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Research Results

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Interoperable Communications-Based Signaling as a Basis for Positive Train Control

SUMMARY

This project demonstrated that the major suppliers of signaling equipment for the North American railroads could modify their existing safety-critical equipment to support operation of a vital interoperable positive train control system based on signaling principles developed over many decades.

Project participants included the major suppliers of signal and train control equipment within North America. These suppliers have provided a wide variety of signaling equipment, including processor-based equipment that has been in revenue service on railroads and transit properties for decades. This includes equipment designed and built to the vital (or fail-safe) requirements of rail and transit properties. The project was sponsored by the Federal Railroad Administration's (FRA) Office of Railroad Development and coordinated through the Railroad Research Foundation (www.railroadresearch.org).

This project was undertaken to show a set of interoperability standards developed and maintained through an industry professional organization, such as the American Railway Engineering and Maintenance-of-Way Association (AREMA), could be implemented. Interoperability is important as trains frequently travel across multiple territories operated by other railroads.

As part of the project, a test environment modeling four sections, each representing a different railroad, was created along with a communications infrastructure for transporting messages. Each of the suppliers modified their own existing equipment to support the AREMA Manual of Recommended Practices and inserted their equipment into one of the sections within the overall test environment. Experience gained through the project was collected and referred to AREMA for inclusion in the next release of Recommended Practices.

The four suppliers demonstrated that their modified wayside equipment operated within the test environment and was interoperable with the other suppliers equipment. Two of the suppliers demonstrated their carborne equipment operated within the system (including across all four suppliers waysides) and was interoperable within the overall system.

Figure 1. Setup for the Interoperable Communication-based Signaling Demonstration

BACKGROUND

Various forms of interoperable advanced train control systems (ATCS) have been investigated since 1983, when an industry project was begun. These train control systems are used to enhance the safety of conventional train control systems through continuous monitoring of train position and the ability to enforce a train to stop before an obstacle or a point where it is desired to control the train.

OBJECTIVES

Project objectives were to develop a system based on the AREMA Manual of Recommended Practices (Recommended Practices). Multiple suppliers with experience in safety-critical (vital) train control and signaling systems modify their equipment to participate in a demonstration. This demonstration shows that the defined system architecture can meet positive train control (PTC) objectives, as well as demonstrate that multiple suppliers can develop systems according to the recommended practices, which would be interoperable over the full system.

METHODS

In principle, a communications-based signaling (CBS) system operates in the same manner as a conventional cab signal system (where train movement authority is continuously transmitted to each train through signals contained within the rails) except for in the following scenarios:

- Physical blocks (as determined by track circuits in conventional systems) are replaced with virtual blocks, which are generally equivalent in length to track circuits in centralized traffic control (cTc) territory,
- Communications via the rails is replaced with a digital data link, and
- Train location is determined as an onboard function.

In a CBS system, instead of transmitting vital cab signal information through the rails to the locomotive, an RF communications data link is employed for this function.

The location of the locomotive is determined via the onboard location determination equipment. This location data is transmitted from the locomotive (in terms of a unique block identification number and indicating either occupancy or no occupancy of that unique track section) to a specific signaling logic processor (SLP). The SLP determines the appropriate governing signal aspect for the track section the train is approaching and the "cab signal" aspect for the track section currently occupied by the train's head-end, and then transmits them to the appropriate requesting locomotive. The SLP also determines signal aspect information using signaling principles defined in the AREMA manual. Switch positions (and other necessary wayside information) are also transmitted via the data communications network, from the wayside to the SLP. The onboard logic processor (OBLP) determines the limiting speed for the train based on the cab signal aspect received from the SLP and the civil speed limits from the onboard database. Temporary speed restrictions, where reduced speeds are enforced due to maintenance situations, are handled similarly to civil speeds. Roadway worker protection is provided by restricting access to defined areas where workers are present.

Since the number of possible signal aspects is no longer limited by the physical characteristics of the track, it is possible to define a larger number of available aspects so additional information can be conveyed to the engineman. This allows more flexibility in operation and better system throughput.

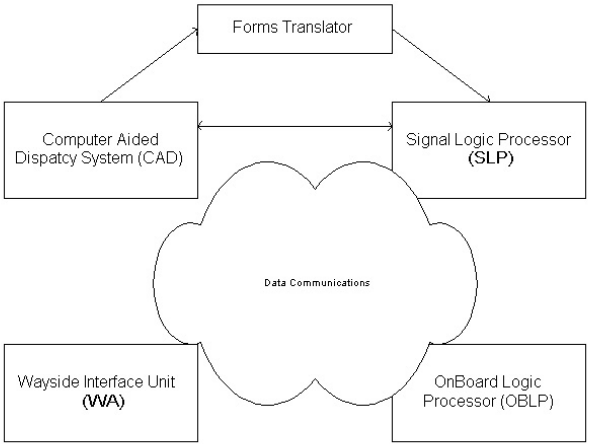

Figure 2. Basics of a CBS System

The Computer Aided Dispatching (CAD) system is used to monitor and dispatch the territory, exactly the same as in a conventional cTc territory. The SLP performs the signaling logic in terms of ladder logic, Boolean Logic, or interconnection of geographic objects. The OBLP determines the train position, as well as displaying and enforcing signal, civil and temporary speeds. The Wayside Unit monitors and controls wayside devices such as track switches.

The territory to be simulated consisted of four contiguous segments, each with double track. Each of the segments contained a variety of turnouts and crossovers between the tracks as shown in the following figure.

The territory was arbitrarily split into blocks and governing signals. Each application of CBS will allow blocks and signals to be defined to achieve the needed operational performance of that section of railroad. Each of the participating suppliers had a similar territory to control, and the overall territory had four of these sections operating contiguously (i.e. a vehicle supplied by a single supplier can move seamlessly across all four sections).

A single commonly formatted track database describing the railroad infrastructure was used by each of the participating suppliers to define their section, as well as allowing each of the locomotive controllers to traverse the entire system.

Once the block being occupied is known, the database is used to determine Lat/Long (Latitude/Longitude) information, curvature, grade, identification of any switch located within the block, civil speed, block length, governing signal aspects for that block, as well as information regarding which block will be entered next along with its governing signal information. The block to be entered next is further conditioned on whether one is traveling UP or DOWN (as defined in the manual part and referring to the direction of travel along the track) and the position of a switch in the block. The blocks can be further divided into subsections, which allow multiple sections to be defined for grades, curvatures, and civil speeds.

For the demonstration project, a computer-aided dispatch office based on existing control office technology provides simulated office control for routing trains and tracking movement.

Communications within the project used the messages and protocols defined in the AREMA Manual Parts. The messages were transported over an IP network through a communications simulator that can be used to introduce errors and limit bandwidth to that which would be provided by various over the air RF communication infrastructures.

When fully integrated, the demonstration showed the ability of trains controlled by different suppliers OBLPs (each simulating a different railroad) to seamlessly move through the four territory sections, each of which is controlled by equipment from a different supplier.

RESULTS

Successful completion of this demonstration showed a high level of cooperation among the principal suppliers of signaling systems for North American railroads toward implementing an interoperable system that should serve the railroads well for the long-term future. A demonstration of the system operation was held for interested parties in January 2009 and was attended by approximately 70 industry and regulatory representatives.

CONCLUSIONS

Interoperable PTC systems based on signaling principles are practical. Recommended practices developed by a professional industry organization for system architecture and interface definitions can be used by multiple suppliers to develop equipment that will work seamlessly with equipment developed by other suppliers.

FUTURE ACTION

No future action is planned at this time.

ACKNOWLEDGEMENTS

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Signal suppliers providing equipment for the demonstration consisted of Alstom Signaling (www.transport.alstom.com), Ansaldo – STS (www.ansaldo-sts.com), General Electric Transportation Systems (www.getransportation.com) and Safetran Systems (www.safetran.com)

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KEYWORDS

Positive Train Control, Communications Based Signaling, Railroads, Rail Transit, Interoperability