

JOINT TRANSPORTATION RESEARCH PROGRAM

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Connected Vehicle Corridor Deployment and Performance Measures for Assessment

Motivation

In November 2016, the American Association of State Highway and Transportation Officials (AASHTO) announced the signal phase and timing (SPaT) challenge to state and local agencies to kick-start infrastructure deployments for V2I communications. The challenge involved the deployment of dedicated short-range communication (DSRC) infrastructure with SPaT broadcasts (current intersection signal light phase) on at least 20 signalized intersections in all 50 states by 2020.

Although the roadmap for agencies to partner with the automotive industry is still evolving, it is important for Indiana to not only support the SPaT challenge but also identify mutually beneficial opportunities for INDOT to partner with the automotive industry because Indiana has the second largest automotive-related gross domestic product (GDP) in the country.

Study

During this study, connected traffic signal infrastructure was deployed at several locations around the state. SPaT message deployment was done using both DSRC and cellular communications. This report details the deployment locations, the various public- and private-sector stakeholders that were engaged during the field-testing, and the several vehicle-infrastructure communication experiments that were used to evaluate connected vehicle use cases.

Results

The findings of this research were as follows:

1. The team successfully demonstrated use cases for placing virtual vehicle detection calls using basic safety messages (BSMs) and evaluated latency.

2. The team developed a scalable methodology for characterizing the probability of a traffic signal phase changing by time of day. This methodology using agency traffic signal data for green light prediction and engine shutdown at red lights is particularly useful to the automotive industry.
3. The team successfully demonstrated that split failures, reduced roadway friction, and hard braking events can be identified on the vehicle and then transmitted to an agency. This enhanced probe data information is particularly valuable to agencies for identifying traffic signal timing problems, segments impacted by winter weather, and locations where drivers are encountering roadway conditions that require hard braking.
4. DSRC provides the lowest latency communication but, in general, commercial cellular interface between vehicles and infrastructure provided acceptable latency for most use cases. For most applications, the team believes a commercial cellular interface between vehicles and infrastructure is the most scalable and feasible for an agency to maintain.

Recommendations

1. In the short-term, there is significant opportunity for placing “virtual pedestrian” calls at traffic signals for users with mobility challenges or for emerging robot delivery vehicles that need to cross the street.
2. The current version of the SAE J2735 SPaT definition is ambiguous on the likelyTime and time interval confidence fields regarding whether the elements refer to start of green or end of green. It is recommended that protocol documentation and messages be updated to support confidence estimates for both start and end of green.



3. Develop a partnership with the automotive sector to obtain enhanced probe data that identify traffic signal phases that experience split failures, locations with hard braking events, and segments with reduced friction.
4. The automotive industry has assumed that traffic signal phases behave deterministically; however, modern traffic signals operate much more stochastically. Longer term, it might be worthwhile to have a “phase-next” data flag provided by signal controllers. This would inform the vehicle of a deterministic window to update their phase predictions 5 to 7s prior to the start of the next phase.
5. It might also be worthwhile to reconsider strategies on running the “free” timing plan overnight. Free operation, based purely on random arrivals, can make the traffic signal predictions even

more challenging than coordinated and adaptive systems.

Recommended Citation for Report

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