Expanding the capabilities of your Traffic Signal Management System by centralizing emergency vehicle pre-emption management

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Abstract

The City of San Jose is pursuing the implementation of city-wide centralized emergency vehicle pre-emption operations for their traffic signals to improve response times of their emergency vehicles. The City desires a centralized operation where emergency vehicle pre-emption requests are sent to the individual intersections via the existing Traffic Control System (TransSuite TCS). The centralized approach makes use of existing systems (AVL, CAD, Traffic Control System) and communications network to process and make the pre-emption requests to the local intersections. This approach alleviates the need to install and maintain equipment at each intersection to process the preemption request (which is the standard used today) at a cost of $9 million. With a price tag between $600,000 and $750,000 the centralize emergency vehicle pre-emption solution will be delivered at 1/10th of the price.

KEYWORDS:

transportation system, emergency vehicle pre-emption, traffic signal operations

Introduction

Emergency Vehicle Pre-emption (EVP) is a traffic signal control strategy used by local transportation and emergency response agencies to improve response time to incidents for fire, police and other emergency responders. The premise behind EVP is to facilitate emergency response by providing response vehicles with a green traffic signal indication as they approach an intersection. By changing the signal operations to provide a green indication, vehicles that are stopped at the intersection can be cleared before the emergency vehicle reaches the intersection, and the emergency vehicle can have a safer passage through the intersection.

The City of San Jose has embarked on a project to that disrupts the traditional emergency vehicle pre-emption technologies that are in use by expanding the capability of their Central Traffic Management System and CAD/AVL system to manage emergency vehicle pre-emption operations.

History

After failing to meet mandated response times to emergency incidents the City of San Jose Fire Department sought methods to improve response times. The primary means to improve response times was through the further deployment of emergency vehicle pre-emption technologies to allow emergency vehicles faster passage to their destinations.

In late 2016 emergency vehicle pre-emption equipment had been deployed at approximately one-third (or 336) of the city's signalized intersections to facilitate fire response vehicles to reach incidents quickly and safely. Because this system requires hardware installation at each signalized intersection, system expansion and ongoing maintenance is costly.

The City policy has been to have emergency vehicle pre-emption devices installed or upgraded in conjunction with planned development or capital improvement program projects, at a rate of approximately 15 intersections per year, and an average cost of $15,000 per intersection. The cost to install this type of EVP devices at the remaining 597 signalized intersections is approximately $9 million under the current implementation model.

The cost implications of deploying emergency vehicle pre-emption citywide proved to be staggering. Beyond the $9 million dollar in hardware costs further impacts include increased maintenance costs and a lengthy implementation process that would take years to complete. Working together the Fire Department and the Department of Transportation identified that there are more technologically advanced and cost effective alternative technology solutions available for implementing emergency vehicle pre-emption.

The Fire and Police Departments centrally manage emergency response resources through a Hexagon/Intergraph Computer Aided Dispatch (I/CAD) System. The Department of Transportation (DOT) centrally manages traffic signal operations at over 900 intersections through its TransCore/TransSuite Traffic Control System (TCS). The departments have collaborated with the system vendors to determine how these systems can be leveraged to provide a centralized emergency vehicle pre-emption system for the City of San Jose. A key component to making this project successful is the cooperation of all parties involved and having agreement on the proposed solution operations.

Based on estimates developed with the vendors a budget between $600,000 and $750,000, exclusive of computer hardware upgrades, was established to contract for professional services related to software integration work for a centralized emergency vehicle pre-emption system.

This approach allows for a quick deployment of emergency vehicle pre-emption to all city intersections at 1/10th the cost of the traditional solution.

Table 1 – Cost to Deploy EVP City-wide

Traditional EVP	Central EVP
$15,000/intersection for hardware	Budget: $600,000 to $750,000
597 intersection requiring hardware	Enhancements to Traffic Control System and CAD/AVL System to provide EVP functions
Total Cost: $8,955,000	Total Cost: $600,000 to $750,000
Central EVP delivers the desired solution at 1/10th of the cost	

The Centralized Emergency Vehicle Pre-emption Solution

The City of San Jose has made the decision to take a new approach to providing emergency vehicle pre-emption that leverages existing infrastructure and software systems already in use and eliminating the need for costly hardware installation and maintenance.

Traditional Emergency Vehicle Pre-emption

The traditional method to provide emergency vehicle pre-emption via hardware installed on vehicle and at the intersection level:

- Emergency response vehicles are outfitted with infrared or GPS emitter equipment that is activated when emergency lights are turned on. This ensures that an EVP request is only applied to vehicles on an active call.

- Intersections are outfitted with infrared or GPS receiver equipment which receives the ECP request and relays the request to the pre-emption detector card in the traffic signal cabinet.
- The pre-emption detector card validates the EVP request, determine phases to be pre-empted and send the EVP request to the traffic signal controller
- The Traffic Signal controller implements the EVP request based on its programmed parameters.

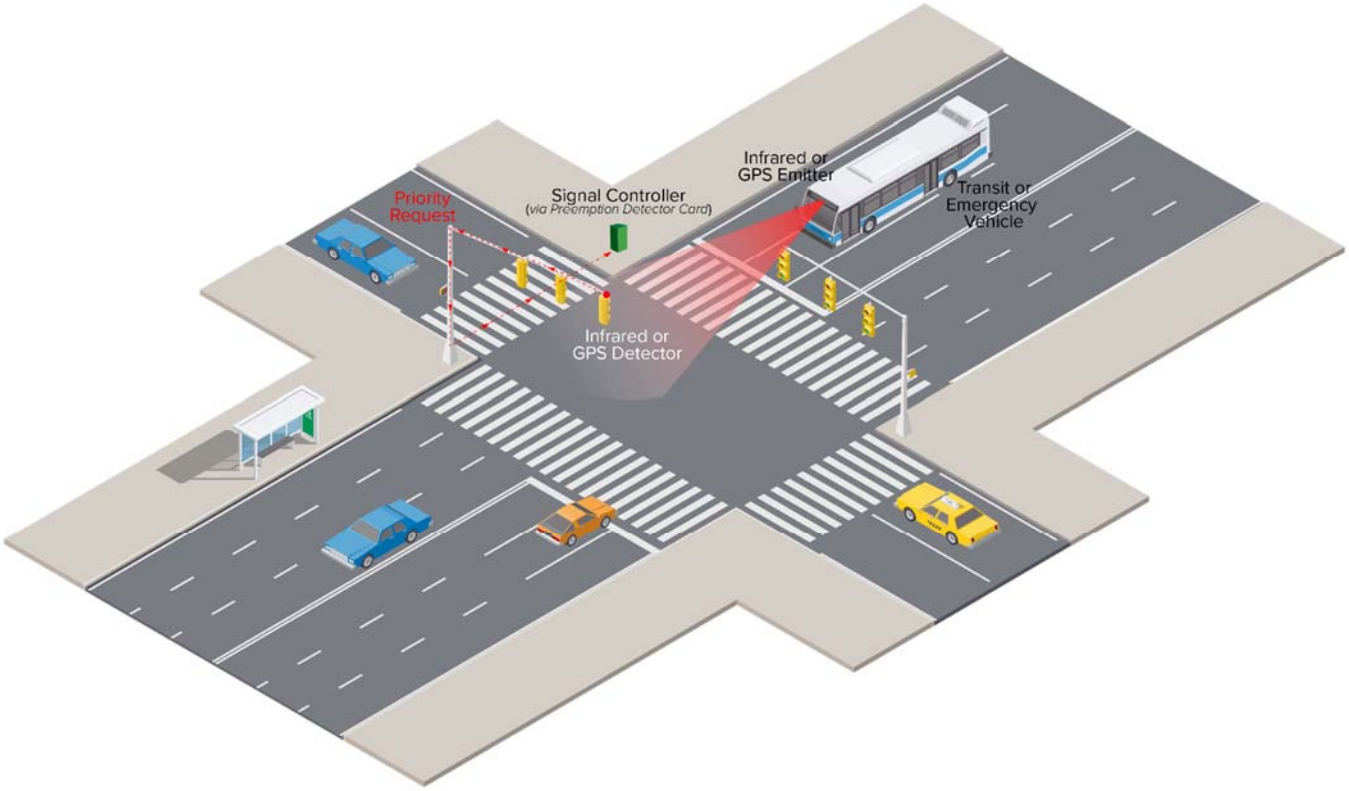

Figure 1 below shows the components of the traditional emergency vehicle pre-emption system.

Figure 1 – Traditional Emergency Vehicle Pre-emption

Centralized Emergency Vehicle Pre-emption

The centralized emergency vehicle pre-emption eliminates the need for additional hardware at the intersection by utilizing existing infrastructure and software systems to send the emergency vehicle pre-emption requests directly to the traffic signal controller at the intersection. The existing infrastructure and software systems that are used are:

- Emergency response vehicles outfitted with Automatic Vehicle Location (AVL) system which provides location and status information
- Intergraph/Hexagon AVL System which collects data on emergency response vehicles location and status.
- TransCore's TransSuite Traffic Control System which is used to manage and monitor the intersection controllers throughout the city.
- The San Jose communication network made up of fiber-optic and wireless connections to the intersection level, allows for communication between TransSuite and the traffic signal controller.
- Traffic Signal Controller – 2070 controllers using the D4 controller firmware.

Figure 2 below shows the components of the centralized emergency vehicle pre-emption system.

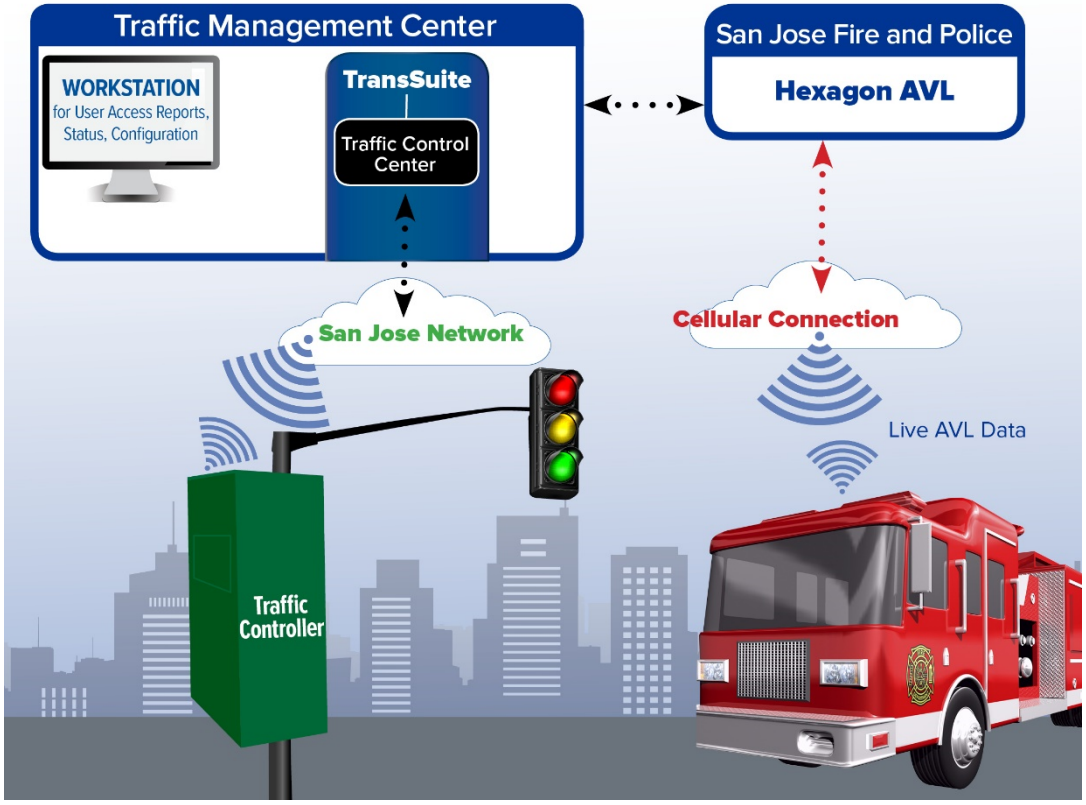

Figure 2 – Centralized Emergency Vehicle Pre-emption Components

The centralize emergency vehicle pre-emption approach changes the overall method of how a pre-emption request is handled. The list below details the central EVP Process and Figure 3 provides a visual depiction of the process.

1. GPS on vehicle tracks location and direction of travel.
2. Vehicle location, ID, direction and status (strobes, door, etc.) information continually provided to CAD System and to Traffic Control System.
3. CAD system monitors all Fire Department vehicle status information and provides required vehicle information (time stamp, agency, incident #, GPS, heading, vehicle ID, vehicle class, priority level, speed) for ACTIVE VEHICLES ONLY (i.e. vehicles currently responding to an incident) to the traffic control system.
4. The traffic control system initiates EVP Request as a vehicle enters an activation zone. Activation zones are configured in the traffic control system by City staff and can vary in size.
5. EVP Request sent to local traffic signal controller.
6. Local traffic signal controller processes EVP Request and adjusts signal operations accordingly.
7. Local Controller Sends Message Acknowledgement back to the TCS.
8. Local traffic signal controller sends status to TCS showing it is in a Preemption state.
9. EVP Request Message is removed by TCS after emergency vehicle's location exits activation zone area.
10. Local traffic signal controller reverts to normal operation.
11. Local traffic signal controller sends status to TCS showing it is in a Normal Operation.

Figure 3 below shows the centralized emergency vehicle pre-emption process.

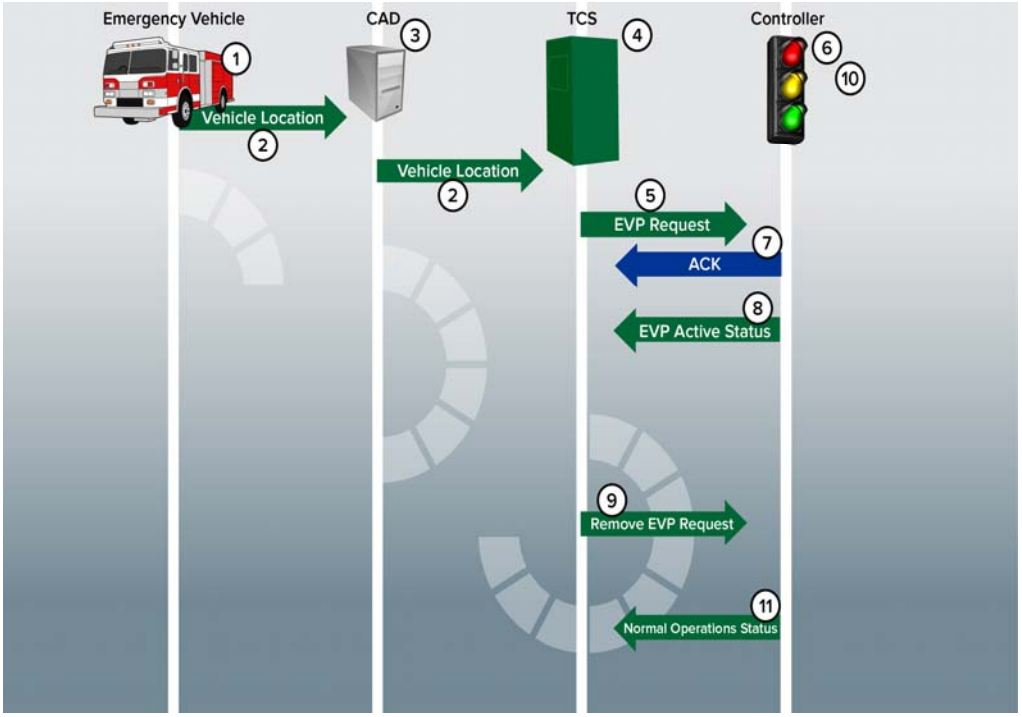

Figure 3 – Centralized Emergency Vehicle Pre-emption Process

System Enhancements

To provide central EVP operations both the Hexagon/Intergraph CAD System and TransCore's TransSuite TCS need enhancements to handle the EVP logic. The system enhancements are detailed in the following sections.

Hexagon/Intergraph CAD System

The CAD System will be enhanced with an interface utilizing IP socket methods to send vehicle data to TransSuite TCS.

The CAD system will track the location of the vehicle using the time stamped location information provided by the vehicle. Based on the status (responding to a call) of the emergency vehicle, the CAD system will send the Traffic Control System the following data: time stamp, agency, incident #, vehicle location (lat / long), direction of travel (heading), vehicle ID, vehicle class, incident code (priority level), and speed.

The CAD system will only send this information for vehicles that are actively responding to an incident and the information would cease being sent once the vehicle arrives at its final location. To ensure the effectiveness of this approach, vehicle information will be provided to the TCS on the lesser of a 3-4 second or 35-meter refresh rate.

TransCore's TransSuite TCS

TransSuite TCS will be enhanced with a CEVP subsystem that will accept data from the CAD System, process location and direction of the pre-emption request, send the pre-emption request to the signal controller, monitor the pre-emption status and clear pre-emption requests at the appropriate time. The CEVP functions added to TCS are described in detail below.

Upon receiving a notice from the CAD system that an active vehicle is present, the CEVP subsystem will process that information and determine whether the vehicle's location is within a pre-determined activation zone. Activation zones are used to indicate the start and end of an EVP request. The activation zones are created by City staff and will vary in size based on the frequency (refresh rate) of information being received from the CAD system, assumed traffic conditions, geographic considerations and type of vehicles being serviced (i.e. fire vs. police).

The CEVP subsystem will use a geographically accurate map of the City roadway network provided by the City. Based on the location and direction of the emergency vehicle, the CEVP subsystem will know which intersections (previously specified by the user) it is approaching and can initiate an EVP request to be sent to the upcoming intersection or intersections to clear traffic and present a green signal indication to the vehicle. The EVP request would be held for a period of time so that the call is not dropped. This ensures a continuous EVP request is sent to the controller the entire time the vehicle is within the activation zone. When there are no longer any active vehicles within an Activation zone associated with the intersection, the CEVP subsystem will clear the EVP request to the intersection.

The TransSuite TCS system communicates with the City's traffic control signals on a once per second basis to manage and monitor their operations. Because the traffic control system is communicating with the local controller on a once-per-second basis the EVP response will be sent to the controller typically within one second of being received. The command to the traffic signal controller will be in the form of an EVP request number (#) via an NTCIP message format, which will correspond to a specific approach at the intersection. This approach will correspond to the approach the emergency vehicle will be arriving on.

The traffic control system monitors the local traffic signal operations to verify that it services the EVP request and provides updated signal operations information to operations staff.

This EVP request can be sent to multiple intersections depending on the intersection spacing, assumed traffic conditions and City operations staff preferences. In the event that the TCS system is tracking multiple vehicles that are responding to a call, or even multiple calls, a separate EVP request will be made for each vehicle. The signal controller will serve high priority calls over low priority calls first. The controller will serve multiple calls of the same priority on a first come first serve basis. City staff would configure which vehicles are assigned high priority and which vehicles are assigned low priority within the TCS system.

Other Considerations

Throughout the project other components of the traffic signal system needed to be accounted for to ensure a smooth operation of central EVP.

Adaptive Traffic Signal Systems

The City of San Jose has two adaptive control systems: Sydney Coordinated Adaptive Traffic System (SCATS) provided by TransCore and Kimley-Horn Kadence Adaptive Signal Control. Each system needs to be taken into consideration to ensure seamless operations with EVP.

The SCATS system provides a unique challenge as it is a system that was developed in Australia to work on SCATS specific controllers. TransCore created a SCATS controller firmware that is compatible with NEMA controllers, allowing the system to be deployed across North America. SCATS operates as a standalone system with limited connection into TransSuite TCS that allow for monitoring of intersection status and generation of alarms provided by SCATS. Because the system is not NTCIP based there are hurdles in providing the central EVP functions to SCATS intersection.

Working with the City of San Jose, TransCore has identified additional enhancements that can be made to TransSuite TCS to allow for central EVP functions to work with SCATS intersections. The City of San Jose is currently reviewing the proposal and will make a decision on whether to fund these additional enhancements.

The Kadence Adaptive Control system is an NTCIP based system that the city is in the process of deploying on several corridors. The unique challenge with this system is that both TransSuite TCS and Kadence will need to monitor the signal controllers and send commands to the signal controllers at the same time. There was a concern that the two systems may interfere with each other. Upon performing testing with a signal controller, it was determined that the two systems can co-exist without any negative implications.

Traffic Signal Controllers

The City uses 2070 controllers with D4 firmware. Upon the outset of the project two key elements related to the signal controllers were identified: creating a pre-emption standard to be used at all intersections and standardizing on a D4 firmware version.

City staff defined a pre-emption standard to be used at all intersections and are in the process of programming all controllers with this standard. This standard ensures uniformity in the expected EVP operations, greatly simplifying the configuration process in TransSuite TCS.

One of the first tasks for TransCore was to test the D4 firmware to ensure the NTCIP object for Central EVP was supported. A single firmware version was to be tested and certified for operation with Central EVP. Upon determining which firmware version to test it was revealed that the city has a total of 916 Traffic Signals connected to TransSuite TCS. In total, there are 19 different firmware versions in use with additional 17 intersection that have no information entered for the firmware type (null or unknown). Working with the firmware vendor, the City and TransCore determined a firmware version to certify and the City is in the process of deploying this version to all intersections.

Next Steps

TransCore and Hexagon are in the process of implementing the required enhancements to their software systems, to be completed by mid-April 2018. While this work is being complete the City is working on programming controllers with the defined pre-emption standards and ensuring all signal controller are using the certified firmware version.

Once the enhancements are completed system deployment testing on city identified corridors will begin, currently schedule for May 2018. An update of the current progress of this project will be provided at the ITS America Conference.