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THE OPTIMIZATION OF TRAFFIC IN URBAN AGGLOMERATIONS

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Abstract: **Traffic jams are very frequent inside crowded cities due to the large number of vehicles. Improving the existing infrastructure entails prohibitive costs, which is why maximizing its use is very desirable. This paper presents a model for the optimization of traffic via dynamic modification of traffic routes in order to minimize the travel time up to the destination. Using dedicated communication capabilities, vehicles can communicate with the infrastructure in order to get updates on the status of the roads or any traffic jams occurring on one of the road segments along the configured traffic route. In a speed-crazed world and using an infrastructure (streets, highways) that failed to keep up in its development – and considering human error – traffic accidents and jams are imminent**.

Keywords: *Intelligent Transportation System (ITS), communication protocols, traffic simulator, European Commission, vehicles.*

I. TRANSPORTATION IN LARGE CITIES

In large cities, there are several factors that influence transportation, such as the number of vehicles and the existing infrastructure, and it depends on the public transportation as well. Improving the infrastructure (widening streets, building new highways and passageways) requires prohibitive costs, and authorities prefer to delay such measures for as long as possible. A study conducted in the United States shows that over the 1980-1999 period, the length of highways increased by 1.5%, while the distances traveled by cars increased by 76% [1]. Alternative solutions such as the development of public transportation were unsuccessful in the American states, while in Europe the increase in the number of vehicles failed to slow down as expected.

As indicated in the documents from the European Commission, "road transport is essential for economic growth and for commercial and social integration, as it enables the free movement of people and goods on a local and regional level. It has a major role in the everyday life of European citizens, as it is a means that enables easy access to social services and activities". We must note that road traffic along with the related industries make up 11% of the European GDP and concurrently ensure more than 16 million jobs.

In the European Union, 44% of freight transport occurs via roads as compared to 39% via short distance maritime routes, 10% via railways, and 3% via inland waterways. As for passenger transport, road transport accounts for 81%, as compared to 6% for railway transport and 8% to airway transport [2].

Communication between vehicles that does not rely on a preinstalled infrastructure can be carried out by implementing ad-hoc mobile networks (VANET), where vehicles act as communication nodes with ever-changing topologies [6]. Communication can also be enabled by a specially implemented fixed infrastructure or by general communications systems, such as cellular or Ethernet based ones. Vehicles can act as information sources, they can relay information or broadcast information to other vehicles within the network. The type of information depends on the application that is used and ranges from data regarding the movement of the vehicle to multimedia data or internet content.

Communication can be either "one-to-one" (between two vehicles), "one-to-many" (between the leader of a group and the members of the group of vehicles), or "many-to-many" (between vehicles that are geographically close to each other and that communicate their relative positions in order to avoid collisions).

II. TRAFFIC JAMS AND THEIR NEGATIVE IMPACT

Air pollution in urban settings as a result of road traffic jams is influenced by specific geographic and urban planning factors. The microclimate conditions created as a result – which often prevents the dispersion of pollutants – allows for a build-up of noxious substances, particularly in high traffic areas. Road traffic affect the environment via the increasing number of vehicles. The streets that were built decades ago are no longer suitable in terms of their load bearing capacity and their plane and cross-section geometrical elements in order to accommodate the current traffic volume.

The pollution generated by means of transportation in traffic has significant effects on air quality, population health and ecosystems' balance, while also adding up to global warming [4].

The need for optimizing vehicle traffic emerged following the alarming growth rate of pollutant emissions, with the transport sector having a significant share in exacerbating global warming.

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III. COMFORT IN TRAFFIC

Intelligent Transportation System (ITS) [5] refers to the effort of adding information and communication technologies to the transport infrastructure and to vehicles for the purpose of improving safety and reducing transportation times, fuel consumption and traffic jams.

Using infrared or speed cameras, inductive loops, jam detectors and other sensors embedded in the asphalt or in traffic lights and in intersection indicators, ITS systems can monitor traffic and make decisions for streamlining it. Other ITS-related applications include automatic highway tolls' collection, automatic number plate recognition or accident notification systems.

Various communication technologies were proposed for ITSs. For short distances (up to 500 m), communication can be made using the IEEE 802.11 protocol. The WAVE standard and the DSRC - Dedicated Short Range Communications standard particularly were selected for short distances up to 500 meters, while infrastructures based on WiMax (IEEE 802.16), Global System for Mobile Communications (GSM) 4G were proposed for long distances.

These communication protocols are very fine-tuned as opposed to low range protocols; however, the implementation of such infrastructures is very costly. Inductive loops are embedded in the asphalt and they detect vehicles travelling by them, measuring their magnetic fields. The simplest detectors count the vehicles passing per a time unit (60 seconds), while more complex sensors estimate the speed, length and weight of vehicles, as well as the distance between them. Inductive loops can be located on one or several lanes and detect stationed vehicles or vehicles cruising at low speeds, as well as speeding vehicles. Traffic measurement and automatic accident detection are made using video cameras. Given their installation on pillars or similar suspended structures instead of inside streets, the system is named non-intrusive. Black and white or color video footage is sent to a processor that can simultaneously analyze data from as many as eight cameras. Such detection systems frequently monitor vehicle speeds, the number of vehicles, lane occupancy rates, and the distance between vehicles.

Traffic safety has become a priority and the development of communications and wireless networks technologies brought about the development of VANET networks. VANET or Vehicular ad-hoc Network [6] provides a communication protocol between neighboring vehicles or between automobiles and the infrastructure (indicator, traffic light, intersection). Vehicular ad-hoc Network can be seen as a component of the Intelligent Transportation System (ITS). Passenger safety and traffic comfort remain the primary objectives of these networks.

IV. VANET CLUSTER SIMULATOR-MG (VCS-MG) TRAFFIC SIMULATOR

VANET Cluster Simulator-MG (VCS-MG) [7] is a traffic simulator made by authors to solve urban and erxtra-urban traffic jams

To starting a simulation with VCS-MG we have to select for every pointed vehicle on the map, the start point and the destination. VCS-MG, using included algorithms, will calculate the shortest way to the destination, for every pointed vehicle.

VCS-MG is a traffic simulator that allows for both implementing a map from the software's memory and creating a new one, implementing any type of traffic by increasing or deleting the number of vehicles, viewing the number of clusters that a target vehicle is included in, as well as the distance between that vehicle and its neighbors in the same cluster, implementing traffic indicators, as well as the instantaneous obstacles occurring along the way.

VCS-MG can create multiple traffic situation in our simulation, by adding in real time obstacles occurring along the way. Also, we can see in real time the vehicles behaviour with implemented softwere.

During the simulation, the vehicle with VCS-MG recive a warning signal from the first car who detect the obtacle. In this moment, the target vehicle will reset the route, will set a new start point, and will recalculate an other shortest route to the destination, avoiding the street with the obstacle.

The number of clusters that a target vehicle is included in can be viewed by selecting the "Masini" button. The pop-up window features two tables. (*Figure 1.a) Table with neighborhood for a specified vehicle, Figure 1.b) Table with*

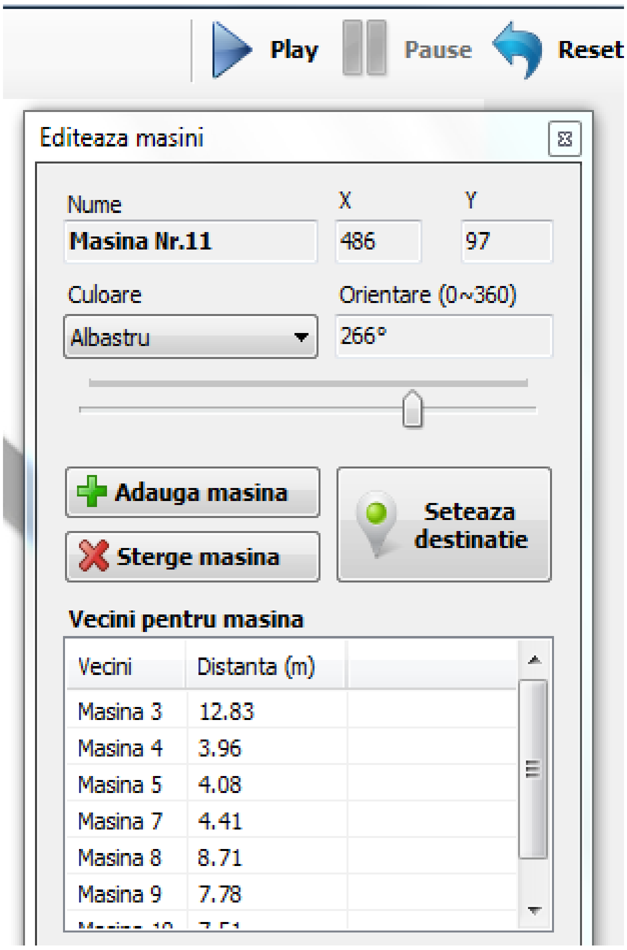

Figure 1.a)Table with neighborhood for a specified vehicle

- *Editeaza masini = Edit Cars*
- *Nume = Name*
- *X,Y = Coordonate Asix*
- *Culoare = Colours*

- *Albastru = Blue*
- *Orientare = Orientation*
- *Adauga Masina = Add Car*
- *Sterge Masina = Delete Car*
- *Selecteaza destinatie = Select Destination*
- *Vecini pentru masina = Neighborhood for a specified vehicle*
- *Vecini = Neighborhood*
- *Distanta (m)= Distance(m)*
- *Masina = Car*

Clustere detectate

Nr.	Participanti	Count
1	[11][3][5][7][10]	4
2	[11][4][5][7][8][9][10]	6
3	[11][5][7][8][9][10]	5
4	[11][7][8][9][10]	4
5	[11][8][9][10]	3

Figure 1.b) Table with Detected Clusters for a specified vehicle

- *Clustere detectate = Detected Clusters*
- *Participanti = Participants*

Detected Clusters for a specified vehicle).

During the simulation, for a randomly chosen specified vehicle, the vehicle nr. 11, blue coloured, VCS-MG detects a certain number of neighborhood wich can communicate, shown in the first column of (*Figure 1.a Table with neighborhood for a specified vehicle).*

In VCS-MG a specified vehicle can belongs of more clusters. The target vehicle will takes decisions by following the information received from the cluster formed by the maximum number of detected vehicles. During the simulation, the vehicle with nr. 11 is part of 5 clusters, but second cluster is the most populated, like in *(Figure 1.b) Table with Detected Clusters for a specified vehicle).*

The first table, “Table with neighborhood for a specified vehicle” features the distance detected between the target vehicle and the other vehicles in traffic, within the coverage area of its proximity sensor.

The range of the proximity sensor for a target vehicle, in the simulation, the vehicle with nr. 11, (*Figure 2.a) Radio Range for a specified vehicle*, reported to the detected neighborhood during the same simulation, there are the values shown in second column from (*Figure 2.b). Altering the range of the proximity sensor.)*

The range of the proximity sensor can vary from one vehicle to another, and this can be seen and altered for simulation in VCS-MG, also by accessing the “Masini” button, where the Radio Range (m) box appears above the “Vecini pentru masina” table. The second table, “Clustere detectate”, indicates the number of vehicles interacting with the target vehicle.

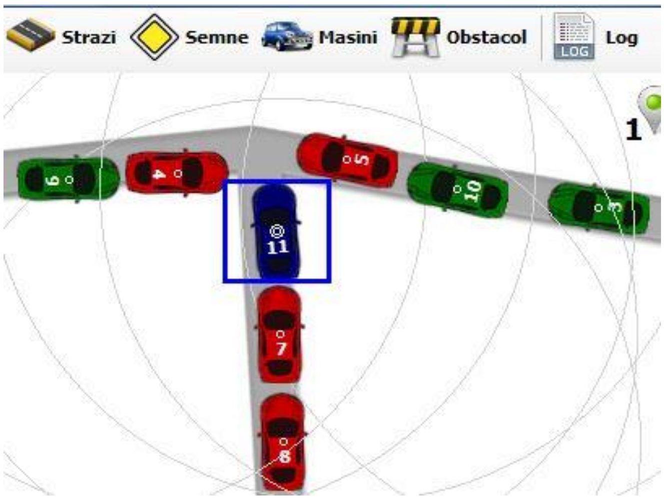

Figure 2.a) Radio Range for a specified vehicle

- *Strazi = Streets*
- *Semne = Signs*
- *Masini = Cars*
- *Obstacol = Obstacle*

Vecini pentru masina

Vecini	Distanta (m)
Masina 3	12.41
Masina 4	4.46
Masina 5	3.94
Masina 7	4.13
Masina 8	8.44
Masina 9	8.26

Figure 2.b) Altering the range of the proximity sensor

- Vecini pentru masina = *Neighborhood for a specified vehicle*
- Vecini = Neighborhood
- Distanta (m) = Distance (m)
- Masina = Car

V. OPTIMAL ROUTE DETERMINATION USING VANET CLUSTER SIMULATOR-MG (VCS-MG) TRAFFIC SIMULATOR

Determining the optimal route inside a city has emerged upon the advent of GPS navigators. Optimal route can mean the shortest route in terms of distance. It can also mean the shortest route in terms of travel time or perhaps the least expensive route from a financial point of view. The most frequent solution is determining the shortest route. This solution is based on static data (city roads) and the position of the vehicle in traffic. However, the roads within a city have a dynamic character. They can be closed for rehabilitation works, can be subject to traffic jams, and can be either crowded or clear. Based on this information we can calculate the shortest route (from a timewise perspective).

The VCS-MG simulator calculates the shortest route from the point of departure entered into the software up to the destination. When the vehicle follows this route, it receives constant updates regarding the status of the road from the other road users. Thus, there is a constant monitoring of the driving speed, traffic density, jams and instantaneously blocked roads. If the information fed into the simulator along the way confirm a blockage, irrespective of its nature, the simulator will reconfigure the route considering the site where the blockage is determined as its point of departure and recalculates the shortest possible route towards the initial destination.

Acording to the simulation, the using of VCS-MG improves the traffic values with 40%. In this moment, VCS-MG is a traffic simulator who can create a simulation for a real traffic situation using a content map, or defining a new one. To solve the situation when the softwere don't have a certain territorial area, the authors works for the implementation in real time of the actualizated maps through Google Maps.

VI. CONCLUSION

Urban traffic jams are a major problem in most metropolises around the world, and intelligent traffic systems are created to offer real time control and route guidance for road users and ultimately to optimize the performances of the traffic network. Updated control policies and adaptive control strategies are used more and more owing to their potential to reduce intersection delays. The solution presented by VCS-MG provides a model for optimizing traffic in urban agglomerations via dynamic determination of the optimal route towards the destination.

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