Performance Impact of Various Bus Priority Strategies Using Vissim 7.0

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Abstract - *In developing countries like India, people are abhorrent towards the public transportation, mainly because of the pitiable service quality and travel delay. Congestion at the intersection is very common these days. In order to improve the public transportation and reduce the congestion, giving priority to the buses at the intersection can be possible approach. In this paper, two different transit priority strategies at an intersection are analyzed and their performance impact is evaluated. The impact of bus priority is measured in terms of reduction in delay of the buses and cars, due to the priority given. The main findings of the study are that the bus priorities are more efficient at high volumes. Transit priority strategies include reservation of existing lane for the buses near the intersection or adding extra lane for the buses and insertion of phase exclusively for the buses in the traffic signal. Micro-simulation tool VISSIM is used to carry out the simulation process. This study can act as the reference for best traffic control methodology that can be adopted at any signalized intersection to reduce the total delay.*

***Key Words*: Bus Priority, Exclusive Bus Lane, Queue Jump Lane, Micro-Simulation, Heterogeneous Traffic.**

1.INTRODUCTION

Due to increasing traffic volume, congestion at the urban intersection is very common these days. This traffic jam at the intersection is mainly attributed to the Indian heterogeneous driving conditions. Traffic in developing countries such as India, Taiwan, and Vietnam is non-homogeneous in nature, which comprises of wide-ranging mix of traffic having different static and dynamic conditions. The mix comprises of motorized as well as non-motorized vehicles plying on the same road. There are no lane markings, no constant lane width and no vehicle follows lane laws. The feeling of owning a private vehicle, comfort level, socio-economic status of the people etc. are the other reasons of the congestion.

One way to tackle the congestion is to augment the geometrical properties of the roads in order to increase its capacity. However, this elucidation is not always conceivable because of many reasons. Another approach is to promote the public transportation like buses, by giving them priority at the signalized intersections over the other vehicles. A bus can carry twenty times as many passengers as a car, and it only contributes to three times to the congestion. But due to the large size of buses and heterogeneous traffic condition leads to unpleasant travel and hence are less appealing to the passengers. This requires giving priority to the buses over the other vehicles.

This paper analyses the impact of giving transit priorities at an intersection in terms of change in the delay of the buses and cars. The paper is divided into following sections:

- Literature review.
- Objective.
- Study area and Data Collection
- Development of model (Calibration and Validation)
- Bus Priorities techniques adopted
- Comparison of output with and without bus priority
- Results and Conclusion

2. LITERATURE REVIEW:

Vast study has been done previously to implement and model various bus priority measures on urban intersections like Queue Jump Lanes, Transit Signal Priority (TSP), Phase Insertion with different locations of the bus lanes, Intermittent Bus Lanes Priority with and without TSP etc. The evaluation of the above methodologies is based on the parameter of total delay reduction for the buses as well as the other traffic. The benefits of these treatments vary greatly depending on the specific characteristics of the study area, including turning movement and pedestrian volumes, signal timing parameters etc.

Tod et al. [1991] in short discuss queue jump lanes, and the authors provide a transit vehicle time savings of between six and 29 seconds, with added delay to traffic of 0.3 to 2.9 seconds per vehicle. Bhargab Maitra et. al. [2014] simulated the provision of queue jump lanes on three intersections in Indian traffic conditions. In case of Exide Intersection, the total delay of the buses reduced from 110 seconds to 50 seconds at 100% traffic volume, where as in case of Hazra Intersection, the delay reduction is of about 5 seconds and in case of Rashbehari Intersection there was no any change in the delay of the buses due to the provision of the Queue jump lanes. The evaluation of TSP in Indian condition is very limited in the previous literature. Although TSP is vastly studied topic in foreign conditions. Vaibhavi et. al. [2004] studied the impact of implementation of TSP along the corridor U.S. 1, having twenty-six intersections. The strategy of 10 second green extension was adopted and simulated in Vissim 3.7. Overall, improvements of up to 4% for transit travel time savings and 5-13% reduction in control delay for transit vehicles were observed. Considering all side street traffic, the total increase in maximum queue length might be up to 1.23%.

Additional signal phase exclusively for buses is inserted in the signal cycle. This strategy is integrated with queue jump lanes, exclusive bus lanes near the intersection for better results. The location of exclusive bus lanes along with the left turners can be kept either along the curb or the median. Various alternative strategies within this can be adopted depending upon the location of bus lanes, provision for left turners etc. Vedagiri et. al [2012] carried out the performance impacts of this strategies at an intersection in Mumbai, using micro-simulation tool Vissim. Total six different strategies were tested out of which three had bus lanes on the curb side and three having it on the median side. The results showed that the delay reduction of whole traffic is not prominent when the traffic volume is less. However, when the traffic volume is more than 3000 Veh/hr, the delay for the whole traffic is reduced considerably. On an average there was a delay reduction of about 40 seconds for the traffic and about 55 seconds for the buses. These methodologies are best suited for Indian traffic conditions, because of its simplicity in implementation and evaluation.

Thamizh Arasan [2009 and 2010] used a microsimulation program to study the effects of reserved bus lanes on heterogeneous traffic on urban roads in India. The effects of provision of exclusive bus lane is measured in terms of the reduction in speed of the other vehicles. This study gives the justification of providing the exclusive bus lanes on the urban road in Indian traffic conditions. However, the transferability of the results on the intersection or on non-urban roads is to be studied. The authors used a computer program exclusively for Indian traffic. However, the Indian traffic conditions can now be simulated in VISSIM itself.

Baichuan Liu [2001] introduces the concept of an Intermittent Bus Lane (IBL). This paper proposes using in-pavement lights to prevent vehicles from changing into the rightmost lane as the bus approaches, but this approach relies on transit signal priority to trigger the green signal at an intersection to clear out an existing traffic queues. This system is not suitable for the heterogeneous traffic conditions and where the traffic volume is much higher.

3.OBJECTIVE

The objectives of the paper are as follows:

- To study various bus priority strategies under Indian traffic conditions at an intersection, in terms of reduced delay for buses.
- To analyze the impact of giving bus priorities at an intersection in terms of change in the delay of the buses and cars.
- To study new features and utilize the applications of micro-simulation tool VISSIM 7.0 to it's potential.

4. STUDY AREA AND DATA COLLECTION:

Four armed intersection, Hinjewadi chowk, in Pune, Maharashtra was selected as the part of study. Figure 1 provides the Google Earth view of the Hinjewadi Chowk, peak hour turning movements and signal phasing.

Hinjewadi chowk is a four-legged intersection with fast moving traffic. Right turning movement is prohibited on Eastbound and Westbound roads during peak hours. The traffic is heterogeneous with no lane laws. The common modes of transport that ply in this area are passenger cars, buses, commercial vehicles, motor cycles and three wheelers. The composition of these modes of traffic is as shown in Figure 2.

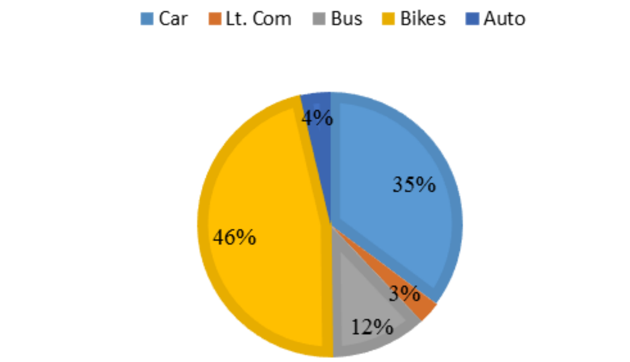

Figure 2: Vehicle Compostion

5. DEVELOPMENT OF MODEL: (CALIBRATION AND VALIDATION)

The micro-simulation software VISSIM 7.0 (PTV) was used to model and represent the traffic and driving behavior at the intersection. For the model to be exact representative of the site conditions, following consideration were adopted. For the traffic to behave heterogeneous the calibration parameters as suggested by Mathew (TRB, 2012) were changed inside the VISSIM.

Moreover, the data collected from site was used to obtained the heterogeneous behavior of the traffic. Lane changing behavior, lateral distances, longitudinal distances were considered as per the site conditions. The signal phasing sequence along with the red, green time and cycle time were recorded from site and added into the software. Traffic volume, turning movement counts and vehicle composition for each approach were taken as per the field. The desired speeds were also taken from the field observation.

The calibration parameters were adopted from Mathew (TRB, 2012) and initial simulation was run. During the field survey it was found that the average queue length in Eastbound approach was 62m. After simulating the model, it was found that the queue length in the same approach was 61m. For any validation to be accurate the error obtained between the simulated and the real data should not be

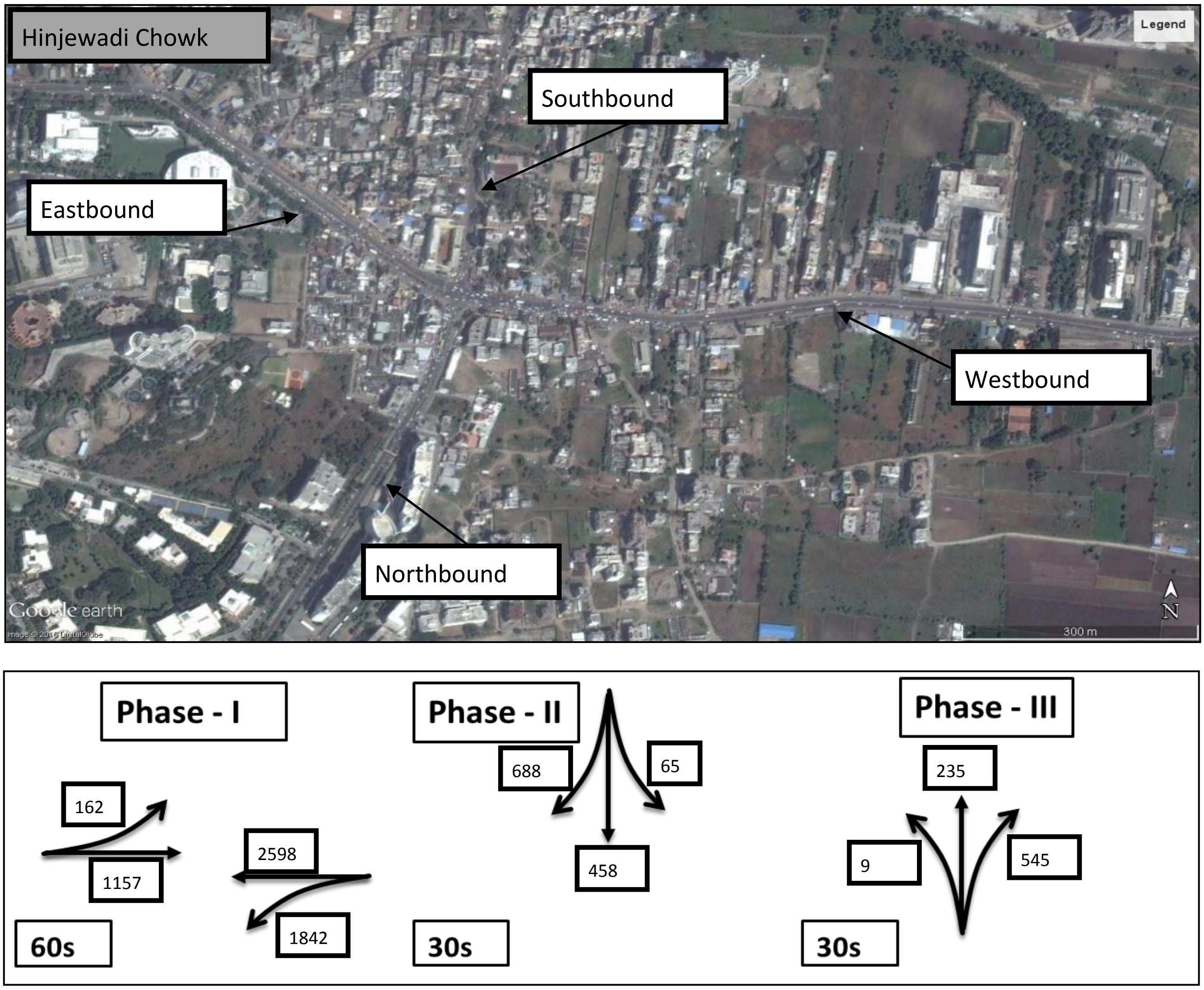

Figure 1: Google Earth view, Peak hour traffic counts, signal phasing.

greater than 10%. As we can see that the simulated results and actual site results are having differences of less than 10%, we can say that the model is the true representative of the real system. Hence model can be used for further analysis and experimentations.

6. BUS PRIORITY TECHNIQUES ADOPTED:

Most of the buses (80%) coming from westbound approach moves left. Hence it was necessary to provide an exclusive lane for buses turning left near the mouth of the intersection. Hence one extra lane of length 150m was provided near the mouth of intersection at the curb side for left turning buses. Southbound approach is very narrow with two lanes for one movement. As a result, the buses entering into the intersection, from this approach were waiting for clearing of the other traffic, which led to considerable delay. Therefore, out of two lanes, one lane up to 150m at the median side was reserved for buses going straight and right. On the eastbound approach, out of 3 lanes near the intersection, one lane up to 150m at the median side was reserved for straight going buses. Similar technique was adopted in northbound approach. This can be seen graphically in Figure 3.

In second strategy, similar technique was adopted in westbound approach. However, in northbound approach, out of four lanes available, one lane at median side was reserved for buses going right and one complete lane was reserved for buses going straight and left. Remaining two lanes were kept for other traffic. Additional signal phase was inserted for these two lanes so that buses can move ahead from the other vehicles and avoid the clearance delay. Out of 30s of green time available for northbound approach, 20s green was given to other traffic while 10s green for the reserved two lanes. No other strategies were adopted on other approaches. This can be seen graphically in Figure 4.

The model was then used to simulate both the conditions: with the priority and with priority techniques (1 and 2) to understand the effectiveness of the strategies adopted.

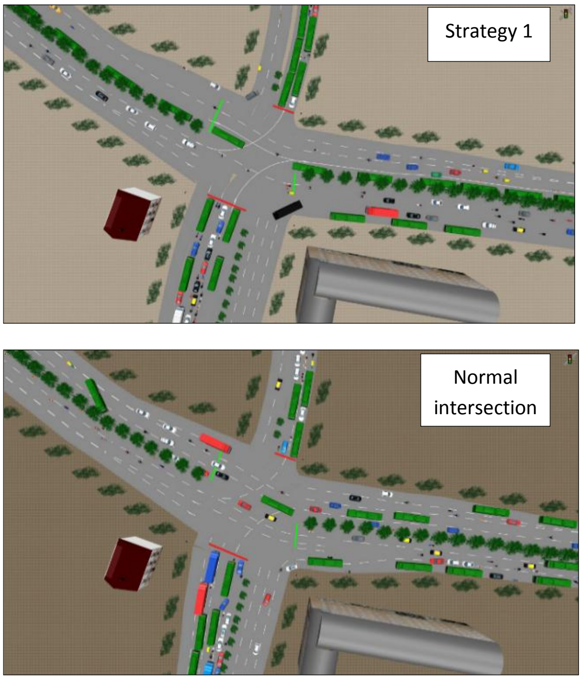

Figure 3: VISSIM model of Bus Priority 1 vs Normal intersection.

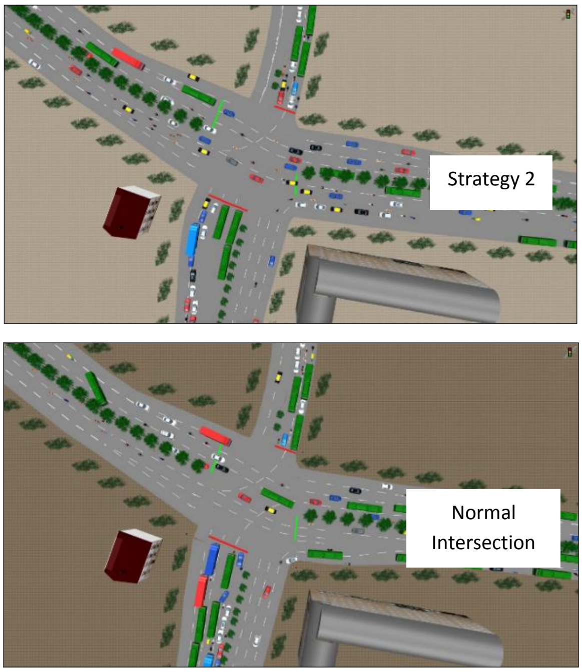

Figure 4: VISSIM model of Bus Priority 2 vs Normal intersection.

7. ANALYSIS OF THE RESULTS AND CONCLUSION:

In this study delay is considered as the parameter for assessment. For priority strategy 1 and 2, the signal cycle was kept unchanged. The traffic volume varies with the time of the day, hence to understand the dynamic effects of the bus priorities, the delays were estimated at 100%, 80%, 75%, 60% and 50% of the observed peak hour traffic volume. Figure 5, shows the impact of bus priority 1 and 2 on the delay of the buses with respect to the percent peak hour volume. Figure 6 shows the effectiveness of the both priorities on the delay of the cars.

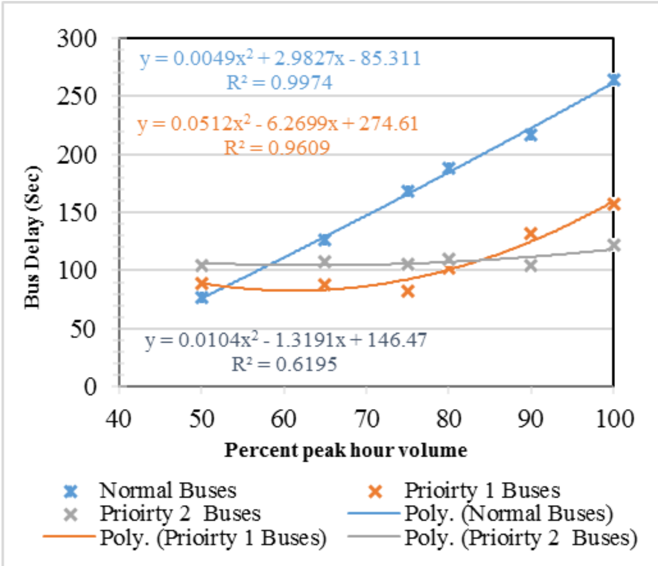

Figure 5: Average delay for the buses with respect to the percent peak hour volume.

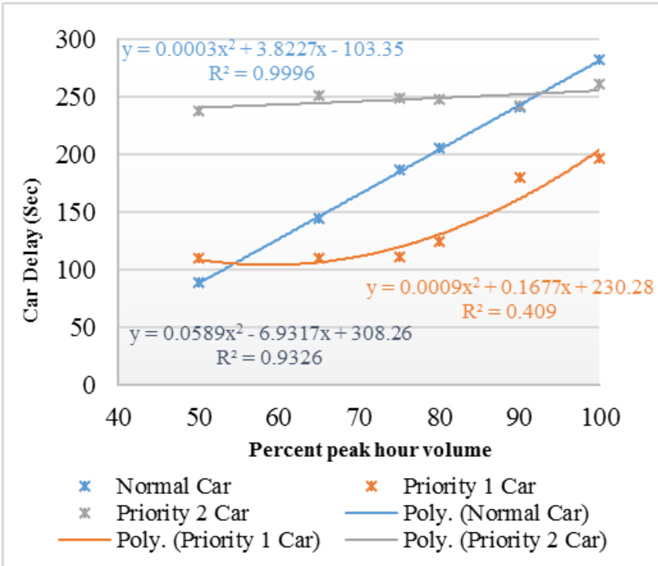

Figure 6: Average delay for the cars with respect to the percent peak hour volume.

Following table 1 shows the effects of bus priorities on the queue length on all four approaches.

Table 1: Effects of bus priorities on the queue length on all approaches, at 100% Traffic Volume

Sr. No.	Approach	Average queue length (Normal Intersection) (m)	Average queue length (Priority 1 Intersection) (m)	Average queue length (Priority 2 Intersection) (m)
1	Westbound	717.1811	596.1567	263.9654
2	Northbound	495.9457	362.3339	533.2782
3	Eastbound	61.96878	42.8284	72.71592
4	Southbound	398.4407	407.7994	406.5796

8. CONCLUSION:

From the results it was clear that these methods of bus priority have shown the good results at high traffic volume, not only in terms of the reduction in delay of the buses but also in reduction of delay for the cars. Priority 2 includes reservation on one complete lane for buses hence reduction the road width for other traffic. Hence, for lower volumes the delay for cars was much higher. But as the volume increases the delay for both cars and buses was lower than the intersection without any priority. Due to reservation of lanes the queue length in all approaches have also been found to reduce considerably.

Bus priorities that are used in this project might have been used in one or the other form in rest of the world. But this time they have been visualized and analyzed for the Indian heterogeneous traffic conditions using microscopic software VISSIM. The results are here for particular intersection with its geometry, traffic volume, traffic composition, turning movements. Same results can be used for different intersection having the similar geometry and vehicle characteristics.

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