Ride Sharing in FEUP

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April 25, 2019

1 Context

Each year, the Portuguese population spends more than 7.8 millions of tons of fuel, of those 7.8, approximately 4.7 are spent in diesel[1] and a bit more than 1 million are spent in petrol.[2]

In 2017 in Porto Metropolitan Area the occupancy tax of a car was 1.56 in average and 1.36 for aggregates with only one person[3] and 47.3% of students spend more than 100 € per month on fuel.[4]

The focus of this project is the segment of the population that we most resemble with, students, more precisely FEUP students. Students in Porto Metropolitan Area are the second most mobile segment, the first being the working class.[5]

In this project the alternative of ride sharing will be tested in order to reduce our fuel consumption and, by consequence, our ecological footprint.

2 Problem Statement

In this project the main problem is, using ride sharing, the minimization, of:

- The amount of fuel used and therefore the emissions of CO_2 and other pollutant gases;
- Traffic Jams and by consequence the time spent;
- The transportation costs;

Commuting in a closed community with the same destination but different starting points.

3 Motivation to tackle the problem

Nowadays the effects that our actions have in the environment around us is a very discussed topic and one which we have to be more aware of.

Since we care about the environment and ride sharing is a relatively new and increasingly popular topic, we decided to combine the two topics and try to think about ways we could use ride sharing to help the environment.

4 Research/Simulation questions & hypothesis

The main questions we want to try to answer with our project are:

- How much does carpooling help to reduce the emissions of nocive gases?
- If more people were open to the idea of ride sharing with someone on a regular basis what would happen to the CO_2 emissions?
- What are the incentives that would motivate people to practice ride sharing?
- Can carpooling improve traffic congestion?

5 Expected contributions

Our project could contribute to:

[1] Paulo Salteiro Rodrigues Direção Geral de Energia e Geologia. *Vendas de Produtos de Petróleo em Portugal 1970 - 2016*. 2018.

[2] Ibid.

[3] I.P Instituto Nacional de Estatística. *Mobilidade e funcionalidade do território nas Áreas Metropolitanas do Porto e de Lisboa 2017*. 2018, p. 40.

[4] Ibid., p. 28.

[5] Ibid., p. 26.

- Universities/Colleges since with our project we would know some incentives that motivate students in that demographic and also the effects of practicing ride sharing;
- Society by attenuating the recurring car parking problem in urban areas;
- Environment due to a decrease of CO_2 emissions;

6 Aim and goals of the project

We expect that this project will help verify some relations between the use of private transportation and ride sharing and how that affects the environment.

We also expect to sensitize people to the effects that something as simple as going to work/school everyday using private means of transportation has on the environment and how they could decrease their ecological footprint if they were open to the idea of ride sharing.

7 Variables and respective domains

There will be 2 types of users, riders and passengers. The riders have a car and can give rides to the passengers.

Each user will have several internal variables:

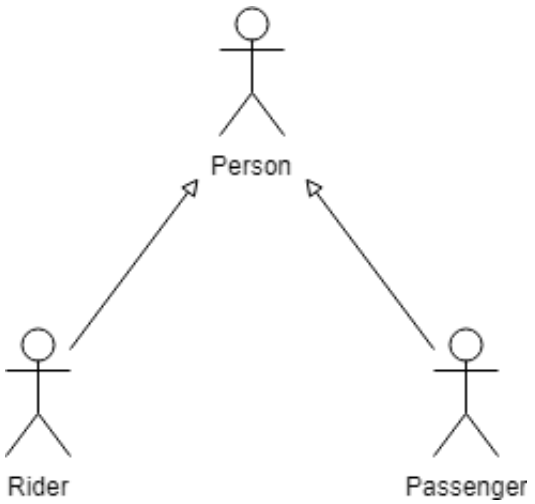
- Time the user stay at FEUP in hours [1-12];
- Location of their house;
- Type of user, rider or passenger;
- Course which he is enrolled in;
- Year in which he is enrolled in;

Each rider will also have:

- Number of seats available [1-6];
- Fuel consumption;
- Friends;
- Willingness to ride share with friends;
- Willingness to ride share with users of the same course;
- Willingness to ride share with users of the same year;
- Max distances the user is willing to traverse to pick other user's up, according to their relationship status

Each passenger will also have:

- Cost of using the public transportation



8 Assumptions and premisses

The base model of "Traffic Grid Goal" in the NetLogo Models Library[6] is a good model of a real world city and the interactions of real world cars.

The fuel spent is proportional to the travelled distance.

Each rider knows the location of the passengers and takes the shortest path possible.

Burning a litre of diesel produces around 2.67 kg of carbon dioxide, whereas gasoline has a lower carbon content and produces about 2.32 kg. Older engines might lose a few percent due to unburnt fuel, but otherwise technology can have little effect on this chemistry.[7]

[6] Wilensky U Rand W. *NetLogo Traffic Grid Goal model*. Northwestern Institute on Complex Systems, Northwestern University, Evanston, IL, 2008. URL: http://ccl.northwestern.edu/netlogo/models/TrafficGridGoal.

[7] U.S. Environmental Protection Agency. *Average Carbon Dioxide EmissionsResulting from Gasoline and Diesel Fuel*. 2005.

9 Constraints and limits

- Unlimited fuel;
- Traffic lights are respected;
- The users will take the same path they took going to the destination at the end of the day when they go home, taking the same passengers home;
- The riders always try to maximize the number of transported passengers;
- The riders always try to minimize the travelled distance;

10 Cost/utility functions

The car footprint *Footprint* expressed in kg of CO_2 can be characterize as the following:

$$Footprint = \frac{Fuel \times Distance \times CO2}{100}$$

where:

Fuel is the car's fuel economy in liters per 100 kilometers

Distance is the travelled distance

CO2 is the quantity of realised CO_2 per liter of fuel burnt

The cost of a ride divided by each of its passengers *SplitCost* can be calculated as the following:

$$SplitCost = \frac{Fuel \times Distance \times FuelCost}{100 \times NumPassengers}$$

where:

Fuel is the car's fuel economy in liters per 100 kilometers

Distance is the travelled distance

FuelCost is the quantity of realised CO_2 per liter of fuel burnt

NumPassengers is the number of passengers plus rider

11 System Model

- Modelling metaphor
  - NetLogo is a multi-agent programmable modeling environment (ABMS).
- Input variables
  - Number of users that have private means of transportation
  - Number of users without a private mean of transportation
  - Ratio of users that use ride sharing to users that rely on their private vehicle
- Output variables
  - Average number of CO_2 emissions;
  - Average car speed;
  - Number of users sharing their car;
  - Number of users on a car shared by another user;
  - Number of users using other means of transportation.
- Indicators
  - Fuel used
  - Emissions of pollutant gases
  - Time spent in transportation
  - Distance traveled
- Decision variables
  - Ratio of the different types of users(with car, without car, willing to use ridesharing etc.)
- Operating policies

  Each turtle represents a user with or without a private vehicle.

  For each user with a vehicle we will calculate the path between the user's house and the destination, in a straight line. After we would calculate the distance between that segment and all the other user's that need a ride. After those calculations we

would also take into consideration the willingness that that user has to go pick up other user's, according to the relationship.

When all those considerations are done we would then see which user's the user with vehicle could pick up, and add their houses to the stops that user will have.

- States of the system

  The system can be in one of these three states:

  - Stopped - When the system is available for inputs;
  - Preparation - When the system is making all the calculations necessary to know all the stops the user's with cars will need to have;
  - Working - When the user's are going from their houses to their destination

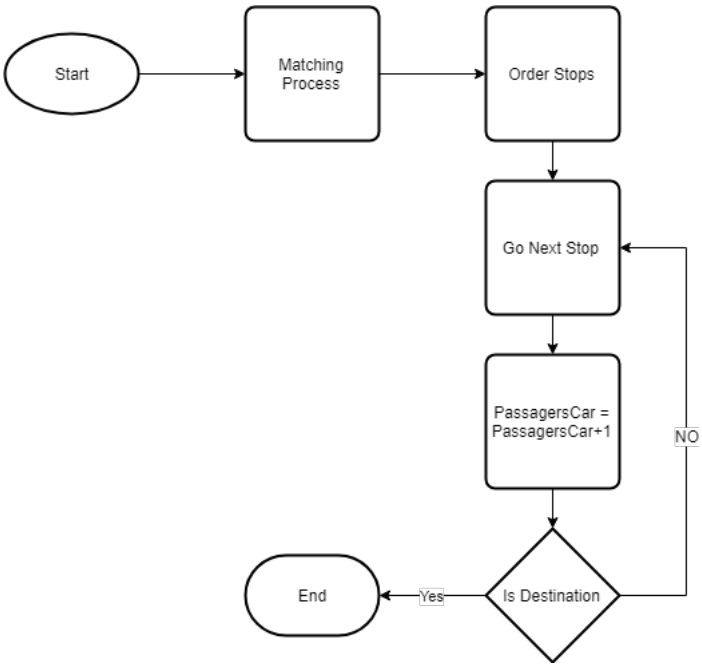
- Entities of the system

  In our system we will have users with a vehicle and users without a vehicle that need a ride.

  We will use clustering to define different types of personality according to the answers to our survey, relatively to the willingness he has to give a ride to a stranger, friend, person enrolled in the same course or person in the same year.

  Each user will also have a lot of variables, described in section 7

12 Logical models



13 Coding

- The programming language and simulation IDE that we will use is NetLogo[8]
- We will adapt the base model of "Traffic Grid Goal"[9] in the NetLogo Models Library

14 Data requirements (input)

- Data sources

  To gather data for the project a survey was sent to over 7500 FEUP students.

- Data preparation methods

  We will use Factor Analysis and clustering techniques to split the user's into different personality types

15 Data requirements (output)

- Data analytics

[8] Uri Wilensky. *NetLogo*. Northwestern University, Evanston, IL, 1999. URL: http://ccl.northwestern.edu/netlogo/.

[9] Rand, *NetLogo Traffic Grid Goal model*, op. cit.

  - Average Number of users per car;
  - Average Fuel spent;
  - CO_2 emissions in cubic meters;
  - Travel distance for each car and user;
  - Average number of cars on the road;
  - Average travel time per car and user.

16 Simulation Scenarios

We will have:

- Multiple scenarios with different percentages of the groups of students;
- Multiple scenarios with different incentive policies;
- A scenario where the population will have the same characteristics of the results we obtained in the survey;
- Reference scenarios

  There will be 3 reference scenarios:

  - Lower Bound - All the users use the available public transportation.
  - Actual real world scenario - Will be modeled using the data collected from the survey without changing any parameter.
  - Upper Bound - All the users with a private vehicle use it for their transportation.
- What-if scenarios
  - If a greater percentage of students use ride sharing, the emissions of CO_2 will reduce;
  - If more students ride share, each student will spend less money in commuting per month;
  - If the university implements more incentive strategies, more students will ride share;
  - A person that doesn't mind who they share their car with will spend less, in the same conditions, than a person that doesn't share their car with anyone.