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.

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.

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**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.

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**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?**

- Task 3 Interim Report completed: Comparison of Vehicle-to-infrastructure (V2I) Communication Latency over Cellular 4G/LTE and DSRC
- Team worked making SPaT and MAP messages received over DSRC available to the DENSO OBU as the DENSO unit has pre-2016 version of IEEE 1609.2 implementation, and can’t communicate directly with test bed RSUs. The research team implemented software on a Savari OBU to receive SPaT and MAP messages from test bed RSUs, decode the messages, and send the decoded data to the DENSO unit via UDP packets. They verified that the DENSO unit can receive the UDP packets correctly. The next step is to make the UDP data can be used as inputs to the CAMP RLVW application running on the DENSO unit.
The California CV Test Bed is in residential area, data usage over 4G/LTE is expected much higher due to the stay-at-home order, which could have impacts on V2I communications using 4G/LTE. PATH conducted data collection and data analysis to investigate the potential impacts. Data collected and used for this analysis is the SPaT messages transmitted from each test bed intersection to the PATH server located at Richmond Field Station, over 4G/LTE.

The metrics used to measure the potential impact is the Intersection Availability, defined as the ratio of number of SPaT messages received by the server within a day to the number of expected SPaT messages at 10 Hz (10 messages per second).

Image 1 shows the analysis result. Each ‘X’ represents a measurement of Intersection Availability by day and by intersection. The duration of data used for this analysis is about 5 months, between January 1 and May 25, 2020. The stay-at-home order was effective since Mar 19, 2020. As it can be seen from the figure, there is no noticeable difference before and after the stay-at-home order. The only exception marked in the oval was due to test bed maintenance which stopped sending SPaT messages from the intersections, not due to 4G/LTE service outage.

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