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Caltrans Division of Research, Innovation and System Information

Research Notes

MMITSS Phase III Extension for Additional Enhancements

A research project by University of California at Berkeley (UCB) California Partners for Advanced Transportation Technology (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

FEBRUARY 2023

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 Federal Highway Administration (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 Dedicated Short Range Communications (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 Santa Clara Valley Transportation Authority (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 developed an Arterial Performance Measurement system (APeMS) that is able to:

- Monitor the status of the sensor network (loop detectors, signal status) in the Test Bed
- Assess the intersection traffic performance
- Help identify traffic bottlenecks and potential causes

The APeMS website is available online at https://caconnectedvehicletestbed.org/apems.

All functions have been tested and are working properly. The use of APeMS system to analyze detector and signal performance in the testbed was demonstrated. Task 2 Technical memo was finalized on 11/15/2022.

Task 3 technical memo was circulated for comments. Field testing was not performed, but before and after comparison of effectiveness tools were developed (e.g., dynamic offset algorithms). Task 4 testing will be conducted and evaluated using Aimsun simulations.

In this direction, a solution was developed using

existing API functions in Aimsun to adjust offsets for a given control plan during simulations. This solution was tested and it was confirmed that it works as expected.

Testbed Aimsun model was calibrated using the observed weekday traffic profiles at the available detectors (both stop-bar and advance). In the calibration, the criterion of "GEH statistic <5 for individual link flows for >85% of cases" see reference: https://ops.fhwa.dot.gov/trafficanalysistools/tat_vol3/sect5.htm was applied. A four-hour PM peak between 3PM and 7PM was calibrated with satisfied GEH results. All field bottlenecks were well replicated in the calibrated model.

IMAGES

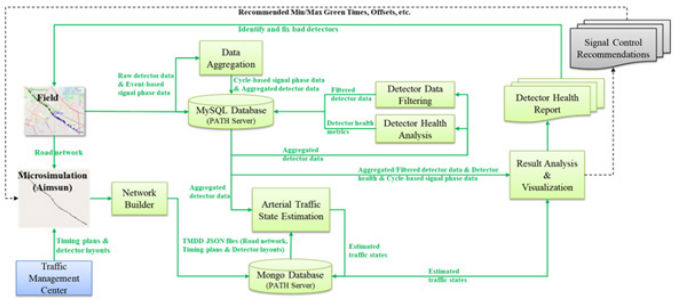

Image 1: Architecture of Arterial Performance Measurement System