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CALTRANS DIVISION OF RESEARCH, INNOVATION AND SYSTEM INFORMATION

Research Results

Connected and Automated Vehicle (CAV) Infrastructure Development

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

Advanced Research

MARCH 2024

Project Title:
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

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WHAT WAS 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 was a need to assess the impacts of different types of V2I communication on the RLVW application.

WHAT WAS OUR GOAL?

The objectives of this project were:

- 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 red-light violation warning system and compare its performance with DSRC-based system.

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WHAT DID WE DO?

The goal of this project was 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 Roadside Unit (RSU) Ver4.1 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.

The following tasks were completed:

- Performed a detailed assessment of how other organizations quantify a RLVW
- Oversaw the integration effort to identify infrastructure challenges, setup, and variations that can lead to unacceptable findings.
- Performed detailed analysis of baseline system performance checking that all systems were functioning properly.
- Conducted tests on the CV testbed along El Camino Real using a vehicle equipped with both DSRC and the proposed cellular solution.
- Aggregated and evaluated 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 connected 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 WAS THE OUTCOME?

Existing 4G LTE is quite capable of supporting non-safety-critical applications. Communication latency over 4G LTE is reliable and within 100 milliseconds for more than 95 percent of the time. 4-week's continuous monitoring of 4G LTE communication latency shows that communication latency does not change much (within +/- 10 milliseconds) by time-of-day and day-of-week. 4G LTE latency has no impacts on warning/alert creating with a RLVW application used in this project.

Comparison of communication latency between 4G LTE and DSRC shows that DSRC can ensure low latency and high reliability, with latency within 100 milliseconds for 99.99 percent of the time, which the current 4G LTE still cannot provide. Direct V2X communication – direct Cellular-V2X (C-V2X) and DSRC – is essential for safety-critical applications such as crash avoidance and autonomous driving.

Utilizing existing 4G LTE as indirect V2X communication can expedite deployment of non-safety-critical applications at much lower costs. Direct V2X communication has a short communication range, typically 300 to 500 meters. 4G LTE does not has this limitation therefore can provide longer lead time for taking corrective actions.

WHAT IS THE BENEFIT?

This project ensured that the designed red-light violation warning algorithm performs to specification. Findings from this project have the potential to advance intersection efficiency, as well as safety, leveraging the existing CV technologies.

LEARN MORE

TBD- Final report link.