

A Travel Optimization System for Academic Environments

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Prof. Doutor Pedro Abreu

Prof. Mestre Paulo Teixeira

Dissertação apresentada ao Instituto Politécnico do Cávado e do Ave para obtenção do Grau de Mestre em Engenharia Informática e Sistemas Empresariais

Este trabalho inclui as críticas e sugestões feitas pelo Júri.

Outubro, 2014



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Abstract

Carpooling initiated in America in the 1970s due to the oil crisis. However, over the past years, carpooling has increased significantly across the world. Some countries have created a High Occupancy Vehicle (HOV) lane to encourage commuters not to travel alone. In additional, carpool websites has been developed to facilitate the connection between the commuters, making it possible to create a compatible match in a faster and efficient manner.

This project focuses on carpooling, especially in an academic environment since younger people are more likely to choose carpool. Initially, an intense research was made to examine carpool studies that occurred all over the world, following with a research of higher education institutes that use carpooling as a transportation mode.

Most websites created carpools by targeting people from a specific country. These commuters have different origins and destinations making it more complicated to create compatible matches. The objective of this project is to develop a system helping teachers and students from an academic environment to create carpool matches. This objective makes it easier to create carpools because these students and teachers have the same destination.

During the research, it was essential to explore, as many as possible, existing carpool websites that are available across the world. After this analysis, several sketches were made to develop the layout and structure of the web application that's being implemented throughout the project.

Once the layout was established, the development of the web application was initiated. This project had its ups and downs but it accomplished all the necessary requirements. This project can be accessed on the link: http://ipcacarpool.somee.com.

Once the website was up and running, a web-based survey was developed to study the reasons that motivate people to consider carpooling as an alternative to driving alone. To develop this survey was used a tool called Survey Planet. This survey contained 408 respondents, which 391 are students and 17 are teachers. This study concludes that a majority of the respondents don't carpool, however they will consider carpooling if there was a dedicated parking space. A majority of the respondents that carpool initiated less than a year ago, indicating that this mean of transportation is recent.

Keywords

Carpool; optimizing transportation; saving fuel; commuting with others.

Abstrato

Carpool iniciou-se em América na década de 1970 devido à crise de petróleo. No entanto, ao longo dos últimos anos, carpool tem aumentado significativamente em todo o mundo. Alguns países criaram uma pista de HOV para incentivar os passageiros a não viajar sozinho. Em adicional, websites de carpool foi desenvolvido para facilitar a ligação entre os viajantes, o que torna possível a criação de uma boleia compatível numa maneira rápida e eficiente.

Este projeto centra-se em carpool, especialmente num ambiente académico, uma vez que os jovens são mais prováveis a escolher uma partilha de boleias. Inicialmente, uma pesquisa intensa foi feita para examinar os estudos de carpool que ocorreram em todo o mundo, seguindo com uma pesquisa das instituições de ensino superior que usam carpool como um modo de transporte.

A maioria dos websites foi criar boleias, atingindo as pessoas de um determinado país. Estes viajantes têm diferentes origens e destinos tornando-o mais complicado para criar boleias compatíveis. O objetivo deste projeto é desenvolver um sistema de ajudar professores e alunos de um ambiente académico para criar correspondência de carpool. Este objetivo torna mais fácil para criar boleias porque esses alunos e professores têm o mesmo destino.

Durante a pesquisa, foi essencial explorar, o maior número possível, websites existentes de carpool que estão disponíveis em todo o mundo. Após esta análise, vários esboços foram feitos para desenvolver o layout e estrutura da aplicação web que está sendo implementada em todo o projeto.

Uma vez que o layout foi criado, o desenvolvimento da aplicação web foi iniciado. Este projeto teve seus altos e baixos, mas realizou todos os requisitos necessários. Este projeto pode ser acessado no link: http://ipcacarpool.somee.com.

Depois que o website foi desenvolvido e funcionando, um questionário foi desenvolvido para estudar as razões que motivam as pessoas a considerar carpool como uma alternativa de dirigir sozinho. Para desenvolver este estudo foi utilizada uma ferramenta chamada Survey Planet. Esta pesquisa contém 408 inquiridos, sendo 391 são estudantes e 17 professores. Este estudo conclui que a maioria dos inquiridos não partilham boleias, no entanto eles irão considerar carpool se houvesse um espaço de estacionamento dedicado. A maioria dos inquiridos que carpool iniciou a menos de um ano, o que indica que este meio de transporte é recente.

Palavras-chave

Carpool; otimizando o transporte; poupar combustível; viajar com outros.

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Writing a dissertation is an intimidating and sometimes frustrating process, luckily I had the support from family, friends, classmates and professors. This was, without question, a learning experience. I learned how to work hard, think things through, and most importantly, deal with problems.

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Finally, I would like to thank my friends and family who always encouraged and supported me in this project, always giving me love and support throughout.

List of Abbreviations

AFC	Average Fuel Consumption
AJAX	Asynchronous JavaScript and XML
API	Application Programming Interface
ASP.NET	Active Server Pages
ATD	Average Trip Distance
AVO	Average Vehicle Occupancy
CSS	Cascading Style Sheets
DBMS	Database Management System
DCPP	Daily Car Pooling Problem
FS	Fuel Saved
GPS	Global Positioning System
GUI	Graphical User Interface
HOV	High Occupancy Vehicle
HTML	HyperText Markup Language
IaaS	Infrastructure as a Service
ID	Identification
IPCA	Instituto Politécnico do Cavado e do Ave
JSON	JavaScript Object Notation
KM	Kilometer
LCPP	Long-term Car Pooling Problem
MM	Matching Matrix

NTV	North Toronto, Vaughan
PaaS	Platform as a Service
PHP	Hypertext Preprocessor
SaaS	Software as a Service
SMS	Short Message Service
SOV	Single Occupancy Vehicle
SQL	Structured Query Language
TDM	Transportation Demand Management
TM	Total Mobility
TPB	Theory of Planned Behavior
TRA	Theory of Reasoned Action
UML	Unified Modeling Language
URL	Uniform Resource Locator
USA	United States of America
WYSIWYG	What You See Is What You Get
XML	eXtensible Markup Language

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1. Introduction

This project proposes an approach for people to share transportation in their daily mobility, thus saving money on gas and decreasing the car wear.

In periods of crisis, carpool is being more and more suitable for situations that involve driving to and from work/school on a daily basis. People who consider using carpool are mainly the people that work or study at the same area or nearby area. This option is especially a good idea to reflect on if the person does not have their own vehicle and also if the person does not want to experience the trouble traveling in public transportation. Furthermore, it's a matter of personal choice and comfort to choose this transportation (Levin, 1982). That is why carpool is a great example to use in an academic environment since everyone works and studies in the same area.

Carpooling, which is also known as ridesharing, is when two or more people travel in a private vehicle to work or to another location for all or part of a journey. The idea behind this concept is that the more people who participate, the more money they will save (Arredondo, 2010).

The carpool approach includes the decision of who will be driving, combining schedules and dividing the gas expenses. However, a common approach consists only in alternating the vehicle without money exchange (Arredondo, 2010).

Nowadays, traffic congestion and the increase of fuel costs has become a worldwide problem resulting people to carpool to work or school. Deciding to carpool brings a lot of benefits such as reducing the travel costs, increasing parking space, reducing stress and more likely to arrive on time if it is well organized. Besides those benefits, carpool also reduces air pollution which helps the environment (Tsao & Lin, 1999).

Carpool is commonly used when people have similar origins and destinations making it easier for the carpoolers to get where they need without wasting a lot of extra time and

money. Using this transportation is a great way to get to know their colleagues better during the ride (Tsao & Lin, 1999).

Carpool can be scheduled on a regular basis or infrequently depends of the needs of the person. Some people choose to take turns to drive their own vehicle or are happy to be passengers. With this transportation it can eliminate the need for a private vehicle (Tsao & Lin, 1999).

Nowadays urban areas often suffer from high traffic jams especially during the rush hours. Even with the traffic volumes being a big issue in the urban areas, people are still insisting in using their own vehicles individually instead of adapting in other alternatives. One alternative is public transportation but an issue is the high costs, especially when used irregularly because no discounts are applicable. For these situations an alternative form of transportation is being more and more popular called carpool. For this transportation, people organize themselves to share vehicles with their main goal to minimize the total traveling time or total traveling expenses. There are many complex variables to form a successful carpool. These variables include items such as: demographics, travel times and wait times (Arredondo, 2010).

Although carpool is a great advantage for most people there are some challenges. The most common challenges are flexibility, reliability and riding with unknown people. Carpool can struggle to be flexible to accommodate with traveling stops or changes related to work times/patterns. To solve these issues, some systems offer a “guaranteed ride home” arrangement with a local taxi company. In relation to reliability, some participants may not follow through on the agreed ride, which is becoming a big concern. Riding with unknown people can also have its twist because the carpooler can enjoy their company by getting to know them better (Arredondo, 2010).

Currently a student and teacher from a higher education institute, especially in environments outside of the area near the institute, has at least two daily trips to do with their own vehicle since the schedules of public transport have little flexibility. Likewise, who usually live in large urban areas carry several trips a week leading monthly costs with gasoline and tolls (Arredondo, 2010).

1.1. Motivation

The reason why this topic was chosen was because it seemed attractive and very important for how the things are going nowadays for the economics. Since we are in a period of crisis, we should take any opportunity we have to save money. One great example of this is carpool. Carpool has become more and more popular in urban areas. It has a huge advantage in these areas because it doesn't cause a lot of air pollution and also a lot of traffic jams. One other important advantage which we cannot forget to mention is the parking spaces. We will have more parking spaces if more people do carpooling.

An important disadvantage of carpooling is the waiting time for a ride. No one likes to wait for anyone, not for the driver or the passengers. If one person is late to carpool then the rest of the carpoolers from the same ride are also going to be late to their destination. That being said, the less waiting time there is for a ride the better. Another disadvantage is the additional travel time spent picking up and dropping off carpooling partners. The need to make detours to meet carpoolers may be a potential restriction, resulting in some people being discouraged from carpooling (DeGruyter, 2006; Shaheen, Sperlmg, & Wagner, 1999).

The lack of parking spaces is a concern to our academic environment, especially for students that study at night. If some or even most of the students tried to do carpooling then this issue would be resolved. Most of the night time students are workers and after work they come straight to school therefore they don't carpool. This project is to encourage students and teachers to carpool that have the same schedule and similar routes. This project will develop a carpool website which will focus on our academic environment; however it will be a future goal to incorporate this project to any academic environment or any workplace.

1.2. Main Contributions

The objective of this project is to develop a system helping teachers and students from an academic environment to create carpool matches that have similar routes and schedules. Initially, the user can search through the application for any compatible match but if none are available, the user will need to register their ride. In addition, when a new ride is registered, all the carpoolers with the same destination and origin will receive a notification

by email. Once the user finds a compatible match, he/she responds to the carpooler through a contact form on the website.

1.3. Structure of the Dissertation

This project is structured as follows:

In the second chapter, the carpooling history and concepts are performed. It has been done an exhausting research of the topic and the most important will be mentioned in this section.

In the third chapter, will be mentioned a brief review of the literature. Also contains several studies related to carpooling in which some has made surveys getting an insight of what the carpoolers thought. In additional, there are some algorithms that calculate the costs of carpooling and some examples of higher education institutes that use carpooling.

Chapter four explains the concepts of designing an interface. It mentions the objectives and principles of usability. In additional it explains how to evaluate an interface using the heuristic evaluation.

Chapter five mentions the most common types of web mapping services. This chapter describes the features of each of these mapping services. The service chosen for this project is Google Maps.

Chapter six mentions the requirements and architecture of the project. This chapter also demonstrates the database diagram and the use case diagram, including the description of the tables and use cases.

Chapter seven mentions the implementation and development of the project. This chapter describes the features of the applications, including a description and illustration of each page of the application. This chapter also contains a brief description about cloud computing and explains the process to deploy the application. In addition, this chapter also contains the results of a survey that has been implemented for this project.

The last chapter provides a conclusion of the project and recommendations for future work.

2. Carpooling History and Concepts

In this chapter will be discussed the definition and functionalities of carpooling. Also will be mentioned the different types of carpooling and practices. Mobility patterns have a strong influence on the success of carpooling services providing two main features, time and route convergence. Subsequently the process of the travel planning optimization will be discussed which has two engines: time-based routing engine and energy consuming computation engine. At last but not least, will be mentioned the carpooling behavior model by Ozanne and Mollenkopf.

2.1. Carpooling

This section is based on the exhausting research that has been made during the development of this project. First it is mentioned about how this transportation works.

There are a large number of vehicles being used by one person, which can be considered a loss of energy and space. A simple solution is to carpool with the objective to reduce the number of cars on the road. To initialize the carpooling process, the drivers and passengers search for journeys through several methods available online. After finding a match they contact each other to arrange any details for the journey(s). Costs, meeting points and other details like space for luggage should be discussed and agreed on (Chen, Yan, & Lin, 2009).

The idea of carpooling started in the 1970s when a major oil crisis caused a rise of fuel costs in the USA, which motivated people to share their vehicles with colleagues or neighbours (Handke & Jonuschat, 2013).

However, other transportation modes like walking or cycling are restricted to short distances while long distances are more restricted to carpooling (Handke & Jonuschat, 2013). There are several benefits of carpooling. Not only will the carpooler save money on gas by sharing a ride, but they'll also save money that would normally go towards the natural daily wastes of their car such as engines, brakes, tires, etc. Carpool is a common

transportation for those that go to the same school or same workplace since it is easier to create carpools with commuters that have consistent and typical school/work hours (Shirazi, Kubitza, Alt, Pfleging, & Schmidt, 2010).

Carpooling can look attractive but commuters perceive ridesharing as unreliable since they are dependent on someone else. Most times carpooling is less suitable for short distance due to the pick-up/drop-off delay and waiting time (Vanoutrive et al., 2009). The downside of carpooling is the loss of privacy when sharing a vehicle. Also it is considered a longer process compared with driving alone since it generally involves spending more time on each journey picking up and dropping off other members. The long process consists in finding carpool partners that matches with their schedules and route (Vanoutrive, et al., 2009).

Carpooling can have several advantages such as saving money, helping the environment, reducing traffic jams and increasing the parking spaces. Besides these advantages the commuters have some concerns related to carpooling such as the fear of traveling with strangers, loss of privacy and having to rely on others (DeGruyter, 2006).

However, carpool is not always arranged for the whole length of a journey. Especially on long journeys, it is common for passengers to only join for parts of the journey, and give a contribution based on the distance that they travelled. This gives carpooling extra flexibility, and enables more people to share journeys and save money (Yang, Tang, Xu, & Xu, 2006).

There exist several factors for people to choose carpool. First of all, people choose carpool based on their personal income. The people that receive less decide to carpool more than the people that receive more. Also young people are more likely to carpool, as are those who live in large households and those who are married. Another important factor is the language, since it can be a barrier when carpooling. It is difficult for people who speak one language to socially interact with people who speak another (K. K. Charles & Kline, 2001).

Setting up a carpool group is relatively easy nowadays due to the Internet. There are a bunch of websites available to match commuters with the right carpooling group – geographically and by personal preferences (gender, non-smokers, etc.) (Westerbeck & Evans, 1981).

The arrangements for carpooling can be made through many different resources, including (Angskun & Angskun, 2009):

1. Public websites;
2. Closed website systems;
3. Carpooling agencies;

The travel planning approach is useful in managing and planning a journey, including the cost of trips. Preferably, the carpool approach should facilitate scheduling a trip based on a traveller's preferences and needs. It should also help these travellers to plan a trip easily and rapidly by themselves (Angskun & Angskun, 2009; Skov-Peterson, Zachariasen, & Kefaloukos, 2010).

In order to support a carpool, a system requires a set of information in order to find appropriate matches, for example, people travelling with the same or similar route. Essentially, establishing a carpool involves finding people with matching schedules and routes. Matches are based on some general information such as their origin and destination, their schedule and their preferences. To make an appropriate arrangement, the collection of travel information would help to improve service quality. But to obtain an optimal route, the length has to be minimized (Calvo, Luigi, Haastrup, & Maniezzo, 2003; Chen, et al., 2009). Summarizing, the success of carpooling depends on providing a sufficient set of benefits to attract the desired number of commuters (Minett & Pearce, 2009).

Currently, there are different carpooling services spread across Europe and the USA, both for long and short distances. Most of the services are located on the web, connecting the drivers and passengers with the objective to reduce individual car traffic (Handke & Jonuschat, 2013). These services are dependent on the users' initiative, since the drivers have to announce their rides on a website and the passengers need to search for a ride. A commuter needs a certain security of getting to work/school on time and flexibility of getting back home. Therefore, a carpooling service for commuters has to offer flexible travel options in order to be a success (Handke & Jonuschat, 2013).

2.2. Types of Carpooling

Carpooling can be functioned in two ways: Daily Carpooling Problem (DCPP) or Long-term Carpooling Problem (LCPP).

In the case of Daily Carpooling Problem (DCPP), a number of users announce their availability for picking up and later bringing back colleagues on a particular day. The objective is to assign passengers to drivers and to identify the routes in order to minimize service costs (Calvo, et al., 2003).

In the case of Long-term Carpooling Problem (LCPP), each user is available both as a driver and as a passenger and the objective is to define carpools where each user will in turn, on different days, pick up the remaining carpool members. The objective is to maximize carpool sizes and to minimize the total distance travelled by all users when acting as drivers (Calvo, et al., 2003).

According to Teal, there are three types of carpoolers: household carpoolers, external carpooler and carpool riders. Household carpooler is when a person commutes with at least one other person from the same household. An external carpooler shares driving responsibilities with unrelated individuals. At last, a carpool rider commutes with other unrelated workers, but rides only, never providing a vehicle. In relation of all these types of carpoolers, the household carpooler has more success since it is easier to form and not very time consuming by making stops during the ride (Buliung, Soltys, & Bui, 2009; Teal, 1987).

2.3. Carpooling Practices

There exist three main groups of carpooling practices which are the following (Handke & Jonuschat, 2013):

- **Informal carpooling (slugging):** It is practiced in areas that have special lanes for cars with more than one occupants (HOV = Highly Occupancy Vehicle). Generally drivers don't take any contributions from the passengers since the main advantage is to use the HOV lanes and to get to their destination faster. Sometimes, the passengers do however pay or contribute for the costs.

- **Pre-arranged carpooling:** This is the most common form of carpooling, since the interne-based services are relatively easy to provide a planned trip in advance. The systems use internet-based databases that match the drivers' and passengers' travel preferences, so that drivers and passengers can get in contact and arrange a meeting point in advance. Pre-arranged carpooling services demand a registration on a website to guarantee security for drivers and passengers.
- **Real-time carpooling:** Many service providers have developed services that support a real-time ride matching. The call for a ride should be instantly matched with a compatible offer in order to keep waiting times as short as possible.

In order to determine the flexibility of a carpooling approach, the forms of organization (informal, pre-arranged or real-time) can be specified by the following characteristics (Handke & Jonuschat, 2013):

- **Spatial flexibility:** Real-time carpooling on a certain pick-up point and informal carpooling demand a simultaneous presence of the driver and passenger on site. Both can determine a meeting point via internet or phone call.
- **Time flexibility:** Internet-based carpooling needs time to arrange a place and time for meeting. However, internet-based services can also integrate to real-time communication via phone calls since it entails a lot of waiting time for the right match.
- **Role flexibility:** The role flexibility is an essential role for reducing traffic. Carpooling forms use the parking lots as pick-up points as well as pre-arranged carpooling which give an opportunity to negotiate who will take the role as a driver.
- **Route flexibility:** With few exceptions, carpooling systems assume a fixed route from a starting point to a certain destination. Most carpooling services use pick-up points fixed to the routes. Internet-based services offers more route flexibility since the meeting points can vary according to the arrangements between drivers and passengers.

2.4. Commute Distance and Work Scheduling

According to Teal, carpoolers tend to travel further than SOV drivers (Baldassare, Ryan, & Katz, 1998; Teal, 1987). In various studies, commute distance was found to be associated with the choice to carpool. Cervero and Griesenbeck examined the suburban commuting behavior and travel patterns among workers. These authors found that employees with trips of approximately fifty miles were twice more likely to carpool than those with trips of about four miles (Cervero & Griesenbeck, 1988). Levin found that females traveling longer than thirty miles were unhappy to travel alone. He also found that the interest to carpool increased with commute distance. However, this interest decreased with the additional time required to accommodate new riders. These results suggest that the most desirable situation for carpooling involve a small group of individuals, with similar schedules, traveling long distances (Levin, 1982).

The work schedule has been shown to influence successful carpool formation (Ferguson, 1990). Tsao and Lin found that sacrifices of time and scheduling flexibility that are associated with carpooling can be significant barriers. These authors suggest that it is potentially easier to create carpools with commuters that have consistent and typical work hours thus scheduling is easier (Tsao & Lin, 1999).

2.5. Route Convergence vs. Time Convergence

2.5.1. Route Convergence

If the driver and the passenger have the same point of departure and the same destination, then a convergence of routes is given. The drivers and passengers that share the same destination generally are from the same school or working place. Therefore, the challenge is to match their starting point. The drivers can pick up passengers and let them get off during the route. In this case, the destination of the driver and passenger does not have to be the same (Handke & Jonuschat, 2013).

The main aim for the route convergence is to identify drivers and passengers that share the same route. However, often there will not be formed a perfect route convergence. Therefore it is important that the drivers and passengers determine a range that is

acceptable. It is important for the passenger to reach the meeting point easily while the driver has a decision for making a detour for the route (Handke & Jonuschat, 2013)**.**

2.5.2. Time Convergence

The drivers and passengers cannot share a ride if their travel time doesn't match, even if they live in the same house or work at the same place. Although, time convergence offers a certain tolerance since the carpoolers don't always arrive at their work or school exactly on time. The route convergence is determined by the road from home to workplace/school while time convergence depends on individual's mobility patterns and preferences. It is important to determine a time tolerance in order to increase the chances of a match (Handke & Jonuschat, 2013).

Summarizing, time convergence is harder to determine than route convergence. Commuter's routes can be flexible when a driver makes a detour in order to pick-up a passenger or when a passenger walks to a certain pick-up point. A solution to matching rides is allowing drivers and passengers to directly negotiate a convenient meeting point and departure time (Handke & Jonuschat, 2013).

2.6. Travel Planning Optimization Process

In figure 1, the travel planning optimization process consists of two engines (Angskun & Angskun, 2009):

1. Time-based Routing Engine;
2. Energy Consuming Computation Engine.

The Time-based Routing Engine calculates routes that visit maximum places of interest under a specific time constraint. The routes must be ended at the same point as they are started. The algorithms can be divided into three steps (Angskun & Angskun, 2009):

1. **Complete-Route Generation:** visits all places of interest or tourist places;
2. **Partial-Route Generation:** for each complete-route in the first step, this step will calculate all the routes that visit some or all tourist places;

3. **Progressive Route Generation:** it simply searches for routes that have maximum places under a period of specific time. The time period includes both travel time and time spent in each tourist places.

The Energy Consuming Computation Engine selects the best route that has the minimum energy consumption. Each vehicle has different energy consumptions: in the city and on the highway routes. There are three processes to calculate the energy consumption (Angskun & Angskun, 2009):

1. **Average Speed Calculation:** gather information of every route, such as travel distance and time between two places, from the Google map APIs and uses the information to calculate an average speed of the routes;
2. **Energy Consumption Calculation:** calculate energy consumption for a specific car (make and model) of a route. The calculation is performed by classifying the route to be in the city or on the highway based on an average speed obtained in the first step. Then, the calculation uses the manufacturing energy consumption data (in km/l or mpg) of a traveler's car to calculate energy consumption (in liter or gallon) of the route;
3. **Designated Route Selection:** select a route that has the least energy consumption from all candidate routes.

Figure 1 illustrates the travel planning optimization process consists of two engines: Time-based Routing Engine and Energy Consuming Computation Engine.

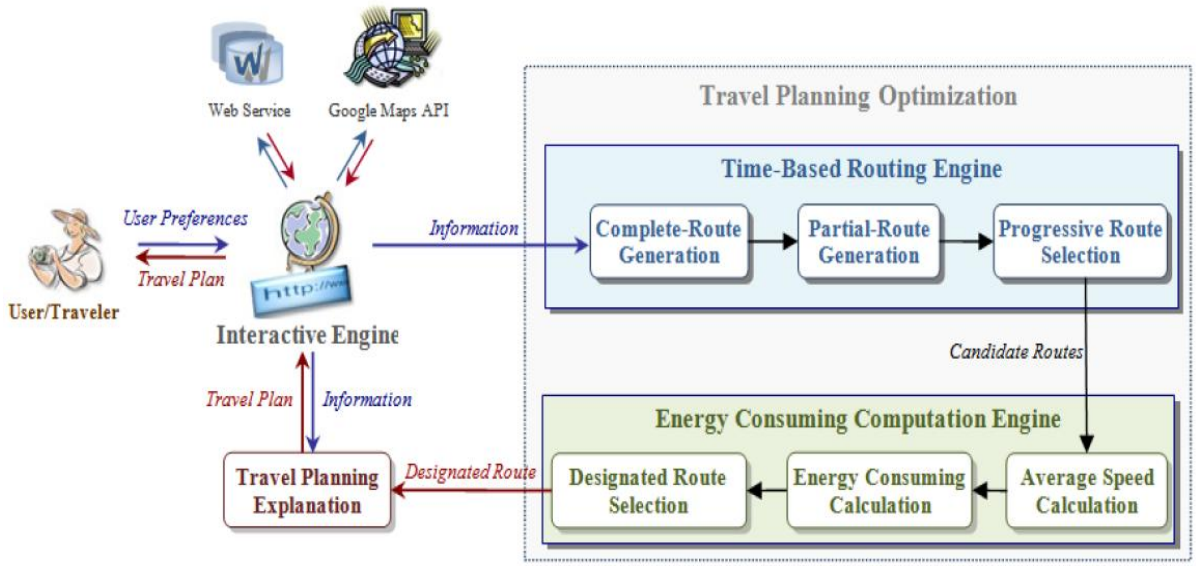


Figure 1 - Travel Planning Optimization Process (Angskun & Angskun, 2009)

2.7. Carpooling Behavior Model

Ozanne and Mollenkopf classify four categories of carpooling routines and behavior (Ozanne & Mollenkopf, 1999):

1. Socio-economic factors like age, gender, employer or working times;
2. Route characteristics like distances, travel times and costs for commuting;
3. General customer demands like reliability or convenience;
4. Personal motivations like the wish for new contacts.

Ozanne and Mollenkopf developed a carpooling behavior model based on marketing theories: TRA (Theory of Reasoned Action) and TPB (Theory of Planned Behavior).

The model TRA explains the relationship between attitude and behavior by a casual sequence from beliefs over subjective norms and attitudes to a behavioral intention and finally to action. The model TRA only refers to situations when a person can completely control the individual's behavior. Figure 2 illustrates the TRA model (Ozanne & Mollenkopf, 1999).

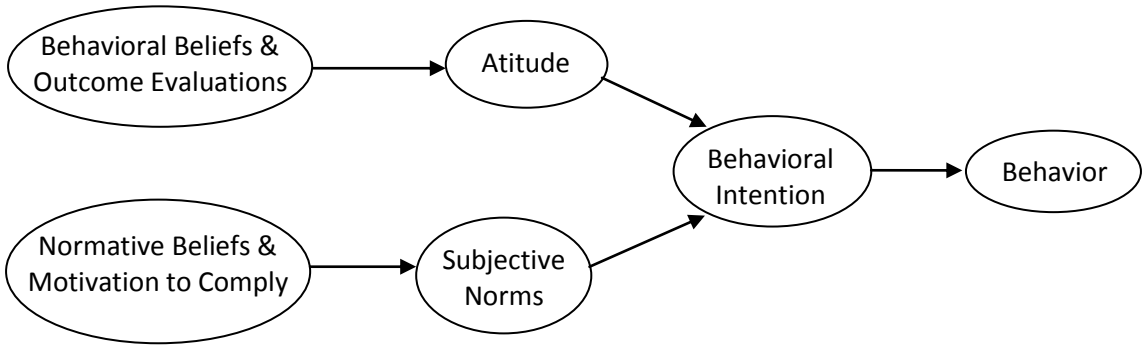


Figure 2 - Model of the Theory of Reasoned Action (TRA) (Ozanne & Mollenkopf, 1999)

Additional to the model of TPB, a behavior intention results not only from a personal attitude and subjective norms, but also from a perceived behavioral control that is based on control beliefs and a perceived facilitation. Figure 3 represents the model of TPB (Ozanne & Mollenkopf, 1999).

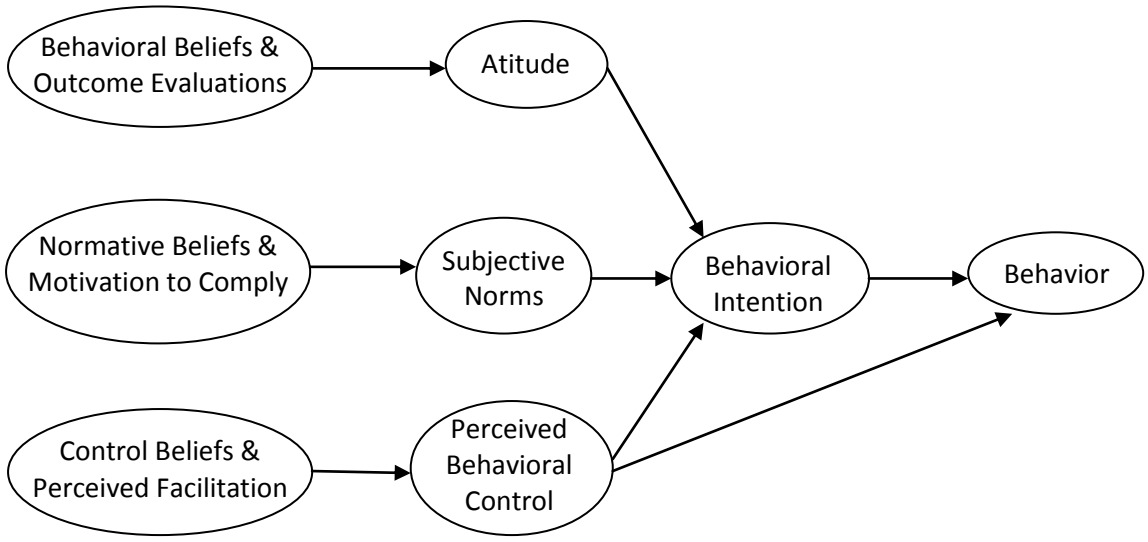


Figure 3 - Model of the Theory of Planned Behavior (TPB) (Ozanne & Mollenkopf, 1999)

3. Literature Review

This chapter focuses on the main studies about carpool that occurred in many countries over the world. The first section represents studies of carpooling that occurred in the past, in which some consists of survey results. The next section mentions the main algorithms that help the commuters to minimize their travel costs. Finally, the last section mentions the examples of carpooling in higher education institutes. Most of these institutes don't have a carpooling website. However, all of these institutes have a department that deals with the transportation on their campus.

3.1. Research on Carpooling

Several carpooling projects and services worldwide have been identified within the research. The research has been concentrated on many countries over the world and many different types of carpooling have been discussed. The people from USA and Canada have a long tradition of carpooling which started in the 1970s due to the oil crisis. In Europe the idea of carpooling started in the mid-1980s, simply following the idea from America (Handke & Jonuschat, 2013).

In the USA, the roads are divided in two types of lanes: Single Occupancy Vehicle (SOV) and High Occupancy Vehicle (HOV). SOV lanes are for vehicles with one occupant and HOV lanes are for vehicles with two or more individuals. The majority of the trips are single occupant vehicle trips (SOV). In 1990, approximately 90% of the work trips and 58% of the other trips in the United States of America were done in SOV. The goal is to minimize the SOV trips by carpooling and if possible using the HOV lanes. The objective of HOV (High Occupancy Vehicle) lanes is to increase carpooling by travelling with more than one rider to compensate the extra time required to pick up and drop off passengers (Giuliano, 1990; Teal, 1987).

Due to the diffusion of the internet and software tools for databases, carpool services became increasingly popular in all parts of the world. Nowadays, smart phones implement

carpooling on their devices by using internet and GPS applications (Handke & Jonuschat, 2013). Massaro also considers mobile phones an excellent platform to access a carpooling service. By using a mobile phone, the carpooler can arrange a ride anywhere and anytime they need (Massaro et al., 2009).

During this chapter will be discussed several examples of carpooling projects from many countries over the world. Also will be mentioned some studies that implemented surveys about carpooling and their respective results.

One example of a carpooling service is called PoliUniPool which targets two universities in Milan, Università Statale and Politecnico di Milano. This system is only restricted to the employees, faculty and students of these universities. In particular, they target students because younger people are more likely to choose carpooling (Gärling, Gärling, & Johansson, 2000). All the employees and students are identified by their email accounts which are provided by the university (Lue & Colorni, 2009).

This carpooling service also estimates the costs for each user in order to let the users know how to share them. The objective is to maximize the number of served users, minimizing the total route length and maximizing the satisfied user preferences. The result is a match between drivers and passengers, their schedules and the routes to be driven by each driver (Bruglieri, Ciccarelli, Colornia, & Lue, 2011).

In 2007, 2008 and 2010, surveys have been carried out in order to estimate the mobility patterns of students and employees from both the universities. The following are the results of the 2007 survey of one of the universities. The amount of students living in Milan is 38%, while 17% live in cities that have direct access to rapid transit (subways and railways) and 45% live in cities that don't have direct access to rapid transit. Since a large number of students don't live near Milan and don't have rapid transit, they only have the solution to use their own vehicle or to carpool. The vehicle is used by 40% of the students to go directly to the university. Among those students, approximately 78% travel alone. In regards of the students that use their own vehicle, 46% are interested in participating in a carpool (Lue & Colorni, 2009).

A study of Foxx and Hake in 1977 (one of the earliest study on travel behavior) showed that changing college students' driving behavior needs a combination of reinforcement and incentives including cash bonuses, free oil changes, etc. The study found that approximately 20% of daily mileages were decreased over the course of a month (Markowitz & Doppelt, 2009).

Some studies state that few drivers are willing to reduce the amount of solo driving. These drivers are more willing to change their behavior if they were presented with some measures that made alternative modes of transport more attractive (Baldassare, et al., 1998; Koppelman, Bhat, & Schofer, 1993). A study of suburban workers in California revealed that the most frequently identified reason for not ridesharing was the freedom of driving alone (Glazer & Curry, 1987).

Studies have found carpooling more common among commuters with lower incomes (Baldassare, et al., 1998; Teal, 1987) and also found that females and younger people are more likely to carpool (Baldassare, et al., 1998; Koppelman, et al., 1993; Tischer & Dobson, 1979).

In California, there is a study that examines the commuting stress when travelling to and from work. This study found that commuting stress is significantly associated with distance and duration of the trip. Females commuting a long distance (more than 20 miles) were predicted to have higher commuting stress than men (Novaco, Kliewer, & Broquet, 1991). According to Koslowsky, the commute to home is more stressful than the commute to work because if the person is caught in traffic they consider it as a loss of personal time (Koslowsky, 1997).

The literature on household structures reports that individuals living in a large household have a greater chance to form carpools (Blumenberg & Smart, 2010; Brownstone & Golob, 1992; Brunso & Hartgen, 1981; K. Charles & Kline, 2006; Tischer & Dobson, 1979). According to Massaro, the biggest obstacle to participate in a carpool is trust. Therefore, the members from the same household have a better chance to form a carpool (Massaro, 1998).

A university in Thailand called Mahasarakham University was used as a case study to evaluate the students' travelling behavior. The university has two campuses, an old campus

and a new campus, which are approximately 7 km a part. The research studied the attitudes of students that change their travelling behavior towards the more energy conservative choices of transportation (Singhirunnusorna, Luesopaa, Panseea, & Sahachaisaereeb, 2011).

This study collected information through a survey with 250 students who were randomly selected from the university. People on the campus prefer to use their personal cars or motorbikes for their daily travelling to and from the campus. Most of the interviewed students were living outside the campus (71.6%) and the rest live in the campus' dormitories (28.4%) (Singhirunnusorna, et al., 2011).

Data from the survey found that most students prefer to travel to the campus with their motorbikes (68.4%) while only 10.8% uses public transport and 1.2% drive their personal cars. This study also found that most students make their trips (back and forth) to the campus by their own vehicles every day and more than once a day (60.0%) followed by the students that travel once in every 2-3 days (28.8%). This concludes that the motorbikes have become a student's riding habit, even if it's a walking distance (Singhirunnusorna, et al., 2011).

This study used three scenarios: carpooling, car-free day, and ribbon-bicycle programs. Carpooling involves sharing journeys so that more than one person travels in a vehicle. Data show that 40% of the students were driving alone and using motorbike as their main choice for travelling to and from the campus. Most of the students chose to share a ride with a friend from the same faculty or department (33.6%), followed by a person they knew who lived in the same dormitory/place (23.1%) and friends from different faculties/departments (18.6%) (Singhirunnusorna, et al., 2011).

For car-free day, students have to leave their vehicle at home and travel with alternative modes, such as carpooling with friends, public transportation or bicycling/walking. Data found that most students are willing to leave their vehicle at home at least once a week (47.6%) followed by twice a week (22.0%). Approximately 60.8% of the students choose to travel with their friend's vehicle and 31.6% of the students travel by public transportation. Only a small number of students will travel by bicycle or walk (7.2%) (Singhirunnusorna, et al., 2011).

The university in question launched a bicycle rental project also known as “ribbon-bicycle project”, but this scenario was unsuccessful among the students. The study found that more than 80% of the students didn’t have bicycles of their own and only 5.6% had rented bicycles under this project. Approximately 34% didn’t want to participate in the project (Singhirunnusorna, et al., 2011).

Among the three projects, data from the survey shows that most students select to carpool as their first choice and the least popular is the bicycle project. However, the 171 students (68.4%) from the survey prefer to travel to school by motorbike (Singhirunnusorna, et al., 2011).

A website in Germany of long-distance ridesharing declares to be one of the biggest carpooling services in Europe. This service was established in April 2001 and has about 850,000 registered drivers and passengers. This website concentrates on single and long distance trips. It offers publication of personal information, searches for travel information, “women only” lifts, shows meeting points by Google maps and uses an internal mailbox system. Furthermore, there is a feature to mark carpooling partners behaving negligent or irresponsible, which is called “black sheep” (Handke & Jonuschat, 2013).

A project called CARLOS aim to test an innovative carpooling service for rural areas in Switzerland from 2002 to 2005. The CARLOS project has matched averagely 1884 lifts, which results in an average of 5 lifts per day. However, the amount of lifts has been decreased from 300 drives (=10 drives per day) in the first month to 60 drives (=2 drives per day) at the end of the project. Initially the main target group were teenagers and students until the age of 24. However, about 30% were aged between 25 and 45 years and another 30% between 54 and 64 years. A survey has been made to evaluate the CARLOS project. The survey showed that a lift from the CARLOS project is equivalent to public transport, which means that this project was mainly used in times of lack of public transports (Handke & Jonuschat, 2013).

Lifeshare.com is a classical internet-based carpooling service. It was founded in 1997 and was one of the first carpooling services in Great Britain. Initially this website only targeted students in the Bristol area, but nowadays it’s operating nationwide. In August 2011, more than 455,000 registered users and 290,000 active users in about 1,300 carpooling schemes

have offered more than 290,000 lifts. After each contact between members, 45% of these contacts result in a journey. This website is free for private users. The software aims to encourage colleagues not only to carpool, but also to walk and cycle together or share a taxi (Handke & Jonuschat, 2013).

Since 2008, Jayride (www.jayride.co.nz) is a popular internet-based carpooling service in New Zealand. On this website only drivers can post lifts and passengers have to contact the drivers. About 15% of the 6,208 users (from August 2011) have already used Jayride once or twice. In August 2011, 33 Jayride members announced on-off rides and 130 members repeating lifts. This service has more than 6000 members and offers 6,833 lifts (=50 lifts per regular driver) (Handke & Jonuschat, 2013).

A study in Toronto and Hamilton has been made to identify the popularity of carpool as a school travel and examine the adxults who drive their children to school. Overall were interviewed 1,001 parents and guardians of elementary school-aged children. The results indicate that 1.7% used carpooling as a travel mode in the morning, while 33.8% drove their child to school in the morning. Only 25% participated in a carpool with friends or neighbours. From the sample of children who participated in a carpool, 39% were driven by a parent or guardian to school, 31% walked to school, 18% used the school bus, 8% carpool and 3% used public transport (Arbour-Nicitopoulos, Faulkner, Buliung, Lay, & Stone, 2012).

The majority of carpool drivers were female (66%), 35 to 44 years of age (62%), worked full-time (76%), and used walking (51%) as their primary travel mode when they were younger. The majority of the children that carpooled were female (65%) and senior students (42%) (Arbour-Nicitopoulos, et al., 2012).

An internet-based application in New Zealand called “Let’s Carpool” (www.letscarpool.govt.nz) was launched in 2009. It examines the factors related to solo driving and aims to increase vehicle occupancy for trips to and from work. Let’s Carpool uses a ride-matching software to facilitate the commuters to find a carpool match to and from work. This study had nearly 1300 registrants which concluded that the commuters that get to work by carpool increased significantly while the commuters that drove alone decreased significantly (Abrahamse & Keall, 2012).

An online survey from Let's Carpool was filled out by 634 registrants, which consisted 57.4% of female participants. The majority of the participants are between 20 and 39 years of age (81.8%). The percentage of participants who carpooled to work increased from 12.4% to 27.9%, while the percentage of participants driving alone to work decreased from 36.6% to 29.9% (Abrahamse & Keall, 2012).

Approximately 7.6% of the participants who used to drive alone to work were now carpooling. An additional 9.9% of participants who used to travel by public transport switched to carpooling. However, 2.8% of commuters were carpooling before registering with Let's Carpool, but were no longer carpooling (Abrahamse & Keall, 2012).

Around 40.5% of the participants formed a carpool through Let's Carpool, either because they contacted somebody through the website (23.4%) or because somebody had contacted them (17.1%). Most people carpooled to work five or more times a week (44.7%), while 39.9% carpooled 1-4 times a week and 9.6% carpooled about once a month. Most carpools consisted of two (53.9%) or three people (30.9%) and 15.2% consisted of four people or more (Abrahamse & Keall, 2012).

A small number of participants (7.1%) had formed a carpool since registering with Let's Carpool, but had stopped carpooling ever since. Among the reasons for not carpooling were: work hours or work location changed (24.4%), moving house (11.1%), or mechanical problems with their car (11.1%) (Abrahamse & Keall, 2012).

About 61% of the participants had not started carpooling since registering. They were still looking for matches (49.1%) or had contacted a match who was not interested in carpooling (20.9%). The issue to start carpooling was an important barrier because the website was not up-to-date (Abrahamse & Keall, 2012).

A case study of Iran constructed a survey that has been used to observe travellers' tendency to carpool. In October 2011, this survey was filled out in fuel stations by 470 travellers that use their own vehicles, in which 80% of respondents were male and 20% were female. More than 90% of the reasons for the trips were work (82%) and education (11%). Approximately 44% of the respondents select carpooling independence of knowing or not knowing someone to carpool, but only 14% of the participants are interested in carpooling if they

know someone to carpool. However, 44% of the respondents select carpooling as a substitute of driving alone (Lipnicky & Burris, 2010).

A survey was used in a case study of Delhi in which 500 participants were interviewed. The amount of people that would like to carpool is almost divided by half. Approximately 48.2% of the respondents do not want to carpool, while the other 51.8% would consider carpooling. The amount of people that were already carpooling before being interviewed was 15.2%. Approximately 65% of the respondents stated that they thought carpooling would save time and 81% believed carpooling would reduce pollution (Dewan & Ahmad, 2007).

A study from Kennesaw State University aims to investigate whether carpooling to and from work reduces stress with an age ranged between 18 to 62 years old. A total of 212 surveys were answered, in which 122 were females and 90 were males. Only 19 participants carpool, when 187 of them use their personal vehicles to get to and from work. Of the 212 participants, 131 had not considered carpooling to reduce stress. Surprisingly, 106 participants felt calm when they arrived to work and 89 participants felt calm when arrived home after their commute. That being said, participants are more stressful from the commute from work to home. One question from the survey asked the participants to rate their overall commute on a scale from 1 to 10 with 1 being “not stressed at all” and 10 being “extremely stressed.” Surprisingly, 46 of the participants gave a rating of 1 and no participant gave a rating of 10 (Peterson, 2008).

Most of the carpooling services mentioned above are common in many countries across the world, but there exists some carpooling services that probably no one has ever heard of. One of these carpooling services is a reward system in the United States called NuRide (www.nuride.com). The users earn points every time they participate in a green trip, including carpooling, taking public transportation and biking. Those points can be redeemed for rewards, such as coupons and discounts. However these services operate as a post-it board and don’t suggest a matching between the users. This board is where everybody can consult or add information about their travel routes. Therefore, the users have to find themselves a compatible trip. DriJo is another uncommon carpooling system that sells long distance rides by internet auction. The drivers post lifts on the DriJo homepage and the

passengers purchase them by auction. After two years, this service has been discontinued due to lack of users (Handke & Jonuschat, 2013).

As mentioned above there are different types of carpooling schemes, from long-distance rides to auctioning rides. Most studies shown above found that females are more likely to carpool and have more concern about the environment than males. This project will develop a system helping teachers and students from an academic environment to create carpool matches. Initially, the user will need to see if there are any possible matches otherwise the user will need to register their ride. Once the user finds a compatible match he/she responds to that match through a contact form on the website.

3.1.1. Algorithms and Equations

In this section will be discussed the algorithms and equations that has been used in some studies mentioned in the previous section. The matching algorithm has been developed in the carpooling service called PoliUniPool. This algorithm creates carpool matches taking into account the time windows, the origins and destinations, and the preferences. Next, an equation from a case study in Iran will be discussed. This equation determines the percentage of single occupancy vehicle (SOV) switched to carpooling by assuming the high occupancy vehicle (HOV) lane. This study also developed an equation to calculate the amount of fuel saved (FS) in the morning peak hour. Finally, will be discussed an equation used in a case study in Portugal. This equation determines the overall costs saved from participating in a carpool.

3.1.2. Matching Algorithms

The matching algorithm uses a matching matrix (MM). It represents the connection among all participants in the carpooling on a certain day of the week. The matching matrix associates a row to each driver's journey, a column to each passenger's journey, both a row and a column to every mixed user's journey (Bruglieri, et al., 2011).

The MM element a_{dp} indicates how the passenger related to the trip *p* can be inserted in the carpool of a driver who makes the journey *d*. The time window $[T_p^{min}, T_p^{max}]$ of a passenger

p, with origin O_p and destination D_p, is compatible with $[T_d^{min}, T_d^{max}]$ of a driver *d*, with origin O_d and destination D_d, if the following are satisfied (Bruglieri, et al., 2011):

- $T_d^{min} + t_1 + t_2 \leq \min \{ T_p^{max} , T_d^{max} - t_3\}$
- $t_1 + t_2 + t_3 \leq MaxLos_d t_d$
- $\max \{ T_p^{min} , T_d^{min} - t_1\} + t_2 + t_3 \leq T_d^{max}$

Figure 4 illustrates the detour of a driver d satisfying the request of a passenger p.

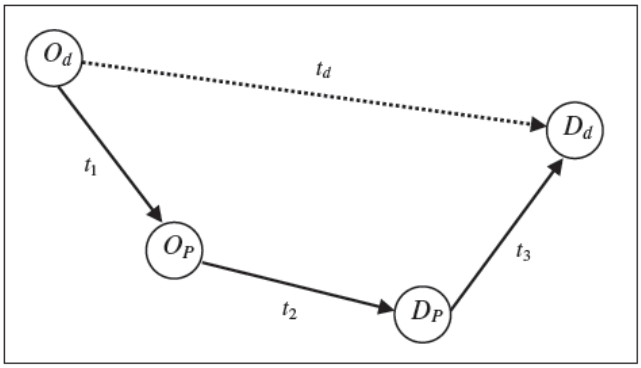


Figure 4 - Detour of a driver d satisfying the request of a passenger p (Bruglieri, et al., 2011)

In figure 4, t_d is the duration of the shortest path from O_d to D_d, t_1 is the sum of the duration of the shortest path from O_d to O_p with the maximum driver waiting, t_2 is the duration of the shortest path from O_p to D_p and t_3 is the duration of the shortest path from D_p to D_d (Bruglieri, et al., 2011).

If the time windows of users *d* and *p* are compatible, the MM element a_{dp} demonstrates in the following equation and it represents the extra travel time of driver *d* to satisfy the journey request of passenger *p* (Bruglieri, et al., 2011):

$$a_{dp} = t_1 + t_2 + t_3 - t_d$$

3.1.3. Percentage of switching to carpool

An equation is developed to estimate the percentage of single occupancy vehicles (SOV) switched to carpooling by assuming the high occupancy vehicles (HOV) lane. In the following describes the equation (Seyedabrishami, Mamdoohi, Barzegar, & Hasanpour, 2012):

$$f(x) = \phi \frac{1 - e^{\frac{1-ax}{1-x}}}{1 + be^{\frac{-ax}{1-x}}}$$

Where:

f(x): is the percentage of SOV being switched to carpooling.

$x = (t^{initial} - t^{carpooling}) / t^{initial}$

$t^{initial}$: the initial travel time without considering carpooling (minutes).

$t^{carpooling}$: the travel time considering carpooling with presence of HOV lanes.

3.1.4. Amount of fuel saved

The equation to calculate the amount of fuel saved (FS) in the morning peak hour is the following (Seyedabrishami, et al., 2012):

$$\mathrm{FS} = \frac{\mathrm{VTR} \times \mathrm{ATD}}{100} \times \mathrm{AFC}$$

Where:

ATD: Average trip distance (km).

AFC: Average fuel consumption for a vehicle (litre/100 km).

VTR: Is the difference of total number of vehicle trips before applying carpooling ($TT^{initial}$) and the total number of vehicle trips after applying carpooling (TT^{new}). This term can be calculated with the following equation:

$$VTR = TT^{initial} - TT^{new}$$

The term TT^{new} can be calculated from the division of total mobility (TM) by average vehicle occupancy after applying to carpool (AVO^{new}). In the following calculates TT^{new} and AVO^{new} (Seyedabrishami, et al., 2012):

$$TT^{new} = TM / AVO^{new}$$

$$AVO^{new} = POC \times AVO^{*} + (1 - POC) \times AVO$$

Where:

AVO: Average vehicle occupancy without considering carpooling (person/vehicle).

AVO*: Average vehicle occupancy considering carpooling (person/vehicle).

POC: Percentage of travelers who choose carpooling.

The term TM, in the previous equation, is the total mobility which shows the number of people who have been moved by vehicles in the trips. This term is calculated by the following (Seyedabrishami, et al., 2012):

$$TM = TT^{initial} \times AVO$$

3.1.5. Overall costs saved from participating in a carpool

The saving costs resulting from participating in a carpooling scheme are calculated in the following equation. It considers the savings that the carpooler benefits from carpooling with x persons (only external to the household and including the driver) in y days (Correia & Viegas, 2010).

$$\%\text{Expenses reduction} = 1 - \left(\frac{y}{x \times 5} + \frac{5 - y}{5}\right)$$

3.2. Examples of Carpooling in Higher Education

In this chapter will be discussed various examples of carpooling in institutes of higher education. Most of these institutes have a carpooling website but only members from the institute have access to them. Since the access to the carpool websites was restricted, a lot of research has been made to learn how these websites work.

3.2.1. Polytechnic Institute of Leiria

The Polytechnic Institute of Leiria has a carpooling website which is only aimed at the students, faculty and staff of the institute. The institute's campus has about 5300 students

and 610 employees (faculty and staff). In the academic year 2007/2008, a study has been made indicating that 82% of the academic community travelled to campus by car with no passengers. Approximately 48% of these users know other members from campus that live near their residence (Leiria, 2009).

The Polytechnic Institute of Leiria has a web application called "gotoCampus" that was developed by two students of Informatics Engineering. This application was developed to help the environment and to prevent students, faculty and staff from travelling alone to school. Some features of this application are: request or offer rides, view the schedules of various users and search for users that live near each other (gotoCampus, 2009).

Figure 5 illustrates the main carpooling page of the Polytechnic Institute of Leiria. The users that can only log in are members from the institute. Therefore, due to restricted access, it was only possible to view the main page. This page can be accessed on the link: http://gotocampus2.ipleiria.pt.



Figure 5 - Main Page from Polytechnic Institute of Leiria

3.2.2. Princeton University

Princeton University has a department called "Transportation Demand Management" (TDM) which provides strategies and policies to reduce the number of single occupancy

vehicles coming to school and parking on the campus. This department provides three alternative methods of travel: biking/walking, vanpool and carpool service (P. University, 2013d).

Princeton University provides a wide selection of bike paths and walk ways throughout the campus. The bicycle registration is required for faculty, staff and students who ride on the Princeton University campus. This registration is important so the bicycle can be recovered in case the bicycle is lost or stolen. This registration is free and must be renewed every five years. On the campus there is a do-it-yourself repair shop for the bicycles in which the tools are provided and volunteer mechanics are available to assist with any repairs (P. University, 2013a).

A Vanpool operates in a similar manner to carpools, only they carry more individuals than a typical carpool. A vanpool is organized when five or more interested participants, who reside in the same area and have similar work schedules. This transport is suitable for longer commutes of ten miles or more each way. The vans are supplied to each group with no costs but the fuel costs are shared among each member of the group, excluding the driver. Currently, the university has six vanpools operating daily but they are considering in expanding more vanpools (P. University, 2013c).

The carpool service is a free carpool matching service for the Princeton University community. The program provides the participants with a list of matches of other Princeton University members who live and work near them and want to carpool. This match is not done automatically; therefore the participants need to set up their own carpool. This service is only available to the faculty and staff of the Princeton University. All of these employees who commute in a carpool are eligible to receive a $50 gas card every three months. In addition to the gas card, every new member is eligible to receive a $25 oil change certificate (P. University, 2013b).

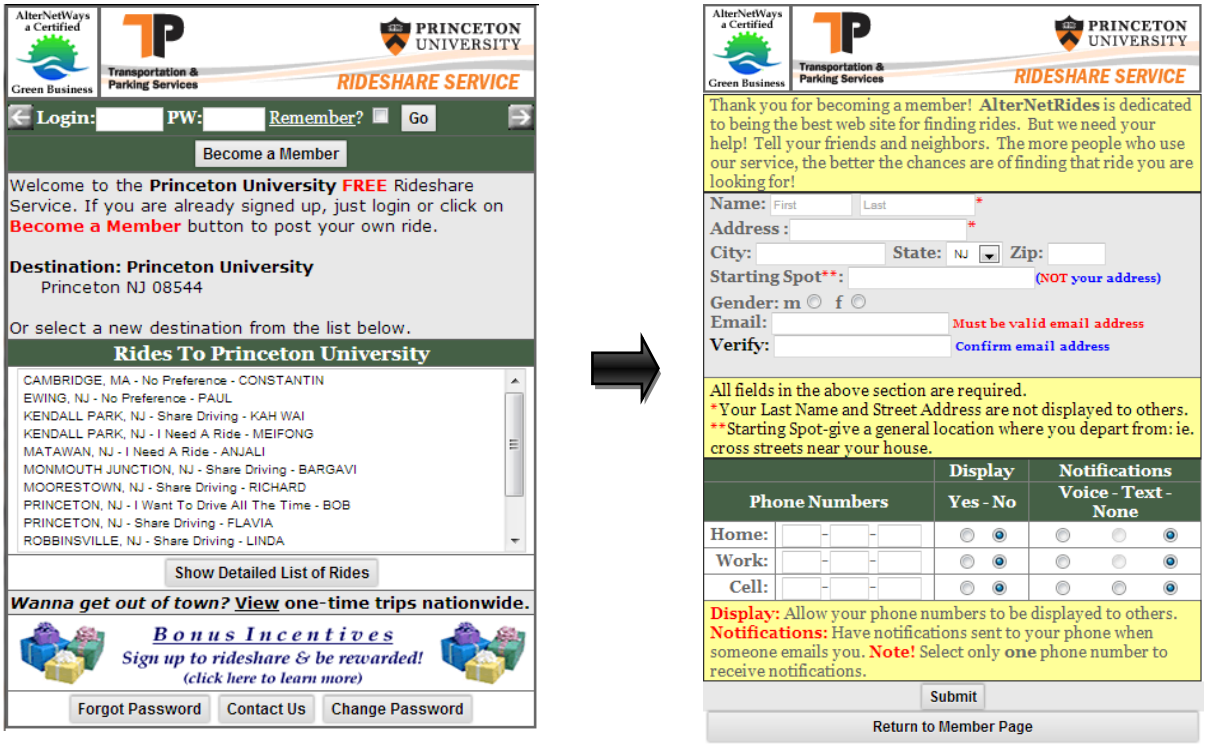
The university offers the participants a guarantee ride home in case of an emergency. This service is free and is only eligible to commuters that use one of the travel modes mentioned above (P. University, 2013d).

Initially, the participant will need to enter their Princeton University email address into the rideshare database. In additional, there is a form that needs to be filled out. Once all the information is entered into the database, the participant can wait for a response or search for a possible ride that meets their criteria.

Surprisingly, it was possible to register on the Princeton's carpool website. Therefore, figure 6 demonstrates step by step how to register on the Princeton's carpool website.

On the main page, it displays a login section and a section to view the available rides in the university. If the user is not a member, they need to click on "Become a member" to register on the rideshare database. Before the user initiates the registration process, they need to agree on the terms and conditions. Once the terms and conditions are agreed, the user needs to enter a login ID and a password. The next step of this registration process is to fill out a form with some personal information about the user.

The next step allows the users to add or edit an existing ride. This phase only needs the user's starting point whereas the destination point is at Princeton University. In additional, the users need to enter their preferences, such as, if they are a driver or passenger, the radio station they prefer and if they are a smoker or non-smoker. Figure 6 illustrates these steps.



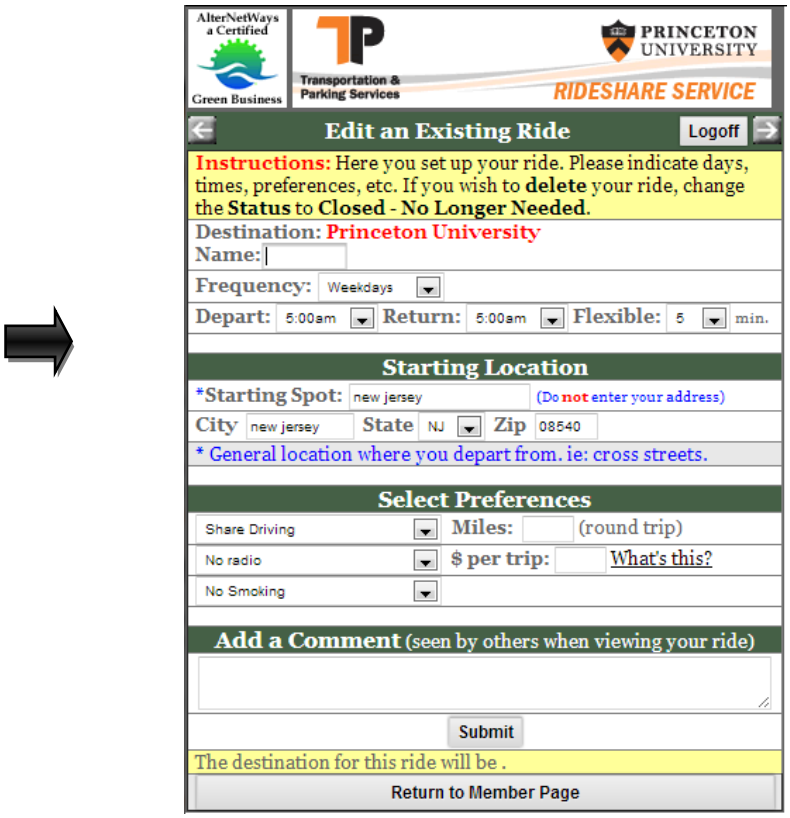


Figure 6 - Princeton University - carpool website

3.2.3. Stanford University

In Stanford University there is a department called “Parking & Transportation Services” that deals with all the transportation and parking occurring on campus. The available transportation modes in the university are: biking, carpool and vanpool.

On campus there are plenty of free parking spaces for the bicycles, an estimated of 12,000 bike racks. All the bicycles used on campus must be registered. The registration fee is $3.50 and lasts for three years. The objective to register the bicycles is to recover any bicycle in case of stolen, lost or abandoned. If a bicycle is not removed from its location in two weeks, the Stanford University Department will claim it as abandoned (S. University, 2013a).

On campus there is a bike repair shop where all the tools are available and a professional bike mechanic is on duty for any assistance. In case of any abandoned bikes, the shop repairs these bikes and sells them for a low price (S. University, 2013a).

In additional, Stanford University contains lockers to keep the bicycles stored. Each locker rental has a fee of $24 annually. In total, there are twelve locker compounds located on the campus with a capacity of 180 bikes (S. University, 2013a).

A vanpool is a group of seven to fifteen people who ride to and from work each day in a comfortable van. Each Stanford vanpool receives $200 per month to cover the expenses of the van and each member of the vanpool can receive up to 12 free hourly car rentals per year, in case a member needs to run errands. In addition, each vanpool will receive a free parking permit and have a reserved parking space on campus (S. University, 2013c).

To initialize a carpool, it is necessary to sign up with Stanford's matching service to find potential partners to share rides. When registering, it is essential to provide the departure location and schedule. Once the carpool has two or more members, they can apply for a Stanford carpool permit. The cost of the permit will be shared equally among all the members of the carpool. At the end of each quarter, each member of the carpool will receive $12.50 (S. University, 2013b).

If a carpool changes (i.e. one member leaves) and still has at least two eligible members, the members must submit a new carpool application. However, if a carpool ends or doesn't have at least two members, the carpool permit is no longer valid (S. University, 2013b).

The staff, faculty and students of Stanford University can organize a carpool online through the link: http://www.zimride.com/stanford. Only members from Stanford University can register on this website. There are more than 3,000 people signed up from this university. Figure 7 illustrates the main page of Stanford's carpooling website. Since this website is only accessible to members of the university, it was only possible to view the main page (S. University, 2013b).

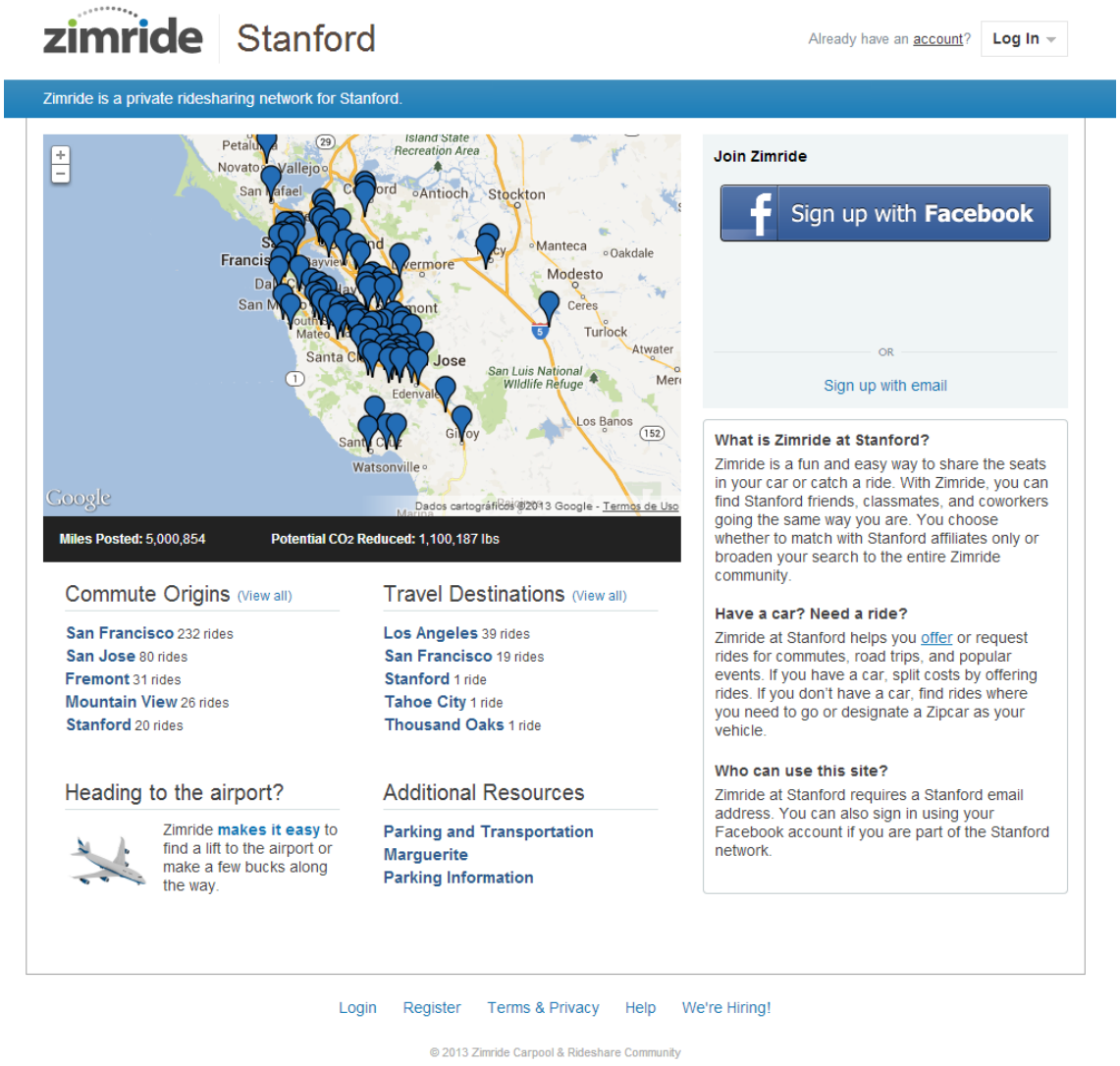


Figure 7 - Main Page from Stanford University

Stanford University rewards all the commuters who do not drive alone to campus with a bonus of $300 per year. Stanford also has a free "Emergency Ride Home" program, which helps the commuters get a ride home in case of a personal emergency. Each commuter has four free rides per academic year (S. University, 2013b).

3.2.4. York University

York University is Canada's third largest university with almost 68,000 students, staff and faculty. In the late 1990s, this university concluded that 70% of the commuters were driving alone while 30% were taking alternative modes. With this conclusion, the university created a department called "Transportation Services" which encouraged members from York

University to take public transit, carpool, bike or walk, with the goal to reduce the parking spaces at York University (Y. University, 2013a).

All the buildings on campus are equipped with bicycle racks where the bicycles can be securely locked. The people interested in using their bicycles on campus should contact the transportation department to register their bikes (Y. University, 2013b).

York University and Zipcar became partners to provide Zipcars to the faculty, staff and students of York University. Zipcar is the world's largest and fastest growing car sharing service, with more than 120,000 members and 3,500 vehicles in major metropolitan areas and college campuses (Y. University, 2013c).

On campus there are nine Zipcars available so the members can use for 24 hours a day, seven days a week. Faculty, staff and students can join Zipcar at www.zipcar.com/yorku for $25 per year and will gain access to York University Zipcars starting at $10.50 per hour or $78 per day (prices vary based on the vehicle's make and model). Figure 8 illustrates the main page of Zipcar (Y. University, 2013c).

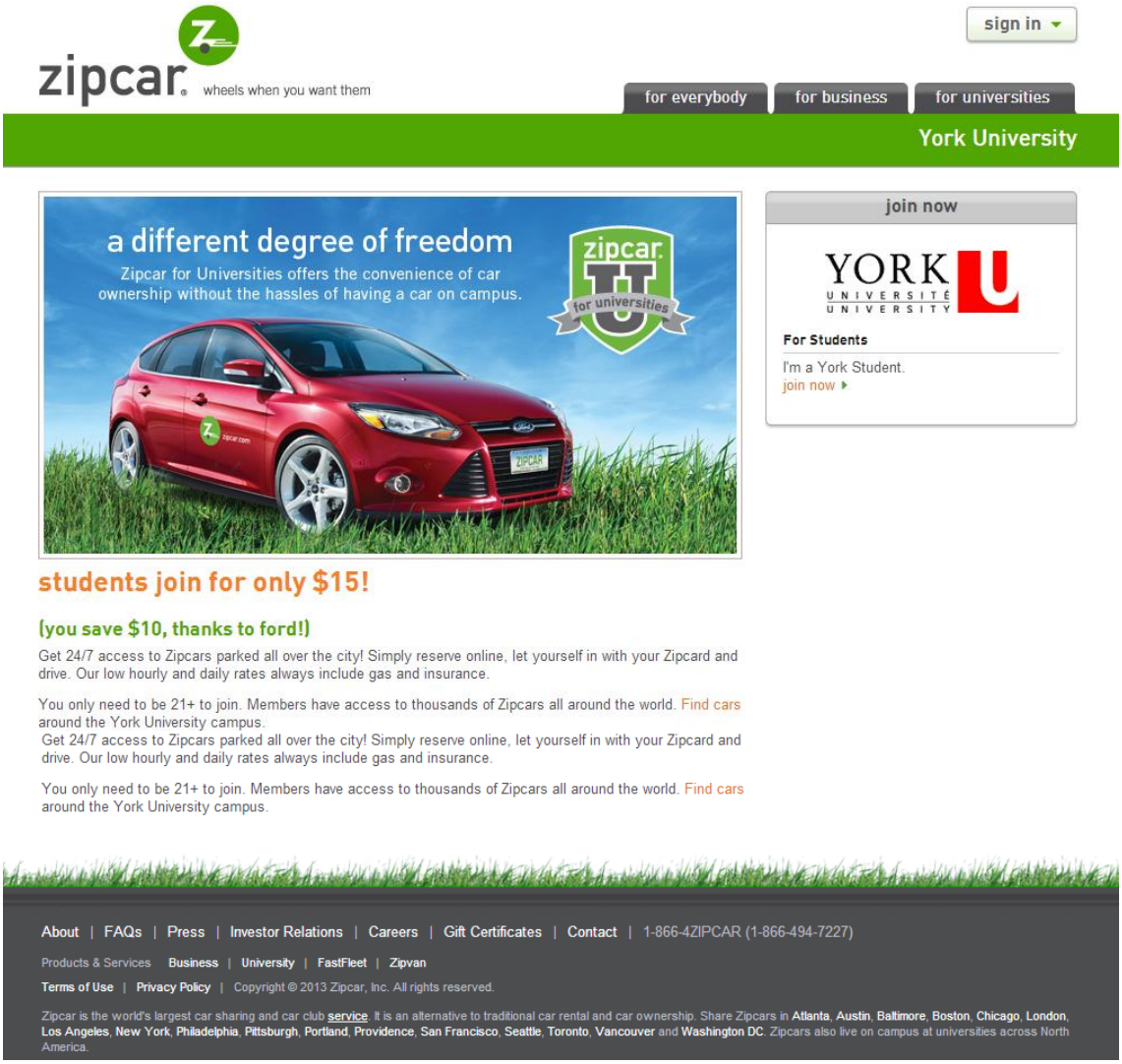


Figure 8 - Main Page of Zipcar (York University)

Any member from York University has to be registered on the Zipcar website before using it. Initially, the user must create a username, also indicating their email and password. Afterwards, the user must indicate the address where they need the car. The York University's website only allows members with a driving license and they should be at least 21 years old. It was not possible to continue on with the registration because it was necessary a driving license from Canada.

York University also has a partnership with Smart Commute NTV (North Toronto, Vaughan). This service is free, easy to use and helps York University staff and students find a carpool partner. This service can be accessed on www.SmartCommuteNTV.ca. After the user registers their information on the site, they will instantly be given a list of compatible

matches for people commuting from within their neighbourhood. Figure 9 illustrates the main page of the link mentioned above.

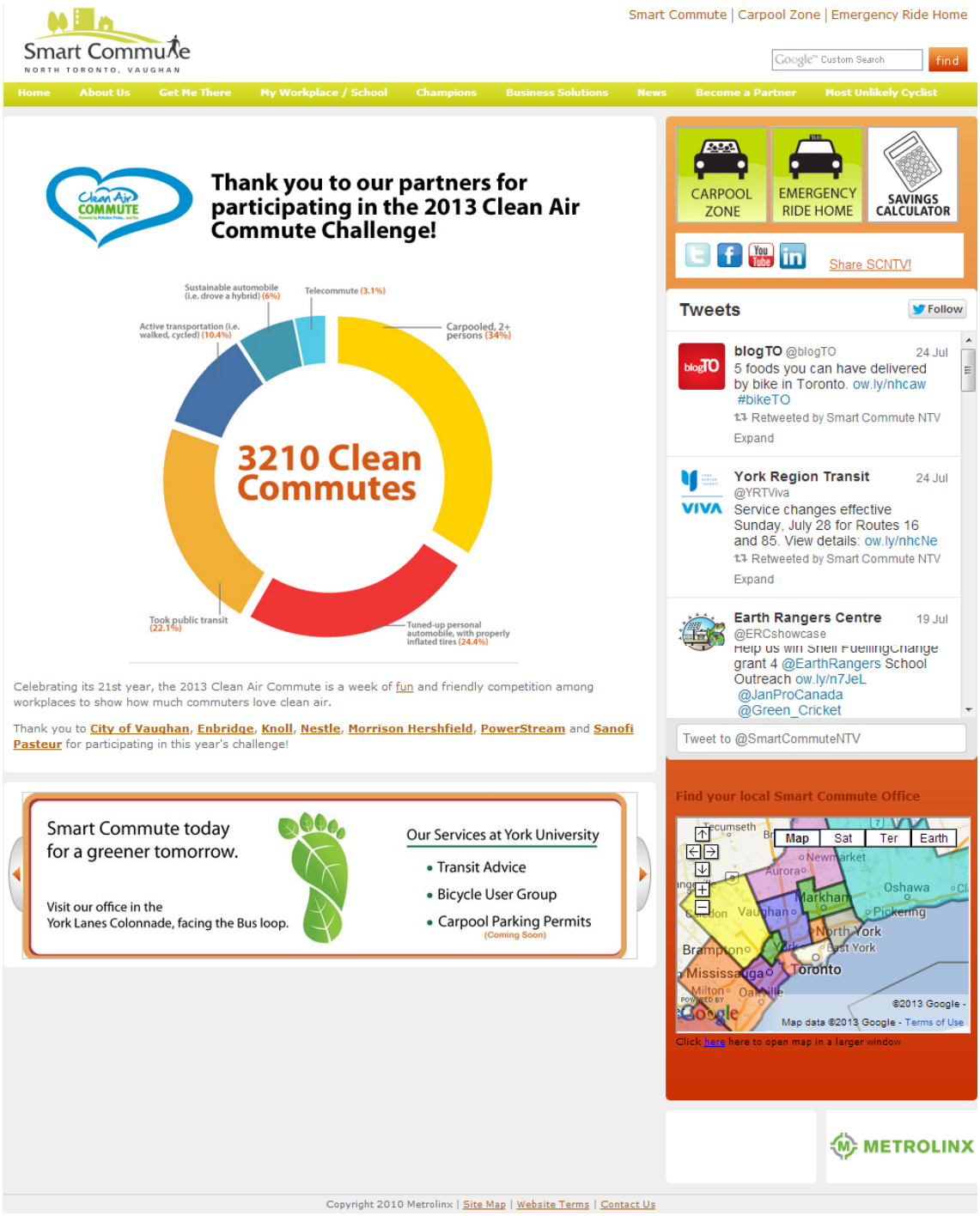


Figure 9 - Main Page of Smart Commute NTV

Any member that is registered with Smart Commute is eligible for an Emergency Ride Home reimbursement. If an unforeseen emergency occurs on any day that the user uses a transportation method to work or school, they can request a reimbursement of up to $75 for the emergency transportation costs (Commute, 2010).

3.2.5. Summary

All the higher education institutes mentioned above have implemented an online service to create carpool matches for the students, faculty and staff. However, some institutes have more transportation modes, such as biking and vanpool. So far, these transportation methods don't exist in all the institutes, especially in Portugal. Throughout the research, it was discovered that only few higher education institutes in Portugal have an online service to carpool as a transportation method. That being said, this project has developed a web application for a specific institute allowing teachers and students to create a compatible carpool match.

Princeton University has a disadvantage allowing any person register with their website, even people that has never been to the university. On the other hand, the application that is being developed for this thesis only authorizes students and teachers from the same university.

The institutes mentioned in this chapter have some advantages compared to the application developed in this project, since they have been developed for long a time. The higher education institutes that have a carpool website also have an Emergency Ride Home program. This program is available to any carpooler in case of an unforeseen emergency occurs. In the future, it will be great to advance with the features of the application and implement new transportation methods, such as biking and vanpool.

An advantage that this system has in relation to the higher education institutes mentioned above is how people can create carpool matches in a fast and efficient manner. For example, for each ride that is registered in the system, the registered users with a similar origin, destination and schedule will be notified by email about this new registration. This feature does not happen to any of the systems that were tested throughout the project.

With this advantage, it will prevent users to go every time to the website to see if there are any compatible matches.

In table 1 demonstrates a comparison between the applications of the higher education institutes mentioned in this chapter and the application developed in this project.

	Polytechnic Institute of Leiria	**Princeton University**	**Stanford University**	**York University**	**IPCA**
Only available for students, teachers and staff	Yes	No	Yes	Yes	Yes
User their own developed application	Yes	Yes	No	No	Yes
Use Emergency Ride Home Program	No	Yes	Yes	Yes	No
Transportation department for Biking, vanpool and carpool	No	Yes	Yes	Yes	No
System creates carpool matches automatically	No	No	No	Yes	No

Table 1 - Comparison of the Higher Education Institutes

4. Design of the User Interface – Some Concepts

This chapter will discuss some concepts of the design of a user interface. First, will be discussed the objectives of usability following with the principles of usability. Next, will be mentioned the main rules for designing an interface. Finally, will be discussed a popular technique of evaluating usability. This technique is called heuristic evaluation and contains a list of ten items to evaluate usability.

An interface allows the user to interact with the system. The best computer system is useless if the user cannot interact with it. The fact that a user cannot often find what they're looking for or not knowing how to perform a certain task is the result of a bad interface, which consequently generates a usability problem. Therefore, this project studied usability and rules for designing interfaces to create an application that users can interact with.

4.1. Objectives of Usability

Usability is defined as the degree of effectiveness, efficiency and satisfaction in which specific users can achieve certain goals in a particular environment (Faulkner, 2000).

- **Effectiveness** refers to the ability of the user to perform a particular task, without going into consideration the time to perform the task or if the system is easy to use, and only considers the system's ability to resolve the task.
- **Efficiency** refers to the resources consumed to perform the task, including the time spent. If a particular system is able to perform the task in five minutes and another system takes ten minutes, then the first system will be more efficient than the other.
- **Satisfaction** refers how the user feels in relation to the use of the system.

Since an interface is not one-dimensional, Nielsen states that usability cannot be defined by a single parameter. However usability is defined by a set of attributes and Nielsen identifies five attributes described below (Nielsen, 1993):

- Learning (easy to learn);
- Efficient use (easy to use);
- Memorizing (easy to remember);
- Prevention and error recovery;
- User satisfaction.

Learning: the system must be easy to learn so that the user can quickly start working with the system. This can be considered as the key attribute because when a user is faced with a new system, learning the system is the first barrier to overcome. One possible way to measure this attribute is to determine the time that a set of users, who have never seen the system, takes to perform a number of tasks (Nielsen, 1993).

Efficient use: once the user has learned to use the system, it should be possible to have a high level of productivity. The efficiency is achieved when the user gets a steady performance when handling the system (Nielsen, 1993).

Nielsen states that to measure the use efficiently it is necessary to determine the users experience and the number of hours the user has worked with the system. The best way to measure this attribute is to perform a test with a group of users who have the same experience and then measure the time it takes to perform a specific task (Nielsen, 1993).

Memorizing: the system must be easy to remember. If a user uses the system intermittently and starts using it again after a certain period of time, the user shouldn't have to learn everything all over again. Since the user has already worked with the system, the user just has to remember how it works. This attribute can be measured by performing some tests with casual users who have not used the system for a while. The tests contain measuring the time it takes to perform a specific task (Nielsen, 1993).

Prevention and error recovery: the system must have a low percentage of errors and if they occur, it should be possible to recover them. It should also never be catastrophic, such as not allowing the user to complete the task. An error can be detected from an action that did not get the desired result (Nielsen, 1993).

User satisfaction: the system should be friendly to use therefore the user enjoy working with it. A consistent way to measure satisfaction is through surveys after the test sessions (Nielsen, 1993).

4.2. Principles of Usability

A major role throughout this project consists of understanding that the system has to adapt to the user and not the other way around. Hence the importance of the principles for the design of user interfaces (Mandel, 1997).

There are several theories and principles for the design of user interfaces, which provides a guide to help designers during the development of the project. The following represents a list of general principles defined by Deborah Mayhew (Mayhew, 1992):

1. The interface must be effective, satisfying and enjoyable to use.
2. There should be a compatibility with the users since not all the users are equal.
3. Has to ensure compatibility with previous product versions otherwise the user would have to learn everything again.
4. The system must be organized by type of task and not by type of data. A particular task may involve the use of different types of data which complicates the performance of the user.
5. The system should facilitate the transition between different tasks in a simple manner.
6. The system should contain consistency. The consistency throughout the interface makes the user be able to perform various tasks. The user should not have to learn new things to perform a familiar task.
7. The user's knowledge should be incorporated in the interface, in order to facilitate their use and learning. The use of concepts and techniques that the user understands allows a quick start and immediate progress.
8. It is necessary to maintain a simple and straightforward interface that users benefit from its functionality. A poorly organized interface with several functionalities can distract the users, therefore the basic functions should appear immediately and the more advanced should be less obvious to the user.

9. The interface should have direct manipulation in which the user takes action directly on the visible objects.
10. The system should allow the users have control of the tool in order to prevent them to feel manipulated by the system.
11. WYSIWYG stands for “What You See Is What You Get”. What the user sees on the screen is equivalent to the final output.
12. The interface must have flexibility between the users. The interfaces are flexible if they are able to cover a wide range of users.
13. The system should always respond immediately to the user’s request. If the response time is high, the user might think that the application crashed.
14. The user should know as little as possible about the technical details of the system. What happens within the system should be invisible to the user.
15. The system must be able to tolerate common human errors. A system that is very sensitive to errors quickly discourages users to explore the system any further.
16. The system should not allow any catastrophic result made by human error.
17. The system must be easy to learn for the beginners and easy to use for the experienced.

During the development of this project, these principles were considered but it wasn’t easy to apply all of them because to obtain a desired result with a principle we may be jeopardizing another principle.

4.3. Basics for Designing Interfaces

The objective of defining the components of an interface will ensure consistency and simplicity. The interfaces should be appealing to all types of users, therefore it will be easy for them to learn and interact with the system. The first thing that users notice on websites is their design, for example, the colors, the font of the text and the images. The interface of the application is the main point of contact between the user and the platform. Once the user considers the website attractive, they will start to use it.

When developing an application it’s fundamental to consider the styles of interaction. The styles of interaction refer to all the ways the user can communicate or interact with the

system (Hix & Hartson, 1993). These styles are one of the main components of a user's interface because through these styles the user will be able to interact with the system to perform tasks.

Aaron Marcus (Marcus, 1997) provides some guidelines for the design of a GUI (Graphical User Interface). Below summarizes a list of guidelines:

1. The interface should be organized so users can understand it and be able to navigate through it.
2. The interface should have consistency, in other words, all the elements from the interface should have the same rules. It should only be inconsistent if this is beneficial to the user.
3. The interface must understand the expectations and experience of the user, rather than forcing the user to understand new tasks and techniques. This makes it more intuitive and easy to learn.
4. The design of the layout should be consistent.
5. The user must recognize the difference between the main and the secondary items, in other words, the hierarchy of elements should be visually clear.
6. The interface should include the essential elements to communicate with the user. The elements should be given emphasis and be distinguishable.
7. The characters, symbols and graphics should be clear and distinguishable to have a good communication with the user.
8. The icons and symbols help with complex communications and make the interface more appealing.
9. The color is the most powerful communication tool because it can emphasize important information to increase its understanding. It also improves the appearance of the interface.

The design of the interface explained above is essential, but there are some components that make an interface functional. The components that will be discussed in this section are the menus and forms that are implemented on the application.

A menu is a list of options in which the user selects the desired option. It should be easy to use and the names on the menu should be easy to understand. It has an advantage that the

user doesn't have to remember the names but just recognizing it (Shneiderman, Plaisant, Cohen, & Jacobs, 2009).

The main objective of a menu is to be understandable, easy to use and remember, and structured in a manner to perform the tasks. Shneiderman says "The key to the design of the structure of a menu is to first consider the objects and actions of the task" (Shneiderman, et al., 2009).

To have an efficient menu, it needs to have a good response time and visibility (display). The response time is the time that the system takes to respond to a user's request and the time of display is the velocity to display the menu. It is recommended to have a short response time and a quick speed to view the menu.

The main menu that is implemented in this project uses a pull-down menu. Besides being a popular menu used in web applications, it was also used to help users navigate faster throughout the application. Figure 10 demonstrates the main menu used in the application developed throughout this project.

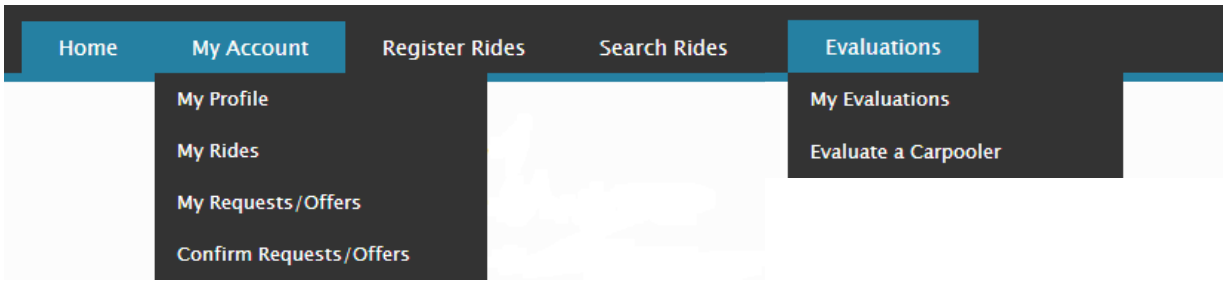


Figure 10 - Main menu of the application

As we saw earlier, the menus are an effective choice when the goal is to select items. However, if it is necessary to introduce some data, the most appropriate option is to use forms (Shneiderman, et al., 2009).

According to Cooper, the forms are independents but in terms of behavior they are identical to dialog boxes, which means that the user needs to provide information but it's also required to make an action. It is easy for the users to understand how to fill out a form online since it is similar to a form on paper. Therefore it gives the user a feeling of control because all the information is visible (Cooper, 1995).

To have an efficient form, it is necessary to define the type of data that needs to be inserted. For example, if the text field only accepts numbers, there should be given that indication to the user. An advantage of filling out a form is that a large amount of data can be filled in a single screen. But a disadvantage can be the user's ability to write. For example, if the users don't have much experience in writing or using a computer it will become slower to fill out a form. Figure 11 demonstrates an example of a form that is implemented in this project.

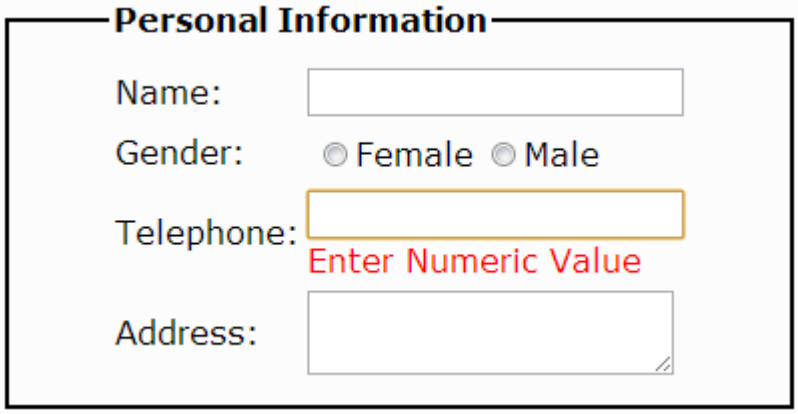


Figure 11 - Form in the application

From the point of view of the design of forms, it is necessary to take into account some aspects in order to maximize their benefits. The aspects may seem obvious but often we encounter forms that break some of these rules (Shneiderman, et al., 2009):

- The forms must have a clear title.
- The fields must be grouped logically and the fields that are related must be aligned together.
- The visual format should be uniform and not all clustered together. A good alignment of fields facilitates the users to understand the form.
- The names of the fields should be simple.
- It should be minimized the incorrect values introduced. For example, if a field requires a number it should not be possible to enter a letter.
- If the user enters a wrong value into the form, an error message should indicate clearly what should be the proper format.

- The optional fields must be clearly highlighted and should preferably be below the required fields.

4.4. Heuristic Evaluation

To develop a project that is concentrated on the users involves a series of methodologies that guarantees a functional system. The usability tests are a set of techniques that ensures that the project is concentrated on the users (Rubin, 1994). Ideally, the usability evaluation of a system should be monitored throughout the whole lifecycle of the project and the results should improve the following modifications.

Dix defines a few objectives of this evaluation (Dix, Finlay, Abowd, & Beale, 1998):

- Guarantees the functionality of the entire system according to the pre-defined tasks;
- Guarantees the effect that has on the user's interface (easy to learn and use);
- Identifies any problems that exist in the system.

In this section will be discussed a technique that evaluates usability which is called "heuristic evaluation". The heuristic evaluation aims to evaluate the usability and the efficiency of the user interface.

According to Jakob Nielsen, the heuristic evaluation contains (Nielsen & Mack, 1994):

1. **Simple and natural dialogues:** It must show only the information that the user needs at the moment. The dialogues should not contain any irrelevant information.
2. **Speaking the language of the users:** The terms that are used must be adapted to the user, avoiding the use of technical terms.
3. **Minimize memorizing in favor of recognition:** The user should not have to remember anything to perform an action and the instructions to use the system should be visible or easily accessible.
4. **Consistency and standards:** The users should not have to wonder whether different words, situations or actions represent the same thing. These items should always be available at the same location and their results should be the same.

5. **Feedback or visibility of the system status:** The system should keep the user informed of all the ongoing activities through appropriate feedback and within an acceptable time period.
6. **Clearly mark the outputs:** The user must control the system and can abort any task when you want.
7. **Shortcut keys:** Shortcuts are necessary for the more experienced users to perform operations more quickly.
8. **Good error messages:** Error messages should be expressed in plain language (no code), indicating the problem and constructively suggesting a solution.
9. **Error Prevention:** It is preferable that the system has mechanisms to prevent errors, instead of a well-structured set of error messages.
10. **Help and documentation:** All the help information and documentation should be easily searchable and focused on the user's tasks, listing the specific steps to perform without being too extensive.

5. Types of Web-based Mapping Service

Often when we go somewhere for the first time we are undecided about which path to take or even what will be the distance and how long it will take. A good service to solve this out is using a web-based mapping service. This service searches for the perfect restaurant, checks out the best hotels, finds the nearest bank and much more. On the internet there are a series of mapping services available for us to choose, such as, Google Maps, Bing Maps and Yahoo Maps. Below will describe each of these mapping services, including their design and features. For this project, the mapping service that will be implemented is Google Maps API v3.

5.1. Google Maps

Google Maps is a user-friendly web mapping service application with detailed street and aerial imagery data embedded and this application is free with no charge. It offers street maps, a route planner for traveling by foot, car, bike or public transport and an urban business locator for numerous countries around the world. We can search and find addresses, streets and tourist sights through the maps. The satellite images in Google Maps are not updated in real time. It can be images of months or even years (Susan Dunnavant, 2010).

Google Maps is a free product and requires no installation or management. However, this product has a programmer's API that will need some programming expertise. Specifically, the person will need to have skills in JavaScript and possibly another Internet programming language such as PHP or ASP.NET. Google provides documentation of the classes, methods and events for Google Maps as well as code examples to help to get started (Consulting, 2006).

Google Maps is implemented with heavy use of JavaScript, this leads to the transitions feeling a lot less smooth when zooming. As the user drags the map, the grid squares are downloaded from the server and inserted into the page. When a user searches for a

location, the results are downloaded in the background into the side panel and map. In this case, the page is not reloaded. Locations are drawn dynamically by positioning a red pin on top of the map (Maurizio Gibin, 2008).

The Google Maps API helps the user to embed Google Maps directly to their website, customizing the look to fit with the style of the website (Google, 2009). A hidden iFrame with form submission is used because it preserves browser history. The site also uses JSON for data transfer rather than XML, for performance reasons (Maurizio Gibin, 2008).

Google Maps got promoted to version 3 (v3) around May 2010 which came with many changes. A big change is the fact that v3 does not require any API key to use Google Maps. Some of the functionality found in the previous API version 2 has been removed or changed to better (Kataria, 2009).

Google Maps can be embedded in websites using JavaScript, providing a number of utilities for manipulating maps and adding content to the map. Version 3 is especially designed to be faster and more applicable to mobile devices (e.g. Android and iPhone) (Kataria, 2009).

With Google Maps, people can search for various things, such as, cities, streets, building, business locations and contact information all in one location, integrated on the map. The more and detailed information that is given, the more complete and specific will be the results of the research. Google Maps also offers the ability to create routes between addresses and to save these routes it's necessary to have a Google account. But to print or send a map to someone it is not necessary to have a Google account.

To create a route, it is necessary to identify which are the addresses of the origin and destination. There is the possibility to choose the transportation of the route. Google Maps has four types of transportation: driving, walking, cycling and public transportation. After introducing the addresses of the route, Google Maps displays the directions step-by-step to get to the destination and demonstrates the distance and time it takes to move between the origin and destination. Figure 12 illustrates an example of creating a route with its directions.

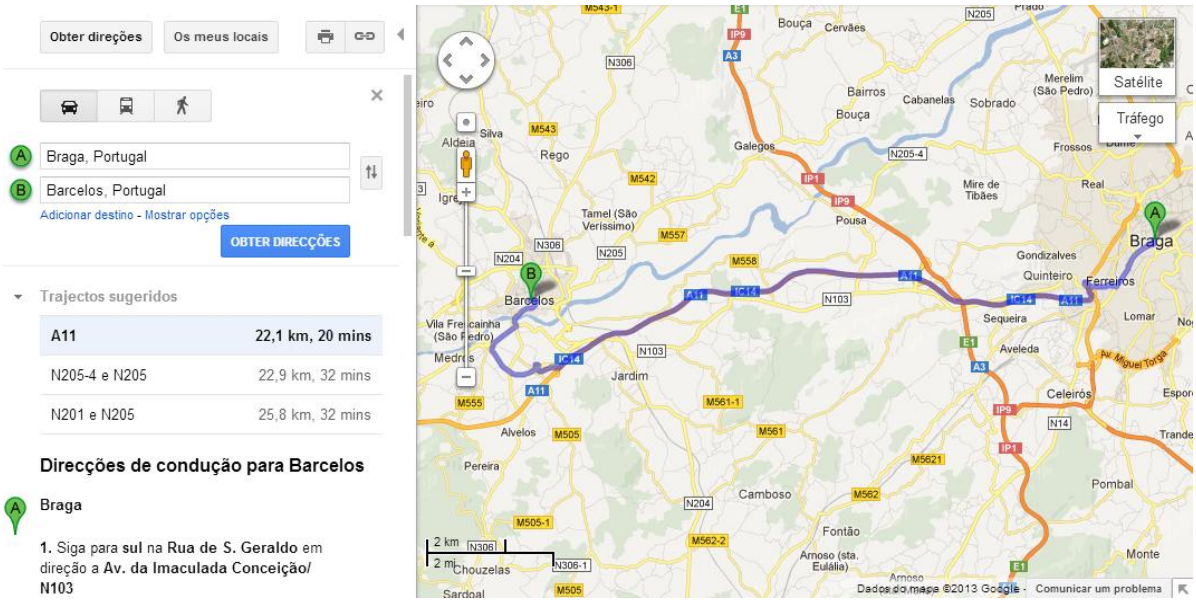


Figure 12 - Creating route on Google Maps

Google Maps also allows us to get directions between two geographical locations by car called route planner. It gives the directions of the location and also on the map it has the traces to make it easier to visualize. In figure 12 illustrates an example of this. One great benefit of this is that it calculates an estimated price of the gasoline that will be wasted.

In some cities people can get information about local traffic. It's possible to get it in real time and it displays by color the speed of the traffic between slow to fast. Green indicates slow traffic while red indicates traffic jams. Figure 13 illustrates an example of the traffic information but also indicates some icons about the roads, for example, some roads are closed and some roads only have one lane working due to construction work.

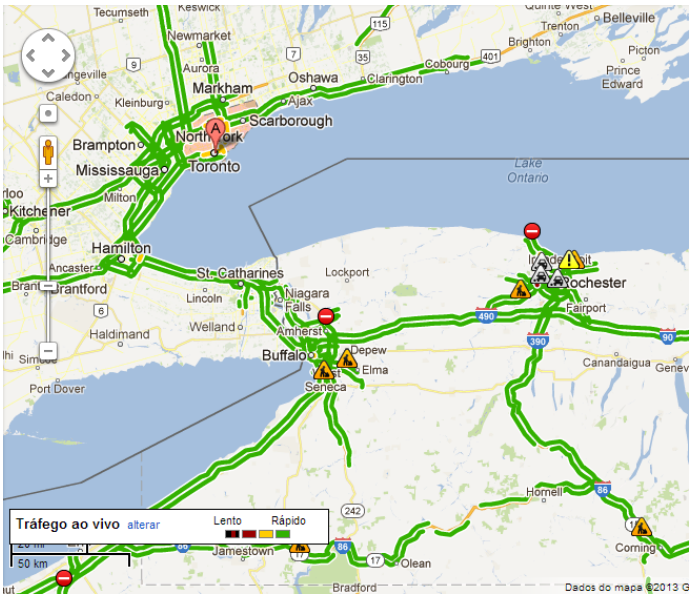


Figure 13 - Traffic information on Google Maps

On Google Maps there are three types of viewing modes: Map, Satellite and Terrain. The Map mode displays the streets in the form of a common map with the most important roads appearing in yellow. The Terrain mode displays only land and this type of view is interesting for a better view of neighborhoods, cities, etc. The Satellite mode displays pictures taken by satellite. This mode is the most interesting way for those who want to see pictures of places around the world. Figure 14 illustrates a comparison of the types of viewing modes Map, Satellite and Terrain, respectively.



Figure 14 - Difference between Map, Satellite and Terrain

In May 2007, Google Street View was launched with the intention of allowing people to see the world with three-dimensional images but unfortunately it's not available in some countries. All you need to do is click and drag the yellow puppet over anywhere on the map and if some parts of the map are blue indicates that Google Street View is available for those areas. The yellow puppet, also known as Pegman, sits above the zoom bar on the left side of the map. A feature of Street View allows visualizing images from Panoramio that has been taken from users (Consulting, 2006).

Google Maps provides a function to interact with a map through the use of map controls which allows the user to pan and zoom in or out. Panning simply gives the user the ability to move the map in any directions by dragging it. Panning is performed another way by using the map control simply clicking on the directional arrows. Another feature of the map control is the zoom, allowing the user to zoom in and out on the map getting a better view.

Other features on Google Maps are the markers and InfoWindows. The marker is a small icon that is positioned at a specific place on the map. Whenever a marker is clicked, an InfoWindow is opened and it displays the details of that marker. Figure 15 illustrates an example of an InfoWindow of IPCA. Once the marker has been clicked, the InfoWindow opens with the details of IPCA. On this InfoWindow it shows the address and website of IPCA, also another option to get directions.



Figure 15 - InfoWindow on Google Maps

5.2. Bing Maps

Bing maps is a popular mapping website provided by Microsoft, offering street-level maps of a number of cities worldwide, road maps of the world, door-to-door travel directions, aerial photographs with map overlay and Bird's Eye imagery (Service, 2010).

Bing maps use Silverlight to give much smoother loading experience and gives interactive features such as Flickr and Photosynth inside the platform. Bing maps automatically changes the style of map as you zoom in and out to give the best map style. When Bing maps zooms into the images, it change to Bird's Eye view and it's easier to understand (Doyle, 2010).

Bing maps features Flickr integration, grabbing geo-tagged photos from Flickr, then relating them to the Streetside imagery. This allows the layering of historical imagery on top of the street imagery, so people can go back in time and see a location as it existed decades ago. The satellite image resolution is higher and sharper on Bing maps (Doyle, 2010).

All the main features of Bing maps appears on the left hand bar, allowing the users to connect whatever they want without searching for it. On the left hand bar appear features such as: getting directions, viewing traffic, viewing businesses, etc. Bing maps also have a shop with many applications to install and they can be personalized. Bing doesn't put any ads into its maps, giving only the information that the user is looking for. But the main disadvantage of Bing maps is having no other language other than English (Adler, 2010).

There exist five types of street map views: road view, aerial view, bird's eye view, streetside view and 3D view. Road view is the default map view that displays imagery of roads, buildings, etc. Aerial view overlays satellite imagery onto the map and highlights roads and major landmarks for easy identification amongst the satellite images. Bird's-eye view displays aerial imagery captured from low-flying aircraft. Unlike the top-down aerial view captured by satellite, Bird's-eye images are taken at an oblique, 45-degree angle, which gives the user better perception for buildings and geography. Streetside provides panoramic (360 degree) imagery of street-level scenes taken from special cameras mounted on moving vehicles. The 3D maps lets the users see buildings in 3D, with the ability to rotate and tilt the angle in addition to panning and zooming. To view the 3D maps, users must install a plugin, then enable the "3D" option on Bing Maps (Energy, 2010). Figure 16 illustrates a

comparison of the types of viewing modes: road view, aerial view, bird's eye and streetside, respectively (Adler, 2010).



Figure 16 - Difference between Road, Aerial, Bird's Eye and Streetside

Bing maps allow developers to create maps on their websites but there aren't a lot of examples to follow. They contain a lot of documentation but not enough examples to help them create maps. Besides creating maps, the users can also share maps by simply clicking the envelope icon on the top right corner of Bing maps. A window will open that displays a shareable URL so others can access the map. This window also provides HTML code to embed the map to any web page (Adler, 2010).

To create a route on Bing maps, it is similar with any web mapping service. The user needs to identify the addresses of the origin and destination. Once a route is created the map shows that route from point A to B. Along with the map, it also has the directions of the route including the distance and time it will take. To create a route on Bing maps it is possible by three types of transportation: driving, walking and public transit. The user can save the routes by using their Windows Live account. The main disadvantage when creating a route or searching for an address is that Bing doesn't have autocomplete, which means when a user starts typing an address Bing doesn't show any address related to what is typed, which is complicated when a user doesn't know how to spell a city or country. Figure 17 demonstrates an example to create a route on Bing maps (Adler, 2010).

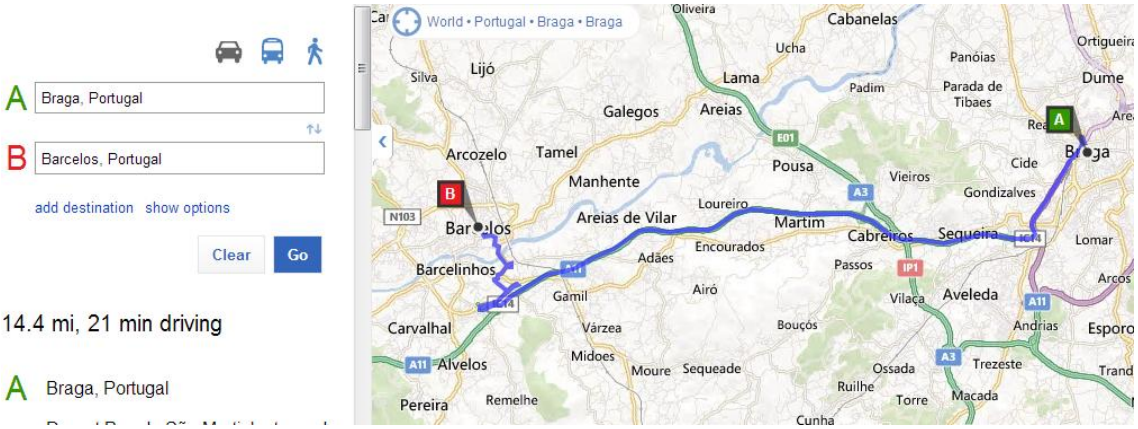


Figure 17 - Creating route on Bing Maps

Bing Maps shows the current traffic information for major highways and roads. The feature uses four color codes (red, orange, yellow, green) to indicate traffic volume, from heaviest traffic to lightest traffic. Figure 18 illustrates an example of the traffic information.



Figure 18 - Traffic information on Bing Maps

Bing Maps provides a function to interact with a map through the use of map controls which allows the user to pan and zoom in or out. This function is located on the top right corner of the map.

The feature of InfoWindow for Bing Maps is much simpler than Google Maps. The InfoWindow doesn't show the complete address of the marker but it still has the option to get directions for that location. Figure 19 illustrates an image of how an InfoWindow appears on Bing maps (Adler, 2010).

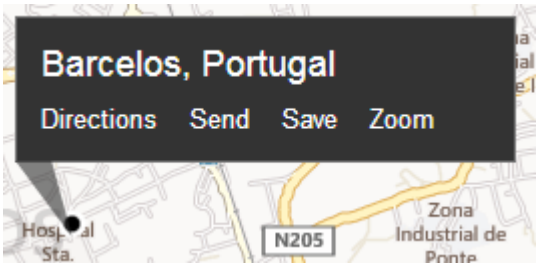


Figure 19 - InfoWindow on Bing Maps

5.3. Yahoo Maps

Yahoo maps are a free online mapping service provided by Yahoo. Yahoo map provides interactive maps with zooming, real time traffic conditions, and accident reports, together

with integrated driving directions. In 2007, Yahoo released a new map style designed by the cartography company Cartifact. It enhanced its offering with a new display format, customizable printed directions and driving directions. The mapping service use AJAX (Asynchronous JavaScript and XML) that allows a more flexible and interactive mapping service (Chiang, 2010).

The interface is nice and tidy, with no excessive advertisements to slow the user down. The map takes up a majority of the space, with a few menus and buttons placed directly on top. There also exists Yahoo Maps API that helps the user to embed Yahoo Maps directly to their website, customizing the look to fit with the style of their website. The maps on Yahoo can be linked, sent by email or printed directly from the Yahoo website.

Yahoo maps has a quite appealing and modern look, it has some functions like obtaining the directions from point A to point B. The rest is quite the same, the basic functions are similar. There's this one interesting function called "Real-Time Traffic". It shows how the traffic is on the route the user chooses. Figure 20 demonstrates an example of how the traffic shows on Yahoo maps (Chiang, 2010).

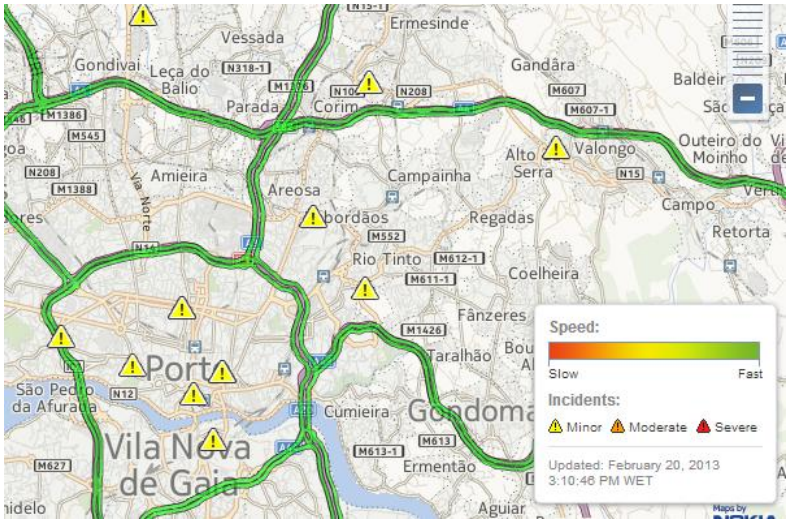


Figure 20 - Traffic information on Yahoo Maps

Users can search for destinations anywhere in the world. The user must enter a location name, address or zip code to get started. Additional tabs are available for users who are searching for a specific business or want to get directions. Like any web mapping service,

Yahoo maps allow the user to create routes. The user needs to identify the addresses for the origin and destination to create a route. When typing the address there is no autocomplete but the only options that appears is the history of what has been searched in the past. Once a route is created, the page displays step-by-step directions from point A to B including the distance and time the route takes. A disadvantage of Yahoo maps compared to the other web mapping services discussed in this thesis, is the fact there is no transportation mode, for example, the user can't choose if would like to drive, walk or public transit when creating a route. Figure 21 illustrates an example of creating routes on Yahoo maps (Chiang, 2010).



Figure 21 - Creating route on Google Maps

Yahoo Maps provides three viewing alternatives: map, hybrid and satellite. Map view can be seen by any general user who wants to search for a specific location. Hybrid view can be seen by the persons who want to see the places in a labeled form and satellite view gives a broader view of any desired location taken by satellite. Figure 22 demonstrates the difference between the three types of maps: map, hybrid and satellite, respectively (Li & Gong, 2010).



Figure 22 - Difference between Map, Hybrid and Satellite

Like any web mapping service, Yahoo maps provide map controls which allow the users to zoom in and out. This function is located on the top right corner of the map.

The InfoWindow doesn't show the complete address of the marker but it still has the option to get directions for that location. The InfoWindow also has the ability to locate nearby places from the marker. Figure 23 illustrates an image of how an InfoWindow displays on Bing maps (Li & Gong, 2010).



Figure 23 - InfoWindow on Yahoo Maps

5.4. Comparison of Web Map Services

Table 2 demonstrates a comparison of the web mapping services mentioned above. The mapping service chosen for this project is Google Maps. This mapping service was chosen to be implemented for this project due to its API being more advanced and has a lot of documentation to help with the programming. Another reason why this mapping service was chosen is the fact that there exist autocomplete when searching for addresses. In other

words, when searching for an address it automatically gives suggestions of what is written. This feature only exists on Google Maps and was used several times during this project.

	Google Maps	Yahoo Maps	Bing Maps
Autocomplete when searching	Yes	No	No
Map Types	Map, Satellite, Terrain, Streetview	Map, Satellite, Hybrid	Road, Aerial, Bird's Eye, Streetside, 3D
Weather	Yes	No	No
Age of Satellite Imagery	1-3 years old	4-5 years old	1-3 years old
Directions	Yes	Yes	Yes
Reverse Directions	Yes	Yes	Yes
Public Transport Integration	Yes	No	Yes
Walking Directions	Yes	No	Yes
Bicycle Directions	Yes	No	No
Send to Device	Yes, via Email	Yes, via Email, SMS	Yes, via Email, SMS
Live Traffic Information	Yes	Yes	Yes
Save Maps	Yes	Yes	Yes
Print Maps	Yes	Yes	Yes
Create/Send hyperlinks	Yes	Yes	Yes
Embed HTML iframe link	Yes	No	Yes
API Available	Yes	Yes – JavaScript and Flash	Yes – JavaScript and Silverlight

Table 2 - Comparison of Web Mapping Services

6. Conceptualization and Design

In this chapter, will be discussed the requirements and the design of the project. This chapter will mention two types of requirements: functional and non-functional. Functional requirements provide the user an idea of how the system works and behaves in a particular situation. Non-functional requirements are constraints of functions offered by the system. In additional, this chapter will also discuss about the design of the project. First, this chapter will explain the architecture, following with the database of the project. Finally, at the end of the chapter, will be discussed the Use Case model, providing a description of the actors and use cases, as well as the sequence diagram.

6.1. Project Requirements

For the development of this application, it's necessary to provide requirements according to the users' needs. The requirements of the application have to fully serve the purpose for which it is created. Each functionality provided to the user should be analyzed for possible impacts, and verify the methodologies and technologies necessary for its implementation.

However, given the iterative process due to the method applied to the analysis and design of the system, it should be noted that discrepancies can occur. During the development of the application, the requirements were changed and updated numerous times, reflecting the deeper understanding of the system and the user experience made throughout the process.

Here are presented the functional and non-functional requirements, which are the functions that the system must perform. These requirements serve as a starting point for the development of the system.

6.1.1. Functional Requirements

Functional requirements provide how the system should react and behave in a particular situation. In some cases, these requirements may also state what the system should not do (Sommerville, 2011).

The developed system should have the following requirements:

- User Authentication;
- Reset the password when the user cannot log in;
- Register new users;
- View and edit user's profile details;
- View, edit and remove rides of the user;
- View and confirm requests and offers;
- Search available rides;
- Register rides;
- View user's evaluations;
- Evaluate a carpooler.

6.1.2. Non-Functional Requirements

Non-functional requirements are restrictions on the services or functions offered by the system. They include timing restrictions and restrictions on the developing process. These requirements often apply to the system as a whole rather than individual (Sommerville, 2011).

The developed system should have the following requirements:

- The system must be easy to use, including for people with little computer knowledge;
- The layout should be simple, appealing and suitable for all types of users;
- The system should maintain a good level of performance regardless of the level of use;
- All the existing icons on the system should be appealing and provide an adequate size;

- The user should always be alerted of which fields are required. However, if the page is submitted and not all required fields have been completed the user should see which fields are missing;
- The system and software should be reliable and secure;
- The system should be fast when consulting information.

6.2. Architecture

In a Web application, the resources necessary for a proper performance are varied. It is essential that the application needs to be scalable and flexible.

The system is based on the client-server architecture, since it's intended to be accessible through the Web. As the system is based by the Web, the communication between the entities is performed over the internet. The architecture can be seen in figure 24 (Shklar & Rosen, 2003).

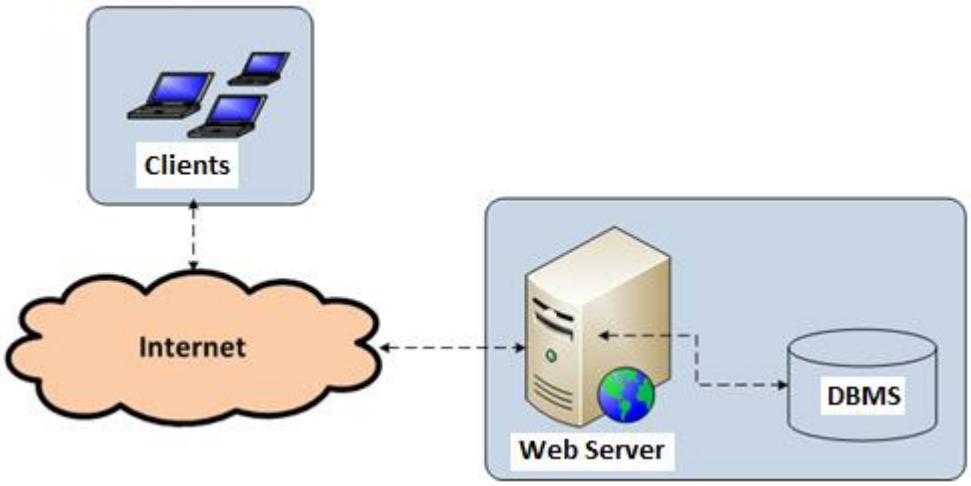


Figure 24 - Client-Server Architecture (Shklar & Rosen, 2003)

In this system, the server side is composed by two components: a Web Server and a Database Management System (DBMS). It is not mandatory that these two components be on the same machine, but to increase the performance of the application it is recommended that the Database Management System is at the same location as the Web server (Shklar & Rosen, 2003).

The Web server is responsible for processing the customer's orders and where the application will be stored. This feature will receive and process requests from the client and treat them according to schedule, in order to provide the client with all the functionality of the application. As the Web application was developed with ASP.NET, the server will send HTML responses to the client's requests. This HTML code is generated by the group of ASP.NET code and the existing data in the request (Shklar & Rosen, 2003).

The Database Management System is responsible for storing information and responding to the requests from the Web server. A database following a traditional relational model is the best option for storing various data and relationships between them (Ziemer, 2002).

Since the application was developed in ASP. NET, the client is a Web browser. The client requests a page to be displayed by sending a request to the server with all the necessary data. The result of this request, as already mentioned, comes in by HTML code, which will generate the requested page in a browser (Ziemer, 2002).

6.3. Tools used during the Development

This application was designed to be used on a Windows platform. For the development of this project were used the following Microsoft development tools:

- Microsoft SQL Server 2008 – To manage the database;
- Microsoft Office Visio 2008 – To design the UML diagrams;
- Visual Studio 2010 (ASP.NET) – To develop the application.

These tools were used to develop the system due to having more experience with these tools and works well with the integration of Google Maps.

6.4. Use Case Diagram

Following the requirements analysed in section 6.1, it was possible to identify a set of use cases that satisfy them. Through graphical diagrams it's easier to visualize the ideas and solutions for the project (Tacla, 2008).

The Unified Modeling Language (UML) is the most common language used for specification and software design. UML is the tool that allows modeling the software, helping software engineers to define the characteristics of the software, such as its requirements and its behavior on which the system should be implemented (Guedes, 2006).

The conceptualization and development of a system is a task that involves several people and goes through many adaptations and updates. If it does not perform a detailed description of all the features and the steps that must be performed, people will not understand the system's functionality (Guedes, 2006).

In this section, the diagram implemented by UML is the use case diagram. The basic elements of a use case diagram are: actors, use cases and relations among them.

Use cases are used in the analysis phase of a project to identify the system's functionality. They separate the system into actors and use cases. Actors may be people, other computers or other software systems. Use cases describe the behavior of the system. This diagram is known for being extremely simple and therefore easy to understand (Tacla, 2008).

In the "General Overview" section will present the use case diagram representing the actors and the use cases. The following sections will describe the actors and the use cases.

6.4.1. General Overview

The Use Case diagram presents a simple and understandable language so that the user can have a general idea of how the system will perform. The diagram identifies the actors (users or other software/hardware that interact with the system) who will use the software in any way, as well as the services (Guedes, 2006).

Figure 25 illustrates the Use Case diagram for a better description of the entire system.

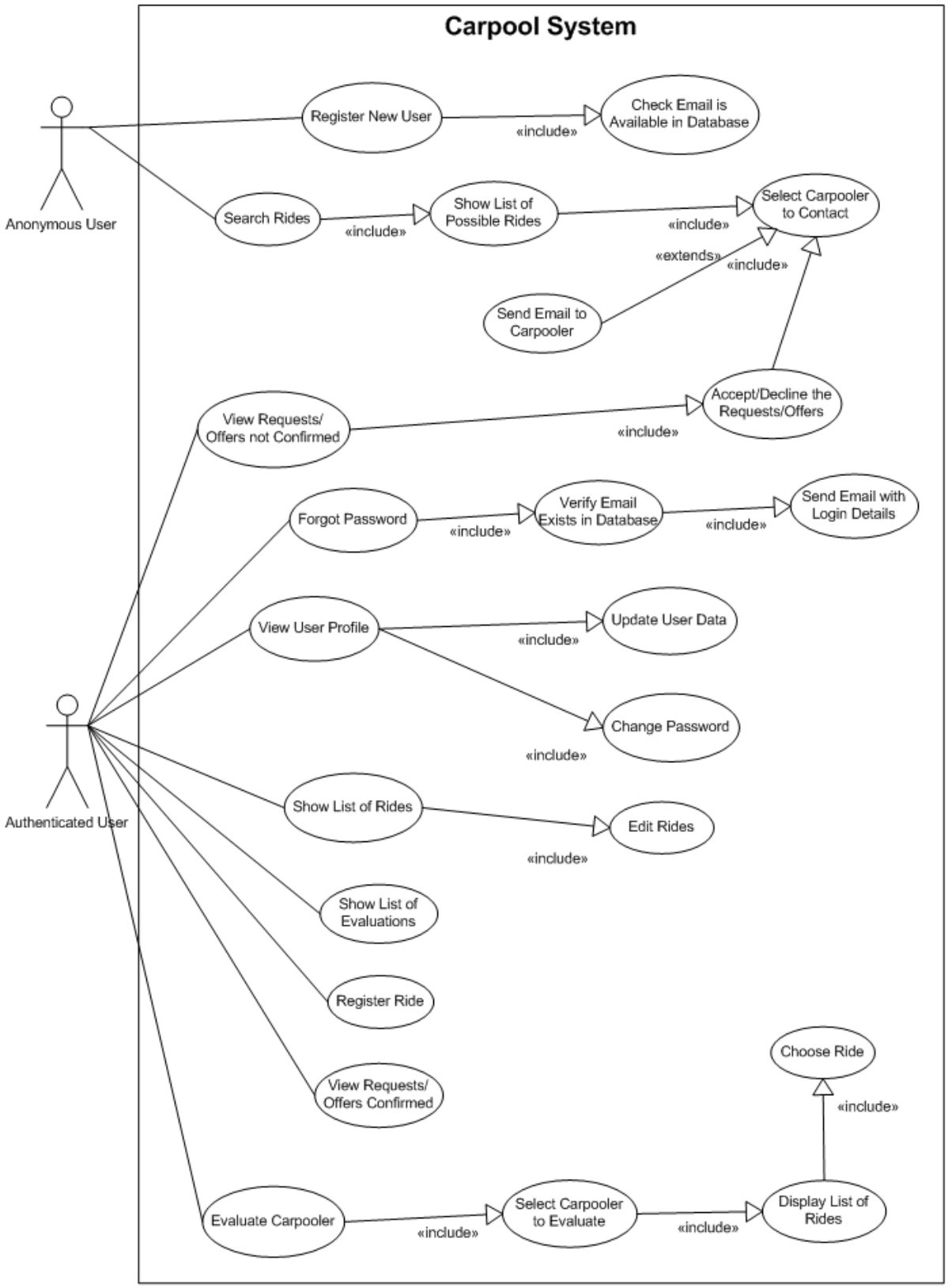


Figure 25 - Use Case Diagram

6.4.2. Description of the Actores and Use Cases

The actors are external entities (people or mechanisms) that the system does not control and that stimulate or influence the operation of the system (Guedes, 2006).

In this project there exist two types of actors: authenticated and anonymous user. The difference between these actors is the type of content they have access. Initially, the user is anonymous until they register with the system. Once the user is authenticated, they can access all the content on the application.

In appendix II will be presented a detailed description of the various use cases shown on Figure 25.

6.5. Sequence Diagram

A sequence diagram describes how objects interact within a system. It also displays a sequence of messages exchanged between the various objects in a given period of time (Nunes & O´Neill, 2004).

Figure 26 illustrates the main interactions applied in the Web application. The first diagram represents the process to reset the password in case a user cannot log into the system. To retrieve the password, the user simply needs to know their email address and the system must verify the email address in the database.

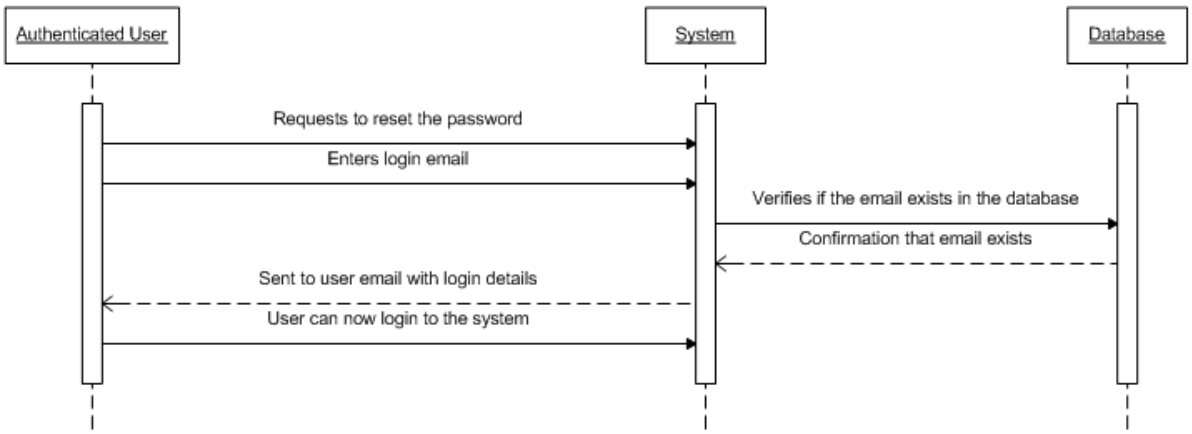


Figure 26 - Sequence Diagram: Reset Password

Figure 27 demonstrates the process to register a user. To view most of the content on the Web application, the user must be registered within the database.

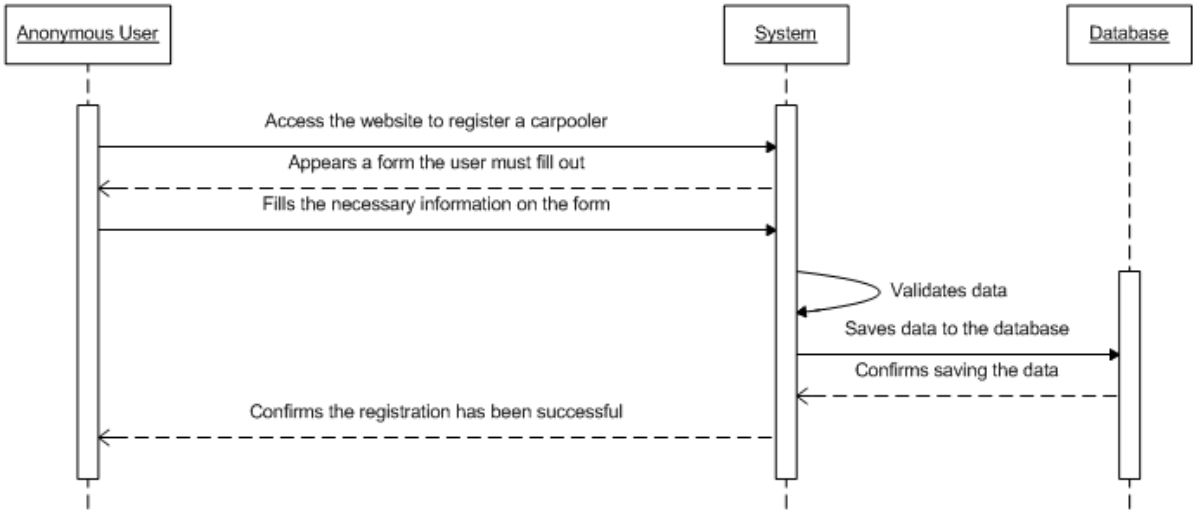


Figure 27 - Sequence Diagram: Register User

Figure 28 explains the procedure to register a ride. Only users that are already authenticated in the system can register a ride. For this step, the user must establish their departure and arrival address, as well as their schedule.

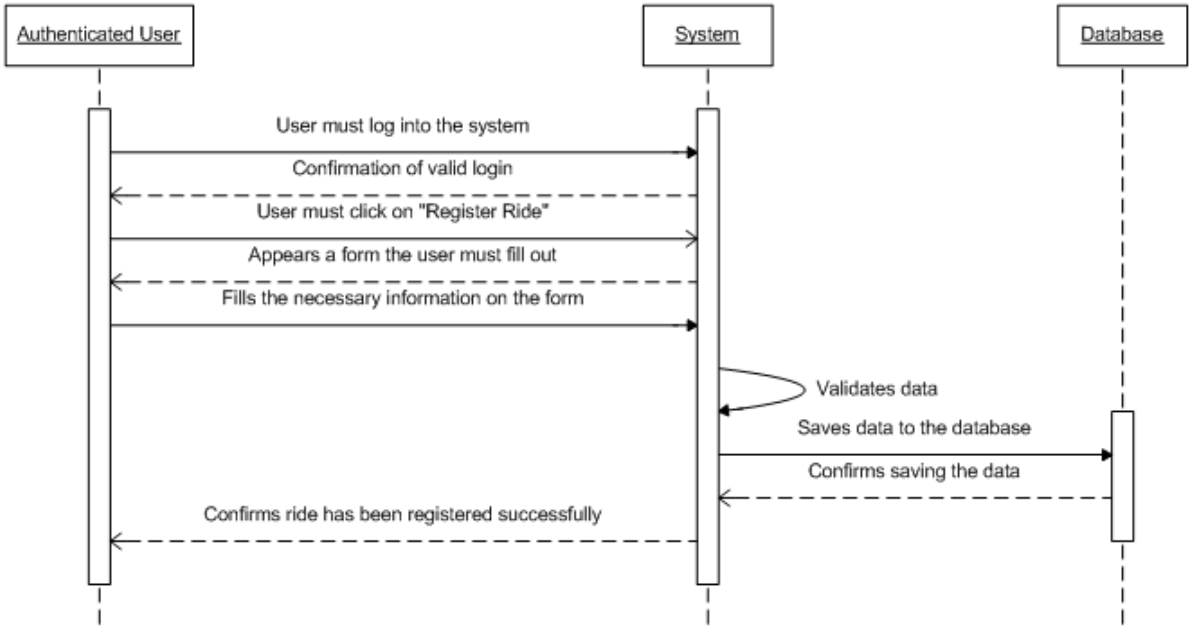


Figure 28 - Sequence Diagram: Register Ride

Figure 29 explains the process to search for a ride. The user can search for a ride based on the type of ride (offer/request) and address. When a user is interested in a ride, they can contact the carpooler by sending an email.

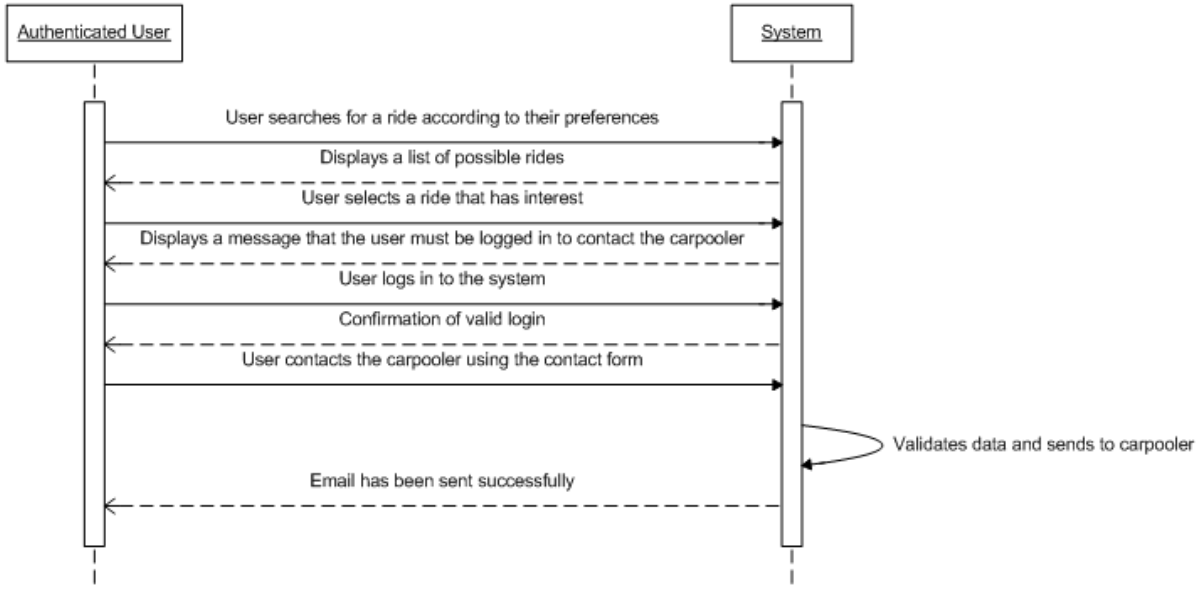


Figure 29 - Sequence Diagram: Search Rides

Figure 30 illustrates the process to evaluate a carpooler. The user must select a carpooler and which ride to evaluate. The user can evaluate the carpooler about their punctuality and friendliness.

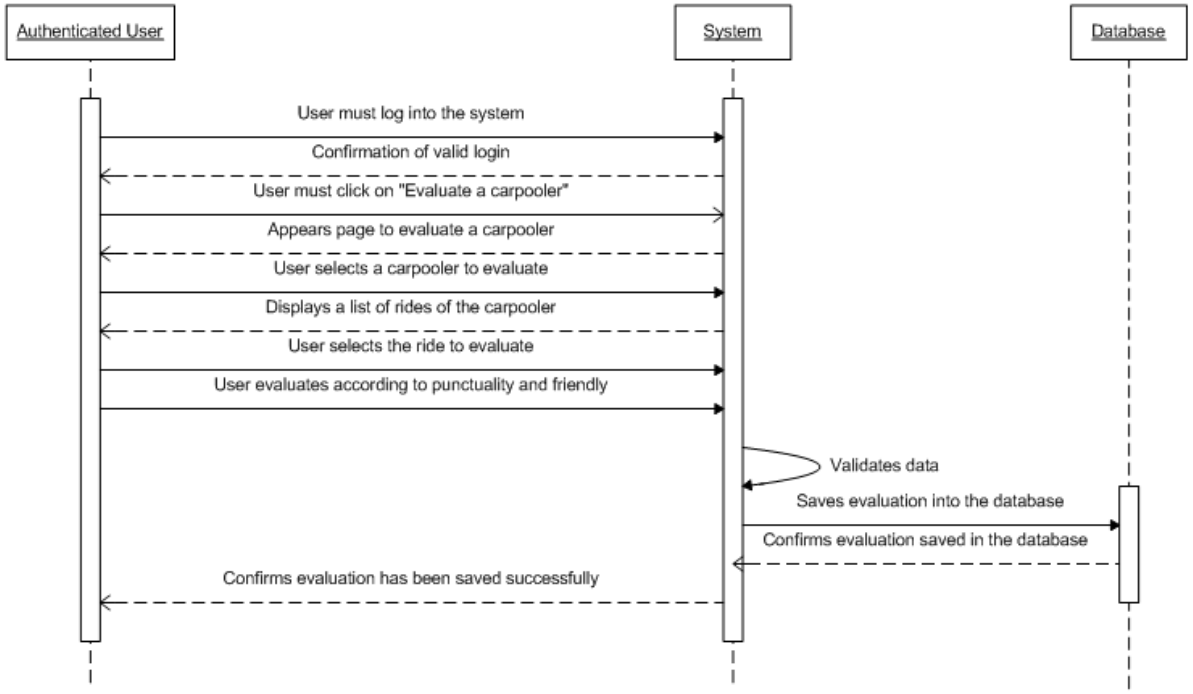


Figure 30 - Sequence Diagram: Evaluate a carpooler

Figure 31 illustrates the process to confirm a request or offer. It will appear a list of requests and offers that hasn't been confirmed yet. Once the user accepts or declines a request or offer, the carpooler will receive an email about the confirmation.

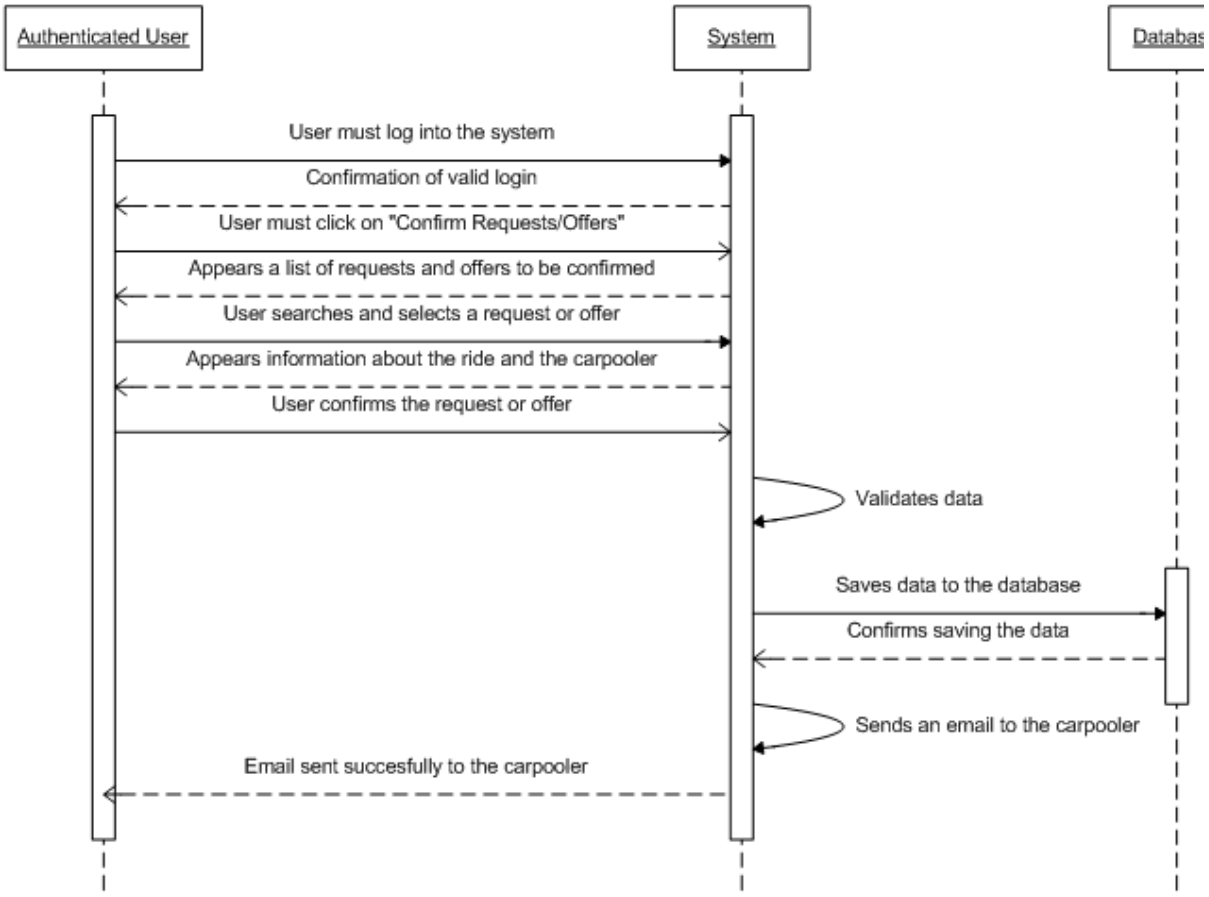


Figure 31 - Sequence Diagram: Confirm Requests/Offers

6.6. Database Diagram

In this section, demonstrates the database diagram which supports the whole operation of the Web application to improve the efficiency of our goals.

The database is an essential component, which allows the exchange of data between applications. It is important that the database has a simple architecture, a good structure and being understandable. With the database, it becomes possible to consult all data at any time.

The conception and design of the database are one of the main tasks to be performed in the implementation and development of the Web application, there will be stored all the records. There should be a particular focus on the development of the database, in order to avoid the risk of underestimating redundant information. Consequently, it is also necessary to take special care of the relationships between tables to avoid redundant connections.

All the tasks of the database are developed in Microsoft SQL Server 2008 and throughout the project have been made some changes to make the project functional. The reason that led to use this tool for the database was the fact that it guarantees quality.

6.6.1. General Overview

In order to build a secure and reliable database, it is necessary to group the necessary information into distinct tables in a careful and phased approach. Each of these entities must be characterized by a set of attributes.

The fields in each table are developed to satisfy all kinds of situations and, following this structure, will always be easy to identify the operations and associated data.

In figure 32 demonstrates the structure of the database, showing the various tables created and the attributes for each table, as well as their respective associations.

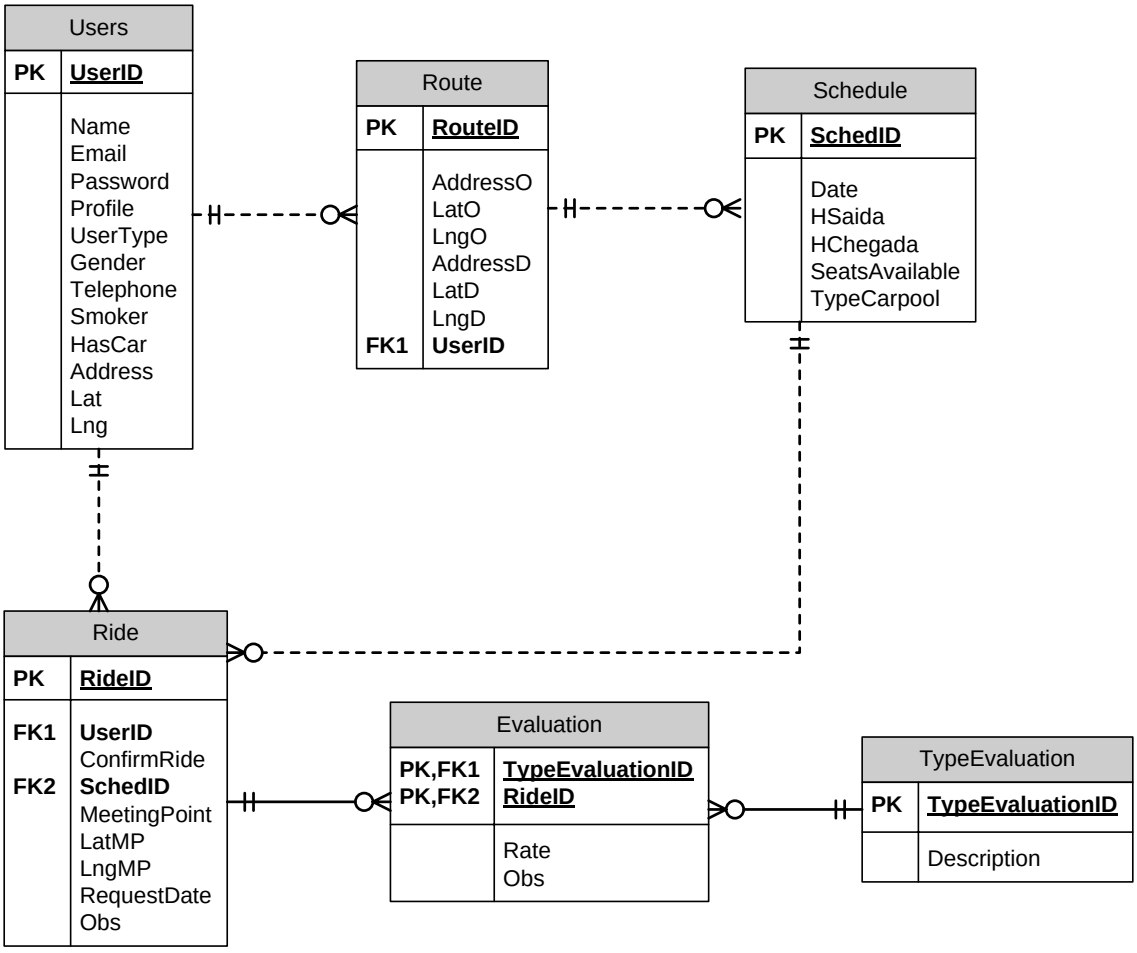


Figure 32 - Database Diagram

6.6.2. Description of the Tables

As seen in Figure 32, the diagram consists of six tables which each table has a specific function. This section will have a brief description of each table and their attributes will be found in appendix I.

Table Users: this table stores all the users of the Web application. It stores information relative to the user, such as, personal information, login details, address and some additional information.

Table Route: this table stores all the routes associated to the users. This table only stores the address of the origin and destination of the route.

Table Schedule: this table stores the schedule of the ride. The necessary information for this table is the date and time for the departure and arrival.

Table Ride: this table stores the rides of the users according to their schedule.

Table Evaluation: this table stores the evaluation of the rides.

Table TypeEvaluation: this table stores all the types of evaluations that exist in the Web application.

7. Project Implementation

This chapter describes the practical part of the project which consists on the development of the Web application. The main objective is to ensure consistency throughout the development of the application.

Before advancing to the development of the application, it is essential to know the type of users that are going to use the system as well as the tasks that are going to be performed. The following sections will describe the users and task of this project.

Initially was designed a sketch of the layout and the menus of the Web application in order to support the functions desired. During the development of this project, the design has suffered changes in order to have a better function. Below will explain the users and tasks developed for this application, as well as the structure of the application, explaining each of the components for a better understanding of its function.

7.1. User's Profile

The first phase of the project focuses on the type of users that will work with the system. Hackos says that it is necessary to study the users because they decide whether they want to use the system (Hackos & Redish, 1998). It is important to know what type of users is going to use the system and their characteristics. Authors such as Mayhew (Mayhew, 1992), Gould (Gould & Lewis, 1985), Sheniderman (Shneiderman, et al., 2009), among others, state that when understanding the characteristics of the users makes it possible to design a usable interface.

This system targets the students and teachers from a higher education institute, in which they both perform the same tasks discussed in section 7.2. The system was developed to help these students and teachers to create carpool matches. The school has a wide range of users and characteristics, therefore some factors will be discussed below.

Mayhew (Mayhew, 1992) defines the following set of factors:

- Psychological characteristics of the user (attitude, motivation);
- Knowledge or experience (academic degree, knowledge and experience of computer systems);
- Experience in the task (how often and how long to perform the task);
- Physical characteristics of the user (color vision, age).

The psychological characteristics is not a significant factor for this project, however, it is necessary to motivate the users to explore the system. In relations to knowledge and experience of the user, the academic degree allows us to determine what level of reading and vocabulary are the users. As previously mentioned, the users of the system belong to a higher education institute; therefore, they have a high level of reading and vocabulary. Since these users belong to a higher education institute, it is assumed that they have a high level of computer skills. However, if some users don't have a lot of knowledge with computers, the system was developed for any types of users even those with low level of computer skills.

Initially, the users will not be experienced using the system, but throughout testing it they will become more experienced in accomplishing certain tasks. Another interesting factor is the physical characteristics of the users, in which the color vision is an important component that cannot be ignored. Some people might have a better color vision than others, that's why it is essential to have an attractive interface.

7.2. Tasks

After defining the profile of the users, it is essential to identify the various tasks that are embedded in the application. Dix defines task analysis as a process that analyzes how the users perform: the things they do, the things on which they act and the things they need to know (Dix, et al., 1998). This analyzes will have a clear understanding of what the system should do. In the following will mention some of the main tasks the users will perform.

7.2.1. Register Rides

One important task in this system is to register a ride. The users can register a ride by filling out a form as shown in figure 33. But before registering a ride, it's best to search for a compatible ride. Once a ride is registered, the carpoolers can view them making it easier to create matches. Figure 33 illustrates the page to register a ride.

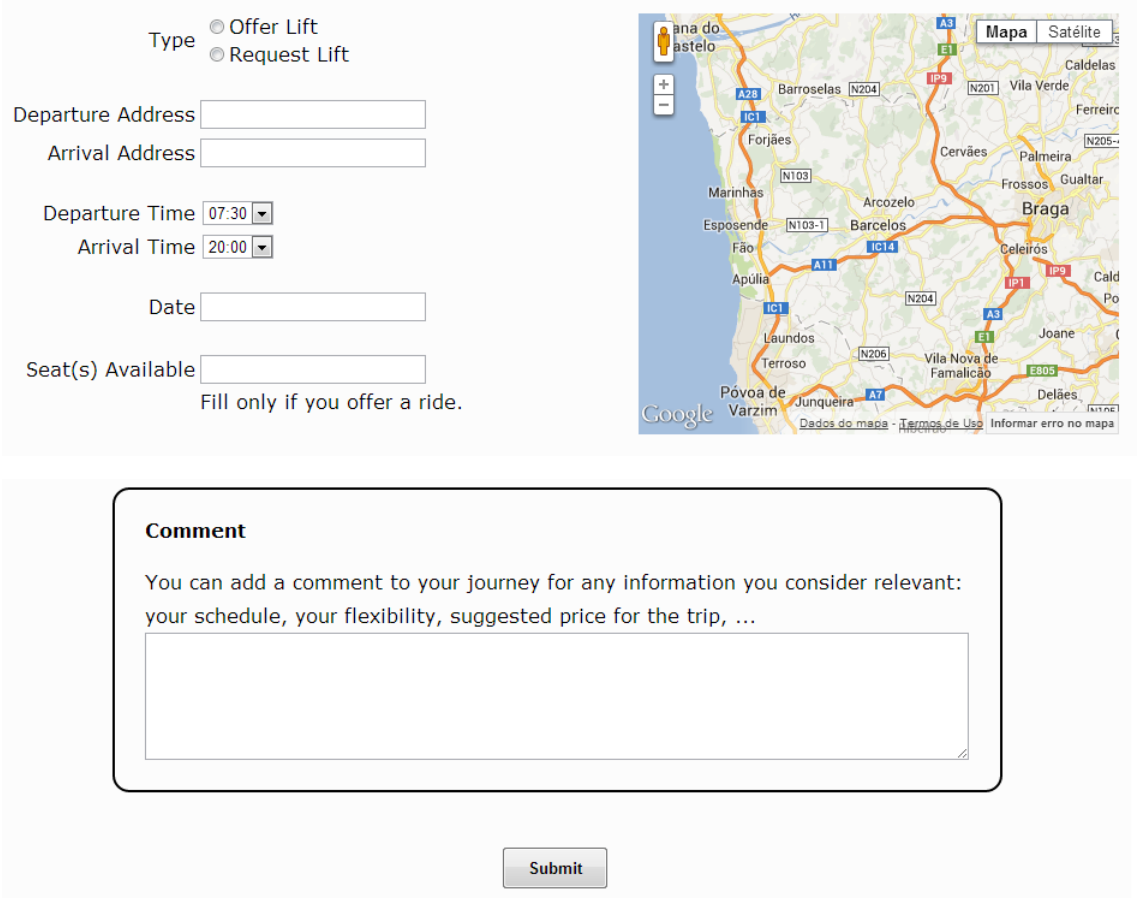
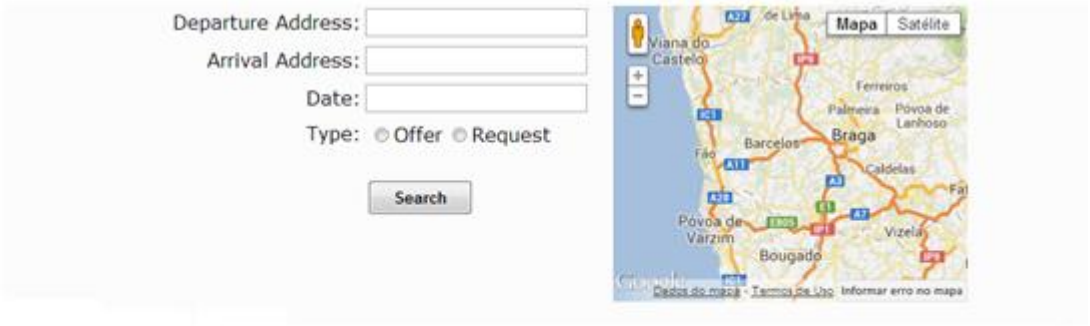


Figure 33 - Register Rides

7.2.2. Search Rides

This system doesn't automatically create matches; therefore the users need to search for compatible matches. The users don't need to be logged in to search for rides. However, if the user intends to contact a carpooler, they need to be logged in. To search for a ride, the user needs to fill out a small form, as shown in figure 34, indicating the departure and arrival address as well as the date of the ride. The type of the ride should also be selected so the search can be reduced.

The results of the search correspond to what is filled out in the form. The only field mandatory is the type of ride (offer/request) because it's the first option that the user knows for certain. The remaining information can be filled out depending on what the user is searching for. For example, if the user wants to go to a specific destination or origin, they simply need to put that information in the form. Therefore, it's not necessary that the commuters share their ride for the whole journey. The more information that's in the form, the more accurate are the results. In relation to the travel costs, the commuters discuss between themselves how they want to divide the costs. Figure 34 illustrates the page to search for a ride.



From	To	Date	Departure Time	Arrival Time	Type	Details
Barcelos, Portugal	Pousa, Barcelos, Portugal	06/24/2012	08:30:00	17:30:00	Request Lift	View
Barcelos, Portugal	Pousa, Barcelos, Portugal	05/20/2012	08:00:00	17:30:00	Request Lift	View
Braga, Portugal	Barcelos, Portugal	07/23/2012	08:00:00	17:00:00	Offer Lift	View

Figure 34 - Search Rides

7.2.3. Evaluate a Carpooler

A user can only evaluate a carpooler that participated in the same carpool. Once the user selects a name of a carpooler to evaluate, it will appear a list of rides that they both have participated together. The user can only evaluate the carpooler's punctuality and friendliness between a rate of one to five. Figure 35 demonstrates how to evaluate a carpooler.

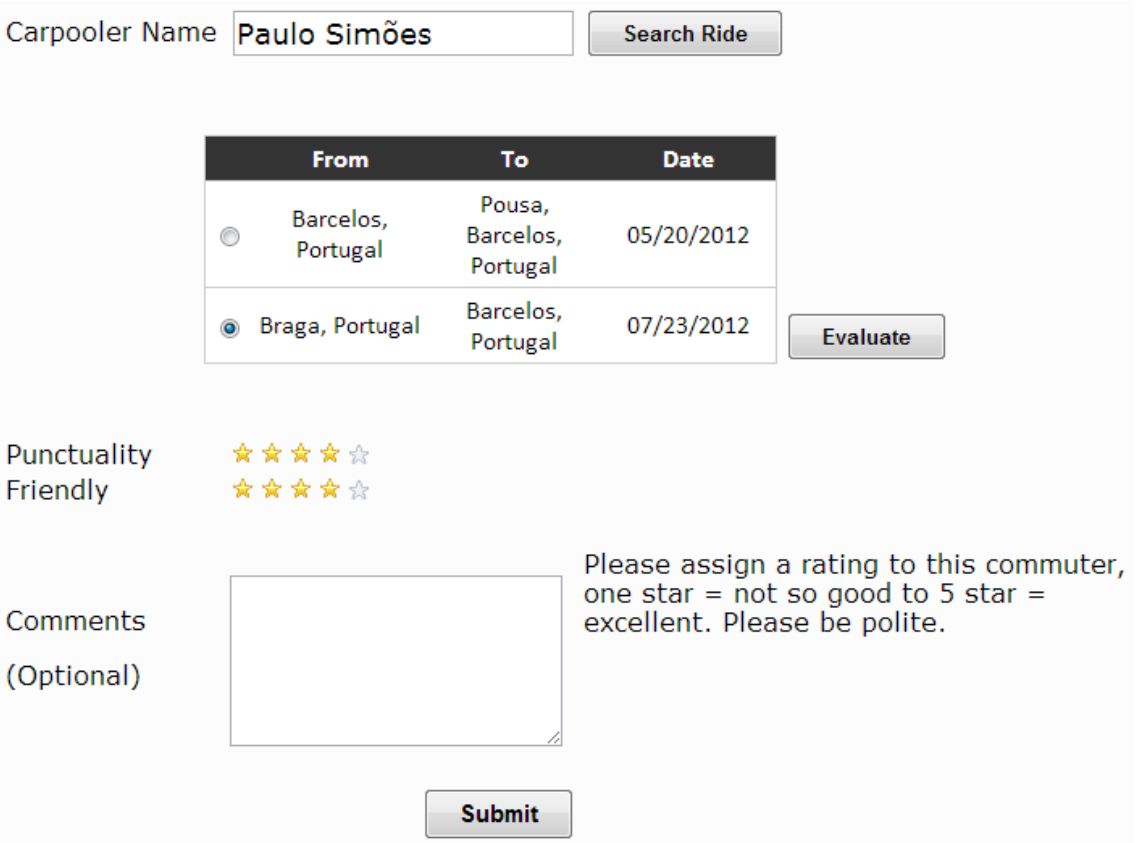


Figure 35 - Evaluate a Carpooler

7.2.4. Confirm Requests/Offers

On this application will appear a list of requests and offers of rides that still need to be confirmed. To confirm any requests or offers, figure 36 needs to be filled out.

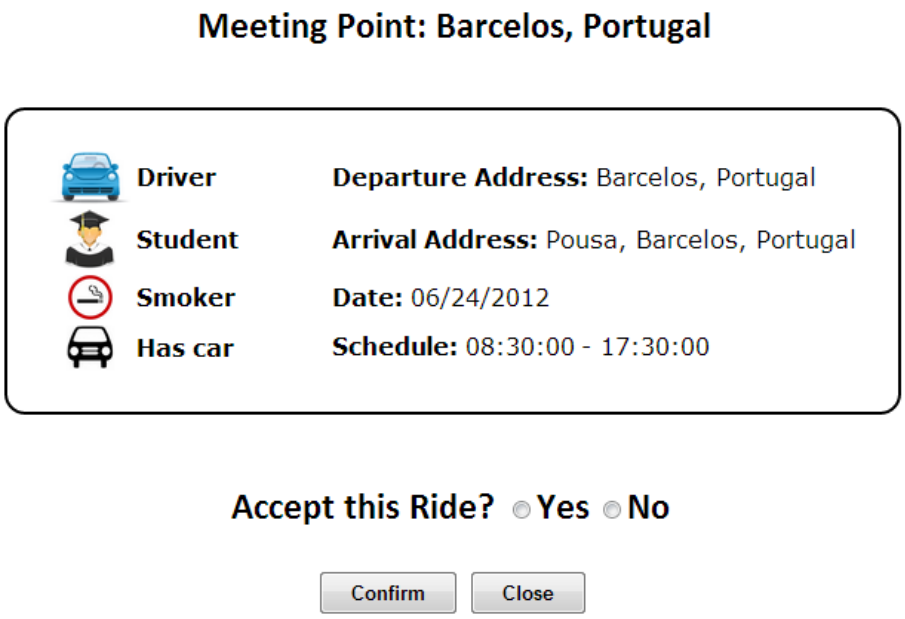


Figure 36 - Confirm Requests/Offers

7.3. General Overview

The interface of an application is the primary point of contact between the user and the system. For any application to have success, it is very important that the design of the interfaces is clear. The heuristic evaluation discussed in chapter 4.4. by Jakob Nielson was taken into consideration to develop a usable interface. To incorporate all the ten heuristics into the application is a long process. Many sketches and testing various solutions were necessary to have a usable interface.

7.3.1. Design of the Interface

The application in question contains the same structure throughout all the interfaces. Therefore, this section will discuss the structure of the interface divided in parts. In figure 37 demonstrates the structure divided in five parts: header, login, menu, content and footer.

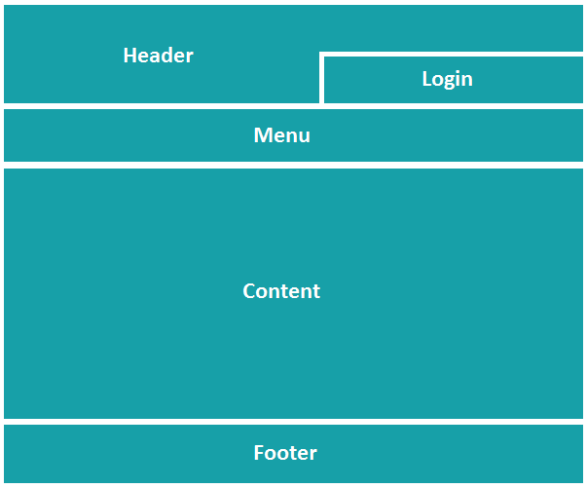


Figure 37 - Structure of the Interface

Header and login: this section is located on the superior part of the application with an image related to carpooling and an area to log in. The login area allows the user to sign in to view their account and to log out of the application. Figure 38 demonstrates the header and login of the application.

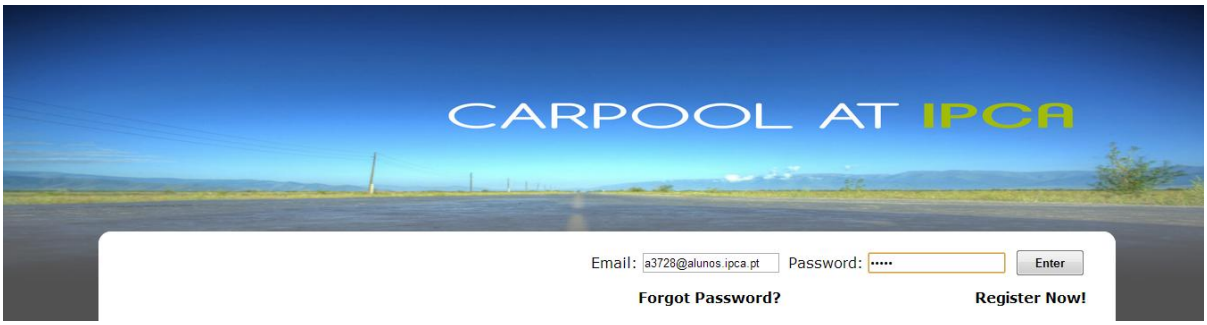


Figure 38 - Header and login of the application

Menu: the menu is the base of the navigation, providing an organized way to navigate through the interfaces. The objective to have a menu is to navigate faster throughout the application. Some content of the menu are only visible when the user is logged in.

Content: this section is where all the data will be located. In some parts of the application, the content will only be viewable if the user is logged in.

Footer: this section displays additional information, such as, weather, transit and fuel. Furthermore, there are links that directs the users to a contact form in which they can contact the administrator of the application.

7.3.2. General Caracteristics

The use of AJAX was a fundamental tool used throughout the application. The objective of this tool is to increase the interaction with the user and to save time. In the following will be discussed the main interactions developed on the application.

Data Validation

The data that the user enters in the system should always be validated before it goes into the database, to prevent any problems of incompatibility. In figure 39 demonstrates an example of validating data on the application. The validation is done in real time when entering data to a field and in case of an error a red alert is displayed.

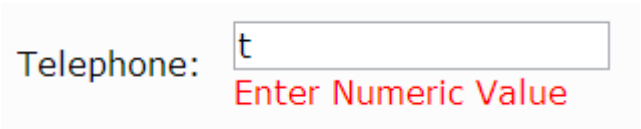


Figure 39 - Data Validation

Data Processing

It is important that the system processes the data to have full control of the system. For example, in the application the users should not have the same emails. Therefore, when a user is registering an email and it already exists in the database, an error message will appear. In figure 40 displays an example when processing data.

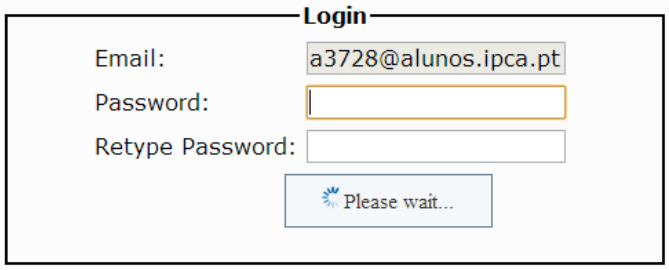


Figure 40 - Data Processing

The use of Windows Modal

In the application in question, there are some cases where it is necessary to provide a lot of information at the same time without losing the context. Therefore, a tool called Modal Windows was used to contain a lot of information in a single interface. As seen in figure 41, the objective of the Modal Windows is to view more information that's not shown in the main interface. The background of this window is dimmed allowing the users to know exactly where they are on the application. Figure 41 illustrates an example of modal windows.

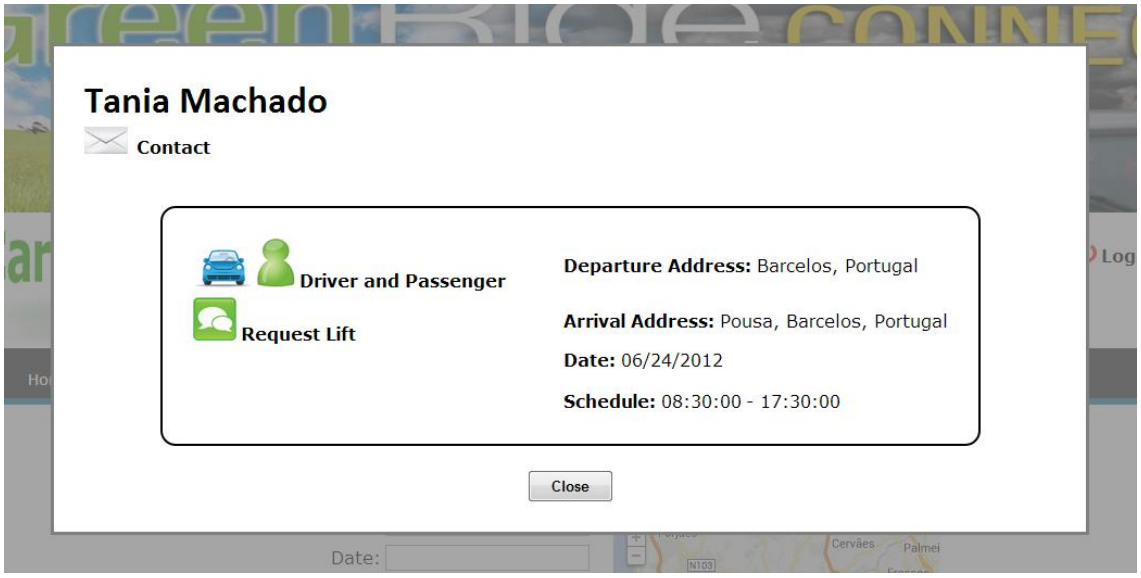


Figure 41 - The use of Modal Windows

AutoComplete

Autocomplete enables users to quickly find and select from a list of values. It works so that when the user writes the first letter or letters of a word, the application predicts one of

more possible words as choices. Once the word that the user intends to write is included in the list they can select it. This function is incorporated into the application when the user enters their city as shown in figure 42.



Figure 42 – Autocomplete

The autocomplete shown in figure 42 requires a function to display the cities while typing. This function is displayed in the following.

```
$(document).ready(function () {
    $(function () {
        $("#tbDepart").autocomplete({
            //This bit uses the geocoder to fetch address values
            source: function (request, response) {
                geocoder.geocode({ 'address': request.term }, function (results,
status) {
                    response($.map(results, function (item) {
                        return {
                            label: item.formatted_address,
                            value: item.formatted_address,
                            latitude: item.geometry.location.lat(),
                            longitude: item.geometry.location.lng()
                        }
                    }));
                })
            },
            //This bit is executed upon selection of an address
            select: function (event, ui) {
                $("#tbDepartLat").val(ui.item.latitude);
                $("#tbDepartLng").val(ui.item.longitude);
                var location = new google.maps.LatLng(ui.item.latitude,
ui.item.longitude);
                marker.setPosition(location);
                map.setCenter(location);
            }
        });
    });
});
```

7.4. Description of the Interfaces

Since the requirements and goals have been specified, it is time to apply them to the development of the web application. The website was carefully designed to be user friendly.

Its design is very intuitive and informative so that even people with little experience in computers can easily use this system. In this section will be demonstrated some images of the user interface with its respective description.

7.4.1. Layout of the Application

The layout of the Web application was mainly developed with HTML, CSS and JavaScript to interact with Google Maps and to create some objects to interact with this API.

The layout consists of four main areas. The upper area is where the user logs in and out of the application with their email and password. Underneath that area remains the navigation menu where the user can browse from page to page. The main area of the application is where all the content of the page is located. And finally, the bottom area is the footer of the application which mentions useful information about the administrators of the application as well as useful websites for meteorology, transit and fuel. In figure 43 demonstrates the main page of this application.

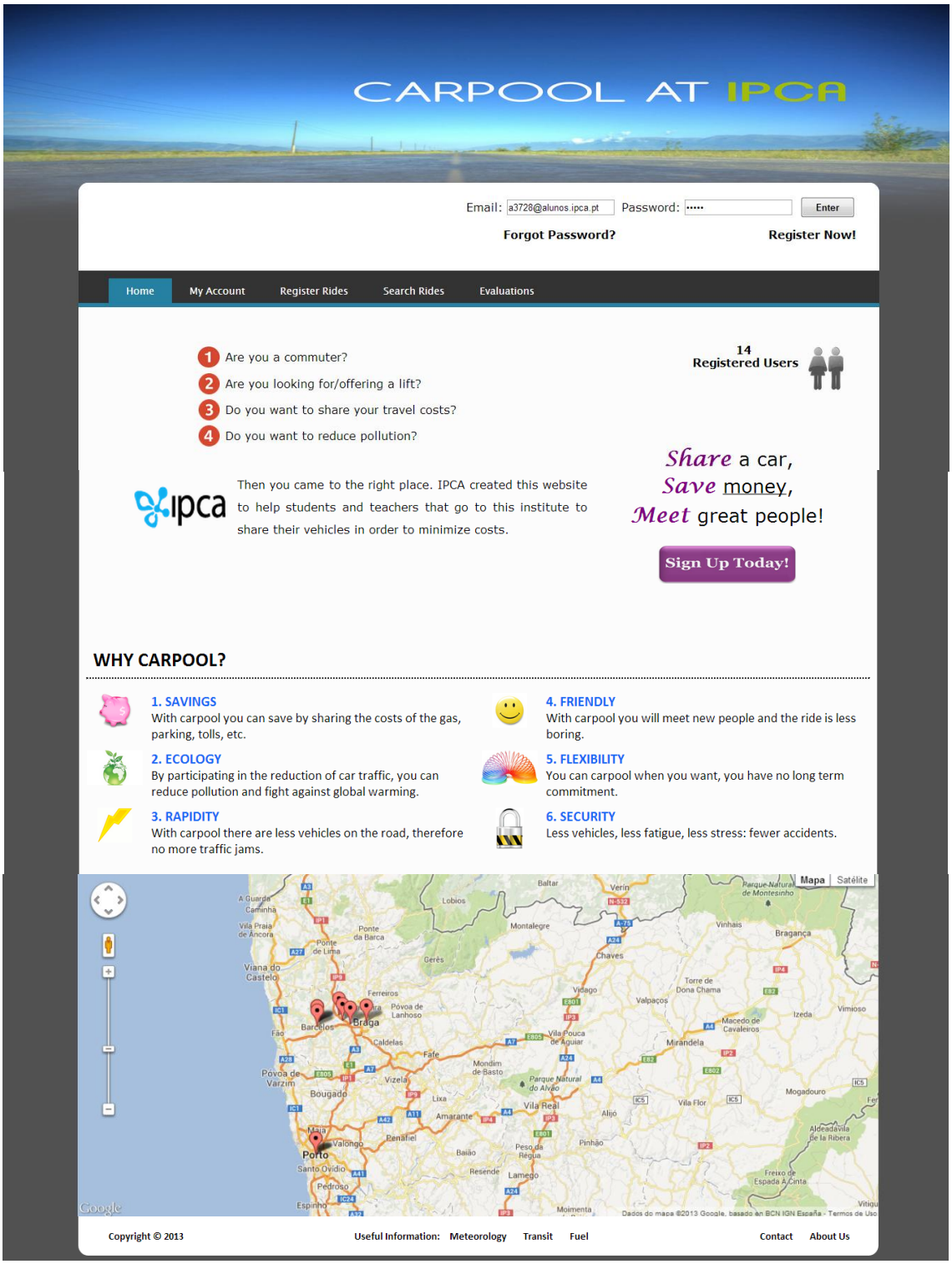


Figure 43 - Layout of the application

7.4.2. Main Menu

The menu allows the user to navigate within the application moving from one page to another. The user has to be logged in to view the majority of the content. The menu in figure 44 was developed with CSS which makes it appealing and easy to navigate.

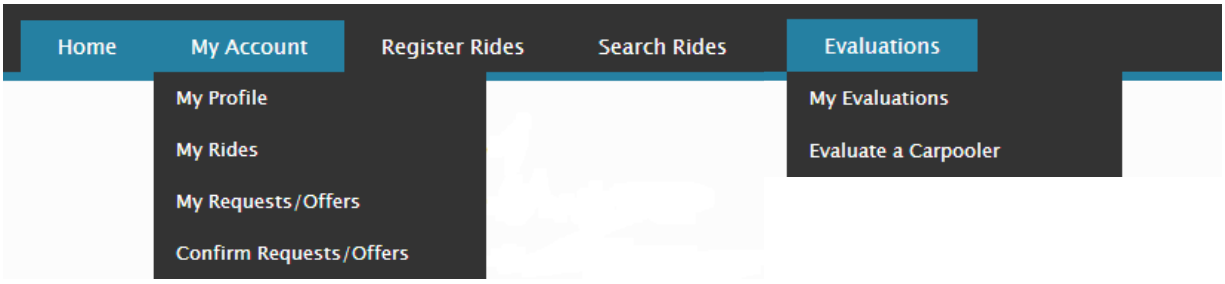


Figure 44 - Main Menu

The “Home” menu displays the welcome page containing information about carpool. From this page it is possible to view the total amount of registered users.

The “My account” menu displays information about the users, their rides and their requests/offers. The user must be logged in to view anything on this menu. The “My Profile” menu contains all the personal information about the user that is logged in. The “My Rides” menu contains a list of rides that belongs to the user. The “My Requests/Offers” menu contains a list of requests and offers that has been made by the user. While the “Confirm Requests/Offers” menu allows the user to confirm all the pending requests and offers.

The “Register Rides” menu displays a form for the user to register their ride. The user must also be logged in to view this page so they can register their ride.

The “Search Rides” menu allows the user to search for any compatible ride. This page only searches for rides that are still available. The user can always view this page but if the user wants to contact a carpooler, they must be logged in.

The “My Evaluations” menu contains a list of all the evaluations that has been made about the user. The “Evaluate a Carpooler” menu allows the user to evaluate any carpooler that has participated in the same carpool.

7.4.3. Login

Security is a fundamental feature to protect the details of each individual. Therefore, there should only be one set of credentials (email and password) for each user. To log into the application, the user must enter their authentication details so they have access to their data.

Before authenticating the form, the user must be registered in the database. If the user isn't registered with the system then they will need to click on "Register Now" and fill out a form. But there is also another option if the user can't remember their password to log into the system. The user must click on "Forgot Password" which will prompt a message to enter the user's email. Once the user enters their password, they will receive in their inbox an automatic message from the application with their login details (email and password) as shown in figure 47.

Only registered users can log into the system using their email and password. If the login is valid, their profile details will appear, otherwise it will display an error message as it shows in figure 45.

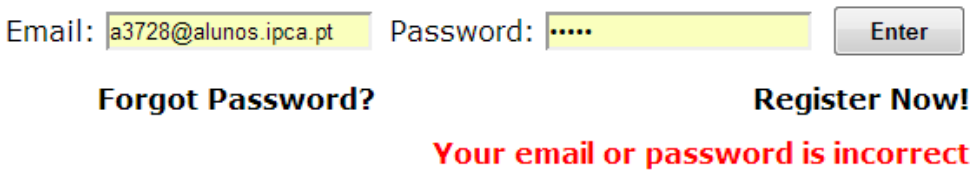


Figure 45 – Login

7.4.4. Forgot Password

If the user is having difficulties logging into the application, he/she can reset the password by clicking on "Forgot password" shown in figure 45. Once the user clicks on that link, it will appear a popup to enter the login email as it shows in figure 46.

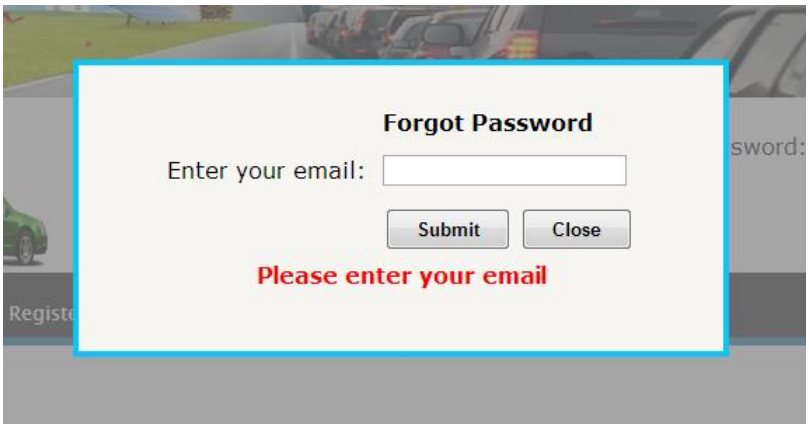


Figure 46 - Forgot Password

As soon as the user submits the email, he/she will receive an automatic message from the database with their login details (email and password) as shown in figure 47.

From: ipca.carpool@gmail.com
To: Tania Machado

Your Login Details

Hello,

You have requested to reset your password. Please check your Login Details.

Your Email: a3728@alunos.ipca.pt

Your Password: [redacted]

Figure 47 - Email to reset password

7.4.5. Register User

The user must be registered to use most of the features from the application. When registering a new user, they must fill out a form indicating their personal information, such as, name, gender, telephone and address. In additional, the user must also indicate their login details by providing a valid email and password. If the email already exists in the database, the system will notify the user. The application only accepts emails from the

students and teachers that are enrolled in the institute. Finally, the user must indicate additional information that might be useful, such as, if the user is a student or teacher, if is a smoker or non-smoker, if has a car or no car and how the user is willing to carpool, such as driver and/or passenger. Figure 48 illustrates an example of registering a user.

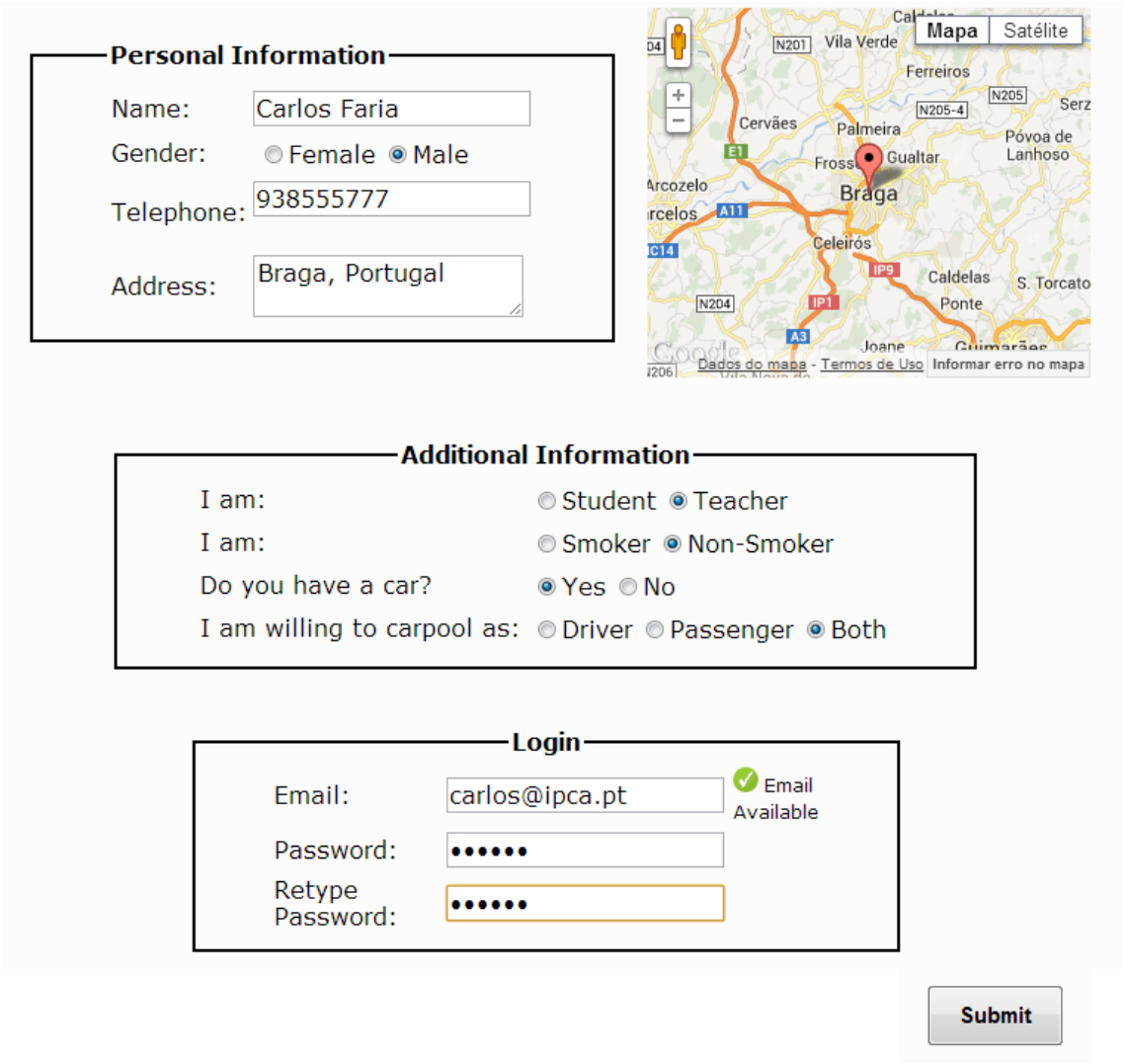


Figure 48 - Register User

7.4.6. My Profile

When the user authenticates into the system, the Web application will display the user's profile details as shown in figure 49. The application displays the same data as the registration process including the user's evaluation. According to the user's evaluation, it provides the following items: punctuality and friendly. These evaluations are displayed by

stars and are calculated automatically. These calculations are an average of all the evaluations made by the carpoolers and it's calculated by the following query:

```
SELECT Round(AVG(Rate),0) as rate
FROM Users, Ride, Evaluation, TypeEvaluation, Schedule, Route
WHERE Evaluation.TypeEvaluationID=TypeEvaluation.TypeEvaluationID and
Evaluation.RideID=Ride.RideID and
Ride.SchedID=Schedule.SchedID and Schedule.RouteID=Route.RouteID and
Route.UserID=Users.UserID and TypeEvaluation.Description='Punctuality' and
Users.Name = 'Tania Machado'
```

This data can be modified by the user at any time except for the evaluations. When an address is inserted, the location will appear on the map using a marker. This is a way of introducing Google Maps to the application. On this web page it is also possible to change the user's password. Figure 49 illustrates the page with the user's profile details.

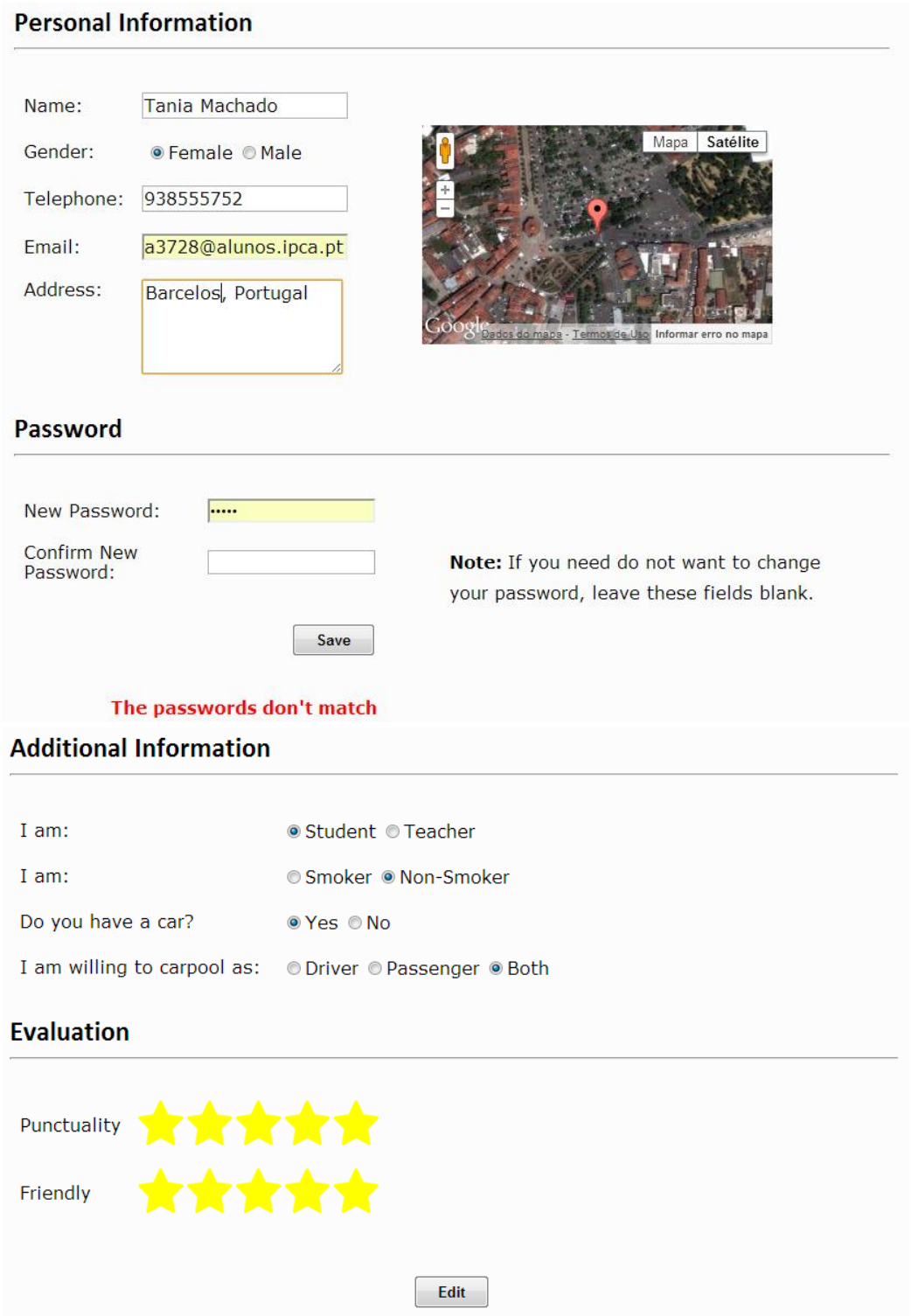


Figure 49 - My Profile

7.4.7. My Rides

When the user goes to the menu “My Rides”, it will display all the rides that belongs to the user that is logged in as shown in firgure 50.

From	To	Date	Departure Time	Arrival Time	
Barcelos, Portugal	Pousa, Barcelos, Portugal	06/24/2012	08:30:00	17:30:00	Edit
Braga, Portugal	Barcelos, Portugal	07/23/2012	08:00:00	17:00:00	Edit
Guimarães, Portugal	Barcelos, Portugal	01/29/2013	08:00:00	17:15:00	Edit
4440-452 Porto, Portugal	Barcelos, Portugal	04/28/2013	08:00:00	17:00:00	Edit
Braga, Portugal	Barcelos, Portugal	02/15/2013	09:30:00	18:30:00	Edit
4755 Pousa, Portugal	Barcelos, Portugal	05/30/2013	09:00:00	17:00:00	Edit

Figure 50 - List of Rides

This user can edit the ride they want by clicking on the "Edit" icon on the table shown above. Once the user clicks on the Edit icon, it will display a popup with the details of the ride which the user can edit. In figure 51 will illustrate an example to edit a ride.

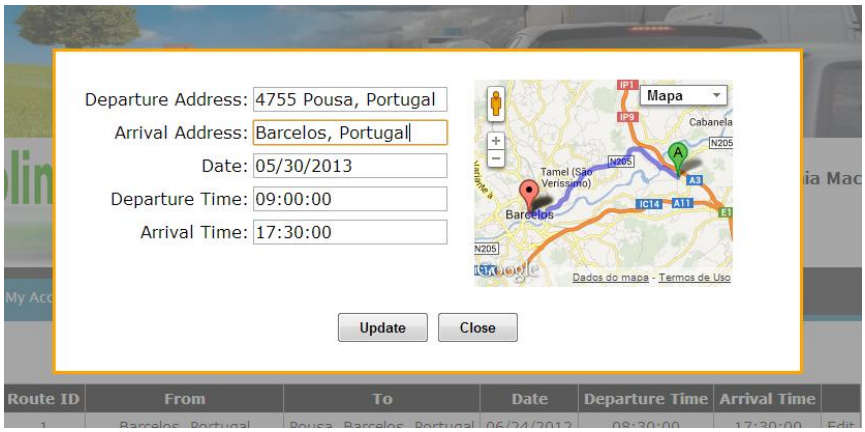


Figure 51 - Edit Ride Details

A function in JavaScript has been developed to design the route on the map shown in figure 51.

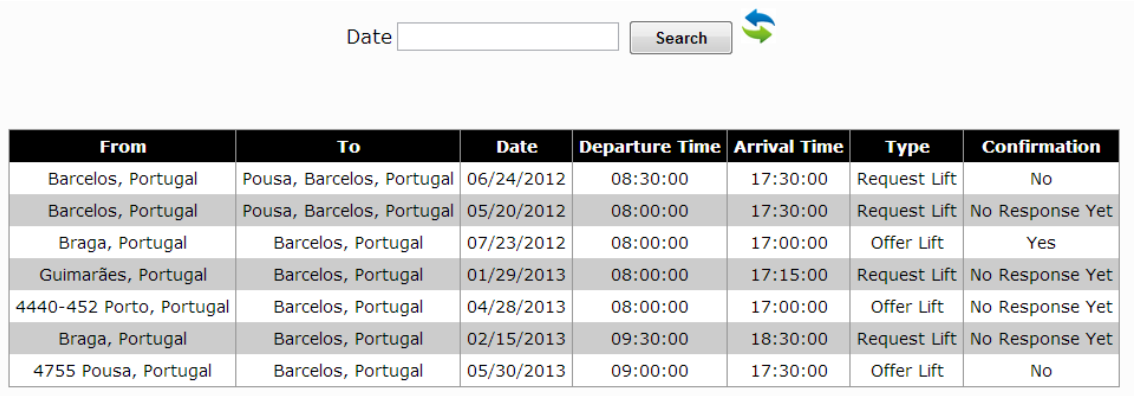
```
var directionsDisplay;

var directionsService = new google.maps.DirectionsService();
var map;

function calcRoute() {
    var start = document.getElementById("tbDepart").value;
    var end = document.getElementById("tbArrival").value;
    var request = {
        origin: start,
        destination: end,
        travelMode: google.maps.TravelMode.DRIVING
    };
    directionsService.route(request, function (result, status) {
```

```
            if (status == google.maps.DirectionsStatus.OK) {
                directionsDisplay.setDirections(result);
            }
        });
    }
```

7.4.8. My Requests/Offers

When the user goes to the menu "My Requests/Offers", it will display all the requests and offers that belongs to the user as shown in firgure 52.

The objective of this page is to see if a specific request or offer is confirmed or not. The requests or offers that haven't been confirmed demonstrate as "No Response Yet" as shown in figure 52.

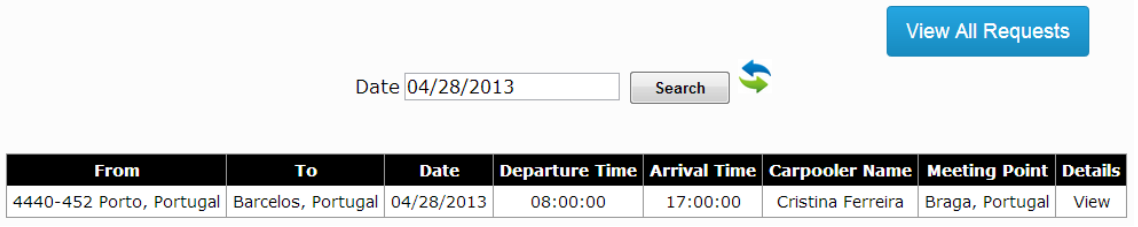


From	To	Date	Departure Time	Arrival Time	Type	Confirmation
Barcelos, Portugal	Pousa, Barcelos, Portugal	06/24/2012	08:30:00	17:30:00	Request Lift	No
Barcelos, Portugal	Pousa, Barcelos, Portugal	05/20/2012	08:00:00	17:30:00	Request Lift	No Response Yet
Braga, Portugal	Barcelos, Portugal	07/23/2012	08:00:00	17:00:00	Offer Lift	Yes
Guimarães, Portugal	Barcelos, Portugal	01/29/2013	08:00:00	17:15:00	Request Lift	No Response Yet
4440-452 Porto, Portugal	Barcelos, Portugal	04/28/2013	08:00:00	17:00:00	Offer Lift	No Response Yet
Braga, Portugal	Barcelos, Portugal	02/15/2013	09:30:00	18:30:00	Request Lift	No Response Yet
4755 Pousa, Portugal	Barcelos, Portugal	05/30/2013	09:00:00	17:30:00	Offer Lift	No

Figure 52 - My Requests/Offers

7.4.9. Confirm Requests/Offers

On the "Confirm Requests/Offers" menu, the user can view all the requests and offers that still need to be confirmed. To make the search easier, the user can search the requests and offers by its date as shown in figure 53.



From	To	Date	Departure Time	Arrival Time	Carpooler Name	Meeting Point	Details
4440-452 Porto, Portugal	Barcelos, Portugal	04/28/2013	08:00:00	17:00:00	Cristina Ferreira	Braga, Portugal	View

Figure 53 – List to Confirm Requests/Offers

To confirm any request or offer, the user must view them by clicking on the "View" option as shown in figure 53. Once the user views the request or offer, a window will pop up with the details of the user and the ride, including a button to confirm the ride. If the user needs to contact the carpooler, it is possible by clicking on the "Contact" link on the popup. In figure 54 illustrates an example to confirm a request or offer.

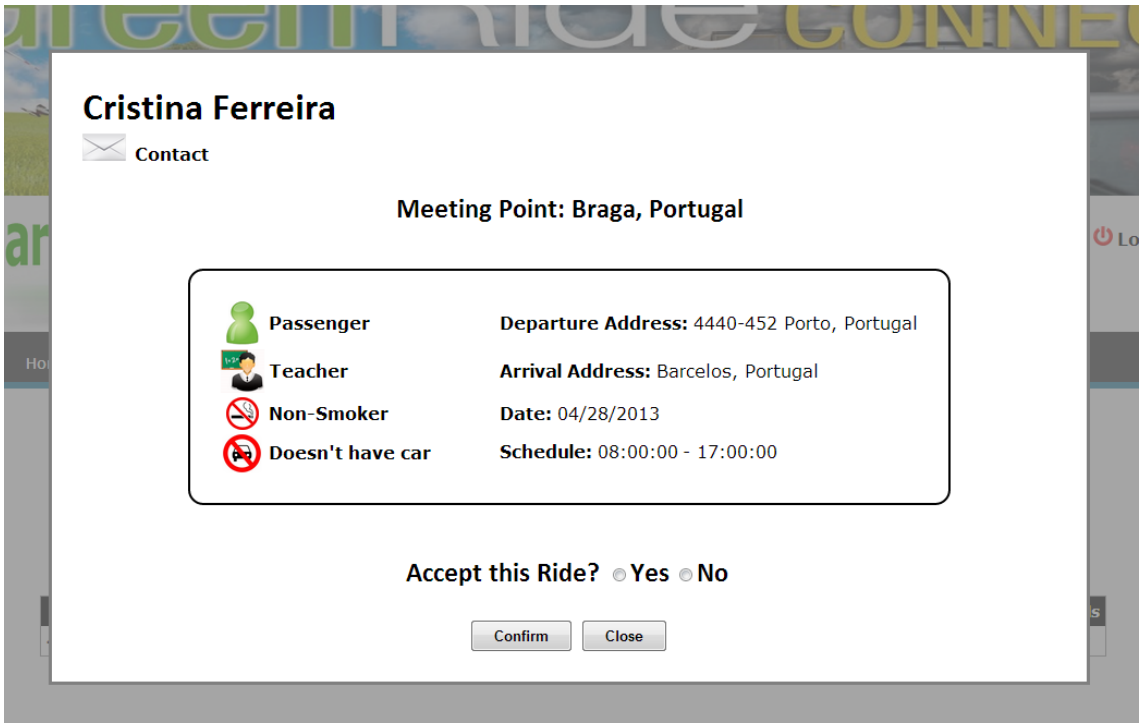


Figure 54 - Confirm Requests/Offers

Once the ride is accepted or declined, the carpooler will receive a notification by email stating its confirmation. Figure 55 illustrates an email confirming a ride.

Confirmation of the ride

The following ride with Tania Machado has been confirmed.

Departure Address: 4440-452 Porto, Portugal
Arrival Address: Barcelos, Portugal
Date: 04/28/2013
Schedule: 08:00:00 - 17:00:00

Figure 55 - Confirmation of a ride

7.4.10. Register Rides

Before registering a ride, the user can search to see if it already exists. If it doesn't exist the user can continue on registering their ride. The information necessary to register a ride are: type of ride (offer or request a lift), departure and arrival address, departure and arrival time, date and if the user is offering a ride then it is necessary to insert how many seats are available in the vehicle. The user can also insert any additional information if needed. In figure 56 illustrates an example to register a ride.

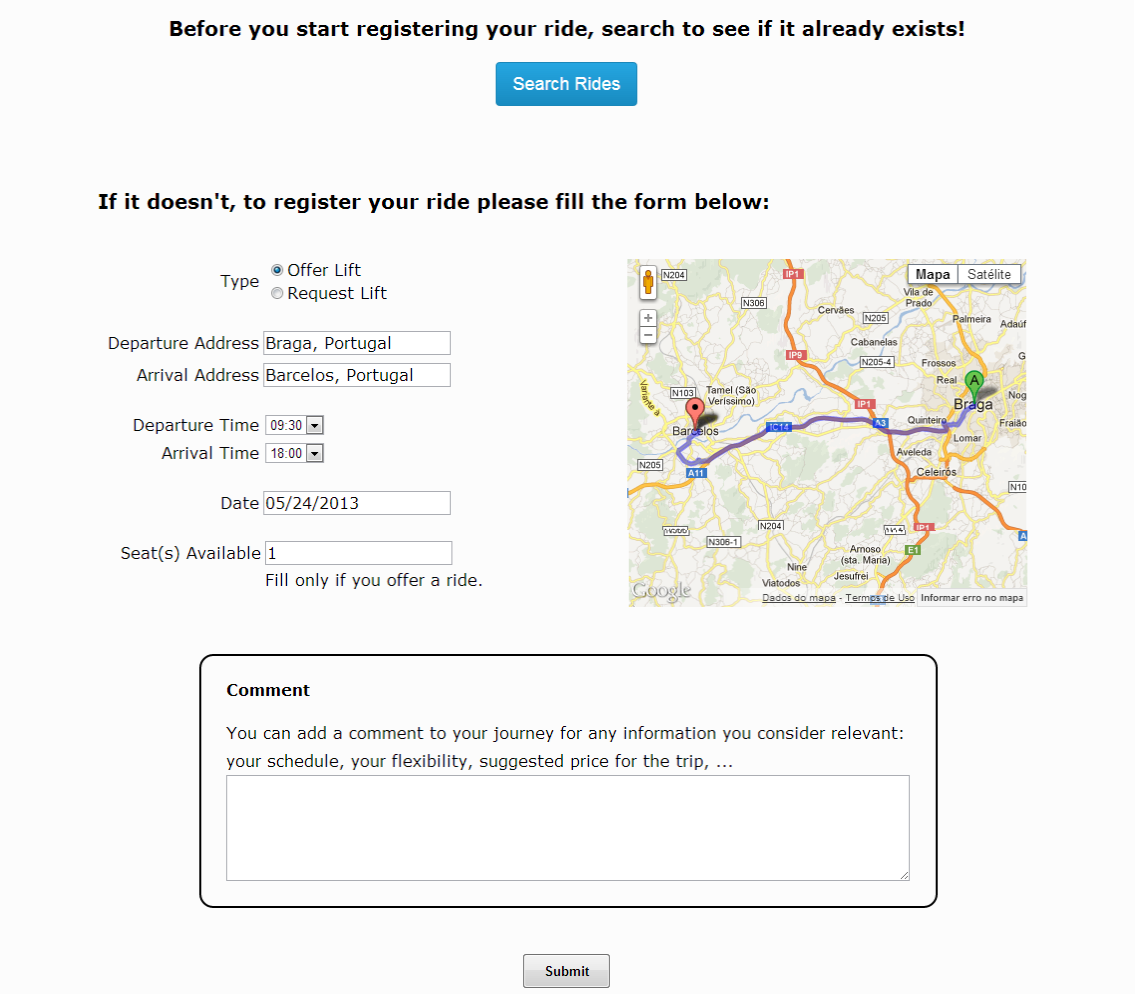
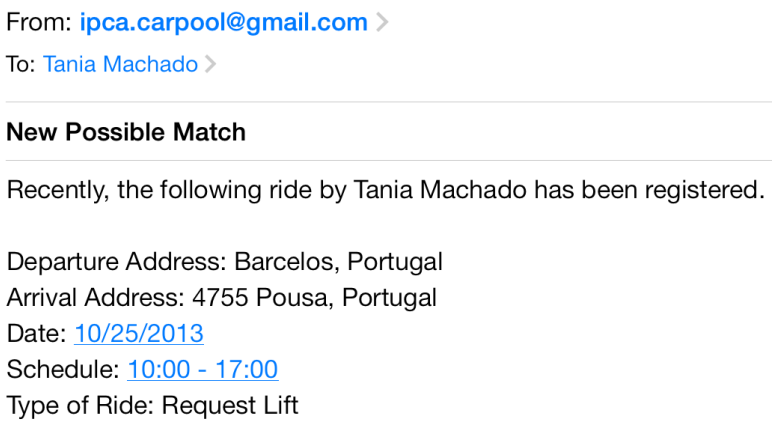


Figure 56 - Register Ride

Once a ride is registered, all the carpoolers with the same origin and destination will receive a notification by email, making it more efficient and faster to create carpools. Figure 57 illustrates an example of the email.


From: ipca.carpool@gmail.com
To: Tania Machado

New Possible Match

Recently, the following ride by Tania Machado has been registered.

Departure Address: Barcelos, Portugal
Arrival Address: 4755 Pousa, Portugal
Date: 10/25/2013
Schedule: 10:00 - 17:00
Type of Ride: Request Lift

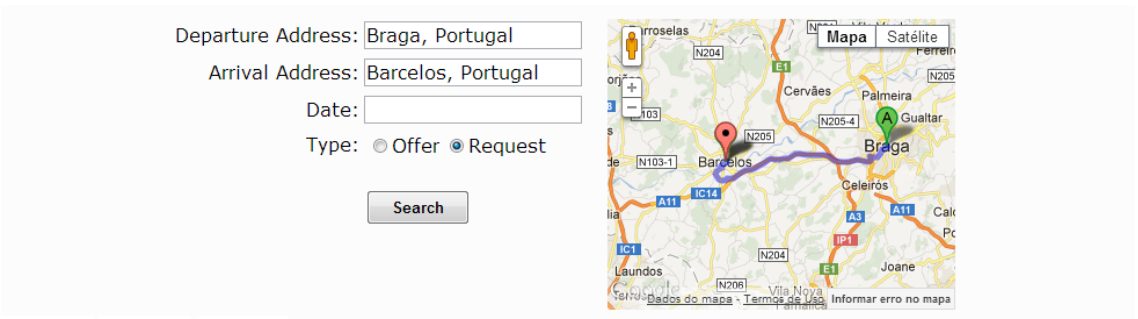
Figure 57 - Email of a new possible match

A query has been developed to determine who will receive this email. The aim of this query is to send an email to all the carpoolers that have the same origin and destination, excluding the carpooler that registered the ride.

```
Select distinct Users.Email as 'Email'
From Users, Route
Where Users.UserID=Route.UserID AND Route.AddressO='Barcelos, Portugal' AND
Route.AddressD='4755 Pousa, Portugal' AND Users.Email <>
'a3728@alunos.ipca.pt'
```

7.4.11. Search Rides

When the user is searching for a ride, it is necessary to fill a form with the departure and arrival address, date and type of ride. The only field mandatory is the type of ride. In figure 58 demonstrates how to search for a ride.



From	To	Date	Departure Time	Arrival Time	Type	Details
Braga, Portugal	Barcelos, Portugal	07/23/2012	08:00:00	17:00:00	Request Lift	View
Braga, Portugal	Barcelos, Portugal	02/15/2013	09:30:00	18:30:00	Request Lift	View

Figure 58 - Search for a Ride

Once the user searches for the ride they want, it will display a table with the information of that ride. On this table there exists a column to view more details of the ride. Once the "View" option is clicked, it will display a popup with the information of the user that created the ride. In figure 59 displays an example to view the details of the ride.

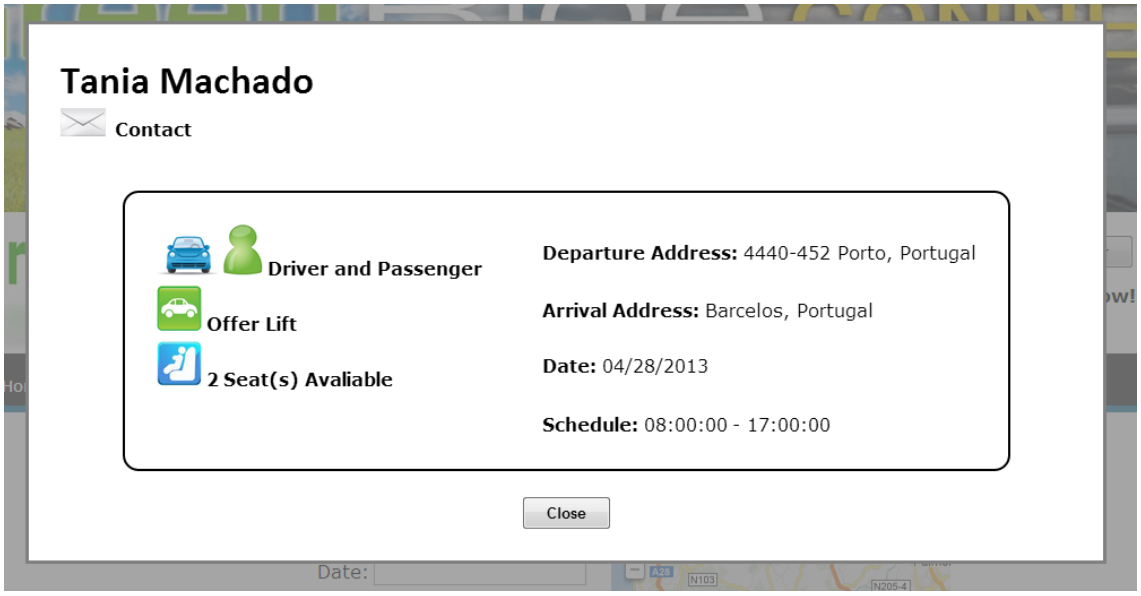


Figure 59 – Details of the Ride

On this popup it is possible to contact the user who created the ride. Simply click on the contact icon (envelope) to get in contact with the carpooler. It is only possible to contact the carpooler if the user is logged in. If the user is not logged in, a warning appears informing the user to log in. In figure 60 demonstrates the message.

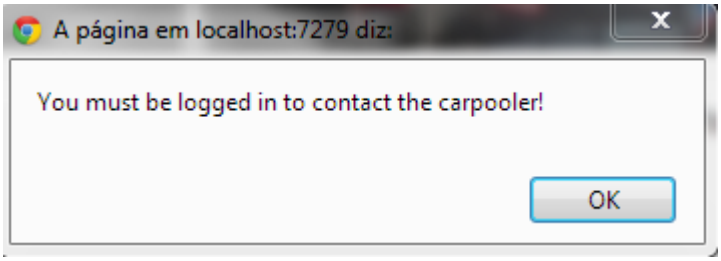


Figure 60 - Message to log in

Once the user is logged in, it displays another window with the contact form as shown in figure 61. The user must fill out the form and then click on "Send". An email will go directly

to the carpooler the user is contacting with the information introduced in the form. Figure 61 illustrates the contact form.

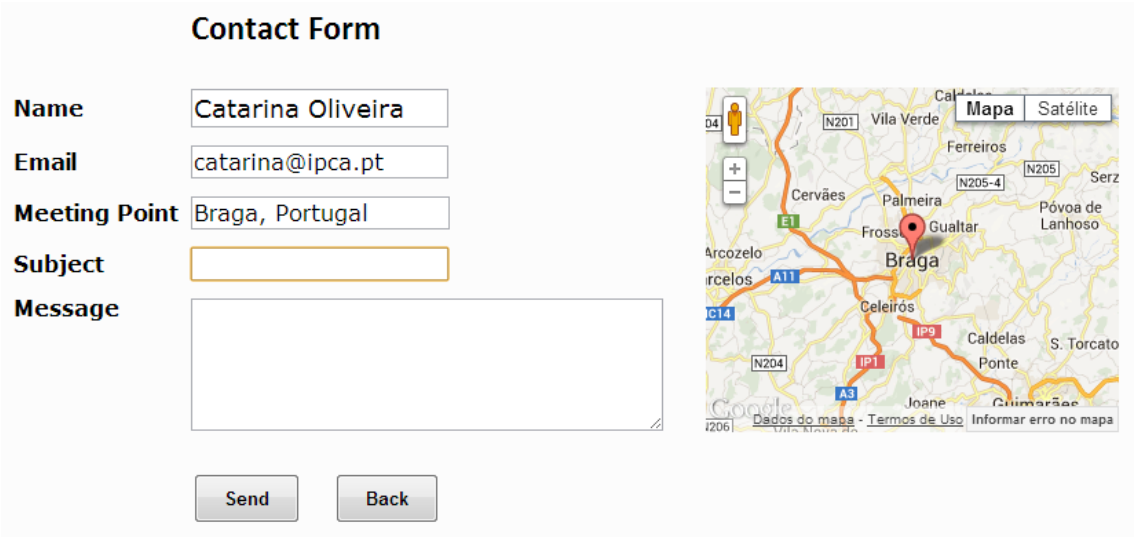


Figure 61 - Contact Form

7.4.12. My Evaluations

The “My Evaluations” page displays all the evaluations made to the user that is logged in. On this page it is also possible to evaluate a carpooler. The number of rates is from 1 to 5, which means 1 is not so good and 5 is excellent. Figure 62 illustrates a list of evaluations.

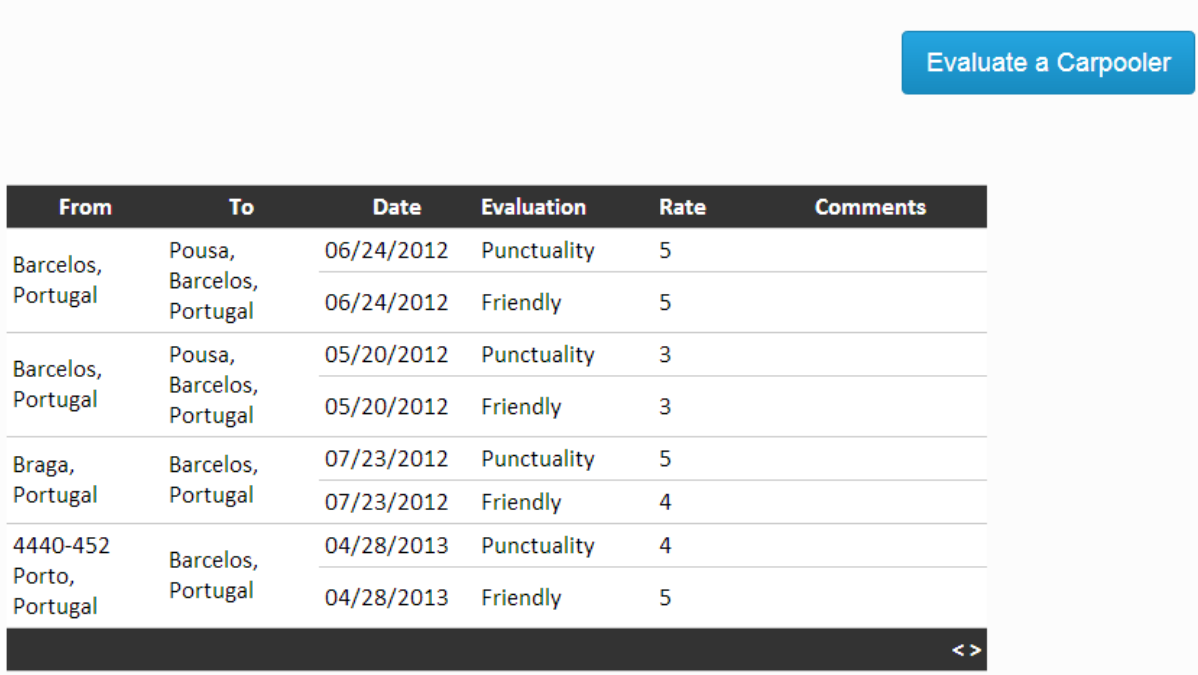


Figure 62 - My Evaluations

7.4.13. Evaluate Carpooler

When a user is evaluating a carpooler, it is only possible to evaluate a different carpooler that is not logged in. Figure 63 illustrates an example.

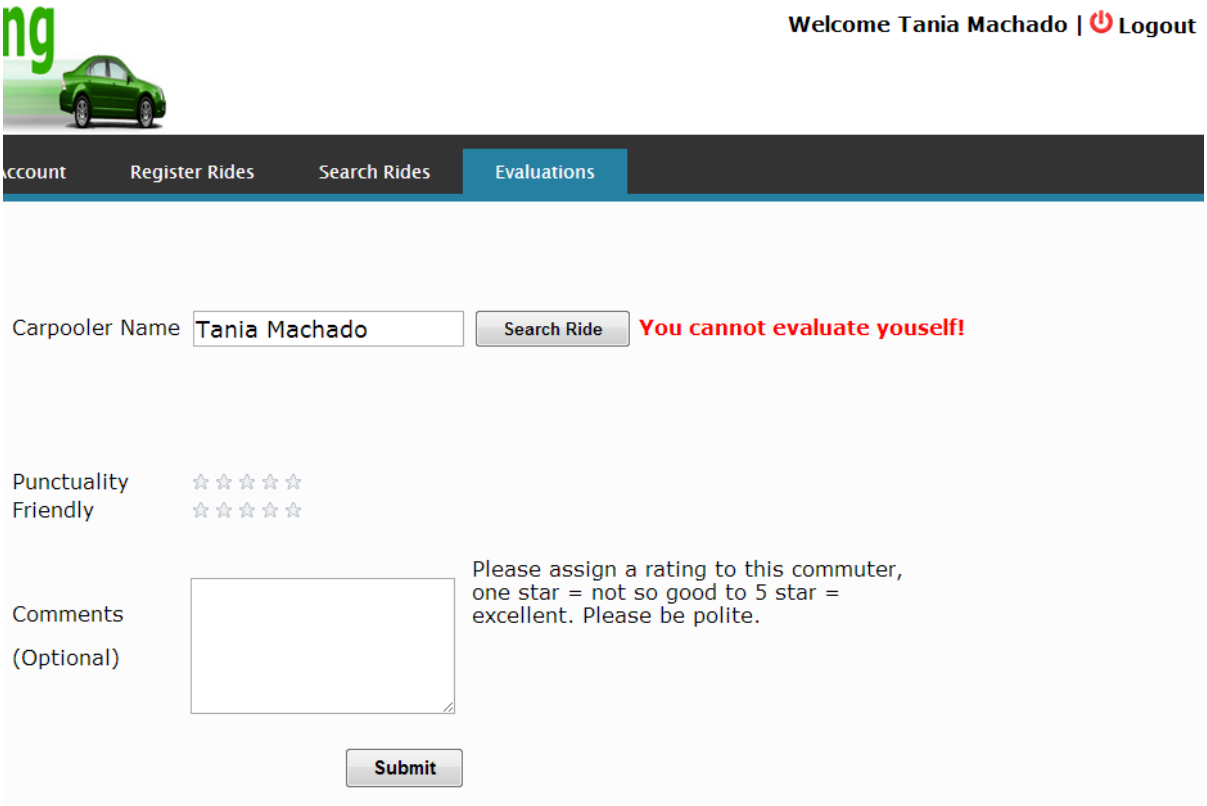


Figure 63 - Evaluate a Carpooler incorrectly

But if a user is evaluating a carpooler that is not the same as the user logged in, it will appear as it shows in figure 64. The user must search a carpooler that exists in the database, in other words, the carpooler is already registered in the web application. Once the user chooses a carpooler, it will display a list of rides that both of the carpoolers have participated together. The user selects the ride they want to evaluate and rate it according to punctuality and friendliness. Figure 64 demonstrates an example to evaluate a carpooler.

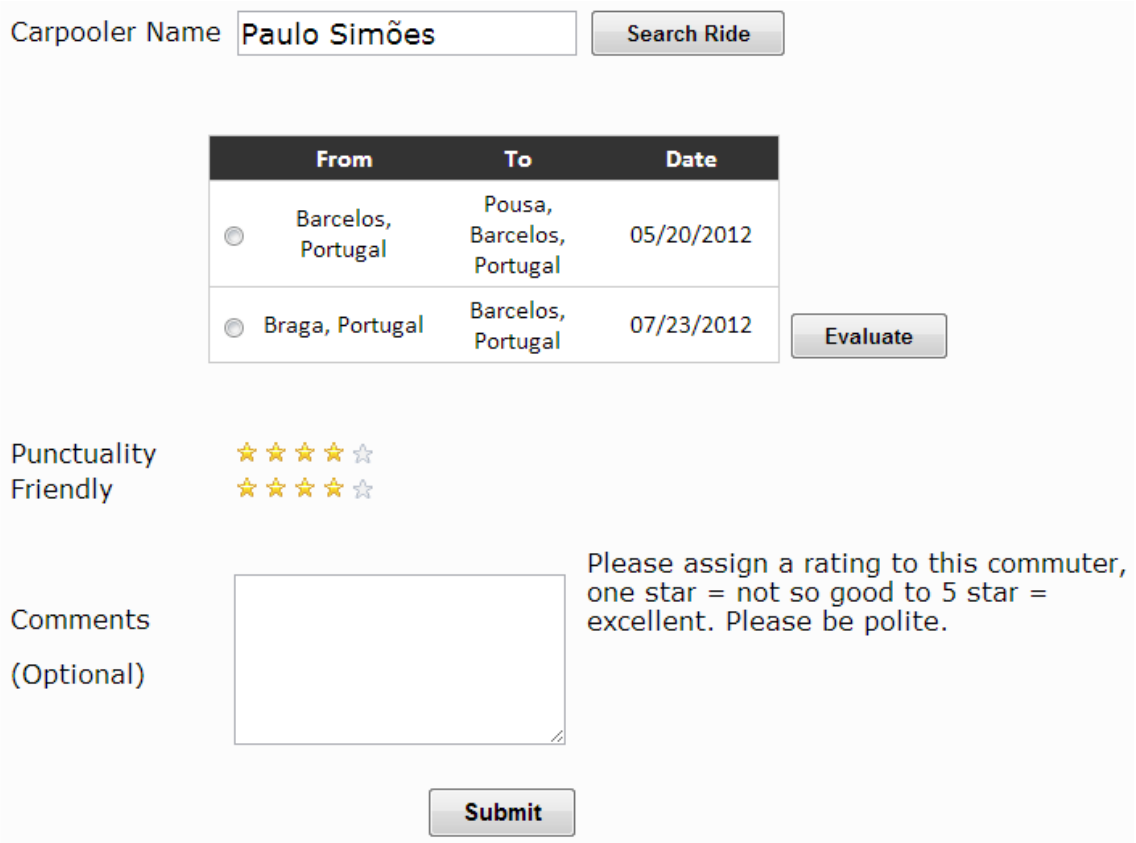


Figure 64 - Evaluate a Carpooler

A query has been developed to display a list of rides that both of the carpooler has participated together. Below demonstrates an example of this query.

```
SELECT Ride.RideID, Route.AddressO as 'From', Route.AddressD as 'To',
Schedule.Date
FROM Route, Schedule, Ride
WHERE Route.RouteID=Schedule.RouteID AND Schedule.SchedID=Ride.SchedID AND
Route.UserID= '1' AND Ride.UserID= '2'

UNION

SELECT Ride.RideID, Route.AddressO as 'From', Route.AddressD as 'To',
Schedule.Date
FROM Route, Schedule, Ride
WHERE Route.RouteID=Schedule.RouteID AND Schedule.SchedID=Ride.SchedID AND
Route.UserID= '2' AND Ride.UserID= '1'
```

7.5. Cloud Computing and Deployment

In this chapter will mention a brief introduction about cloud computing, including the types of clouds and the types of cloud providers. There are four types of clouds which are: public cloud, private cloud, community cloud and hybrid cloud. For the cloud providers, there are three which are: Software as a Service (SaaS), Platform as a Service (PaaS) and Infrastructure as a Service (IaaS). After this introduction, explains how to deploy the application developed in this project.

7.5.1. Cloud Computing

With the technology advancing, it is emerging new computing services, such as, cloud computing. With this service it is possible to access any information from anywhere at any time. But to have access to the information, it is required an internet connection (Corporation, 2010).

There are four types of clouds that the user can subscribe to depending on their needs: public cloud, private cloud, community cloud and hybrid cloud. In figure 65 illustrates an example of these clouds (Corporation, 2010).

- **Public cloud** can be accessed by any user with an internet connection and access to the cloud space.
- **Private cloud** is operated and managed by a specific organization and has limit access to just that organization.
- **Community cloud** is shared among two or more organizations with similar interests and requirements and is only available for these groups.
- **Hybrid cloud** is a combination of at least two clouds (private, community, or public) that have the ability through their interfaces to allow data or applications to be moved from one cloud to another.

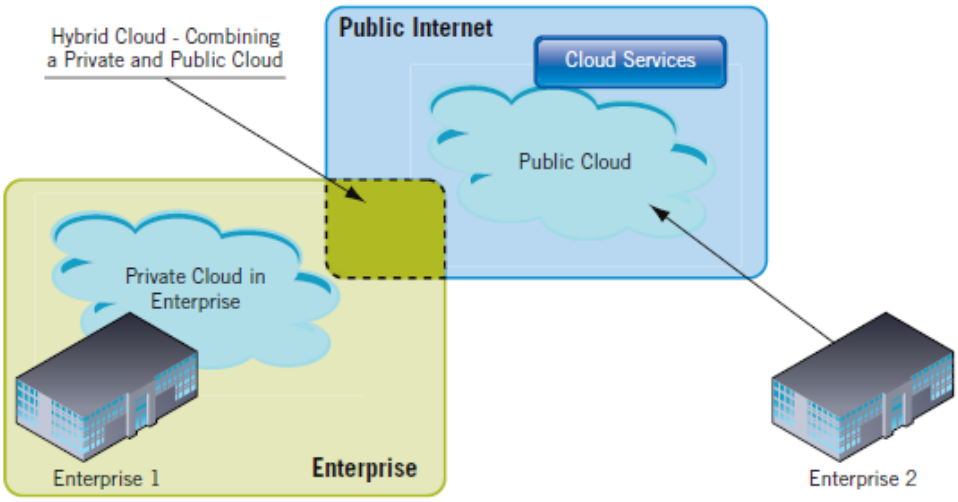


Figure 65 - Example of the types of clouds (Corporation, 2010)

There are three types of cloud providers: Software as a Service (SaaS), Platform as a Service (PaaS) and Infrastructure as a Service (IaaS). These three types differ in the amount of control that the user have over their information and how much they can expect from their provider (Huth & Cebula, 2011).

- **Software as a Service (SaaS)** gives the user access to the resources and application that is hosted in the cloud. SaaS also makes it easier to have the same software on all of the devices at once by accessing it on the cloud. The user does not manage or control the cloud including network, servers, operating systems, storage, or even individual application capabilities.
- **Platform as a Service (PaaS)** gives the user access to the components that they require to develop and operate their own applications over the internet. The operating systems and network access are not managed by the user and there might be constraints as to which applications can be develop.
- **Infrastructure as a Service (IaaS)** provides just the hardware and network. The users control and manage the systems in terms of the operating systems, applications, storage, network connectivity and possibly limited control of select networking components (e.g., host firewalls).

7.5.2. Deploy Application

The final phase in the development of the application is to load the application to a web hosting so it can be available for the users. For this project was chosen a service called "somee". This service is free and allows the users to update the application at any time. With this service there is no concern about the software installed and the users only use the resources provided by somee. This service is versatile and easy to use without having to worry about the license of the software.

This tool was used to manage the application in an efficient way, including updating the application and uploading the database. In figure 66 it is possible to update the application by simply clicking on the "upload" button on the following panel. This application is available on the link: http://www.ipcacarpool.somee.com.

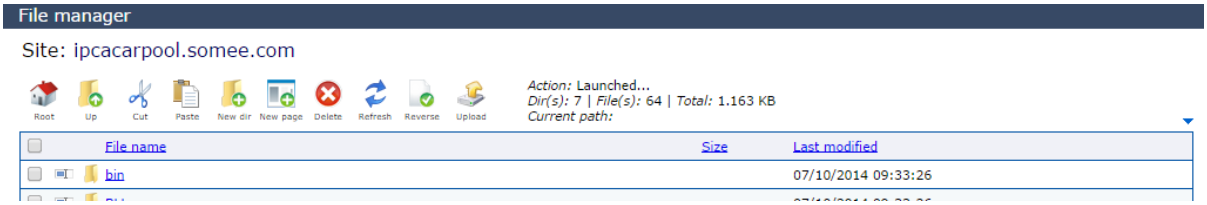


Figure 66 – Managing application with somee

7.6. Methodology

This study aimed to estimate the potential of carpooling in an academic environment. Part of this study was a web-based survey in which the attitude of the students and teachers towards carpooling was investigated. This survey was sent to all students and teacher from the Polytechnic Institute of Cavado and Ave. The total amount of respondents from this survey is 408. The main contribution of this project is to give an insight of the reasons that motivate people to consider carpooling as a possible alternative to driving alone with their own private vehicle.

7.6.1. Surveys/Questionnaires

A survey is a data gathering method that is developed to collect, analyze and interpret the views of a group of people from a target population. Surveys can be divided into two categories: questionnaire and interview. Questionnaires are usually forms that the respondent completes individually. Interviews are completed by the interviewer based on what the respondent says.

Matthews & Ross (2010) state that the design of the questionnaire is the most important stage in any type of research because once the questionnaire is designed the researcher has determined the questions and the answers. The researchers need to be certain that the questions they ask are going to enable the gathering of the needed data (Matthews & Ross, 2010).

According to Phillips, a questionnaire may contain any or all of these types of questions (Stawarski & Phillips, 2008):

- Open-ended questions allow unlimited answers. Questions are followed by ample blank space for the responses;
- Checklists provide a list of items and the respondent is asked to check those that apply in their situation;
- Two-way questions limit answers to a pair of alternative responses (yes and no);
- Multiple-choice questions provide several possible answers, and the respondent is asked to select the one that is most applicable;
- Ranking scales require the respondent to rank a list of items.

Matthews & Ross states that a questionnaire is designed to collect a number of different types of data including (Matthews & Ross, 2010):

- Facts about people or events;
- People's description about something that, for example, has happened to them;
- Knowledge of what people know about something;
- People's opinion of what they have experienced or know about;
- Background information about the respondent.

For this study the questionnaire will be designed in the way that all types of questions except open-ended questions will be used. For instance, two-way questions will help with the direct yes/no questions by determining whether the respondents have ever carpooled. The checklists will be used in order to determine which factors are most important to choose as their main mode of transportation to work/school. The multiple-choice questions were mainly used to provide several possible answers to the respondent in which one must be selected. Furthermore, ranking scales will require the respondents to rank between tasks from very unsatisfied to very satisfied. The survey that was conducted in this study was managed through the web and is illustrated in Appendix III.

Web surveys are a data collection method that can collect a large amount of varied information which can benefit the analysis. Additionally, web surveys allow data to be collected and downloaded into statistical software without additional data entry (Witt, 1998). Web surveys may also collect more honest and forthcoming answers as participants have a greater feeling of anonymity and confidentiality. However, it must be acknowledged that there is a risk of incomplete response, as well as vague responses resulting from an inability to provide clarification to respondents (Montello & Sutton, 2006).

After consideration of the above noted benefits and potential limitations of utilizing web surveys for empirical research, it was determined that sufficient controls were in place to negate the potential difficulties and elected to utilize a web-based survey format. The Survey Planet tool was both easy to use and economical. The questionnaire was sent via email, which provided an easy and immediate means of response for the participants. The results were delivered in aggregate and anonymous form and the data remained private.

7.6.2. Sampling

According to Marshall, choosing a study sample is an important step in any research project since it is rarely practical, efficient or ethical to study whole populations (Marshall, 1996).

Marshall defined three broad approaches to selecting a sample for a qualitative study (Marshall, 1996):

- Convenience sample
- Judgement sample
- Theoretical sample

Convenience sample is the least rigorous technique, involving the selection of the most accessible subjects. It is the least costly to the researcher, in terms of time, effort and money, but may result in poor quality data and lacks intellectual credibility (Marshall, 1996).

Judgement sample is also known as purposeful sample. This is the most common sampling technique. The researcher actively selects the most productive sample to answer the research question. This can involve developing a framework of the variables that might influence an individual's contribution and will be based on the researcher's practical knowledge of the research area, the available literature and evidence from the study itself (Marshall, 1996).

Theoretical sample is the iterative process of qualitative study design which means that the samples are usually theory driven to a greater or lesser extent. Theoretical sampling necessitates building interpretative theories from the emerging data and selecting a new sample to examine and elaborate on this theory. It is the principal strategy for the grounded theoretical approach but will be used in some form in most qualitative investigations necessitating interpretation (Marshall, 1996).

There are quite a lot of debates about how many participants are enough for sampling. Saldana believes that a number of sampling participants can depend on many factors, but as long as the researcher has sufficient interview data he or she then has a sufficient corpus for analysis (Saldana & Leavy, 2011).

The sample of this study contains 408 respondents, which 391 are teachers and 17 are teachers. The selection of the sample was random providing all of the elements the same probability of being included in the sample.

7.6.3. Tools used to validate the study

The Survey Planet was the tool to develop the questionnaire for this study and analyze the statistics. The Survey Planet (Figure 67) has many features to create and manage the survey, as well as the statistical analysis. This tool has a database which stores all the answers from the respondents. In addition, Excel was also used to complement the statistical analysis for this study. Figure 67 illustrates the toolbar from Survey Planet to manage the survey and results.

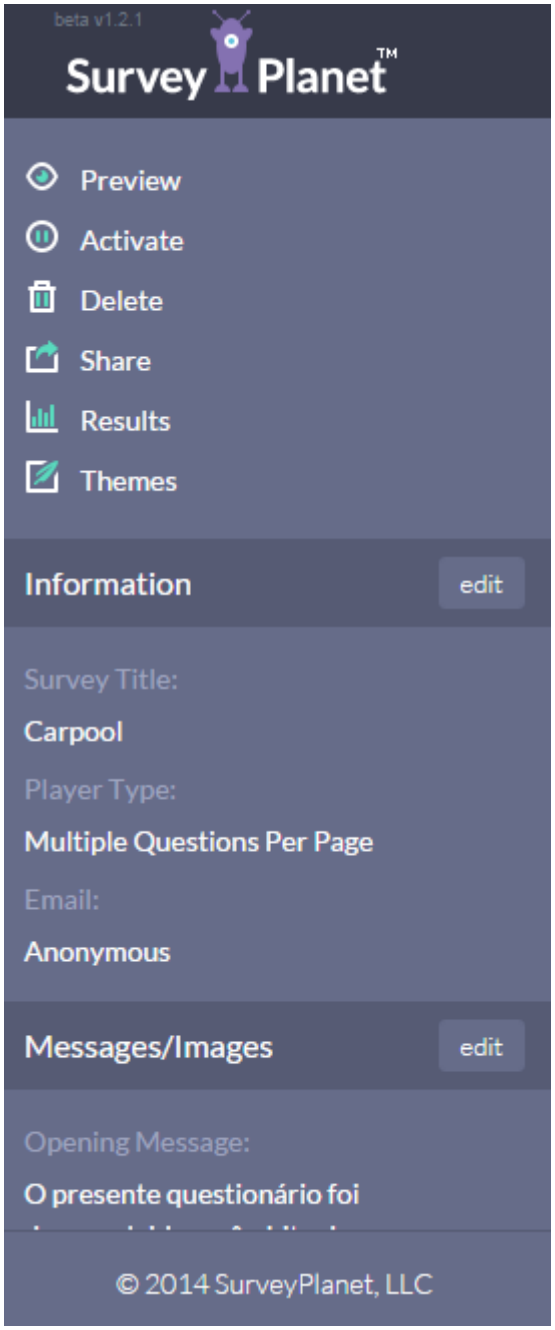


Figure 67 - Survey Planet toolbar

7.6.4. Data Analysis

In this section will demonstrate the statistical graphs that summarize the responses to the survey questions. The total amount of responses to this survey was 408 respondents. The analysis will be presented by the order of the survey and this survey can be found in Appendix III.

1. **Are you a student or teacher at IPCA?**

	Number of respondents	Percentage
Teacher	17	4%
Student	391	96%

Table 3 – Analysis of the responses from question 1

The 408 respondents of this survey, 391 (96%) were students and 17 (4%) were teachers. A significant large amount of this sample is students which is understandable since this survey was intended for an academic environment. Figure 68 illustrates the analysis of the responses regarding teachers and students.

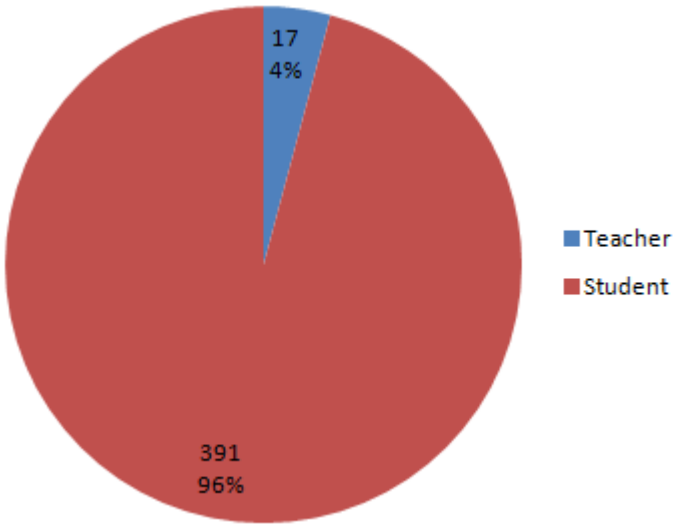


Figure 68 - Analysis of the responses from question 1

2. Gender

	Number of respondents	Percentage
Female	210	51%
Male	198	49%

Table 4 - Analysis of the responses from question 2

Of the 408 respondents who had reported their gender, 210 (51%) were female and 198 (49%) were male. The gender of this sample is approximately equal which makes it ineffective to take conclusions. Figure 69 illustrates the analysis of the responses regarding the gender.

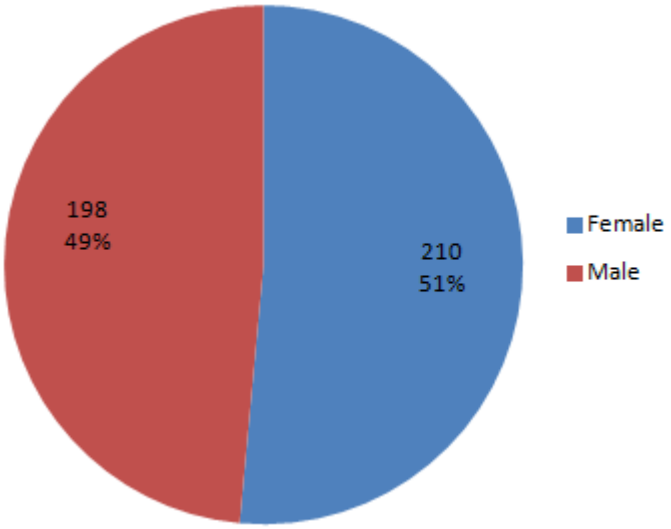


Figure 69 - Analysis of the responses from question 2

3. Age

	Number of respondents	Percentage
Less than 20 years old	20	5%
20-25 years old	112	27%
25-30 years old	138	34%
30-40 years old	100	25%
More than 40 years old	38	9%

Table 5 - Analysis of the responses from question 3

The ages of this sample were mainly from the range of 20-40 years old. From 20-25 years old were 112 (27%) respondents, 138 (34%) were from the age of 25-30 years old and 100 (25%) were from the age of 30-40 years old. Figure 70 illustrates the analysis of the responses regarding age.

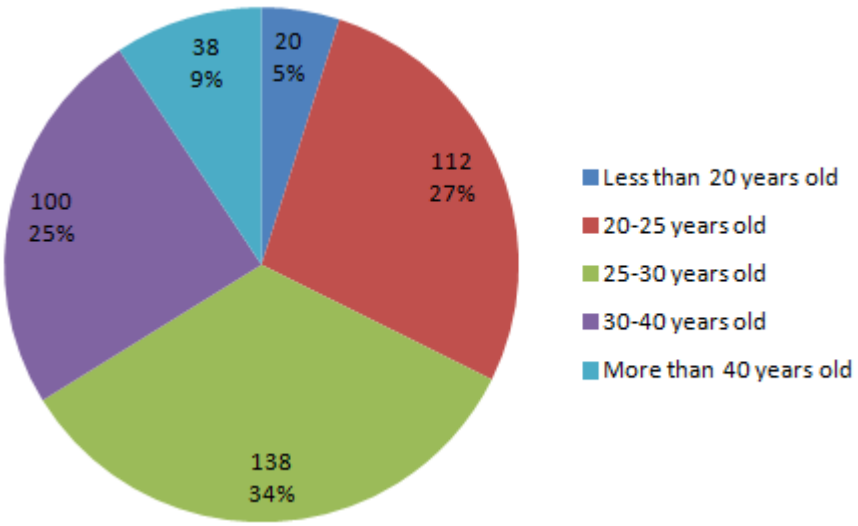


Figure 70 - Analysis of the responses from question 3

4. Approximately how long does it take you to travel from your home to campus?

	Number of respondents	Percentage
Less than 15 minutes	109	27%
15-30 minutes	127	31%
30-45 minutes	115	28%
45-60 minutes	36	9%
60-90 minutes	18	4%
More than 90 minutes	3	1%

Table 6 - Analysis of the responses from question 4

The table demonstrated above concludes that a majority of the respondents travel 15-30 minutes from home to campus (31%). However, a good quantity of respondents takes less than 15 minutes (27%) from home to campus and 28% takes 30-45 minutes. Figure 71 illustrates the analysis of the responses from question 4.

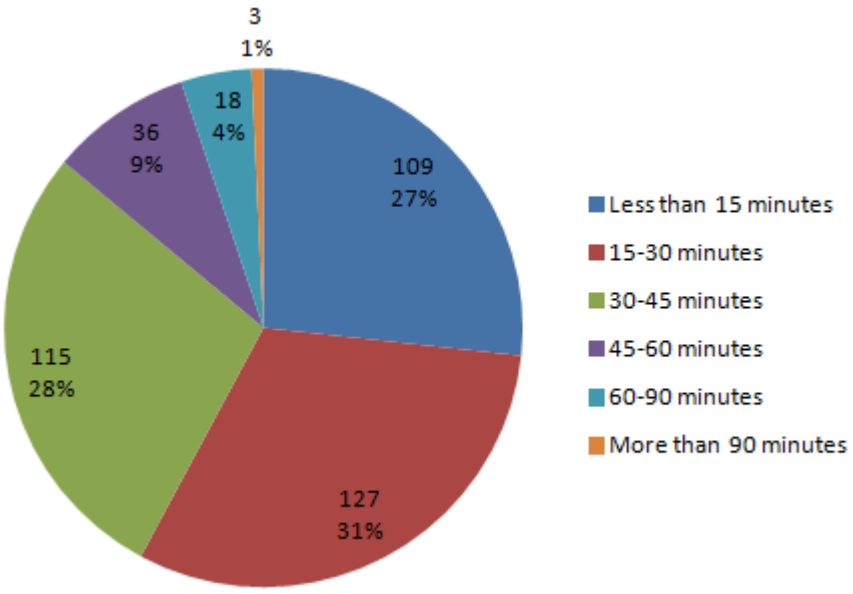


Figure 71 - Analysis of the responses from question 4

5. What is your main mode of transportation when commuting to work/school?

	Number of respondents	Percentage
Walking	5	1%
Bike riding	2	1%
Public transport	78	19%
Car (single occupant)	201	49%
Car (multi occupant)	121	30%
Other	1	0%

Table 7 - Analysis of the responses from question 7

While a majority of respondents drive a car to and from work/school, most do not carpool. The table demonstrated above concludes that almost half of the sample for this study commutes alone to work/school (201 respondents – 49%). However, a fair amount of respondents carpool to work/school (30%) or in other words 121 respondents commute to work/school with someone. Figure 72 illustrates the analysis of the responses from question 5.

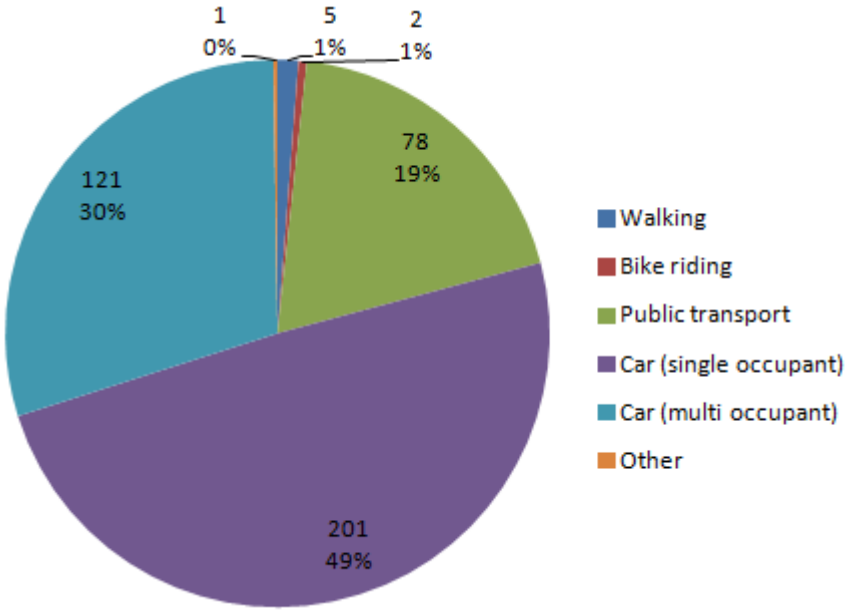


Figure 72 - Analysis of the responses from question 5

6. What factors are most important for you to choose your mean of transportation to work/school?

	Number of respondents	Percentage
Travel time	212	24%
Cost	310	34%
Flexibility	151	17%
Comfort and safety	49	5%
Reducing pollution and conserving energy	27	3%
Ability to make stops on route	83	9%
Stress	69	8%

Table 8 - Analysis of the responses from question 6

For this type of question was used a checklist in which the respondent can check as many items from the list that applies to them. The 3 most popular factors that the respondents choose as their main mode of transportation are: cost (34%), travel time (24%) and flexibility (17%). Figure 73 illustrates the analysis of the responses from question 6.

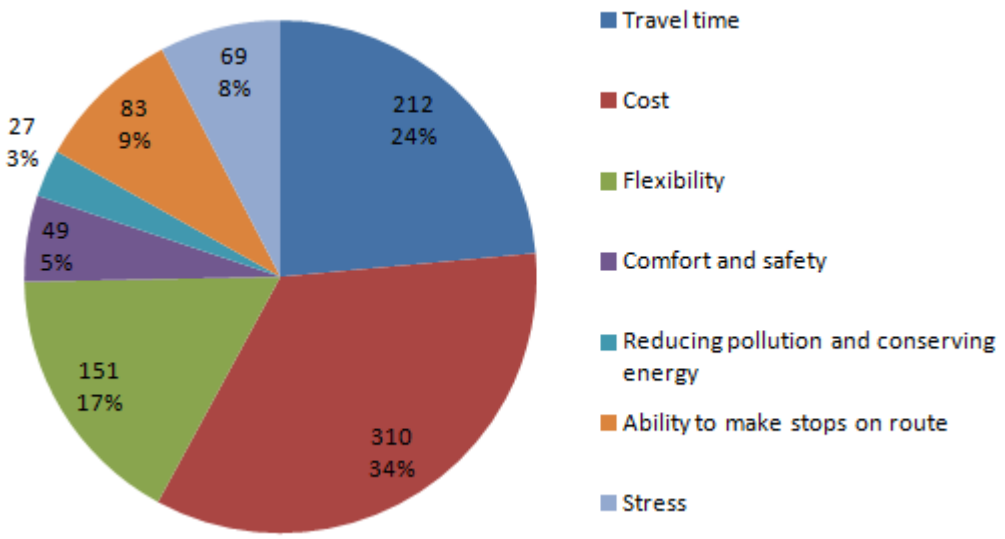


Figure 73 - Analysis of the responses from question 6

7. Please rate how satisfied you are with the following areas.

	Very Dissatisfied	Somewhat Dissatisfied	Neither	Somewhat Satisfied	Very Satisfied
The way you currently get to work/school	4 (1%)	11 (3%)	54 (13%)	129 (32%)	210 (51%)
Walking distance from parking to work/school	7 (2%)	21 (5%)	79 (19%)	139 (34%)	162 (40%)
Finding a parking space	126 (31%)	130 (32%)	120 (29%)	23 (6%)	9 (2%)

Table 9 - Analysis of the responses from question 7

This type of question used a ranking scale in which the respondent rank the items between 1 to 5 where 1 is very dissatisfied and 5 is very satisfied. The table demonstrated above concludes that the respondents are satisfied with the way they currently get to work/school and the walking distance from the parking spot to work/school. However, most of the respondents are dissatisfied of finding parking spots. Figure 74 illustrates the analysis of the responses from question 7.

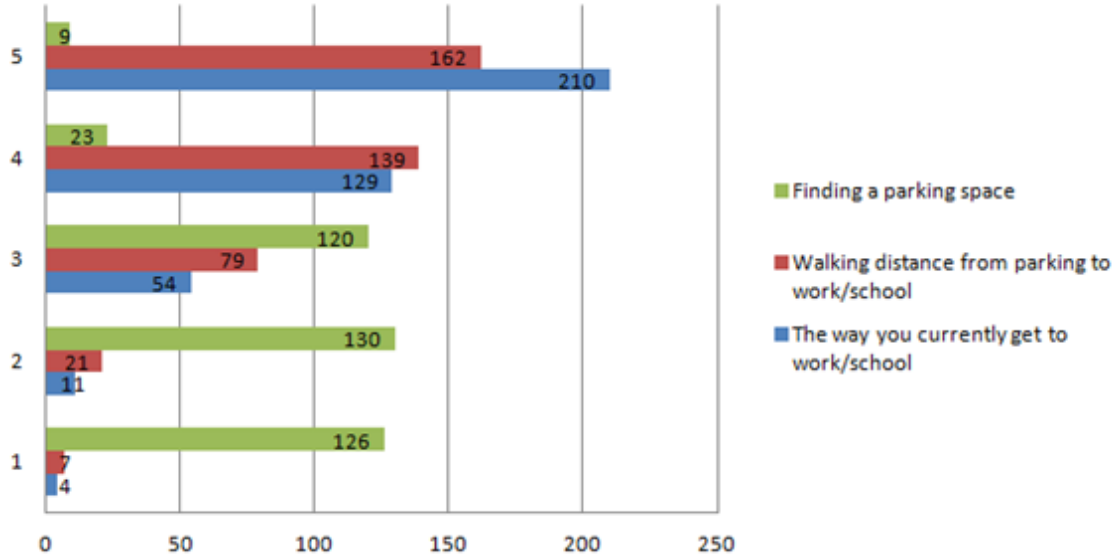


Figure 74 - Analysis of the responses from question 7

8. Have you ever carpooled? If no, skip to question 14.

	Number of respondents	Percentage
Yes	121	30%
No	287	70%

Table 10 - Analysis of the responses from question 8

The table demonstrated above concludes that, out of 408 respondents, 287 (70%) respondents have never carpooled. The following questions until question 14 are related to respondents that have already carpooled in the past. Figure 75 illustrates the analysis of the responses from question 8.

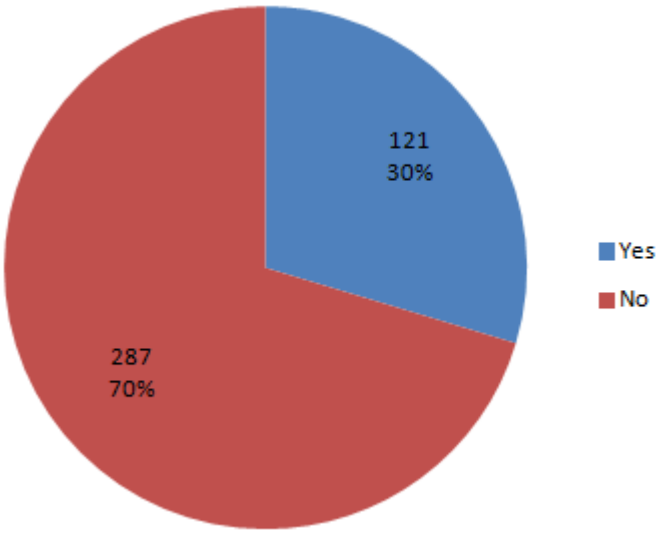


Figure 75 - Analysis of the responses from question 8

9. What motivated you to carpool?

	Number of respondents	Percentage
Needed a ride	25	21%
Had space in vehicle	22	18%
Travelling with friends/colleagues	74	61%

Table 11 - Analysis of the responses from question 9

The table demonstrated above concludes that a majority of the respondents (61%) were motivated to carpool due to travelling with friends/colleagues. However, approximately the same amount of respondents (around 20%) was motivated to carpool because they needed a ride or had space in their vehicle. Figure 76 illustrates the analysis of the responses from question 9.

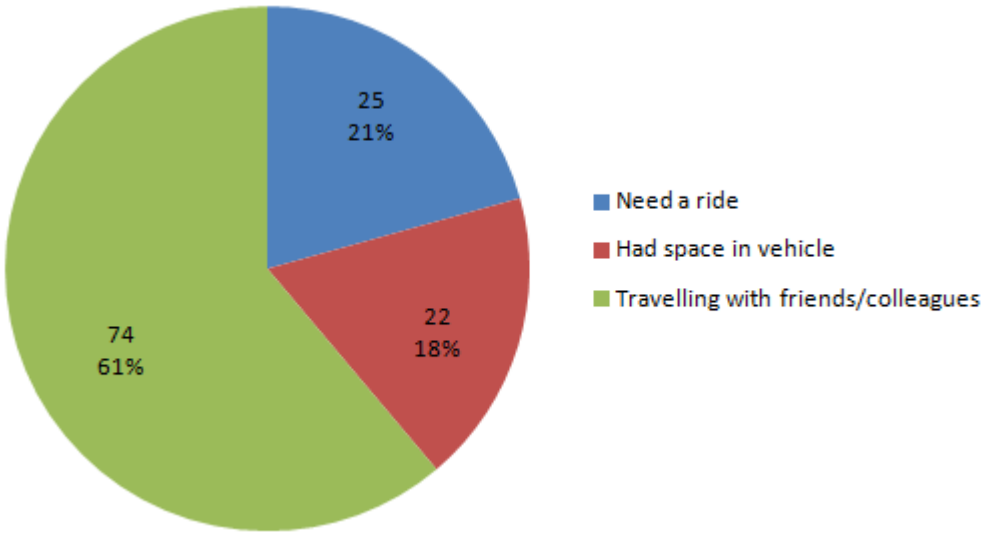


Figure 76 - Analysis of the responses from question 9

10. What is the main reason you carpool?

	Number of respondents	Percentage
Save time	27	22%
Reduce traffic congestion	0	0%
Save money	76	63%
Transit too crowded and unreliable	5	4%
Improve air quality	0	0%
More flexible than other options	13	11%

Table 12 - Analysis of the responses from question 10

The table demonstrated above concludes that most of the respondents (63%) choose carpool because it saves money. This can be very understandable due to our economics. On

the other hand, no one from the sample chose the environment as a reason to carpool. No respondents chose reduce traffic congestion and improve air quality as their reason to carpool. Figure 77 illustrates the analysis of the responses from question 10.

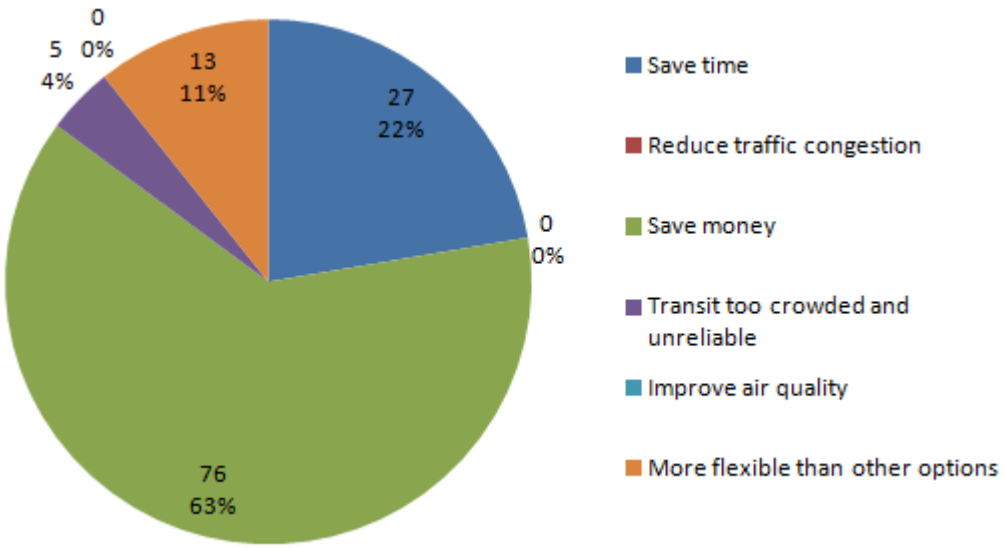


Figure 77 - Analysis of the responses from question 10

11. How long have you been carpooling?

	Number of respondents	Percentage
Less than a year	63	52%
1-2 years	42	35%
3-5 years	13	11%
6-9 years	2	1%
More than 10 years	1	1%

Table 13 - Analysis of the responses from question 11

Out of the 121 respondents that have carpooled, 63 (52%) respondents started carpooling less than a year ago. However, only 3 respondents have carpooled over 6 years. These results conclude that carpool is a recent mode of transportation. Figure 78 illustrates the analysis of the responses from question 11.

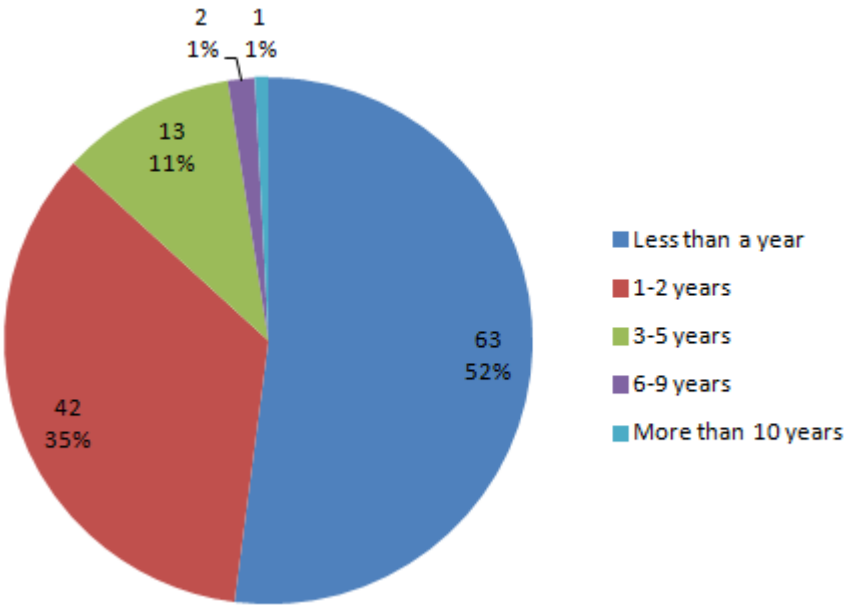


Figure 78 - Analysis of the responses from question 11

12. How often do you carpool to work/school?

	Number of respondents	Percentage
Occasionally	39	32%
Once a week	26	21%
2-3 days a week	42	35%
4-5 days a week	13	11%
6-7 days a week	1	1%

Table 14 - Analysis of the responses from question 12

Most of the respondents carpooled to work/school occasionally or up to 3 days a week. 39 (32%) respondents carpooled occasionally to work/school, 26 (21%) respondents carpooled once a week to work/school and 42 (35%) respondents carpooled 2-3 days a week. Figure 79 illustrates the analysis of the responses from question 12.

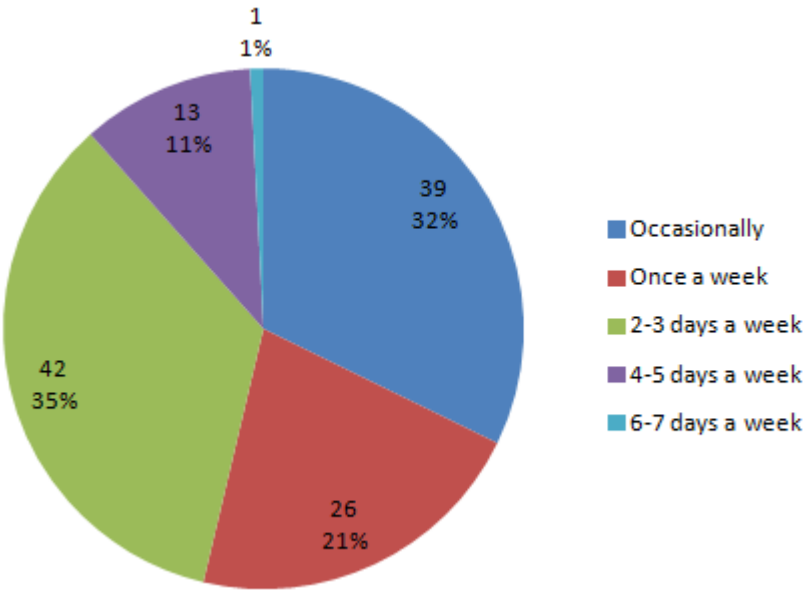


Figure 79 - Analysis of the responses from question 12

13. Are you normally a driver or passenger? After this question please skip to question 19.

	Number of respondents	Percentage
Normally I drive	63	52%
Normally I'm a passenger	42	35%
A little of both	13	11%

Table 15 - Analysis of the responses from question 13

All respondents that have carpooled were classified as drivers, passengers or a little of both (i.e., sometimes they drive and sometimes they are passengers). Half of the respondents (52%) normally drive in a carpool, while 35% of the respondents are normally a passenger. However, 11% of the respondents travel in a carpool alternatively as a driver and passenger. Figure 80 illustrates the analysis of the responses from question 13.

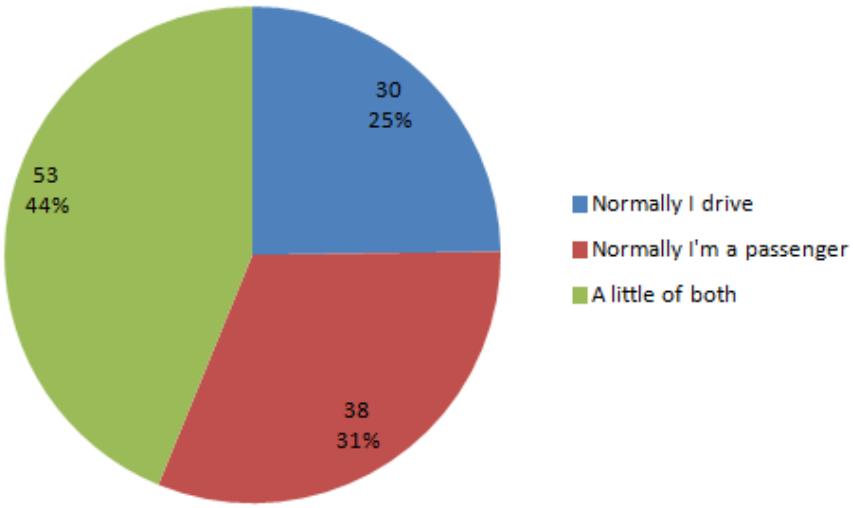


Figure 80 - Analysis of the responses from question 13

14. What is your main reason to not carpool in a regular basis?

	Number of respondents	Percentage
Need to run errands before and after work/school	47	16%
Irregular work/school schedule	76	27%
Cannot get home in an emergency	15	5%
Prefer to drive alone	69	24%
Don't have anyone to ride with	41	14%
Don't like to depend on others	39	14%

Table 16 - Analysis of the responses from question 14

The two main reasons why the respondents don't carpool in a regular basis are irregular work/school schedule (27%) and prefer to drive alone (24%). The least common reason respondents don't carpool in a regular basis is that they cannot get a ride home in case of an emergency (5%). Figure 81 illustrates the analysis of the responses from question 14.

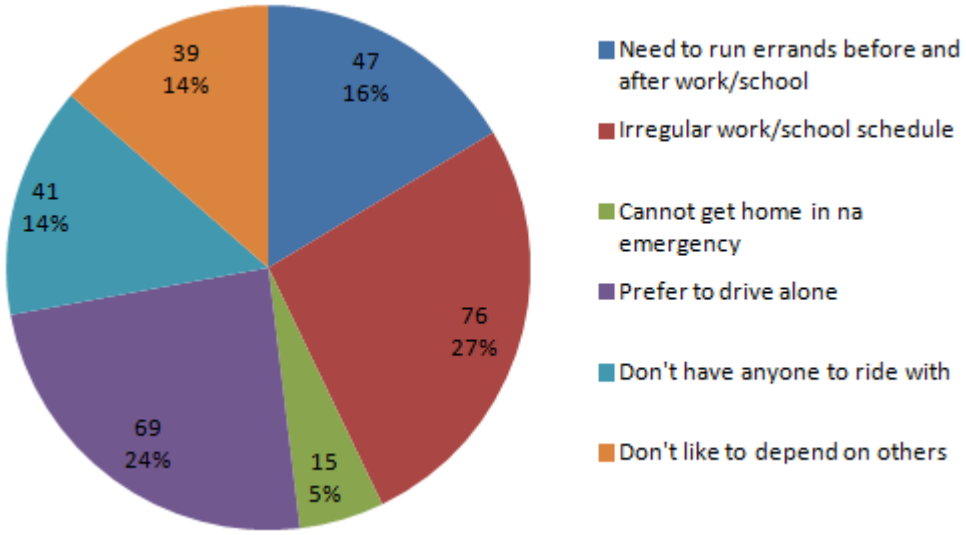


Figure 81 - Analysis of the responses from question 14

15. What concerns do you have about carpooling?

	Number of respondents	Percentage
Concerned about not knowing who my fellow passenger(s) might be like	63	22%
They won't be ready to arrive or leave when I'm ready to	153	53%
Not comfortable with giving out my information to strangers	71	25%

Table 17 - Analysis of the responses from question 15

The table demonstrated above concludes that half of the respondents (53%) that don't carpool have concerns that the commuters won't be ready on time to leave or arrive at the location. Approximately 25% of the respondents have concerns about carpooling about not

knowing who the passenger(s) might be like and not being comfortable with giving out information to strangers. Figure 82 illustrates the analysis of the responses from question 15.

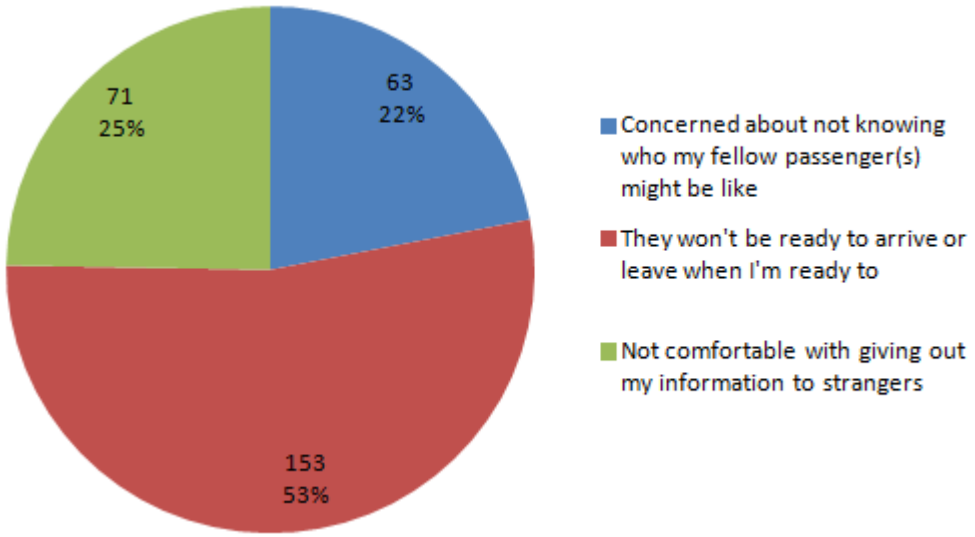


Figure 82 - Analysis of the responses from question 15

16. What would motivate you to join a carpool?

	Number of respondents	Percentage
Cost savings	138	48%
Time savings	16	6%
Stress reduction	17	6%
Guaranteed ride home program	31	11%
Save wear and tear on vehicle	36	12%
Preferential parking	49	17%

Table 18 - Analysis of the responses from question 16

The table demonstrated above concludes that half of the respondents (48%) that don't carpool would be motivated to join a carpool to save money. The next motivation that respondents would choose to join a carpool is preferential parking (17%). Figure 83 illustrates the analysis of the responses from question 16.

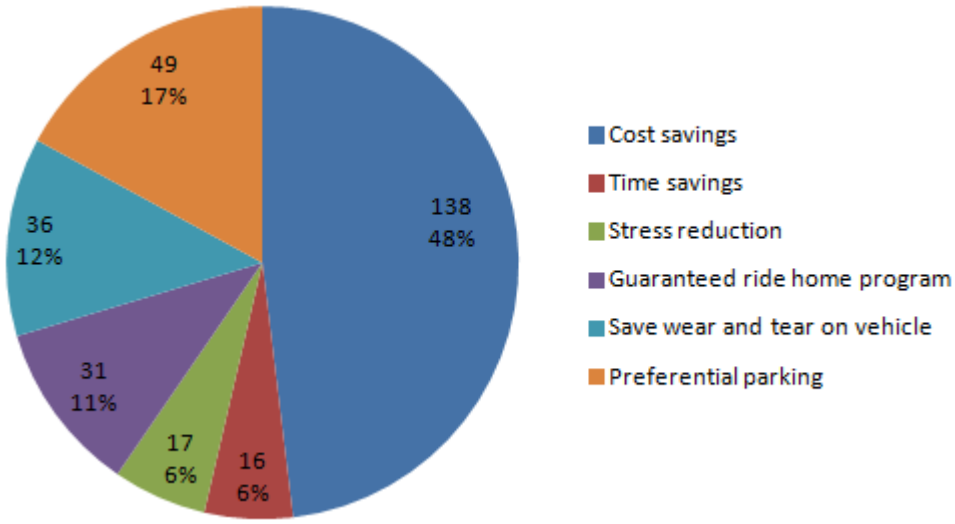


Figure 83 - Analysis of the responses from question 16

17. Would you be more likely to carpool if there was a dedicated parking for carpool vehicles?

	Number of respondents	Percentage
Yes	241	84%
No	46	16%

Table 19 - Analysis of the responses from question 17

The table demonstrated above concludes that a majority of the respondents (84%) would more likely carpool if there was a dedicated parking for carpool vehicles. If better parking spots were guaranteed, as compared to traditional lot parking, they would consider carpooling. Figure 84 illustrates the analysis of the responses from question 17.

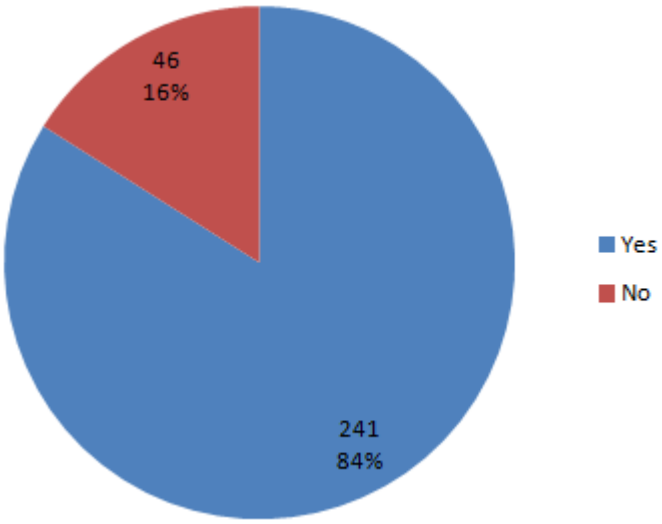


Figure 84 - Analysis of the responses from question 17

18. Would you consider carpooling?

	Number of respondents	Percentage
Yes	264	92%
No	23	8%

Table 20 - Analysis of the responses from question 18

Among students and teachers, 8% state they would not consider carpooling, whereas 92% of the respondents have an open mind towards carpooling. These results show that if an incentive to carpool existed, many students and teachers would take advantage. Figure 85 illustrates the analysis of the responses from question 18.

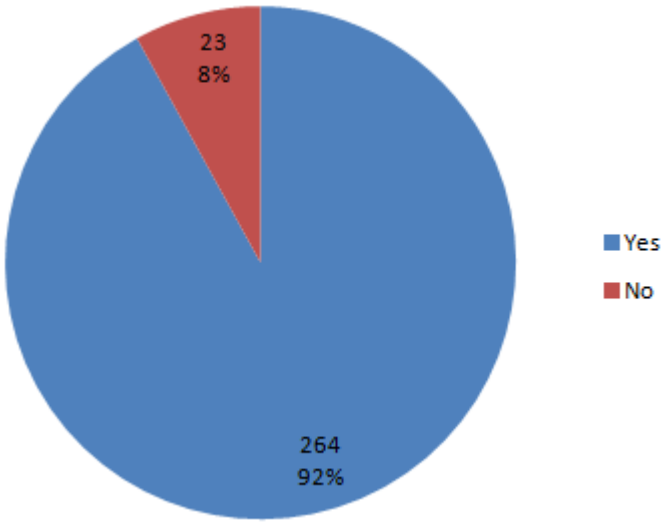


Figure 85 - Analysis of the responses from question 18

19. How would you rate the website?

	Number of respondents	Percentage
Very poor	2	1%
Below average	8	2%
Average	99	24%
Good	155	38%
Excellent	144	35%

Table 21 - Analysis of the responses from question 19

According to the results in the table demonstrated above, most of the respondents rate the website as good or excellent. Among the students and teachers, 38% of the respondents rate the website as good and another 35% rate as excellent. In additional, 24% of the respondents rate the website as average. Figure 86 illustrates the analysis of the responses from question 19.

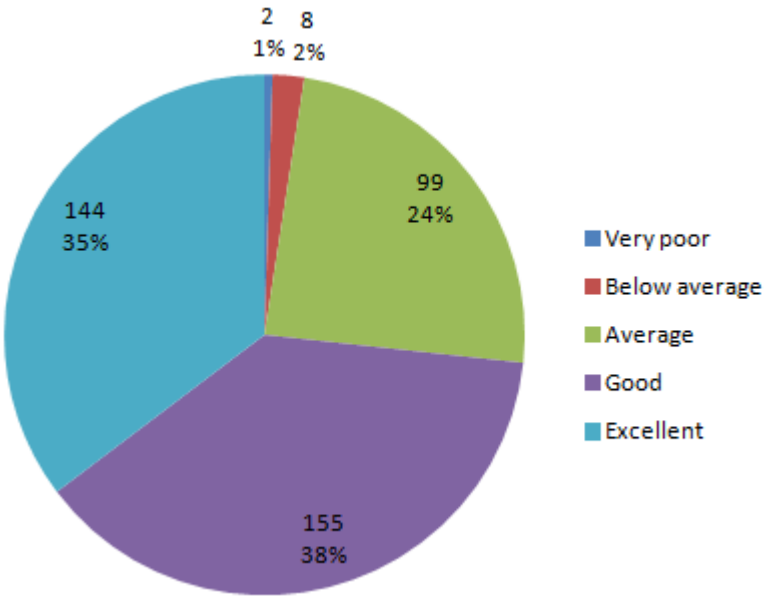


Figure 86 - Analysis of the responses from question 19

20. Please rate your overall experience with the website.

	Number of respondents	Percentage
Very poor	12	3%
Below average	16	4%
Average	87	21%
Good	140	34%
Excellent	153	38%

Table 22 - Analysis of the responses from question 20

According to the results in the table demonstrated above, most of the respondents rate their overall experience as good or excellent. These results are similar to the previous question. 34% of the respondents rate their overall experience as good and another 38%

rate as excellent. In additional, 21% of the respondents rate their overall experience as average. Figure 87 illustrates the analysis of the responses from question 20.

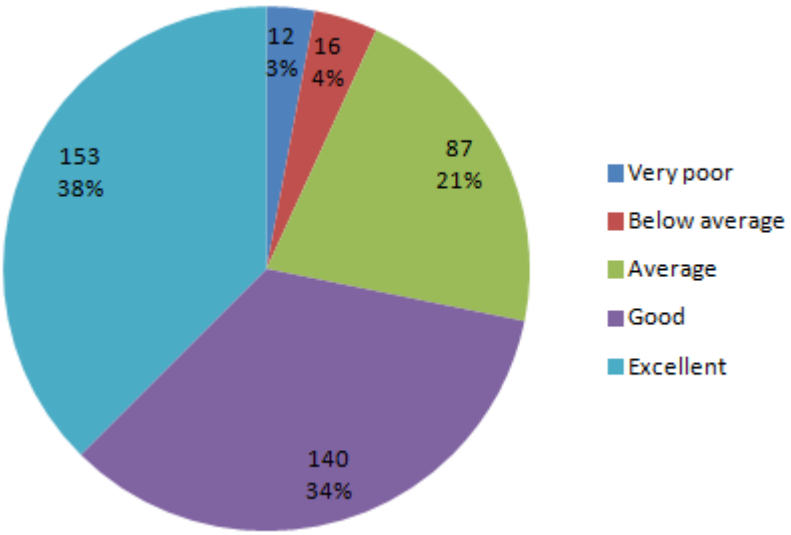


Figure 87 - Analysis of the responses from question 20

21. How successful were you in accomplishing what you were trying to do?

	Did not try to do this	Not at all Successful	Partially Successful	Completely Successful
Register within the system	5 (1%)	13 (3%)	203 (50%)	187 (46%)
Gather ride/commute information	10 (3%)	14 (3%)	185 (45%)	199 (49%)
Gather information about requests/offers	3 (1%)	9 (2%)	194 (47%)	202 (50%)
Register ride	7 (2%)	15 (4%)	189 (46%)	197 (48%)
Search ride	4 (1%)	5 (1%)	197 (48%)	202 (50%)

Table 23 - Analysis of the responses from question 21

This type of question used a ranking scale in which the respondents rank how successful they were in accomplishing the tasks listed in the table demonstrated above. This table concludes that a majority of the respondents were partially or completely successful in accomplishing the task listed in the table. Figure 88 illustrates the analysis of the responses from question 21.

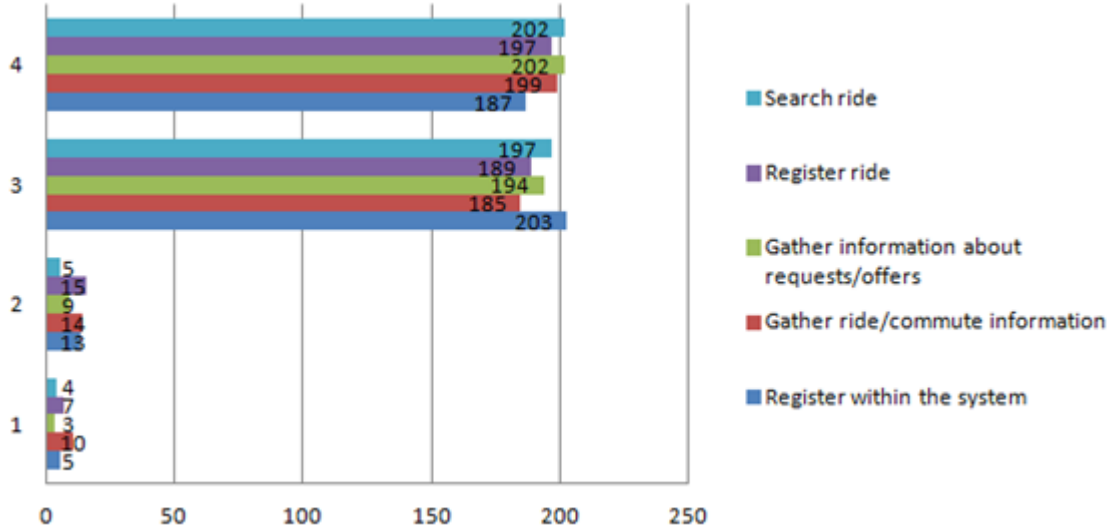


Figure 88 - Analysis of the responses from question 21

22. Please rate the website in each if the following areas.

	Very Poor	Below Average	Average	Good	Excellent
Quality of the content	5 (1%)	10 (3%)	115 (28%)	149 (37%)	129 (31%)
Ease of navigating the website	7 (2%)	13 (3%)	113 (27%)	141 (35%)	134 (33%)
Layout/design of the website	6 (1%)	8 (2%)	99 (24%)	141 (35%)	154 (38%)
Organization of the website	3 (1%)	7 (2%)	101 (24%)	155 (38%)	142 (35%)
Ease in accomplishing what you were trying to do	5 (1%)	17 (4%)	103 (25%)	135 (33%)	148 (37%)

Table 24 - Analysis of the responses from question 22

This type of question used a ranking scale in which the respondents rank the items between 1 to 5 where 1 is very poor and 5 is excellent. The table demonstrated above concludes that the respondents rate the overall website as average to excellent. Figure 89 illustrates the analysis of the responses from question 22.

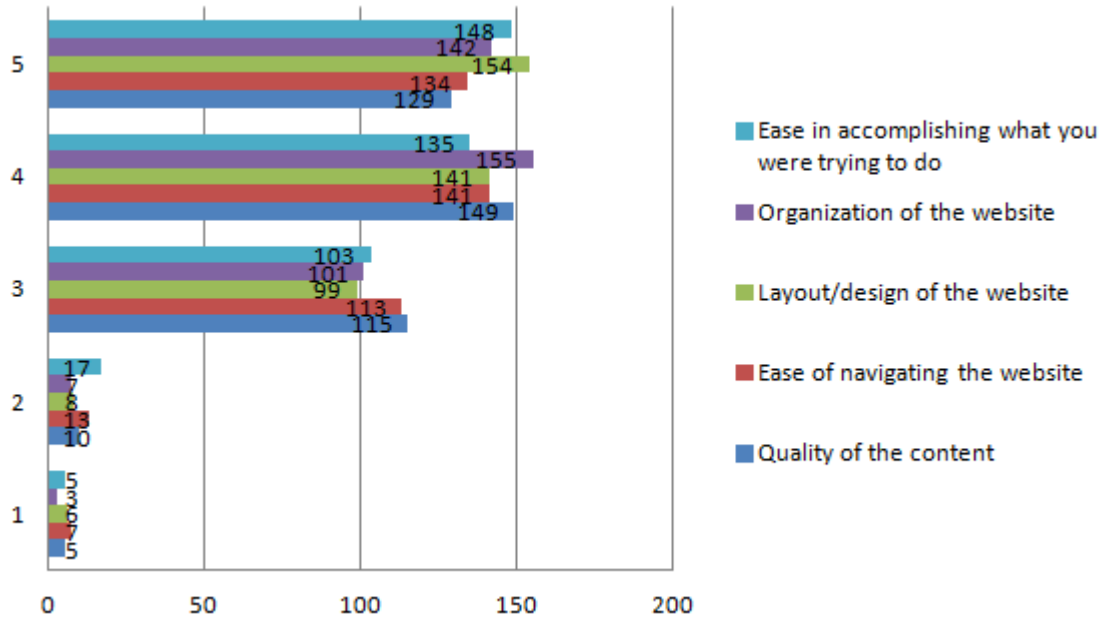


Figure 89 - Analysis of the responses from question 22

23. Would you recommend this website to a colleague/friend?

	Number of respondents	Percentage
Yes	395	97%
No	13	3%

Table 25 - Analysis of the responses from question 23

According to the table demonstrated above, 97% of the respondents would recommend this website to a colleague or friend. Figure 90 illustrates the analysis of the responses from question 23.

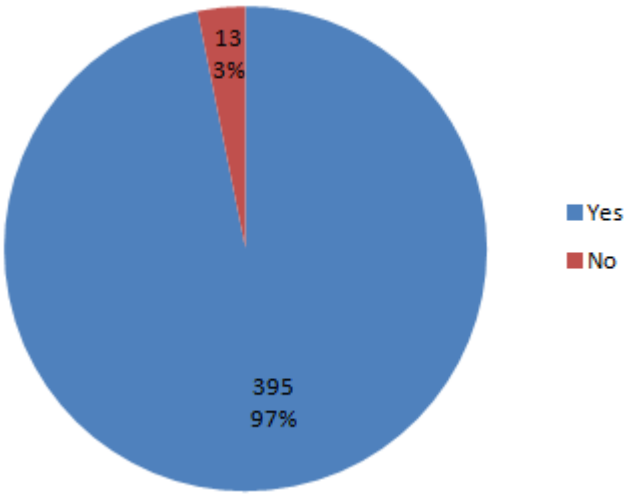


Figure 90 - Analysis of the responses from question 23

24. Would you visit this website again?

	Number of respondents	Percentage
Yes	391	96%
No	17	4%

Table 26 - Analysis of the responses from question 24

According to the table demonstrated above, 96% of the respondents would visit this website again. Figure 91 illustrates the analysis of the responses from question 24.

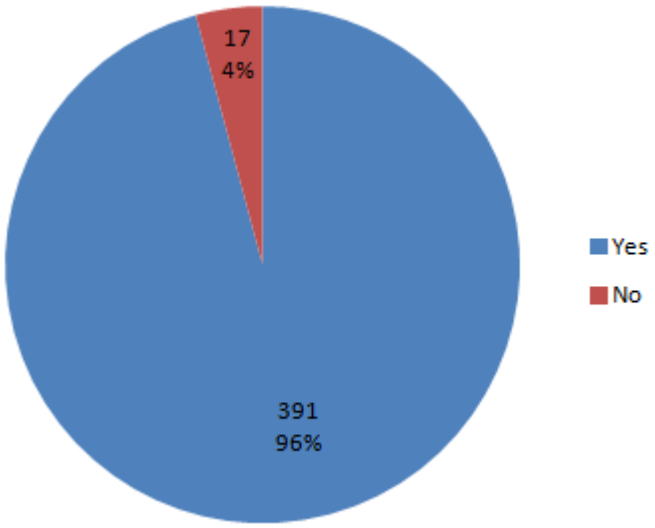


Figure 91 - Analysis of the responses from question 24

8. Conclusion and Recommendations for Future Work

This project developed a Web application that helps teachers and students from an academic environment to create carpool matches. The objectives and requirements have been successfully implemented, achieving our original expectations for this thesis.

This thesis demonstrates the results of studies that has been made in the past and demonstrates the implementation of the application step by step. With this implementation, knowledge and experience has been achieved by programming in ASP.NET and AJAX in Visual Studio and programming in JavaScript by integrating Google Maps API. The implementation of this project gained a learning experience, such as, the capability of being creative and the ability to solve problems.

During the development of this project, several skills and knowledge learnt in the past were put into practice and new knowledge has been achieved that will certainly be an asset in the future in a professional and personal level. The development of this application had many difficulties, particularly in the programming area. However, these difficulties have overcome all the expectations giving a successful result.

The implemented system has a great deal of potential for future expansion. This application requires improvements in order to increase its efficiency and to implement new features.

A web-based survey was developed to study the reasons that motivate people to consider carpooling. To develop this survey was used a tool called Survey Planet. This survey contained 408 respondents, which 391 are students and 17 are teachers. This study concludes that a majority of the respondents don’t carpool, however they will consider carpooling if there was a dedicated parking space. This study also concludes that a majority of the respondents don’t carpool because they have irregular schedules. Most of the respondents that carpool only started less than a year ago, indicating that this mean of transportation is recent.

As future work there could be added more features to the application, such as:

- Generate the schedules of the students and teachers. For example, when a student registers with the application, automatically the system will know what their schedule is for that academic year;
- Adding a new program for an emergency ride home;
- Optimizing the rides by widening the radius of each search.

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APPENDICES

Appendix I – Description of the Tables

In this appendix will be focused on the description of the tables of the database.

Attribute	Description
UserID	User identification (primary key)
Name	Name of the user
Email	Email of the user to login
Password	Password to login
Profile	If user is passenger, driver or both
UserType	If user is student or teacher
Gender	Gender of the user
Telephone	Contact number of the user
Smoker	If user is smoker or non-smoker
HasCar	If user has a car or no car
Address	Address of the user
Lat	Latitude of the address
Lng	Longitude of the address

Table 27 - Table Users

Attribute	Description
RouteID	Route identification (primary key)
AddressO	Address of the origin
LatO	Latitude of the origin
LngO	Longitude of the origin
AddressD	Address of the destination
LatD	Latitude of the destination
LngD	Longitude of the destination
UserID	User identification

Table 28 - Table Route

Attribute	Description
SchedID	Schedule identification (primary key)
Date	Date of the schedule
HSaida	Time of the departure
HChegada	Time of the arrival
RouteID	Route identification
SeatsAvailable	Available seats for the ride
TypeCarpool	Identify if the ride is offered or requested

Table 29 - Table Schedule

Attribute	Description
RideID	Route identification (primary key)
UserID	User identification
ConfirmRide	Confirm the ride
SchedID	Schedule identification
MeetingPoint	Address of the meeting point
LatMR	Latitude of the meeting point
LngMR	Longitude of the meeting point
RequestDate	Date when the ride was requested
Obs	Observations of the ride

Table 30 - Table Ride

Attribute	Description
RideID	Route identification (primary key)
TypeEvaluationID	Identification of the type of evaluation (primary key)
Rate	Rate of the evaluation
Obs	Observations of the evaluation

Table 31 - Table Evaluation

Attribute	Description
TypeEvaluationID	Identification of the type of evaluation (primary key)
Description	Description of the type of evaluation

Table 32 - Table TypeEvaluation

Appendix II – Description of the Use Cases

In this appendix will be focused on the description of the use cases.

Use Case	Register New User
Actors	Anonymous User
Summary	Register a new user in the system.
Precondition	The user is registered with the Polytechnic Institute of Cávado and Ave (IPCA).
Post condition	The user has registered successfully with the carpool system.
Basic Flow of Events	
Actors Action	**System Response**
1. The user opens the Carpool website and clicks on “Register Now”. 3. The user enters all the information needed and clicks “Submit”.	2. System prompts the user to enter personal information including name, gender, telephone, address and email into the empty fields. The user will also choose a password, entering it twice for confirmation. In additional, the user will indicate: if is a student or teacher, if is a smoker or non-smoker, if has a car or no car and how the user is willing to carpool, such as driver and/or passenger. 4. System validates form data, then saves the information into the database and acknowledges that the user has been registered.
Alternative Flows	
	4a. Invalid or missing information. System prompts user to correct any incorrect or missing fields and resubmit. 4b. The user already exists in the system. System informs the user that the user already exists.

Table 33 - Use Case: Register New User

Use Case	Check Email is Available
Actors	Anonymous User
Summary	Check if email is available in the system.
Precondition	The user is registered with the Polytechnic Institute of Cávado and Ave (IPCA).
Post condition	The email is available and the user has registered successfully with the carpool system.
Basic Flow of Events	
Actors Action	**System Response**
1. The user opens the Carpool website and clicks on "Register Now". 3. The user enters all the information needed.	2. System prompts the user to enter personal information, including their email. 4. System validates the email and displays "Email available".
Alternative Flows	
	4a. Email already taken. If email already exists, the system displays "Email already taken".

Table 34 - Use Case: Check Email is Available

Use Case	Search Rides
Actors	Anonymous User
Summary	The user can search a ride on the system.
Precondition	The user already exists in the system.
Post condition	The user has searched successfully a ride.
Basic Flow of Events	
Actors Action	**System Response**
1. The user clicks on the "Search Rides" menu. 3. The user enters the information and clicks "Search". 5. The user can view the details of each ride and contact the carpooler directly.	2. System prompts to enter the details of the ride they want to search, such as, departure and arrival address, date and type. The only field mandatory to enter is the type of ride (offer or request). 4. System displays a list of rides according to the search. 6. System prompts a contact form for

	the user to contact the carpooler of the ride they want.
Alternative Flows	
5a. The user must be logged in. To contact the carpooler directly, the user must be logged in.	

Table 35 - Use Case: Search Rides

Use Case	Show List of Possible Rides
Actors	Anonymous User
Summary	The user can view a list of rides from their search.
Precondition	The user already exists in the system.
Post condition	The user views a list of possible rides from their search.
Basic Flow of Events	
Actors Action	**System Response**
1. The user clicks on the "Search Rides" menu. 3. The user enters the information and clicks "Search".	2. System prompts to enter the details of the ride they want to search, such as, departure and arrival address, date and type. The only field mandatory to enter is the type of ride (offer or request). 4. System displays a list of possible rides according to the search.
Alternative Flows	

Table 36 - Use Case: Show List of Possible Rides

Use Case	Select Carpooler to Contact
Actors	Anonymous User
Summary	The user can contact a carpooler of a specific ride.
Precondition	The user already exists in the system and is already logged into the system.
Post condition	The user can contact a carpooler.
Basic Flow of Events	

Actors Action	**System Response**
1. The user clicks on the "Search Rides" menu. 3. After making a search, the user can view the details of each ride and contact the carpooler directly.	2. System prompts to enter the details of the ride they want to search, such as, departure and arrival address, date and type. The only field mandatory to enter is the type of ride (offer or request). 4. System prompts a contact form for the user to contact the carpooler of the ride they want.
Alternative Flows	
3a. The user must be logged in. To contact the carpooler directly, the user must be logged in.	

Table 37 - Use case: Select Carpooler to Contact

Use Case	Send Email to Carpooler
Actors	Authenticated User
Summary	The user can send an email to a carpooler.
Precondition	The user already exists in the system and is already logged into the system.
Post condition	The user can send an email to a carpooler.
Basic Flow of Events	
Actors Action	**System Response**
1. The user clicks on "Confirm Requests/Offers" on the "My Account" menu. 3. The user clicks on "view" to view the details of the requests and offers that hasn't been confirmed yet. 5. The user clicks on the "Contact" button. 7. The user fills out the contact form and clicks "Send".	2. System displays a list of all the requests and offers that hasn't been confirmed. 4. System displays the details of the selected request or offer. 6. System displays a contact form, where the user needs to enter their name, email, subject and message. 8. System validates the contact form and sends an email to the carpooler.
Alternative Flows	

3a. Carpooler not logged in. The user needs to be logged in to view the details of the requests and offers.	8a. Contact form incomplete. System prompts an error message if all the fields of the form are not filled out.

Table 38 - Use Case: Send Email to Carpooler

Use Case	View Requests/Offers not Confirmed
Actors	Authenticated User
Summary	The user can view a list of requests and offers that has not been confirmed.
Precondition	The user already exists in the system and is already logged into the system.
Post condition	The user can view a list of all the requests and offers that has not been confirmed.
Basic Flow of Events	
Actors Action	**System Response**
1. The user clicks on "Confirm Requests/Offers" on the "My Account" menu.	2. System displays a list of all the requests and offers that has not been confirmed.
Alternative Flows	

Table 39 - Use Case: View Requests/Offers not Confirmed

Use Case	Accept/Decline Requests/Offers
Actors	Authenticated User
Summary	The user can accept or decline a request or offer.
Precondition	The user already exists in the system and is already logged into the system.
Post condition	The user can confirm all the requests or offers.
Basic Flow of Events	
Actors Action	**System Response**
1. The user clicks on "Confirm Requests/Offers" on the "My Account" menu.	2. System displays a list of all the requests and offers that hasn't been confirmed.

3. The user clicks on "view" to view the details of the requests and offers that hasn't been confirmed yet. 5. The user accepts or declines the requests/offers.	4. System displays the details of the selected request or offer. 5. System validates the confirmation and saves this information into the system.
Alternative Flows	

Table 40 - Use Case: Accept/Decline Requests/Offers

Use Case	Forgot Password
Actors	Authenticated User
Summary	If the user can't remember the password, he/she can obtain it via email.
Precondition	The user has a carpool account.
Post condition	Password is sent by email and the user can log in.
Basic Flow of Events	
Actors Action	**System Response**
1. The user clicks on "Forgot Password". 3. The user enters their email address and clicks "Submit". 5. The user enters the password received by email into the login form on the website.	2. System prompts user to enter their email address. 4. System sends an email to user with the login information about the email and password. 6. System authenticates user's details successfully and logs in.
Alternative Flows	
3a. Email entered does not correspond to any registered user. System displays "The email you entered does not exist".	6a. Invalid Login. The user's email does not match the database. The system prompts an error and asks the user to re-enter the email and/or password.

Table 41 - Use Case: Forgot Password

Use Case	Verify Email in Database
Actors	Authenticated User
Summary	Verify if email exists in the system.
Precondition	The user has a carpool account.

Post condition	The email exists in the system and the user receives an email so they can log in.
Basic Flow of Events	
Actors Action	**System Response**
1. The user clicks on "Forgot Password". 3. The user enters their email address and clicks "Submit".	2. System prompts user to enter their email address. 4. System validates if email does or does not exist in the system.
Alternative Flows	
	4a. Email entered does not correspond to any registered user. The user's email does not match the database. The system prompts an error and asks the user to re-enter the email and/or password.

Table 42 - Use Case: Verify Email in Database

Use Case	Send Email with Login Details
Actors	Authenticated User
Summary	Send email to user once resets password.
Precondition	The user has a carpool account.
Post condition	The email exists in the system and the user receives an email so they can log in.
Basic Flow of Events	
Actors Action	**System Response**
1. The user clicks on "Forgot Password". 3. The user enters their email address and clicks "Submit".	2. System prompts user to enter their email address. 4. System validates if email does or does not exist in the system. 5. System sends email to the user with their login details (email and password).
Alternative Flows	

	4a. Email entered does not correspond to any registered user. The user's email does not exist in the database. The system prompts an error and asks the user to re-enter the email and/or password.

Table 43 - Use Case: Send Email with Login Details

Use Case	View User Profile
Actors	Authenticated User
Summary	The user can view personal information on the profile page.
Precondition	The user already exists in the system and is already logged into the system.
Post condition	The user can successfully view their profile page.
Basic Flow of Events	
Actors Action	**System Response**
1. The user clicks on "My Profile" on the "My Account" menu. 3. The user can view their profile. The information that the user can view are: personal information (name, gender, telephone, email and address), evaluations and additional information, such as, if the user is a student or teacher, if is a smoker or non-smoker, if has a car or no car and how the user is willing to carpool, such as driver and/or passenger. In additional, the user can change their password.	2. System displays the current personal information of the user that exists in the database.
Alternative Flows	

Table 44 - Use Case: View User Profile

Use Case	Update User Data
Actors	Authenticated User
Summary	The user can edit personal information on the profile page.
Precondition	The user already exists in the system and is already logged into the

	system.
Post condition	The user has successfully updated their profile page.
Basic Flow of Events	
Actors Action	**System Response**
1. The user clicks on “My Profile” on the “My Account” menu. 3. The user clicks on the “Edit” button. 5. The user changes any information needed and clicks on the “Submit” button.	2. System displays the current personal information of the user that exists in the database. 4. System enables the fields so the user can edit their personal information. 6. System validates form data and then saves the information into the database. Afterwards displays a message saying that the profile has been updated.
Alternative Flows	
	6a. Invalid or missing information. System prompts the user to correct any incorrect or missing fields and resubmit.

Table 45 - Use Case: Update User Data

Use Case	Change Password
Actors	Authenticated User
Summary	If the user wants to change the password.
Precondition	The user already exists in the system and is already logged into the system.
Post condition	Password is changed successfully.
Basic Flow of Events	
Actors Action	**System Response**
1. The user clicks on “My Profile” on the “My Account” menu. 3. The user enters a new password twice for confirmation.	2. System displays the current personal information of the user that exists in the database, including a password section. 4. System validates the password and acknowledges the user that the password has been saved successfully.
Alternative Flows	

	4a. Passwords does not match. Both passwords do not match. The system prompts an error and asks the user to re-enter the password twice for confirmation.

Table 46 - Use Case: Change Password

Use Case	Show List of Rides
Actors	Authenticated User
Summary	The user can view the list of rides that belong to them.
Precondition	The user already exists in the system and is already logged into the system.
Post condition	The user views the ride history.
Basic Flow of Events	
Actors Action	**System Response**
1. The user clicks on “My Rides” on the “My Account” menu. 3. The user can view the history of rides that belong to them. The information that the user can view are: departure and arrival address, departure and arrival time, date. In additional, the user can edit and delete the rides.	2. System displays a list of all the rides that belongs to the user.
Alternative Flows	

Table 47 - Use Case: Show List of Rides

Use Case	Edit Rides
Actors	Authenticated User
Summary	The user can edit a ride once it has been created.
Precondition	The user already exists in the system and is already logged into the system.
Post condition	The user has successfully edited the ride.
Basic Flow of Events	

Actors Action	**System Response**
1. The user clicks on “My Rides” on the “My Account” menu. 3. The user clicks on the “Edit” button of the ride that wants to edit. 5. The user changes any information needed and clicks the “Update” button.	2. System displays a list of all the rides that belongs to the user. 4. System prompts the user a window with all the details of the selected ride. 6. System validates the form and prompts a message confirming the details have been updated successfully. Once the changes have been made the list of rides also appears up to date.
Alternative Flows	
	6a. Invalid information. System prompts the user to correct any incorrect fields and resubmit.

Table 48 - Use Case: Edit Rides

Use Case	Show List of Evaluations
Actors	Authenticated User
Summary	The user can view a list of evaluations that belong to the user.
Precondition	The user already exists in the system and is already logged into the system.
Post condition	The user can view the evaluation history.
Basic Flow of Events	
Actors Action	**System Response**
1. The user clicks on “My Evaluations” on the “Evaluations” menu. 3. The user can view the history of evaluations that belong to them. The information that the user can view are: departure and arrival address, date, type of evaluation, rate for each type and comments.	2. System displays a list of all the evaluations that belongs to the user.
Alternative Flows	

Table 49 - Use Case: Show List of Evaluations

Use Case	Register Ride
Actors	Authenticated User
Summary	The user can register a ride on the system. Before registering a ride, the user can search for existing rides to see if there are any matches.
Precondition	The user already exists in the system and is already logged into the system.
Post condition	The user has registered successfully a ride.
Basic Flow of Events	
Actors Action	**System Response**
1. The user clicks on the "Register Rides" menu. 4. The user enters all the information needed and clicks "Submit".	2. Before registering a ride, the System first prompts the user to search for existing rides to see if there are any matches compatible with their ride. 3. If no matches exist, System prompts to enter the details of the ride, such as, type of ride, departure and arrival address, departure and arrival time, date and how many seats are available. In additional, the user can add a comment about their ride of any useful information. 5. System validates form data, then saves the information into the database and acknowledges that the ride has been registered.
Alternative Flows	
	3a. Enter number of "Seats Available". System prompts an error and asks the user to enter a numeric value when enters the "Seats Available". 5a. Invalid or missing information. System prompts user to correct any incorrect or missing fields and resubmit.

Table 50 - Use Case: Register Ride

Use Case	View Requests/Offers Confirmed
Actors	Authenticated User
Summary	The user can view a list of requests and offers.

Precondition	The user already exists in the system and is already logged into the system.
Post condition	The user can view a list of all the requests and offers.
Basic Flow of Events	
Actors Action	**System Response**
1. The user clicks on "My Requests/Offers" on the "My Account" menu. 3. The user can view all the requests and offers that belong to them. The information that the user can view are: departure and arrival address, date and time, type of ride and if the ride is confirmed or not.	2. System displays a list of all the requests and offers that belongs to the user.
Alternative Flows	

Table 51 - Use Case: View Requests/Offers Confirmed

Use Case	Evaluate Carpooler
Actors	Authenticated User
Summary	The user can evaluate a carpooler that exists in the system.
Precondition	The user already exists in the system and is already logged into the system.
Post condition	The user has successfully evaluated a carpooler.
Basic Flow of Events	
Actors Action	**System Response**
1. The user clicks on "Evaluate a Carpooler" on the "Evaluations" menu. 3. The user selects the ride that would like to evaluate and then click "Evaluate". 4. The user needs to rate the ride that selected based on punctuality and friendly. Optionally the user can add comments in relation to that ride and once everything is entered the user clicks "Submit".	2. System prompts the user to enter a carpooler's name. Once a name is selected, the System searches for existing rides that the carpooler and the user evaluating has done together. 5. System validates form data, then saves the information into the database and acknowledges that the ride has been evaluated.

Alternative Flows	
	2a. Invalid Carpooler. System prompts user the carpooler does not exist in the system and to choose another carpooler. 2b. Incorrect Carpooler. System prompts a message that the user cannot evaluate themselves. 5a. Invalid or missing information. System prompts user to correct any incorrect or missing fields and resubmit.

Table 52 - Use Case: Evaluate Carpooler

Use Case	Select Carpooler to Evaluate
Actors	Authenticated User
Summary	The user can select a carpooler to evaluate.
Precondition	The user already exists in the system and is already logged into the system.
Post condition	The user has chosen successfully a carpooler to evaluate.
Basic Flow of Events	
Actors Action	**System Response**
1. The user clicks on "Evaluate a Carpooler" on the "Evaluations" menu. 3. The user selects a carpooler that wants to evaluate.	2. System prompts the user to enter a carpooler's name. 3. System validates the carpooler's name and display existing rides that the carpooler and the user evaluating has done together.
Alternative Flows	
	2a. Invalid Carpooler. System prompts user the carpooler does not exist in the system and to choose another carpooler. 2b. Incorrect Carpooler. System prompts a message that the user cannot evaluate themselves.

Table 53 - Use Case: Select Carpooler to Evaluate

Use Case	Display List of Rides
Actors	Authenticated User
Summary	The user can view a list of rides that belong to them.
Precondition	The user already exists in the system and is already logged into the system.
Post condition	The user views a list of rides that they have participated.
Basic Flow of Events	
Actors Action	**System Response**
1. The user clicks on "Evaluate a Carpooler" on the "Evaluations" menu. 3. The user enters a carpooler's name.	1. System prompts the user to enter a carpooler's name. 4. Once a name is selected, the System displays a list of rides that the carpooler and the user evaluating has done together.
Alternative Flows	
	4a. Incorrect Carpooler. System prompts a message saying that the user cannot evaluate themselves.

Table 54 - Use Case: Display List of Rides

Use Case	Choose Ride
Actors	Authenticated User
Summary	The user can choose a ride to evaluate a carpooler that exists in the system.
Precondition	The user already exists in the system and is already logged into the system.
Post condition	The user has chosen successfully a ride.
Basic Flow of Events	
Actors Action	**System Response**
1. The user clicks on "Evaluate a Carpooler" on the "Evaluations" menu. 4. The user selects the ride that would like to evaluate and then click "Evaluate".	2. System prompts the user to enter a carpooler's name. Once a name is selected, the System searches for existing rides that the carpooler and the user evaluating has done together.
Alternative Flows	

	2a. Invalid Carpooler. System prompts user the carpooler does not exist in the system and to choose another carpooler. 2b. Incorrect Carpooler. System prompts a message saying that the user cannot evaluate themselves.

Table 55 - Use Case: Choose Ride

Appendix III – Survey

This questionnaire was developed as part of a dissertation for Masters in Informatics Engineering and Business Systems. Before completing this questionnaire, it's necessary to take a look at the website ipcacarpool.somee.com.

The objective of this study is to analyze opinions about carpooling and the experience of using a carpool website. Carpool is when two or more commuters share a ride to get to a nearby or same destination.

This questionnaire is anonymous and the data collected will be treated with confidential. Your support is essential to this dissertation and I thank you for your time and participation.

1. Are you a student or teacher at IPCA?
   - Student
   - Teacher

2. Gender:
   - Female
   - Male

3. Age:
   - Less than 20 years old
   - 20-25 years old
   - 25-30 years old
   - 30-40 years old
   - More than 40 years old

4. Approximately how long does it take you to travel from your home to campus?
   - Less than 15 minutes
   - 15-30 minutes
   - 30-45 minutes

- 45-60 minutes
- 60-90 minutes
- More than 90 minutes

5. What is your main mode of transportation when commuting to work/school?
   - Walking
   - Bike riding
   - Public transport
   - Car (single occupant)
   - Car (multi occupant)
   - Other

6. What factors are most important for you to choose your mean of transportation to work/school?
   - Travel time
   - Cost
   - Flexibility
   - Comfort and safety
   - Reducing pollution and conserving energy
   - Ability to make stops on route
   - Stress

7. Please rate how satisfied you are with the following areas.

	Very Dissatisfied	Somewhat Dissatisfied	Neither	Somewhat Satisfied	Very Satisfied
The way you currently get to work/school					
Walking distance from parking to work/school					
Finding a parking space					

8. Have you ever carpooled? If no, skip to question 14.
   - Yes
   - No

9. What motivated you to carpool?
   - Needed a ride
   - Had space in vehicle
   - Travelling with friends/colleagues

10. What is the main reason you carpool?
    - Save time
    - Reduce traffic congestion
    - Save money
    - Transit too crowded and unreliable
    - Improve air quality
    - More flexible than other options

11. How long have you been carpooling?
    - Less than a year
    - 1-2 years
    - 3-5 years
    - 6-9 years
    - More than 10 years

12. How often do you carpool to work/school?
    - Occasionally
    - Once a week
    - 2-3 days a week
    - 4-5 days a week
    - 6-7 days a week

13. Are you normally a driver or passenger? After this question please skip to question 19.
    - Normally I drive
    - Normally I'm a passenger
    - A little of both

14. What is your main reason to not carpool in a regular basis?
    - Need to run errands before and after work/school
    - Irregular work/school schedule
    - Cannot get home in an emergency
    - Prefer to drive alone
    - Don't have anyone to ride with
    - Don't like to depend on others

15. What concerns do you have about carpooling?
    - Concerned about not knowing who my fellow passenger(s) might be like
    - They won't be ready to arrive or leave when I'm ready to
    - Not comfortable with giving out my information to strangers

16. What would motivate you to join a carpool?
    - Cost savings
    - Time savings
    - Stress reduction
    - Guaranteed ride home program
    - Save wear and tear on vehicle
    - Preferential parking

17. Would you be more likely to carpool if there was a dedicated parking for carpool vehicles?
    - Yes
    - No

18. Would you consider carpooling?
    - Yes
    - No

19. How would you rate the website?
    - Very poor
    - Below average
    - Average
    - Good
    - Excellent

20. Please rate your overall experience with the website.
    - Very poor
    - Below average
    - Average
    - Good
    - Excellent

21. How successful were you in accomplishing what you were trying to do?

	Did not try to do this	Not at all successful	Partially Successful	Completely Successful
Register within the system				
Gather ride/commute information				
Gather information about requests/offers				
Register ride				
Search ride				

22. Please rate the website in each if the following areas.

	Very Poor	Below Average	Average	Good	Excellent
Quality of the content					
Ease of navigating the website					
Layout/design of the website					
Organization of the website					
Ease in accomplishing what you were trying to do					

23. Would you recommend this website to a colleague/friend?

- Yes
- No

24. Would you visit this website again?

- Yes
- No