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CTRANSPORT: Multi-agent-based simulation

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KEYWORD	ABSTRACT
Electric vehicles; Multi-agent Systems;Eco-friendly	*Pollution nowadays is a really important issue that must be solved. Big cities suffer from overcrowding which result in traffic congestion and a lot of air pollution. Adapting to the idea of cities bike lane expansion, we design a Multi-agent simulation to distribute among the users green energy vehicles; concretely bikes, scooters and electric cars.*

1. Introduction

It is highly known that the world is facing an environmental crisis within the last centuries, specifically since the industrial revolution in the eighteenth century. The air pollution has passed from being a novelty problem to a day by day pain to citizens of big cities (*Laumbach, & Kipen, 2012*). Recognized as one of the most important current problems, a solution needs to be found. Many reports had claimed that the overuse of carbon and fossil fuels is one of the climate change's causes (*Hardy, 2003*). Therefore, an alternative must be implemented (*Dresselhaus, & Thomas, 2001*). The rely on clean energies is one of the near future approaches in order to keep the planet clean.

To help solving this problem, this paper describes an eco-friendly vehicle distribution simulation which could be implemented in real life. The simulation is based on a multi-agent system or also known as M.A.S in which every agent corresponds to a real-life object. Concept of agent was first proposed by Hewitt (*Hewitt, 1977*), and makes reference to a computational system that inhabits a complex environment and acts autonomously in order to achieve specific goals. M.A.S are composed by several agents that cooperate, coordinate, negotiate, and the like (*Wooldridge, 2009*, Pinto *et al.,* 2017).

The simulation includes users, stations and green energy vehicles such as electric cars, bikes or scooters. Users will be able to travel from a station to another using these vehicles. A request will have to be sent to the system indicating the type of the vehicle that is being demanded and the station the user is going to. Then, the station where the user is will receive a petition by the system which content is the type of vehicle the user requested. If the station has the vehicle demanded, an assignation will be made by the system, and the user would get the vehicle. However, the only vehicle that can go from a station to another despite the distance between them is the electric car (for battery reasons). Scooters and bikes are only adequate to go to the nearest stations. Thus, if the station where the user is in does not acquire the vehicle the user requested, a query will have to be sent to the nearest stations asking for the vehicle needed. The simulation is based on that principle, the idea of stations responding each other. At this point, the agents come in.

2. Related Work

The aim to investigate alternatives to the overuse of carbon-based fuels and the associated pollution issue has been studied before in countless researches. One of these issues is human health, as *Laumbach, & Kipen(2012)* researched. Respiratory and allergic diseases are getting common within young and older population, mostly because of gas emissions to the atmosphere. In order to solve these issues, this paper designs a M.A.S as *Burmeister, et al.,(1997)* did in their research to demonstrate the applicability of M.A.S in traffic and transportation, as *Kari, et al.,(2014)* whose work in 2014 shows the improvement of traffic using a M.A.S based on signal priority algorithm, and as *Li, et al.,(2018)* did recently in 2018, whose paper shows a transportation simulation system for clean energy vehicles in scenic area based on multi-agent. From the view of introducing clean energy electric vehicles with limited funds and unlimited funds, they investigated the optimal introduction scheme and the optimal traffic scheme of clean energy vehicles in order to alleviate air pollution and tourist overcrowding.

It is known that traffic congestion in big cities is a current topic that increases the greenhouse effect, but the final solution has not been found yet. Thus, with the construction of new bicycle routes as *García-Palomares, et al.,(2012)* proposed using GIS-based method which calculates the most efficient distribution of bike stations in a city, and using a system which recommends the greatest eco-friendly route plan to each driver like *Bothos, et al.,(2012)* said in his article, a new opportunity of using this kind of vehicles has turned into a great alternative.

This article approximates to a definitive solution, which is a simpler version of other analysis made before based on predictions and real time information like *Mensing, et al.,(2013)* made in his article which studies several optimization methods in order to save fuel consumption in eco-driving vehicles or like *Boriboonsomsin, et al.,(2012)* whose paper presents an eco-routing navigation system that determinates the most eco-friendly route.

3. Model and M.A.S Architecture Description

The system is designed based on a series of assumptions:

1. The stations are placed at the same distance. See Figure 1.
2. The simulation spawns four users with random attributes.
3. There are three types of vehicles: electric car, electric bike and electric scooter.
4. All vehicles have a single seat.
5. Electric cars have enough autonomy to reach any station from any other.
6. Electric bike and electric scooter have a limited autonomy and they only can reach the stations that are near of the department station (one unit away).
7. Stations will have a random number of vehicles.
8. The Users will have a random arrival station.
9. Station will always assign to the User a car if it is available. If it isn't, Station will assign a bike or scooter, giving priority to the bike.

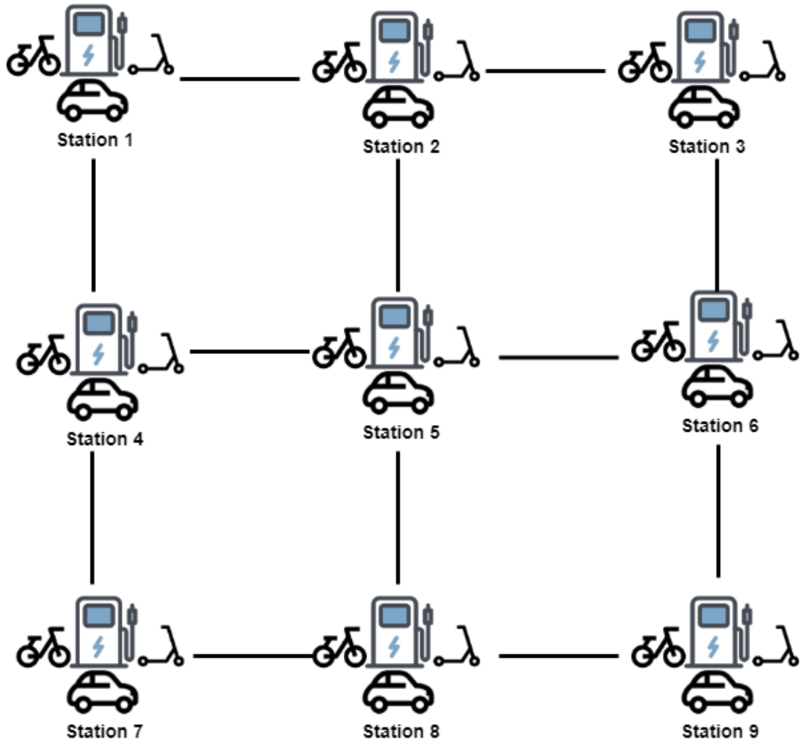


Fig. 1: Stations Map

The architecture of the simulation is based on three reactive agents: *User Agent, Station Agent and Manager Station Agent.* The messages used for the communication among the agents uses *REQUEST* and *INFORM* performatives.

The User Agent follows the principles descripted below:

1. User Agent has four attributes: User Number, Origin Station, Arrival Station and Type of Transport.
2. The first thing that User Agent does is to send a message to the Agent Station that have assigned the number of his Origin Station requesting a vehicle.
3. Depending on the answer of Agent Station the behaviour of User Agent will be different.
4. If a scooter or a bike are assigned to the User Agent, then he will ask to the Manager Station Agent what the nearest station is.
5. When User Agent reaches the Arrival Station, sends a message to the Agent Station with the Type of Transport used. The same behaviour is done when Agent User reaches a near station via scooter or bike.

The Station Agent follows the principles descripted below:

1. Station Agent must wait for User Agent vehicles request or parking request.
2. Station Agent has the control of the number of vehicles parked in the station.
3. When a vehicle request is received, Agent Station will assign a vehicle to the User Agent.
4. When a parking request is received, Agent Station will add the vehicle to number of vehicles of the station.

The Station Map Agent follows the principles descripted below:

1. Station Map Agent knows the connections between stations.
2. Station Map Agent must wait for User Agent near stations request.
3. When a request is received, Station Map Agent will send a message to the User Agent informing what is the nearest station considering his current position.

A more exhaustive description of the communication among the agents is described more clearly in Figure 2

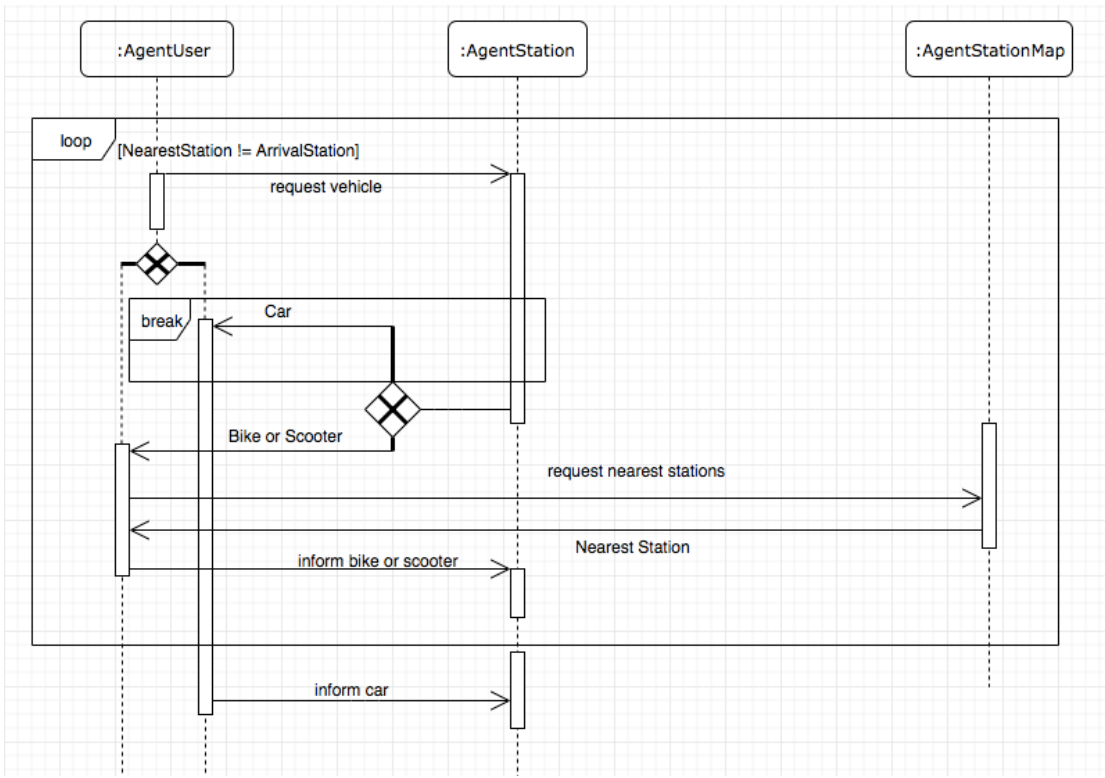


Fig. 2: Protocol Diagram

Following the model that has been descripted before, the simulation program code was written in Java using the JADE library. Every Agent Class is associated with a model class. Also, each one creates their own behaviours, which use the Utils class in order to stablish communication between Agents. This can be seen in Figure 3.

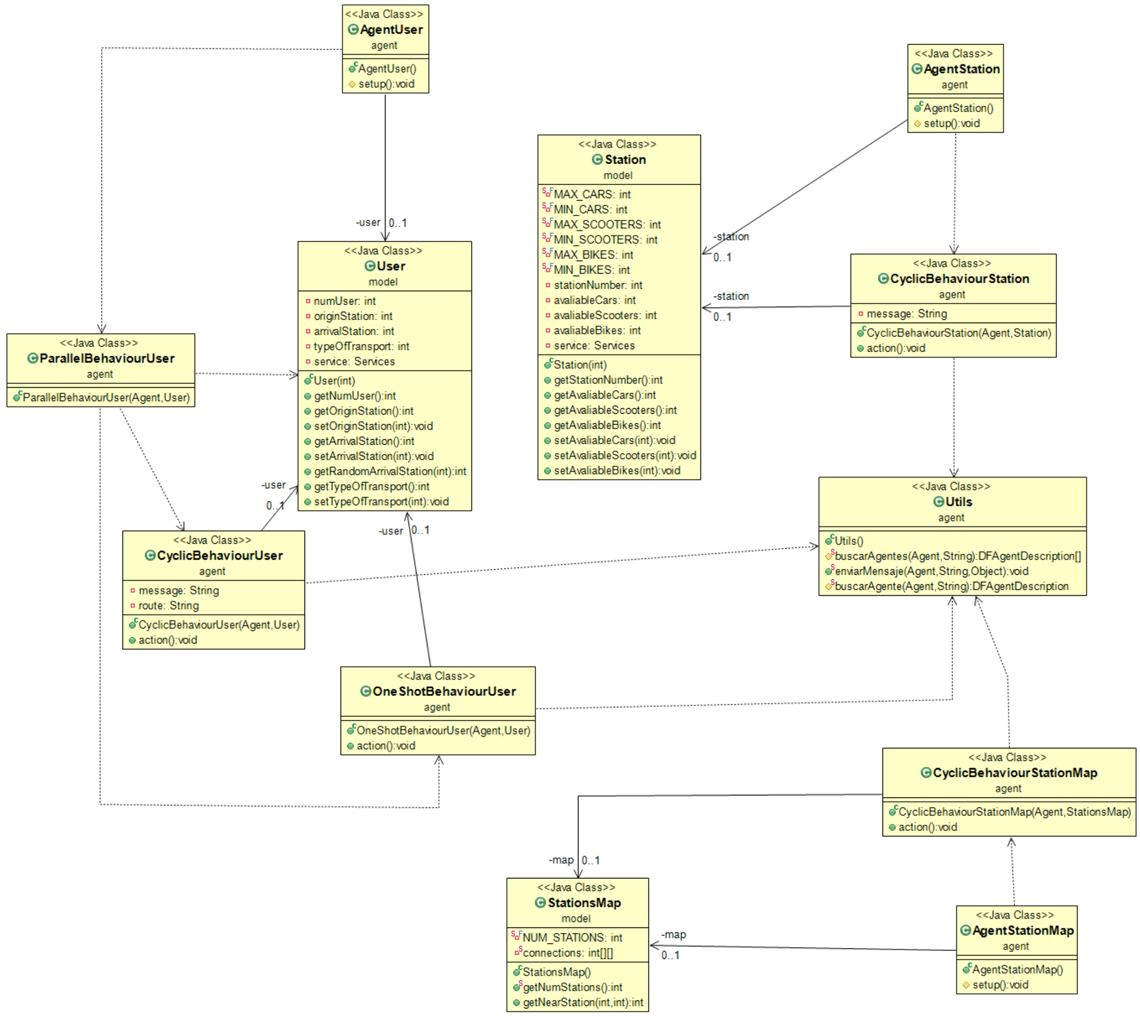
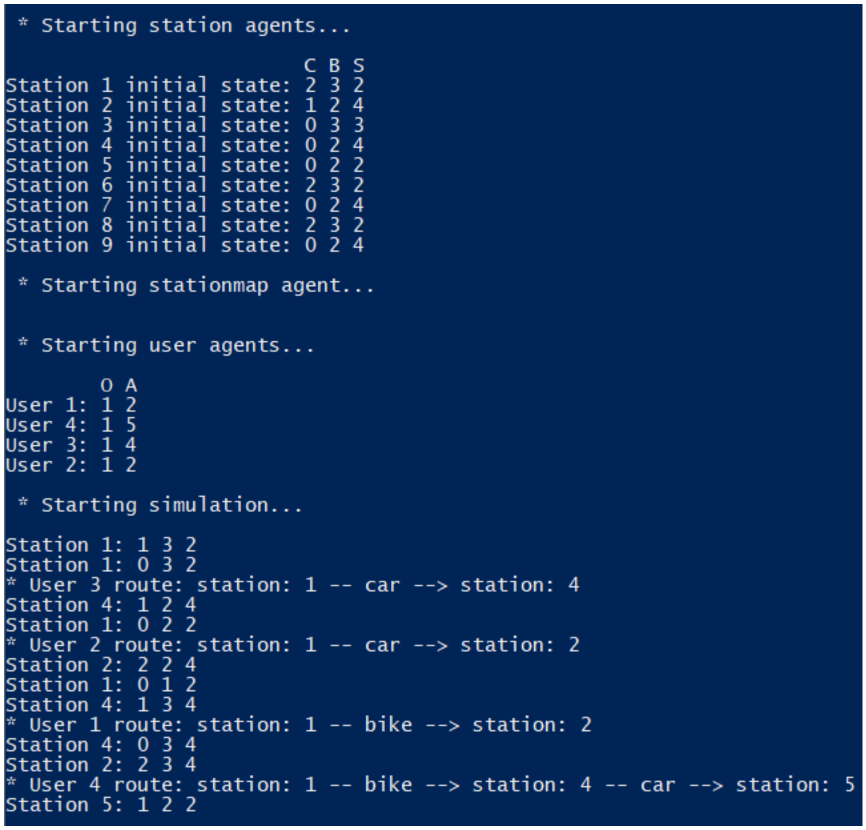


Fig. 3: Class Diagram

4. Simulation

The simulation is based on the map descripted before in the model section above. There are nine stations, whose available vehicles are random generated and shown at the start. In this case, there are four users spawned in station number one. The arrival station of each user is also arbitrarily generated (Figure 4). When each Agent User is started, they request a vehicle to the station they are in. Thus, stations receive petitions and answer the Agent Users with the type of vehicle assigned to them, depending on the quantity and type of vehicles in the station, giving priority to cars.



```
 * Starting station agents...

                    C B S
Station 1 initial state: 2 3 2
Station 2 initial state: 1 2 4
Station 3 initial state: 0 3 3
Station 4 initial state: 0 2 4
Station 5 initial state: 0 2 2
Station 6 initial state: 2 3 2
Station 7 initial state: 0 2 4
Station 8 initial state: 2 3 2
Station 9 initial state: 0 2 4

 * Starting stationmap agent...


 * Starting user agents...

        O A
User 1: 1 2
User 4: 1 5
User 3: 1 4
User 2: 1 2

 * Starting simulation...

Station 1: 1 3 2
Station 1: 0 3 2
* User 3 route: station: 1 -- car --> station: 4
Station 4: 1 2 4
Station 1: 0 2 2
* User 2 route: station: 1 -- car --> station: 2
Station 2: 2 2 4
Station 1: 0 1 2
Station 4: 1 3 4
* User 1 route: station: 1 -- bike --> station: 2
Station 4: 0 3 4
Station 2: 2 3 4
* User 4 route: station: 1 -- bike --> station: 4 -- car --> station: 5
Station 5: 1 2 2
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Fig. 4: Simulation

Two cases can be contemplated in the simulation, on the one hand, the user receives car from the origin station and he moves to the arrival station directly. This can be seen in Figure 4 and Figure 5.

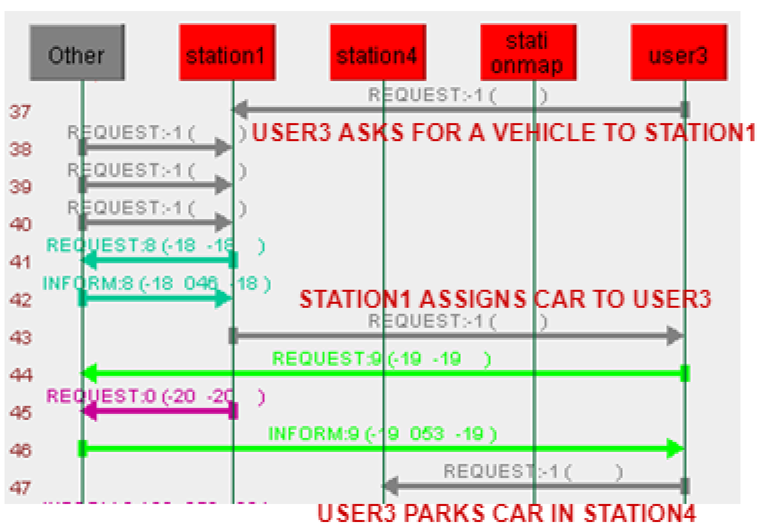

Fig. 5: User gets car

On the other hand, user receives a bike or a scooter in which case, he will have to move to the nearest station and if the station is not his arrival station, he will have to ask for a vehicle again to continue moving (Figure 6).

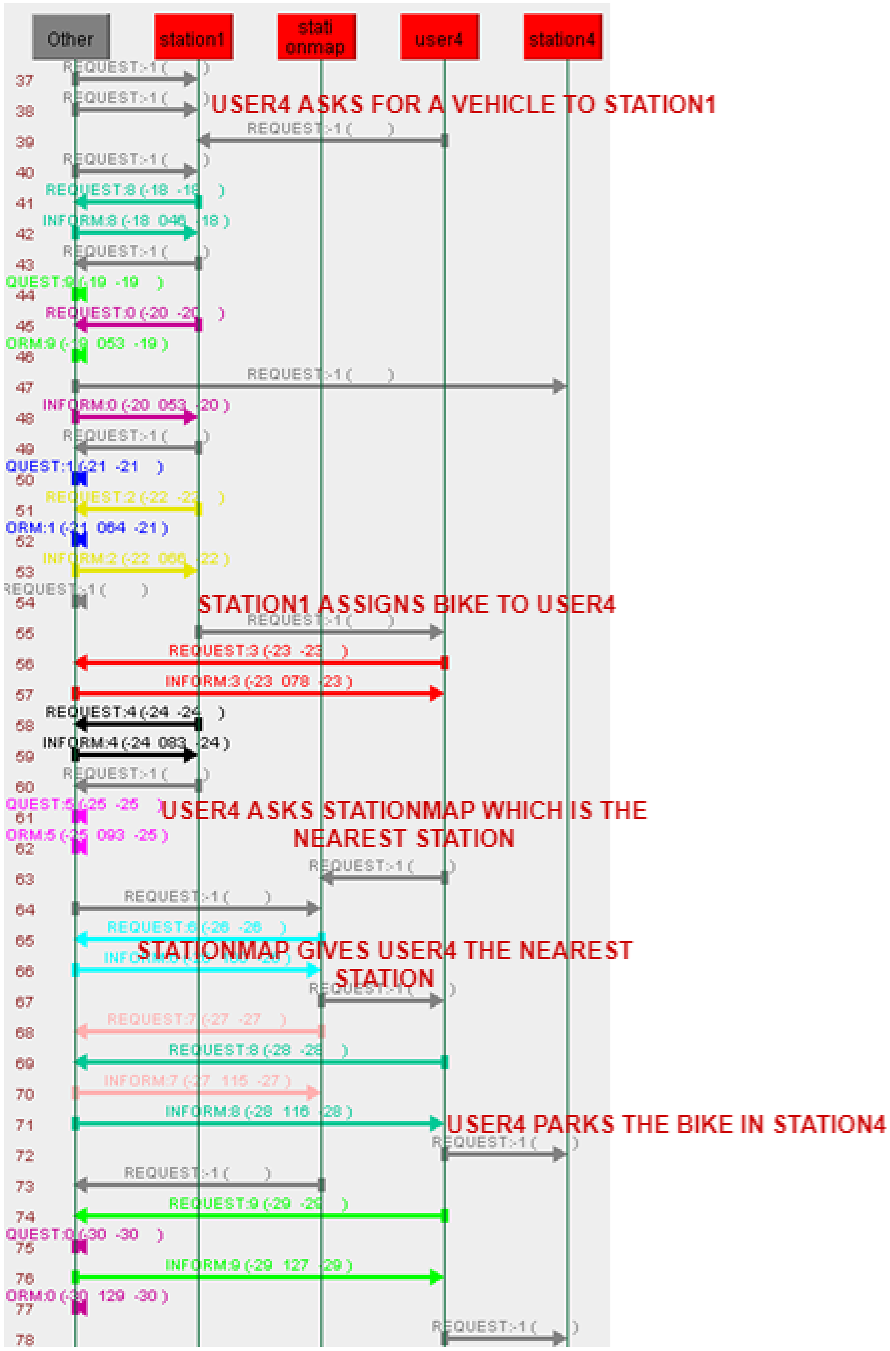

Fig. 6: User gets bike or scooter

5. Conclusion

The main idea of this paper was to design a Multi-agent simulation that had to be able to manage and distribute the vehicles among the users. For that, we focused on an efficient way of communication between agents and so, we introduced the Agent StationMap, a new agent with the aim of facilitating the search of near stations to find a new vehicle. Also, it tries to find a way of reducing pollution in cities using affordable and smaller vehicles, like electric bikes and electric scooters. This follows the tonic of bicycle lane expansion of most cities in the world. In this case, the model has just nine stations. This could be easily adapted to the size of a specific city adding more stations. The limitation of this paper is that the Multi-agent simulation is based on a series of assumptions as the lack of traffic congestion, vehicles battery life, inefficient routes, etc; that obviously will make the simulation more difficult, but more precise.

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