

THE INTELLIGENT TRANSPORTATION MANAGEMENT INFORMATION SYSTEM OF RAILWAY IN CHINA

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Abstract: The intelligent transportation management information system for Chinese railway is the most complex and superhuge railway network information system in the world. This paper systematically investigates the research and development works on the system, and describes the concept model of the system and its component parts and corresponding functions. The paper gives three basic forms of the overall structures of the system, they are centralized system structure, distributed system structure and the combination of centralized structure and distributed structure. This paper analyses and compares advantages and disadvantages of these system structures in detail, and then proposes that it is better for the system to adopt the structure scheme of the combination of centralized real-time information base and distributed processing in accordance with the characteristics of railway transportation network in China.

1. INTRODUCTION

The organization of railway in China composed of three huge components including transportation, industry and engineering, and science & technology system, education system, rear-service system, etc., is comprehensive system. In respect of the railway transportation, the central component part of railway in China, the Ministry of Railway has 12 subordinate Railway Administrations, which have 56 subordinate Railway Sub-administrations, all these Railway Sub-administrations are responsible for managing more than 6000 stations. All these organizations make up the four-lever management system of China railway transportation.

The unified command and dispatching of locomotives, vehicles and trains are critical because railway is a interact combined body. It makes the management of railway transportation peculiarly complex, and the command and decision of transportation work are based on the information entirely. Therefore, railway has its own independent communicative net. The management and dispatching of traditional railway were undertaken by using the information collected by telephones and telegrams, but the modernized railway collects and deals with information and provides decision support by the information center based on computer net. The railway companies in developed countries have all set up integrated information systems, for example, American TOPS (Total Operation Processing System) and TRACS (Traffic Reporting And Control System) of CN, and the applications of these system have brought large economic and social benefits.

The application of computer technology in Chinese railway started in 1960s, and the three-grade computer centers have set up, including Railway Ministry, Railway Administrations and Railway Sub-administrations. In the past more than 20 years, the main task was to build computer network in Railway Ministry, Railway Administrations and Railway Sub-administrations for the applications of some single project and batch processing on line, and now the railway data communication net is going to be set up, which will connect the three-grade computer centers with the computer equipment of the basic stations and sections into a integrity, so that the developing and applying work of all information systems can be done in the basis of it. The huge transportation tasks taken by China railway and its efficient transport management modes make China railway operation system a very large and comprehensive system. Therefore, the transportation management information system of railway in China is the most complex and superhuge railway network information system in the world.

The transportation management information system of railway in China (short for "TMIS", started in 1994 and expected to complete in about five years) is the first network information development project managed and taken by China Railway Ministry according to the means of engineering. Based on TMIS, we have undertaken the research and development work of intelligent transportation management information system of railway in China since 1996. This project is supported by the National "863" Hi-Tech Program of China and is one of the largest information system projects started in China. It is a very urgent and significant task for Chinese railway to built the intelligent transportation management information system.

2. CONCEPT MODEL OF SYSTEM

The research contents of the intelligent transportation management information system include mainly five parts as following:

- **Aided Dispatching Decision System in Railway Ministry**

It consists of freight traffic working plan management, locomotive working plan management, daily and shift train working plan management and train stage operation plan management.

- **Aided Dispatching Decision System in Administrations/Sub-administrations**

Basically, the function modules of the aided dispatching decision systems in Railway Ministry and in railway administrations / sub-administrations are similar to each other. They are described above.

- **Aided Dispatching Decision System in Marshalling Station**

The functions of aided dispatching decision system in marshalling station are: station daily and shift operation plan management, station stage operation plan management and station shunting operation plan management.

- **Management Information System of Cars on Hand in Marshalling Station**

The main functions of management information system of cars on hand in marshalling station contain train arriving-departure list information processing, cars on hand

management and inquiry, analysis and statistics, system and network maintenance and management, and so on.

● Primary Data Collection and Transmission System

The primary data collection and transmission system includes the communication interfaces with other related systems, mainly collecting and transmitting basic data at stations and sections.

The concept model of intelligent transportation management information system for Chinese railway is shown in Figure 1. The information flow graph of it is described in Figure 2.

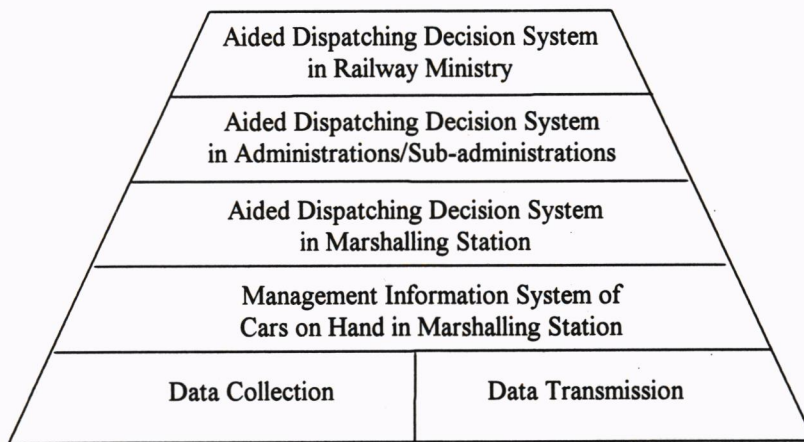


Figure 1. Concept Model of Intelligent Transportation Management Information System of Railway

3. COMPONENTS AND FUNCTIONS OF SYSTEM

This section describes the system's component parts and corresponding functions.

Intelligent transportation management information system, the core of the railway operation information system, is researched and developed in accordance with the characteristics of railway transportation of China based on using the experiences of TRACS (Traffic Reporting And Control System) of Canada for reference. The system mainly consists of three parts as following:

- (1) Information Sources part, where about 1800 stations are selected as on-line real-time information reporting spots from more than 6000 stations according to the information traffic, the other ones act as non-on-line information reporting spots. The distribution of the online information reporting spots in Chinese railway administrations is shown in Table 1.
- (2) The part of Collecting and Processing Real-time Information, where the real-time information base is built in order to collect and process real-time information from the basic spots, the main real-time files in real-time information base include locomotive files, vehicle files, train files, container files, station files, freight invoice files.

- (3) Application part, where it is realized for the real-time tracing of locomotives, vehicles, trains and containers, freight invoice information management, train list information management, traffic plan information management, the information management of cars in motion and traffic calculating.

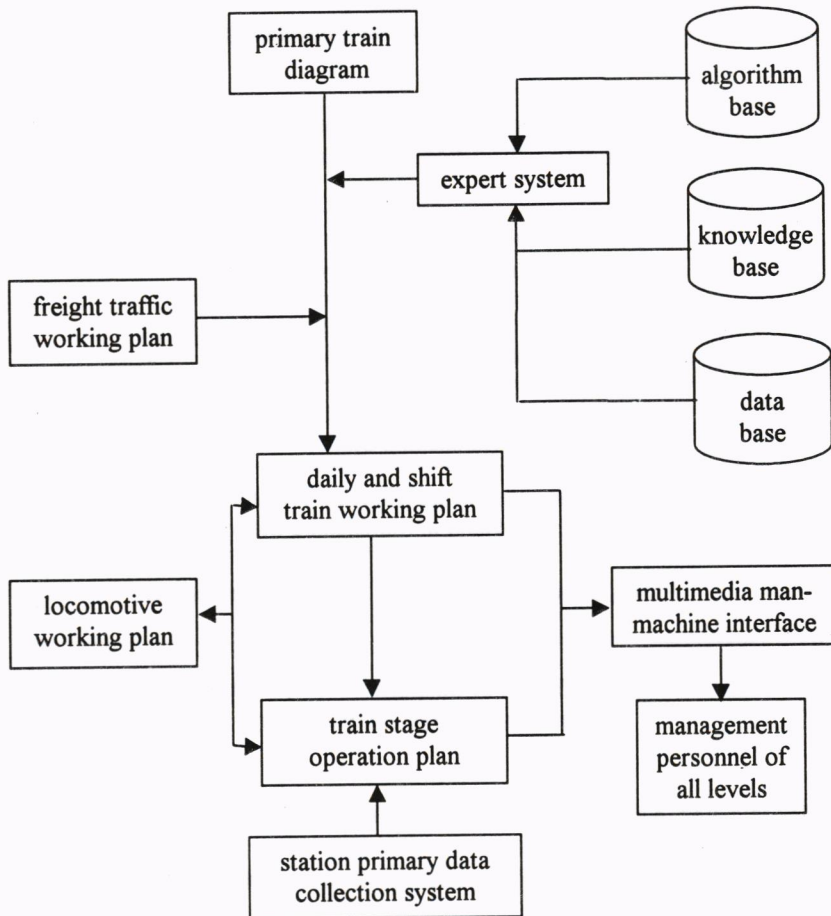


Figure 2. Information Flow Graph of Intelligent Railway Transportation Management Information System

The system mainly accomplishes two functions, the first is real-time report of information, and the second is transportation management in connection with all levels and all kinds of professional fields of transportation. The system can provide the prompt exact complete dynamic information and the decision support plan of dispatching command of the locomotives, vehicles, containers and the freight in the process of transportation for every grade people responsible for transportation organization and dispatching.

The strategy to implement the project of intelligent transportation management information system is to divide the whole system into 12 subsystems. They are:

- Vehicles management information subsystem

- Locomotives management information subsystem
- Train management information subsystem
- Containers management information subsystem
- Station and sections management information subsystem
- Freight invoice management information subsystem
- Train arriving-departure list information management subsystem
- Railway Ministry / administration / sub-administration dispatching management information subsystem
- Traffic plan management information subsystem
- Loading cars, unloading cars, cars on hand management information subsystem and traffic calculating information subsystem
- Computer network subsystem
- Central processing subsystem

Table 1. Number of Online Reporting Spots in Administrations

Name of Administrations	Number of Online Reporting Spots	Name of Administrations	Number of Online Reporting Spots
Harbin	168	Shengyang	252
Beijing	271	Huhehaote	46
Jinan	113	Shanghai	240
Zhengzhou	199	Guangzhou	99
Liuzhou	66	Chengdu	197
Lanzhou	104	Wulumuqi	42
Total	1797		

4. THE OVERALL STRUCTURES OF SYSTEM

The core of the overall structure scheme of the system is that how to establish real-time information bases and how to assign processing functions. We could have many combination ways of the overall structure schemes of the system. The paper gives three basic forms of the system overall structures in the sections below. They are centralized system structure, distributed system structure and the combination of centralized structure and distributed structure.

4.1 Centralized System Structure

The centralized system structure is to set up a real-time information base shared by the whole railway in Ministry of Railway with the function of centralized collection and procession of information. The information needed by Ministry of Railway, railway administrations, railway sub-administrations, stations and sections can be all obtained from the central database. The formations of all kinds of decision plans and data processes are done in the center. Figure 3 shows the centralized system structure. This kind structure is used by the railway companies in many countries.

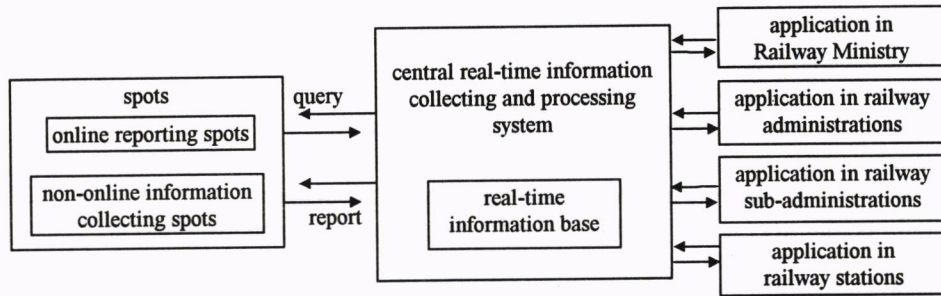


Figure 3. The Centralized System Structure

The advantages and disadvantages of the centralized system structure are given below:

1. Advantages:

- Simple structure and easy realization. The real-time information of the whole railway are stored into the central data base and are processed centrally. It can not concern to the problem of division of work in multiclass computer centers because the terminals are set up in Railway Ministry, railway administrations, railway sub-administrations and stations. This makes the information flow simple. The original data are collected and adjusted centrally in order to ensure accurate and to realize easily.
- High concentration and convenient management. Because of the high concentration of the system, the information collection, the acquired content and the form alternation that always occur in the procedure of the system running, are very easy to modify so as to manage the database easily.
- The easiness of backing up and assurance of safety. Because of the high concentration of the information, besides the work of the double processor backing up in the local computer center, there is also set up a standby center for fear of the disaster such as earthquake. On the contrary, it is hard to set up such a standby center for the distributed system.
- The saving investment and the decreasing cost.
- More system adaptability and flexibility. Because the information is collected and processed centrally in the system, the change of organizations (such as the change of boundary railway administrations and sub-administrations) has less effect on the system, as well as the corresponding software need less modification.
- Adopting exist experience in the world for reference to establish centralized system has less risk. For example, Canada's TRACS, on which thousands of people have worked, has safely run for more than 20 years. These technologies would help us establish our system faster and reduce the risk of failure greatly.

2. Disadvantages:

- A powerful communication network is required to collect all the real-time information, which can be used in the whole railway after processed, and the powerful communication ability is highly demanded, especially the amount of the result information of inquiry is as 4.5~5.5 times as the amount of the input information of inquiry in general.

- A powerful processing center is required. The processor of it should process all the real-time information in limited response-time. The process rate should be as 10 times as that of CN's TRACS.

4.2 Distributed System Structure

The scheme of distributed system structure is that the real-time databases are built in all the three-grade centers including Railway Ministry, railway administrations and railway sub-administrations. They collect the real-time information needed respectively, at the same time, the railway sub-administrations send their summarized data to railway administrations, and the railway administrations send their summarized data to Railway Ministry. The three-grade computer centers process their own related data needed respectively in order to provide those data to their own related dispatchers to use. The railway sub-administrations query the data that belong to the railway administrations to the computer centers of railway administrations. The railway administrations and railway sub-administrations query the data related to the whole railway to the computer centers of Railway Ministry. The stations query the data belong to railway sub-administrations to the computer centers of railway administrations and query the data related to the whole railway to the computer center of Railway Ministry. The distributed system structure is shown in Figure 4.

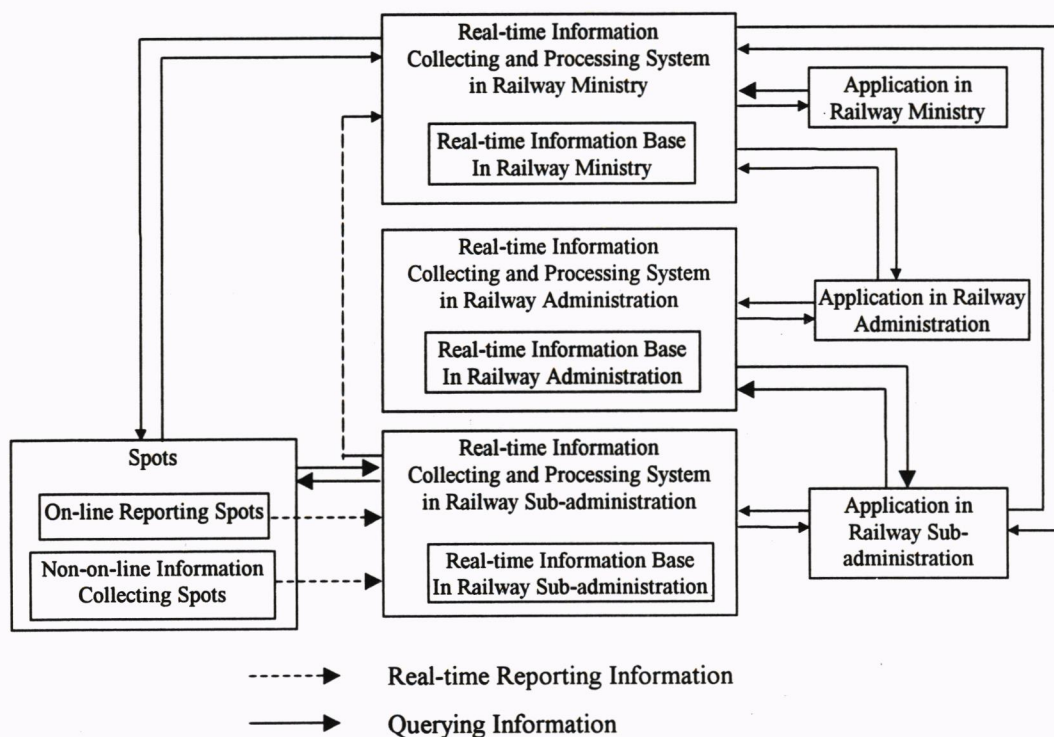


Figure 4. The Distributed Structure of System

The advantages and disadvantages of the distributed system structure are given below:

1. Advantages:

- This kind of structure can match completely with Chinese exist transportation management system for which railway administrations and railway sub-administrations process their own information respectively, so it can stir up their enthusiasm and be acceptable easily to them.
- The information is more distributed, and the data transmission is also more distributed and more-distributed on communication network.
- The processing ability of each grade computer center is distributed due to the distributed processing scheme so that there is no need to require computer equipment with huge processing ability.

2. Disadvantages:

- It is difficult to ensure the consistency of data because of the complexity of this kind of system.
- A large amount of man-power, huge investment and a lot of work time are needed to establish this kind of system.
- It is very hard to ensure the 69 real-time information centers run synchronously because for the data the contents and formations of the collecting and the contents and ways of the processing must be modified constantly in the running of the system.
- There is no exist experience for reference. Establishing the system depend on our own strength completely, so the circle of development is longer and the risk is larger.

4.3 The Combined System Structure of Centralized Database and Distributed Processing

The combined system structure of centralized database and distributed processing integrates the advantages of centralization scheme and that of distribution scheme, avoiding their disadvantages. The basic content of this scheme is: the central real-time information base, where the data reported by the stations and sections enter directly, is built centrally. the real-time information collecting and processing system processes the real-time data received and returns to the computer centers of railway administrations and that of railway sub-administrations the timing stage information needed by them per three hours. The application files are established at the computer centers of railway administrations and railway sub-administrations. All real-time information needed by administrations, sub-administrations, stations and sections is obtained from the central real-time information base. Various grades of computer centers take use of these data to process and sustain various applications. This kind of combined system structure is illustrated in Figure 5.

The following are the advantages and disadvantages of this kind of combined system structure:

1. Advantages:

- It keeps the advantages of centralized structure and avoids the disadvantages of distributed structure basically. Establishing the central real-time information base in Railway Ministry with centralized man-power and various other resources make it

possible to introduce foreign mature software, and can speed up the development of this system.

- Because the real-time information processing results account for very large part in the applications of railway administrations and sub-administrations, the timing transmission of them to railway administrations and sub-administrations can reduce greatly the amount of information transmission, relieve pressure on communication network and also reduce the processing amount of central main process system.
- It can take advantage of the exist equipment of the computer centers of railway administrations and sub-administrations sufficiently. It can meet needs only to add proper devices on the basis of present devices.
- The application software of each of railway administrations and sub-administrations can be divided into standard and non-standard, which stir the enthusiasm of various grades including Railway Ministry, railway administrations and sub-administrations and look to the needs required by the present transportation management system.

2. Disadvantages:

- The usage of IBM large-scale hosts which the technicians in Railway Ministry are not acquainted with will bring some difficulties to software development.
- Establishing network in various kinds of hosts will lead to more complexity of technique and larger expense of system.

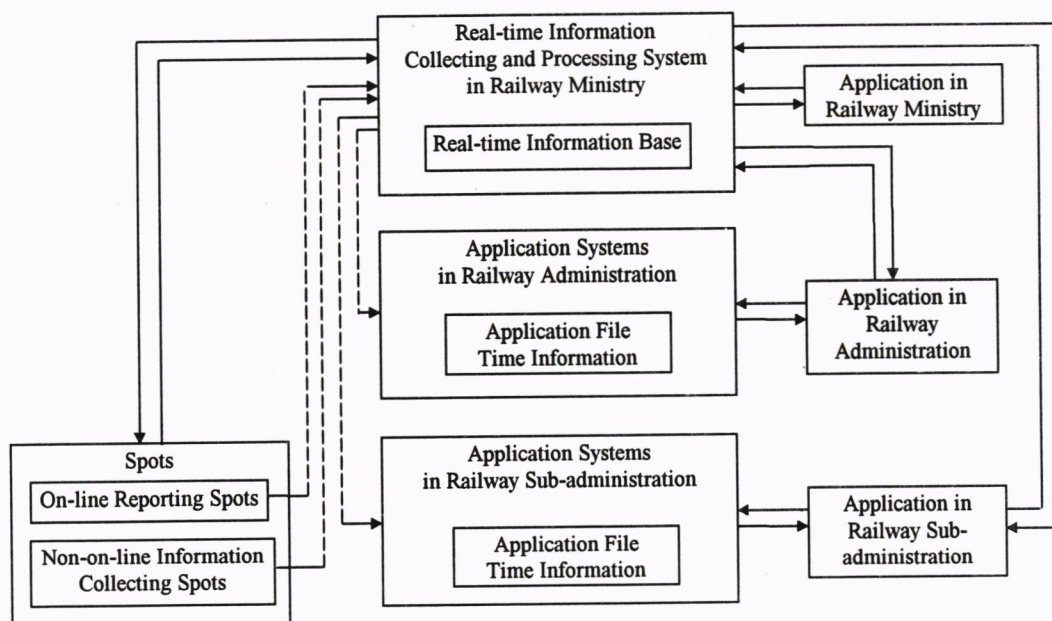


Figure 5. The Combined System Structure of Centralized Database and Distributed Processing

5. CONCLUSIONS

As we know, the three kinds of overall structures of the system, centralized system structure, distributed system structure and combined system structure of centralized database and distributed processing, have their own corresponding characteristics respectively. We analyses and compares these structures in detail, and can conclude that it is better for the system to adopt the overall structure scheme of the combination of centralized real-time information base and distributed processing in accordance with the characteristics of railway transportation network in China.

The strategy to implement the project on the basis of adopting the structure scheme of combination of centralized real-time information base and distributed processing is to divide the whole system into 12 subsystems, such as real-time car tracing management information system, real-time locomotive tracing management information system, real-time container tracing management information system, marshaling station management information system, computer network system, central processing system and so on. And 1800 information spots support center real-time database by computer communication network, the system can provide the prompt exact complete dynamic information and the decision support plan of dispatching command of the locomotives, vehicles, containers and the freight in the process of transportation. When the system is full completed, it will make huge economic and social benefits.

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