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# Intelligent Parking Management System by Multi-Agent Approach: The Case of Urban Area of Tunis

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**Abstract:** By coordination and cooperation between multi-agents, this paper proposes the network of intelligent agents which can reduce the search time needed to finding a parking place. Based on multi-agent model, the fined solution is designed to help drivers in finding a parking space at anytime and anywhere. Three services are offered: the search for a vacant place, directions to a parking space and booking a place for parking. The results of this study generated by the platform MATSim transport simulation, show that our approach optimizes the operation of vehicles in a parking need with the aim of reducing congestion, and improve traffic flow in urban area. A comparison between the first method where the vehicles are random and the second method where vehicles are steered to vacant parking spaces shows that the minimization of time looking for a parking space could improve circulation by reducing the number of cars in the morning of 2% and 0.7% of the evening. In addition, the traffic per hour per day was reduced by approximately 4.17%.

**Key words:** Intelligent parking management, multi-agent system, benefit evaluation, urban transportation.

## 1. Introduction

The parking activity accounts for a link in the chain of urban travel. It is also the point of departure and arrival of any vehicle traffic. With a lack of parking space, in the end of the trip, the driver will spend its time in the search of vacant place, or turn around the car park, or postpone his activity. Gradually, the driver spends more time to find a parking place and so the congestion of traffic city can be increased. This lost time has serious impacts on traffic, on activities and the environment. Traffic congestion, traffic noise, traffic pollution, fuel consumption and insecurity are some examples of negative externalities of parking problems. To resolve these problems, local authorities of cities have a strong need for an intelligent parking management which could reduce the search time and in turn associated negative impacts.

Parking problems are a great challenge to facilitate traffic and ensure the quality of urban life. For a long time, looking for a place to park was neglected because of its invisibility, even though its negative externalities have been identified. The severity of impacts caused by the problem of finding a parking space motivates researchers to study the parking management problem and to come up with solutions to solve problems met by drivers and to reduce impacts on traffic, environment, and society. Studies have shown that a small search time by car can create a surprising amount of extra traffic which is source of urban traffic congestion [1]. Finding a parking space is still responsible for the causes of accidents, waste fuel and time, air pollution, and degradation of the pedestrian environment [2, 3]. Reducing of the traffic externalities is one of several objectives of good parking policy. There are other goals such as ameliorating accessibility, maximizing turn-over for shops to develop the local economy, reducing the congestion, encouraging the using of public transport. Generally, the establishment of an optimal parking is often difficult because these objectives are in conflict [4].

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The good parking policy is then which taking into account the maximum of economic, social and environmental constraints. It needs the evaluation of its numerous effects as many other urban policies (urban transport policy, land-use policy). The literature showed that numerous tools have been used to achieve one or more of these objectives. Some of them are economic as parking pricing [5], fiscal as parking taxing, and technological as intelligent parking management.

In this paper we interest to studies which have proposed the application of Technologies of Information and Communication (TIC) to elaborate an intelligent parking system. These studies proposed parking models which are based on technologies as especially on Cellular Automata (CA) and Multi-Agent System (MAS). Contrarily to traditional regional models, these new models have permitted to pass from macroscopic to microscopic parking modeling approach throughout the simulation models [6]. Particularly, Traditional models aggregate all origin and destination points of traffic flows in zones of the considered area to “average points” namely “centroids” and all drivers to the “average driver”. However, new models disaggregate all variables in areas and can studding the behavior of every driver taking into account the variety of parking’s, links, origins, destinations, and real traffic and parking environment. Search time for place parking, walking time, traffic flow, traveled distance gain and associated energy consumption and pollutants emission and destination are the main impacts measured by these studies.

A lot of information and communication technologies are likely to set up a promising smart parking such as the website, staking systems dynamics parking lots, mobile phones, the multi-agent and ad hoc networks without son. Vehicular Ad Hoc Networks (VANETs) is a new technology that has mostly gained the attention of researchers in road traffic management. Safety and efficiency of transportation system are the two essential problems where it is applied. Dynamic staking systems of parking lots try to bring the flow of vehicles heading to saturate parking and to less busy areas. They display the name of the car park, the direction and the filling of the parking lot. The search strategy, based on dynamic staking systems of parking lots, is unassisted. Indeed, the driver turns into a search radius where the node information on the availability of parking spaces and it can get as close to parking spaces. Nevertheless, it’s to be noted that ad hoc network without a son is an opportunistic assisted research strategy. Thanks to standard interfaces without son, the information on the availability of vacant parking spaces is provided to all motorists who are in the coverage area. Vehicular Ad-hoc Networks based real-time navigation of parking was studied recently [7]. The basic idea consists to use of restricted stock units for monitoring and management of the entire parking lot. These units are activated by communication between vehicles and RSUs (Road Side Units: units across the road) in an ad-hoc network.

Mobile phones, the Web site and multi-agent systems represent a centralized assisted research strategy. In this case, it is a central server or a central unit responsible for the dissemination of data on vacant parking spaces. Once the reservation is made, the driver simply moves to the designated space. The Internet can be the best way to help drivers find a space to park, online in an occupied city. Motorists can also use their cell phones to check available space, make a reservation and get directions. Furthermore, the multi-agent artificial intelligence is one of the new technologies of information and communication that are now applied to parking. Numerous existing studies have created a multi-agent platform for several objectives and with a variety of constraints. [8] proposed a platform which correspond to an implementation of a dynamic system of negotiations parking spaces. They used a system of intelligent agents, and given that the price of parking is negotiable, it selects the best car for the driver. [6] presented a parking model, PARKAGENT, which simulates the behavior of drivers capture the complex self-organizing dynamics of a large collective of parking agents within a non-homogeneous (road) space. Authors applied their multi-agent model to residential parking in Tel Aviv city and aimed to determine if the additional parking supply can reduce the search time of parking place. Along similar lines, [9] created a system of information and guidance for parking by the alliance of GIS (Geographic Information System) with GPS (global positioning system) and 3G (wireless system).

The objective of this paper is then to optimize the search time for a parking space by integrating a multi-agent network. With rapid technological advancement in computing and telecommunications, Multi-Agent approach, may be appropriate to minimize wasted time and to improve urban traffic flow, we propose a solution based on multi-agent approach which allowed the development of a sensitive method to reduce the wasted time looking for parking space in a given area. After presenting the various methods and technologies to solve the problem of finding a place or park in section 2, the architecture of our proposed solution is described in section 3. A section 4 deal with the implementation of the architecture proposed in the simulation model MATSim, presents the results and their analysis, and describes the algorithms used in the system. Conclusions are drawn in section 5.

## 2. System Architecture

The conceptual model of our solution is based on Multi-Agent systems. This model is a way of representing our real world. This allows us to represent the dynamics of resource parking use, namely the interactions regarding the use of parking resources between vehicles which are the main actors of our solution.

The basic organizational structure of our system is a hierarchical structure. The hierarchical organization of agents allows a default message routing which facilitates the development of agents. There are five types of agents having each one characteristic that distinguish it from others: vehicle agent, traffic agent, global traffic agent, parking agent and station agent.

## 3. Vehicle Agent

This is the only dynamic component that drives the road network. Each vehicle is equipped with sensor information allowing the agent to perceive its environment. The vehicle agents collaborate to monitor the road network. Indeed, they produce information contributing to knowledge in real time, traffic conditions or to predict traffic conditions.

All events observed by the vehicle during its movement must be transmitted to other vehicles, which transmit this message to the nearest traffic agent. In turn, the traffic agent may send a message to staff vehicles. Generally the exchanged data are intended to produce alerts and inform drivers of an event occurring. All the parameters such as: average speed, travel time, inter-vehicular time ... will be calculated by the agent on board the vehicle to determine the approximate state traffic: fluid or dense.

### *3.1 Traffic Agent*

This is a static component that represents a specific point of the transport network: at each intersection (or node), we introduce a traffic agent. It produces, in real time, information about the current state of traffic within the road segments that it manages.

The traffic agent must handle messages emitted by vehicles in the first place to inform the global traffic agent of disruptions to normal traffic situation. Second, he warns motorists on their way to the place of accident for example. Average speeds, the time inter-vehicle ... can be exploited by the traffic agent as information on the status of traffic: fluid, dense or saturated.

### *3.2 Global Traffic Agent*

Communication inter-vehicle and communication road vehicle used to exchange a couple of accurate information on traffic conditions. Following these exchanges, the global traffic agent will have a global vision on the road network of the area it oversees. The main goal of this supervision is to maximize road safety and minimize the time spent on the roads to make them friendlier.

The global traffic agent collects the information on road conditions from traffic agents then synthesizes the data. Once the global traffic agent has a more complete view of the road network, it broadcasts information to traffic agents. For example, the agent tries to thin the road network by seeking alternative routes for vehicles aware of traffic conditions: it produces a map of their route guide to alternative routes more secure.

### *3.3 Parking Agent*

The parking agents are installed in car parks spaces (parking, sidewalks). Their role is to follow in every moment the state of occupation of parking spaces. They get precise information on the availability of parking space through sensors installed throughout the car park on-Street, or through the automatic gates installed at the Off-street parking. Each park agent must in turn report to the station agent, in real-time, the number of parking spaces available compared to the total capacity of the park.

In fact, the parking agent provides to the station agent two data types: static and dynamic. When it comes to static data, it represent an invariable data such as the name of the park, the maximum capacity, the price (sometimes variable), the coordinates of the car, type of parking (to determine if this is a car park on-Street or off-street) parking time. With respect to the dynamic data they stand for a variables one: the number of seats reserved and the number of places available.

### *3.4 Station Agent*

The station agent is a central location for storage of information detailing the state of parking spaces in the area it manages. At each time, he gathers the list of vacant parking and with the collaboration of the global traffic agent coordinates with motorists to guide them to open space.

### *3.5 Communication Protocols*

The vehicle agent acquires information in the form of observed events, either by itself, or through exchange of information with other vehicles, or whether through an infrastructure. Similarly to the traffic agent who acquires information by the vehicle agents, or through the global traffic, or by other traffic agents in control of the global traffic agent. Each vehicle will be equipped with a sensor (eg antennas) to detect data and with an agent to deal with them. At each intersection and we install a post in charge of collecting information and an agent responsible for processing information. And with the 802.11 communication protocol information can flow in real time between the different agents in the same area.

Coming to the parking agent, it collects information from plates installed in the ground for each parking space or through the automated gates installed at the entrance of the park. In addition, it receives information from the station agent. The latter has two sources of information: the parking agents and the global traffic agent (Fig. 1). The plates are sensors powered by an onboard battery. The signals from these small devices will be transmitted in real time, to parking agents installed on sidewalks. Signals from the sensors contain information on seat availability.

Sometimes during the existence of traffic lights, different agents can cooperate to minimize the waiting time of vehicles at intersections. Agents of highest priority vehicles such as ambulance vehicle [10], the police vehicle ..., inform the parking agent of their attentions to park. The parking agent on his part communicates with the global traffic agent for information. And the latter under the action of the agent traffic, will try to reduce the waiting time of the vehicle by adjusting the next sequence of each traffic light.

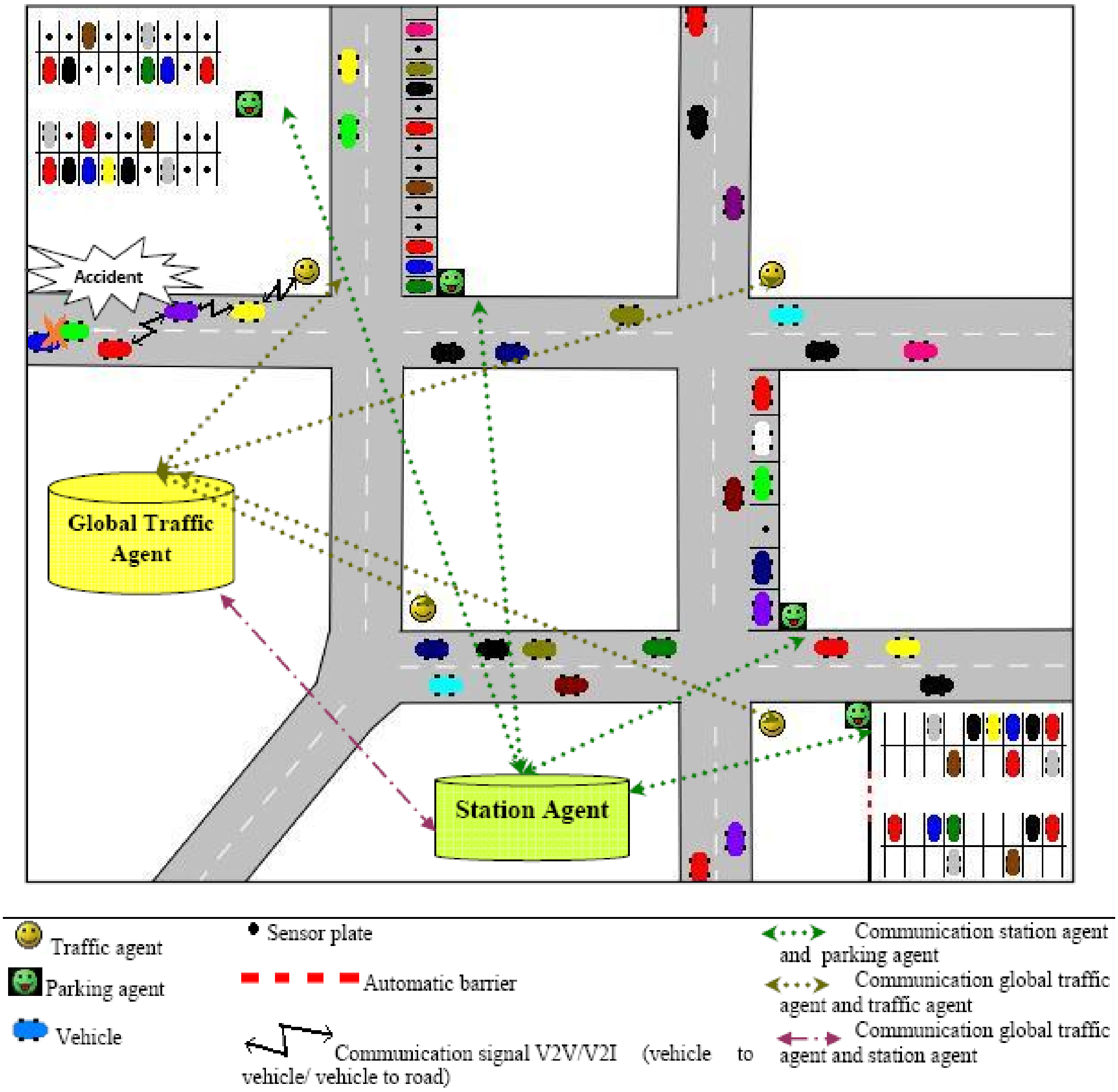



**Fig. 1 Scenario of communication between different agents.**

## 4. The Functioning of the Solution

The idea of our smart parking system is to develop a procedure which coordinates road between driver and car parks in order to solve the problem of finding a parking space and then provide more convenience and comfort in terms of conduct. New information technologies such as GPS and GIS are used to facilitate the process of parking (Fig. 2).

Our system will enable pilots to:

Search free parking spaces, quickly, at anytime and anywhere.

Acquire a lot of information, among others, as prices, locations of parks around their destinations.

Search for the optimal path to reach the destination quickly and avoid traffic jams.

Ensure the principle of seat reservation.

### *4.1 General Design of the Solution*

Once the driver reaches the air in "D" where he wants to park, it must register with the station agent by entering its destination: the GPS accurately measures the coordinates of the current location of driver [9]. Through the GIS, the positioning of this point will be located on a map displayed in the GUI man-machine. The user can then view its destination and highlight it. Besides the destination, the driver must specify certain personal data such as length and type of parking his vehicle (gasoline or diesel). At this stage, the vehicle is the agent responsible for transmitting all information to the station agent. It's worth noting that the station agent, who has, in real time, the list of car parks with open space, interacts with the global traffic agent and asked him to find the shortest path associated with each parking space. The global traffic agent refers to the current location of the driver and contact information for each parking space contained in the list.

The idea of seeking for the shortest path can lead to beneficial results not only in terms of reducing time spent on the road but also in terms of improving traffic efficiency and reduced consumption of fuel (energy saving).

Based on the information transmitted by the global traffic agent and on the price and duration of parking, the agent assigns a cost to each parking space. Indeed, the cost (C) is the combination of three elements. The first element is the multiplication between the travel time of the shortest path (K) leading to the parking and fuel consumption (F). The second element is the multiplication between the parking price (P) and the parking duration (D) of the driver. Finally, a multiplication of the length of the distance in feet to walk (M: distance between parking and destination) and the time's value of the driver and his companions (R). Afterwards, all costs will be sorted in ascending order from minimum to maximum, which is likely to allow the solicitor the opportunity to choose the most convenient parking.

$$C = (K \times F) + (P \times D) + (M \times R) \qquad (1)$$

Where C is the cost evaluated with Tunisian dinar (TND), K is the travel time by car (h: hours), F is the fuel consumption (TND/h: dinars/hour), P is the price of parking (TND/h: dinars/hour), D is the parking time (h: hours), M is the travel time to work in feet (h: hours), R is the time value of the driver and the number of people in the car (TND/h: dinars/hour).

*4.2 Guidance to a Parking Space*

As soon as the calculations are completed, the list of free parking spaces (unoccupied) appears instantly on the screen of the dashboard: the GIS produced a map that illustrates consulting geographical positioning of each parking space compared to the driver's location and destination. Several information associated with each parking are also displayed: name parking, type of parking (on-street or off-street ...), cost (C), parking price (P)…

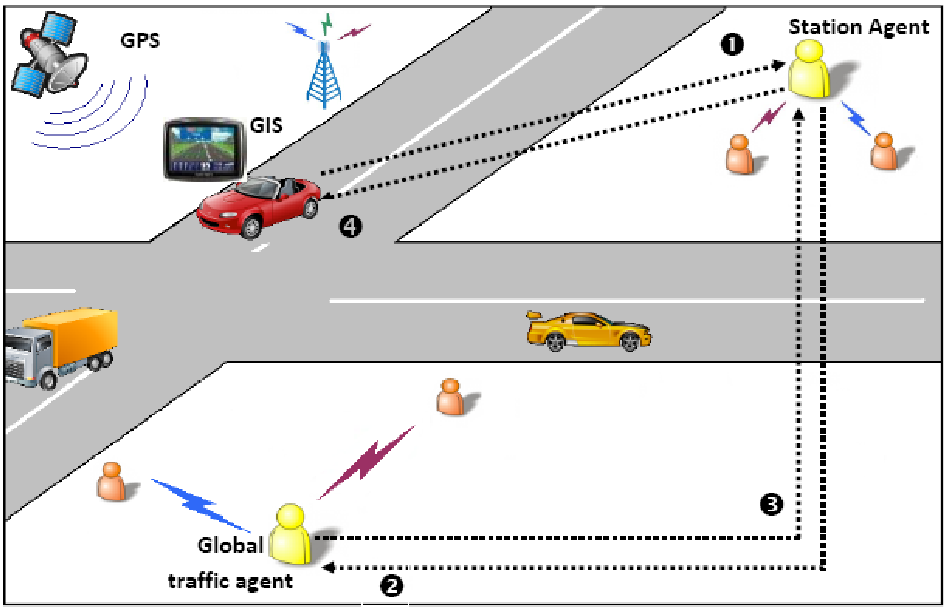
Once all information at the disposal of the user, it must take the initiative to decide which parking space he wants?

The driver can select the parking that suits him on the basis of the cost function calculated by the station agent, or according to its time value, calculated on the basis of the distance of walking. This latter is between the parking and the chosen destination target. This factor reflects the time value of driver that can be solved at its selection of the location of the parking lot.

A simple touch of the screen and the choosed car park is designated by the user. Following this choice will start two steps: (1) The GIS produces a path map that guides the driver's current location to the desired parking location (display the shortest path already computed by the global traffic agent). (2) The station agent must sign a seat booking contract with the vehicle agent.

*4.3 The Reservation*

The system must ensure, through the principle of reservation, a parking space available for the driver. Indeed, the station agent must provide to the vehicle agent a reservation guarantee, if we fall back into the same conflict of lost time due to the search for a place. In a simpler way, once the driver manages to have the reservation, it will go straight to the choose car park. But at the same time, there's certainly other cars




The vehicle requires the station agent a parking place.
Parking agent sends the list of car parks available to the global traffic agent.
The global traffic agent returns the shortest path for each car.
The station agent calculates the cost of parking (C) and returns to the driver a dataset.

**Fig. 2 Process of parking.**

currently looking for a place to park. When the driver reaches the target location, it will most likely find its space already occupied by another vehicle. Subsequently, our driver must try to do another search [11, 12].

Once the order booking is confirmed by the station agent, the vehicle agent and the parking agent must inform each other to follow the progress of the vehicle. When the space detects the presence of a vehicle, the parking agent must check the identity of the agent vehicle. If the identity is not confused, the agent must warn the car driver through the vehicle agent, that this space is reserved.

## 5. Simulation and Results

The network created in our project is an extract from Open Street Map (Fig. 3) containing only roads in the region of interest, Tunis city center.

According to the municipality of Tunis, the selected area has a capacity of 11,200 parking spaces divided into two categories: parking in the blue zone and on street parking. Parking in the blue zone of Tunis offers 5200 seats including parking time shall not exceed two hours and this is what allowed from 8:00 until 20:00. The unit price of a place to park is 0.500 TND per hour. To reduce the parking street, the center of Tunis has several parks with capacity reached 6000 seats. The price of these parking varies between 0.300 TND and 0 TND per hour.

This sample contains about 50,000 vehicles / day (randomly generated). This network includes only roads with cars of 2500 links and 1000 nodes.

We have developed a simulation's environment in the software simulation MATSim (Multi-Agent Transport Simulation). As a matter of fact, this software provides a toolbox to implement large-scale transport simulations based agents.

Figure 4 provides an overview of the data structure.

Moreover, for the project described, two methods were highlighted. For the first method, people can move randomly in the hope of finding places to park their vehicles. However, in the second method, our people are guided to parking spaces. Thus, a comparison between the two methods was established.

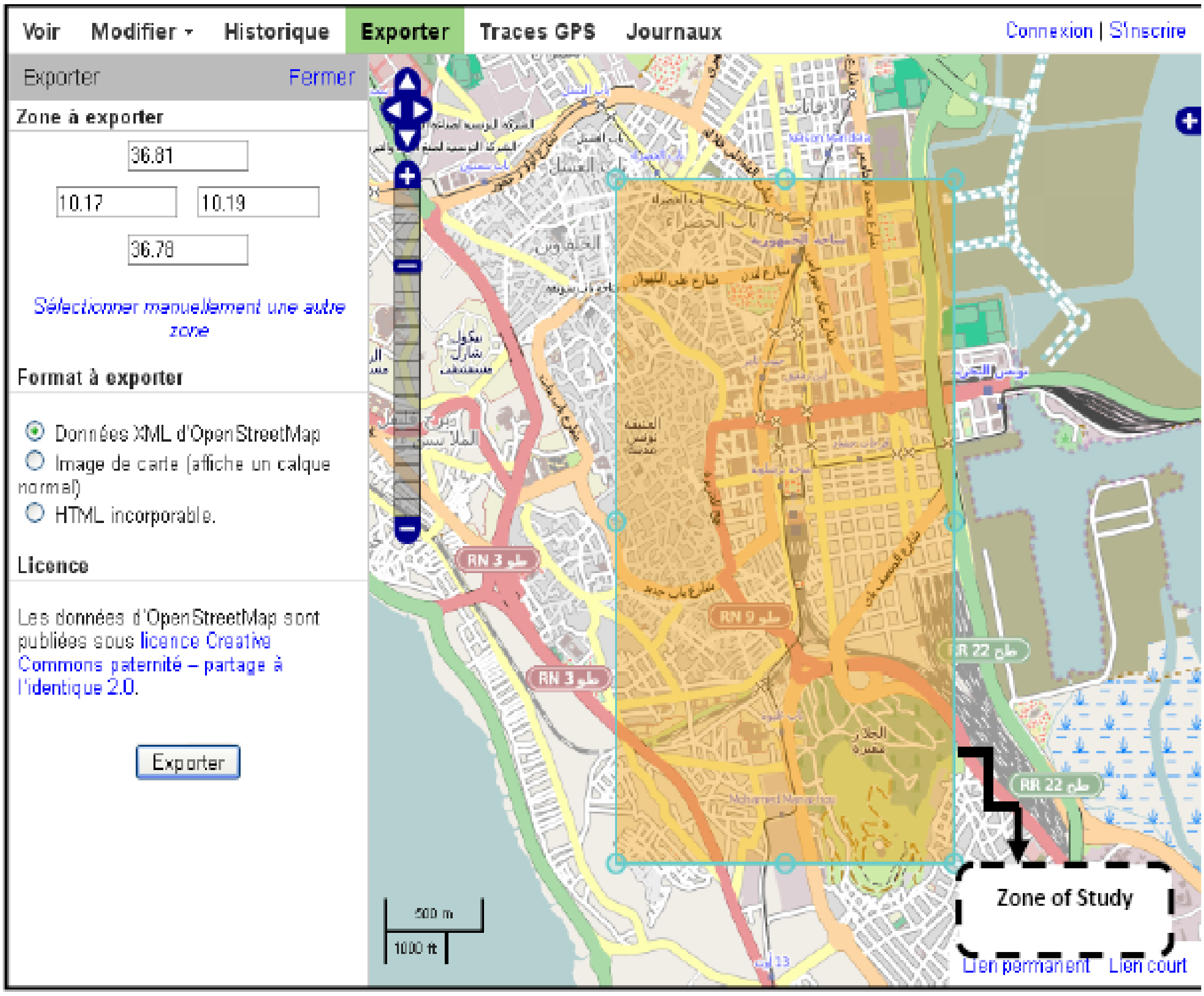



**Fig. 3 Tunis city center according to Open Street Map.**

Network:

1) node: each node is identified by a unique id and has x, y attributes which are converted from geographical location.

2) link: each link has a unique id and is defined by a start and end node. Further important link attributes are length, capacity (vehicles per hour), free-flow speed and number of lanes.

Plan:

3) agent person : each agent person refers to a citizen.

4) itinerary: each itinerary contains the trips and activities done by the agent throughout a given time period. Within that period, each agent only has one itinerary. Each agent should and only have one itinerary for one day.

5) trip: each trip contains multiple nodes and has distance, start and end time attributes. Hence the exact location of an agent at certain time can be retrieved.

6) activity: each activity is what the agent is doing at a given time. It contains the activity type, such as shopping and education, location, start and end time attributes. Activity can also be considered as a trip with a event type and no change in the location.

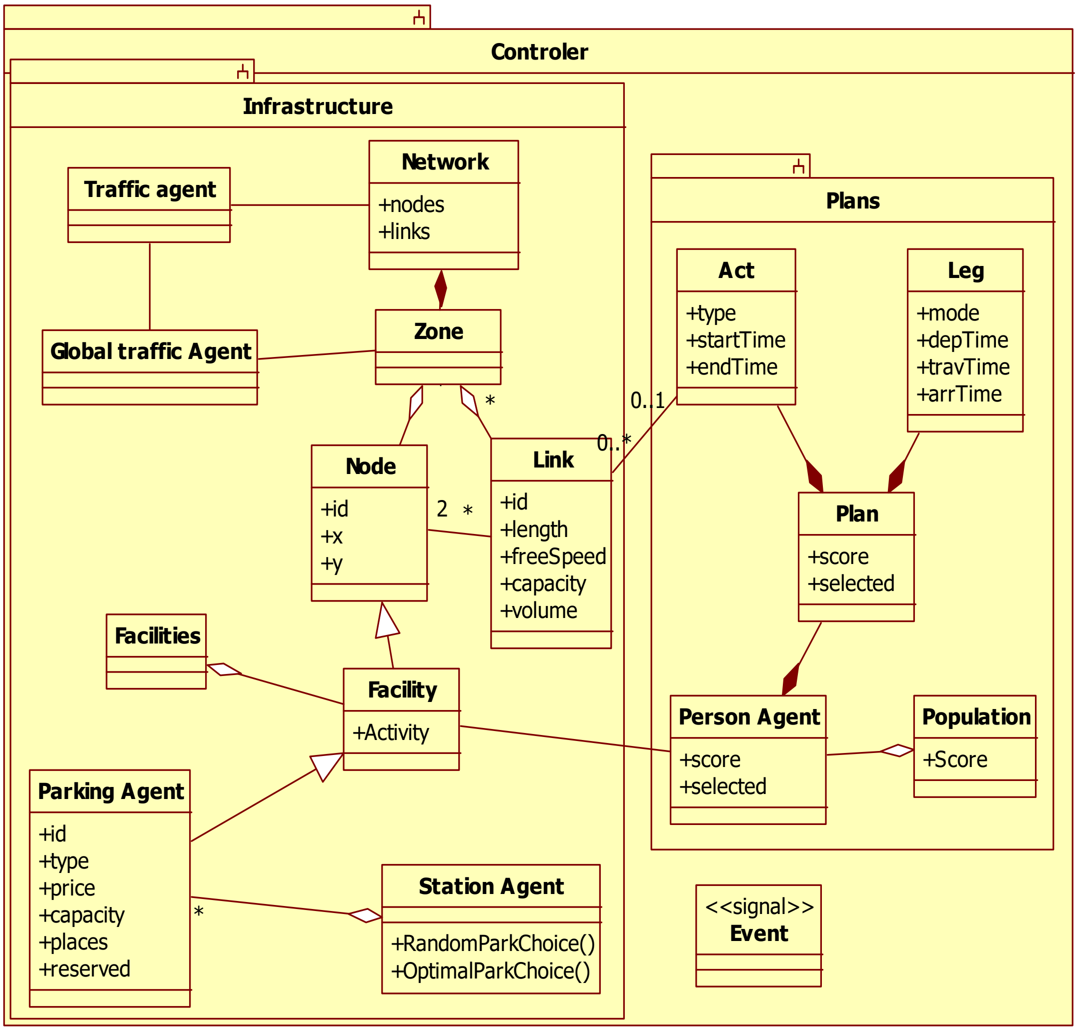



**Fig. 4 The data network-based activity data.**

*5.1 Changes in the Number of Vehicles in Circulation Over Time*

After each simulation, MATSim generates a set of curves representing departures and arrivals of vehicles agents and the number of those on the road. Figures 5 and 6 show the road one day during the week and by the two methods. These are curves that reflect the number of staff vehicles arriving, departing or are moving every hour of the day. By doing so the red symbolizes the number of vehicles that have left their places of origin, the green curve represents the number of cars circulating in the street, whereas the blue curve shows the number of vehicles that have reached their destinations.

In order to compare the results of both methods, we proceed by comparing the curves, and then we can notice that:

Search free parking spaces, quickly, at anytime and anywhere.

With the method 2, the green curve is lower and the red curve is higher than of method 1. This implies that if drivers are guided to parking spaces, first the number of cars circulating in the street is fewer, and second the number of vehicles which have reached their destinations is higher despite that the number of vehicles which have left their places of origin is more important than if drivers are moved randomly in the hope of finding places to park their vehicles. The blue curves show that the number of vehicles that have led to their destinations on the 24 hours studied is higher in the case of method 2.

The curves have two peaks: a first peak in the morning, which peaked at 8.00 and a second peak at the end of the day which peaked at 18:00. In fact, the morning peak reflects the number of vehicles that gets to the desktop. While the evening peak reflects the vehicles leaving work and returning home. In the morning, the maximum number of car (pic) is 12100 cars for method 1 against 11100 cars for method 2. It can be concluded that first, the traffic for method 2 is proportionally more fluid than the traffic of method 1. Second, the 2% of vehicles or 1000 cars reduced for method 2 represent the proportion of motorists who were looking for places to park. Therefore, less time to find a parking spot represents a reduction of travel time. This reduction has positive repercussions on the psychology of drivers, especially in the morning. The evening was recorded by more than 14.250 cars for method 1 against 13.900 cars for method 2. The traffic is fluid in the evening and compared to method 2, the percentage of reduced vehicle traffic is currently equal to 0.7%. It's lower than that found in the morning because the conductive agents who broke away from their workstations will move toward the periphery of the city center (away) or they will move downtown to a pattern of leisure or purchase; they are more likely to find vacancies. Similarly, for people arriving from the outskirts of the city center will be guided to parking spaces unoccupied.

The number of vehicles in circulation is damped to 22:00 for Method 1 and to 21:00 for the method 2. One hour of traffic accounts for 4.17% of road traffic or 2084 vehicles. This is explained by traffic that has become more fluid and by lessening the time to find a parking spot.

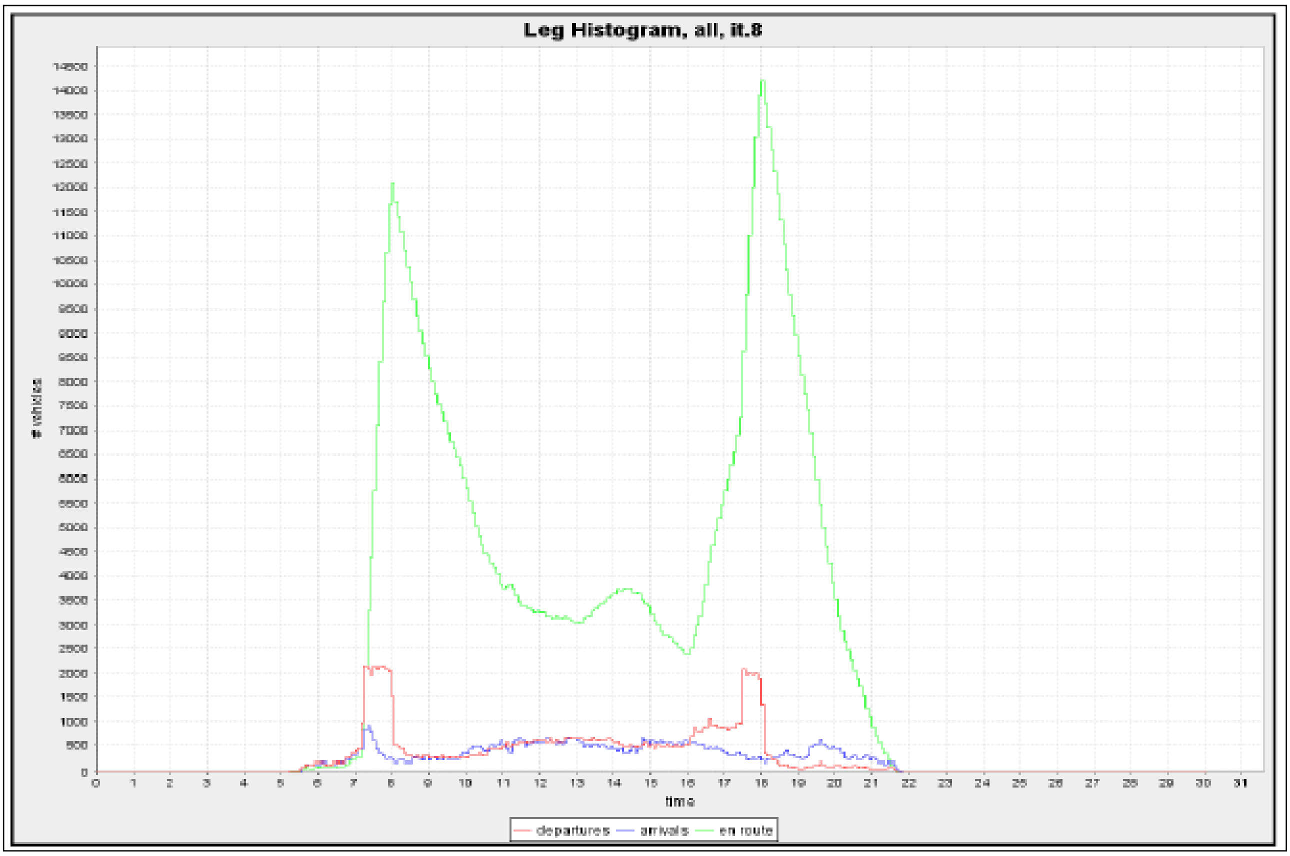



**Fig. 5 Simulation of 50000 vehicles (method 1).**

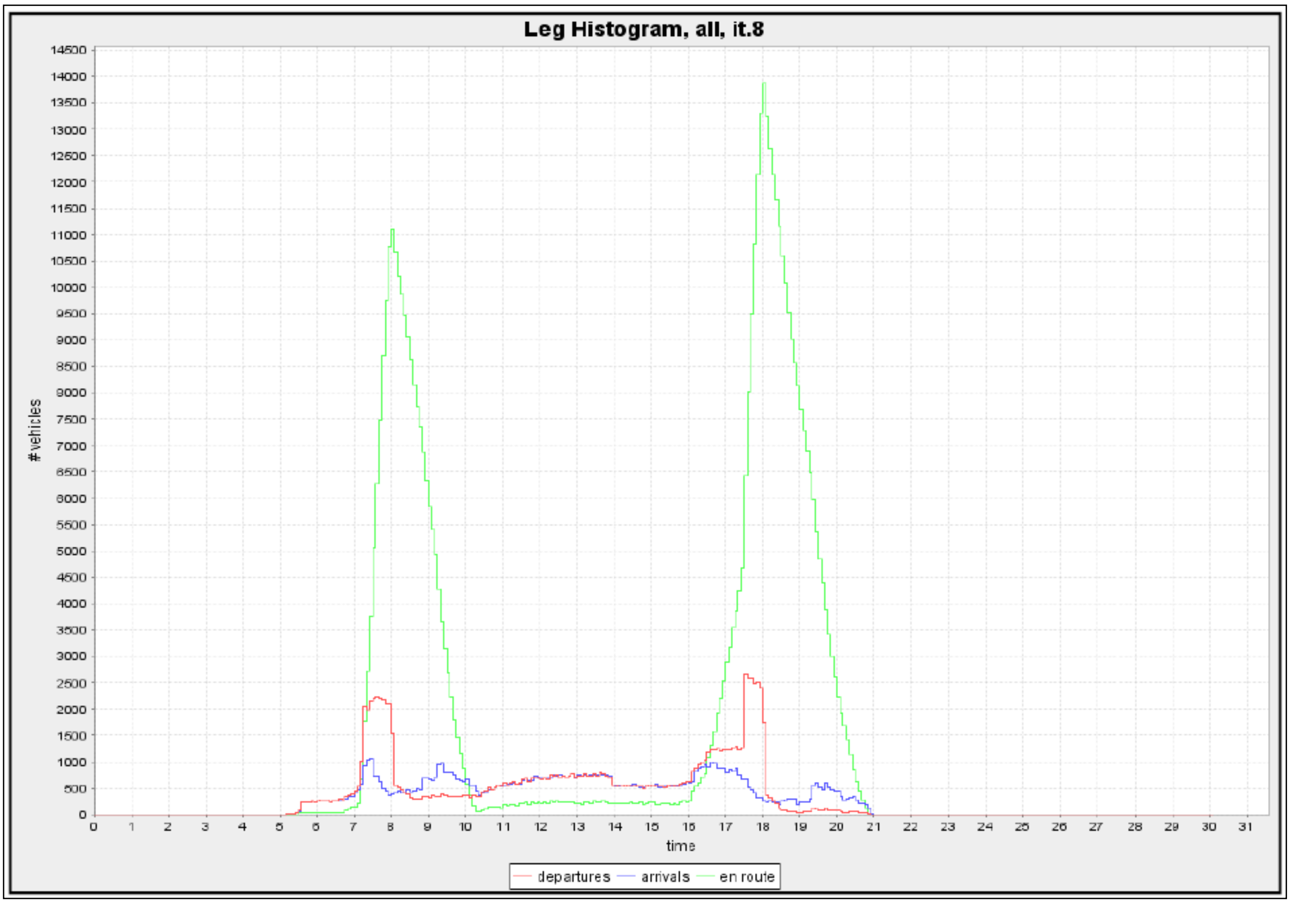



**Fig. 6 Simulation of 50000 vehicles (method 2).**

Results obtained from method 2 imply that an intelligent management of parking demand could have several positive impacts on the environment (pollution, noise, energy ...), society (health, comfort, lower gas evolution ...), public investments on urban infrastructures and buildings,

5.1.1 Study of Statistical Scores

Three types of statistics are available for each iteration: the best plan, the average plan and the worst plan as curves. Thus, the score function is defined as:

$$U_{plan} = \sum_{i=1}^{n} \left( U_{act,i} + U_{wait,i} + U_{lat,i} + U_{travel,i} \right) \quad (2)$$

Where, i denotes the activity, n the number of activities, the utility of a plan (Uplan) is the sum of four components: the total utility due to the implementation of the plan of activity i (Uact,i), the positive utility due to the establishment of the activity i (Uwait,i), the negative utility following a delay to achieve the activity i (Ulat,i ), and the negative value due to the effect of the distance traveled to arrive at the i acitivity (Utravel,i).

Results of statistical scores (Table 1) show that method 2 is more efficient and more effective than Method 1.

5.1.2 Statistics Distance Travel

Figures 7 and 8 show the evolution of the travel distance traveled by vehicles for each iteration.

Table 2 presents the main differences between the two methods in term of the best distance traveled, the worst distance traveled, the average distance traveled, and the associated average saving of energy consumption.

Results of statistics distance travel (Table 2) show also that method 2 is more efficient and more effective than Method 1.

Depending on the distance traveled, the average saving of energy consumption can be measured as:

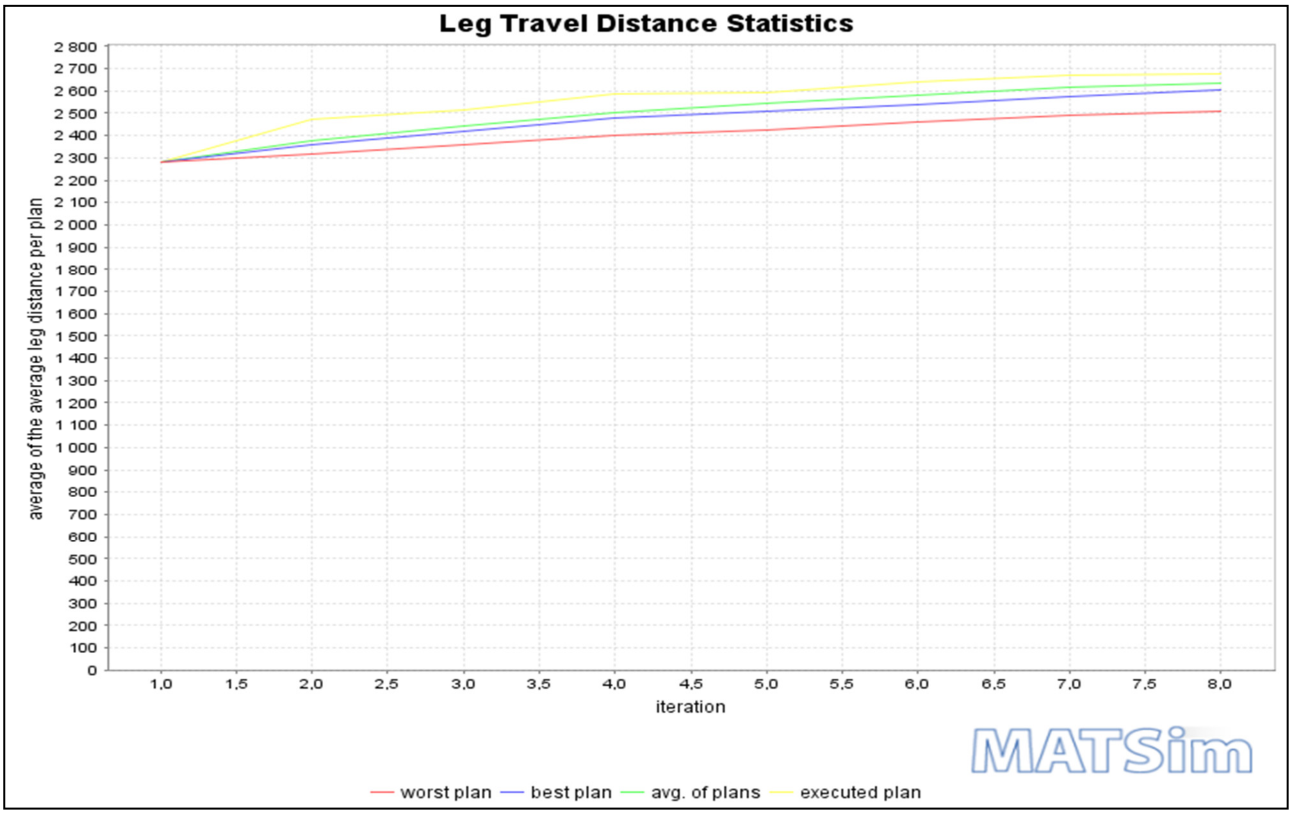



**Fig. 7 Statistics on Distance Travel (Method1).**

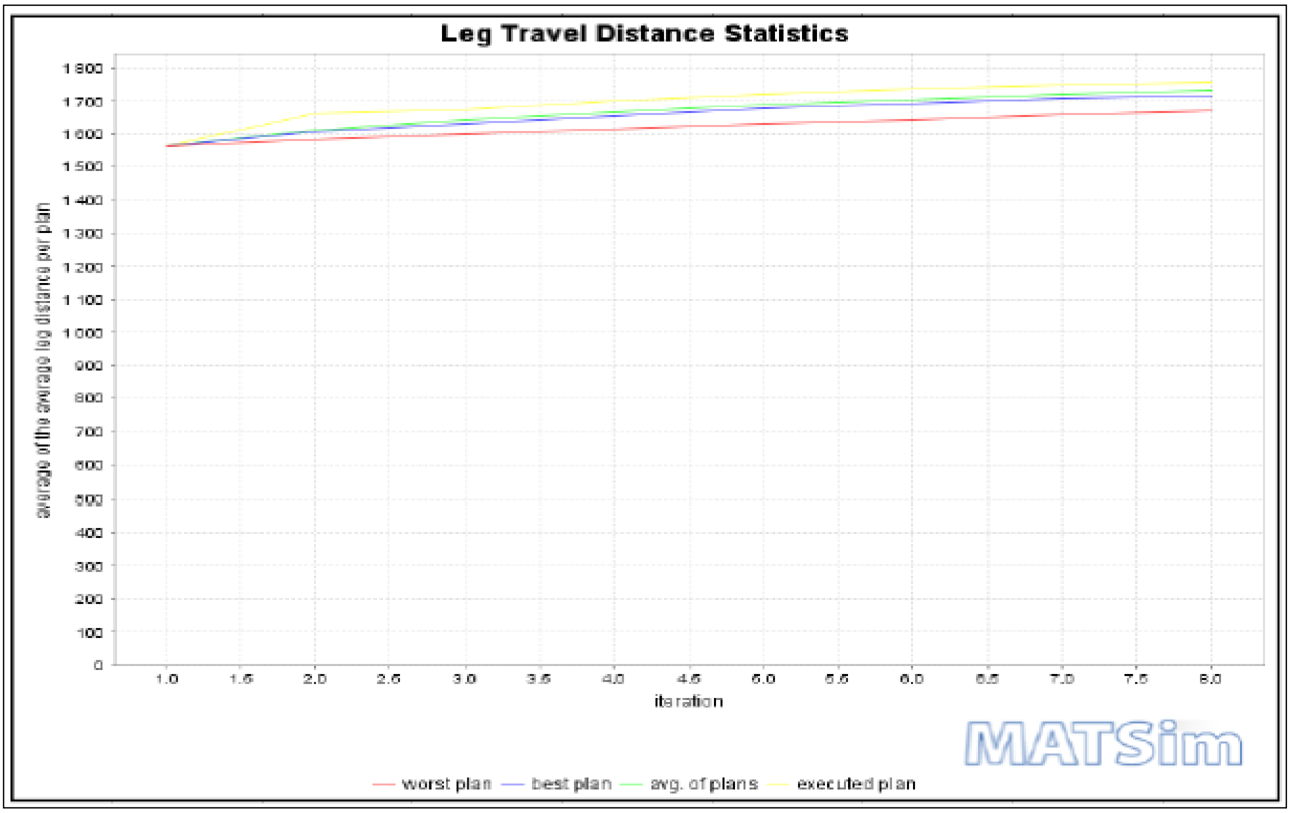



**Fig. 8 Statistics on Distance Travel (Method2).**

$$ASEC = NV \times AFC \times D \times APD \quad (3)$$

Where, ASEC is the Average Saving of Energy Consumption, NV is the number of vehicles (50000), AEC is the average fuel consumption per 100 km (7 liters/100 km = 7%), DT is the distance traveled, and APD is the average price of fuel (1.250 TND). According the method 1, the average saving of energy consumption is:

$$1.09375 \times 10^{10} = (50000 \times 7\% \times 2500 \times 1.250).$$

However, according method 2, it's:

$$0.74375 \times 10^{10} = (50000 \times 1700 \times 1.250).$$

A decrease in daily distance traveled by the resulting method 2, causes a reduction in average savings of energy consumption of $0.35 \times 10^{10}$.

Statistical scores

| | Method 1 | Method 2 |
|---|---|---|
| Score of the best plan | -55 | 23 |
| Score of worst plan | -310 | -103 |
| Average score | -187.5 | -47 |
| Score of implementation | -160 | -37.5 |
| Score of start | -305 | -92 |

Comparative statistics

| | Method 1 | Method 2 |
|---|---|---|
| Best distance traveled | 2500 km | 1700 km |
| Worst distance traveled | 2400 km | 1680 km |
| Average distance traveled | 2520 km | 1710 km |
| *ASEC* | $1.09375 \times 10^{10}$ | $0.74375 \times 10^{10}$ |

Therefore, vehicles of a method 1 began with a distance of -305 km. While at iteration 1, vehicles reached a distance of 1570 km in method 2. The results of the travel distances reinforce the idea that method 2 is more efficient and more effective than Method 1.

The proposed method has the advantage of advancing the benefits of new information technology and GIS for managing vehicle traffic in urban areas. The results show that finding a parking space is now guided. It can also provide a time saving, less congestion, less mileage, less movement and energy consumption and therefore less pollution. Then, it is possible to calculate for instance the average saving of energy consumption on the study area (table 2).

An impressive difference between the two proposed methods appears in the average distance traveled. Indeed, the best distance traveled by vehicles is 2500 km by method 2 against 1700 km by method 1, so there's been down for 800 km through the park during the 24 hours studied, making a decrease of 292000 km throughout the year. This decrease is synonymous with significant decrease energy consumption.

However, the Tunisian fleet consists of 40% of gasoline vehicles, diesel vehicles of 42% and 18% of diesel-50 vehicles (National Agency for Energy Conservation, 2009). Light vehicles, rolling months of 50 km-h average consume 7.17%, making 20936.4 liters of energy for all the vehicles and over a period of one year.

$$EE = 209364 \ liters \times AEP \quad (4)$$

Where AEP is the average price of all energy types $((1.25+1.200+1.350+1.380)/4)$. So, with this intelligent parking management energy consumption expenditures can be reduced by 27112.638 (TND).

## 6. Conclusions

In order to research an intelligent parking management system, this paper proposed a multi-agent system for minimizing the time spent in search of a location in a parking lot. It starts with the description of the considered system organization in order to arrange the interactions, communications and coordination between agents. The coordination between them implies to find a vacant parking space, guide the driver to this area, and guarantee the reservation of the targeted area. Faced with all the possibilities that are available, the agents try to optimize the choice of driver for convenience and comfort.

Simulations established in this work show firstly the importance of our model of multi-agent in organization parking in a town center and secondly the differences between two methods, the first involving that people can move randomly in the hope of finding places to park vehicles and the second supposes however that our people are guided to park spaces. The results of the simulations from downtown Tunis are considered quite satisfactory in terms of reducing the search space for parking. Indeed, one could improve circulation by reducing the number of cars in the morning of 2% and 0.7% of the evening. In addition, the traffic per hour per day was reduced by approximately 4.17%. These results are due to the minimization of time looking for a parking space. The consequences of this minimization of research time have resulted in a reduction of the distance traveled, energy consumption, pollution, noise and other benefits such as an increase in the average age of the infrastructure, improving the psychology of drivers...

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