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INVESTIGATION ON EFFECT OF CELLULAR AUTOMATION ON BENGALURE TRAFFIC FLOW WITH FIXED BUS LANE AND TEMPORARY BUS LANE

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ABSTRACT

The aim of the paper was to investigate effect of cellular automation public traffic flow system for solving the Bengalure transport problem. This developed approach was investigated on fixed bus lane (FBL), tempraury bus lane (TBL) and two way traffic instances are simulated and the problem providing an adequate compression in the from of the basic diagram of speed-density function graphs. FBL solution can be applied to real transport networks in order to increase the transport capacity FBL is only appropriate for low traffic flow in a two lane traffic system, and this limitation can be partly overcome by opening the bus lane to general traffic intermittently when the bus lane is not in use by buses. A case study based on an actual public bus route in Bengalure is used to demonstrate the usefulness of such an integrated simulation framework.

KEYWORDS: Traffic Flow, Dedicated Bus Lane, Design Numerical Model, Density of Vehicle

INTRODUCTION

These covered several cities, including both Bangalore and Chennai. A 2003 Confederation of Indian Industry survey of urban populations in Southern India showed 90% dissatisfied with roads, and 58% dissatisfied with public transport services. It is noteworthy that 65% of the respondents were willing to pay higher public transport fares to get more comfort and frequency, and 89% of the respondents were willing to pay for good-quality toll roads [1]. The narrow roads and traffic congestion produces a direct impact on the economy, causes an increase of pollution, and reduces citizens' welfare [2]. According to the recent data available, in Beijing the road transport sector generates 23% of the total air pollution [3], close behind the industrial sector, while in the European Union the transport emissions are accounted for around 20% of total greenhouse gas emissions [4]. In US, urban traffic congestion caused during 2007 a waste of fuel equal to $87.2 billion as well as 4.2 billion hours of transport delay [5]. On the other hand, it is possible to exert an indirect control of such externalities, by promoting policies aimed at improving the quality and accessibility of the public transport network. In that regard, the provision of an integrated and high-quality transport system can represent a valid tool. To develop new public transportation solutions it is very difficult or even impossible to use direct experimentation considering legal, financial, material or time constraints.

Many researchers [6-7] are focused on traffic and transportation problems, in general the public transport system is one of the most critical in general in urban traffic. They have proposed many models to simplify the complex transport system, and the representative works are as follows: Nagatani proposed time-headway model [8]; the car-following model was presented by Nagatani and Huijberts, respectively [9]; additionally, Jiang et al.[10] has introduced the bus capacity, as well as the number of passengers getting on and off at each stop into a new bus route model to make it more realistic. This process of review was repeated ten times under alternative scenarios of attribute levels, each time requiring the individual to indicate the preferred main and access mode. The choice sets comprised all existing available main modes and access modes plus two of the new modal options from the full set of three evaluated across the entire sample.

At present, the transportation problems about the Bus rapid transit (BRT) system, fixed bus lane (FBL), temraury bus lane (TBL), transit signal priority (TSP) and public conveyance model have studied extensively [12]. The main contribution of this paper is that it highlights the importance of Zhu [13] proposed model and is implemented in Bangalore as per his work, a traffic CA model with intermittent bus lane priority is proposed. The property of two-lane urban traffic flow is studied by numerical simulation. The comparisons are made among FBL strategy, TBL strategy and ordinary two-lane.

DESIGN NUMERICAL MODEL

In this model assumed that the two-lane traffic has a lattice cells per lane with periodic boundary conditions. Two types of vehicles move along one direction characterized by two different speeds of v_f and vs corresponding to the fast (cars) and slow vehicles (buses) respectively. The value assumed for $v_s = 3$ and $V_f = 5$. Similarly, ρ_s and ρ_f are density of the cars and buses respectively. They are expressed as follows [14].

$$\rho_s = {}^{N_s}\!/_{(2\,L)}$$

$$\rho_f = {}^{N_f}\!/_{(2\,L)}$$

and

Where N_f and N_s are number of cars and buses respectively, while $N = N_f + N_s$ is the total number of vehicles. Then

$$\rho_s = {}^{N}\!/_{(2\,L)}$$

R is ratio of the buses and (1-R) is the ratio of the cars then

$\rho_s = \rho\, R$ and $\rho_f = \rho.\,(1-R)$

In FBL strategy, cars and buses move along their own lanes strictly and the ordinary two-lane traffic without bus priority, it is assumed that the symmetric lane changing rules are adopted, and then a vehicle changes lane with a probability p_l provided: Incentive criterion:

$d_n < \min(v_n + 1, v_{max})$ for safety $d_{pred} > d_n$ and $d_{succ} > d_{safe}$

where v_n denotes the velocity of the n^{th} vehicle at the time t, d_n is the current empty sites in front of the nth vehicle, $d_n(t) = x_{n+1}-x_n -1$, x_n and x_{n+1} denote the positions of the n^{th} and $(n+1)^{th}$ vehicles at the time t respectively; d_{pred} is the gap between the n_{th} vehicle and the preceding vehicle on the target lane, while d_{succ} is the gap between the n^{th} vehicle and the succeeding vehicle on the target lane; d_{safe} is the safety distance, i.e., the maximum possible speed of the vehicle succeeding on the target lane. For the sake of simplicity.

The TBL strategy is proposed the rules for lane changing, which is based on the asymmetric lane changing rules[2]. That is to say, the rules are asymmetric with respect to the vehicles, as well as with respect to the lanes. Only the fast cars need change lanes, and the left and right lanes are referred to as the ordinary lane and the dedicated bus lane, respectively.

Rule # 1: Cars moving from the left lane to the right lane with probability p_l provided:

$d_n < \min(v_n + 1; v_{max})$ Safety criterion $d_{pred} > v_{max}$ and dsucc > dsafe: This rule indicates that a car driver wants to change the lane when the current empty sites in front of him is less than the minimum of accelerated velocity at the next step and the maximum velocity.

Rule #2: Cars moving from the right lane to the left lane with probability pl provided:

$d_{pred} > \min(v_n + 1; v_{max})$ and $d_{succ} > d_{safe}$: A car driver wants to change the lane when the gap between his car and the preceding car in the target lane is larger than the minimum of the accelerated velocity at the next step and the maximum velocity of his car and the gap between his car and the succeeding car in the target lane is larger than the safety distance.

RESULTS AND DISSCUSSIONS

In this section, an implementation of the differetn approach is proposed. Also, several simulation in order to select their appropriated parameters are analyzed. Finally, the performance of the algorithm on different instances of the problem is compared between FBL and IBL explained previous sections. The initial assumption all vehicles are assumed randumly arrnged and each vehicle occuiped miniumum 7-8 meter.

Case I: FBL for short in which the right lane is dedicated for buses and the left lane is dedicated for other vehicles strictly, as per BMTC rule.

Case II: TBL, for short, in which the right lane is for buses when a bus is approaching a given section, but vehicles are permitted to change lanes into the bus lane when the influence of the vehicles on a bus is small.

Case III: Ordinary two-lane traffic strategy with no bus priority t the fundamental diagrams of above three cases are presented in Figure 1 with the factor R = 0:1, which is the ratio of the bus number to the total vehicle number. It is found that when the bus lanes are dedicated, the buses move in the free flow phase even when the total density is larger than 0.17, at which point the bus flow begins to decrease in cases II and III. Then a large margin in the bus flows between case I and cases II and III corresponding to the same density for a large density region. That is to say, buses are interfered with by cars due to the lane changing in the TBL strategy and the ordinary two-lane traffic strategy with the increasing of density, while buses can avoid being interfered with by cars in the FBL strategy.

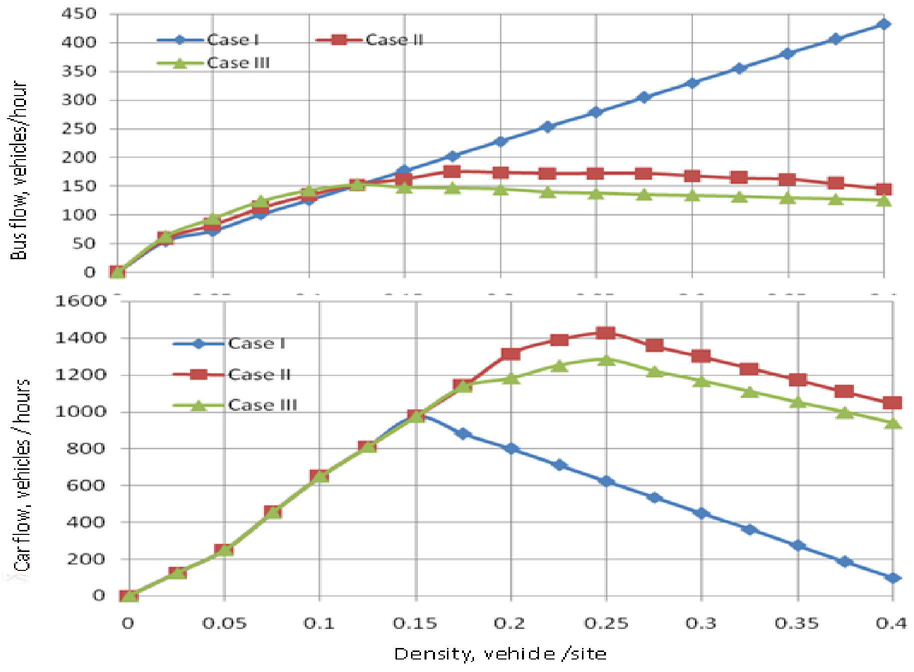

Figure 1: Basic Vehicle Flow Diagrams with Bus

On the other hand, the car flow in case I is lowest when the total density is larger than 0.07. As the increase in the number of cars is more rapid than that of the number of buses on account of the bus ratio R, the increasing number of cars makes the lane jam-packed when lane changing is forbidden. However it indicates that the FBL has the advantage of freeing buses from traffic interference, and also has the disadvantage of disrupting traffic. Then examine the traffic property in the TBL (case II) and the ordinary two-lane traffic strategy with no bus priority (case C). It is shown that when the total density is larger than 0.17, the bus flow in case II is larger than that in case III. This should be ascribed to the fact that the TBL strategy implements more restrictive safety criteria in the lane changing rule from the left lane to the right lane (bus lane).

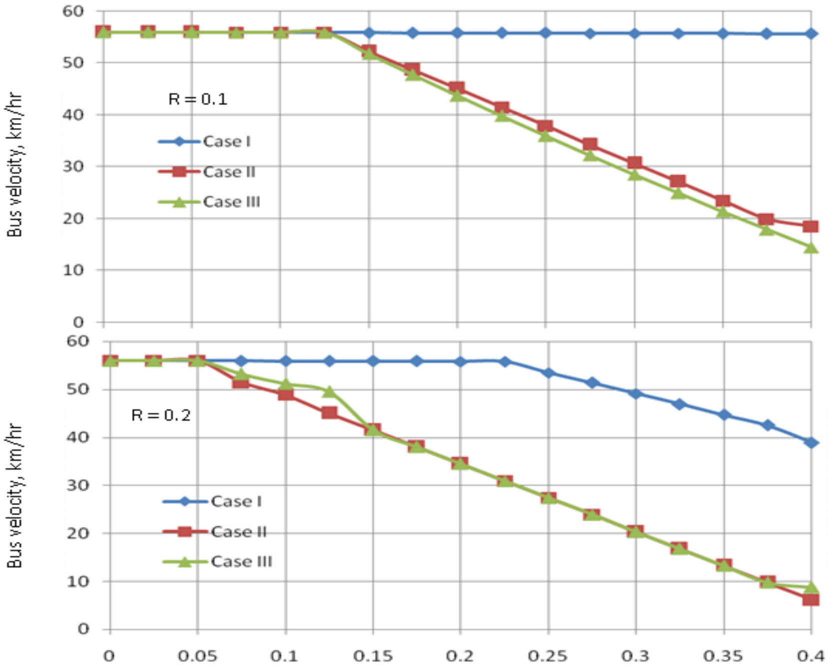

Figure 2(a,b): Profile of Velocity Density Profile of Buses

Then buses in the TBL strategy will be less interfered than in case III within the same density region, and they will move faster than that in case III. Meanwhile the car flow in case II is lower than that in case II when the total density is larger than 0.12. And this is because of less restrictive safety criteria in lane changing rules of TBL strategy from the right lane to the left lane than that in case III. Compared to case III, more numbers of cars in the left lane obstructed the car velocity when TBL strategy is adopted. However, the car flow in the TBL strategy is higher than that in the FBL strategy. So the TBL strategy is more efficient in improving the bus flow than the case III, and maintaining the car flow in a higher level at the same time than the FBL. It is obvious that the ordinary two-lane traffic (case III) suppresses the public transportation and is not advantageous to ease the urban traffic congestion. Figure 2 presents the velocity density profiles of buses in three cases. It is found that when the total density is low, the velocities in three cases exhibit the same behavior and buses move in a desirable velocity because there is little interference between them. With the increasing of the density, the velocities in cases II and III begin to drop, while the velocity in case I with a dedicated bus lane remains the free flow state, and the advantage of the FBL in improving bus flow is shown. Also the difference between the bus velocities of the FBL with different bus ratio is found in Figure 2(a) and (b) when the total density increases. However, the behaviors of bus velocity in cases II and III are almost the same with different R. This should be ascribed to the fact that the bus velocity in FBL strategy is related to the bus density in the bus lane, while the bus velocity in cases II and III is related to the total density instead of the bus density due to lane changing. Then the behavior of bus velocity in case I with R = 0:1 is different from that with R = 0:2, and the bus velocities in cases II and III exhibit similar behavior when the value of R changes.

It seems that the bus velocities in case II (TBL) and case III have little relation with the bus ratio R from the Figure 2, the ratio R has great influence on the bus flow. The fundamental diagrams of TBL strategy with different ratios are presented in Figure 3. It is shown that the bus flow increases with the increasing of the R, and the car flow decreases with the increasing of R when the total density is getting large.

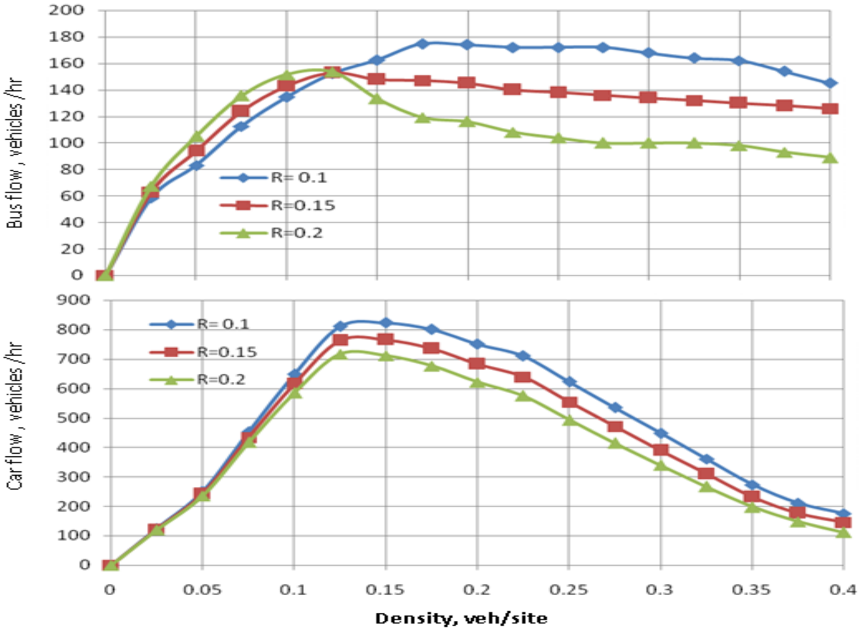

Figure 3: Basic Flow Diagrams of TBL Strategy with Different Bus Ratio R. (a) Bus Flow; (b) Car Flow

This phenomenon coincides with the property shown in the Figure 3. The increasing of the value R means increasing of bus density and decreasing of car density corresponding to the same total density. Then the bus flow increases because the bus velocity changes little as shown in Figure 3. Meanwhile, the opportunity for cars to change lane to the bus lane becomes smaller with the increasing of value R, and more cars remains in the left lane with a lower velocity due to the jamming. Then car flow decreases with an increasing of value R.

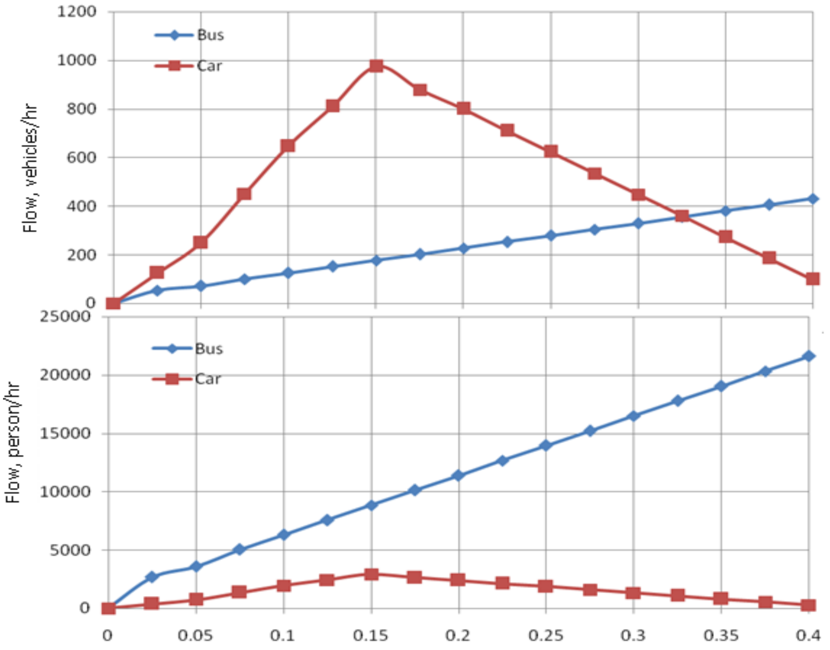

Figure 4: Trafic Flow Comparison for Case A (FBL Strategy) with R = 0:1
(a) Vehicle Capacity; (b) Passenger Capacity

Figure 4 gives the traffic flow comparision in terms of vehicle and travelers capacity in case I (FBL) 0.1 R. It could be FBL is adopted, the small vehciles flow in terms of vehicle capacity is larger than the bus flow as $\rho < 0:39$ because of the low ratio of buses. Cars reach their maximum flow at very small densities, and then traffic jams appear with the increasing of density. It can be imagined that when buses move smoothly in the dedicated bus lane, cars move slowly in the car lane because of traffic jams.

This is the advantage of high-capacity in public transport, Figure 4 shows the traffic flow comparision in terms of vehicle capacity and travellers capacity in case II (TBL strategy) with R = 0:1. From Figure 4(a), it can be seen that the car flow in terms of vehicle capacity is larger than the bus flow all the time. However, the value of density corresponding to the maximum flow of cars is larger than that in Figure 4(a). It indicates that cars can maintain a free flow state for a wider range of densities than that in the FBL strategy. That is to say, the FBL strategy is only appropriate for low traffic flows in a two-lane traffic system. This limitation can be partly overcome by opening the bus lane to general traffic intermittently when the bus lane is not in use by a bus.

CONCLUSIONS

In this study, is distinguished the objectives of private cars and public vehicles based on the observation that buses would obtain operation efficiency and service quality from the public transit system rather than the high level of driving velocity. The comparison of the traffic flow in terms of vehicle capacity and passenger capacity in FBLs and IBLs are also made based on the situation that the average capacity of a bus is 100 passengers and the average capacity of a car is 3 passengers. It is shown that the FBL strategy is only appropriate for low traffic flow in a two-lane traffic system. This limitation can be partly overcome by opening the bus lane to general traffic intermittently when the bus lane is not in use by buses. The system performance is then improved with the cruise control strategy, which has certain applicability and practical significance.

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