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Public Transportation Simulation by using Agent-based Modelling: Case of Tirana

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Abstract

Nowadays, handling the public transportation is a huge problem for every city worldwide. For this reason there is a need for a computer solution that aims providing consistent and accurate forecasts and simulations that will make possible the minimization of the traffic with the scarce resources available. Tirana has eleven public transport operators that have their assigned stations to traverse every day. Each of these operators has at the same time their peak hours, in which there is a larger number of people using the public transportation what causes crowded means of transportation and traffic on the roads resulting than in a chaos in the streets. The insufficient road capacity to afford the need of transportation of people and commodities leads to a longer time of travelling, higher costs of transportation and a decreasing level of life in the city of Tirana, which makes the traffic a major issue that requires a solution as soon as possible. The computer based simulation through agent based modelling will consist on building a model which analyses the factors affecting the traffic situation in the peak hours and later on provide forecasting and simulation methods by combining these factors. The model equipped with the right combination of the factors will help the specialists on finding ways how to optimize the available resources to decrease and regulate the traffic, so that the situation goes into normality and everyone remains content. The municipality of the city is the party that will make use of this type of system and its specialists will use the model efficiently so it will reduce the traffic in the roads during the peak hours by helping in this way the people to save their precious time, the community to reduce the pollution by reducing the time of waiting in the automobiles' line which will have an overall positive effect in the community life.

Keywords: *public transport simulation, agent-based modelling, optimisation, community life*

1 Introduction

Each of us use transportation means every morning to travel to work or school and not everyone has its private vehicle, so we are obliged to use the public transportation provided by the municipality. At the same time, each of us every single morning, especially on Mondays, experiences a terrible chaotic situation in the streets of the city, buses are overcrowded during the peak hours, the drivers go too slowly because of the traffic jams, causing in this way confusion and irritation to the people.

Many studies are made on finding ways of traffic simulation and optimization, [7][8][4] but still this issue is one of the most concerning ones. The municipals have added the number of semaphores in the streets, have improved the streets' quality and tried to expand their capacity, urban lines operators also have increased the number of buses especially during the peak hours, which according to the official data from the municipality correspond to be the hours 7:30-8:30 in the morning and 15:30-17:00 in the afternoon,[1]

when most people go to and leave their schools/jobs. One other solution that was experimented in the streets, was the idea of leaving a lane dedicated to the public transportation buses which was quite fruitful but as always there are also other vehicles that use these lanes affecting in this way in the urban buses' efficiency. [10][3]

In order to help the municipals in defining new strategies that would improve the traffic situation in Tirana and concretely the public transportation problems, we are going to build an Agent Based Model using the Netlogo program that will analyze the set of factors that affect the traffic and the public transportation's efficiency and at the same time will provide forecasts and simulations in order to optimize the roads' capacity and minimize the traffic.

2   Methodology

The data gathered in this paper are produced from a detailed research and official information from the municipality office, the directorate of transport, concretely the public transport's sector and also from the Ministry of Transport and the Institute of Statistics [10][5][3]. The research and data gathering process started from February 2015 and consist on information related to the area of Albania's capital, Tirana. There are made surveys and questionnaires with the people that use the service offered by the public transport, and the people that work in this sector, such as the drivers of these buses etc. Another side of data collection is that of collecting data in the area, measuring average delay time of the bus, measuring the speed and noticing the peak hours of the day.

The data were thoroughly analyzed and put into the 'Netlogo' platform in order to make simulations which provide a model from the real situation of the traffic, so to make easier the process of finding optimal solutions.

3   What is ABM (Agent-Based Modeling)

Computer usage has received great importance nowadays, and their usage has become vital. The science has evolved so fast, that it needs new technologies and solutions every day. Modeling solutions to today's problems has become a very difficult task, and the simulations are being used widely, in experiments and testing of hypothetic solutions to specific problems.[6]

According to the definition used in the economic field, a model is a simplified version of the real situation, but with fewer features in order to be more understandable. Despite this fact, simulation is still seen as a way of prediction that produces not very reliable data and the economists are sceptic about its usage, which actually is not true, because if the model is developed in the right way, the simulation produces very reliable results. Simulations based on modeling have many benefits, 16 of which are mentioned by Joshua Epstein, [2] such as guiding data collection, revealing dynamical analogies,discovering new questions, illuminating core uncertainties, demonstrating tradeoffs,training practitioners, and least decision support, particularly in crisis situations. [6]

In Agent –Based modeling, econometric parameters and variables act as turtles and patches, and this type of simulation offers at the same time a nice visual representation and the adequate data and results that someone might want to get from the model. [8][2]

To implement this simulation we have used the NetLogo simulation platform which is defined as a simple environment for modeling complexity, so the complex situations become much simpler when put into Netlogo. In the respective literature, it is shortly defined as a multi-agent programming language and modeling environment for simulating complex phenomena. It is used for as a tool for research and for teaching at the undergraduate level

and higher. It is provided with a behavior space, in which the programmer inputs the data and it manipulates it to give the expected results. [9]

4 Traffic situation in Tirana

It is already known and very clear that the people living in Tirana have to face the heavy traffic situation every morning and every afternoon and almost everyone has to admit that the situation is most of the time chaotic. Even the officials like the municipality have admitted that the traffic in this city is a major issue that requires an improvement, and at the same time the officials also admit that managing the situation especially during the peak hours is a real challenge and it affects a lot the security and the safety in the roads. [1][3][10]

According to the municipality's official website, the traffic is very heavy most of the time, especially around the city center and the ring line (unaza) and this happens because of the lack of the necessary space in the streets that cannot afford the large number of vehicles that circulate every day.[3] This inadequate capacity derives in longer time of travelling, higher travelling costs, higher cost for the transportation of the people and matter and at the same time in affects the level of living in Tirana as it decreases it. [1]

Following new policies from the officials will bring ways of managing the traffic by limiting the circulation of private vehicles and making public transportation more attractive by increasing the time of transportation and giving priority to the public transportation's vehicles in crossroads. They believe that these strategies and policies will attract even the users of private transport to return to the public one, which is a reasonable situation if the conditions get this better.

4.1 Urban lines in Tirana

In Tirana currently there are 11 urban operators [1][3], and there are some private companies that own more than one line of this type of public transportation. From the latest projects of the municipality, the directorate of transport has decided to have a preference on public transportation by giving priority in the semaphores and using the lanes reserved for these buses, while the private transportation will be discouraged by high parking tariffs, and by creating more space for pedestrians. [10][3]

Fig I: the map of the urban line operators in Tirana. Source : Tirana Municipality

5. Investments to reach the solution

In order to be able to manage and find possible solutions to this major problem, the municipality has thought to intervent and invest in four main fields that are thought to help the further improvement of the situation. Their fields of solutions include increasing the capacity of the roads of Tirana, especially the areas that are mostly frequented and needed most of the day by building new roads and expanding the current ones, repairing and better organizing the traffic flow by giving priority to the public transport and the pedestrians, improving the capacity of parking areas by gaining around 2000 new parking places in the city in the areas that are planned to be expanded and also undergoing a study and research which will give solutions, advices and recommendations on finding ways to have a leveled parking, the underground parking etc. [1][3]

6. Simulation of the traffic model

We already know that it is crucially important to predict accurately the demand of traffic and the transport necessities in order to have a utile distribution plan and have the overall situation under control. That is why the simulations' importance has grown so fast recently[4]. This model uses some components that are thought to affect the situation of traffic especially in the peak hours. The factors are represented below:

6.1 Population

In Albania, only Tirana is the city which has the most problematic road system, because the other cities have low number of population compared to the capital's population, so they are much quieter and rarely have peak hours. According to the national institute of statistics (INSTAT) the population of Albania in the 1st of January 2015 was measured to be 2.893.005, and more than half of these residents are living in Tirana, taking into consideration even the people who are working or living in the city without figuring as its official residents. Two years ago, the overall population in Tirana was around 1,3 million which is surely increased in these two years.[5] This huge number of people living in a city that does not have the capacity of course causes the congested traffic system and is one of the main factors affecting it.

The number of the people in the model is increased in the peak hours which correspond to the 7:00 hrs in the morning and 15:30-17:00 in the afternoon, hours these that correspond to the time when people go to and leave their jobs. [3]

6.2 Location and area of operating of each line

As any other metropolis, even in Tirana there are some specific areas that are usually more congested and busy most of the day. These areas of course correspond to the areas near to the center of the city and the areas near the university campuses and faculties, such as the areas of 21 Dhjetori, Zogu i Zi, Rruga e Elbasanit and the area of Hospitals. These lines are most of the time very busy and congested by the large number of people that use the public transportation. In this model, the line of Unaza is taken into consideration, since it is one of the most problematic ones regarding to the delays and congestion. [3][1]

6.3 Number of buses for each line

Most of the cases the number of buses operating in the urban lines is an important factor that affects the congestion and overcrowded buses. The lines that are most critical logically should have more buses available, but practically this is not always possible. In the model it is supposed the ideal case in which, when one bus reaches the next station from where it is started, one other bus starts from that current station, so no delay and no crowded is created and the people won't lose any time and be annoyed because of the waiting time in the stations. In this way people will be more contented and will be likely to use the public transportation instead of the private one. [3]

6.4 Other factors

in the case of Tirana there are also some other factors that affect the congestion and crowded means of transport and these factors are the atmospheric ones. During the winter rainy days the buses are much more crowded and the situation is much heavier, the number of people using the public transportation is almost doubled. Some other factors that affects the traffic in Tirana is of course the lack of awareness of the drivers to respect the road signs and rules, and especially the young drivers who have paid to get their driving license are an important factor that most of the time causes traffic jams and congestions sometimes even resulting to chaotic situations in the streets of our capital. [3][1]

7. Agents and model description

The agents used in this model are defined by the shapes of buses and they are dynamic agents, since the flow over the assigned path. Each bus starts its route from the same station, which in the case of Unaza line, is the station near Zogu i Zi. The buses flow in both directions, clockwise and counterclockwise direction and each stop at the defined stations. Each bus is obliged to stop at every station in its path and wait for ten ticks until all the passengers are into and off the bus. After the first bus leaves the first station and reaches the second station, automatically in the first station is released the second bus, so the people who missed the first bus, will not get late to work or to school since they will immediately get into the next bus. Each of the urban lines is taken in separate simulations, so the model can be idealized and each simulation can show the best ideal conditions which suggest that if implemented, could lead to a better traffic situation in Tirana.
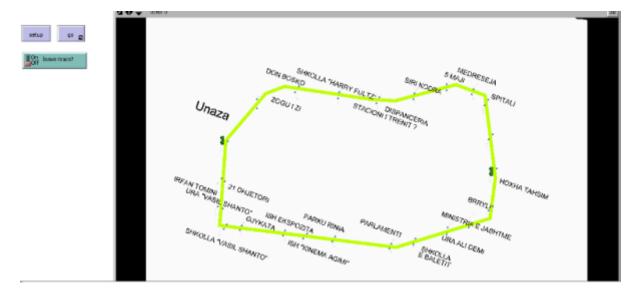
Fig. II: Simulation of the model in Netlogo

8. Results and conclusions

The model into simulation included the situation of traffic in Tirana and it was used to show the relationship and interaction of all factors that affect the traffic, such as the population of the city, the defined locations of each urban line and the number of buses that each of these lines has, and also other factors which include environmental factors like rain and thunderstorms and also the disrespect of the drivers with regard to the road signs. The area of Tirana has a population around 1,2 million and almost half of this population use the public transportation means every day, and the peak hours correspond to the 7:30-8:30 in the morning and 15:30-17:00 in the afternoon[5]. The simulation period lasts as long as a working day of the urban lines of the buses, starting from 6:00 in the morning and continuing until 22:30 in the night [3]. The simulation showed that the lines passing through or near to the city center are the most crowded lines and are busy most of the day, not only in the peak hours. The traffic density in these lines is higher than the lines that go to peripheries and the situation is more critical and needs special attention. The simulation also suggests that it is of crucial importance the expansion of the roads capacity in Tirana, because this action would lead to a reduction of traffic, a very noticeable increase of public transportation efficiency and a more stable situation in the city.

In the future work we have planned to expand the size of the simulation by taking into consideration all the lines of Tirana and other cities in which operate urban lines and also involve the interurban lines that make possible the transportation of people between the cities.

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