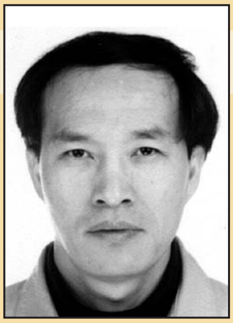

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Intelligent Railway Systems in China

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The Chinese rail transportation system has been going through a period of rapid improvement and innovation. As figure 1 shows, the total length of the main railroad lines now exceeds 75,000 kilometers, and trains have reached 160 km per hour as a result of five recent projects to increase their speed (data from www.rail-info.com). Passenger rail traffic now represents about 35 percent of the national traffic over all transportation modes. Even more striking, the freight rail traffic is about 55 percent of the national freight total. Although the Chinese railway network represents only 6.5 percent of the track laid worldwide, the Chinese system handles about 24 percent of the total world traffic.

The Chinese urban mass transit systems are also experiencing significant growth. By the year 2010, more than 1,500 km of subway lines will be operational. In Beijing, one of the earliest Chinese cities to have a subway system, the subway lines will grow from about 100 km in 2005 to 350 km in 2010.

Despite this rapid development, the railroad lines are far from meeting the country's expanding travel and freight transportation needs. According to some recent estimates, the current systems meet only 35 percent of the freight orders on a typical day. The shortfall has significant negative economic impact on many sectors of the economy. During major national holidays and festivals, getting a railway ticket and making the trip are major endeavors for travelers. Figure 2 shows a typical railway station scene during the Spring Festival, the most celebrated national holiday and busiest railway travel season.

As a national response to these gaps between capacities and needs, the government is investing heavily in the rail transportation system. During the next five years, China will build more than 9,800 km of dedicated passenger lines, costing more than 1,250 billion yuan. Of these DPLs, more than 5,457 km will serve trains with speeds up to 300 kph. By the end of 2015, China expects to have a 32,000 km high-speed railway network, including both new DPLs and rebuilt lines.

This rapid expansion is bringing significant opportunities as well as challenges to both academia and industry. The next-generation Chinese rail transportation system will require major advances in related technologies. Intelligent rail transportation systems represent a critical enabling framework.[1–4]

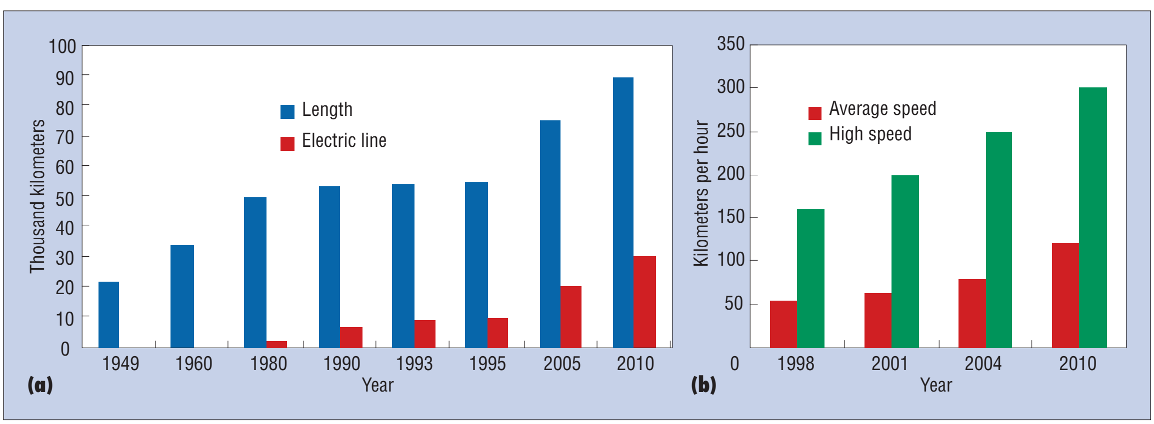

Figure 1. China's rail transportation systems: (a) lengths of the main railroad lines; (b) train speeds.

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Figure 2. Overloaded Chinese rail systems during Spring Festival, the busiest travel season of the year. (photo courtesy of cnsphoto)

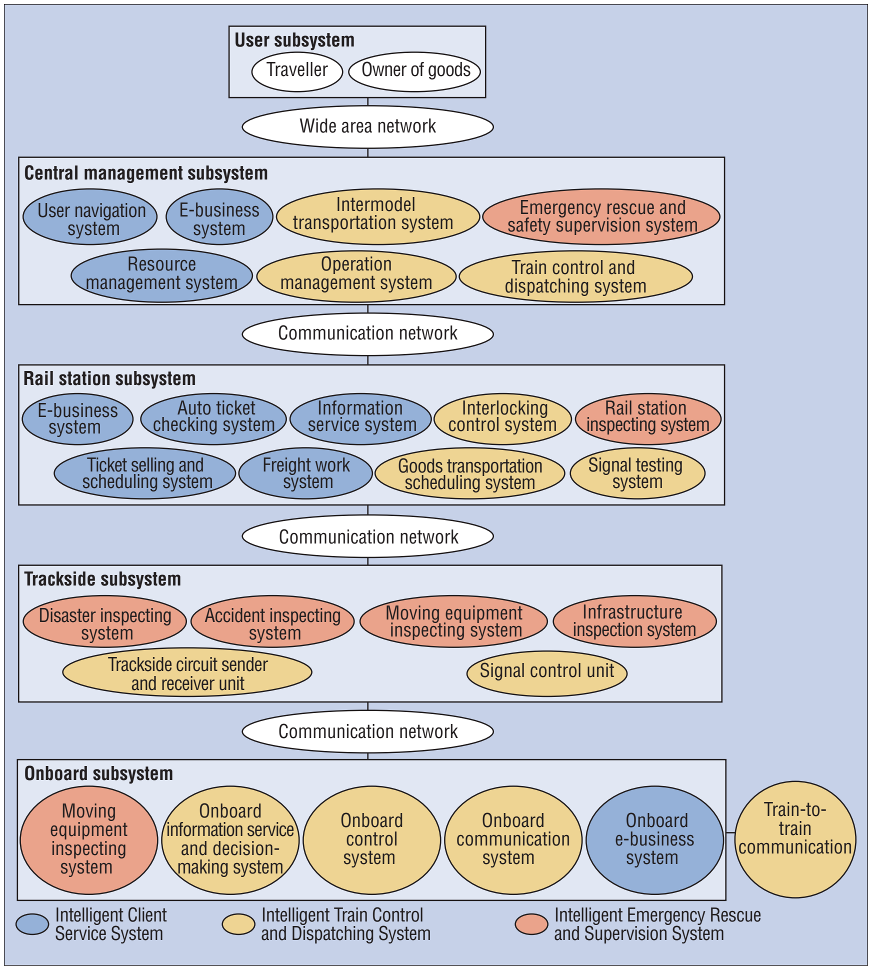

Figure 3. Architecture and key components for intelligent rail transportation systems.

IRTS architecture and key components

IRTS brings together an array of technologies such as sensor, communications, computing, and intelligent control to address various aspects of rail system management and control, such as customer service, planning and scheduling, dispatch, block control, interlock, and speed control. IRTS aims to meet important technological and economics objectives such as increased capacity and asset utilization, improved reliability and safety, higher customer service levels, better energy efficiency and less emissions, and increased economic viability and profits.

In recent years, China has developed several advanced rail transportation control systems. Among several prominent nationwide implementations, the Transportation Management Information System supports transportation planning, train scheduling, and administrative decision making. TMIS also integrates real-time data collected from various train and support stations and facilitates information flow among different units within the rail system. Another such implementation, the Dispatching Management Information System, constitutes a transparent traffic-dispatching system that applies signaling, communications, computing, and multimedia technologies. DMIS has improved traffic-control efficiency and customer-service quality.

These and other operational systems also provide a platform for IRTS development.

Figure 3 illustrates the IRTS layered architecture and key components. The components operate at different levels of railway management (onboard, trackside, rail stations, and central management/systemwide). The figure is color-coded according to three main systems: client service, train control and dispatching, and emergency rescue and safety supervision.

Intelligent Client Service System

The ICSS helps passengers make optimal travel choices. It also helps the owners of goods make freight shipment decisions. The system includes a rich set of information about such things as train timetables, ticket prices, and train operation status, which it presents through Web-based or cellular phone interfaces.

Intelligent Train Control and Dispatching System

The ITCDS is a train control and integrated dispatching system based on real-time communications. It aims to increase the speed and density of train traffic for more efficient rail system utilization. It's also responsible for managing locomotives, rolling stocks, personnel, and other resources.

Intelligent Emergency Rescue and Safety Supervision System

The IESS aims to improve rail transport safety. As an important preventive measure, this system tracks the rail infrastructure's current status and supports decisions concerning maintenance.

IRTS control and safety

Several technologies address IRTS control and safety issues.

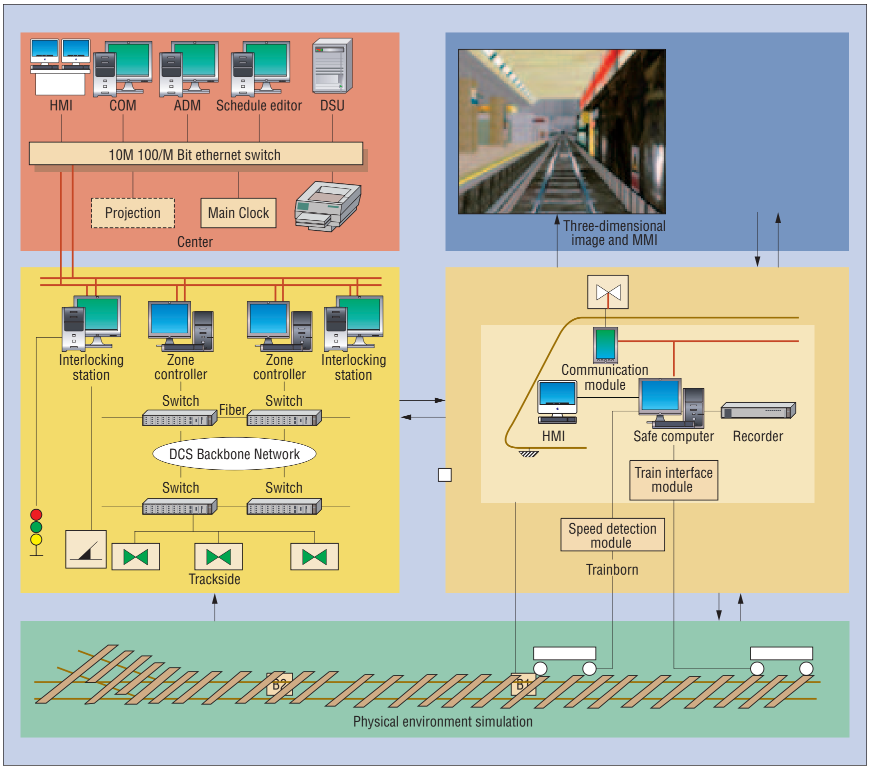

Figure 4. IRTS simulation system architecture.

Safe, reliable control software

The train control software is the brain and nerve system of the entire rail transportation system. As transportation systems become increasingly complex, IRTS research must find ways to ensure a safe, highly available, fault-tolerant, and reliable design.

Train-to-ground station communication

Communication-based train control is at IRTS's core. In particular, communication between trains and ground stations must be dependable in real-time. The infrastructure to support this communication requires development of technologies such as optical fiber leakage, cross cables, and the Global System for Mobile Communications-Railway (GSM-R) wireless platform.

Advanced dispatching systems

Developing models and related algorithms for advanced dispatching systems is an important component of IRTS research. Methods such as intelligent dispatching and adjusting algorithms have received a lot of attention lately.

Human-machine safety simulation and assessment

People are a crucial factor for the rail transportation system, especially with respect to safety studies. It's important to develop a computational platform that can assess the reliability and safety of rail systems—both existing and under study—with different types of human behavior. Inspired by the concept of artificial transportation systems,[2] an artificial rail transportation system is currently under development for conducting computational experiments with various human-machine behaviors, control regulation, management strategies, and their long-term performance, quality, and reliability.

Emergency response and rescue

To prevent accidents and reduce losses if accidents take place, the IRTS must develop a technical approach to detect signs of a possible accident, alarm the controller in advance, monitor the ongoing unfolding of the events in real-time, and possibly recommend courses of action. In addition, capabilities to coordinate rescue efforts and support related decision-making are highly desired.

Information integration and knowledge discovery

Rail transportation system management and control is information intensive. How to collect, integrate, mine, and learn from distributed data poses significant challenges. Yet knowledge uncovered from such data promises to further improve IRTS operations on a continuous basis. Related data warehousing, stream data management, and spatial-temporal data management and mining issues are current research topics attracting a lot of attention.

Beijing Jiaotong University's Rail Traffic Control and Safety State Key Laboratory has become a key innovator in the control and safety area. As part of its ongoing work, the laboratory is developing a comprehensive IRTS simulation platform; figure 4 shows its architecture design.

With support from the Chinese research-funding agencies and Ministry of Railway, researchers are working actively on these technical issues to support IRTS development. IRTS applications will help promote changes in the rail operations and management mode to increase efficiency and meet market demand. ■

Acknowledgments

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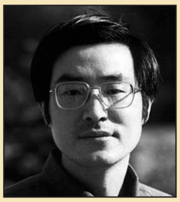

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