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ABSTRACT

INTER-INTERSECTION COORDINATION USING SUMO TRACI WITH MAX PRESSURE CONTROL

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Congestion at signalised intersections is a growing problem in fast-urbanising cities, including in Indonesia, where fixed-time signal plans are unable to respond to real-time fluctuations in traffic demand. Max Pressure (MP) control, introduced by Varaiya (2013), offers a decentralised alternative in which each intersection selects its own signal phase based on the real-time queue imbalance, or "pressure," between incoming and outgoing lanes, without requiring a fixed cycle or centralised infrastructure. However, the standard formulation of MP operates independently at each intersection: it has no mechanism to communicate with neighbouring signals along an arterial corridor. As a result, a platoon of vehicles released by one green phase can arrive at the next intersection just as it turns red, producing stop-and-go waves that degrade overall network throughput.

This research designed, implemented, and evaluated a lightweight inter-intersection coordination mechanism that extends the standard MP controller. When an intersection released a platoon on its arterial through phase, it broadcast a departure event to its downstream neighbour, which used the expected travel time of the platoon to bias its own pressure calculation around the platoon's predicted arrival. The system was implemented in SUMO (Simulation of Urban MObility), a microscopic traffic simulator, using the TraCI (Traffic Control Interface) Python API to read real-time queue states and issue signal-phase commands at each control step.

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The coordinated controller was evaluated on a four-intersection arterial corridor against two baselines — a conventional fixed-time signal plan and a decentralised, uncoordinated MP controller — under four synthetic demand scenarios representing low, medium, high, and very high traffic volume, across 96 simulation runs (eight random seeds per scenario), plus 192 runs at eight stress levels up to 19200 veh/h. Both Max Pressure variants reduced average waiting time by 61–71% relative to the fixed-time baseline across all demand scenarios. The proposed coordination mechanism produced a statistically significant reduction in the number of stops per vehicle relative to the decentralised controller at every demand level from medium upward ($p = 0.0045$, $p = 0.0012$, and $p < 0.001$ for medium, high, and very high respectively), with the effect size growing larger as demand increased (Cohen's d from -1.71 to -3.04), while maintaining throughput identical to the decentralised baseline; the corresponding reduction in total waiting time, although consistently in the expected direction, did not reach statistical significance at any demand level tested, including under very high demand. A stress test up to eight times the very high demand showed that the benefit of coordination vanished at 7200 veh/h and that waiting time and teleports became worse than under decentralised Max Pressure from 6000 veh/h, while computation (4–5 ms per decision) was not a constraint.

Keywords: Max Pressure Control, Inter-Intersection Coordination, SUMO, TraCI, Traffic Signal Control, Urban Traffic Management, Adaptive Signal Control