DRISI

Caltrans Division of Research, Innovation and System Information

Research Notes

Red Light Violation Warning (RLVW) Over Cellular Network

A comparative study between Dedicated Short-Range Communications (DSRC) and Fourth-Generation Long Term Evolution (4G/LTE) Technologies for RLVW.

Advanced Research

MAY 2020

Project Title:
Vehicle Infrastructure Integration (VII)

Task Number: 3309

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WHAT IS THE NEED?

Connected Vehicle (CV) technologies and applications have shown a promise in improving safety, mobility, and the environment. The communications component in the form of vehicle-to-vehicle (V2V), vehicle-to-infrastructure (V2I), and vehicle-to-everything (V2X) of the CV system has been focused on the use of Dedicated Short-Range Communication (DSRC). Until the market penetration rate of DSRC-equipped vehicles reaches critical mass, the potential of CV technologies in making surface transportation safer, smarter, and greener cannot be fully realized.

DSRC communications is essential for V2V critical safety applications, such as V2V-based collision warning and avoidance, as these applications require short response times. Many V2I applications, such as transit signal priority (TSP), red-light violation warning (RLVW), and CV-based intelligent traffic signal control, could tolerate certain level of communication delay. Utilizing the existing Cellular 4G/LTE network for V2I applications can complement DSRC-based applications to start improving safety, mobility, and the environment by utilizing the existing infrastructure, vehicular, and communications technologies.

There is a need to assess the impacts of different types of V2I communication on the RLVW application.

WHAT ARE WE DOING?

The goal of this project is to compare how two different communications technologies (DSRC and 4G/LTE cellular) can support a specific CV application utilizing the California CV Test

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Bed in Palo Alto. RLVW aims to warn the drivers of the danger of potentially violating an upcoming red signal based on their speed, distance to the signalized intersection, and intersection signal phase and timing (SPaT) information.

The California CV Test Bed is compliant with the latest CV standards and is broadcasting SPaT and MAP over DSRC. Each test bed intersection has 4G/LTE backhaul for supporting this proposed project by simultaneously streaming SPaT and MAP over 4G/LTE.

- Perform a detailed assessment of how other organizations quantify a RLVW
- Oversee the integration effort to identify infrastructure challenges, setup, and variations that can lead to unacceptable findings.
- Perform detailed analysis of baseline system performance checking that all systems are functioning properly.
- Conduct tests on the CV testbed along El Camino Real using a vehicle equipped with both DSRC and the proposed cellular solution.
- Aggregate and evaluate the collected corridor results against the metrics and requirements.

RLVWs are highly dependent upon accurate high-resolution SPaT information in conjunction with vehicle telemetry data. This project will connect the current roadside data stream to SinWaves' cloud so that SinWaves' in-vehicle communication software can demonstrate its ability to accurately estimate phase remaining timing using vehicle telematics and geosynchronous timing.

WHAT IS OUR GOAL?

The objectives of this project:

- To quantify point-to-point communication delay over 4G/LTE and DSRC for message transmitting and receiving;
- To develop and test a 4G/LTE cloud-based RLVW system and compare its performance with DSRC-based system.

WHAT IS THE BENEFIT?

This project will ensure that the designed RLVW algorithm performs to specification. The research findings have the potential to advance intersection efficiency, as well as safety, leveraging the existing CV technologies.

WHAT IS THE PROGRESS TO DATE?

- Obtained a DENSO On Board Unit (OBU) with the Crash Avoidance Metrics Partner's (CAMP) RLVW application. They plan to use this to compare the DSRC vs 4G/LTE communication protocols.
- Completed the implementation of a simplified version of RLVW application to run on the Savari OBU. Three types of warning were implemented:
  - Prepare to Stop warning
  - Stop for Red warning
  - Red Signal Ahead warning
- Conducted corridor testing with real-time vehicle location data, and with SPaT and MAP data communicated in real-time simultaneously via DSRC and 4G/LTE. Two instances of the simplified versions of RLVW application are running on the Savari OBU, with one instance generating warnings based on DSRC communications and the other based on 4G/LTE communications.

IMAGES

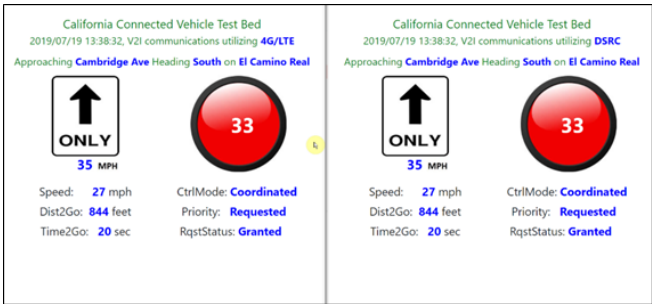

Image 1: In-vehicle HMI simultaneously displays the V2I information received over DSRC and 4G/LTE.

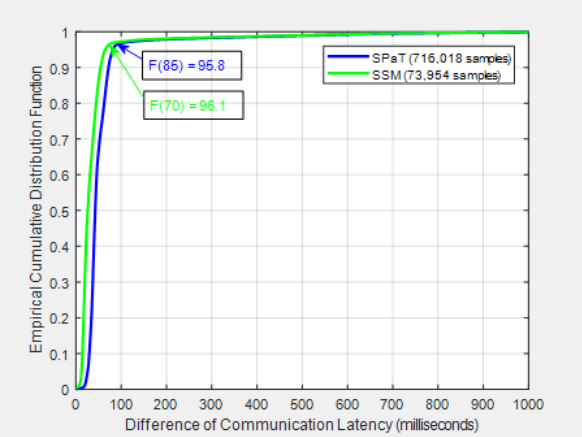

Image 2: Communication latency difference = Message received time by the OBU over 4G/LTE – the Same message received time by the OBU over DSRC

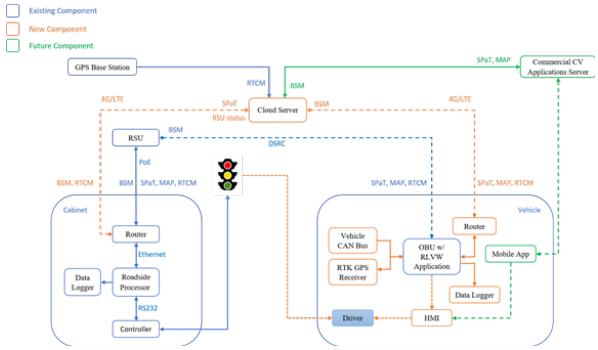

Image 3: System Architecture of the Hybrid V2I Platform

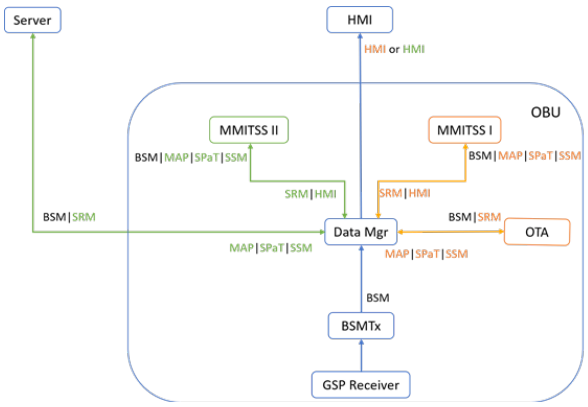

Image 4: OBU Applications of the Hybrid V2I Platform

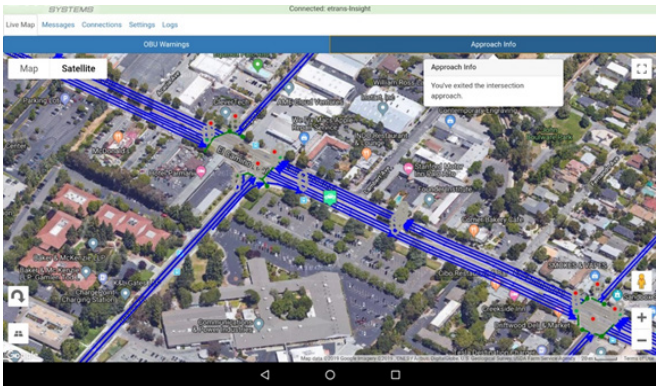

Image 5: SPaT/MAP Visualization at Portage/ Hanson at El Camino Real (12/27/2018)

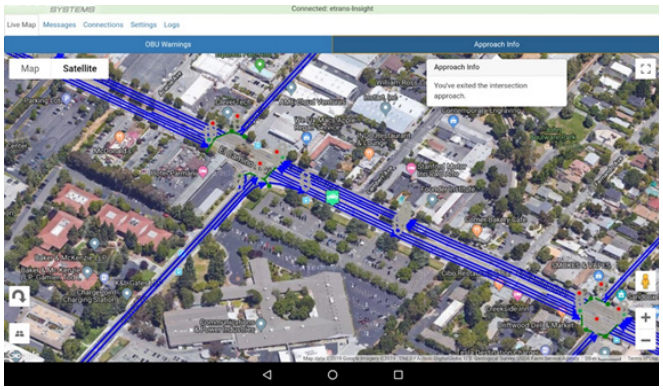

Image 6: SPaT/MAP Visualization at Portage/ Hanson at El Camino Real (01/23/2019)

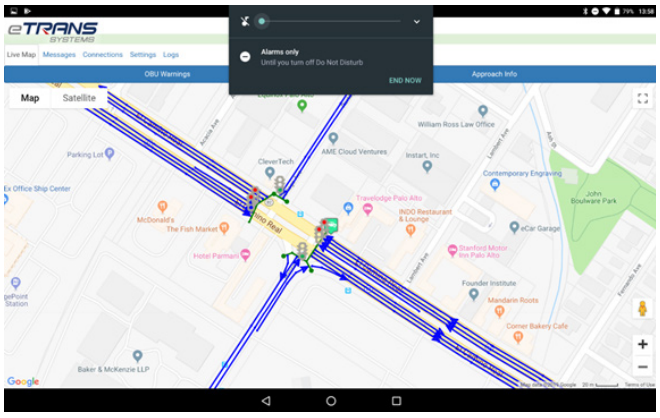

Image 7: SPaT/MAP Visualization at Portage/ Hanson at El Camino Real (02/07/2019)