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EMERGENCY VEHICLE PREEMPTION STRATEGIES: A MICRO-SIMULATION BASED CASE STUDY ON A SMART SIGNALIZED CORRIDOR

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ABSTRACT

Emergency-Response-Vehicles (ERVs), like firetrucks operate with the purpose of saving lives and mitigating property damage. Emergency-vehicle-preemption (EVP) is implemented to provide the right-of-way to ERVs by displaying the green indications along the ERV route. This study proposes a strategy, “Dynamic-Preemption”, which utilizes Connected-Vehicle technology to detect the need for preemption prior to the ERV reaching the vicinity of an intersection in real-time. To choose the best EVP strategy, several KPIs are measured for: (a) the ERV route, which is chosen to be along the mainline for this case study, and (b) the side streets, which are adversely affected by EVP. The study tests different strategies under varying scenarios, on a simulated signalized corridor testbed, and provides a methodology for selecting the most favorable one. It was observed that, there is a potential for ERV travel time improvements on the order of 25% with minimal impact to the conflicting traffic.

1 INTRODUCTION

EVP is not a new concept and has been used in the past with varying levels of reported success. There have been recent technological developments in this space with the integration of GPS device based triggering mechanisms for preemption. With recent advances in the testing and deployment of Connected Vehicle (CV) technologies, there is a massive surge in the quantity and quality of data that is becoming available for aggressive feedback into real-time operations of transportation management systems, especially signal systems. CV technology provides a seamless means to integrate live vehicle position and multiple intersections’ signal status data-streams, enabling enhanced strategies for optimal EVP performance. With Emergency Response Vehicle (ERV)’s on board CV equipment and CV roadside units (RSUs) connected to the signal controllers, the line-of-sight restriction is no longer required. This opens up the possibility of creating a free-flow path through the signalized intersections for the ERV. By anticipating the arrival of the ERV, based on its position as recorded by CV messages received at other RSUs in the system, vehicles on the approach of interest may be cleared before the ERV arrives.

2 MODEL DEVELOPMENT

2.1 Model Description

A microscopic simulation model is built for a 6.2 mile stretch along the Peachtree Industrial Boulevard (PIB) corridor from Holcomb Bridge Rd at the south-west end to Pleasant Hill Rd on the north-east end, in Norcross, Georgia using VISSIM® 2021 (PTV 2021). Replicate runs are made efficiently using Python 3.7 scripts to drive VISSIM® using its Component Object Model (COM) module. The model was built with 25 signalized interchanges with 14 of them lying on main line PIB. It was built with PM peak hour in mind. More specifically, a typical weekday was emulated to run 1.5 hours of simulation with the first 30 minutes being excluded for any KPI analysis (as simulation warm-up period) for the simulation to saturate.

2.2 Data Sources

Several data sources were in use for get (a) traffic volume, (b) signal phase patterns. Primarily for traffic volume there were 3 sources, namely, (1) real turn counts from the County, (2) real historic MaxView® detector data counts, and (3) turns counts from Automated Traffic Signal Performance Measures (ATSPM) webpage ((GDOT) 2021). For signals, the primary source was signal pattern info provided by the county in forms of Maxtime® controller database files.

2.3 Model Calibration and Validation

For model calibration, speed and headway were use and several statistical tools were used to make the model emulate real-field results. And the calibrated model was validated using travel time of some pre-determined routes in the main-line of the corridor.

3 EXPERIMENTAL DESIGN

For the experiment a route consisting for eight contiguous intersection on main-line PIB were used. Experiments were made regarding how an EVP call would be made (entry transition) and how the EVP phase is exited to get the signal into normal coordination (exit transition). Several variations were used in the experiment, (a) the tradition EVP at a certain distance, (b) no preemption, (c) a preemption with an ad hoc heuristic algorithm that uses the queue length in real-time, i.e. Dynamic Preemption (DP). The algorithm here is expected to (1) calculate the queue-length in real-time estimate the number of vehicles to be cleared in time for ERV arrival, (2) make an estimate of the number of vehicles between the end of the queue to the front of the ERV, and (3) make a call on how early the EVP call needs to be made to clear out for free-flow of ERV. Several experiments were performed on the best strategy for exit transitions. For comprehensiveness, both main-line and side street EVP were considered.

4 RESULTS AND DISCUSSION

Simulations were run with 160 iterations with variations in random seed of simulation and variations in arrival time of ERV into the network. Exit transition strategy has to be chosen based on the traffic demand in the movement needing EVP. The strategy changes based on whether EVP is requested on a main-line phase or a side-street phase. Overall the DP algorithm improved the travel time up to 25 percent compared to no preemption, when comparison are made on a mainline ERV route of 4.4 miles. Additionally, the delays in the conflicting movements dissipated within 3 signal cycle length duration. The same trend was noticed when side-street EVP experiment was performed on an interchange with the similar 160 simulation iterations. While the results thus far are promising, a more realistic model needing less CV penetration is currently being built, with the power of simulation and novel Machine Learning techniques. At the same time, software in the loop simulation (SILS) architecture is being tested on the simulated model to check the transferability of the simulation results onto real-filed with controllers used by the practitioners all over the state.

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