MODERN SOFTWARE TECHNOLOGY FOR NEXT-GENERATION TRAIN CONTROL SYSTEMS

5G Technology, Virtualization, and Containerization Technologies Deliver Safe and Secure Train Systems

THE CHALLENGE

Safe operation of locomotives and trains has been part of rail transportation since the first passenger trains debuted in 1825. What originally started as the manual communication and control of locomotives, track operations, and rail conditions via flags, telegraph, and manual track switch levers has evolved to computerized automation, GPS, and wireless communication systems. As rail transportation has evolved, the sheer density of trains using the tracks has increased, and faster high-speed trains have also entered the space.

These factors have brought new engine technology, wayside rail systems, and higher concern for safe and secure operations. The next generation of train control systems must manage these new conditions with modern technology and faster methods of providing real-time data. These systems will utilize the latest computer platforms, software, and wireless communication technologies to provide a new level of safe, secure, and efficient train operation.

THE APPROACH

Modern Technologies: Making Train Travel Safe, Secure, and Efficient

Train control systems are made up of three different components: on-board automatic train control systems linked to train signaling systems and overall system control; wayside train signaling and track/platform assignment rail monitoring; and a back-office train management system (TMS) that collects, stores, and communicates information to train and wayside rail networks. The next generation of train control systems brings new technology to each of these areas to make rail transportation safer, more secure, and efficient.

NEXT-GENERATION RAIL TRANSPORTATION CHALLENGES

- Create the next generation of train control systems that will meet the growing safety and security requirements of modern rail transportation.
- Use modern software, hardware, and communication technology that will provide performance, flexibility, and ease of updating and maintaining today's train control systems cost-effectively and efficiently.

WIND RIVER SOLUTIONS

- **Wind River Helix Virtualization Platform:** A real-time, embedded, Type 1 hypervisor that can manage unmodified guest operating systems running in virtual machines, consolidating train control system applications and providing safety, performance, and flexibility for modern rail transportation operations

On-Board Automatic Train Control (ATC)

A major component of a train control system is the on-board automatic train control (ATC), which monitors a train's position (GPS) and speed, enabling it to activate brakes as necessary to enforce speed restrictions and movement in order to prevent accidents. The three key functions of on-board ATC are:

- Acceleration and control of locomotive speed according to route location, rail conditions, and various stations or stops
- Control and implementation of the braking system as required by the data supplied to the ATC from the back-office train control system
- Relay and reception of communication about the train's location, other train locations, and track conditions

The ATC comprises many separate compute systems that provide the central system with data. These separate functional systems can be consolidated using virtualization technology. Rather than multiple single-function compute platforms — with, for example, one reading rail condition data and another controlling speed and a third operating the brake system — these systems can function as three virtual machines, managed by a hypervisor on a single compute platform for the on-board ATC system.

Wind River® Helix™ Virtualization Platform is a virtualization software technology based on the VxWorks® real-time operating system (RTOS) that can provide the virtual machine capability to consolidate these different functions onto a single system with real-time capability as defined by the application, communications backhaul application, or safety requirement. In addition, the latest release of VxWorks includes support for OCI containers to use traditional IT-like technologies for development and deployment.

Communications today are provided using GSM-R wireless network and optical networks; recent new systems are using LTE-R, a high-speed network specifically designed for railways and smart trains, to quickly transmit data to the on-board ATC from the various components, sensors, and rail communications. Ultimately, 5G technologies, such as those in the Future Railway Mobile Communication System, or FRMCS, will become the wireless communication mainstay. 5G will provide the bandwidth and speed for real-time processing of massive amounts of video-based data and rail data, both in the train and as part of the track condition monitoring.

Wayside Rail Monitoring

A wayside system monitors and operates track signals, switches, and track circuits to communicate data permitting the on-board system to authorize movement of a locomotive and train. Additionally, wayside rail monitoring systems can assess the operational performance of infrastructure assets, rolling trains, and the surrounding environment of the track. Their management data improves performance and preventive maintenance strategies, increasing asset availability, cost optimization, and safety.

- **VxWorks:** The world's leading real-time operating system, enabling deterministic applications scaling from very small compute packages and including support for OCI containers
- **Wind River Linux:** Industry-leading open source operating system for connecting, securing, and running IoT systems, application containers, networks, and devices
- **Wind River Studio Linux Services:** Embedded Linux platform solution design, implementation, security, and lifecycle management capabilities services
- **Wind River Studio Operator:** Distributed cloud infrastructure with analytics, automation, and lifecycle management for virtualization of train control system applications, reducing OpEx and increasing agility
- **Wind River development tools:** Powerful tools to save developers time and increase quality

The wayside system communicates track-to-train and vice versa to connect with the on-board ATC equipment, providing data for both systems. The data is communicated to the back-office server system to monitor and assess train locations, wayside operations, and operation of trains across the system. The data transmission is supported by fiber-optic systems and radio equipment using the current GSM-R wireless network that is, as noted above, being replaced by LTE-R and ultimately by 5G technologies and fast over-the-air (OTA) communications.

The wayside rail monitoring system combines multiple applications, sensors, and communication systems to improve efficiencies and data speed. It will require a virtualization platform such as Helix Platform that can handle multiple applications in safety-partitioned virtual machines. Helix Platform can provide virtual machines that can run virtually any operating system — unmodified — such as VxWorks, Wind River Linux, and Windows. Helix Platform eases portability for legacy applications mixed with modern applications and operating systems.

Back-Office Train Management System (TMS)

For central monitoring and control of train operations, the back-office TMS is integral to the overall system. Safety is its primary requirement. Running on the back-office server system, the TMS will analyze the data received and send appropriate data and instructions to the on-board automatic train control and wayside rail monitoring systems. For example, one critical application is on-board train location and detection, enabling trains to be "aware" of the positions of other trains. This reduces the risk of collision while enabling trains to operate safely in close proximity to one another, thereby making efficient use of track capacity. Soon, with 5G communication, trains will be able to communicate their locations to one another.

Speed monitoring and control is another important safety application. Newer systems can display train velocity for drivers and report speeds back to central control systems. When on-board automatic train control systems are interconnected with wayside signaling systems, they can regulate train speeds or even command locomotives to stop, based on track conditions, the positions of switches, the presence of other trains on the track, weather conditions, and other factors. The next-generation TMS needs to run on a cloud infrastructure that provides the performance and flexibility to safely, efficiently, and cost-effectively run the multiple applications, functions, and data analysis required. A modern cloud infrastructure using virtualization and containerization technologies running on the latest server technology can fulfill this need.

Wind River Studio provides this necessary function and level of performance and flexibility. Studio Cloud Platform provides a Kubernetes, container-based distributed cloud infrastructure that can support multiple applications using virtual machines and/or containers. With Studio, safety applications can run in partitioned virtual machines that will operate without interference from other applications or server functions. This ensures that the safety applications required by a TMS will be provided.

THE RESULT

Safety is the top priority of all train control systems. Next-generation systems must ensure safe train operation for people, cargo, and the track surroundings. Wind River provides a portfolio of products to enable the next offering of train control equipment and systems to be more efficient, cost-effective, and secure. To request more information, contact Wind River at salesinquiry@windriver.com.

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