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A comprehensive information system for railway networks

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Abstract

With development of railway networks in the world, as one of the green transportation means, requirements for railway transport, such as safety, comfort, high-speed, convenience and economy, is greatly increased. In order to meet the requirements, a comprehensive information system (CIS) should be planned carefully, designed and implemented. In fact, the CIS will have become the core of railway network construction. Due to the reasons of historical and technical development, the existing information systems for railways are limited in the aspects of functions, data sharing and common platforms. The concept and configuration of a CIS is put forward as a whole in the paper, based on the existing information systems for railways. The paper gives how a CIS completes the tasks to ensure railway to be safety, comfort, high-speed, convenience and economy. The standardization of data format, various kinds of software systems development, software platform and databases in a CIS are explained. The main functions of CIS and the related technical issues are also described.

1 Introduction

Rail transportation systems, including main line railway networks, light rail systems and underground systems, even maglev systems, have been considered as a green and sustainable transportation system. In fact, a comprehensive information system (CIS) is the core of rail systems [1]. The implementation of a CIS for rail network is the foundation of the green transportation system. A CIS

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should be carefully planned, designed and constructed in order to ensure the rail systems to be safety, comfort, high-speed, convenience and economy. Compared with other transportation systems, it is easier for its CIS to be implemented for rail system since all the vehicles are running on the rails. It is true that a CIS can be developed easily for a new rail network. While it is more difficult for a CIS to be implemented for the existing rail network since there are the existing independent information systems. For example, there are more than six management information systems on the Chinese Railway Networks, such as TMIS (train management information system), DMIS (dispatching management information system) and PMIS (passenger management information system), which have been independently developed for the solo purpose at the different year before a CIS is put forward. This is a normal process of technique development. The question is how to build a CIS based on the existing information systems. The concept and its configuration of a CIS for a rail network is put forward in the paper. The functions of the CIS are described. The consideration and the principles for a CIS is both for a new rail system and the upgrading of the existing rail systems.

2 The Concept and its configuration of CIS

In a CIS, a rail network is considered as an integrated system from rail bed including bridge and tunnel, rails and points to vehicle, locomotive and train operation. A picture is given to show roughly what a CIS is look like. Based on static database, dynamic data to supervise the state of line and train operation are established in uniform format in real-time way. The data can be shared by various kinds of subsystems and systems in a CIS. At any time, by the CIS, the director of the railway network can know the situation of rail network and train operation on the network. Based on the CIS, the head of the railway network can make decision. The operators can make their train plan, automatically generate train graphs, then supervise, dispatch and command train operation on the network. Apart from the daily train plan, the operator can easily add a new train plan according to the increased transport requirements from the CIS. If a train is late since some reasons, train operation can be automatically adjusted to its normal situation in a reasonable short time. If there is something wrong with a line or a train, by the CIS, it is convenient for the maintenance to be organized, commanded and completed. It is also very easy to make statistics and analysis to train operation in terms of train operation safety and its economy.

For a train driver, there is an intelligent driving auxiliary system in the cab which can operate automatically train or help the driver to operate the train in a optimum way in terms of safety, efficiency and energy-saving etc. Train crew and other service person are also easily organized by a subsystem in a CIS. For passengers and related persons who want to know train operation for meeting person at station, by the CIS, before they travel, it is easier for them to know which train they should take in terms of cost, speed and convenience etc, to book or buy tickets, and to know if a train is on time or late. If passengers are on board, at any time, they can know the speed and the position of the train, when

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the train can arrive at their destination, the related transferring information if they need to transfer at the train destination. For good delivers, by the CIS, before they deliver their goods to carriers, it is easier for them to choose the different carriers; after they deliver their goods to carrier, it is convenient for them to pay and know when their good can arrive at their destination [2].

The figure 1 shows the architecture of a rail network. It includes junction stations, normal stations, marshalling yards, depots, lines, maintenance center, headquarter and control center of the rail network. The rail network is an independent system which connects with other systems such as government offices system, other transport systems and Internet etc. It must provide the related information for the above systems. In a rail network, there are the six parts: (1) the data center and control center (the headquarter); (2) the depots (cars, vehicles and locomotives); (3) the logistics centers (materials for rails, bridge, tunnel and rolling stocks etc.); (4) the maintenance centers; (5) the stations (marshalling yards (M_i), normal station (S_i), junction station (SJ_i)); (6) the wayside systems in blocks. As a system, the six parts are coordinated by the control center to complete the transport task of passengers and freight. Therefore, a CIS becomes the core of a rail network. Based on the CIS, the control center is able to get all the required data from the six parts, and command the system to operate safely and efficiently.

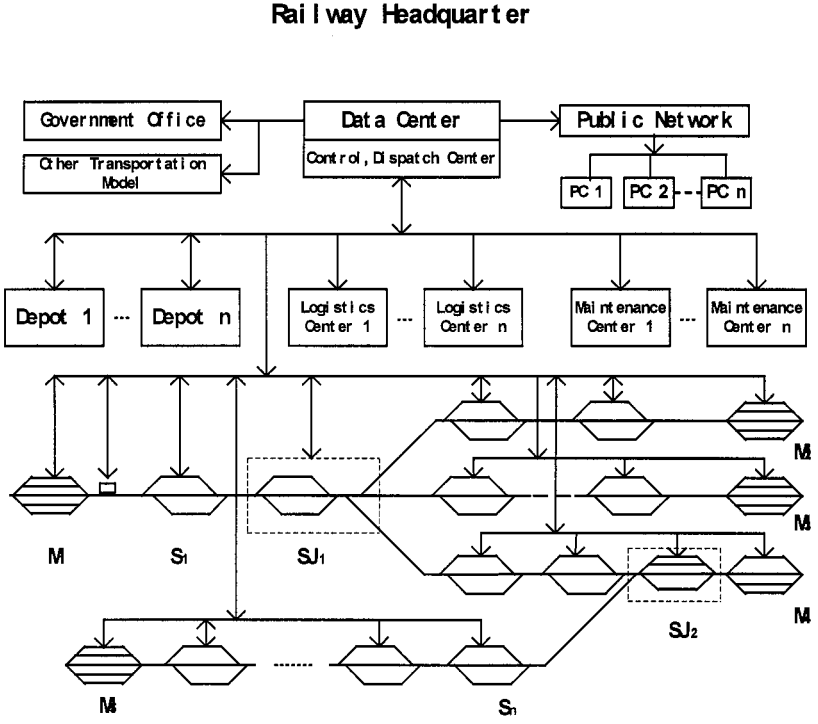

Figure 1

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A CIS must have a telecommunication network covering rail network, which is given by the figure 2. Since train are in motion on the rail network, a mobile telecommunication network is also needed to ensure the communication between a station and a train, and the two following trains in the same direction. From the figure 2, it is seen that all the stations including the junction stations and the marshalling yards, the maintenance centers, the depots, the logistics centers and the wayside systems in blocks are connected by the telecommunication network. By the mobile communication system, each train is connected to the network. Through the data center, the rail company headquarter can also provide the related information for other systems, such as the government information system, Internet, the public information system and other transport information system etc. At the same time, the outside systems can also provide the requirement information of passengers and freight for rail system. For example, people can book tickets by Internet, goods delivers can select freight agents and send their goods to the agents who give the related data to the data centers or stations. It is obvious that the telecommunication system is the nervous system of the rail network [2].

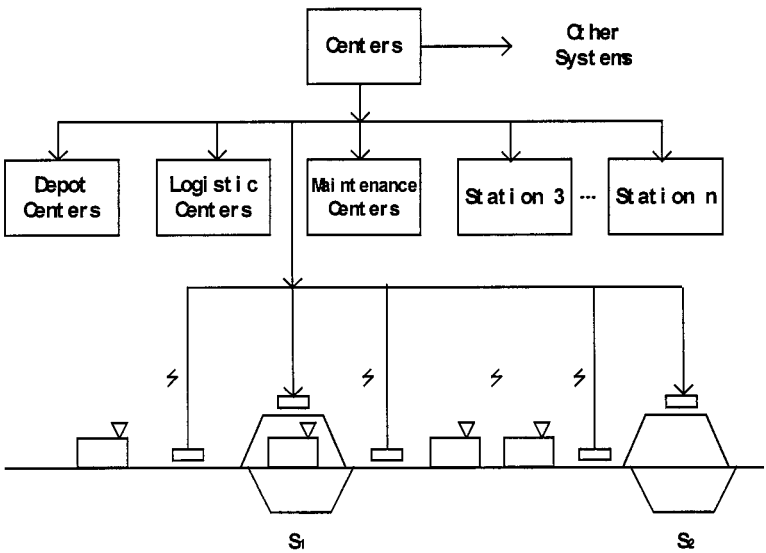

Figure 2

3 Databases for CIS

For a CIS, there are the databases to support its operation. The databases can be divided into the two types: the static databases and the dynamic databases. The static databases include the data for the rail network and the rolling stock. The

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data in the static databases can not changed with time and train operation. Its maintenance needs to be done by the special software engineers with special permission. For example, after the line maintenance is done, or new vehicles and locomotives are bought, the corresponding data in the databases are modified. The static databases include mainly the data for block, station and rolling stock. The data for each block between the two stations should include: the length of each block section, the slqpe and curve radius of the section, the position, the feature and number of each signal, the length and the related feature of each track circuit, the position and the feature of each sensor in the block, the length, the highness and the feature of each tunnel and each bridge etc. The data for each station should include: the length of each track, the position and related feature of each point, the position, number and the related features of each signal, the length and the related features of each track circuit, the describe data of each route (train route and shunting route), the layout data of the station etc. The rolling stock database includes data for locomotives and cars. The database for each locomotive and each cars include: the data of locomotives or cars' features, manufacturing data and place, maintenance recorder etc.

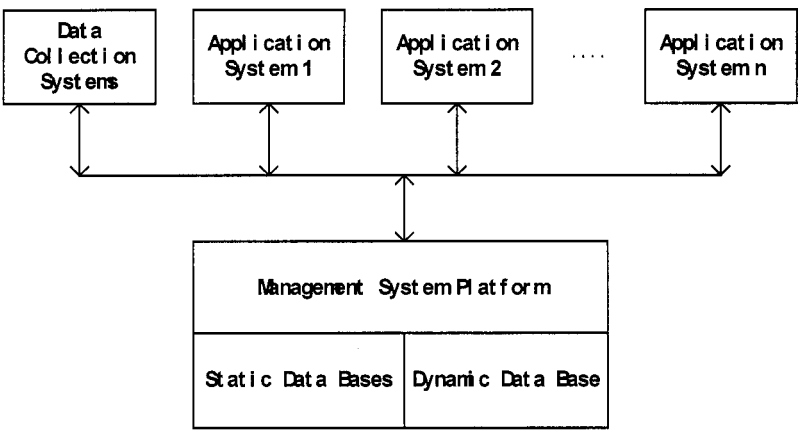

Figure 3

Dynamic databases are established in a certain time unit, or with train operation. It includes train dynamic database, line dynamic database and station dynamic database. Each train has its dynamic database. Train operation, from start point to its destination, is recorded. It includes train speed, its start time, arrival time, departure time and stop time at station, the route states at station, the real-time state of locomotive and its cars during the whole operation, the other related train operation data etc. Each station has a dynamic database in 24 hours. All the events taken place at station in 24 hours are recorded. For example, route

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establishment, train arrival and departure, the state of each signal and each point machine, the time and its contents of the station device maintenance etc. must be recorded into its database. The past situation at station can be playback on the screen at any time based on the database if it is necessary.

Each block has a dynamic database in 24 hours. By the sensors installed along the rail line, the state data of the line are recorded in a certain time unit. Particularly, the line state must be monitored after a train pass it. Based on the dynamic database and static database of a block, the safety state of the line can be reflected, and maintenance can be done in time to ensure train operation safety.

Figure 3 gives the position of the database in a CIS. It is the foundation of the system. All the systems operate on the databases. Data format standardization is the key issue for the database. All the data must be written in the uniform format into the database. The data are shared by the management systems and all the application systems. For a CIS of a new rail network, it is easier for the data to be the uniform format. For an existing rail network where information systems have been designed and operated, data format standardization is more difficulty. A common platform and transformer software must be designed and implemented to ensure that the data are shared.

4 Management system of CIS

From the above description, a CIS is a very complicated system that involves every aspect of the rail network and its operation. The management system of the CIS is the key to ensure its normal operation. On the telecommunication network, there are the non-safety data and the safety-related data for real-time control of train operation. Every second, the data from the various kinds of sensors along the line and vehicle and locomotive are collected into the dynamic databases. A great number of files are generated during the CIS operation. The files need to be managed efficiently by the management system. Data sharing and the common platform are ensured and established. Dispatching of application software execution is accomplished by the management system [3].

The objective of the data management is to make the obtained data be in the uniform standard. It is the prerequisite for data-sharing of the different software systems. After the static databases establishment, the main task of the data management is to process the dynamic data from the different systems of the CIS during its operation to build dynamic databases.

For any of the information system, its file management system is the key to the efficiency operation of the system. In the CIS, the files are managed hierarchically in line with its type and features. It is ensured that all the files are easily searched out.

System security management includes data security and file security. Some of the data and files are confidential. The different managers have the different access right to the same data and files. Some of the data and the files must be ensured not to be sent to other systems such as the Internet or the public information system. There are only the authorized staff who have the right to do

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the maintenance for the databases after going through the procedures. A CIS is also related to the safety operation of rail system. The vital data transmitting and processing are ensured to be fail-safe. Fault-tolerant design and redundancy of the data and files are taken into account.

The management of a CIS is required with change of the system requirements. The management system must be modular to make the system functions extension to be easier and flexible. The figure 3 shows that management system is the bridge between databases and various kinds of application systems.

5 Development of application systems

Based on the databases and the telecommunication network, there are the great amount of the application software to be developed. The application software is described as follows.

Decision-making supporting system is developed for the directors of a rail company. The system is based on experts system and database. Its task is to help decision-maker to select the optimum schedule in terms of efficiency and safety etc. Train plan system is based on the requirements. Its task is to make automatically train plan by computer in line with the transport requirements of passengers and freight. Every minute, the transport requirement data about passenger and freight can be sent to the data center in a CIS. Train graph system is the foundation of train operation dispatching and commanding. According to train plan and data from the databases of block, station and rolling stock etc., train graph can be generated automatically by train graph application system. Train graph generation, real-time train-graph management and train graph adjustment can be accomplished by the system. In a normal situation, initial train graph is the same as final real-time train graph. Due to some reasons, a train is late. It is very often for train graph to be adjusted according to the real situation.

The task of the train dispatching and commanding system is to dispatch and command train operation according to train graph. The orders of train operation are sent to stations and train drivers. The results of the order execution are fed back to the control center. All the trains on the rail network can been dispatched and commanded by the system at the control center. The operation situation on the rail network can be supervised on the screen at the control center.

Passenger information management and service system is the mark of a modern rail network. It is also one of the high quality service contents provided by a rail system. The system can provide the planned passenger information and the real-time passenger information including transferring information. The information can be obtained easily at waiting rooms at station, by computer at home or at offices and on-board.

The task of the goods management information system is to send the requirements information to the data center from stations and goods agents in order to make train plan, train making-up plan and train breaking-up plan. The system provides the service contents, cost and types to the good delivers for selection. By comparing the cost, transport time, the goods deliver can decide

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which kinds of service they need. All the related information can be obtained from Internet. People can do the selection and decision at offices or at home. After they deliver their goods to station or agent, the data archive about the goods is established. On the rail network, the data about the goods is transmitted automatically with train making-up, breaking-up and its operation.

Vehicle management information system is developed to manage all the wagons and car running on the rail network. Based on the static database and dynamic database of rolling stock, the state of each vehicle is supervised. The optimum usage and circulation, allocation of each wagon and car can be made. During the train operation, each vehicle can be traced. At the same time, instead of the fixed time maintenance, the state maintenance can be implemented to reduce maintenance cost and ensure train operation safety. Locomotive management information system is very similar to vehicle management information system. Instead of vehicle, the objective of the system management is locomotives.

Civil engineering maintenance management information system is developed mainly for the line maintenance including bridge and tunnel. Based on the database of the blocks, the state of the line is supervised. Maintenance service is organized and carried out according to the supervision result.

There are also other application systems, such as Train driver and crew management information system, Financial clear-up information system and Statistics information systems etc. The application systems are modular. Its functions can be easily extended if it is necessary. The relationship between the application system and the management system is shown in the figure 3.

6 Conclusion

A CIS is the foundation of modern rail network. Without a CIS, it is not possible for a rail system to operate in the way of safety, comfort, high speed, convenience and economy. As one of the sustainable, green transport systems, rail network operation is based on the CIS. It is necessary for a CIS to be planned, designed and implemented for a rail network as a whole. The telecommunication network including mobile telecommunication, and databases in the uniform format are the foundation of a CIS.

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