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CALTRANS DIVISION OF RESEARCH, INNOVATION AND SYSTEM INFORMATION

Research Results

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

MAY 2024

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

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WHAT WAS THE NEED?

The Multi-Modal Intelligent Traffic Signal System (MMITSS) represents the next generation of traffic signal systems, aiming to provide a comprehensive traffic information framework to serve 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 was deployed in the California CV Test Bed. Caltrans statewide Traffic Signal Control Program (TSCP) was enhanced to support MMITSS operations, including Signal Phase and Timing Message (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 could not be tested and evaluated in real-world condition.

The coordinated traffic control systems at that time utilized a few time-of-day timing plans (cycle length, green split, and offset) for time-based coordination and relied on loop detectors for phase service calls and vehicle actuations. The time-of-day timing plans were preset based on traffic data collected through site surveys. Inductive loops were typically installed near the intersection stop line and were unable to detect and measure the fluctuation of traffic demand in real-time. As a result, the traffic control systems were not adequately informed about the state of traffic and were unable to select the appropriate timing plan to adapt to the prevailing traffic conditions. Additionally, pedestrian service requests were detected through pedestrian pushbuttons, but the systems were not necessarily aware of the number of pedestrians or their locations on the crosswalk.

In a CV environment where equipped vehicles and pedestrians communicated 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 allowed 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 in improving safety and mobility were promising, due to the low market penetration rate of connected vehicles at that time, the benefits of CV technologies were difficult to assess in a real-world condition.

WHAT WAS OUR GOAL?

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

WHAT DID WE DO?

The objectives of this project were as follows:

1. Enhance Traffic Control Features: Utilize multimodal road user detection and classification data (e.g., vehicles, pedestrians, and bicyclists) from NoTraffic Smart Sensors and adaptive signal timing features of the existing TSCP to incorporate additional enhancements into MMITSS for improved mobility and safety.
2. Enhance the Deploy ability 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. This allows the vehicle-resident CV applications to run on a separate computer and interface with an On-Board Unit (OBU) (either a Dedicated Short-Range Communications (DSRC) or a Cellular-Vehicle to Everything (V2X) device) through the API for transmitting and receiving over-the-air messages. The API is designed to accommodate OBUs from multiple vendors.
3. Conduct Field Testing with Augmented Market Penetration: Field testing involves the participation of equipped Santa Clara Valley Transportation Authority(VTA) buses and PATH testing vehicles. PATH testing vehicles collect ground-truth travel time and delay data, which serve as inputs for before-and-after analysis on the impacts of market penetration.

WHAT WAS THE OUTCOME?

The MMITSS underwent additional enhancements to support new infrastructure upgrades in the California CV Testbed. These upgrades included the installation of NoTraffic sensors and HAWK signals. The MAP Engine Library was improved to identify multiple downstream intersections and calculate distances and travel times. Furthermore, functions were added to incorporate accurate detection data from NoTraffic sensors into V2X messages, determine the lane-of-travel for vulnerable road users, and track road user movements in intersection conflict areas

To monitor traffic performance, an Arterial Performance Measurement System (A-PeMS) was developed. It collected and analyzed raw detector and signal phase data, aggregating them into fixed time intervals and cycles. A-PeMS included algorithms to filter out unreliable data and provided metrics to assess intersection signal performance. Furthermore, a microsimulation model in Aimsun was calibrated for the California CV Testbed, allowing testing of control strategies and CV/CAV applications.

In terms of traffic coordination, an active control strategy was devised for major arterials such as the El Camino Real (ECR). This strategy recommended new offsets based on changing traffic conditions measured by advance detectors. Simulation results demonstrated that the active control strategy reduced vehicle delay by approximately 2% for the network of 16 intersections in the testbed. These developments enhanced the functionality, performance, and coordination of the MMITSS system and contributed to improving traffic flow and efficiency in the California CV Testbed.

WHAT IS THE BENEFIT?

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

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TBD-Final report link.