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Investigating the Effects of Mixed Driver Reaction Times in the Transport Network

C. B. Rafter, S. Box – c.b.rafter@soton.ac.uk

Introduction

Given the advances in autonomous vehicle technology, vehicles may soon be able to drive as well as humans.

Here, autonomous vehicles are approximated as drivers with reaction times smaller than those of human drivers, but with the same driving competency. Experiments were performed to simulate the effects of loading the transport network with increasingly high proportions of vehicles with faster than normal reaction times, on four different road models.

Figure 1: Connected vehicles such as the Tesla Model S [3] incorporate sensor technology and driver assist functionality which may facilitate better driver reaction times or shorter time headways over traditional vehicles [4].

Simulation

The SUMO traffic microsimulator [1] was used to run experiments on traffic with different levels of vehicles with slow reaction (SR) and fast reaction (FR) times, on four road topologies (cf. Fig. 1). The details of the experiment are as follows:

- The Krauss car-following model [2] was used.
- Reaction time parameter τ was 1 s for SR vehicles, and 0.1 s for FR vehicles.
- Vehicles introduced at $\approx$ 1500 vehicles/hr.
- Percentage of FR vehicles incremented from 0% to 100% in steps of 5%.
- Experiment repeated 15 times.
- Delay calculated as the vehicle travel time less the freeflow travel time on the vehicle route.

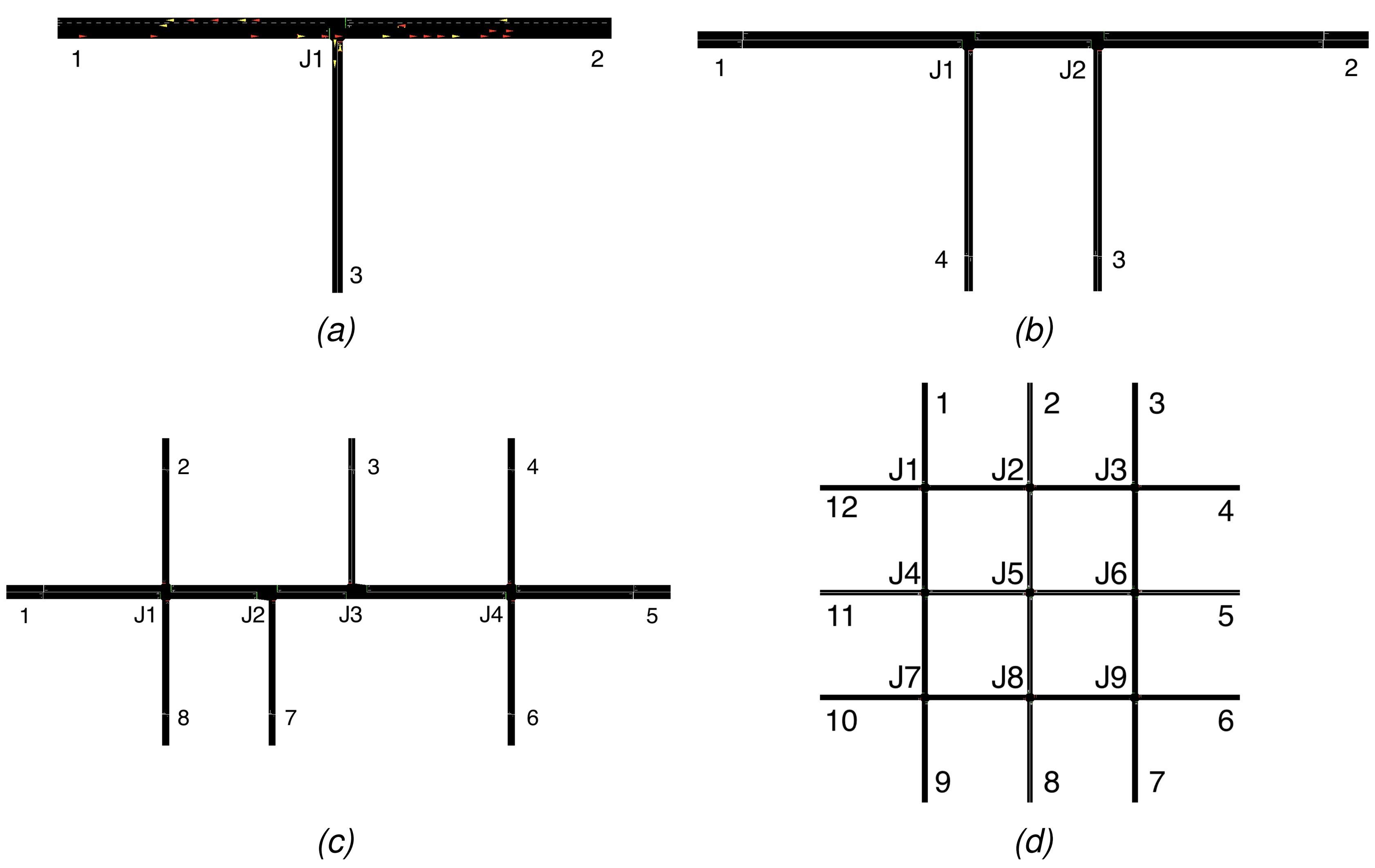

Figure 2: Snapshots of each of the four road topologies used in the simulations. (a) Simple T-Junction, (b) Twin T-Junction, (c) Corridor, (d) Manhattan grid.

Figure 3: An example of platooning in action. Slow reaction (SR) time vehicles can be seen in yellow, fast reaction (FR) vehicles in red. Note how the FR vehicles form a close grouping i.e. a platoon, with the SR vehicles, whereas the SR vehicles maintain larger less effective spacing due to their slow reaction times. The top lane shows 100% SR vehicles, the middle lane shows 50% SR & 50% FR vehicles, and the bottom lane shows 100% FR vehicles.

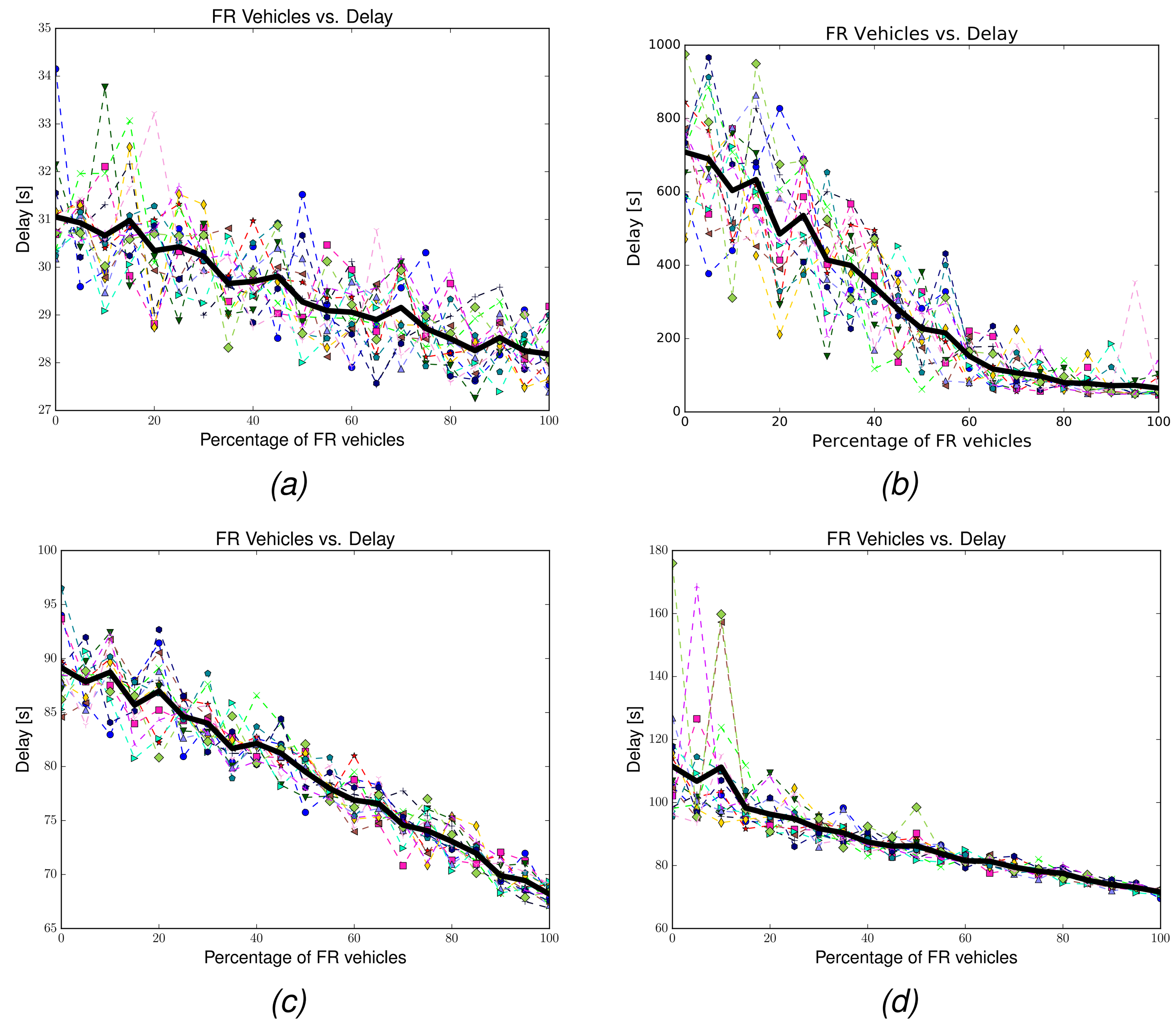

Figure 4: Delay results for increasing percentages of fast reaction vehicle traffic for each of the 4 simulations, the mean of the 15 runs is shown in black. (a) Simple T-Junction, (b) Twin T-Junction, (c) Corridor, (d) Manhattan grid.

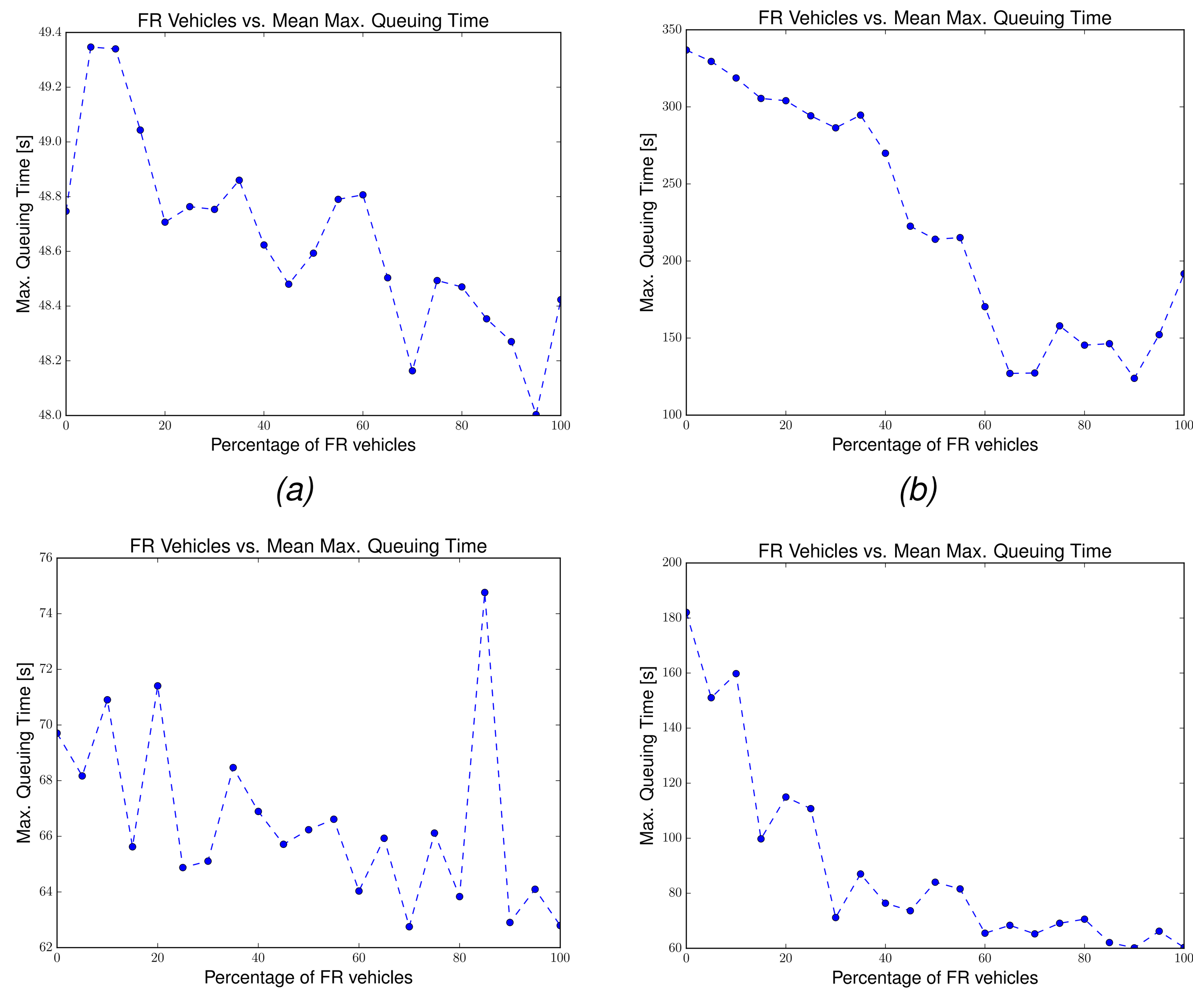

Figure 5: Mean max queing time results for increasing percentages of fast reaction vehicle traffic for each of the 4 simulations. (a) Simple T-Junction, (b) Twin T-Junction, (c) Corridor, (d) Manhattan grid.

Results & Discussion

The results suggest that the mean delay (cf. Fig. 2) in the network can be reduced if higher proportions of vehicles react faster to changes in the network. Interestingly, the decrease in delay is linear, possibly suggesting that the interaction between fast reaction time and slow reaction time vehicles is unimportant. It is also observed that vehicle queue durations are seen to decrease even if their length is stationary.

Further work must be done to determine a suitable car-following model for autonomous vehicles, and to better describe the dynamics between human drivers and autonomous vehicles.

Acknowledgements

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References

[1] D Krajzewicz, M Bonert, and P Wagner. *The open source traffic simulation package SUMO. RoboCup 2006 Infrastructure Simulation Competition*, 2006. [2] Stefan Krauß. Microscopic modeling of traffic flow: Investigation of collision free vehicle dynamics. *DLR - Forschungsberichte*, (8), 1998. [3] Photograph By User raneko on en.wikipedia, via Wikimedia Commons, under license CC BY 2.0 [4] Photograph By User Asterion on en.wikipedia, via Wikimedia Commons, under license CC BY 2.5