Metropolitan Transit Simulation: Assessing the Symbiosis of Public and Private Mobility

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Overview

- **Problem:** Due to mounting challenges posed by traffic congestion and air pollution within urban city centers, authorities are implementing more restrictions and regulations. Public transportation, car-sharing, sustainable vehicles, and Mobility-as-a-Service have all increased in popularity as solutions to tackle these challenges. Nevertheless, there is evidence that these new trends might not help as expected[1,2].
- **Why it matters:** Traffic congestion decreases the effectivity and punctuality of commutes, impacting individuals, and businesses by making logistics operations more costly. Worse air quality derived from congestions impacts human and ecosystem health.
- **Gap:** Research focuses more on improving vehicle technology than on optimizing the transport system. There is a need for more studies using a systems engineering perspective.
- **Research Question:** In the context of a congested city block, does the type of transport (private car or public bus) in the network affect the dynamics of the system?
- **Hypothesis:** *If the ratio between public bus and private cars is modified, and the dynamics of the transportation system change, then there exists an optimal ratio for system efficiency.*

Methods

- Use a model using AnyLogic to simulate a square city block of standard dimensions of 210x210m (690x690ft).
- The base model of the city block has a 4 nodal layout, where passengers are created at any of the nodes with another destination node assigned and a form of transport selected: private car or public bus.
- Each simulation tests a different private car to public bus passenger ratio (ρ) and different agent generation rates (α) .
- It measures how many passengers arrive to their destinations, and their commute duration to assess system performance.

Model Diagram

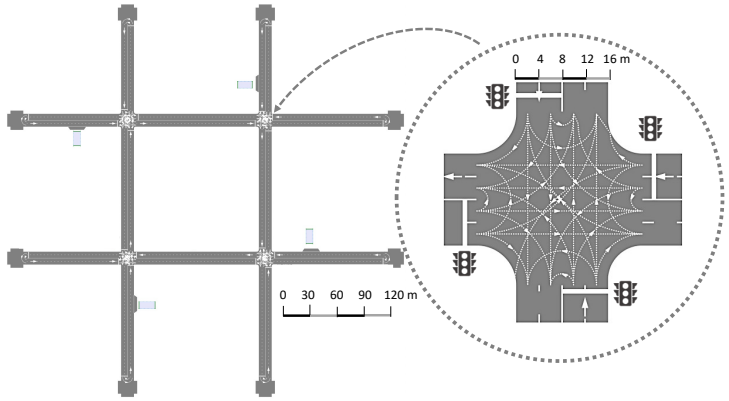

Figure 1:Nodal Layout with Intersection Design. Images from AnyLogic model

Results

2970 runs: 9 different rates of generation (α) to evaluate different levels of congestion, and ratios (ρ) from 0 to 1 in 0.1 increments to evaluate different transport type configurations. Each simulation is run 30 times to mitigate any bias caused by the stochasticity of the model.

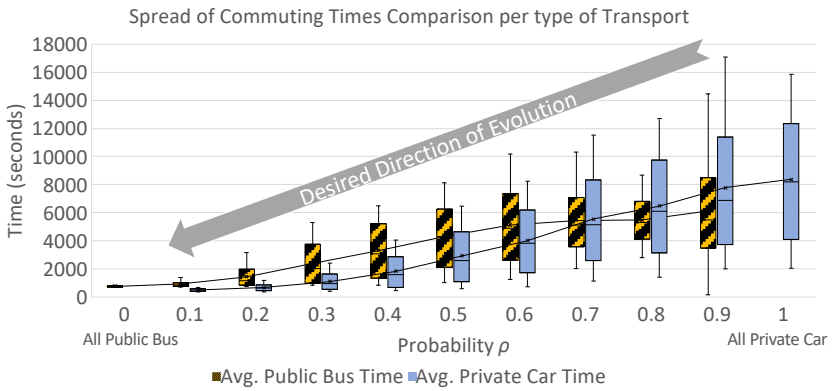

Figure 2: Box and whisker plot of Average commuting times for Public Bus and Private Cars per Probability ρ value

Discussion

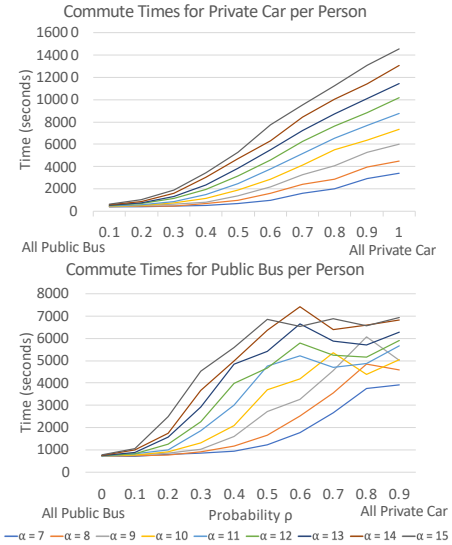

Figure 3: Commute Times for Private Car and Public Bus per Generation rate (α)

Conclusion

- There is no ratio that optimizes system performance. **The more public transport is used, the less congestion**.
- **Regulators have to be careful when promoting public transport**. In the region for $\rho>0.5$, an incremental decrease of ρ leads to more uncertainty and variance in the system, increasing commuting times for public transport users.

Future Work

- Adapt model to simulate a real city network and present findings to regulators.
- Increase precision of ρ ratios simulated to understand better bus commuting times patterns for $\rho>0.5$ area.
- Add excess / shortage of available buses scenarios.

Citations

1. Schaller, B. (2018). The new automobility: Lyft, Uber and the future of American cities.
2. Qian, X., Lei, T., Xue, J., Lei, Z., & Ukkusuri, S. V. (2020). Impact of transportation network companies on urban congestion: Evidence from large-scale trajectory data. Sustainable Cities and Society, 55(C), 102053–. https://doi.org/10.1016/j.scs.2020.102053

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