DRISI
Caltrans Division of Research, Innovation and System Information

Research Notes

MMITSS Phase III Extension for Additional Enhancements

A research project by UC Berkeley PATH program to add traffic adaptive and multimodal aspect enhancements to Multi-Modal Intelligent Traffic Signal System (MMITSS) for improved mobility and safety.

Advanced Research

MAY 2022

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

Task Number: 3747

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WHAT IS THE NEED?

The Multi-Modal Intelligent Traffic Signal System (MMITSS) is the next generation of traffic signal systems that seeks to provide a comprehensive traffic information framework to service all modes of transportation, including general vehicles, transit, emergency vehicles, freight fleets, and pedestrians and bicyclists in a connected vehicle environment. Under the sponsorship of the Connected Vehicle Pooled Fund Study (CV PFS) and FHWA, MMITSS has been deployed in the California CV Test Bed. Caltrans statewide Traffic Signal Control Program (TSCP) has been enhanced to support MMITSS operations, including SPaT broadcasts, CV-based vehicular service calls and actuations, pedestrian service calls, CV-based signal priority, and dynamic force-off to adapt signal timing to the prevailing traffic conditions. However, due to the low market penetration of connected vehicles and the lack of multimodal road user detection and classification data, the effectiveness of traffic adaptive features cannot be tested and evaluated in real-world condition.

The current coordinated traffic control systems utilize a few time-of-day timing plans (cycle length, green split, and offset) for time-based coordination and utilize loop detectors for phase service calls and vehicle actuations. The time-of-day timing plans are preset based on traffic data collected through site surveys. Inductive loops are usually installed near the intersection stop-line and cannot detect and measure the fluctuation of traffic demand in real-time so that the traffic control systems are not well informed about the state of the traffic and are unable to select the appropriate timing plan that adapts to the prevailing traffic conditions. Furthermore, in the current systems, pedestrian service requests are detected by pedestrian pushbuttons, the systems are not necessarily aware of how many pedestrians and their location on the crosswalk.

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In a CV environment where equipped vehicles and pedestrians communicate their state (type, location, speed, heading, etc.) to the roadside infrastructure via Basic Safety Messages (BSM – vehicle) and Personal Safety Messages (PSM – pedestrian), this rich data set allows the traffic control systems to measure the fluctuation of traffic demand in real-time, adapt timing plan to the prevailing traffic conditions, and provide cooperative services to each mode.

Although the anticipated benefits of CV technologies on improving safety and mobility are promising, due to the low market penetration rate of connected vehicles, the benefits of CV technologies are difficult to assess in a real-world condition.

WHAT ARE WE DOING?

The objectives of this project are:

1. Enhance Traffic Control Features: Utilize multimodal road user detection and classification data (e.g., vehicles, pedestrians, and bicyclists) of NoTraffic Smart Sensors and adaptive signal timing features of the existing TSCP to add additional enhancements to MMITSS for improved mobility and safety;
2. Enhance the Deployability of MMITSS Vehicle-Resident Applications: Modularize the existing vehicle-resident CV application software and develop an application programming interface (API) to support a hardware-agnostic solution, that the vehicle-resident CV applications run on a separate computer and interface with an OBU (either a DSRC or a Cellular-V2X device) via the API for transmitting and receiving over-the-air messages. The API will support the use of OBUs from multiple vendors.
3. Conduct Field Testing with Augmented Market Penetration: Field testing will comprise both equipped VTA buses and PATH testing vehicles. PATH testing vehicles will collect the ground-truth travel time and delay data, which provide inputs to the before-and-after analysis on impacts of market penetration.

WHAT IS OUR GOAL?

The goal of this project is to add traffic adaptive and multimodal aspect enhancements to MMITSS for improved mobility and safety.

WHAT IS THE BENEFIT?

The State would be able to better assess the effectiveness of traffic adaptive features that support multimodal transport and impacts of market penetration of CVs and providing better safety and mobility for all modes of travel.

WHAT IS THE PROGRESS TO DATE?

During the last quarter, PATH built a microsimulation network in Aimsun for the California CV Test Bed. This model will be used for Traffic State Estimation and Performance Evaluation of proposed timing plan changes to improve intersection efficiency. Detailed road geometries of 31 test-bed intersections from Medical Foundation Dr to Grant Rd at El Camino Real have been coded in the Aimsun simulation model. Detector layouts and field signal timing settings at 16 operational test-bed intersections from Medical Foundation Dr to Dinah's Ct have been coded in the Aimsun model. The Aimsun model has been tested with synthetic traffic demands.

PATH has developed algorithms to aggregate raw detector count and occupancy data into 5-minute intervals, and to filter the aggregated data (i.e., missing values and high values). PATH analyzed the health of detectors at test-bed intersections using proposed health metrics for arterial detectors, which are consistent with the criteria in Caltrans Performance Measurement System (PeMS) but with adjustments for arterial traffic. Analyzing results are documented in a drafted report on the detector health in the California CV Test Bed.

PATH also worked on building an Arterial Performance Measurement System (APeMS) utilizing real-time data collected in the California

CV Test Bed. The following functions have been implemented:

- Check real-time asset availability (i.e., detectors & traffic signals).
- Show the detector health analysis (at the detector-level and at the intersection-level).
- Show the aggregated and the filtered detector data.

PATH has worked on incorporating the information of pedestrian presence on crosswalk in SPaT broadcasts, utilizing NoTraffic's real-time detection and classification data at four test-bed intersections from Medical Foundation Dr to Serra/Park Blvd. Pedestrian presence on crosswalk information is delivered to connected vehicles via SPaT and MAP broadcasts:

- SPaT broadcasts to include the optional ConnectionManeuverAssist data frame with LaneConnectionID and PedestrianBicycleDetect.
- MAP broadcasts to include lane connections IDs that are associated with a particular pedestrian crosswalk (so the connected vehicle would know whether the information of pedestrian presence on crosswalk has impacts on vehicle's lane-of-travel).

PATH has completed determining pedestrian presence on crosswalk using NoTraffic data and including ConnectionManeuverAssist in SPaT messages and is working on adding LaneConnectionID to MAP messages.

Caltrans District 4 has installed six HAWK signals along the California CV Test Bed and these HWAK signals are operational. These HAWK signals are standard pedestrian signals with signal heads controlling vehicle movements (Figure 1), thereby each HWAK signal needs to be treated as an intersection with its own MAP and SPaT broadcasts. PATH has been working on adding MAP and SPaT for these HAWK signals

IMAGES

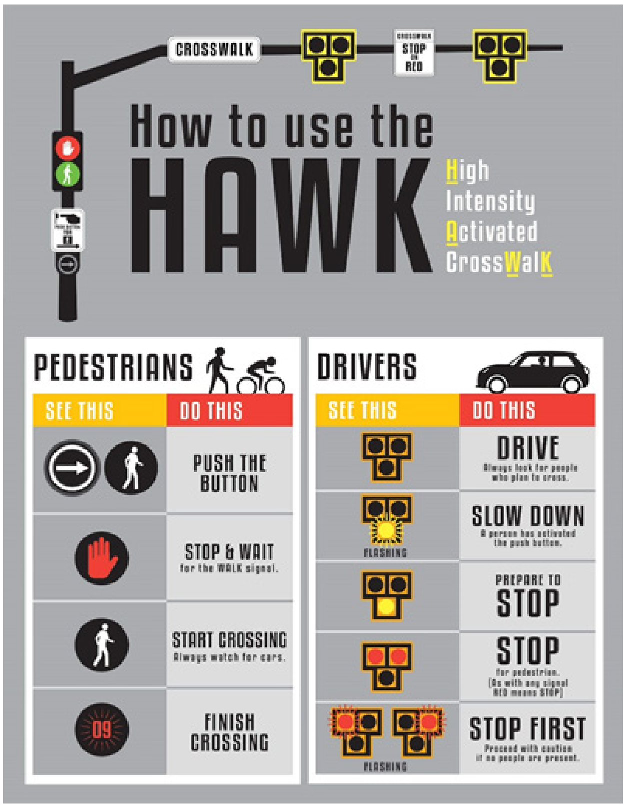

Image 1: HAWK Signal Phases