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Abstract

Conventional intersection management (IM) strategies that allow vehicles from one road at a time are still prone to tra_c congestion,leading to time loss as well as fuel wastage and ecological damage. Therefore, we proposed an Intelligent IntersectionManagement Architecture (IIMA) and associated Synchronous Intersection Management Protocol (SIMP) that explore the maximumconcurrency at the intersection level limited by safety rules, only. In this paper, we briefly present SIMP together withpreliminary simulation results based on the Veins/SUMO/OMNeT++ framework for a simple intersection model common in urbanresidential areas. The results indicate that SIMP can surpass traditional Round-Robin IM in reducing trip delays in basic scenarios.

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Synchronous Intersection Management to reduce Time Loss

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Abstract

Conventional intersection management (IM) strategies that allow vehicles from one road at a time are still prone to traffic congestion, leading to time loss as well as fuel wastage and ecological damage. Therefore, we proposed an Intelligent Intersection Management Architecture (IIMA) and associated Synchronous Intersection Management Protocol (SIMP) that explore the maximum concurrency at the intersection level limited by safety rules, only. In this paper, we briefly present SIMP together with preliminary simulation results based on the SUMO framework for a simple intersection model common in urban residential areas. The results indicate that SIMP can surpass traditional Round-Robin (RR) IM in reducing trip time loss in basic scenarios.

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Keywords: Intelligent Transportation System; Intersection Management; Mixed Traffic Flows; Traffic Congestion Control; Time Loss.

1. The Context and Motivation

The INRIX global traffic scorecard survey shows that traffic congestion, fuel wastage, and vehicular emission for France, Germany, the US, and the UK for 2013 were $200 billion USD, and are expected to reach $300 billion USD by 2030 (Inrix Global., 2018). On the other hand, Information and Communication Technologies are being growingly used to develop smart road infrastructures and integrate autonomous (AV) and human-driven (HV) vehicles. One relevant example is Intersection Management (IM). Here, conventional strategies, like Round-Robin (RR), are vulnerable to traffic situations with vehicles arriving from several directions simultaneously, generating extra time-loss, fuel consumption, and polluting vehicular emissions, e.g., NOx, PMx, and CO (Srivastava et al., 2013; Bui et al., 2017). This led us to propose the Intelligent Intersection Management Architecture (IIMA) and associated Synchronous Intersection Protocol (SIMP) (Reddy et al., 2020) that explore the maximum concurrency in the intersection. For the moment, we focus on typical cross-roads found in urban residential scenarios, in which vehicles run at low speed, i.e., 30 Km/h.

2. Synchronous Framework and Preliminary Results

In IIMA, the intersection and a specified length of the incoming road lanes are featured with a virtual grid of equal-sized cells that provide space for a vehicle and some safe distance between consecutive vehicles. Several roadside sensors allow identifying vehicle arrival in the grid-area, desired direction, as well as entering and exiting the intersection. Each incoming road lane is associated with one Road-Side Unit (RSU), and another RSU runs the traffic

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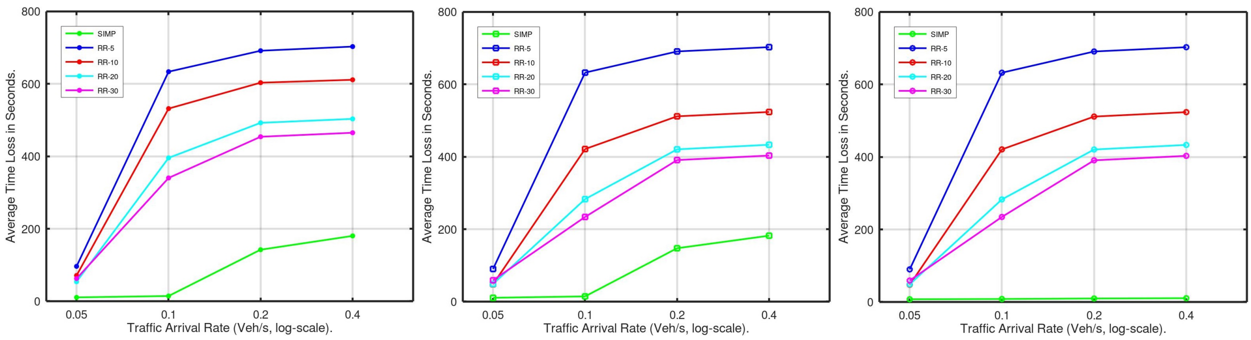
lights controller. RSUs communicate with each other, AVs communicate with RSUs while HVs are detected with sensors. The SIMP protocol gets information about the cars in the grid-area approaching the intersection, decides which cars can safely enter the intersection using a *Conflicting Directions Matrix*, and instructs the TLC component to allow or block the vehicle's access. This is done in a cyclic way that starts with the vehicles' detection, including the desired direction, then proceeds with the access decision and then waits for vehicles exit to restart a new cycle.

We have implemented the IIMA and SIMP protocol using the SUMO v1.6.0 simulation framework on Intel Core i3-4160 CPU, 3.60Ghz × 4 processor, NVIDIA RTX 2070, 8GB RAM, and 64 bit Ubuntu 18.04.4 LTS OS. Experiments performed for basic situations of all vehicles turning left, right, or going straight under settings that are common in residential areas (speed of 30 Km/h). The 1000 mixed vehicles (50% AVs and 50%HVs) arrival was random with uniform distribution, and the frequencies per inflow road are 0.05 Veh/s, 0.1 Veh/s, 0.2 Veh/s and 0.4 Veh/s. We compare the time loss due to congestion at the intersection of RR policies with 5s, 10s, 20s, and 30s of green time (followed by a 4s yellow time) assigned per road against SIMP, in which multiple vehicles one from each non-conflicting lane are allowed into the intersection per cycle. Six runs were performed with different non-linear random-seeds but keeping the same among different IM policies, and the average of six-runs are presented in Fig. 1.

Results show that the SIMP offers the best performance, while RR shows a progression from low to better performance as the green time increases. Nonetheless, as shown in Fig. 1 SIMP dominates the tested scenarios, with a significant improvement in right turns (Fig. 1c), since it allows vehicles from all roads to take the intersection in parallel in a single cycle.



(a) Left Crossing (b) Straight Crossing (c) Right Crossing

Fig. 1: Average Time Loss in Seconds due to congestion at the Intersection.

3. Conclusions

In this paper, we have shown comparative simulation results showing that our synchronous IM that maximizes concurrency with guaranteed safety can reduce the waiting times at simple intersections in urban residential scenarios when compared to traditional Round-Robin management. The full paper will consider random directions and different travel speeds, as well as interesting results on fuel consumption that the SUMO framework provides.

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