PUBLIC TRANSPORTATION SIMULATION BY USING AGENT-BASED MODELING: CASE OF TIRANA

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PUBLIC TRANSPORTAION SIMULATION BY USING AGENT-BASED MODELING: CASE OF TIRANA

By

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DEDICATION

To my precoius family and Geri for their eternal love and support in every initiative of mine, to my friends for their presence during my bad and good days, to my professors for their availability and willing to help in any case!

ABSTRACT

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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 transportation simulation, agent-based modelling, optimisation, community life

ABSTRAKT

Fakulteti i Ekonomisë dhe Shkencave Administrative

Udhëheqës: Igli Hakrama

Ne ditet tona, menaxhimi i duhur i tranportit publik eshte nje sfide dhe nje problem shume i madh per cdo qytet ne Bote. Per kete arsye eshte nevoja e nje zgjidhjeje kompjuterike e cila synon te prodhoje parashikime te besueshme dhe te sakta, si edhe simulime qe do te bejne te mundur minimizimin e trafikut pavaresisht burimeve te limituara qe ekzistojne.

Tirana ka njembedhjete operatore te transportit publik te cilet kane nje numer te caktuar stacionesh per te pershkuar çdo dite. Secili nga keta operatore ka orarin e vet te pikut, ku arrin numrin maksimal te personave qe e perdorin kete sherbim, çka sjell automjete te mbipopulluara dhe trafik te renduar, duke rezultuar ne nje situate kaotike ne rruget e qytetit. Kapaciteti i pamjaftueshem i rrugeve per te perballuar nevojat e transportit te njerezve dhe mallrave çon ne zgjatjen e orareve te udhetimit, rritjen e kostos se transportimin dhe uljen e nivelit te jeteses ne qytetin e Tiranes, çka shton arsyet per te kerkuar nje zgjidhje per situaten sa me shpejt te jete e mundur.

Simulimi kompjuterik me ane te modelimit te bazuar ne agjente do te konsistoje ne ndertimin e nje modeli i cili analizon faktoret qe ndikojne trafikun dhe situaten kulminante, e me pas prodhon parashikime dhe metoda zgjidhjeje duke kombinuar keta faktore.

Modeli, i pajisur me kombinimin e duhur te faktoreve do t’i ndihmoje specialistet ne gjetjen e menyrave te optimizit te burimeve per te ulur dhe rregulluar situaten e trafikut, ne menyre qe qytetaret qe i perdorin keto sherbime te mbeten te kenaqur.

Pala qe do ta perdore kete sistem eshte Bashkia e qytetit, specialistet e se ciles do ta perdorin modelin ne menyre efektive ne menyre qe te rregullohet dhe reduktohet trafiku sidomos gjate oreve te pikut. Ne kete menyre perdoruesit e transportit do te kursejne kohen e tyre te vyer, komuniteti do te ndihmohet duke ulur ndotjen duke ulur kohen qe automjetet presin ne radhe, dhe te gjitha keto do te kene nje efekt te pergjithshem pozitiv ne jeten e komunitetit.

Fjalë kyçe: simulimi i transportit publik, modelimi i bazuar ne agjente, optimizim, komunitet

ACKNOWLEDGEMENTS

I would like to express my appreciation and gratitude toward all the professors and staff of the University, for always helping me to clear up the question marks, pushing me to work always hard and giving precous advices in order to get prepared for the real labor market. Thank you for all the time dedicated to me and the support in every activity during the years of study.

A special thank goes to my thesis advisor, Mr. Igli Hakrama who has always been opened and ready to help and give advices, anytime.

Thank you!

DECLARATION

I hereby declare that the thesis is based on my original work except for quotations and citations which have been duly acknowledged. I also declare that it has not been previously or concurrently submitted for any other degree at Epoka University or other institutions.

Erilda Duzha

13 June 2015

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NOTATIONS / GLOSSARY OF TERMS

ABM –Agent Based Modeling

Nlogo – NetLogo

GIS – Geographic Information Systems

GUI – Graphical User Interface

IT – Information Technology

CHAPTER 1

INTRODUCTION

Each of us uses 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, [16] 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 [17], 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 [17].

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.

CHAPTER 2

AGENT BASED MODELING AND TRAFFIC SIMULATION MODELS

This chapter is made of different sections which introduce the main terms of Agent Based Modeling and its core concepts. A short comparison between different softwares that make possible the simulation will also be included. Here will also be shown the solutions proposed from other authors on the traffic problems that big cities face everyday in every corner of the world.

2.1 What is ABM?

ABM stands for Agent-Based Modeling and it is a relatively new, especially in Albania, computational paradigm that is considered as a modeling phenomena; as systems that are dynamical and are composed of agents that interact with one another. Another name that can be found in different literature for the Agent Based Modeling is that of Individual Based Modeling (IBM), in where the individuals have the same role as agents, basically they represent the same thing expressed in two different names. The models of this type if seen in details , can be noticed as natural extensions of previous models, such as the Ising model of 1925 and the Cellular Automata of 1994. [1]

One new and special feature of the ABMs is the behavior space, what means that each of the agents operates in an independent way from the other agents or their environments, called 'world' in the simulation language. [2]

The actors in ABM follow a sequential schedule when they perform their actions, what is exactly the factor that allows the cohabitation and interaction of different agents and different environments of specific agents in the model. The models of Agent Based Modeling are very interesting and attractive, at the same time very useful for different fields of the science such

as biology, physics, arts, mathematics and different computer games, because these models are very rich in details and at the same time simple to understand as mechanisms. [1]

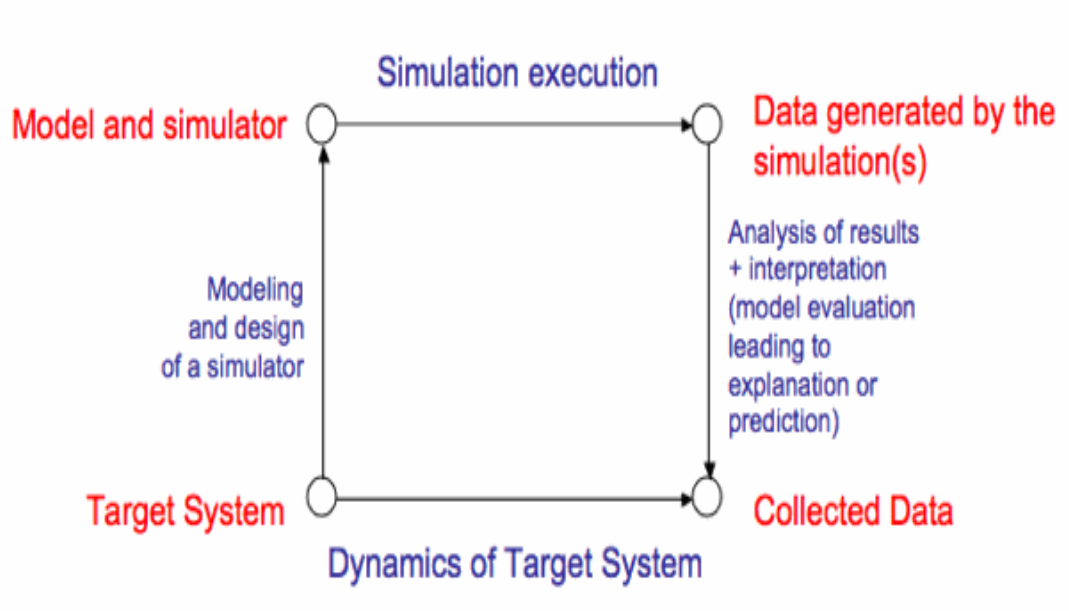


Figure 1. A general schema describing the usage of simulation as a predictive or explanatory instrument[3].

In ABMs, the overall result and success of the model is not dependent on the global function's work, but on the specific tasks that each agent has in the whole model, what emphasizes the fact that each agent has a specific role and a certain importance in the model's success as a complete model, so each of theses agents should be carefully taken into consideration, in order to provide accurate and consistent results. Above there is described a picture that shows in a simplified way the agent's tasks and specification in a model:

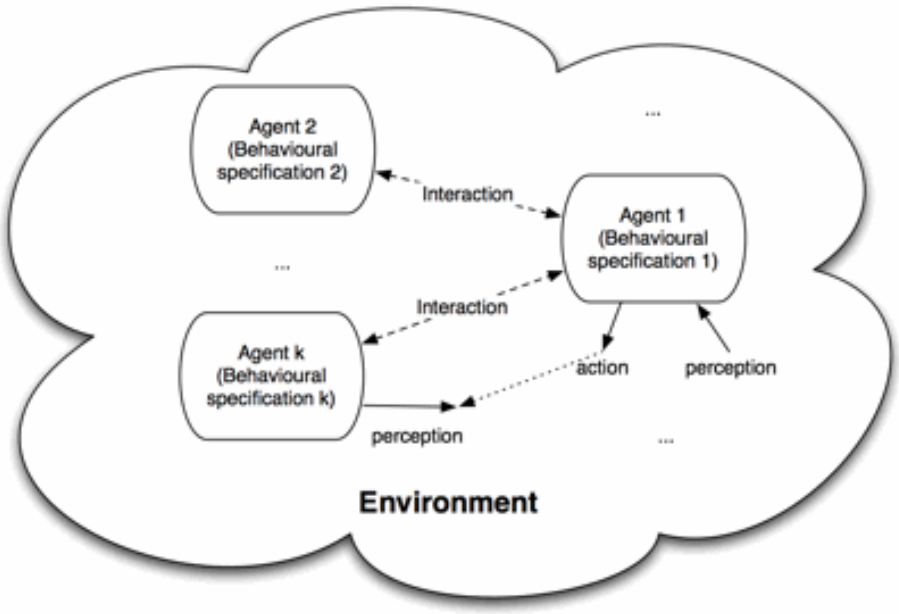


Figure 2. An abstract model to analyze, describe and discuss different models, concrete simulation experiences, platforms legitimately claiming to adopt an agent-based approach[3].

So as seen clearly from the introductory section of the ABMs, they have a very positive impact and benefits, among with must be mentioned[6], [8], [9]:

- These models are used in capturing phenomena considered to be emergent
- They are described in simple 'natural' way what makes easier the process of understanding and accepting the model
- The models are very flexible and can adapt to any update or modification based on the situation's constraints
- The models can be described in terms behavior of individual agents and boundaries which are clear and well defined
- They can work even when there is no correlation between the states of work in the past, the present and the future expected development
- The models are cost effective and also time saving

~ The Agent Based Models provide a testing framework with the model itself

2.2 Platforms using ABMs

As also mentioned in the first part of this chapter, there are currently some different softwares that implement and make possible the simulation of different models, called as ABM platforms. Some of these most famous softwares are listed below:

- ***NetLogo-*** a platform in which there exists and overall process of simulation and the agents provide general purpose data structures and are all manipulated by the main process. It can be mentioned as a dialect of the Logo programming language and is especially used in simulation of models that are characterized by an interconnected and decentralized nature of the processes [3]. In NetLogo, the agents of the model are called 'turtles' and the simulation process is made of a cycle which assigns an action to every turtle and performs it always taking into consideration its state. NetLogo has become one of the most popular platforms of ABMs, because it uses a programming language which the users can learn even if they do not have a professional background in informatics field and it provides very nice and clear visualizations of the models with its vizualization tools. Very similar platforms of the same category as NetLogo are StarLogo and StarLogoT [3].

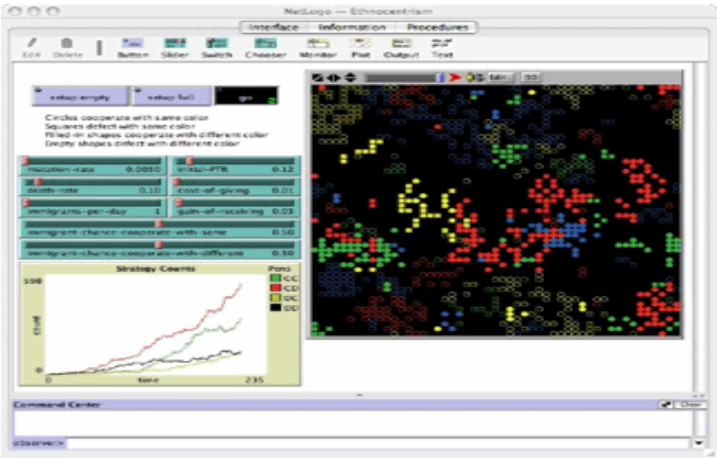


Figure 3. A screenshot of a NetLogo simulation applet[3].

- ***Repast-*** this is a platform diferent from NetLogo in the aspect that is usually based on a general programming language, most commonly the object oriented one. This is also a very useful platform employed in many simulations and is mainly based on Java language. In order to be correctly used, Repast needs modelers who have at least a general background in informatics and basic knowledge of programming, but is makes very easy the task of integrating internal libraries with the external ones. With its latest and current version, Repast also provides instruments and tools of vizualization, analysis of data, different types of reporting and also connetion with GIS(Geographic Information Systems) [3]. Very similar platforms of simulation that fall into the same category are Swarm(1996) , Ascape(2001) and Mason(2003)[4].

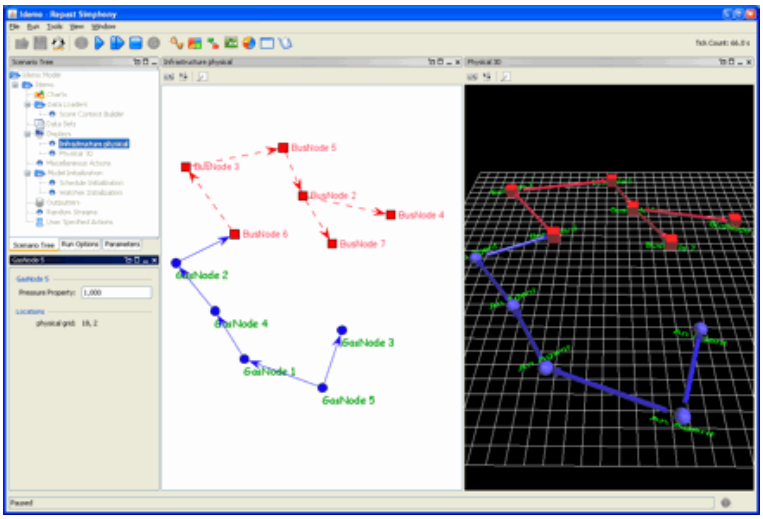


Figure 4. A screenshot of a Repast simulation model[3].

- ***SimSesam-*** is the third category of the simulation platforms used nowadays. It is considered as a high-level model as it tries to provide a higher programming language level. This platform describes the behavior of the agents throught the usage of a set of functions that are defined as primitive functions. SimSesam simulation model also provides visual representation of the models implemented into it [4].

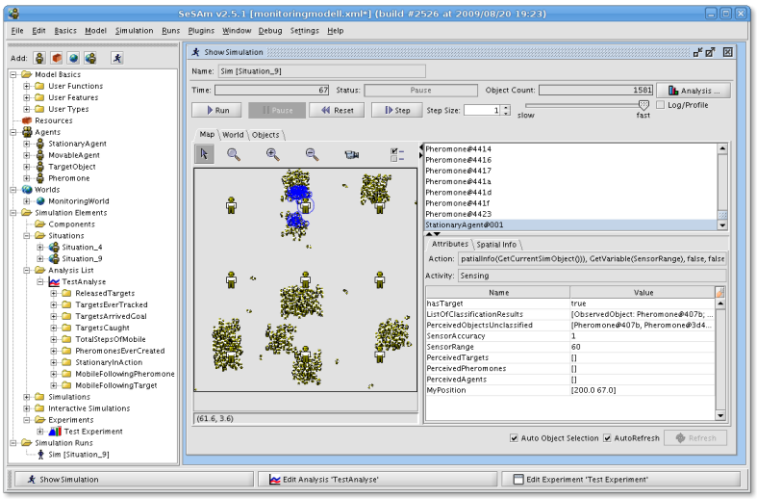


Figure 5. A screenshot of a SimSesam simulation model[4].

2.3 Why is Netlogo the best?

Accodring to the experts' definition, Netlogo is an Agent Based Simulation platform that is used as a tool to create agents synchronized to each other which live together in a grided world. Netlogo itself is Java based, even though in order to write agent based models one should know its the Netlogo's internal language, and after being written they can be generated as aplets. The Netlogo language is procedure oriented as it is based on the procedures of each of the agents living in the grid. One other advantageous feature of Netlogo is that its time is discrete and the unit with which the time is measured is the tick, so the agents can only complete an action on a time tick while there cannot be events occurring between the ticks separately. Netlogo is also an easier language to learn since it has fewer features than the other programming languages, so it takes shorter to learn and immediately put it into practice and this option is valid even for the new programmers who have not any informatics or programming background and skills[23]. In Netlogo, if you are stuck in a point of the code, you can ask the very active users forum which is a real supportive community. This tool when compared to other tools or platforms that are used to build agent based

models, performs much better because of the GUI elements that it contains make the model much simpler to understand and work with. In this platform, the users can also make the connection with mathematics by calling certain functions from within the model and reach to deviations of the primitives which are not an attribute of the current model [24].

According to the professionals, Netlogo is a tool that is simple enough to be used by the students and teachers who can run different simulations. Even for the new ones to the programming community it shouldnt make a problem since the programming language is pretty easy to learn, intuitive and well documented, so one can reach by logic to derive the code [25]. Its main advantages that the researchers using Netlogo are using are the Behavior Space that runs experiments which are already automated, they also provide 3D visualization, makes possible the user's own extensibility, ther also exists a feature called System Dynamics Modeler that makes possible the mixation of agent based and aggregate representations, and also the NetLogoLab , a feature that makes possible the conncetion with the external physical devices.

One major advantage of NetLogo is that it is free and works almost in every computer that is installed. When downloaded and installed, it automatically loads also a library with examples from different categories such as arts, probability, biology, space, games, code examples etc, which together make a total of almost 150 examples available[25].

Even the university of Information Technology (IT) in India has chosen a group of researchers to make a research and try to prove the efficiency and the easy-to-learn language of Netlogo. They have made an experiment by simulating the states of a process and built a graph through Netlogo which resulted to be accurate and the same as the graph generated from the other softwares that they have used, reaching to a conclusion that Netlogo is an effective platform of simulation [26].

2.4 Traffic problems and simulations in the big cities

Since the traffic is a major issue in every big and medium sized city all over the world, it is natural to expect that many authors, informaticians, engineers and governmental institutions have tried to find possible solutions deriving the optimal ones.

- ~ One of the most important and similar papers to my case is that one published in the ScienceDirect platform in 2014, presented in the meeting of the EURO working group on Transportation held in Spain [10]. This paper's aim was to be able to find a possible way to integrate the public transportation system by designing a nearly perfect system of public transportation, putting it into the simulation software and comparing the resutls with the existing solutions[10]. The simulation technique used was VISUM platform and the model was build upon a series of questions that include:
- ~ How many travellers can a bus afford?
- ~ What is the direction of this line's bus? [12]

What can be mentioned as one of the oldest models that the professionals of that time were trying to write a general situation of the traffic and its simulation features, was that of the INTEGRATION model evolved in the mid 1980s [11]. This model tried to provide an overall model that included both freeways and arterials, what would lead in also including the solution of the assignment and simulation of the traffic. The traffic flow was represented as a line of vehicles following the macroscopic flow[11]. In the model there were included different attributes of simulation. Recently it has evolved and become more understandable since it includes the graphic animations and visual representations of the data as all other models being used today. According to INTEGRATION model, the most problematic issues that affect the traffic are the merges and diverges in the streets, especially highways. The authors have also included a simple visual representation of this two factors whicha are

thought to affect the traffic density leading to congestion in the streets of the large cities, in order to make it clearer to understand.

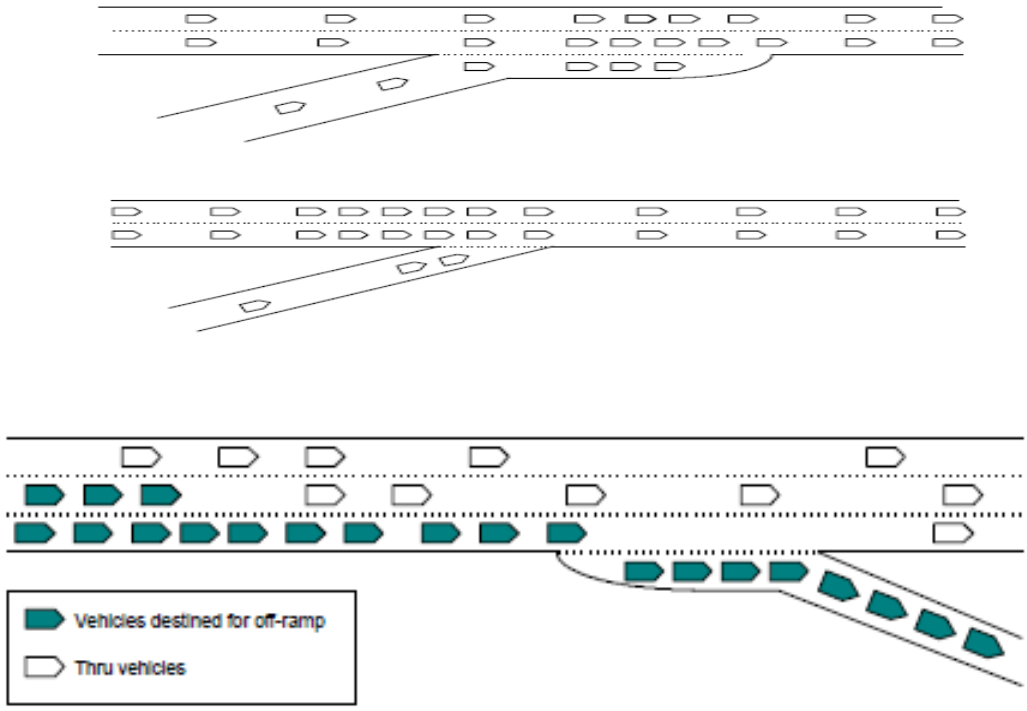


Figure 6.Congestion formation at merge and queue formation due to diverge[11].

The authors of the paper explaining this model state that its features adapt to almost all the situations in the road, starting from the single lane streets up to very complicated streets with lots of links, crossroads and so on [11].

There are also papers written about models of simulation for the traffic situation and visualizing the traffic flow, but most of these papers were based on micro and macroscopic simulations, while there are still very few models implemented in simulation tools as the categories of software mentioned in the previous section. One paper of these type of simulations, based on the micro simulation is that of John Taplin from the University of Western Australia[13] , who has used the micro simulation through the Cellular Automata [2]

model, which is one of the first models used, quite different from the ABMs but can simulate networks of large urban networks with the help of massive computer usage. As mentioned in this paper the term of simulation is almost always used in cases when there are models that try to provide visual representation of the traffic with accurate proportions and including at the same time equilibrium models. The solution that the author proposed was assigning the routes in congested areas such as big cities according to the shortest paths algorithm, as also described visually in the following figure:

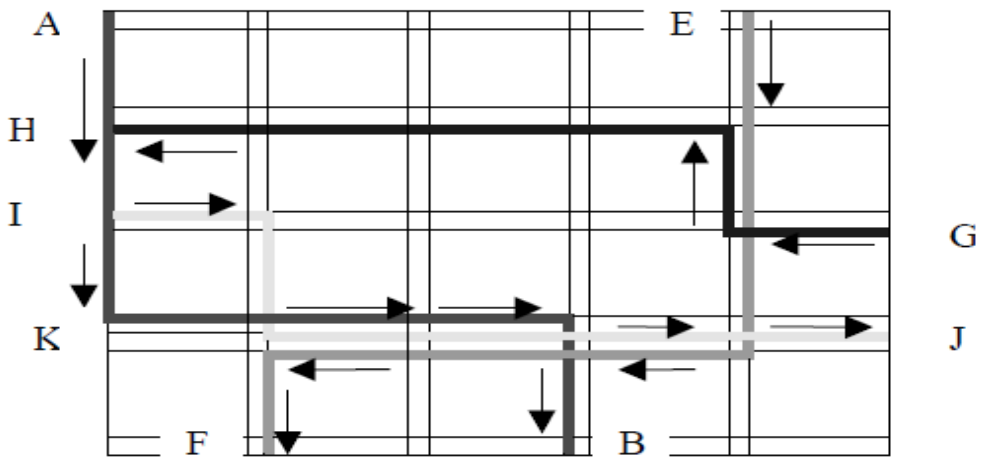


Figure 7. Initial assignments of origin-destination traffic to shortest routes[13].

It is clear that public transportation is cheaper and much more easier than the private one, that is why it is highly encouraged from the governments and public administration insitutions. If in good conditions, it is much more preferred than the small personal vehicles by the mass population of the world's metropols. Even the efficiency of the public transportation system is a hot topic which has a great impact on the choice of the people who use this mean of transportation each day. In order to be able to measure the efficiency of the ublic transportation system, it is important to define some steps through which should be walked. As the 'problem' is defined and the indicators of the performance and the efficiency are set, there are each of the operators of these urban lines who measure them and compare to the

other operator's results in order to determine the week and strong points[14]. The paper of two British authors C.Mulley and J.Nelson also mentioned the ownership of the urban lines as a factor that highly affects the performance of the transportation service. This case is also analogous to the Albanian case. There are some specific urban lines, like Kamza line that is privately owned and the service there is evidently different from the other ones. The publicly owned transportation means are always taken less care by the people who use them.

One last paper that might be mentioned about the traffic simulation models is that written by Hans-Thomas Fritzsche, who notices the continuous increasing of the traffic volume, especially in large cities where people migrate every day and at the same time states that the solutions are urgently required[15]. The author in the paper has tried to calculate the traffic flow by analyzing the relationship between the traffic density and the mean velocity which are correspondingly denoted as q, p and v, while the formula that he has derived is that of Q = p * v, but which is still not very relevant and satisfctory in the results that it produces. This kind of relationship between this three factors is called as the fundamental diagram[15].

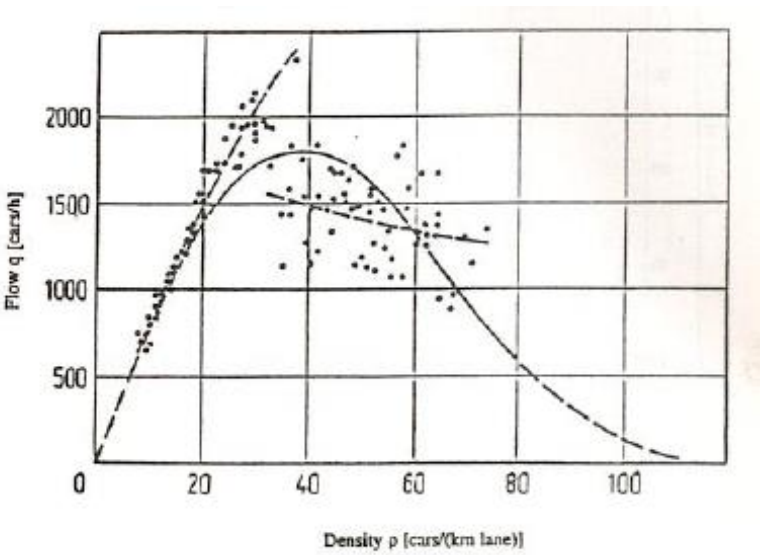


Figure 8. the fundamental diagram [16].

In the paper of the mentioned aouthor, one of the solutions proposed is that of calculating the trajectories of each vehicle separately as a function of the time, denoted by ‘t’ [15]. The author also simulated the cases in which there was added an extra lane in the first case on the right part as a driving lane and in the second case on the left part as an overtaking lane. The simulation results firstly showed a trend favouring the idea of addding a lane to the right, thus a driving lane, which was thought to have a certain impact in regulating and attempting to minimize the traffic density and congestion [15].

CHAPTER 3

CURRENT TRAFFIC SITUATION IN TIRANA

(A General Overview)

Tirana is the capital of Albania, and since the communist regime was over, the city has been in the top list of preferences to move on. The people of all other citites and villages saw Tirana as a place that offered the opportunity for a better life and better future for their children. For this reason the population of Tirana kept and still keeps increasing day by day.

According to the national institute of statistics (INSTAT) [17], the population of Tirana is around 40 percent of the overall population of Albania which can be rounded as about 1,3 million residents, taking into the consideration that still there are people who are not officially residents of the city but do live in Tirana, such as the students who have the domiciliation documents in their cities still, but live and work in Tirana, increasing in this way the population even more.

Because of the high number of the people using and developing their activities in Tirana, one of the main consequences of these activities is the congestion in traffic because of the overusage of the means of transportations. Most of the students and simple people(people who work in jobs with minimal wages) use the public transportation to go to school or to work, causing often crowded means and chaos in the urban line's buses. This situation occurs almost every day, in the morning, when the people run to their work and their schools, and in the afternoon when they leave their jobs to go and everyone is in a rush to go home and rest. Everyone is aware of this chaotic situation, even the officials. The municipality and its experts admit that managing the traffic in Tirana, especially in the peak hours represents a real challenge for the institution and its representatives[18].

According to the official reports of the municipality of the city, which is also reflected in their website, the traffic in Tirana is very have and congested most of the time, especially around the most populated ares, such as the city center, the ring line (unaza), and all this congestion happens mainly because of the high number of people circulating there and the lack of the necessary space in the streets, which cannot afford the high number of vehicles [19]. This insufficient capacity leads to consequences such as longer time of travelling, higher travelling costs, higher costs of transportation of the people and commodities, at the same time it affects the quality of life in Tirana, by significantly decreasing it [18]. Even from the interviews made with random people that were living in Tirana, most of them stated that they were not satisfied with the living conditions in the city, mainly because the traffic never ends and because the pollution is in it highest levels, not allowing them to even breath freely. There were around 500 people living in Tirana and using often the public transportation (at least three times a week) and their results about the satisfaction of the life quality and the traffic situation are reflected as follows: [20].

Figure 9. Satisfaction by the life quality and traffic situation in Tirana

So, as seen even from the questionnaires results, around 80,4 % of the people living in Tirana are not satisfied from the quality of the life they are living in this city, but they have to stay there for different reasons, such as their jobs, their kids who are studying in Tirana or other family members, and for other opportunitites that Tirana offers which are almost inexistent in other cities such as having different professional or artistic educational institutions, nearer hospitals and governmental institutions. The results of the second questionnaire are also represented graphically below:

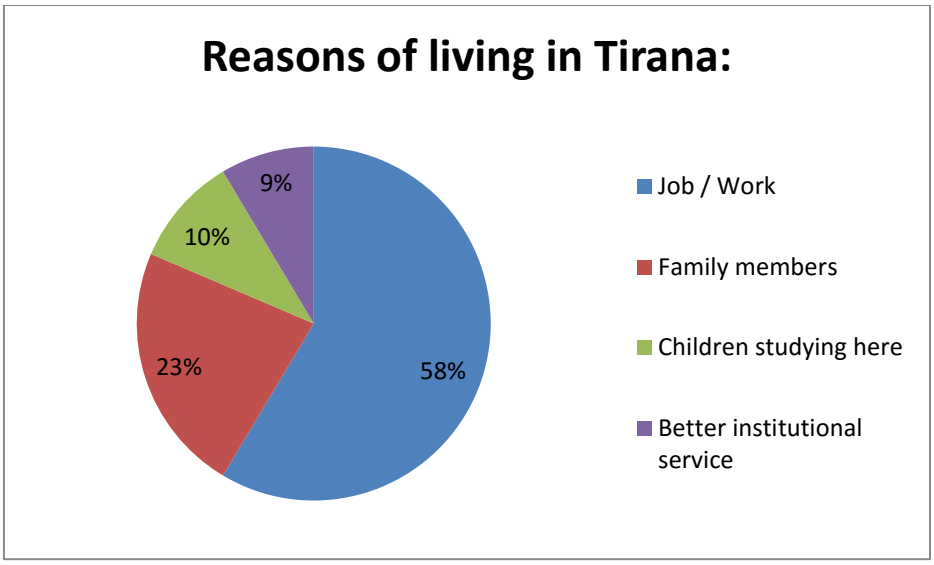


Figure 10. Reasons of living in Tirana

3.1 Urban lines operating in Tirana

In Tirana there are currently twelve urban lines operating, and each of them has their assigned length of distances and a certain number of stations to stop and traverse in each cycle that they complete. The municipality of Tirana has in its database a map of the trajectories through which each of the public transportation offerers traverse each day. According to the

officials of the municipality, the instituion has a clear vision about the development and further integration of the city's public transportation.

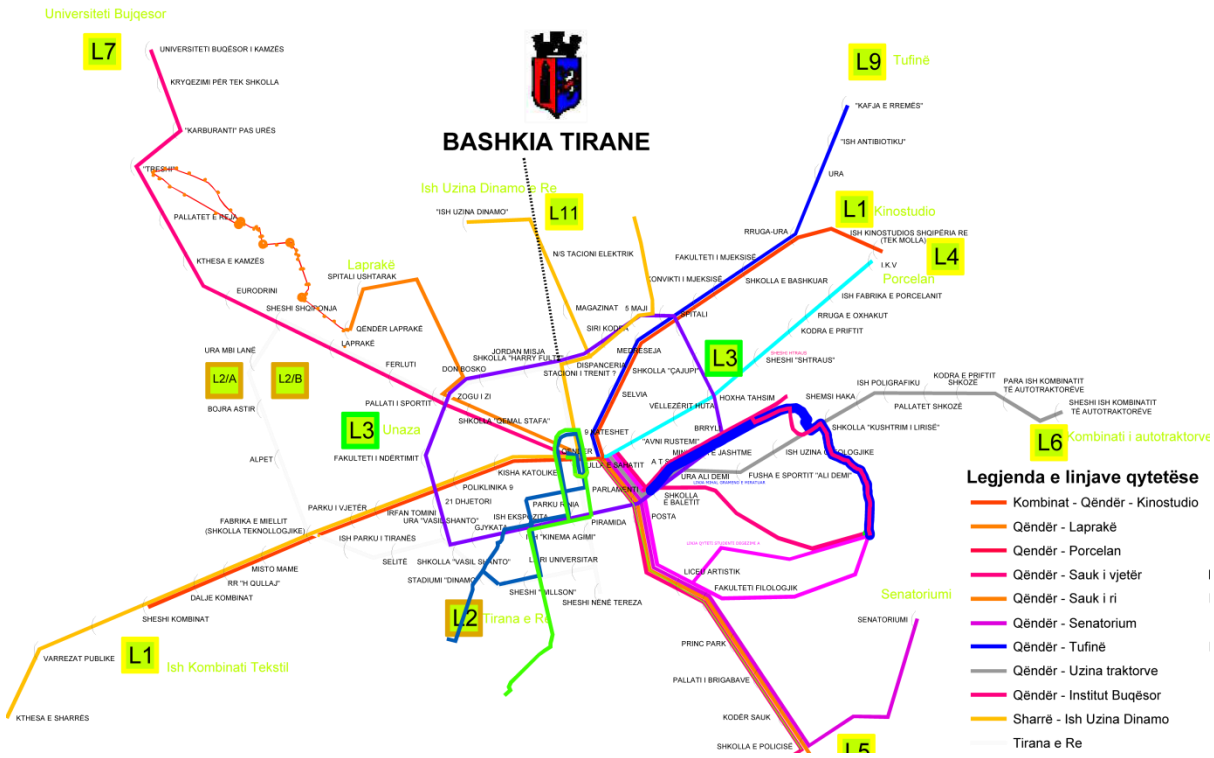


Figure 11. Urban lines operating in Tirana

The figure above represents each of the urban operators with different colours so that they can be easily noticed and differentiated from one another. There are lines which have a part of the itinerary the same, and then divide in a certain point to take different directions. The lines mainly start from the city center to come back again to the city center, in that case one cycle is completed. Exception are three lines which start from different combinations such as Kombinati – Kinostudio which starts its cycle from the first station in the Kombinati neighborhood in Tirana, Sharra – Ish Uzina Dinamo which also starts from the pheripheral area of Sharra and the two lines which have a circular trajectory and do not go to and come back from the center. The municipality has also available the stations in where the monthly subscription can be made and at the same time there is a table what shows the distances in

meter which are traversed by each urban operator and which are represented visually in the below table:

No.	Urban Line Operator	Distance (in meters)
1	Kombinat – Qendër – Kinostudio	L= 8025 m
2	Qendër – Laprakë	L= 3460 m
3	Qendër – Porcelan	L= 3010 m
4	Qendër – Sauk i Vjetër	L= 4310 m
5	Qendër – Sauk i Ri	L= 4361 m
6	Qendër – Senatorium	L= 5017 m
7	Qendër – Tufinë	L= 4135 m
8	Qendër – Uzina e Traktorëve	L= 5605 m
9	Qendër – Instituti Bujqësor	L = 6226 m
10	Sharrë – Ish Uzina Dinamo	L= 8928 m
11	Tirana e Re	L= 9995 m
12	Unaza	L= 11800 m

Table 1. Lengths (in meter) for each urban line

The vision of the municipality aims to improve the economic development of the city, to improve the quality of life and reduce the pollution and protect the environment by improving the road network and by sustaining a public transportation which is often, fast, reliable and comfortable [19].

The strategy of the institution aims the application of the contemporary methods to make possible a steady circulation and a socio-economic development that will integrate the regulation of both forms of the transportation, the private and the public one bu creating a kind of an equilibrium between them.

As a consequence of these measurements, the public transportation in Tirana will take a preferential treatment, through the priority in the semaphores and through the reserved lanes for the buses of the urban lines only. While the private transportation will be pushed to limit the flow in the center of the city , by creating and promoting points of exchange (PoE) and will also be discouraged through the high parking tariffs and providing pedestrian areas.

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.

According to the municipals, it is expected that by 2020 there were by added 6 other new urban lines covering the whole region of Tirana, not only the areas inside the city [22].

3.2 Solutions proposed and investments made to reach a solution

In order to be able to manage and find possible solutions to this major problem, the municipality has thought to intervene 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 [21].

The intervention of the municipality also includes a very big project in order to facilitate the situation of the traffic in the roads of the city. This intervention will be made through different directions, starting from the first drafts of the policies, continuing with the planning process end ending up in the implementation and the application of concrete projects in order to contribute in the improvement of the chaotic situation.

Following these policies which are public transportation oriented, will bring new ways of managing and administering the traffic which will limit the increase of the vehicles' flow. These policies will serve as tools helping the public transportation be more attractive, especially near the center of the city, by increasing the velocity of transferring and giving priority to the public transportation's buses in the crossroads too. Here cannot be skipped the fact that, the same as it has happened in other European industrialized cities, many drivers change their driving habits by passing from the cars to motorcycles, bicycles and the public transportation [18]. This situation can be thought as logical even in Tirana, since in the near future the road conditions will be continuously improving even for these categories of drivers.

What the officials believe that is the main aspect of the further development of the road system in Tirana and in the spreading of the traffic according to the areas of the origin an the destination of different activities such as education, entertainments, trade etc, is the completion of the overall road system of the city with multiple rings [18].

Tirana will even have a 'Center of Control for the Urban Traffic' which will supervise, control and manage the flow of traffic in the roads of the city. This project will also insist on promoting the use of the ecological vehicles of transportation. The management offered by

the center of control will provide a management of high quality and at European standards, the same as developed cities of Europe. The implementation of this project will make possible to have a better quality flow of traffic and an increase of the safety in the streets of Tirana. The work for the application of this project is expected to be finished in about six months from now and it has had an overall duration of the working period of 18 months [18].

This project will make possible the supply of 60 new controllers, 51 of each will be put into existing semaphores, while the 9 others left will be installed in new semaphores. The municipality will also provide 22 cameras which will be observing 24/7, with no distinction between the day and the night, continuous supply with electricity of the current semaphores, implementation of an Operational Room of the Center of Control which will use all the necessary software and applications in order to gather the needed data and all the devices used by the operators will be connected to each other by the usage of the optical fibers [18].

CHAPTER 4

IMPLEMENTATION OF THE MODEL

From the previous chapters and the information gathered from the literature review, we already know and are aware of the importance of an accurate forecast which provides the closest values to the real values for the traffic demand and the transport necessity in Tirana, in order to be able to draft a management plan and a utile distribution plan, so we can keep the overall situation under control. This is what explains why the importance of the simulation has grown so fast recently [27]. The model that we have simulated takes into account some components which are thought to affect the overall traffic situation, especially during the peak hours. Let us first provide a short description of these factors and their importance and then explain the simulation and how these same factors are represented in there.

Factors affecting the overall traffic situation in Tirana:

- ***4.1 Population :*** in Albania, Tirana is the city with the most problematic road system, mainly because of its population over its capacities. Other cities have much fewer people, so the situation is much quieter than the capital's situation and they 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[17]. 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 [18].

- ***4.2 Location and area of operating of each line :*** as any other metropolis, even 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 [18].
- ***4.3 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 [19].
- ***4.4 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 [18], [19].

There are also other models that have studied the traffic and congestion, such as that of one of the authors of the Netlogo programming book, who has implemented a model in which the automobiles are sensitive to the semaphores' lights and also sensitive to the pedestrians waiting in the white lines, which we have also included in our model.

After making an analysis about the factors that have a certain impact in the traffic situation in Tirana, we were able to put these factors as components of the simulated model, so that they can cooperate and provide the most precise forecasting possible. As also stated in the Netlogo description section, the agents in Netlogo are called as turtles and patches. The agents in this model are defined by the shapes of buses, since we are dealing with the public transportation and the buses are the means of transportation used for this purpose. The agents in Netlogo are dynamic and they can be defined any shape that is available in the 'turtle shape editor' found under the 'Tool' tab in the platform. Even if any shape is not part of this set, it can be imported from the library and is automatically included in the model, and can be used anywhere in the model just by defining its shape as follows:

```
breed [buses bus]
set-default-shape buses "bus"
```

through this single line of code, the agent's shape is automatically defined as the shape and the figure of a bus. But in order to be able to visually show the shape of a bus, beside being imported from the library, it also needs to be declared as a set of objects, called a 'breed' in the Netlogo language.

The agents (buses) are dynamic and interactive, since they flow over the assigned path, which corresponds to the path that the real public transportation buses need to traverse in the city.

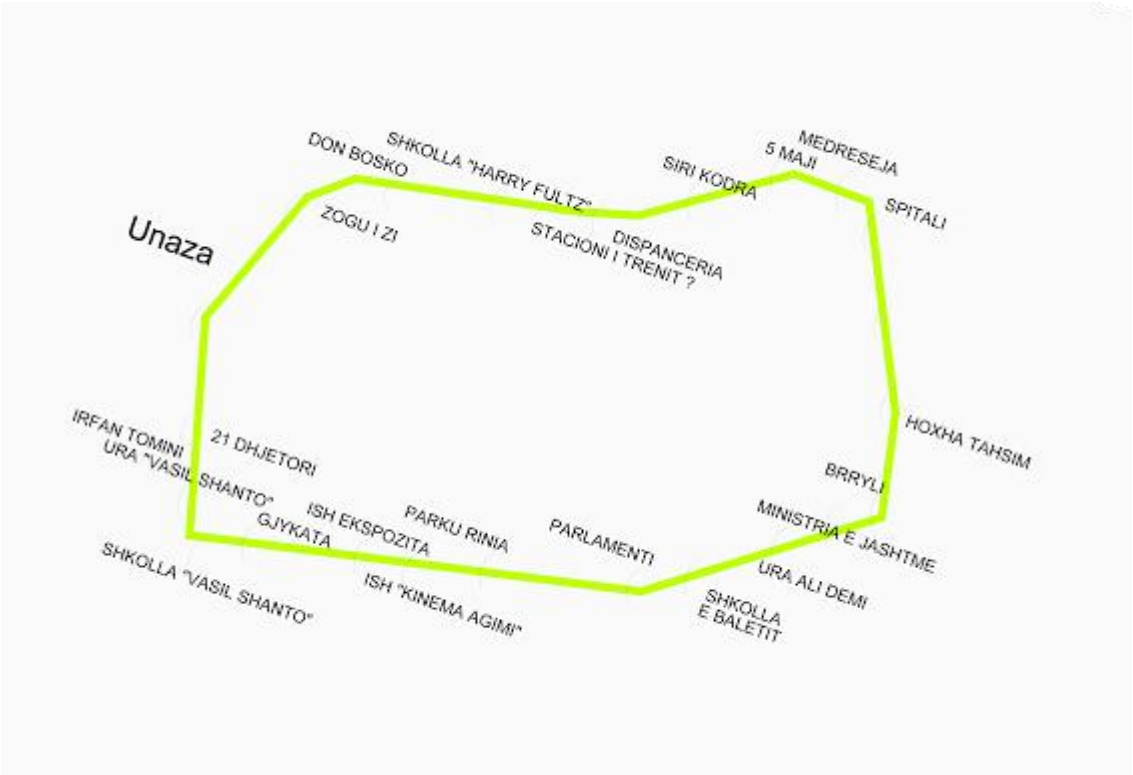
The two main buttons of the model are the ‘Setup (S)’ and ‘Go(G)’ button, inside which there are written all the necessary procedures of the agent’s activity. As even the name implies, the Setup button is the button that is initially pressed in order to put the model into its initial form, without having executed any procedure and it contains the declaration of the variables that are to be used in the model. While the Go button is the button which runs the play of a ‘run’ command in other programming languages and it contains all main functions and procedures to be executed. Below there is a capture of how these buttons look like:

Figure 12. The Setup and Go buttons in Netlogo

```
to setup
clear-all
set-default-shape buses "bus"
set-default-shape nodes "circle"
ask patches [ set road? false ]
import-pcolors "unaza.gif"
ask patches with [pcolor < 50 and pcolor > 42] [ set road? true ]
ask n-of 2 patches with [road?] [ sprout 10 [set shape "bus" set color green set size 8] ]
```

Here it is given the code of the setup procedure, which surely contains the clear all command and it is this command that sets the entire model to its initial situation. In the declaration of the variables we have also declared a circle variable which is the position of the station of the bus, and each point in the image has its corresponding station in the figure.

Through the 'ask-patches' command, the buses are said to start the road or not, and they have to walk through the set path, so they know the color of the path and walk only through the assigned line. The buses are set to be green and of a size of 8 in the Netlogo programming language, and in total there are ten buses that are to be released in the entire cycle of the assigned path. Below there is an image of the path which we are going to use for the model and implement the simulation.



Each bus of the public transportation means starts its route from the same station, which is already set and is fixed, does not change frequently. In our case, we are studying the urban line of Unaza and the starting point for these buses is the station near Zogu I Zi, in both

directions, clockwise and counterclockwise. Each of the buses is obliged to stop at each consecutive bus station and stay there for 10 ticks, which represent the time that the real buses stop in the station while the people are getting 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. Another feature that we have used is that of showing the starting time of the buses and that of showing the path or not which are visually represented below:

Because from the data that we have gathered we have noticed that the buses' drivers define the time in which they start their operations.

What we can other generate from the model is also the graphical representation of the pedestrians who are waiting at the bus station during the time they are waiting for the bus. Obviously the number of the pedestrians is also affected during the peak hours, so in these specific rush hours, not only the buses are overcrowded, but also the number of the people in the streets increases. Below there will be represented both cases, the fluctuation of the pedestrians' number during the peak hours, and the graphical representation of the number of pedestrians during the other time of the day.

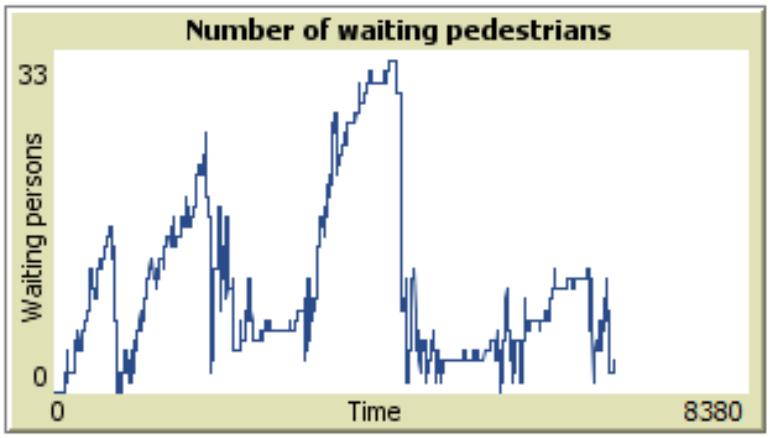


Figure 13. The graph of the number of pedestrians waiting for the bus during the peak hours

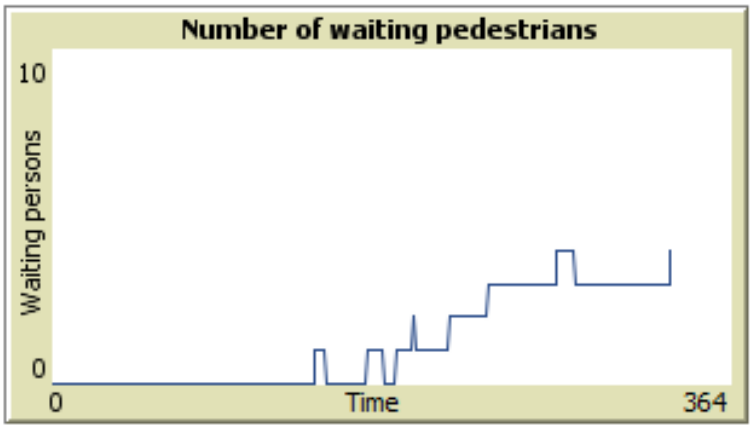


Figure 14. The graph of the number of pedestrians waiting for the bus during normal hours of the day

While the graphs are shown above, still there will be represented a simple screenshot from the simulation in its first step, what means, when the two buses just start to work, and only the two first buses are released because the other ones have not been released yet.

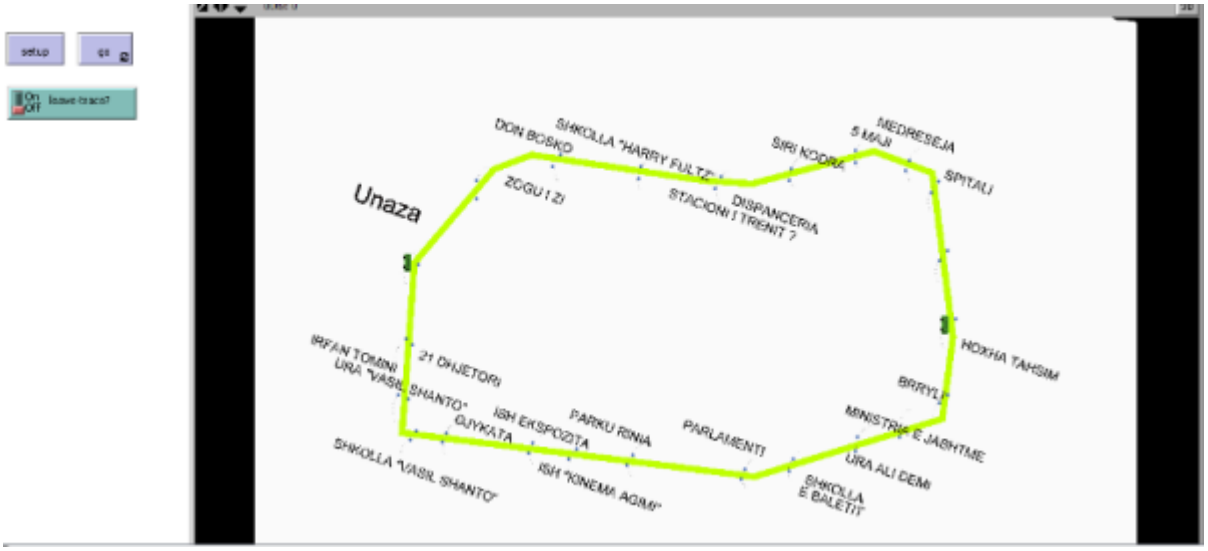


Figure 15. Simulation of the model in Netlogo

In order to have the map of the urban line as a background, we save it as a portable format for Netlogo and import it as an image by using the following code:

```
import-drawing "unaza.gif"
```

CHAPTER 5

CONCLUSIONS AND FUTURE WORK

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 (mainly also focused on that part of the population that uses the public transportation service) , 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 1,3 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, which are those hours of the day when people have to go to their schools or jobs, and the afternoon hours also correspond to the time in which the official working hours have finished and the institutions and main companies are closed, meaning that people will turn back home using the public transportation that they have used in the morning too [17].

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 [18]. 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. Of course that the need for investment is crucial and after a period of time this platform might be spread to different institutions who need these type of data.

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APPENDIX A Screenshots of the model

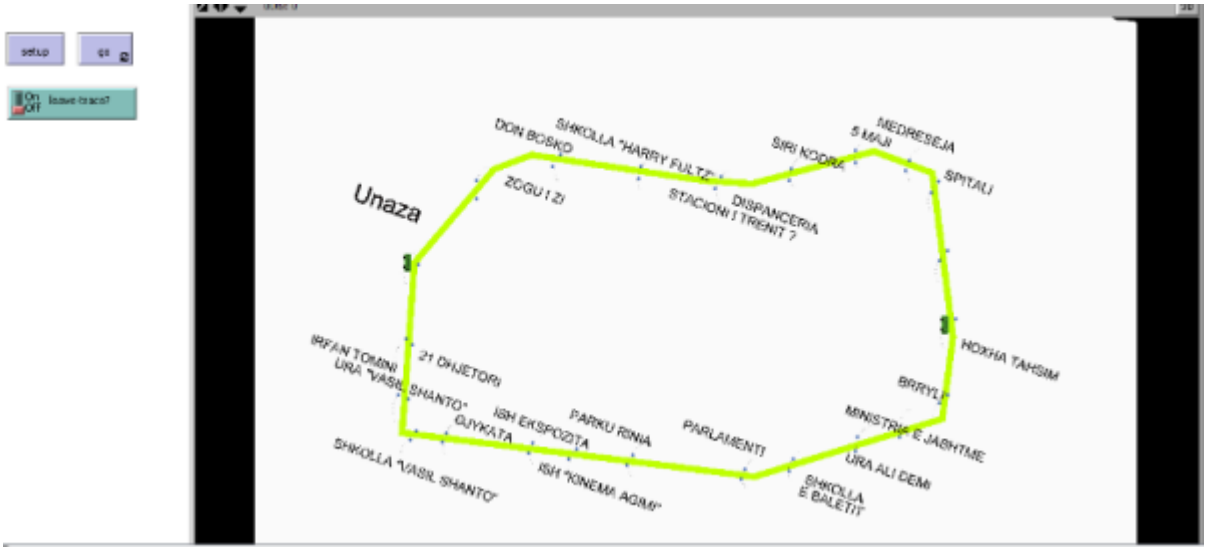

Figure: screenshot of the model in its starting time

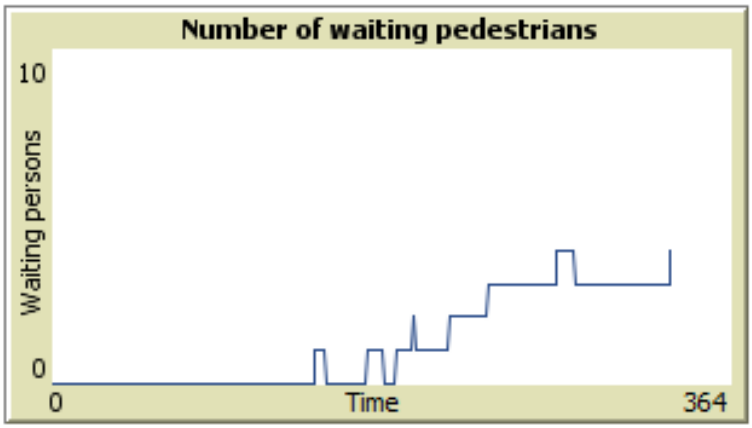

Figure: number of waiting pedestrians in normal hours of the day

Figure: number of pedestrians in the peak hour

Figure: the Setup and Go button

Figure: the slider of showing the time