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# Research Results

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## System for Monitoring Multiple Railroad Operations Using an Integrated Track Display and Common Data Protocol

### SUMMARY

The key objective of this novel approach to monitoring trains is to improve the coordination of freight and passenger rail service in heavily-trafficked, metropolitan areas using multi-railroad track displays that enable users to view trains from multiple railroads simultaneously. To meet this objective, a low-cost train monitoring system, known as Common Operational Picture (COP), was developed so that operating personnel can anticipate and avoid congestive situations in areas where multiple railroads' rights-of-way converge and cross at grade, or where trains are frequently handed off from one property to another. Because such areas are chokepoints in the US rail network, improving throughput at those points is critical to the efficient transport of goods nationwide.

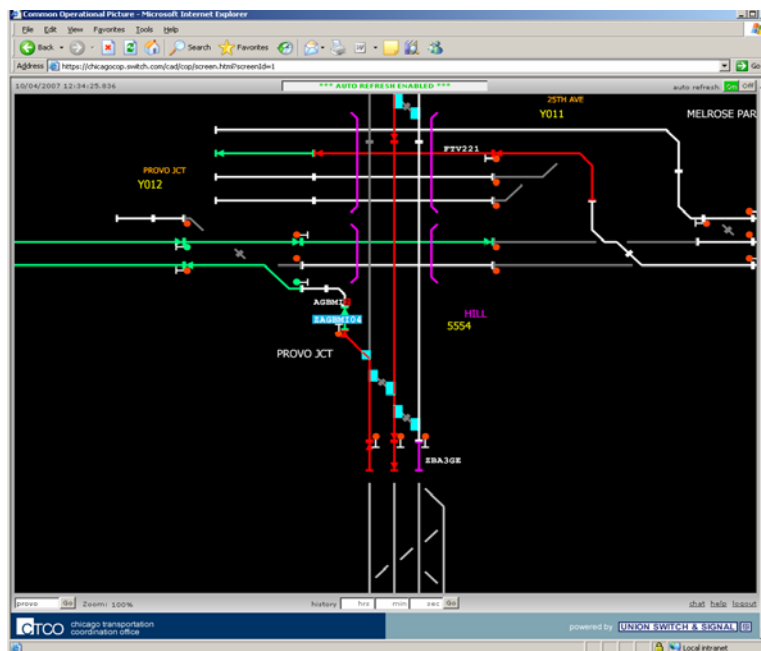


Figure 1. Integrated display of UP and CSX tracks and trains. A northbound CSX train (red) is cleared (green) to move onto UP tracks heading west. There is also a cleared route (green) for an eastbound UP train and a UP train (red) cleared to move west (green).



## INTRODUCTION

Trains spend far too much time navigating metropolitan areas like Chicago (where they often take 24 hours to move 20 miles) due to the number of railroads and, consequently, the *coordination* of numerous inter-railroad train moves. Projected increases in rail traffic suggest that this situation will only deteriorate (intermodal transport alone is growing approximately 7 percent per year [2], [3]), severely limiting growth opportunities for the rail industry, unless steps are taken to improve traffic flow in such areas. The Chicago CREATE program is a response to this problem.<sup>1 2</sup>

Railroads currently monitor their own right-of-way from computer screens that display only the points where other railroads' tracks cross, with little or no advance notice about approaching trains. This information is communicated "manually" (human to human), leaving what is, at best, a fragmented view of traffic flow across regions where multiple railroads converge. When required to move a train into or across another railroad, a dispatcher must contact his peer on the other railroad to coordinate the move. Slowdowns are therefore inevitable, given the tight coupling of train operations in areas with large numbers of trains. The multi-railroad display developed on this project will enable railroad personnel to proactively manage train moves between railroads, thereby improving traffic flow.

## TECHNICAL OBJECTIVE

The COP system is designed to receive data about the movements of trains from multiple railroads and display them on a single computer screen. It must be able to communicate with each of the railroads, receive all data in the same format, and graphically display it to anyone who is authorized to use the system. Data about the locations of trains

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<sup>1</sup> The Chicago Region Environmental and Transportation Efficiency (CREATE) program was unveiled in 2003 with the goal of improving the flow of rail traffic through the Chicago area.

<sup>2</sup> The COP project has received guidance and support from the Chicago Transportation Coordination Office (CTCO), which was formed in 2000 to "establish operational efficiencies to improve traffic flow through railroad cooperation." [1] The CTCO is involved in the CREATE program.

and the states of tracks, switches and signals are obtained from each railroad's Computer-Aided Dispatching (CAD) system, which the railroad uses to monitor and control the movements of its trains. Because the CAD systems of different railroads are located across North America, the Internet was the obvious choice for the communications infrastructure.

Having been developed by different CAD suppliers, the railroads' CAD systems employ a variety of internal data and message formats to send, receive and store field data. To address this issue of multiple formats, an *open* interface schema was developed in XML (eXtensible Markup Language) specifying how data sent to the COP system should be formatted. Each CAD system supplier is provided with the schema so that it can write a translation program to convert data in its internal format to the XML-based format. This provides the COP system with a universal data format for all the railroads.

The multi-railroad display integrates as many railroads' tracks as required into a *network* of tracks that are graphically represented on a computer screen. Since the displays used by dispatchers at railroad dispatch centers depict only their railroad's tracks, the tracks are typically drawn horizontally across their screens in a "Z" configuration, irrespective of actual track directions. This scheme, however, will not work when multiple railroads must be displayed. So a track configuration program that approximates direction was developed to accommodate multiple railroads' tracks on the same display.

## SYSTEM OVERVIEW

The COP system is comprised of three main components: 1) a network architecture, 2) an open interface for standardizing the data from all railroads, and 3) a multi-railroad display that enables users to monitor the trains from a plurality of railroads.

The COP network architecture is depicted in Figure 2. At the bottom of the figure are different railroad CAD systems and at the top are users of the system. In the middle is the COP Application Server, which collects data from the railroads and integrates it for display. The COP Application Server continually



receives updates from the railroads about the locations of trains and states of wayside devices. Since the data are owned by the railroads, they must be adequately protected when transported over a public network like the Internet. The COP system has multiple safeguards in place to ensure data security, which are shown in Figure 2, including Virtual Private Network (VPN) connections between the railroads and Application Server, firewalls, and user authentication at login through Apache and Web Login servers.

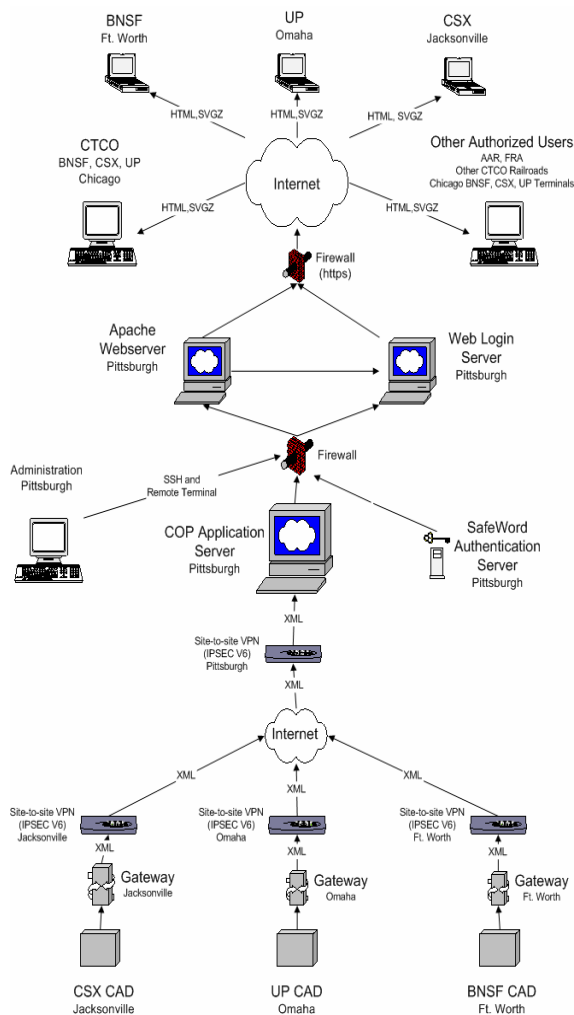


Figure 2. COP Network Architecture

XML message generation programs (the Gateways) for each CAD system reside at the bottom of the figure. These programs are also represented in Figure 3, which is a schematic

of the COP software architecture. XML messages carrying data that indicate changes in the states of the railroads (e.g., a new track occupancy by a train, a change in switch position, etc.) are received by the COP Application Server, which is represented by the middle area in the figure. The messages update the railroad state data stored in the Application Server. The railroad infrastructure data is stored and updated *locally* (that is, by someone with direct access to the Application Server) because it does not change very often. The Scalable Vector Graphics (SVG) generator takes the current state and infrastructure data and generates either a full screen display or a set of updates since the last time the user requested data. The resulting display is sent to the user (left-most area) when requested. Users' systems are equipped with an SVG plug-in (downloadable from the Internet for free), which displays the graphics commands on their screens.

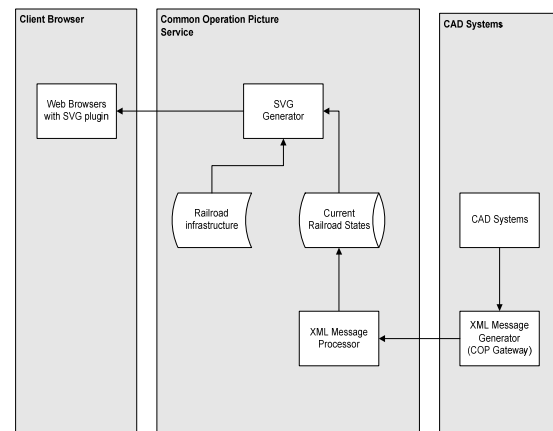


Figure 3. COP Software Architecture

The user display, depicted in Figure 1, shows tracks, track occupancies, track authorities (clear ahead), switches, signal lamps, location names and train IDs. Users may view an area like the one shown in the figure from laptops, hand-held display devices, or a large array of screens that easily captures the entire Chicago area. The only software required is an Internet browser (currently, COP uses Microsoft's Internet Explorer) and the SVG plug-in. The user interface offers continuous zoom, panning and search-and-center capabilities to make it easy for a user to navigate an area of the railroad that does not fit on a single screen.



## IMPLEMENTATION AND TESTING

This demonstration project integrated four of the ten railroads and passenger lines that run through the Chicago area: BNSF, CSX, IHB (Indiana Harbor Belt railroad, which is owned and controlled by CSX) and Union Pacific. The trackage for these railroads has been configured for the entire Chicago area (approximately 20 to 25 square miles) and stored in a database for display on the COP multi-railroad display.

BNSF/Wabtec, CSX/UP/Union Switch & Signal developed translation programs to convert their internally formatted data to the open data format, copies of which were provided to them. The architecture depicted in Figure 2 was set up as shown with the requisite servers in place at the railroads and at Union Switch & Signal's offices in Pittsburgh, PA.

The first test of the COP prototype was with CSX and IHB. Live data was received from CSX and displayed in real-time. UP was brought online next. Finally, the BNSF connection was established, their state data received, and trains added to the display. Currently, the CTCO is testing the system, which is running 24 hours a day, 7 days a week, at their offices in Chicago. The COP system will remain up and running there for the foreseeable future.

## NEXT STEPS

To provide a complete picture of the Chicago area, subsequent funding is needed to bring the other six railroads/passenger carriers online: Amtrak (Union Station), BRC (Belt Railroad of Chicago), Canadian National, Canadian Pacific, Metra (Chicago's commuter line), and Norfolk Southern. The COP system has been designed to handle any number of railroads. Each remaining railroad/passenger carrier CAD system supplier must write translation programs for converting their internal data formats to the open data format and provide their track data to the COP Application Server, which will be entered into its database.

Once all the railroads are represented in the system, COP will be used to monitor railroad operations in the Chicago area by the CTCO

and by individual railroads. This technology can be applied in other cities where multiple railroads converge, such as Kansas City and New Orleans, as well as other major interchange points between two or more railroads.

## REFERENCES

- [1] Hanford, D.J. (2007) Capacity to CREATE, Progressive Railroading, Nov. 2007
- [2] Miller, L.S. (2006) Can intermodal ease the squeeze? Railway Age, Aug. 2006
- [3] Stagl, J. (2006) 7 lanes ... 7 stories, Progressive Railroading, Oct. 2006

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UP and CSX provided servers and support for setting up connections to COP.

BNSF/Wabtec managed the translation effort at BNSF and support for setting up the connection to COP.

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## KEYWORDS

Multi-railroad, track display, XML, train monitoring system, CTCO, Chicago CREATE, dispatch system, COP

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