The effects of ride-pooling on network capacities: A microscopic simulation approach

Master‘s Thesis of Tonmoy Das

Mentoring:
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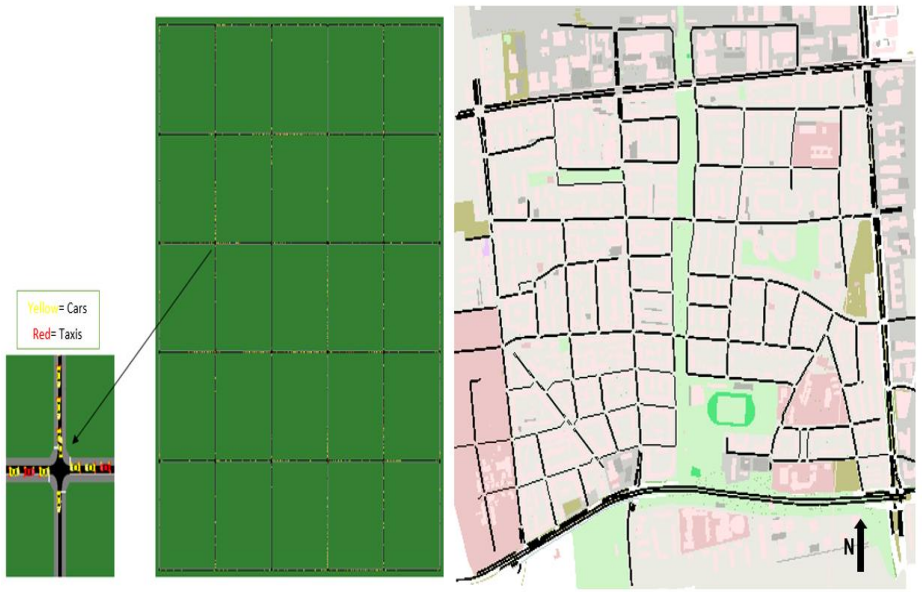

Fig 1: Grid network and real-world network

In this thesis, p-MFDs for different scenarios with varying mode ratio are simulated for an artificial and real-world network to analyze and compute the optimal flow state of these networks. The simulations were generated in the microscopic simulation environment of SUMO and the outputs were analyzed using python scripts to find the relationship between multi-modal vehicle accumulation and passenger production. The simulated results show that network with vehicles which reroute according to the congestion occurrences has more capacity compared to the network without rerouted vehicles, which means adaptive driving behavior increase network capacities.

p-MFD for scenario 1 shows that maximum passenger production is significantly higher between ride-hailing and ride-pooling taxis for grid network, proving that for grid network ride-pooling services increase network capacity. Although similar observation can be seen in the real-world network, the difference isn’t significant. Scenario 2 with real-world ride-hailing services shows higher network capacity compare to the ride-pooling services, however at lower accumulation ride-pooling services have better serviceability.

Scenarios	Grid network			Real-world network		
	Production, p	Accumulation, Q	Average density, k	Production, p	Accumulation, Q	Average density, k
Base scenario (rerouting off)	66815	2104	30	43932	3342	49
Base scenario (rerouting on)	72363	2687	38	54296	2135	31
Scenario 1 (ride-hailing)	80025	4444	64	81610	7164	105
Scenario 1 (ride-pooling)	85151	5385	77	82493	7037	104
Scenario 2 (ride-hailing)	69660	3912	56	71754	6796	100
Scenario 2 (ride-pooling)	75342	4342	62	61738	6970	103
Scenario 3 (ride-hailing)	60309	4206	60	50851	6349	93
Scenario 3 (ride-pooling)	63147	2853	41	59614	5043	74

Tab 2: Grid and real network maximum p-MFD values for different scenarios.

The network capacity of large urban networks is rapidly being consumed by the increasing number of private vehicles. Although, different novel mobility services are trying to serve increasing passenger demand, however, it is difficult to measure the impacts of these mobility services on the network capacity by the existing traffic management tools. Passenger Macroscopic Fundamental Diagram (p-MFD) allows transport management authorities to assess optimal passenger demand allocation by relating total accumulation of the private vehicles and ride-pooling or ride-hailing taxis to the total passenger production of the network. Main goal of this thesis study is to analyze how network capacity changes due to adaptive driving behavior and to find out the impact of ride-pooling vehicles on the network capacities using microscopic simulation environment of SUMO.

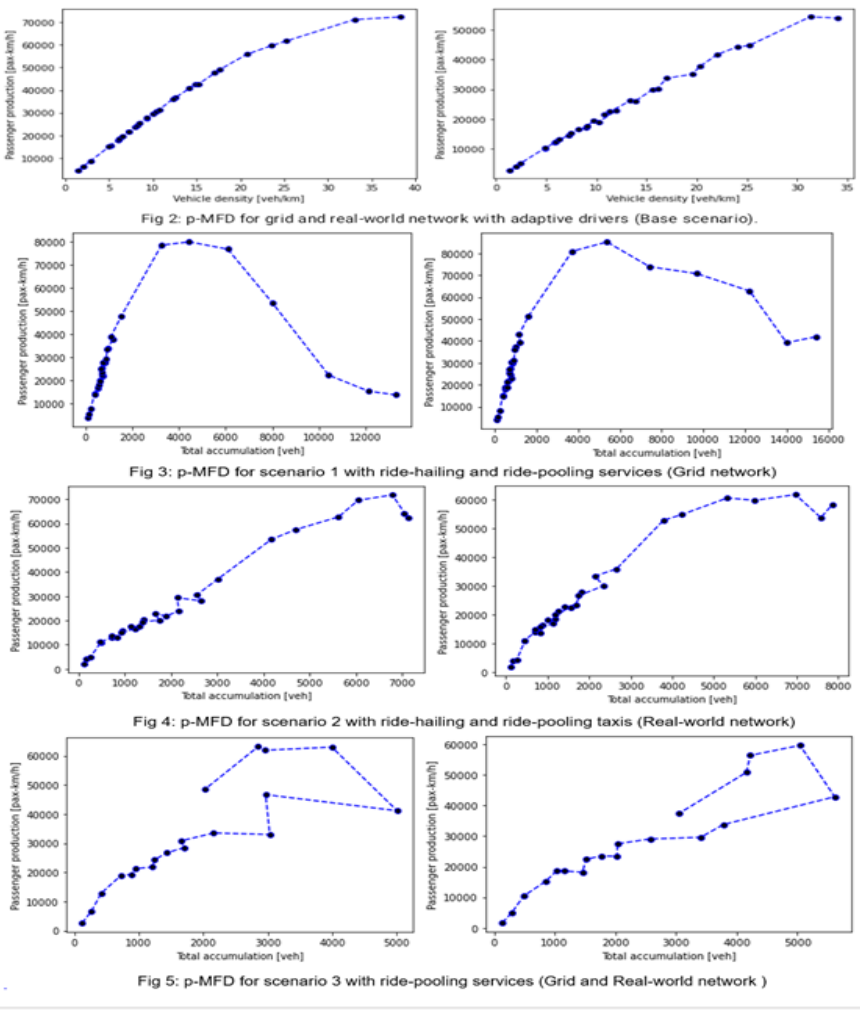

Fig 2: p-MFD for grid and real-world network with adaptive drivers (Base scenario).

Fig 3: p-MFD for scenario 1 with ride-hailing and ride-pooling services (Grid network)

Fig 4: p-MFD for scenario 2 with ride-hailing and ride-pooling taxis (Real-world network)

Fig 5: p-MFD for scenario 3 with ride-pooling services (Grid and Real-world network)

Scenario 3 shows high scattering when the aggregation period is 5 minutes. In higher aggregation period, a low-scatter p-MFD can be seen with anti-hysteresis loop occurring in higher average density. Ride-pooling vehicles are constantly repositioning to pick up passengers, leading to collisions between vehicles. When queue gets cleared, passenger production increases and average density reduces, as a result an anti-clockwise hysteresis loop form on the p-MFD shape.

Comprehensively, p-MFD for the scenarios with ride-pooling taxis shows well defined and low scatter p-MFD curves. Moreover, ride-pooling p-MFDs have higher passenger production and higher jam density. By comparing between ride-hailing and ride-pooling p-MFDs, it is proven that the mode choice of the passengers affects the shape of the p-MFDs.