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

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

Advanced Research

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Project Title:
Connected and Automated Vehicle (CAV) Infrastructure Development

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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 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?

1. Conference meeting FHWA to discuss their project on C-V2X vs. 4G/LTE and Caltrans/PATH RLVW project on DSRC vs. 4G/LTE. The FHWA project measures the communication latency at the physical layer, i.e., the time gap between a message was sent on the radio interface and the message was received on the radio interface, while the Caltrans/PATH project measures the communication latency at the application layer, i.e., the time gap between a message (e.g., SPaT) was generated by the roadside application (before it was transmitted on the radio interface) and the message was received by the vehicle resident RLVW application (after it was received on the radio interface). Therefore, the communication latency measured by the FHWA project on C-V2X vs. 4G/LTE is shorter than that was measured by the Caltrans/PATH project on DSRC vs. 4G/LTE. The results from both projects agree on the additional communication latency on 4G/LTE over C-V2X/DSRC, i.e., on average, 4G/LTE communication latency is about 70 milliseconds longer than C-V2X/DSRC.

2. Conference meeting to discuss the availability of Palo Alto test bed real-time MAP and SPaT messages over wide area network cellular for a FHWA demonstration project, which utilizes MAP and SPaT messages to provide driver distraction alerts on users' mobile phone. Additional meeting with the demonstration project team (Global Mobile Alert - GMA) to discuss technical details on making test bed MAP and SPaT messages available to GMA. PATH has started forwarding MAP and SPaT messages from the PATH server located in the Richmond Filed Station to the GMA server in real time.
3. PATH has change from using the CAMP RLVW application running on the DENSO unit to using the simplified RLVW application that PATH has implemented on the Savari OBU to conduct corridor testing to collect data and analysis the impacts of 4G/LTE vs. DSRC on the generation time of red-light violation warnings. Per the approval from the Caltrans PM, PATH has added the data logging software module on the Savari OBU to simultaneously log inputs, outputs, and intermediate processed data of the RLVW application using DSRC vs. 4G/LTE. To improve the accuracy of OBU's GPS accuracy, PATH also added an external RTK-enabled GPS receiver (i.e., u-blox C94-M8P) to the data collection system to utilize RTCM data that is already available in the test bed for improved detection of lane-of-travel.

IMAGE

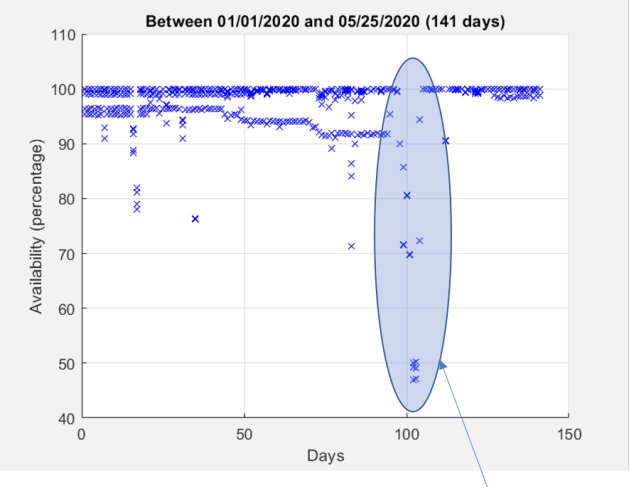

Image 1: Intersection Availability by Day and Intersection