Data Transfer and Exchange in Information Systems of Transrapid Shanghai

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Abstract

Different from the operation core system, the information system is specially designed and built for satisfying the commercial operation requirement. Being the world first high-speed maglev transportation commercial demonstration operation line, the Transrapid Shanghai information system has the significance of pioneer and demonstration, its construction is facing the challenges from all aspects.

The architecture core of the Transrapid Shanghai information system composed of the backbone transmission network and the central data system. This article, based on how to satisfy the data transfer and exchange requirement of the information system, analyzes and explains the plan and design of the backbone transmission network and central data system. The successful construction and operation of the Transrapid Shanghai fully validate the effectiveness of the design, and provide with valuable experience to the construction of the new projects of maglev transportation.

1 Preface

The high-speed maglev system is a new type rail traffic running under high automation. After several ten years of research and test, the world first commercial demonstration operation line was built in Shanghai in early 21st century. The running of the maglev vehicle is mainly based on four operation core systems: guideway, vehicle, propulsion power supply and operation control systems, as well as the civil engineering facilities of stations and transformer substations. But in order to realize the commercial operation, it must build an advanced and practical information system to satisfy the requirements of maglev transportation's automatic running and high standard management and service.

The Transrapid Shanghai information system is a complicated system with nearly 20 sub-systems, between the sub-systems, there are information exchanges of different levels, and each sub-system uses different hardware products, the key technologies are different. In addition, the characteristics of the maglev transportation surely have high requirements on the reliability, security and continuity of the information system's operation, additionally, the construction period of Transrapid Shanghai is short, and it is the first commercial operation line's construction in the world, there is no successful case and experience, many sub-systems need to be customized and developed during the construction period, all these factors increased difficulty and complexity to the construction.

In order to ensure to build up the information system on schedule, it is important to carry out uniform plan and interface coordination to the information system to ensure the harmony of the entire system's design, the share and smooth exchange of the information between different systems, to realize the marriage of the computer technology and the commercial operation mode, to exert the utmost information technology advantage, improve working efficiency, and at last build up a advanced and

practical information system, form a solid base for the construction of Transrapid Shanghai and for entering into the commercial operation.

This article first analyzes the requirement features of the data transfer and exchange of the Transrapid Shanghai information system, and carries out a stress research on the backbone transmission network and central data system. The construction of the Transrapid Shanghai fully proved the validity of the design, and obtained a better effect.

2 General of the Transrapid Shanghai Information System

The Transrapid Shanghai Information System mainly includes the following several categories of system:

1) The operation guarantee system
2) It mainly includes the maintenance management system (MMS) and diagnosis system of each operation core system; it is used for realization the on-line supervision, failure detection, and full management on scheduled and unscheduled maintenance of the status of the operation core system's equipment, to ensure the normal running of the maglev system's operation.

3) Public basic system
   It includes backbone transmission network, central data system (CDS), premises distribution system (PDS), clock system, telephone system, etc.; it provides data transfer, exchange, standard time and other public services for each application system.

4) Passenger service system
   It includes Automated Fare Collection (AFC), and Passenger Information System (PIS) which provides passengers information dynamic display, broadcasting, and other services.

5) Other information basic facilities
   It includes Closed Circuit Television (CCTV), Building Automation System (BAS), Fire Alarm System (FAS), and Office Automation (OA), human resource, finance, and other management information systems.

3 The requirement features of data transfer for information systems and data exchange between information systems

3.1 The requirement features of data transfer

Like subway, the data transfer of the maglev transportation has features of high requirements on widespread, real time, redundancy, reliability, availability, security, and etc. Furthermore, because of the particularity of the maglev transportation, the information system's data transfer has sharp-cut features on vehicle-ground communication, security level, and etc.

1) The vehicle-ground communication

The information system's data source distributed in the high-speed maglev vehicle, apart from the ground building of operation control center, stations, maintenance area, transformer substations. Therefore, the data transfer between the vehicle and the ground must be realized. The running of the maglev vehicle has features of levitation, and the highest running speed exceeding 500km/h, and the quantity of the data transmitted between the vehicle and the ground is large, real time requirement is high, it involves many access systems of operation control, propulsion power supply, passenger

system and diagnosis system. This causes high requirements on the design of vehicle-ground radio transmission system.

2) Security level

Comparing the operation core system of the maglev transportation with normal information system, it has a higher security level on data transfer, a more strict limitation on system access. Therefore, the whole maglev system network plan is divided into two areas, i.e. integrity area I where the operation core system is located, and integrity area II where the normal information system is located, see figure 1.

Due to that the operation core system's online diagnosis system is located at integrity area I, and the maintenance management system is located at integrity area II, but the maintenance business requires that the real time data transfer must be realized between the diagnosis system and the maintenance system; furthermore, the vehicle load part of the passenger information system is located in the integrity area I, while the ground part is located at the integrity area II, therefore, must solve the problem of data transfer between the data sources with different security level.

3.2 The requirement features of the data exchange between systems

According to the difference of the business type, the data exchange between information systems can be divided into two categories:

1) Maintenance management

This category's data exchange mainly happens between the diagnosis system and the maintenance management system. For Transrapid Shanghai, the diagnosis system includes the operation control diagnosis sub-system, propulsion power supply diagnosis sub-system, guideway switch diagnosis sub-system, vehicle diagnosis sub-system and guideway monitoring sub-system; among them, except the guideway monitoring system, the others are all online diagnosis system. The data content for transport, except not only includes various kinds of diagnosis data, but also includes the operating data of the vehicle operation hours, levitation time and traveled distance of trains and many others, to be used to generate the failure reports and work orders in MMS system, and to provide information support to failure analysis and maintenance execution.

The diagnosis systems are provided by various independent vendors, their realization mechanisms and interfaces to MMS system are different, and a large amount of engineering development has been done during the period of construction. All above factors in addition to a short time for construction increased difficulty and complexity to the design and implementation.

2) Operation management

Along with continuous improvement in service and management, the operation company will set up step by step many management information systems, such as OA, DSS, EAM, finance and HR, to collect, store and analyze important information of transaction records, ticket business data, schedule, in order to manage and assign operation resources. As result, these systems must be reasonably planned and the related interfaces must be reserved to make it possible to add new function and new system with lower secondary development cost and implementation difficulty.

In order to satisfy the above requirement on data transfer and exchange, must uniformly plan the network system structure and exchange form of the maglev transportation to ensure the data information to be transmitted and exchanged high efficiently and security. For Transrapid Shanghai,

that target is realized mainly through the backbone transmission network and central data system (CDS). Now, present its design scenario as follows.

4 Backbone transmission network

The network system structure of the maglev transportation mainly includes public backbone transmission network, sub-system's dedicated network. Under the precondition of ensuring the backbone transmission network's enough bandwidth, speed rate, security, high reliability and high availability, during the period of planning, fully reserve the up-link interface for each sub-system, provide enough up-link bandwidth and many kinds of up-link form, make each information system be able to be linked into the system conveniently and quickly, satisfy the requirements of the business and application.

The backbone transmission network of Transrapid Shanghai is composed of the optical fiber based wide area transport network WAN #1 and WAN #2 laid along the line, furthermore, it includes 38GHz radio transmission system for realizing the vehicle-ground communication, and the Security Translator System (STS) for realizing the inter-linkage between WAN #1 and WAN #2. The general plan of the backbone transmission network is shown in figure 1.

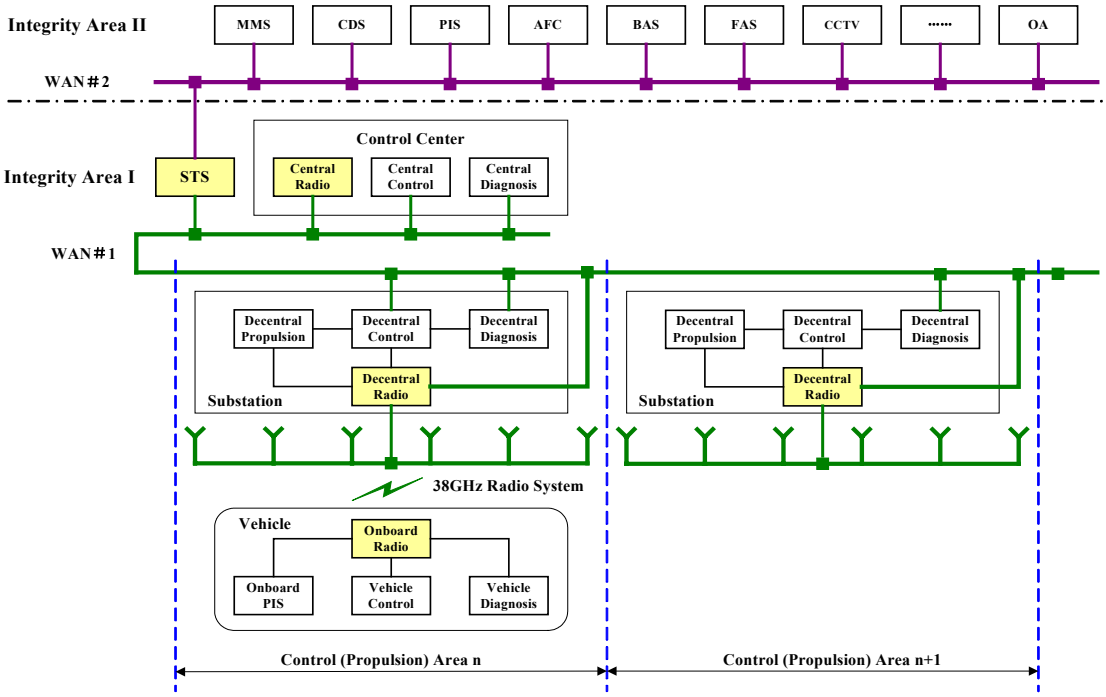

Figure 1 Sketch map of the backbone transmission network

The WAN #1 and WAN #2 of Transrapid Shanghai use OTN (Open Transport Network) to realize. OTN is an open transport network, it uses single step multiplexing allowing the direct access of many kinds of voice and data interface. OTN provides comprehensive network protection against failures. The dual redundant ring can automatically switch fiber path (ring change or loop-back).

The 38GHz radio communication system has solved the vehicle-ground communication problem. The system is composed of central, decentral and vehicle three parts. The whole line is divided into several radio segments corresponding with the propulsion segments, each segment's radio system, through its own fiber-optic network, sends and collects the data transmitted between the ground radio base stations and onboard mobile radio stations. Generally, the distance between the radio base stations is

0.3...1.1 km. The radio system operates with frequencies between 37.1 and 38.5 GHz, and in each radio segment a set of four frequencies (two in the low band and two in the high band) is required.

The Security Translator System (STS) located between the WAN #1 and WAN #2 has solved the data transmission problem between the information systems located in different integrity area I and II. All communication connections between the two WAN networks are made known to the STS. A filter function within the translator verifies the parameters of the partners (IP addresses, port numbers of the services to be used, telegram header, telegram structure) of all telegrams going towards WAN#1. In the opposite direction, it only verifies the communication relationship, all telegrams are allowed in principle. Furthermore, a volume control is implemented for the STS, which lets only a limited number of telegrams pass within a certain period of time in order to avoid potential influence to the systems in the integrity area I.

5 Central data system

The data exchange between the information systems widely uses point-to-point mode traditionally to interconnect the systems, but when the number or scale of systems is large and the relevancy between the systems is complicated, normally the potential problems includes:

- Data storing format of each system are incompatible, it will easily causes a isolated “information island”;
- When carrying out data exchange between many application sub-systems, need to do huge amount and complicated data transforming and transfer works;
- When carrying out data exchange between different systems, cannot effectively ensure data’s integrity and consistency;
- The complicated system relevancy and complicated data exchange results in extreme difficulty for adding new functions and new systems.

Aiming at the above problems, being an attempt of the first maglev transportation commercial operation project in world, for supporting the expanding of the future business, it is most important to set up an open, easy to expand information system architecture. During the construction of Transrapid Shanghai, it adopts the central data system (CDS) to settle the relevancy between the information systems, uses the central data system as a data exchange and access source of the information system, realizes the transparent and integrity of data access, establishes an open, structural data storing and accessing mode. The systematic structure of the data exchange between Transrapid Shanghai information systems is shown in the following figure 2.

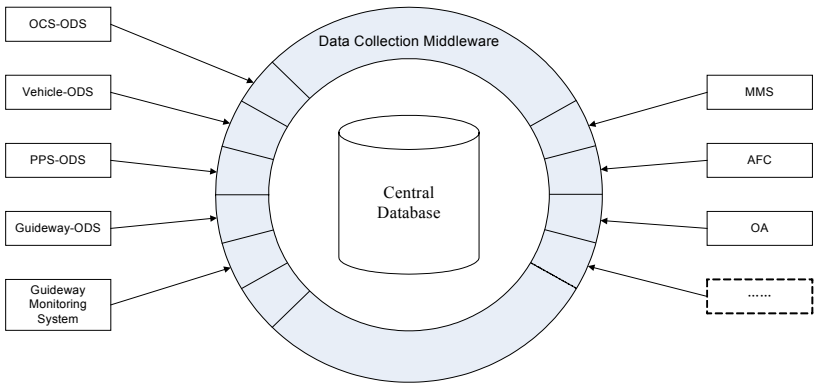

Figure 2 System structure sketch map of the data exchange between Transrapid Shanghai information systems

The central data system, being the hub and platform for share for exchange of the data between information systems, is composed of a data collection middleware and a central database. The central database is responsible for the storage of the share data; the data collection middleware is responsible for the acquiring, parse, validation, storage, and publishing of the share data.

For the central data system, the information system is divided into two categories, the producer and user. The producer's data must go via data collection middleware to enter central database, to ensure the security and accuracy of the central database; while the user can directly access database, or access indirectly via data collection middleware.

This data exchange system structure has the following merits:

- Keeping independence and reducing coupling level between information systems of maglev transportation;
- Overcome "information island" phenomena;
- Easy to expand the system;
- Ensure the integrity and consistency of the share data;
- High efficient data exchange;
- Satisfy the complicated data exchange requirement of maglev transportation.

5.1 Data collection middleware

The treatment procedure of the data collection middleware follows the flow of "input -> treatment -> output", its main function module includes:

1) Data acquiring module
   Be responsible for communicating with each information system and acquiring data. The data acquiring module has comparative independence and without any interruption to each information system, and is uniformly controlled by monitoring interface.

2) Data parse module
   Uniform the data providing mode of different information systems, and parse the acquired data to each information area.
3) Data validation module
   Check the parsed data and store the data that satisfies the condition to the database.

4) Data storing module
   Store the complete information into the database. The data parse module stores data via data storing module, the information publishing module reads information via the data storing module.

5) Information publishing module
   Uniformly publishes information to information users; the publishing privilege is controlled by monitoring interface.

6) Monitoring interface
   The platform for the interaction of the system administrator and the data collection middleware, the provided functions include: start, pause and stop the working of each data acquiring module; set up interface parameter; set up information publishing privilege and examine data.

5.2 Central database

The central database is the core of Transrapid Shanghai information system. It is used to store and exchange the public data needed for operation, including diagnosis data, operating data, schedule information, fare collection information and business statistics information etc. Each sub-system uses its own dedicated database, responsible for the dedicated data needed for storing, exchanging and treating the internal affairs. The dividing of the central database and dedicated database not only can reduce the data flow on the backbone network, improve system's security and performance, and also reduce the dependence level of the sub-system to the backbone network and central database.

The quantity of the shared public data of the maglev transportation information system is very large. In order to improve the system's performance, ensure the system's capacity, the online database reserves data for a certain period of time, the historical data exceeding that period of time will be moved to history database.

The availability requirement of the information systems to the central database is also very high, it requires the database server working in double machine hot-standby mode, therefore, the database should also use hot-standby mode, and the backup and fault tolerance mechanisms are necessary.

6 Tag

The backbone transmission network and central data system, being the supporting platform of the data transfer and exchange of Transrapid Shanghai information systems, have the core position to the entire information system architecture, and are very important to the success of the system integration.

The backbone transmission network is composed of WAN #1, WAN #2, STS and 38GHz radio system, it mainly solved the vehicle-ground communication and the data transfer problem between systems located in different integrity areas. The central data system is composed of data collection middleware and the central database, it effectively solved the data exchange and store problems between different information systems with different designs of multiple interface, it built an open and structural data storage and exchange mode, and formed the foundation for information system's later completion and development.

The successful construction of Transrapid Shanghai information systems fully proved the design effectiveness of the backbone transmission network and central data system, and provided with valuable experience to the construction of new projects of maglev transportation.