Effectiveness of Public Buses to Mitigate Traffic Congestion in Dhaka City: An Agent Based Simulation Study

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Executive Summary

Dhaka, the capital of Bangladesh and the 4th most densely populated city in the world, is experiencing the worst traffic congestion in recent years. Currently, there is no specific policy to curb the number of private cars (75% cars versus 25% public buses) on the overcrowded roads of the city, leading to serious traffic congestion. To be more specific, the over-reliance on private cars over mass public transit is one of the major causes of local traffic congestion, and its impacts have not been investigated judiciously. In this study, we design a microscopic traffic simulation using Agent-Based Modeling (ABM) approach to represent the traffic flow and understand the congestion patterns. This design specifies the characteristics and behavior of numerous interacting agents (vehicles, roads, traffic signals, and bus stoppages) in a spatially explicit road network. Further, we evaluate the effectiveness of various 'trade-off' strategies between the proportion of private cars and public buses. Our simulation results show that, with the composition of 65% car versus 35% public bus, the average traffic speed can be increased by 13.5% and delay time can be decreased be by 15.3% while with a composition of 55% car versus 45% bus can raise the speed by 29.9% and cut the delay time by 29%.

Background

- 3,200,000 work-hours lost everyday due to traffic congestion in Dhaka [1]
- Yearly loss: USD 3.75 Billion (Source: World Bank). [2]
- Passenger car and public bus volume: 75% versus 25%

Figure 1: Traffic congestion in Dhaka city [3,4]

Objectives

- To study the effectiveness of passenger cars and public buses volume ratio tradeoff strategies on traffic congestion in major roads in Dhaka city.
- Impacts on the key performance parameters of road traffic (average vehicle speed, average delay) are evaluated satisfying the hourly demand of passengers' travel need.

Data used

Field survey on Mirpur Road (Technical bus stop to Azimpur), one of the major arterial roads in Dhaka city [5-7].

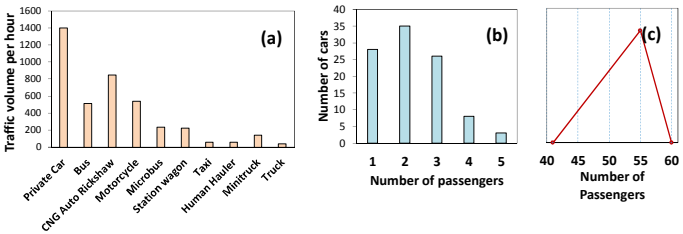

Figure 2: (a) Hourly traffic volume of different types of vehicles at pick hour
(b) Passenger car occupancy distribution
(c) Public bus occupancy distribution

Experimental Setup

Table 1. Experiments

Scenario	Passenger Cars per hour	Public Buses per hour	Passengers to transport
Base	1560 (74.9%)	522 (25.1%)	Target amount is 30,600 passengers per hour
1	1014 (65%)	546 (35%)	
2	684 (55%)	560 (45%)	

Software used : AnyLogic 8.1.0
Studied road network : Mirpur Road
Simulated road network length: 24km (approx)
Traffic driving direction : Left-Hand
Warm up time : 30 minutes
Statistics collected : 9 -10 am (morning pick hour)

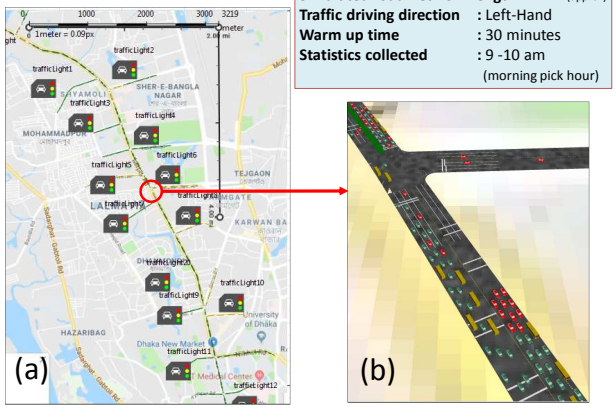

Figure 3: (a) Mirpur Road network in Agent Based Simulation
(b) Enlarged view of a portion of the simulated road network

Simulation Results

Table 2. Simulation output for different scenarios

Run number	Average speed (kmph)			Average delay (minutes)			Passengers transported		
	Base model	Scenario 1	Scenario 2	Base model	Scenario 1	Scenario 2	Base model	Scenario 1	Scenario 2
1	13.70	16.59	18.11	29.47	23.06	20.12	30,167	31,301	30,501
2	14.43	16.99	18.60	27.60	22.08	18.81	30,252	30,939	29,393
3	13.86	16.02	15.74	28.52	24.01	23.32	32,047	31,296	32,876
4	13.43	16.43	16.55	29.84	23.19	22.81	30,559	30,702	29,343
5	14.68	16.80	18.93	26.92	22.05	19.44	29,978	30,910	29,987
6	13.49	14.54	19.48	28.71	26.42	19.08	33,085	29,884	29,837
7	14.52	15.38	19.45	27.25	24.28	18.20	29,054	31,560	30,326
8	13.80	15.89	18.67	28.16	23.59	19.96	31,491	29,900	30,053
9	13.74	15.68	18.39	29.22	24.73	19.57	33,228	32,361	31,126
10	14.94	15.30	18.79	26.77	25.71	19.37	31,444	29,705	30,441
Average	14.06	15.96	18.27	28.25	23.91	20.07	31,131	30,856	30,388

Scenario	Performance Parameters	
	Vehicle average speed (kmph)	Average delay (minutes)
Base model VS Scenario 1	13.5% ↑	15.3% ↓
Base model VS Scenario 2	29.9% ↑	29.0% ↓

Statistical Analyses of the Simulation Results

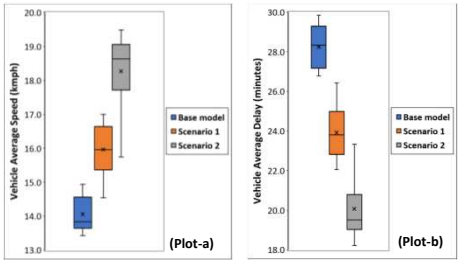

Figure 3: Boxplot of data for different simulation runs
(a) average speed (b) average delay

Table 3: Tukey Simultaneous Tests for Differences of Means (Vehicle Average Velocity, kmph)

Difference	Difference of Means	SE of Difference	99% CI	T-Value	P-Value
Scenario 1 - Base	1.903	0.395	(0.647, 3.159)	4.82	0.000
Scenario 2 - Base	4.210	0.395	(2.954, 5.466)	10.67	0.000
Scenario 2 - Scenario 1	2.306	0.395	(1.051, 3.562)	5.84	0.000

Table 4: Tukey Simultaneous Tests for Differences of Means (Vehicle Average Delay, minute)

Difference	Difference of Means	SE of Difference	99% CI	T-Value	P-Value
Base - Scenario 1	4.334	0.635	(2.313, 6.355)	6.82	0.000
Base - Scenario 2	8.178	0.635	(6.157, 10.199)	12.88	0.000
Scenario 1 - Scenario 2	3.844	0.635	(1.823, 5.865)	6.05	0.000

Table 5: Dunnet Simultaneous Tests for Differences of Means (Passengers transported)

Difference	Difference of Means	SE of Difference	99% CI	T-Value	P-Value
Scenario 1 - Base	-275	492	(-1796, 1220)	-0.56	0.801
Scenario 2 - Base	-742	492	(-2237, 752)	-1.51	0.244

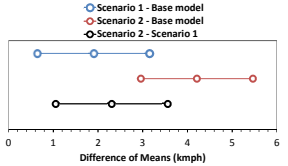

Figure 4:Tukey pairwise comparisons of vehicle average speed

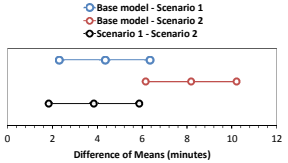

Figure 5:Tukey pairwise comparisons of vehicle average delay

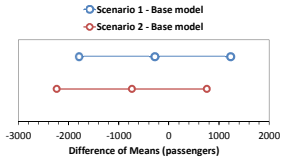

Figure 6: Dunnet pairwise comparisons of number of passengers transported (with respect to control group, base model)

Conclusions

- Shifting 10% of the cars' passengers to public buses can improve average vehicle speed by 13.5% and cut average delay off by 15.3%.
- Shifting 20% of the cars' passengers to public buses can improve average vehicle speed by 29.9% and cut average delay off by 29%.
- The findings might help the policymakers to decide the appropriate trade-off of car-bus ratio.

In this study, traffic behavior of one of the major arterial roads in Dhaka city has been simulated using ABM. In future, a more comprehensive simulation model can be developed by including rest of the road networks in the city to get more specific results. Impact of unconventional road intersection designs on traffic congestion can be also incorporated in the study.

References

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