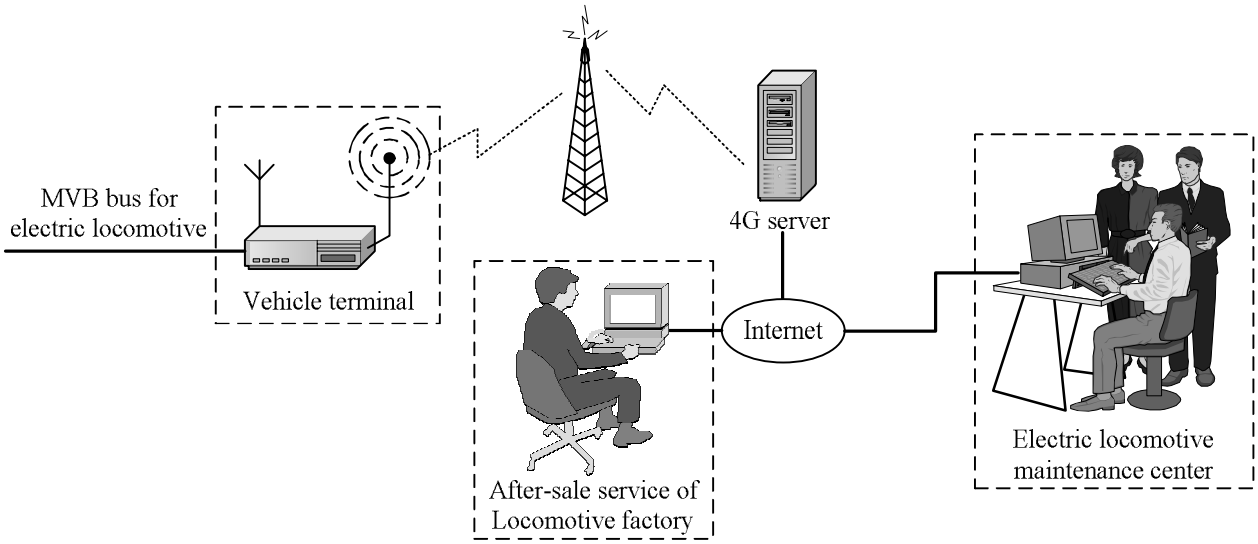

Fig. 1 Composition of remote fault diagnosis system for electric locomotive

Design of remote fault diagnosis scheme for electric locomotive

The research object of this system is the domestic “He Xie” electric locomotive. As a complex large-scale electromechanical product, it has many fields to diagnose and analyze the electric locomotive’s fault, including computer pattern recognition, system control theory, and signal

processing and so on. The system mainly adopts the fault diagnosis method based on knowledge reasoning to predict and locate the fault for electric locomotive. The locomotive fault diagnosis process is shown in Fig. 2.

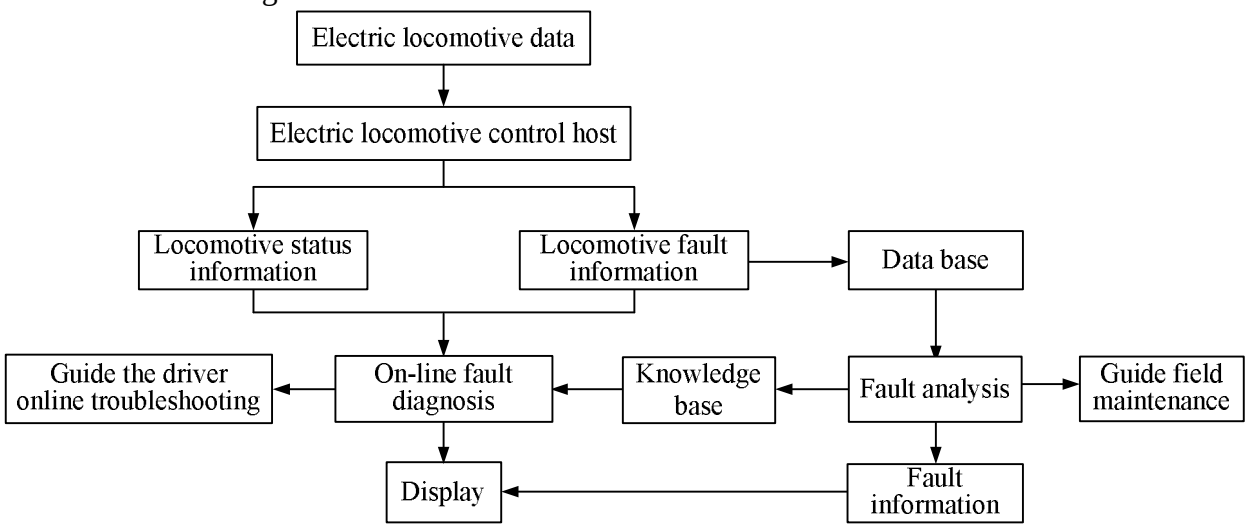

Fig. 2 Process of remote fault diagnosis for electric locomotive

Because the system adopts the fault diagnosis mode based on the 4G network, the running state information and fault information of electric locomotive can be transmitted to the ground maintenance center through the 4G wireless network. The staff can monitor and analyze the data online and feed back to the driver in time if the exceptional case is found. At the same time, the locomotive data sent to the ground maintenance center is stored in the system database, and the data is analyzed and researched by the electric locomotive experts, so as to establish expert system knowledge base. As a reference for on-line fault diagnosis and processing, and to assist and guide the maintenance center to repair the locomotive.

Design of vehicle terminal of electric locomotive

At present, the advanced train communication network TCN is adopted for electric locomotives, which is a train control and diagnostic information data communication network developed on the train distributed control system. In this system, to realize the data communication between the electric locomotive control host and the 4G network, the communication gateway between the two must be opened up. This is one of the important functions of the designed vehicle terminal. In addition, as a link between the electric locomotive control host and the 4G network, it has the following functions: receiving instructions from the ground maintenance center in real time, and collecting the operation status information, fault information and GPS information of the electric locomotive according to the instructions. Next, transmitting this information to the ground maintenance center through the 4G network.

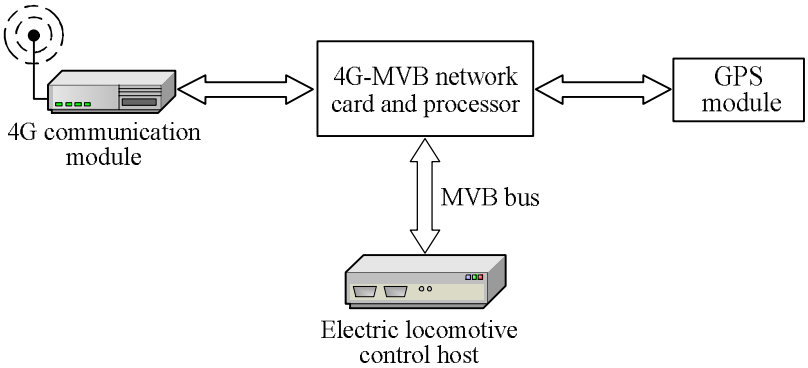

Fig.3 Diagram of vehicle terminal structure

The vehicle terminal is mainly composed of four basic modules: 4G communication module, 4G-MVB network card and processor module, GPS module and electric locomotive control host, as

shown in Fig.3. As the main central processor unit of the system, 4G-MVB network card and processor module performs the functions of communication and processing of various locomotive data, and transfers the data to other modules in real time. The 4G communication module and the 4G-MVB network card and the processor module communicate full duplex data through the serial port.

Design of control software for ground maintenance center

The design of control software is the key link to determine the success or failure of the whole system. The initialization, operation and stop of the vehicle equipment, and the acquisition, transmission, reception, storage and display of all kinds of data of electric locomotive are controlled by the system control software. Its function mainly includes the following: (1) Establishing the link channel of the wireless network to complete the data exchange between the PC and the 4G communication module of the vehicle terminal. (2) Receiving and transmitting various related locomotive data in real time through the 4G network. (3) The running state information of the electric locomotive is displayed on the monitoring screen of the maintenance center in real time. As a result, the running state can be monitored on line. (4) Storing the information data of the locomotive to the database. The system uses Delphi2010 to program the software, and realizes the function of transmitting, receiving, storing, analyzing and displaying the state data. Meanwhile, the combination of "SQL Server 2008+Visual Studio 2010" is used as the development environment of the fault diagnosis expert system, so as to complete the construction of knowledge base and the design of inference engine.

Conclusions

The presented new system remotely connects the electric locomotive control host with the ground maintenance center. The service personnel of the maintenance center and the locomotive factory can jointly monitor the operation of the locomotive. As a result, the small fault is eliminated in the bud, and the larger fault can be used for joint consultation with a fault diagnosis expert system. Finally, the solution is fed back to the driver in time through the network, which can remotely guide the driver to remove the faults. This greatly reduces the time of locomotive maintenance, improves operation efficiency, and ensures the operation safety of locomotive in real time.

Acknowledgements

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References

[1] F.Y. Ding, Y.P. Du: Railway Locomotive & Car, Vol. 4 (2004) No.4, p.24.
[2] Y. Zhang: *Research on Remote Locomotive Fault Diagnosis System* (Beijing Jiaotong University, China 2006), p.12.
[3] Z.L. Yang, Y.M. Wang: Development & Innovation of Machinery & Electrical Products, Vol. 21 (2008) No.6, p.156.
[4] L. Wang, Z.Y. He: Urban Mass Transit, Vol. 11 (2008) No.2, p.57.