Impact of Distributed Routing of Intelligent Vehicles on Urban Traffic

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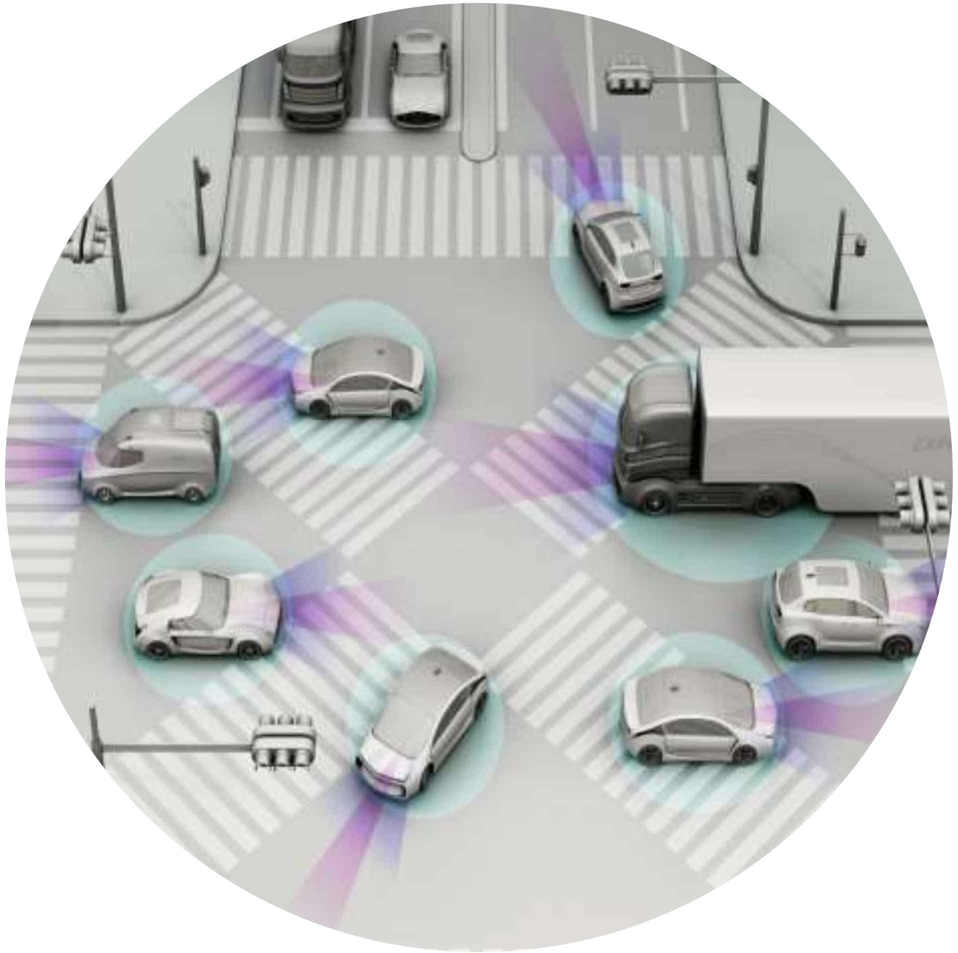
Project Synopsis

The impact of a distributed dynamic routing system has been studied in an agent-based traffic simulation for Downtown Toronto network with:

- Different market penetration rates (MPRs) of connected autonomous vehicles (CAVs)
- Different congestion levels

Content



Motivation

- Urban congestion has affected the traffic safety, air pollution, and use of energy.
- Urban congestion effects have been seen in the form of annual cost to commuters and to the economy.
- It has been shown that the higher the efficiency of a routing system, the less the congestion and the better the network performance.

Background

Distributed routing systems overcome the below shortcomings of centralized systems:

- Large capital investment
- Higher sensitivity to system failures
- Complexity of system upgrades

Background

- Hawas and Mahmassani found that distributed routing systems are more robust in the case of different traffic incidents e.g. lane blockage and for different levels and durations
- Joyung and Brian evaluated the efficiency of a route guidance strategy based on vehicle-infrastructure integration (VII). They found that the higher the MPR of equipped vehicles the better the network characteristics.

Methodology

Highly congested (demand factor=1, and 100% of CAVs are what we used to define the parameters below)

Updating Interval
- 4sec
- 30sec
- 60sec
- 180sec

IDM set
- Regular IDM
- Reduced IDM

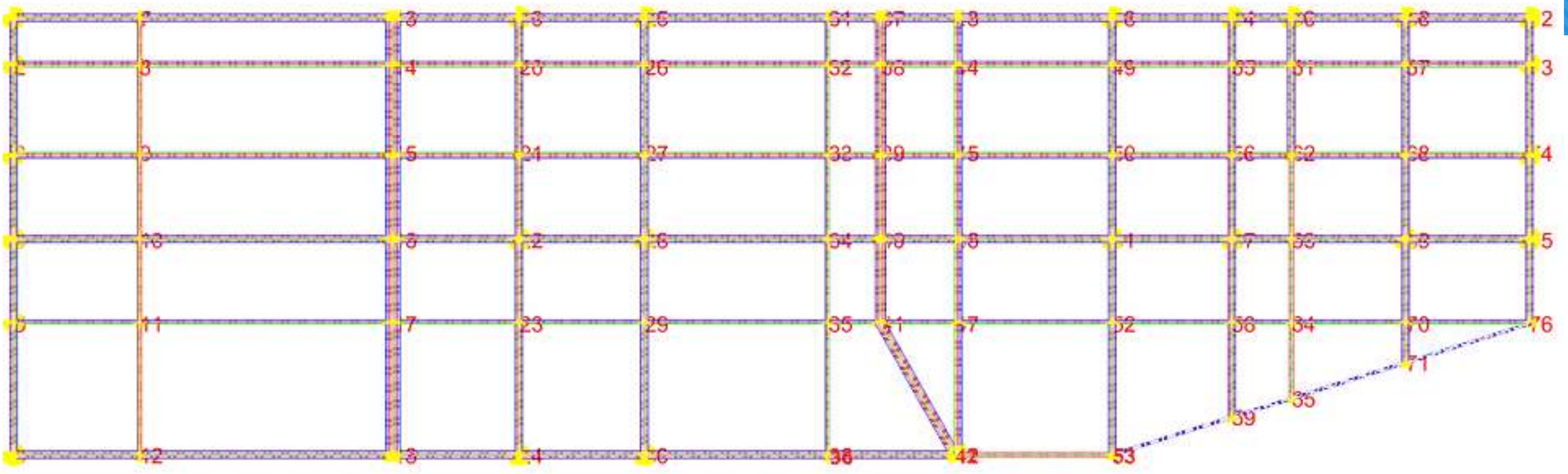
K-Paths
- 1 K-Path
- 2 K-Paths

MPRs of CAVs and Congestion Levels
- MPR (0%, 5%, 30%, 50%, 70%, 100%)
- Congestion level (Highly congested, congested, not congested)

Methodology

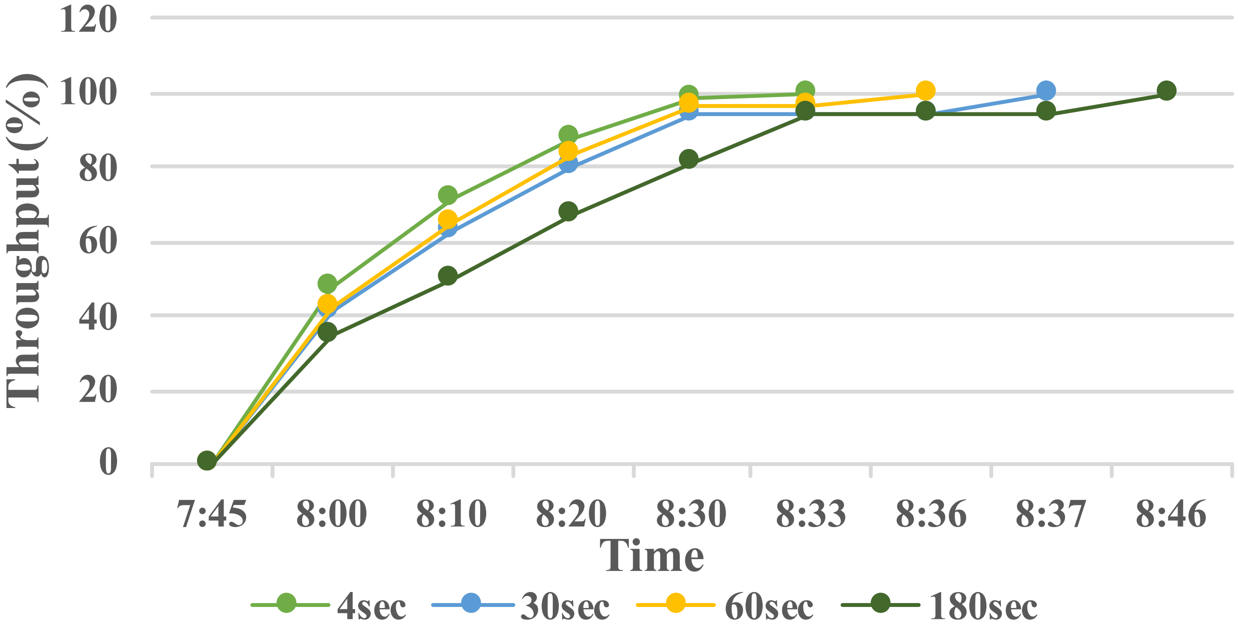
In this Study, the E2ECAV dynamic routing system algorithm developed by Djavadian and Farooq is employed

Case Study

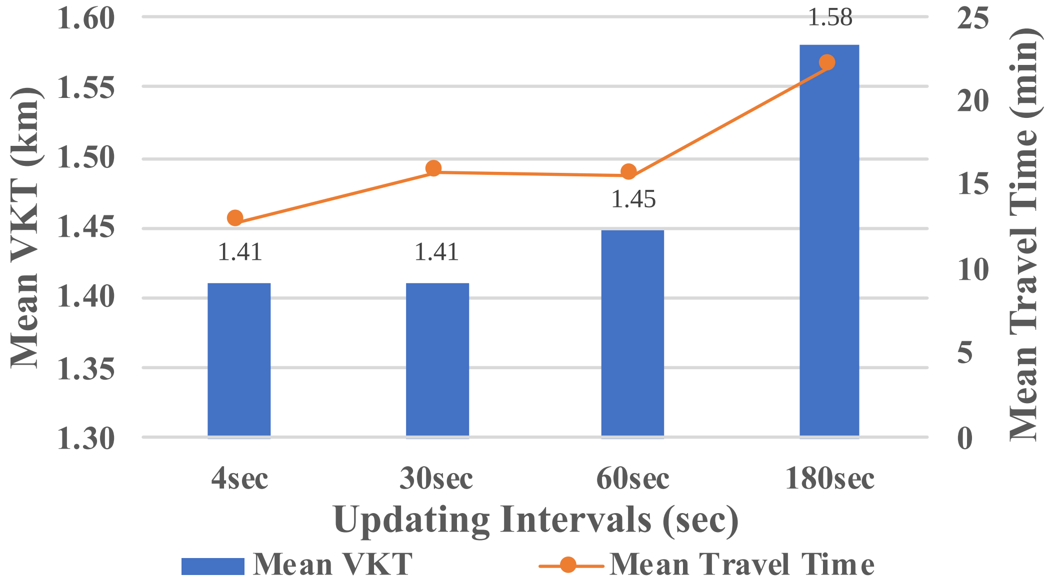


- Urban network of central downtown Toronto
- 223 links, 76 nodes (intersections), and 26 centroids (matched to the closest intersections)
- Morning peak hour: 7:45am - 8:00am

Discussion and Results



Throughput for Different Updating Intervals



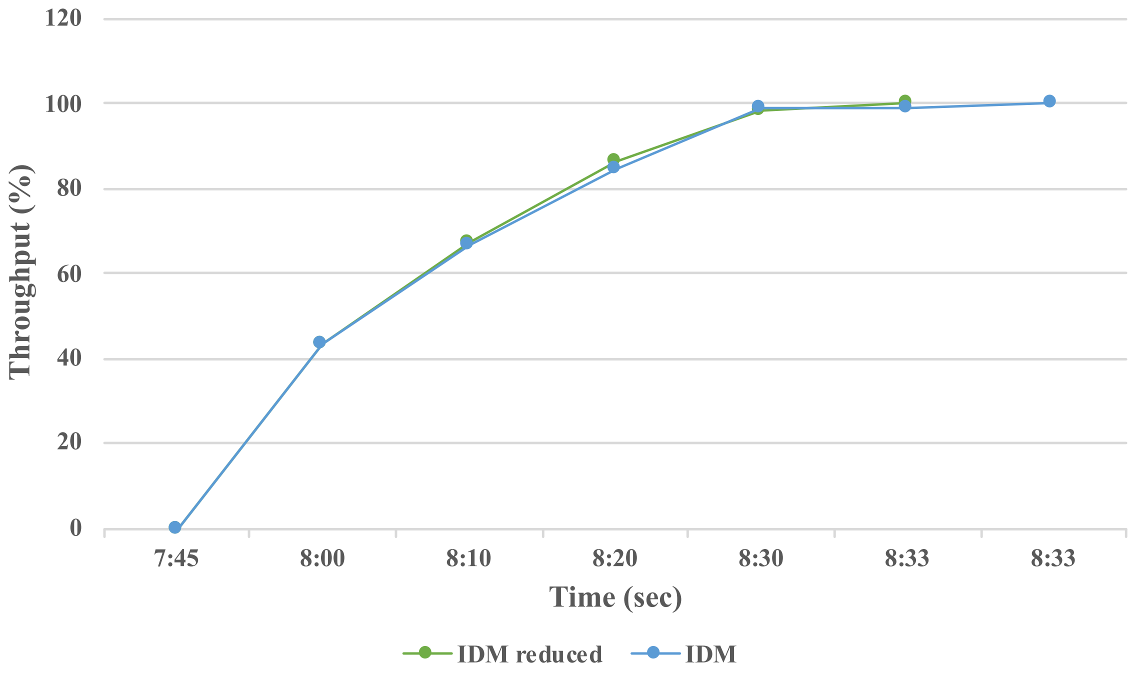
Mean Travel Time (min) and Mean Vehicle Kilometers Travelled (km) for Different Updating Intervals

Updating Interval | IDM Set | K-Path | MPRs of CAVs and Congestion level

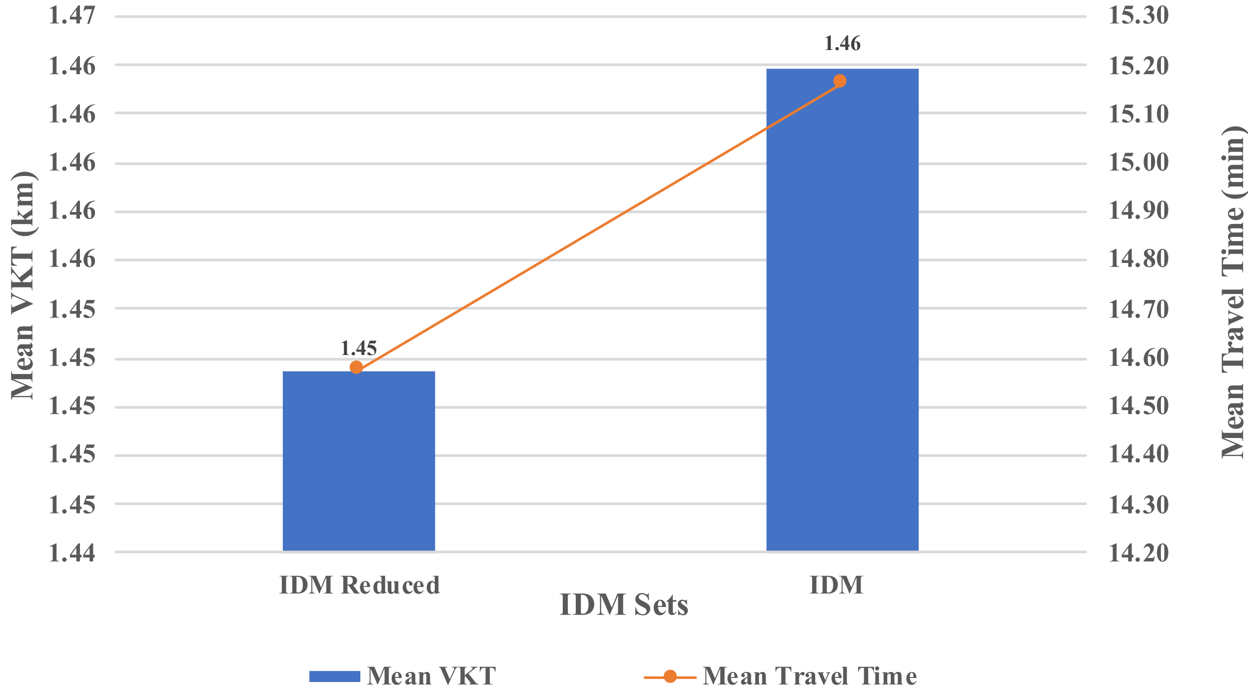
Discussion and Results

IDM	Safe spacing (m)	Reaction time (sec)
HDV	2	2
CAV	2	2
Reduced for CAV	1	1

Discussion and Results

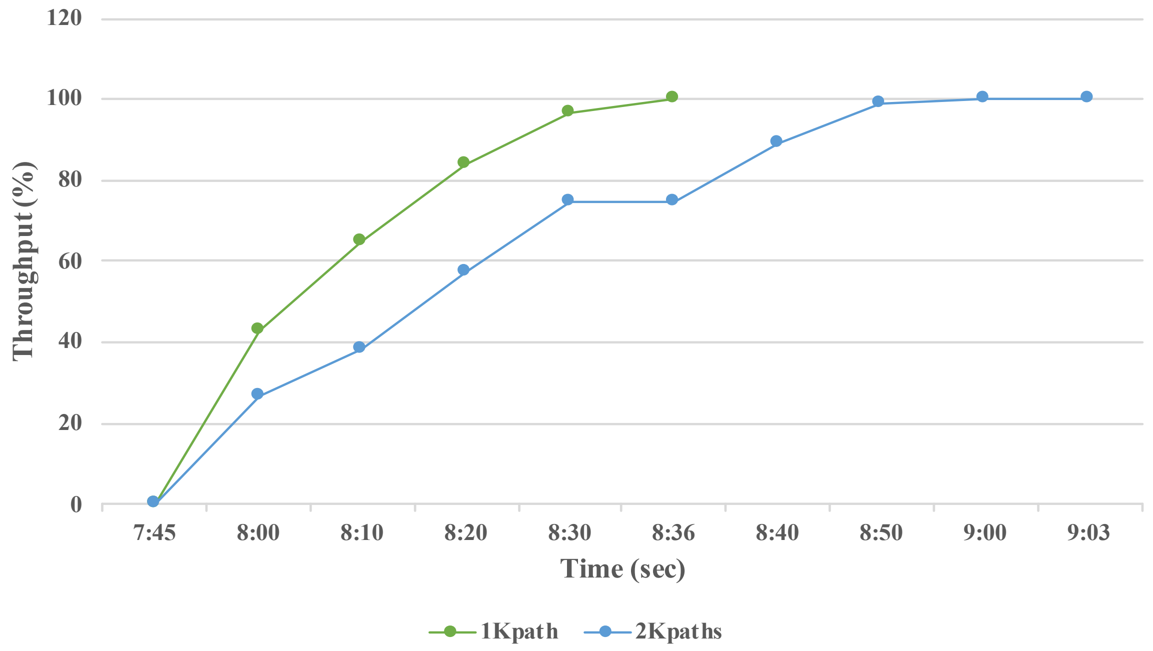


Throughput for Different IDM Sets

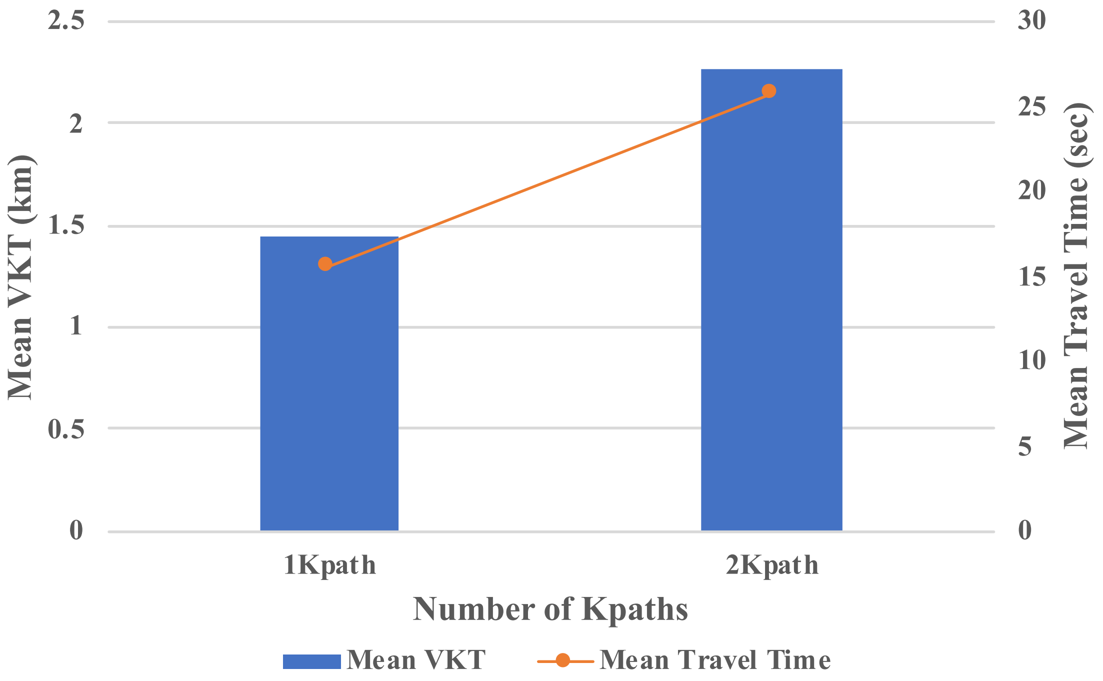


Mean Travel Time (min) and Mean Vehicle Kilometers Travelled (km) for Different IDM Sets

Discussion and Results

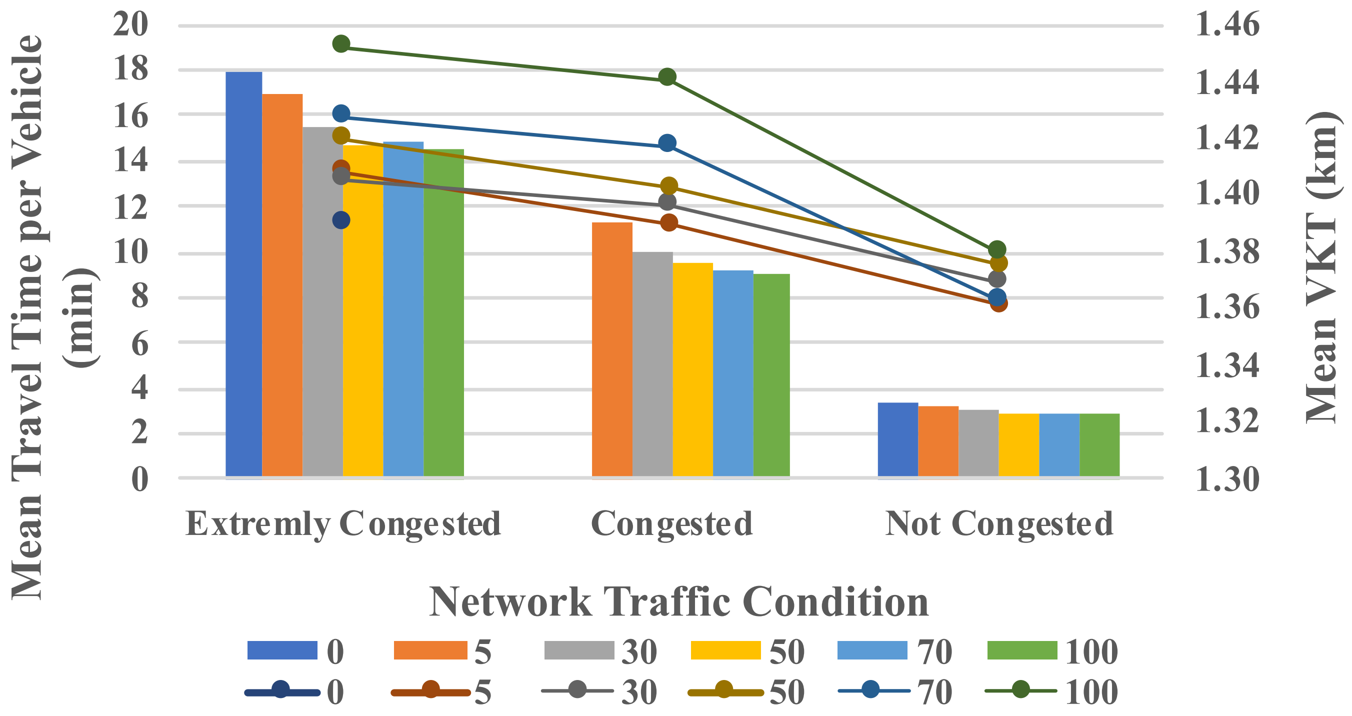


Throughput for Different K-Paths



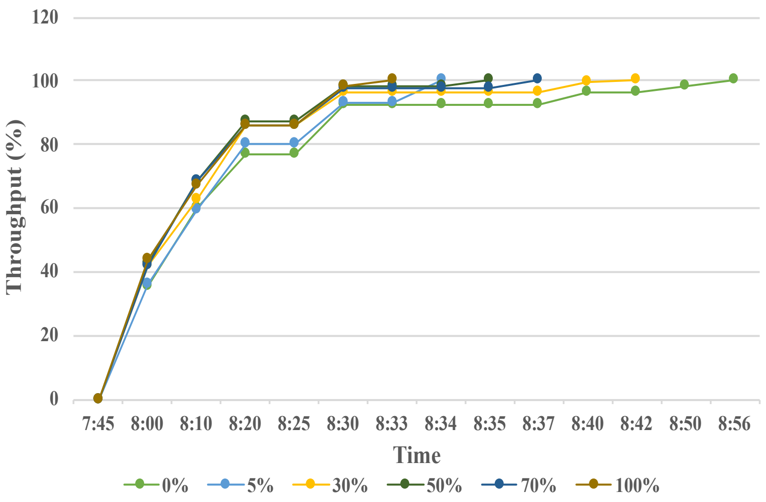
Mean Travel Time (min) and Mean Vehicle Kilometers Travelled (km) for Different K-Paths

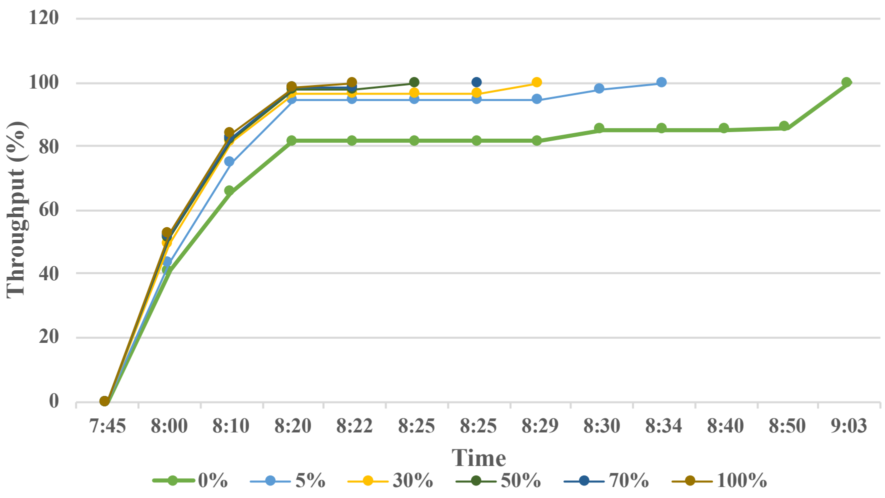
Discussion and Results

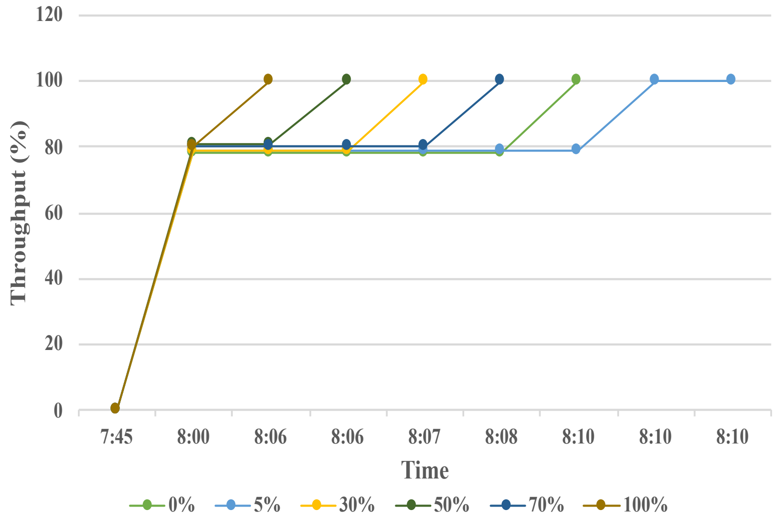


Mean Travel Time and Mean Vehicle Kilometers Travelled (VKT) for Different MPRs of CAVs and Traffic Conditions

Discussion and Results





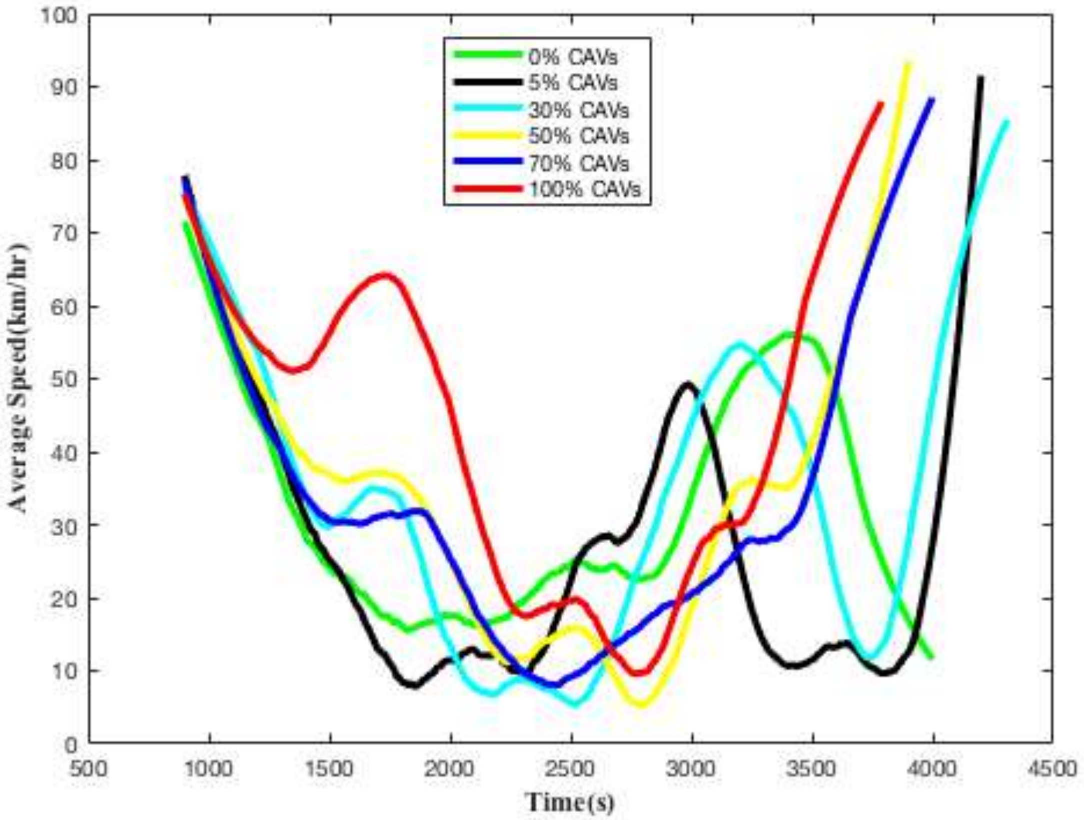


Throughput for Different MPRs of CAVs for the Highly Congested Traffic Condition

Throughput for Different MPRs of CAVs for the Congested Traffic Condition

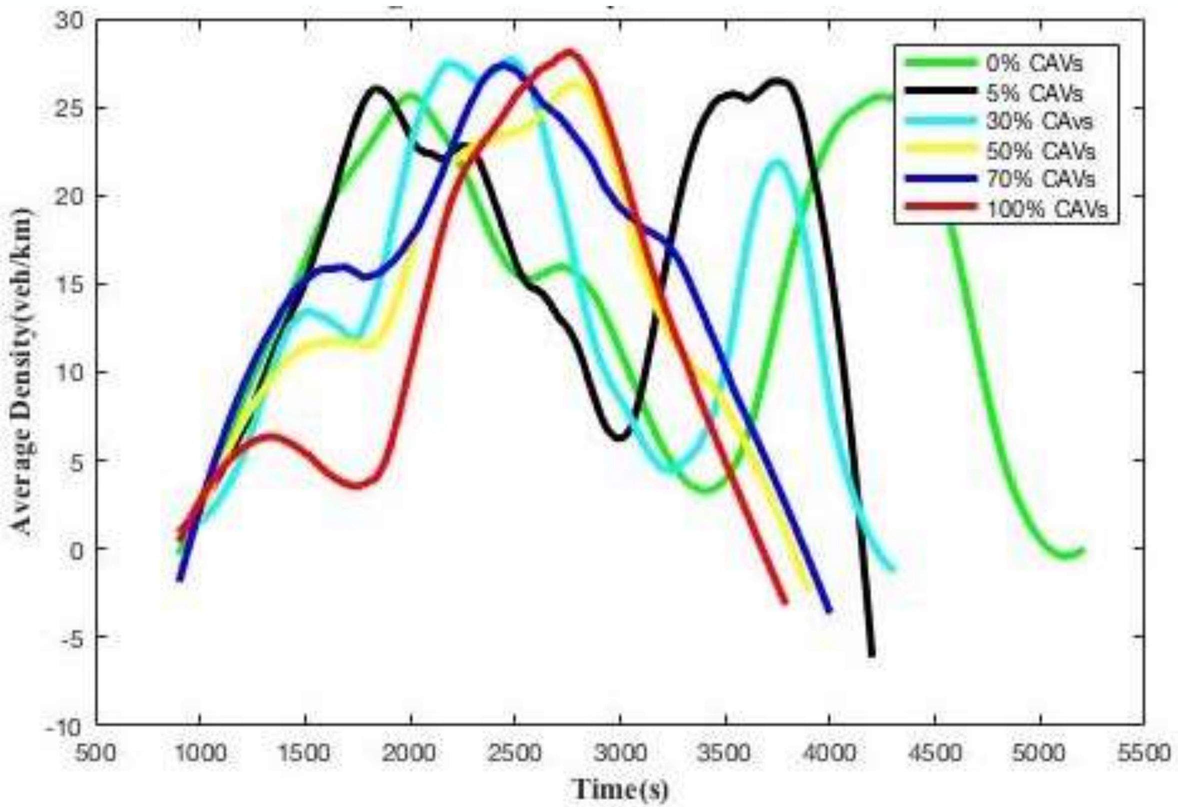
Throughput for Different MPRs of CAVs for the not Congested Traffic Condition

Discussion and Results



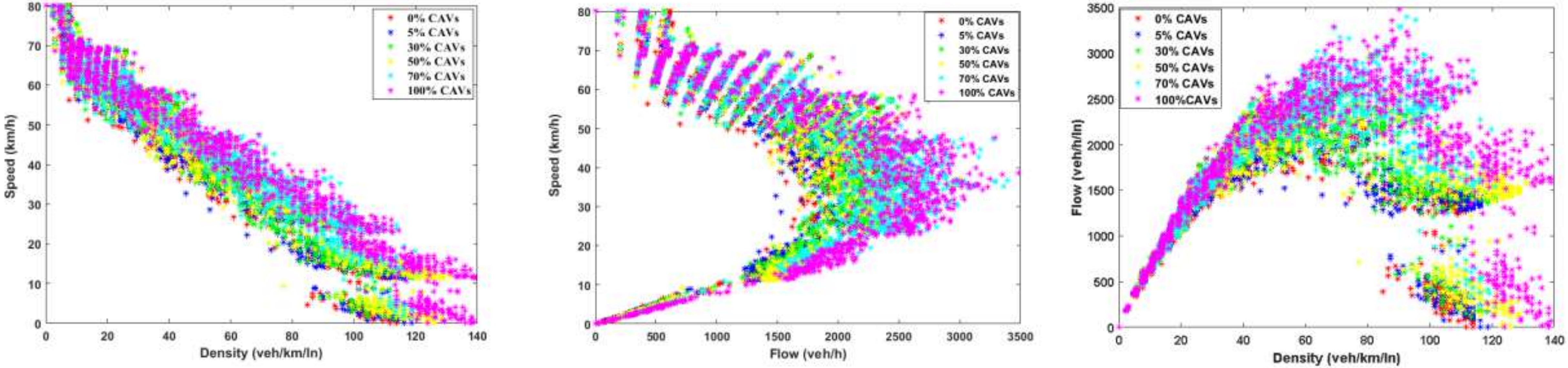
Average Speed for Different MPRs of CAVs for the Highly Congested Traffic Condition and for the Most Congested Link

Discussion and Results



Average Density for Different MPRs of CAVS for the Highly Congested Traffic Condition and for the Most Congested Link

Discussion and Results



Fundamental Diagrams for Different MPRs of CAVs of the Highly Congested Traffic Condition and for the Most Congested link of the Network

Conclusion

We demonstrate the effectiveness of a distributed dynamic routing system for intelligent vehicles (CAVs) at various levels of MPRs and traffic conditions on a large scale urban network

Conclusion

It was found that:

- 60sec updating interval is the optimal updating interval.
- Reduced IDM implementation is slightly better than the regular IDM set.
- The higher the MPR of CAVs, the better the traffic network characteristics.
- For the highly congested case, 100% CAVs resulted in an increase in the average speed of as high as 50km/h for the most congested link.

Conclusion

- A 4% increase of the mean vehicle kilometer travelled when employing 100% CAVs
- The impact of higher MPRs of CAVs is profound in the case of congested and highly congested traffic networks
- Density reduced by 88% when 100% CAVs were employed compared to 5% CAVs employed.
- For the highly congested traffic network, employing 50%, 70%, and 100% has relatively similar amount of reduction of the mean travel time of 18%.
- Fundamental diagrams of the most congested link illustrate substantial improvements

Future Studies

- We argue more emphasis on the effect of CAVs and on setting strategies that prevent looping and rerouting for more efficient algorithms that can be employed in the case of distributed routing systems.
- More replications of every scenario would give more consistent results and show the trend more accurately.
- Micro and Macro fundamental diagrams would definitely reflect the impact of the suggested E2E dynamic routing system

Acknowledgement

Ontario

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