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Development and Evaluation of Bus Priority Scenarios via Microscopic Simulation Models ⋆

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Abstract: The number of private vehicles increased dramatically during the last two decades in the island of Cyprus. This phenomenon had a negative effect on the bus transport mode which over the years its use has been considerably reduced. As traffic congestion increased considerably during the same period the need for a high quality public transportation system became clear. This need is also supported by the demand for public transportation by the aging and disadvantaged population. The best way to attract people back to public transportation is to have a reliable bus system with a high quality of service which can compensate for the lack of freedom and flexibility a private vehicle can provide. However such a system should not have a negative effect on the traffic network in terms of congestion and travel times but should coexist serving both the needs of people who do not drive and those who use the public transport mode.

The purpose of this paper is to present the development and evaluation of a number of scenarios aiming at attracting commuters back to public transportation. This idea stems from the fact that surveys among the Cypriot commuters show that people will use buses if buses provide a fast and reliable service. For this purpose, microscopic simulation models are developed in order to examine several scenarios of dedicated bus lanes and bus priority schemes so that the buses can provide the desired level of service with the minimal impact on the rest of the traffic.

Keywords: Traffic Modelling, Microscopic Simulation, Bus Priority, Bus Rapid Transit, Traffic Analysis

1. INTRODUCTION

In 2008 there were almost as many vehicles in Cyprus as the number of people of the island. Meanwhile the use of the bus transport mode is decreasing and as a result traffic congestion is rising to unprecedented levels. As a matter of fact, on a daily basis in Cyprus, we are confronted with rush hours, road accidents, air pollution and driver-stress, causing an increasing number of economic, social and environmental problems.

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People are simply turning away from the bus to use their own private car for their daily transportation. In fact, during the last three decades the number of registered vehicles has increased from 100,000 in 1980 to more than 600,000 by the year 2008, which represent more than a 600% increase in a period of 28 years! In addition to the increased number of cars, the use of the bus transport mode has sharply fallen. From 13 million passengers during the year 1981 we are down to 3 million for the year 2008. This represents more than a 400% decrease in the bus transport use. As a result, Cyprus cities have serious traffic congestion problems in main arterials, and at signalized intersections.

In an attempt to resolve the rising traffic congestion problems the Government of Cyprus and particularly the

Fig. 1. Study Area with the nearby Traffic Network

Ministry of Communications and Works aim for a systemic transport policy. The policy involves restraining the use of private cars, the enhancement of the urban bus transport system and betterment of its level of service, the promotion of alternative means of transport such as the bicycle, and the construction of a modern urban road network. Under this framework, specific strategies for improving the effectiveness of Cyprus traffic networks need to be developed and evaluated prior to their implementation.

In this paper such strategies are developed and tested via scenario analysis in a computer simulated environment. Specifically various scenarios are developed and tested for enhancing the quality of service of the bus transport mode as a long term solution to the traffic congestion problem. Scenarios to be evaluated include a number of configurations regarding the introduction of dedicated bus lanes as well as bus advance signal areas. Further on our agenda is the evaluation of signal pre-emption plans for bus priority. The scenario analysis is carried out via computer experiments using a microscopic simulation model of an urban traffic network. The work presented in this paper is part of the Trafbus research project, partially funded by the Cyprus Research Promotion Foundation. The Trafbus research project is concerned with the modelling, simulation and analysis of traffic flow and the use of Bus Rapid Transit Systems in Cyprus (Papageorgiou, 2006; Papageorgiou et al., 2006; TRAFBUS, 2008).

The study area, which is depicted in Figure 1, includes Strovolos Ave. with its many side roads and signalized intersections. Strovolos Avenue is the main road connecting the South-West to the center of Nicosia, where the central business district is located. Nicosia, which is the capital of Cyprus has a population of around 350,000. Strovolos Ave., which is a main arterial road exhibits the highest traffic flows as compared with the other regions of metropolitan Nicosia. Further, Strovolos Avenue serves as the connector between Nicosia and a large and heavily populated area of urban and rural communities.

The paper is organized in five sections. First we go through a short overview on traffic flow modelling and simulation where the limitations and capabilities of the technique are discussed. This is followed by a brief overview on Bus Rapid Transit, where the importance and relevance of such systems is made as a measure against traffic congestion. Next, the process of developing the traffic simulation model of Strovolos Avenue is described, where evidence for the validity of the model is provided. Afterwards, a number of scenarios are developed and analyzed involving the various configurations of bus dedicated lanes, high occupancy vehicle lanes and bus advance signal areas. Finally conclusions are drawn and future work directions are given.

2. TRAFFIC SIMULATION MODELING

Traffic simulation studies were successfully carried out in many cases for solving transportation problems and especially in the evaluation of new transport designs. For the case of public transport several recent studies are reported as follows. Muthuswamy et al. (2007) evaluate transit signal priority and optimal signal timing plans on transit and traffic operations. They utilize a traffic simulation model using WATSim in order to study the impact of transit signal Priority. Liao and Davis (2007) in another study employ AIMSUN simulation modeller to examine a Bus Signal Priority Strategy based on a global positioning system, automated vehicle location and wireless communications. Using the simulation results they conclude that providing bus signal priority would improve bus travel time by 12-15% during the morning peak and 4-11% during the afternoon peak. Yet another study (Zhou and Gan, 2005) based on a microscopic simulation model using VISSIM examines the performance of transit signal priority with queue jumper lanes. A microsimulation-based transit prediction model (Lee et al., 2005) was also used for more effective transit priority operations.

In a two-level view the problem of modelling vehicle traffic flow, may be approached mathematically by two main scales of observation: the microscopic and the macroscopic levels. In the microscopic level every vehicle is considered as an individual, and therefore for every vehicle we have an equation, that is usually an ordinary differential equation. In a macroscopic level we use the analogy with fluid dynamics models, where we have a system of partial differential equations which involves variables such density, speed, flow rate of traffic stream with respect to time and space. There exists also a third level of analysis the so called mesoscopic level, which is somewhere between the microscopic and the macroscopic levels. In a mesoscopic or kinetic scale, which is an intermediate level, we define a function $f(t, x, v)$ which expresses the probability of having a vehicle at time t in position x at velocity v. This function, following methods of statistical mechanics, can be computed solving an integro-differential equation, like the Boltzmann Equation.

The choice of the appropriate model depends on the level of detail required and the computing power available. As a result of advancements in computer technology in recent years, the trend today is towards utilizing microscopic scale mathematical models, which incorporate human factors and car-following models as a driver-vehicle simulated based environment. Among the most widely used traffic simulation software modellers include CORSIM, VISSIM, PARAMICS AND AIMSUN.

Examining several reviews (Bloomberg and Dale, 2000; Boxill and Yu, 2000; Choa et al., 2003; Panwai and Dia, 2005) on traffic software modellers it may be concluded, that CORSIM, VISSIM, AIMSUN, and PARAMICS have comparable capabilities. In our case we are utilizing VISSIM (Fellendorf and Vortisch, 2001) which is known to be especially competent with modelling public transport operations as well as traffic control signal operations. VISSIM is a microscopic modeller based on a psychophysical car-following model developed by Wiedemann (1974).

Even though traffic simulation models will never be able to capture fully reality they are probably the best means to evaluate potential traffic management strategies prior to their implementation. Traffic simulation modelling is still under research and development and we are looking forward to see better models in the near future. The work presented in this paper partly contributes to the better understanding of the concept of traffic simulation modelling as well to the provision of insights regarding its capabilities and limitations.

3. BUS RAPID TRANSIT

Bus Rapid Transit refers to a number of ways in order to provide a better level of service for the bus transport mode. Bus Rapid Transit Systems aim for a high level of service that could reach that of the railroad transport mode. This is achieved at a much lower cost than constructing a railroad system. There are various types of Bus Rapid Transit Systems that have been implemented worldwide. In a seminal report Levinson et al. (2003a; 2003b; 2003c) reviews applications of Bus Rapid Transit Systems in North America, Europe and Australia. Bus Rapid Transit systems may be classified based on a number of features including, dedicated bus lanes, attractive bus stations and bus stops, easily recognized vehicles that aesthetically convey a strong identity and a respectable image, easy, comfortable and safe boarding and alighting, off-vehicle fare collection, frequent service all day.

Central to the success of a bus rapid transit system is the use of dedicated bus lanes, which would make the bus transportation really rapid. Further, bus priority could be given to buses at signalized intersections via extending the green phase so that the bus can pass through the intersection without having to stop, or by starting the green phase earlier if a bus is detected approaching the intersection. In this way buses are differentiated from the rest of the traffic.

Evidence from several studies (TRB and NRC, 2001; Currie, 2005) suggest that Bus Rapid Transit increase the quality of service of public transportation, which increases bus ridership at very high levels. Bus Rapid Transit is beneficial not only to those who already use the bus and those who shift to the bus transport mode due to improved service but also those who continue to use the private car as they experience less traffic congestion.

In our case Nicosia and particular Strovolos Avenue represents a candidate for a pilot application of BRT. Starting with dedicated bus lanes and bus advance areas, the next step would be to move on to signal pre-emption. Then other BRT characteristics may be employed such as appropriate vehicles with easy and comfortable boarding and alighting, comfortable bus stops, frequent service, off-vehicle fare collection and so on. Once the benefits of BRT are realized the concept could be implemented all over Nicosia and all over Cyprus as a long term strategy to solve the rising problem of traffic congestion.

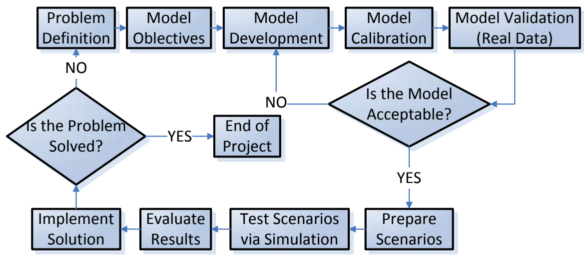

Fig. 2. Proposed Traffic Modeling and Simulation Method

As we see in the following sections the aim of the work presented in this paper is to evaluate alternative scenario solutions involving BRT features, such as dedicated bus lanes and bus signal priority. The evaluation is carried out using a validated microscopic simulation model which is described in the next section.

4. THE MODELLING AND SIMULATION PROCESS

As described above traffic phenomena constitute a dynamical problem situation, which make traffic modelling, and simulation a very complex, iterative and tedious process. In order to increase our chances for a realistic simulation model the following methodology is adopted, which is based on the suggestions of Lieberman and Rathi (1997) and Dowling et al. (2004). This is applied for modelling the Strovolos Avenue traffic network as described below.

As shown in Figure 2, the first step of the proposed approach is to identify and define the problem. In our case the symptoms of the problem which are attributed to traffic congestion manifest themselves as increasing travel times. As explained in the introductory section the main causes for the problem of traffic congestion in Nicosia consist of the increasing number of vehicles and the decreasing use of the bus transportation system. Adding more capacity to the road infrastructure will only make things worse, as a reinforcing feedback loop is created where we encourage the further use of private vehicles and discourage the use of the public transport. Therefore the long term solution to the problem is to balance or even turn around the situation by encouraging the use of the public transport mode.

The question then becomes how do we change our bus transportation system and make it more attractive. This is what we aim to investigate in the Trafbus project concentrating on providing a faster and better quality level of service for our bus passengers. The objective therefore in our modelling and simulation method is to examine various scenarios such as dedicated bus lanes and Bus Rapid Transit Systems that would provide a better level

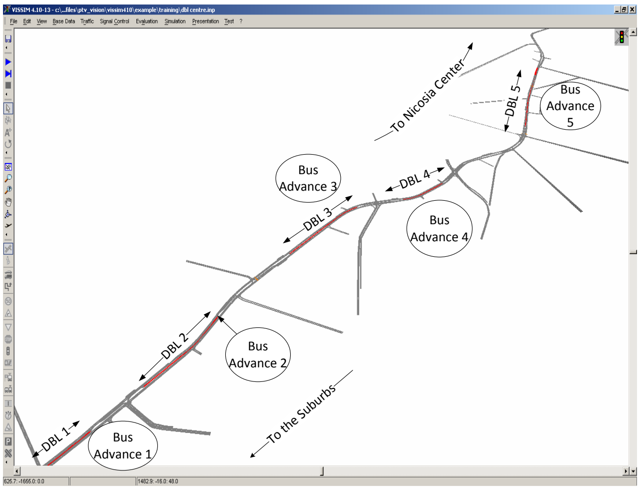

Fig. 3. The Traffic Simulation model showing potential regions for dedicated bus lanes and bus advance areas.

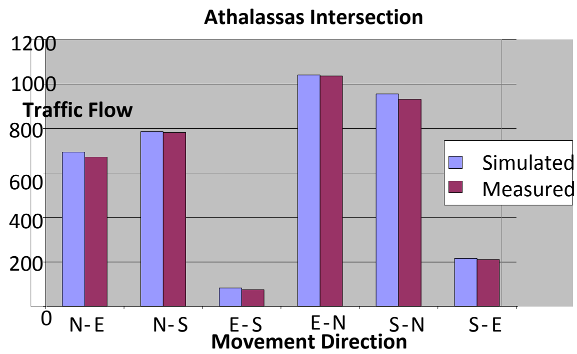

Fig. 4. Model Validation

of service for the bus transportation system. Meanwhile, we need to anticipate and assess any side effects of to the rest of the transportation system.

Based on the stated model objectives, a simulation model of Strovolos Avenue is developed. Like any other traffic network, Strovolos Avenue consists of many traffic parameters that need to be taken into account. These include traffic control signals, priority rules, routing decisions, pedestrian crossings, signalized and unsignalised intersections and so on. A helicopter view of the simulation model of Strovolos Avenue is depicted in Figure 3 (see also Figure 1). Figure 3 shows the layout of Strovolos Ave, which is a four-lane road about 4 kilometers long, as well as the main roads that intersect Strovolos Avenue. Figure 3 also shows potential areas for introducing dedicated bus lanes and bus advance areas. These are evaluated in the next section under traffic scenario analysis.

The model incorporates a significant amount of various traffic data that may be classified it terms of static data and dynamic data. Static data represents the roadway infrastructure. It includes links, which are directional roadway segments with a specified number of lanes, with start and end points as well as optional intermediate points. Further, static data includes connectors between links, which are used to model turnings, lane drops and lane gains, locations and length of transit stops, position of signal heads/stop lines including a reference to the associated signal group, and positions and length of detectors. Dynamic data needs also to be specified for our traffic simulation applications. It includes traffic volumes including vehicle mix for all links entering the network, locations of route decision points with routes, that is the link sequences to be followed, differentiated by time and vehicle classification, priority rules, right-of-way to model unsignalized intersections, permissive turns at signalized junctions and yellow boxes or keep-clear-areas, locations of stop signs, public transport routing, departure times and dwell times.

Having introduced the necessary traffic parameters in our model, we enter the iterative process, which consists of model development calibration and validation of the model. Going through several iterations in developing the model, we are in a position to present some optimistic results concerning the validity of our model.

Figure 4 shows the real Vs simulated traffic flows of the various vehicle movement directions of a central intersection of our traffic network, in particular that of Athalassas-Strovolou (the intersection downstream DBL5 on Figure 3). As seen in the bar chart traffic flows of real measurements obtained and those of simulated results, are quite comparable. In particular the error ranges from only 1% to 3%, a fact that contributes to building confidence for the model. Further, our simulation model demonstrates the queues that we encounter in reality during the morning peak hours (Papageorgiou, 2006).

With a validated model in our hands, next comes the preparation of scenarios, testing and evaluation of the results. After consultations with the transportation planning section of the Ministry of Communications Works that involved suggestions from external transportation engineering consultants and the public transport authority we came up with several plausible scenarios. In summary the various scenarios to be evaluated involve the use of dedicated bus lanes and bus signal priority as described in the next section.

5. BUS PRIORITY SCENARIOS DEVELOPMENT AND TRAFFIC SIMULATION ANALYSIS

The success of any Bus Rapid Transit System is dependent on making the bus transport mode really rapid. In order to attract more people to use the bus transport mode buses should run on time and delays should be minimized as much as possible. We might even say that buses should provide a better level of service to commuters than the private car does. To achieve such an ambitious goal it is necessary to introduce certain bus priority strategies. These involve major changes in the current road infrastructure with the addition of bus dedicated lanes as well as changes in the traffic management schemes with the introduction of extra traffic lights for bus advance as well as signal preemption at road intersections.

Considering the layout of Strovolos Avenue there are a number of possible solutions for dedicated bus lanes. One solution would be the construction of two bus-lanes one in each direction. As space limitations exist though, a second plausible alternative that emerges is a single bus-lane on

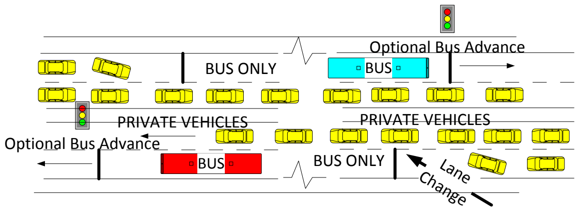

Fig. 5. Two Dedicated Bus Lanes one at each side of the Road

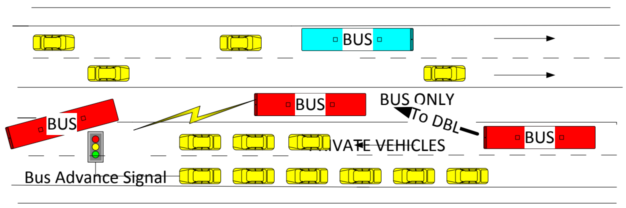

Fig. 6. The Single Dedicated Bus Lane Scenario in the Middle of the Road with Bus Advance

either the right or left hand side of the road. An innovative third alternative, which could handle space restrictions would be a single bus-lane in the middle of the road. The option of creating underground bus tunnels or elevated bus lanes is not considered here as the high expenses and disruption to the traffic while construction is carried out would be disastrous for the city of Nicosia. In addition to the above alternatives bus advance areas before signalized intersections could be employed in order to ensure that buses are allowed to enter the main traffic stream and proceed rapidly to pass through the signalized intersection.

The first alternative of two dedicated bus lanes one at each side of the road would definitely be the best solution for the public transport and the best way of speeding up buses. The existing space constraints however, do not permit the construction of two extra dedicated bus lanes on top of the current four-lane road. Therefore, in order to have two dedicated bus lanes one in each direction, the four-lane road should be reduced to a two-lane road for the general traffic as two of the lanes are made into bus lanes. The layout of the developed scenario, which was suggested by the public transport authority is shown in Figure 5. With the current volumes of traffic though, clearly such a scenario would make things worse for all transport modes.

Figure 5 shows that buses take advantage of the bus lane to rapidly move through traffic while private vehicles will need to merge to the one lane which remains. This represents a problem though, not only for private vehicles but also for buses as buses will also be delayed and get stuck with rest of the traffic upstream of the bus lanes. Carrying out traffic analysis of the above scenario using computer simulation it was shown that major congestion bottlenecks are created. Further this scenario raises safety issues at the merging and weaving areas where heavy lane changing occurs. As expected under this scenario, the level of service for the private car transport mode deteriorates to unbearable levels. The simulation results revealed also that this scenario is not only adverse for private cars but also for buses! The results show that for the bus transport mode total travel time is increased by 36%, average speed is decreased by 43% and delay time is increased by 58%. This is attributed obviously to the loss of capacity but also to the coupling effects and the high complexity of the traffic network.

In an attempt to make this scenario work as two bus lanes in each direction is desired by all major stakeholders, we run computer experiments where both buses and high occupancy vehicles are allowed to use the dedicated bus lanes. Simulation results show that the situation gets slightly better but still is a lot worse than the existing situation for all transport modes. Results for the network performance regarding the bus transport mode show still an increase in travel time by 39%, a drop in the average speed by 43%, and an increase in delay time by 60%. After trying out a number of solutions we have managed to compensate somewhat for the loss in capacity by redirecting the traffic at major bottlenecks but with further negative consequences for safety. Surely the alternative of the two dedicated bus lanes (one in each direction) as shown in Figure 5 should be abandoned since it makes traffic congestion worse for all transport modes.

An alternative that the current space constraints permit without sacrificing the four lane road is one dedicated bus lane either on the left or the right side of the road. This will be achieved by slightly reducing the current lane width and utilizing the separating strip between the two directions. The single dedicated bus lane would provide a service to commuters either on the way to Nicosia city Center or on the way home. Considering the importance of being on time during the morning peak, a compromise for the public transport can be a single bus-lane in the direction to the city center. This might be a good solution for roads where the worst delays are during the morning and where the traffic load towards the suburbs in the afternoon and evening peaks are lower and fewer delays are expected. This alternative would then solve the delays during the morning peak and speed up buses. However as there is an evening peak the benefits from such a solution are substantially compromised. Therefore the success of this alternative remains rather doubtful.

As the two dedicated bus lanes scenario proved to be ineffective and a single dedicated bus lane takes people to work but leaves no provision for their rapid return home, the third alternative that emerges is a single dedicated bus lane serving both directions, that is towards the center and towards the suburbs (inbound and outbound). As shown in Figure 6 such a bus-lane would be placed in the middle of the road utilizing the separating strip between the two directions with a slight reduction to the width of the general traffic lanes. In Figure 6 we see the bus utilizing the dedicated bus lane in the congested direction while the bus in the non-congested direction moves on the regular general traffic lanes. The middle dedicated bus lane will be used by buses that take people to work and by buses that bring them back via inbound and outbound bus lines. Therefore, buses will use the dedicated bus lane depending on the time of day but also on the direction they travel. During the morning times buses traveling towards the city center will use the dedicated bus lane and buses going towards the suburbs use the non-congested regular lanes. In the afternoon or the evening the scheme is reversed.

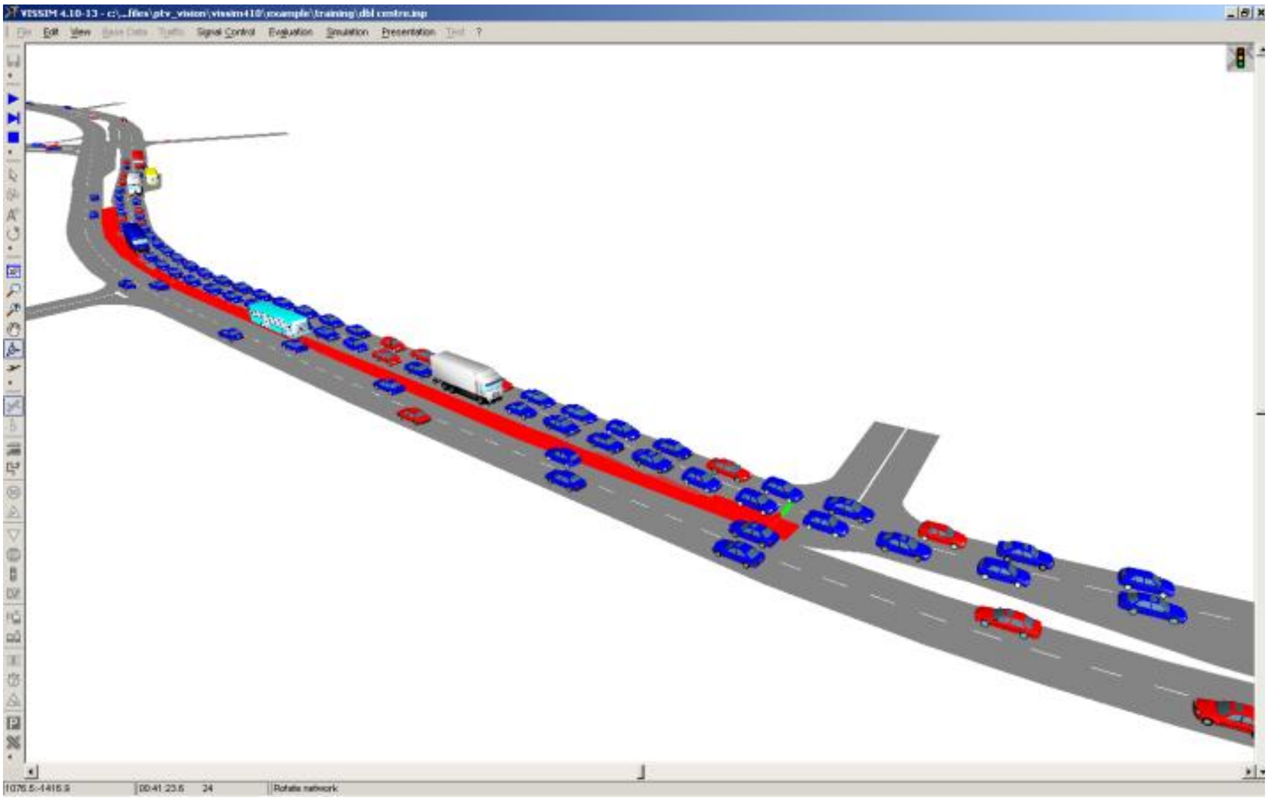

Fig. 7. A Bus going through the dedicated bus lane towards the Bus Advance Area

The current space limitations allow the construction of such a dedicated bus lane. The lane width of the four-lane road has to be reduced slightly but this represents no loss in capacity and it would be beneficial for safety as it could represent a measure for traffic calming and confine speeding. Of course a crash barrier would need to be installed to isolate the bus lane from the general traffic. To compensate slightly to the natural environment for the removal of plants at the separating strip grass could be planted in the middle of the dedicated bus lane.

Figure 7 shows a screenshot of the computer simulated model of the single dedicated bus lane in the middle of the road. The simulated model shows a bus moving in free mode through the traffic by utilizing the suggested dedicated bus lane. The dedicated bus lane shown in Figure 7 is DBL 4 as shown in Figure 3, which is located between the singalised intersections of Kantaras-Strovolos Ave. and Pythonos/Alexandroupoleos-Strovolos Ave. Further, in Figure 7 one can observe the bus advance area which will be utilized by the bus to re-enter the main traffic stream. This is located 40-50 meters from the downstream signalised intersection. A detector located on the surface of the dedicated bus lane will sense the approaching bus and accordingly give a red signal to cars in order to stop for the bus to be able to enter the general traffic stream.

Carrying out a series of computer experiments the performance of the network is evaluated for the scenario of a single dedicated bus lane in the middle of the road. Table 1 shows the simulation results and the comparison between the middle of the road single dedicated bus lane scenario as compared with the existing situation. Further table 1 shows the simulation results based on adding bus advance signals for faster re-entry of the bus to the main traffic stream.

Specifically on table 1 we see various Measures of Effectiveness (MOEs) for the whole simulated traffic network based on the existing situation and the introduction of dedicated bus lanes (DBL) at the separating strip, and dedicated bus lanes plus Bus Advance (DBL+BA) signal priority. The measures of effectiveness include the number of vehicles in the network, the total path distance traveled, the total travel time, the average speed, the total delay time, the average delay time per vehicle, the total stopped delay, the average stopped delay, the total number of stops and the average number of stops, for the private car and bus transport modes.

As it can be observed from table 1, the dedicated bus lane scenario, is quite an attractive solution for enhancing the quality of service of the bus transport mode. The simulation results show that for the bus transport mode total travel time is reduced by 21%, average speed is increased by 27% and delay time is decreased by 18%. The quality of service for the private car transport mode remains virtually the same. In fact there might be even a slight improvement in the general traffic conditions as there is no loss in capacity and the buses operate mainly out of the main traffic stream. In addition to the dedicated bus lanes in the middle of the road scenario Bus Advance signals may be installed for the smother, faster and safer re-entry of buses in the general traffic stream before signalized intersections. As seen from the simulation results traffic conditions improve even more for the bus transport mode.

Table 1. Scenario Analysis

MOEs	Existing	DBL	DBL+BA	Dif.1	Dif.2
Number of vehicles in the network, Car	719	728	718	1%	3%
Number of vehicles that have left the network, Car	6793	6765	6741	0%	-1%
Total Path Distance [Km], Car	11353	11282	11280	-1%	-1%
Total travel time [h], Car	621	619	632	0%	2%
Average Speed [Km/h], Car	18	18	18	0%	-2%
Total delay time [h], Car	404	403	417	0%	3%
Average delay time per vehicle [s], Car	194	194	201	0%	4%
Total stopped delay [h], Car	249	251	261	1%	5%
Average stopped delay per vehicle [s], Car	119	120	125	1%	5%
Number of stops, Car	35562	35017	36538	-2%	3%
Average number of stops, Car	5	5	5	-1%	3%
Number of vehicles in the network, Bus	6	4	4	-33%	-33%
Number of vehicles that have left the network, Bus	15	17	17	13%	13%
Total Path Distance [Km], Bus	39	39	42	1%	6%
Total travel time [h], Bus	4	3	3	-21%	-27%
Average Speed [Km/h], Bus	11	14	16	27%	45%
Total delay time [h], Bus	3	2	2	-18%	-28%
Average delay time per vehicle [s], Bus	432	355	311	-18%	-28%
Total stopped delay [h], Bus	1	1	1	-17%	-33%
Average stopped delay per vehicle [s], Bus	235	195	156	-17%	-33%
Number of stops, Bus	258	226	206	-12%	-20%
Average number of stops, Bus	12	11	10	-12%	-20%

As seen on Table 1 total travel time is reduced by 27%, average speed is increased by 45% and delay time is decreased by 28%. Simulation results of network performance for the private car transport mode show a slight increase in travel time by 2%, a drop in the average speed by 2%, and an increase in delay time by 3%. The above results clearly demonstrate that the introduction of a dedicated bus lane in the middle of the four-lane road utilizing the separating strip represents quite a viable alternative. Principally this system is favorable as the current space layout is not capable of providing two separate bus lanes for each direction. It has to be noted though that, for the organization of such a system, there must be clear internal regulation among the bus drivers about when to use a bus lane and in what direction. However, this should not be expected to cause any problems for the Nicosia Public Transport administration. Further the above system could be enhanced with bus stops at the dedicated bus lane in the middle of the road, which would increase even more the quality of service of the bus transport mode. On the other hand this represents higher investments for bus stops because of the need to have two bus stops one at the bus lane and one at the curbside of the road. This is because while the inbound buses during the morning peak use the bus stops located in the middle of the road, outbound buses will have to use the curbside bus stops. The opposite of course will happen in the evening. Additionally at each bus stop located in the middle of the road there needs to be a pedestrian crossing that enables the passengers to cross the street and reach the bus lane.

We are looking forward to more improvements for the bus transport mode by the introduction of signal preemption. In such a scheme the bus will be sensed by special detectors when approaching an intersection and the green phase will be extended or the red phase will be truncated and switched to the green so that the bus will cross the intersection without having to stop at the traffic lights or wait in the queue. We are actually now in the process of testing various traffic management strategies that would give priority to buses without significantly disrupting the flow of the rest of the traffic.

Finally, we foresee that the use of dedicated bus lanes and bus advance signals will provide the basis for a true BRT system. As evidenced in many parts of the world the increase of the quality of service of the bus transport mode via a BRT system will encourage more people to switch from the private car to the bus transport mode and thereby traffic conditions will improve for everybody.

6. CONCLUSIONS

Computer simulation proves to be a very powerful tool for analyzing complex dynamical problems such as the case of congested roads. On the other hand, the development of computer simulation models requires extensive time, effort, rigor and high persistence. In this paper an approach to modelling and simulating traffic networks is proposed and implemented. The proposed approach goes through various stages, which include problem identification, model objectives, model development, model calibration, model validation, scenario preparation, simulation experiments and simulated results evaluation. The proposed approach is applied in the case of developing a microscopic traffic simulation model for an urban traffic network in Strovolos, Nicosia, Cyprus in order to examine alternative bus transport mode enhancements.

Utilizing the microscopic simulation model, various scenarios which take the form of computer experiments were carried out. As seen from the simulation results the attractive scenario of bus dedicated lanes could make things worse for all transport modes if not properly designed. By examining all possible options, and going through detailed traffic analysis via computer simulation experimentation a viable solution is derived where the measures of effectiveness of travel time, average speed and time delay show significant improvements for the bus transport mode while the impact to rest of traffic is kept to a minimum. In particular, with the suggested solution we have managed to reduce total travel time by 27%, increase average speed by 45% and reduce delay time by 28%. To further enhance the bus transport mode and move closer to a Bus Rapid Transit System we are now in the process of testing signal preemption strategies in conjunction with the bus advance signals in our computer traffic simulated environment. The work presented in this paper could be utilized as a knowledge base for future studies in other areas, where the bus transport mode level of service could be improved. Taking into consideration the current space limitations, the scenario of the dedicated bus lanes by utilizing the separating strip in the middle of the road represents an attractive proposal for many other congested roads in Cyprus.

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