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A smartphone application prototype for exchanging valuable real time public transport information among travellers

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Mestrado Integrado em Engenharia Informática e Computação

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Abstract

United Nations' reports and projections say that more than half of the world population lives in urban areas, and that the population growth will be mostly absorbed by these areas too. This is contributing to the chaos that our ability to move inside the cities is becoming, and thus, to the increase of urban mobility related problems.

Improving the public transport' services and the users' perceived experience, might be an important step to increase the number of public transport travellers and therefore, help fighting the mobility problems.

At the same time, with the increasing trend of smartphones paired with the increasing geographical scope of the ubiquitous communication networks, the way we access and share information is changing on an everyday basis. Many tasks that used to require fixed computing devices can now be executed from mobile ones.

If it is easier for people to communicate with each others, being actually together is becoming more difficult.

Regarding public transport, an increasing proportion of passengers are connected to social networks through their personal mobile devices, exchanging information related to several aspects of their journeys in real time. This information might be useful to help travellers making decisions about their trips, as to assist the transportation network managers implementing service improvements. However, the lack of systems able to aggregate and distribute personalized information to passengers and managers means that currently the exchanged data is too scattered, reducing its usefulness.

This dissertation aims to develop a functional prototype of a social network based mobile application that allows public transport passengers to share organised and structured information on public transportation, and forward it to those who might benefit from it. Initially, research had to be done in order to understand what types of information travellers would like to have access to. Later, the developed prototype was subjected to usability tests on a real environment, allowing also for the gathering of feedback from potential users about the usefulness of such application.

This work can be seen as a first step for the study and development of the application's concept.

Resumo

Segundo relatórios e projeções das Nações Unidas, mais de metade da população mundial vive em áreas urbanas. Além disso, prevê-se que essas áreas irão suster grande parte do crescimento populacional. Esta aglomeração de população nas cidades contribui para o caos no que diz respeito à capacidade de nos movimentarmos facilmente e, consequentemente, para o aumento dos problemas relacionados com a mobilidade urbana.

Melhorar os serviços de transportes públicos e a experiência de quem os utiliza, pode ser um passo importante para o aumento de utilizadores dos mesmos, contribuindo para o combate aos problemas de mobilidade.

A progressiva tendência de utilização de *smartphones* aliada à crescente abrangência geográfica de redes de comunicação ubíquas está a provocar significativas alterações na forma como acedemos e trocamos informação diariamente. Diversas tarefas que recentemente conduziam à utilização de aparelhos fixos de computação são cada vez mais executadas a partir de dispositivos móveis.

Se é cada vez mais fácil comunicar com outras pessoas, estar efetivamente com elas começa a ser bem mais difícil.

No domínio dos transportes públicos, uma proporção crescente dos passageiros está ligada às redes sociais através dos seus dispositivos móveis pessoais. Isto permite que se troquem informações entre passageiros em tempo real, relativas a diversos aspetos do serviço de transporte num determinado momento. Este tipo de informações pode ser útil tanto para ajudar os passageiros a tomarem decisões relativas às suas viagens como para auxiliar os gestores da rede de transportes a implementar melhorias ao serviço. Contudo, a inexistência de sistemas capazes de agregar e distribuir informação personalizada a passageiros e gestores leva a que a informação esteja atualmente demasiadamente dispersa e à diminuição da sua utilidade.

Esta dissertação tem como objetivo o desenvolvimento de um protótipo funcional de uma aplicação móvel ao estilo de uma rede social, que permite a partilha de informação organizada e estruturada entre utilizadores de transportes públicos sobre o serviço de que estão a usufruir. Pretende-se que essa informação seja reencaminhada para utilizadores realmente interessados na mesma. Inicialmente foi realizada pesquisa para perceber a que tipos de informação os viajantes gostariam de ter acesso. Após o desenvolvimento do protótipo, foram realizados testes de usabilidade, que permitiram recolher *feedback* de potenciais utilizadores da aplicação acerca da sua utilidade.

Este trabalho pode ser visto com um primeiro passo para o estudo e desenvolvimento do conceito base desta aplicação.

Acknowledgements

I would not be able to accomplish this work without the help (even if unconsciously) of some people that I would to like thank.

First, I would like to thank my family, specially my parents, without their constant support and motivation I would not have had the strength to carry on through the most difficult times.

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A special thanks to Eng. António Nunes, for always being present to help and give valuable advices. For sure his broad knowledge, curiosity and proactivity inspired me to explore more and to make better use of my free time. I hope I met his expectations and correctly implemented his idea.

To all the people at CAS, thank you for making work so pleasant and for providing me with some great moments.

Finally, I would like to thank all the people that gave their free time to participate in the brainstorming session and in the prototype testing without them this work would not be possible.

Tiago Gonçalves

"Being challenged in life is inevitable, being defeated is optional."

Roger Crawford

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Abbreviations

C2DM Cloud to Device Messaging Framework

GPS Global Positioning System

NFC Near Field Communication

OS Operative System

SOAP Simple Object Access Control

QR Quick Response Code

REST Representational State Transfer

STCP Sociedade Portuguesa de Transportes do Porto

TFL Transports for London

XML Extensible Markup Language

Chapter 1

Introduction

We live in an era where the speed of innovation and evolution regarding technology reaches levels that guide to constant changes on how we face our daily life. Communication is probably the field where most of the people feel that evolution. We just have to go back 15 years to see huge differences in the easiness of how people communicate with each others. Recent studies about the "6 degrees of separation theory", that refers to the idea that people are only separated by six steps, by way of introduction, from any other person on Earth, show that this value has been decreasing in the last few years [Rib11].

The boom of social networking is undoubtedly one of the main reasons for this approximation between people. With these new platforms for information sharing and interaction between people, as well as with how easy it became to access the internet anywhere at any time, being constantly connected to the network became an habit.

While communication goes through a complete revolution, we are witnessing an increasing migration of people to large cities, promoting an increment of population in urban areas [oESA10]. This contributes to the chaos that our ability to move around easily and quickly to reach desired destinations is becoming. If communicating with each others got easier, actually being together has become much more difficult.

Public transport has a vital role in the promotion of urban mobility. Encouraging its use reduces the number of cars on the road, reducing traffic and the likelihood of traffic jams, while at the same time, increases the efficiency of public transport themselves [CSV11].

As an attempt to promote the use of public transport, and taking advantage of the popularity of social networks, we have been witnessing a great increase of transport companies trying to publicize their services and getting closer to its customers through platforms such as *Twitter* or *Facebook*.

The concept that supports this thesis is based and emerges from this phenomenon. Why not join the social networks' ability to share information and the willingness of people to share information through them to provide more and better information about public transport, benefiting not

only its users but also the operators of these networks? All by using information generated by the users themselves.

Summarizing, this thesis aims to explore the usage of social networks for information sharing among travellers, fostering them to help each others and increasing the use of public transport. All this by taking advantage of new technologies, such as mobile devices and their applications, that enable data exchange anywhere and in real time.

1.1 Motivation

Everyday time seems to become an even more scarce resource. Something that greatly contributes to this shortage is the time spent travelling, especially in large cities where traffic jams transform trips that should last ten minutes into thirty minutes nightmares. People's unwillingness to use public transport is often due to the lack of information available about them, from information such as the existing routes, to the delays and problems that arise unexpectedly and without predictability [BC07].

Public transport' real-time status information is certainly something that can stimulate people to use them. This can reduce the number of private vehicles in circulation and thus de-congesting the transit lines, saving time and at the same time, helping people making travel decisions. The use of social networks has been increasingly exploited by public transport companies in an attempt to get closer to customers and provide them with real time information. This interaction allows to receive feedback that can help improving the quality of service. However, despite the advantages that arise from this new way of acting, the information provided is sometimes not fully exploited, leading users to underestimate it [NGeCP11].

The existence of a social network that provides structured information in real time to the right people, through a mobile device application, is something that could help improving the public transport' perceived experience. Moreover, if this information had origin in the users themselves, the transport operators would be freed from the charges regarding the maintenance of these services. At the same time, they would be provided with information from their own customers about their services, opening doors for the improvement of these services' efficiency and quality.

The advantages of this network would not only be economic, but could also be felt in other areas. The travellers' well-being could increase, by reducing the stress related with the constant bustle that characterises the public transport systems. Environmentally speaking, the ecological footprint generated by the widespread use of private vehicles on routine trips to workplace, could be also reduced. And at the same time, promoting all the mutual aid and conviviality that characterise social networks.

1.2 Problems and Goals

This work aims to develop a smartphone application prototype that materializes a concept that has been explored in several studies in different parts of the world. Associate the share and commu-

nication power of social networks with the need of information of public transport' users is the concept's base. Currently there are several studies (such as *Travelers' need for information in traffic and transit: results from a web survey* [CGC07] or *Social networks and collective intelligence applied to public transportation systems: A survey* [CSV11]) that have conducted surveys in order to understand what information travellers want to have access to when travelling or preparing to do so. These studies also explore ideas for the practical application of the above concept, however, and despite the increasing concern with sustainability, nothing has been implemented yet.

One of the difficulties associated with the evolution of this concept, is structuring and organising relevant information in a way that enables it to flow within social networks and arrive to the right people.

Since travellers are the source and engine of all the data that will flow through the system, their acceptance and usage of the application can be an obstacle for the idea's success. Therefore, testing the usability and predicting the integration of the concept on travellers' daily routines is the main goal of the prototype development.

1.3 Document structure

This document is composed of eight chapters that intend to present all the work that was done.

The second chapter aims to contextualise the reader into concepts that in one way or another are related with the work that was done.

Chapter 3 goes deeper into the main topic of this thesis, the public transport. It presents data gathered from other projects that aimed at understanding travellers needs. It also shows what already exists to help them in their trips.

In chapter 4, the user centered design development methodology is presented as well as some techniques used to evaluate the prototype that was created.

The idea behind this thesis is presented in Chapter 5, while Chapter 6 goes through all the implementation phase, providing insights of the work that was done.

Tests were done over the prototype and their results are presented in Chapter refchap:chap7

Finally Chapter 8 present the conclusions taken from this thesis as well as suggestions about future work that can be done around the concept and application.

Chapter 2

State of art

Social networks are changing the paradigm of communication and sharing of information between people. We have been witnessing to an increasing growth and time spent by people in these communities that are already part of our daily life. All this popularity confers a huge potential to these platforms. They become environments conducive to the promotion and marketing of products, at the same time that stimulate the collaboration among its users by sharing their knowledge, skills and other information.

Through this strong sharing component and with the incorporation of more features such as chat, messaging and even video conferencing, these platforms resemble to collaborative environments, making them attractive to implement the concept of Collective Intelligence [CSV11].

Ubiquitous communication networks certainly had an impact on the social networks popularity. To be connected to the web anywhere at any given time, has become a habit to which the smartphones' expansion greatly contributed. However, these platforms' popularity does not mean that people are easily driven to use new ones, instead they get bored faster and their acceptance of different environments diminishes. This carries the obligation for new platforms to find ways of getting people addicted to their services. This chapter attempts to clarify the concepts that underlie or that somehow are related with the project.

2.1 Collective intelligence

Collective intelligence emerges from the debates held by Pierre Lévi [Lév98]. This concept attempts to harness the potential of social networks in order to exercise citizenship. It is assumed that the intelligences of each individual are added and shared by the society.

> "What is collective intelligence? It is a form of universally distributed intelligence, constantly enhanced, coordinated in real time, and resulting in the effective mobilization of skills... My initial premise is based on the notion of a universally distributed intelligence. No one knows everything, everyone knows something, all knowledge

> resides in humanity... The ideal of collective intelligence implies the technical, economic, legal, and human enhancement of a universally distributed intelligence that will unleash a positive dynamic of recognition and skills mobilization." [Lév98]

With the popularity of forums, *weblogs*, *wikis* and social networks, collaboration among people has been getting more popular. It is actually responsible for the growth of a new business model, known as *crowdsourcing*[1]. In this new model, instead of trying to solve a problem by themselves and with their own resources, people can submit it to a community that may provide new and more creative solutions.

There are already initiatives that put collective intelligence in practice, including the *WikiCrimes*[2] or the *Collaborative Map of Corruption in Brazil*[3]. While the first one allows users to share information about the occurrence of criminal acts, the later is a site hosted on *Google Maps*[4] where people can provide information and research about corruption in Brazil.

The increase of existing applications based on collective intelligence, is an indicator of people's will to collaborate with each other for the benefit of the group they are part of, and therefore also for their own. Hence, collective intelligence can help solving problems of various sectors of society, including public transport systems [CSV11].

2.2 Collaborative work environments

Work environments suffered great changes over the past 20 years. These changes were the result of advancements in new technologies, that brought new ways of communicate, collaborate and share information. Moreover, the strong competition and globalization has contributed for companies to care and invest more in work environments in order to increase their employees' efficiency and quality of work. They will continue to change in the future towards an increasingly virtual world, where the network – the Internet and the network of people - will be the workplace [HS06].

In the basis of this virtualisation is the emergence of Collaborative Work Environments that aim to support people in their individual and cooperative work. Applications and services such as email, instant messaging, video-conferencing or *wikis*, are examples of elements of a Collaborative Work Environment.

Companies' investments in the development of such services can highly benefit the social networks and the collective intelligence environments, since these technologies also play an important role in them.

[1] *Crowdsourcing* - production model that uses intelligence and knowledge of the web to solve problems, create content and develop new solutions or technologies.

[2] http://www.wikicrimes.org

[3] http://bit.ly/ltTJ9u

[4] http://www.maps.google.com

2.3 Social Network

According to James Clyde Mitchell [Mit69], a social network is a set of specific links between a group of people, with the additional property that the characteristics of these connections as a whole can be used to interpret the social behaviour of the involved individuals. Being this the general definition of a social network, with the internet came the phenomenon of online social networks, which Nicole B. Ellison [BE08] described as Web services that allow an individual:

- create a public or semi-public profile within a bounded system;
- articulate a list of other users with whom they share a connection;
- view and go through their list of connections and those made by others within the system.

However, time and evolution, made online social networks evolve beyond the definition given by Nicole B. Ellison. Uploading content (such as photos, music or videos), sending messages between users or host small applications and games, have become common functionalities provided by online social networks [Joi08].

Nowadays, social networks have a tremendous power. Especially due to the enormous popularity of *Facebook*[5] and *Twitter*[6], two of the most used platforms. A proof of this power are the recent developments in the political world. Cases like the revolt in Tunisia [Del11] or the revolution in Egypt [Sut11], which were possible in part thanks to the massive mobilization of people through *Facebook* and *Twitter*, show how this phenomenon has a huge influence on our world. Even world leaders realize its importance and have themselves profiles in networks through which disseminate messages, that are then replicated by the media. Recently *Google+*[7] surprised the online community and provided a live forum with the President of the United States of America, Barack Obama. Through the *Hangouts*[8] functionality, the President answered to questions from some of this platform's users. This forum can be reviewed at the White House's page[9] or on *YouTube*[10].

On the 18th of May of 2012, *Facebook* became the first social network to get into the stock market [Del11], which is another example of the popularity, success and potential of these platforms.

2.4 Ubiquitous computing

Something that has greatly contributed to the smartphone's growth is undoubtedly the fact that networking is no longer considered a luxury, but instead it is becoming a necessity.

[5] http://www.facebook.com
[6] http://www.twitter.com
[7] http://www.plus.google.com
[8] *Google Hangouts* – functionality that allows video conferencing between multiple users of the social network simultaneously.
[9] http://www.youtube.com/whitehouse
[10] http://www.youtube.com

The evolution of technology brought us services that were seen as science fiction just a decade ago. Ubiquitous computing, also known as *Four "A's" Networking* or *"Anytime, anywhere, by anything and anyone" Networking* [KP10], was originally proposed by Mark D. Weiser in 1988 and may be considered an evolutionary development of traditional computing methods and platforms.

> "...is related to a vision of people and environments augmented with computational resources providing information and services when and where they could be desired, going beyond than just infrastructure aspects, and suggesting new paradigms of interaction inspired by widespread access to information and computational capabilities." [Bab11]

The possibility to connect to the Internet anywhere and at any time, is probably the most known side of this concept. It is also the greatest strength of smartphones as their portability and ability to browse the Web, makes them together with tablets, the perfect devices to meet the need of those who want to be constantly online. Even on their way to work or anywhere else.

2.5 Serious Games

Serious games differ from traditional games. While the later ones are aimed at players' entertainment, the first ones are usually created for educational purposes. To train, teach, show something in another perspective or alert players to a specific problematic, while taking advantage of games entertainment characteristics, are typically the goals of these games [Gui11].

> "Even a brief survey of the literature soon reveals that there seems to be as many definitions available as there are actors involved, but most agree on a core meaning that serious games are (digital) games used for purposes other than mere entertainment." [TS07]

In the past few years, we have been witnessing to the growing and increase of importance of serious games in the game industry. They are even studied in game related courses and object of attention in most of game related conferences. Many commercial games, such as *SimCity*, *Civilization* or *Microsoft Flight Simulator*, are also being used for other purposes mere than entertainment.

Serious games' growth brings new opportunities not only for game developers, but especially for the game industry that employs tens of thousands of workers all around the world [Ini].

2.6 Summary

Currently, there is a constant evolution and innovation in technologies related to the communication between people. The emergence of smartphones and mobile applications has brought new

forms of Internet access which has become almost ubiquitous in our day-to-day life. This ubiquity together with the popularity of social networks brought new ways of promoting mutual help between people when solving their problems.

These technologies are already part of people's lives, leading to a large production and delivery of multimedia resources, which become increasingly more appealing and addictive. These resources can be used not only for entertainment but also to promote education and culture.

This chapter aimed at the contextualisation of the reader to the different topics covered by this thesis, which are somehow important to the work that was done.

Chapter 3

Urban mobility and social networks for travellers

Providing relevant information to travellers about their travel options is something that is accepted as having the potential to change their behaviours benefiting the efficient use of public transport.

As this project aims to explore a new concept that provides information to travellers in real time, it is necessary to understand if they really lack of public transport' information and explore the research already done on this topic.

In this chapter we will start by trying to understand whether there is a need for more and better information for travellers and also to what data they would like to have access to. These insights are based on already undertaken work over these matters. The research that will be presented comes from different parts of the world and, therefore, reaches travellers who deal with different travel realities.

Later on will be presented some examples of existing or imagined services, that, in different ways, seek to contribute to a more efficient mobility of people, bridging the lack of information that often affects travellers.

3.1 The need for information

This thesis aims to explore new ways to provide real time information to users of public transport. Understanding if these users actually feel a lack of information is indispensable in order to be able to justify the efforts done over this issue.

The article *Travellers' need for information in traffic and transit: results from a web survey* [CGC07], tries to understand and distinguish what are the information needs of travellers when travelling to frequently visited places or to never visited before ones. It is based on online surveys with mostly Dutch participants.

Information type	Frequently visited destination	Destination never visited before	sig. difference
Early warning function	3.85	4.08	.000
Full trip assistance	3.54	4.03	.000
Time-related information	3.46	4.54	.000
Personalized information	3.38	3.89	.000
Location-specific information	2.98	3.43	.000
Multimodal information	2.92	3.63	.000
Cost-related information	2.78	3.85	.000
Information on other than time- and cost-related aspects	2.75	3.57	.000

Figure 3.1: Need for specific types of information.

Figure 3.1 shows that, as it would be expected, the need for more information is greater when travelling to unfamiliar places. Moreover, it can be seen that with respect to the more advanced types of information, those that promise to make travelling "easier" are needed (such as early warning functions, trip guidance), rather than the ones that facilitate advanced search possibilities (such as multimodal information).

Despite the need for public transport users to obtain information about arrival, departure and travel times, the available resources, are not usually satisfactory. This dissatisfaction is mainly originated from the fact that usually information is static and based on estimates of transport network's operators, that do not account for delays or unpredictable circumstances. The data collected under the project *UbiBus* presented in the article *Social networks and collective intelligence applied to public transportation systems: A survey* [CSV11] reveals how often Brazilian travellers have to deal with delays (see Figures 3.2) as well as the reasons why transports do not arrive on time (see Figure 3.3).

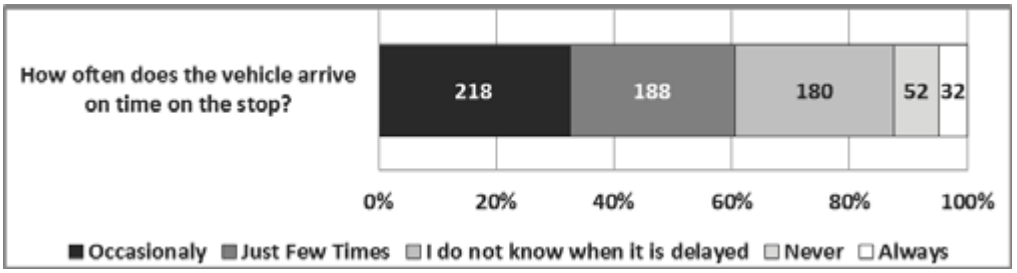


Figure 3.2: Frequency of delayed vehicles.

Under the same project, and as a way to find means to generate relevant information for travellers, the authors tried to understand whether public transport users have the habit of using social networks to share things that occurred while travelling (see Figure 3.4) and if they would make use of an application that would provide information on transport lines in real time (see Figure 3.5). Although only 34% of the participants have the habit of sharing information, half answered that they would do it if there was an application for it. Moreover, more than 95% said that would welcome an application to obtain real time information.

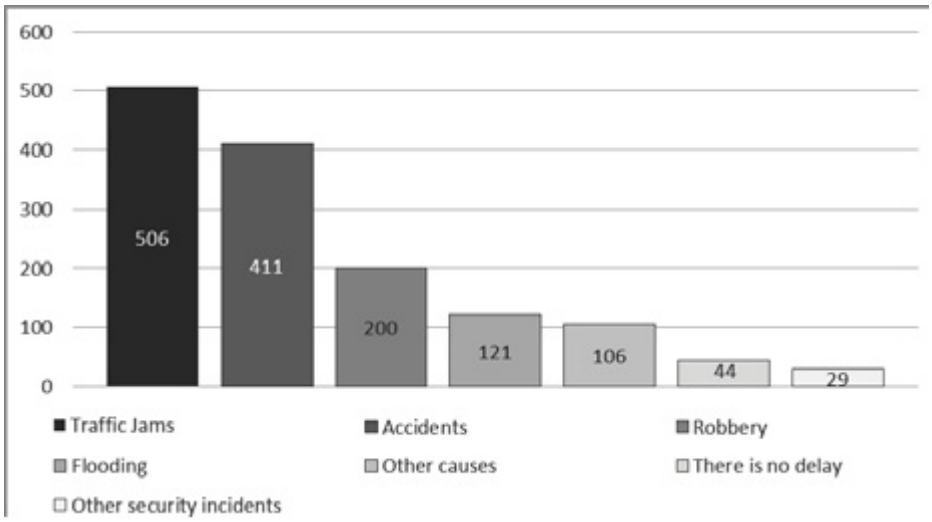


Figure 3.3: Reasons of delays.

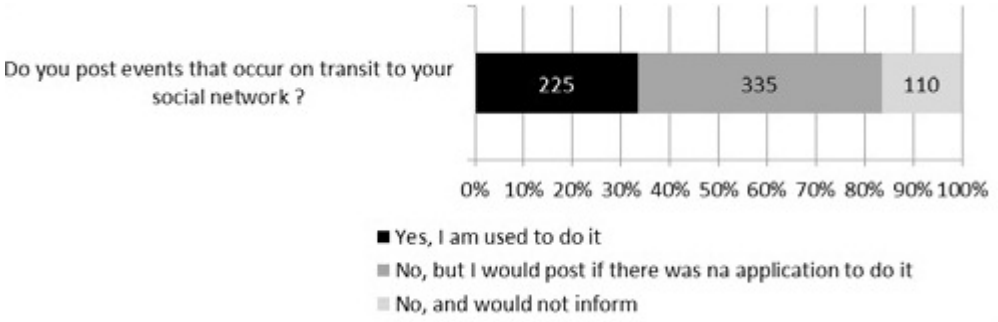


Figure 3.4: Information sharing on social networks.

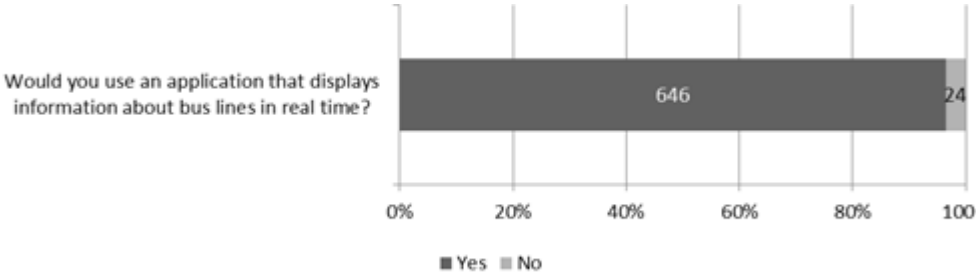


Figure 3.5: Use of an application to obtain real time information.

The idea of using social networks to disseminate information on public transport is further strengthened by the fact that the vast majority of travellers trust (see Figure 3.6) on information originated from people connected to their social networks.

Although the studies presented above are related to Brazil, many of the conclusions can be extended to other parts of the world, making room for new ideas to improve the experience of public transport users. This thesis can also serve as a way to help confirming the results of the presented surveys.

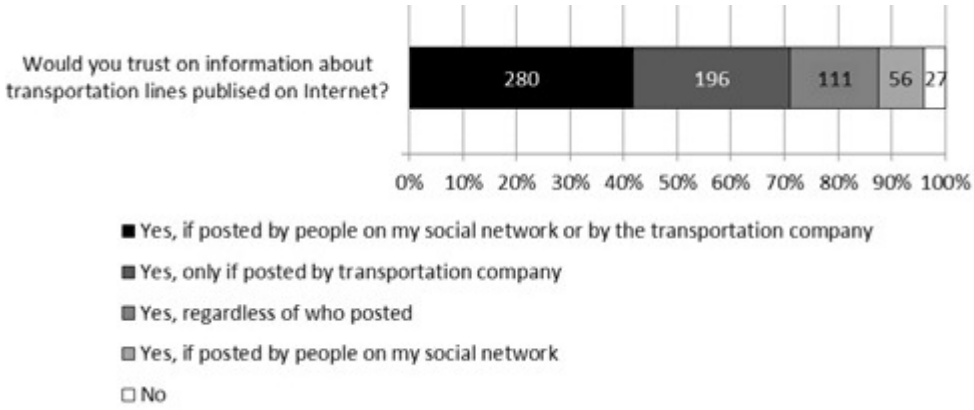


Figure 3.6: Trust on information posted on social networks.

3.2 Response platforms

Currently there are several platforms to help travellers, either by planning their trips, or by providing relevant information while they travel.

There are many options available, from systems that calculate routes based on various parameters (such as cost or time) to social networks where the goal is to share trip experiences and promote mutual aid among travellers.

The following sections will present examples of these platforms, providing an overview about the existing offer so that the developed concept's originality can be attested.

3.2.1 Social networks for travellers

When it comes to social networks for travellers, the list of available platforms is extensive. There are several websites that promote the sharing of information between travellers, trying to become a must see for those who are thinking about travelling, or who only want to find a good hotel to spend the night.

WAYN[1], *Tripatini*[2], *Gogobot*[3] or *IgoUgo*[4], are just some examples of platforms that try to connect travellers and tour operators, through social networks. As it can be seen, these platforms are usually aimed at sharing information about long distance trips and not exactly for in city mobility. This is why there is often a strong presence of the tourism industry, filling users' email boxes and occupying large percentages of the websites' "face" with offers and promotions.

The marketing offers pileup, turning the navigation and understanding of the platform's flow into a nightmare. Also, to rely on these platforms' travel information is not entirely advised, as it is quite evident from the adventure of Arianne Cohen [Coh10]. This journalist has tested the limits of social networks by travelling to a foreign and unknown destination, armed only with mobile applications and social media.

[1] http://www.wayn.com
[2] http://www.tripatini.com
[3] http://www.gogobot.com
[4] http://www.igougo.com

Despite the less positive experience of Arianne, the truth is that these social networks are quite popular. Simply check the number of registered users of *WAYN*, where 17 million people share their experiences, or *IgoUgo* where more than half a million people are connected.

In addition to these social networks dedicated to travellers, public transport companies are also beginning to realize the potential that these platforms have as a way to get closer and communicate with costumers. Nowadays, it is easy to find companies with *Facebook* or *Twitter* pages, that are used to inform and interact more directly with their customers.

Some examples are *Metro do Porto*, that is present both on *Facebook*[5] and *Twitter*[6], or *STCP* that also has a *Facebook*[7] and *Twitter*[8] accounts.

3.2.2 Route planners

Route planning services are probably the main means used by those who plan trips using the internet.

There are two particular services that occupy the first places on the popularity tops (see Figure 3.7). They are the *MapQuest*[9] and *Google Maps*[10].

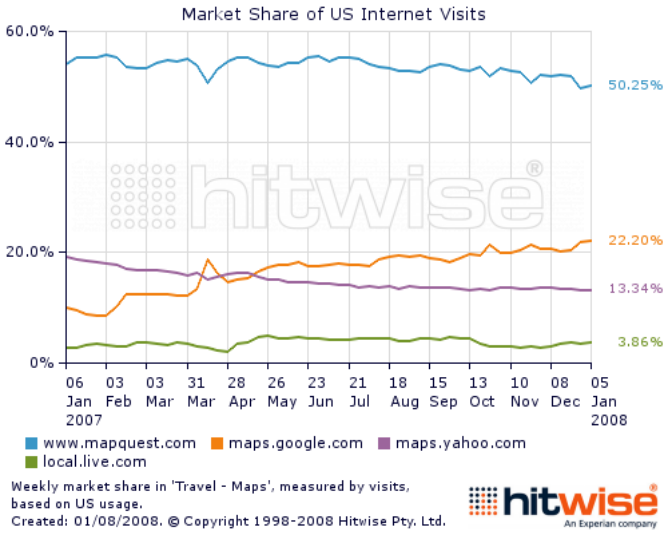


Figure 3.7: Market share of US internet route planer services.

These are free services that allow to discover and view Earth's maps and satellite images. The additionally offered route planning features, such as route planning using different transport types (walking, car or even public transport), also turn these services into very attractive means for finding ways to get from point A to point B.

[5] http://www.facebook.com/MetroPorto?sk=wall
[6] https://twitter.com/#!/metrodoporto
[7] http://www.facebook.com/STCPSA?sk=wall
[8] https://twitter.com/#!/STCPServicos
[9] http://www.mapquest.com/
[10] http://www.maps.google.com

Both services are characterised by having simple and adequate interfaces, making them easy to interact with, and useful tools for trip planning, whether these trips are from home to the nearest grocery store, or to another country.

3.2.3 Mobile applications

The mobile computing evolution came along with the development of richer and more powerful mobile applications. These applications bring greater mobility to a variety of services. Nowadays, with a smartphone and the right application, we can perform tasks, such as booking flights[11] or check the next day weather forecasts[12], while we ride the metro on our way home.

With the available mobility and the possibility of being able to get information anywhere at any time, several mobile applications arose that provide real time public transport information.

London Underground[13], *Catch that Bus*[14], *UK Train Times*[15] or *iMetroPorto*[16] are just few examples of public transport related applications that provide users with valuable information. But not only the public transport are entitled to dedicated applications. Car-drivers also have available platforms that help them when driving, from the most common navigation applications, such as *NDrive*[17], to even more ambitious ones, such as *Waze*[18].

While the first ones provide timetables, vehicle frequencies, maps and routes, information on tickets and pricing, and even travel planning features. The latter allow for real time navigation, route calculation based on different characteristics (such as shortest path or fastest track) and also help users to follow their routes.

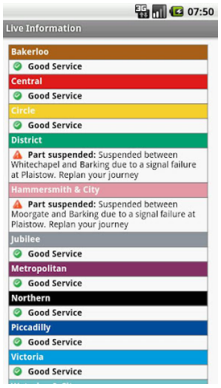


Figure 3.8: *London Underground*

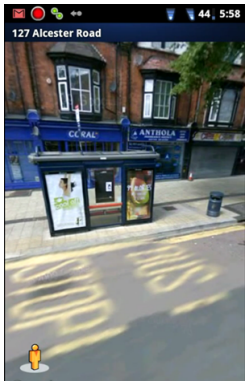


Figure 3.9: *Catch that Bus*

Figure 3.10: *UK Train Times*

[11] https://market.android.com/details?id=com.mobiata.flighttrack&feature=top-paid

[12] https://market.android.com/details?id=com.accuweather.paid.android&feature=top-paid

[13] https://market.android.com/details?id=com.visualit.tubeLondonCity&hl=pt_PT

[14] http://intrications.com/wp/

[15] http://www.nationalrail.co.uk/times_fares/info_on_the_move/apps/mobilecommerce_android.html

[16] http://www.metrodoporto.pt/PageGen.aspx?WMCM_PaginaId=16779&noticiaId=24322&pastaNoticiasReqId=15503

[17] http://www.ndrive.com/webshop/android

[18] http://www.waze.com/

Below there are relevant characteristics of some of the mentioned applications.

London Underground (Figure 3.8)

Provides real time state information of the London Underground, providing users with a journey planner that avoids problematic paths.

Catch that bus (Figure 3.9)

Displays real time information about upcoming buses at 370000 bus stops in Britain. It also allows the user to actually see the bus stop.

UK Train Times (Figure 3.10)

The *Next Train Home* feature automatically finds the nearest train station and plans the trip back home. Offers alternatives and warns the traveller in case of a delayed or cancelled train that is part of the user's travel options. Allows the user to see the current vehicle's location.

iMetroPorto (Figure 3.11)

Travel planner for the city of Porto's light rail network.

Waze (Figure 3.12)

It is the application that is closest to the concept studied by this thesis. It was created to help car-drivers by warning them about unpredictable situations that are happening in real time. The information is fed by the users themselves, that are able to report traffic issues, such as traffic jams, or accidents. This way, other drivers can be warned and act accordingly with the situation. Traffic status can be constantly updated based only on what the users report.

Figure 3.11: *iMetroPorto*

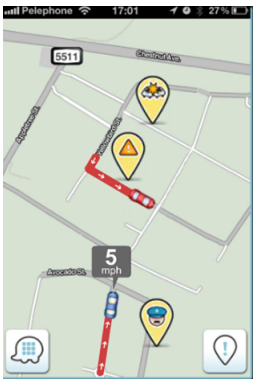


Figure 3.12: *Waze*

3.3 Summary

These findings emphasize social networks' popularity and their potential to help answering questions of those who wish to travel. However, despite of public transport managers recent efforts to understand the real value of social networks, and their enrolment into the most popular ones, these platforms potential is not yet fully exploited.

Social networks exclusively devoted to travellers are an example of how carefully the structuring and organisation of information must be handled. Moreover, these platforms usage warn about the importance that should be given to the shared information's quality, so that they can actually be useful to users.

As for mobile applications, although they begin to appear more and more with the goal of providing real time information to public transport users, these applications are often confined to a specific city or urban area, constraining their usage and potential. It is also clear that most of the current platforms depend on entities that are constantly surveying the public transport, or on the existence of sensors and devices that allow to do it automatically. These factors result in costs for transport companies, which makes the investment in these applications less appealing.

The surveys' results presented in this chapter as well as the existing platforms, indicate that there might still be some room for a mobile application in which information about public transport arrives in real time to travellers who actually need it, being this information provided by the users themselves, while at the same time it promotes a community sense characteristic of social networks. This application has potential to help solving the mobility problems that are increasingly evident in urban areas.

Chapter 4

User Centered Design

During the development of a platform that interacts with its users, the interface design must be target of the developers attention. In fact, when that platform is an application that runs on devices with the characteristics of smartphones, these matters gain a all new importance.

From screen size constraints to the limited data input options, there is a huge set of particularities that must be taken into account when designing smartphone applications. Moreover, due to the numerous shapes and features that different mobile devices can assume, it is important that the interface is able to be used in all of them.

As this thesis work aims at the development of an application whose success might depend on how easily users relate and interact with it, in this chapter will be presented one of the most popular methodologies used for the design on interfaces, the User Centered Design. There will also be explored the Usability concept, Usability testing evaluation paradigm and the DECIDE framework technique, that were adopted for prototype tests.

4.1 What is it?

When designing applications it is important to understand users' needs and goals in order to assure a more appropriate and usable product. User centered design focuses on the users to increase the chances of the product's success.

It is a structured product development methodology that involves the users in different development stages and tries to find out as much as possible about them and their tasks to better meet their needs. All the gathered data is studied and taken into account in the product's design.

In the past, when eliciting requirements, developers would show the products to the managers or to *proxy-users*[1]. However, this approach can never be as reliable and efficient as bringing the real end users to the process and obtain direct feedback on the work that is being done throughout, not only the requirements stage, but also the all development process. Moreover, there are two

[1] people who role-played as users

other aspects that despite not having anything to do with the product's functionalities, are equally as important to achieve success. These are expectation management and ownership.

While expectation management relates to making sure that the users' views and expectations of the product are realistic, ownership concerns to give users the feeling that they contributed for the development process, improving the chances of their receptiveness to the final product.

These two concepts help justifying the user involvement in the development of a product. However, it is important to keep in mind that there are also not so bright sides on this process, since it implies time to organise, manage and control such involvement. This "wasted" time can be of great importance, as there is a huge competition between companies which leads to the necessity of reducing the development length [SRP07].

Summarising, user centered design is based on the premise that users' needs are taken into account throughout products' design and development. This can only be achieved through the evaluation of the design and the amending of functionalities at various stages of the process to better suit users' expectations [GL83].

Something that is highly evaluated in the user centered design is the product's usability. The next section will provide some insights about this concept.

4.2 Usability

Usability concerns to the ease of use and learnability of a human-made object. It is a quality attribute that assesses how easy it is for a human to interact with things such as a machine, a website, a software program or even a book.

As user centered design is a development model that tries to reach as much as possible users' desires, as well as design it so that it can be easily used and to understand, usability plays then a key role in the design process.

According to Jakob Nielsen [Nie93a] usability is composed of five components:

Easy to learn - The user can quickly go from not knowing the system to getting some work done with it.

Efficient to use - Once the user has learned the system, a high level of productivity is possible.

Easy to remember - The infrequent user is able to return to using the system after some period of not having used it, without having to learn everything all over.

Few errors - Users do not make many errors during the use of the system, or if they do make errors they can easily recover from them. Also, no catastrophic errors should occur.

Pleasant to use - Users are subjectively satisfied by using the system; they like it.

These five aspects are very important for the success of a product, since users' perception of it is highly related to them. For instance, if two different products have the same purposes but one is

much easier to interact with than the other, the chances of a user to use the first one instead of the later are much higher.

The next section will introduce the usability testing evaluation paradigm.

4.3 Usability testing

Usability testing aims at the evaluation of a product by testing it on users.

It is a technique often used in user centered design development, where users are usually asked to complete a set of tasks with the product. While testing it, the users are constantly observed by developers that watch, listen, take notes and sometimes record every relevant action.

The goal is to identify what usability related issues must be evaluated and collect quantitative (such as time on each task, error rates) and qualitative (such as how easy was to accomplish the task) data that allows, not only to determine the participant's satisfaction with the product, but also to understand what can be changed or redesigned to increase the product's quality and value.

Sometimes additional questionnaires and interviews are done in order to attest the users' satisfaction and perceived experience. This data is usually categorised and presented as average ratings [SRP07]. Videos and other evidence are also analysed to help finding the most common user mistakes as well as reactions that are hard to perceive during the test.

Regarding the number of users to test, Jakob Nielsen [Nie93b] defends that it is better to test only with five users, fix the uncovered problems and redo the tests again with five different users, instead of doing one test with ten users at once. He says that there is no point in keeping people testing a functionality after two or three found a problem with it.

Based on this idea, Robert Virzi [Vir92] later described it with a mathematical model where he concluded that with only five subjects it was possible to identify approximately 80% of the usability problems. Increasing up to ten testers, the results could uncover more than 90% of the usability problems (see Figure 4.1).

This type of methodology gains even more importance when designing applications that will run on devices, such as smartphones, where users' input is severely constrained. It is extremelly important for them to easily and intuitively interact with the application, as there is also not space for tips or help in the navigation.

4.4 DECIDE framework

DECIDE is a framework that provides a checklist to assure the correct planning of evaluations. It also helps to run the evaluations with clear goals and appropriate questions [SRP07].

DECIDE stands for the first letter of each of the checklist items.

Determine the overall goals that the evaluation addresses - what are the reasons that sustain the evaluation? It is important to know why and what is going to be evaluated, in order to understand how should it be done.

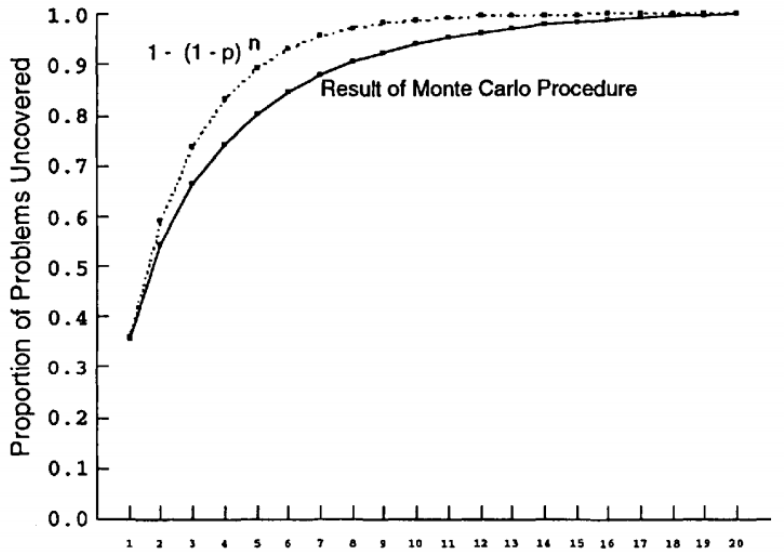


Figure 4.1: Proportion of usability problems uncovered as a function of the number of subjects who participated in an evaluation (solid line) [Vir92].

Explore the specific questions to be answered - it is important to identify which questions must be answered in order to satisfy the goals.

Choose the evaluation paradigm and techniques to answer the questions - knowing the goals that need to be achieved and the questions that have to be answered, the next step is to decide what evaluation paradigm and technique (such as usability testing) better address these objectives.

Identify the practical issues that must be addressed - practical issues, such as selecting the participants, defining schedules and budget or what facilities and equipments are required, must also be considered before starting the evaluation. Sometimes there are constraints associated with these matters that involve adapting or substituting already defined techniques.

Decide how to deal with the ethical issues - privacy details about the participants must be carefully handled. Also, professional organisations usually provide ethical codes that must be respected, especially when dealing with "outsiders".

Evaluate, interpret, and present the data - it is of high importance to decide about what data should be collected, how to analyse it and how to present the findings to the development team.

This checklist should be an help for all those who seek to evaluate their products.

4.5 Summary

There are several methodologies that guide development processes in order to guarantee good levels of quality of the final products.

In this chapter was presented the user centered development design that guided the implementation of the developed prototype. This model tries to approximate the users of the products development providing insights that can have a huge impact on the final product's acceptance.

Constant product's evaluation was also object of focus through the exploration of the usability testing methodology, that with the help of the DECIDE framework, allows for the gathering of data from users in order to assess the product.

Chapter 5

Application

In this chapter, the concept behind the project will be presented. It will allow the reader to realise what is actually going to be developed and what are the main goals of the application. A conceptual model for the idea will also be explained.

5.1 Introduction

The increasing number of public transport users who are constantly connected to social networks, such as Facebook or Twitter through their mobile phones, during their trips, allows them to share operational and emotional information about the journey and the transport they are taking. These informations have an enormous potential not only for other travellers, but also for the public transport operators. The problem is that these data is not structured nor organized, and does not reach the right people.

With the goal of allowing the exchange of valuable information between public transport users in real-time, a new idea came up, that takes advantage of the new technologies and uses them to improve public transport users' experience. This concept was presented in article *Using social networks for exchanging valuable real time public transport information among travellers* [NGeCP11] and it was what leveraged this thesis work.

Basically, the idea consists of a smartphone application that allows travellers to share and receive information about the public transport in an organised and structured way. It can then be forward to all users to whom it might have value.

In this model, the users and maybe some automatic systems (such as temperature sensors), would provide information, such as punctuality, noise levels, or even drivers' skills, referenced to a vehicle, a route and time. Then, other users would be able to have access to that information, evaluating it in terms of truthfulness and utility, by making use of a validation system controlled by the public transport providers. After validated, the information would be either available to everyone, or private in some degree within a social network, taking into account security aspects

that need to be preserved. In a mature environment, more valuable information could only be available through subscription or freely to the most contributing users [NGeCP11].

The data would flow through networks of users that would be connected according to the level of importance that their knowledge of the public transport would have to each others. In other words those users that somehow possess information that might be useful for others, would share a temporary and anonymised network. These networks would be, not only a good method to share information, but also a way to give users a sense of community, increasing their will to share knowledge and help other fellow travellers.

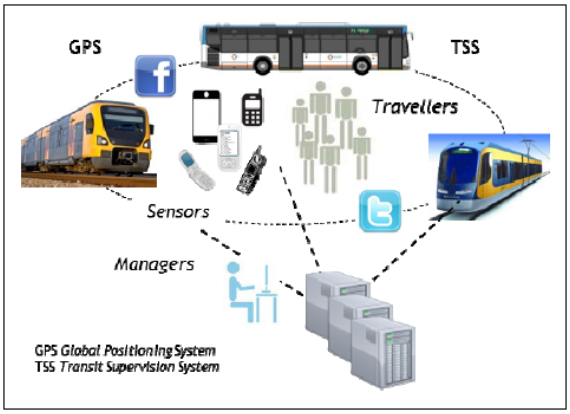


Figure 5.1: Social network interaction for collecting and distributing objective and subjective public transport information [NGeCP11].

Although the existing social networks provide an excellent environment to share information, most of them connect users through their friendship level, which is not the kind of relationship that is useful to aggregate users who have valuable public transport' related information. So, instead of a network of users where friendship and common interests dictate the rules and that stays stable and permanent after a certain period of time, this model requires the capacity to create communities that are dynamically adapted to travellers' location, travel patterns and intentions [NGeCP11]. This ability to create clusters of users that only exist temporarily in space and time, is probably one of the biggest challenges of this system.

The criteria used to connect users to each others can be improved by taking advantage of machine learning functionalities. Through users evaluation of the shared information's relevance, the system can implement ways of improving the clustering of users in time and space.

Since users are the main source of information, there must be something that encourages them to participate and share information. This could be done with the help of one of the main stakeholders of this project, the public transport providers. Through the sharing of information between travellers, the transport providers can have access to valuable information about their services. Information that comes directly from the people to whom they work and that might be used not only to improve their services, but also to warn them about important events that might influence the flow of travellers [NGeCP11].

This way, travellers that better contribute for a valuable information flow, can be rewarded with discounts on travel tickets provided by the transport' management, giving a real transactional value to the shared information. A new paradigm for electronic commerce emerges, bringing opportunities to be taken by all the stakeholders [NGeCP11]. At the same time, it supplies the system with serious games' characteristics, as users are now motivated to participate and be rewarded by feeding the system with valuable information.

Summing up, it is expected that this model saves structured and organised information about the public transport that has origin on travellers themselves. Based on these data, the system must allow three key services: an unique travel profile, travel information for users and a feedback service for transport network managers.

Unique travel profile

Through the information about the user's past journeys, the system is able to elaborate a travel profile that will be constantly updated. This profile will allow the service to predict the user's intentions, providing them with personalized journey plans that improve the travel experience [NGeCP11].

Travel information for users

Being the main goal of this project to supply the travellers with useful information about their trips, which is provided by other travellers, the service must constantly forward the right information to the right users. This flow of information is done accordingly to the time and route of each user, and using social networks, such as Facebook or Twitter to distribute the data [NGeCP11].

In order to identify who are these right users, it is necessary that the system is able to know where and when people are travelling. It is important to recognise who is going to start a journey and who is already in a journey so that it can understand which information is important to whom. This identification can be done through the user's travel profile that can recognise routine journeys and predict movements, or through expressed pre-trip travel intentions. Also, by matching the user's GPS location, provided by a smartphone, with the location of the nearest vehicles, or through a mobile-based check-in application[1], the system is able to identify the en-route passengers.

This dynamic combination between potential travellers and actual passengers referenced to a particular route and time, is the responsible for the creation of the previously referenced temporary communities of users that may have valuable informations to share.

The privacy issues that come up with the creation of communities and social networks, are also a motive of concern and must be carefully handled. Each user has to be able to know and define how to be reached by other users and how do they see the information that he or she provides. Private profiles that allow users to provide information without sharing their real identity, either through anonymous profiles or avatars, are very important tools to create a sense of security regarding the user's personal informations. Sharing the information only within a certain group of travellers that are trusted, is also another way of assuring the security of the user's identity.

[1] Check-in application - allows users to check-into a place, such as a store, or bar, and share their current location with friends (*http://www.foursquare.com*)

The unique travel profile cannot be known or accessed by other users under any circumstance to safeguard the security of the traveller [NGeCP11].

Service feedback for the transport network managers

Being the system fed with travellers' feedback about their journeys in real-time, transport network managers can highly benefit from the information that is shared. Through corporate social networks pages, they can access to privileged data that can help them enhance the quality of service [NGeCP11].

From a business perspective, it is important for the long-term success of this service, that the users who contribute the most with valuable information to the system are rewarded. Public transport providers are the key that allows for the existence of the reward model, since they can provide the prizes that will motivate the users to share information.

To sustain the rewarding model and, at the same time, to assure the reliability of the data provided by the users, a validation system must exist. Figure 5.2 presents the flow of it. With this system, users have to evaluate the level of correctness and usefulness of the information provided by others. This way, each one assumes three roles of interaction within the model: the user provides, receives and evaluates the exchanged information [NGeCP11].

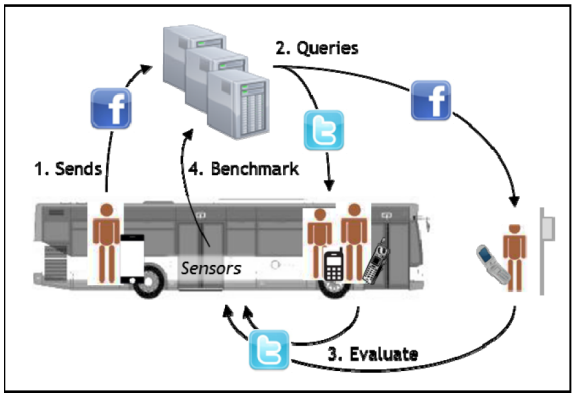


Figure 5.2: Validation model to assure the information reliability [NGeCP11].

As rewards for the travellers, transport providers can supply discounts on travel passes, free tickets or even access to more valuable information provided by the system itself. The shared information acquires a real transactional value since the operators pay for the information provided by the travellers [NGeCP11].

From a business perspective, the transport providers find this model commercially viable, as long as the revenue obtained through the improve of quality of service generated, by the exchanged information, is greater then the costs of sustaining the reward model [NGeCP11].

5.2 Goals

This thesis aims at the development of a prototype that puts in practice the concept mentioned above (see Section 5.1).

It is expected that the prototype allows to test the concept in an environment as close as possible to the one where it will be used. In other words, it must be possible to test and evaluate the application while using public transport.

By the end of this project, results that permit to attest the receptiveness of travellers to such an application and the potential of the concept, must be achieved.

There is also already some work done, such as a non-functional prototype, that can serve as a start basis and that can provide some feedback regarding the interface design of the application.

The prototype should be seen as a first step to evaluate the feasibility of the system as well as one more motivation to continue developing and improving the idea.

5.3 Conceptual Model

Before starting to develop the application, it is necessary to understand the concepts that will be part of it and how they are related. Figure 5.3 presents a simple conceptual diagram of the idealised system. As it is possible to perceive, it can be splitted in three main groups. The public transport' related concepts, such as lines or stops, that will support the indexation to a place or a vehicle of users' generated information. The group composed by the core of the application's main functionalities, such as users, comments or networks. And finally, representing the user's actions and intentions when travelling in public transport, the check-in and the planned journey concepts.

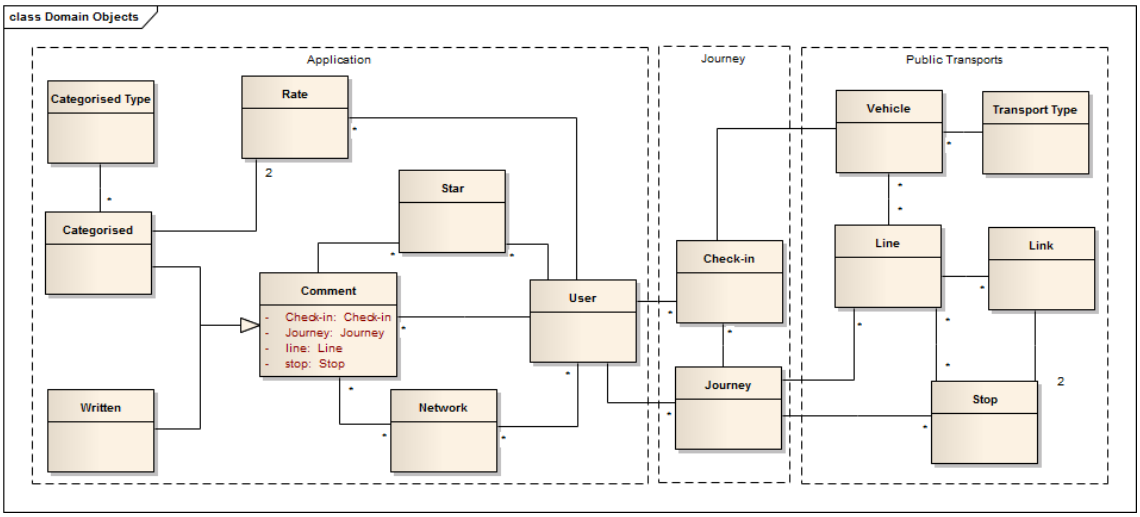


Figure 5.3: Conceptual Diagram.

Although the concepts' names are self-explanatory of what they are intended to represent, the next paragraphs will explain why they are needed. A database structure presented in section 6.3.1 will provide a deeper understanding of these concepts.

- **Transport related concepts**

As an application where it is intended to share information about public transport, concepts directly related to that environment are necessary, not only to allow for route planning functionalities, but also to index the shared information by the users with a place or route. By referencing the information to a public transport related object, a huge step is given towards solving the problem of the lack of organised information. Moreover, this linkage between information and places or routes, allows the system to generate and constantly improve the users' travel profile by having time and location referenced information of their activity.

A brief explanation of what each concept represents is given below.

Stop - Represents a stop where travellers catch public transport.

Line - Represents a public transport's route. Is a sequence of stops that form a path that the vehicle must follow to transport passengers.

Transport Type - Represents a transport mean, such as metro, buses, or trains.

Link - Associates stops to lines.

Vehicle - Represents a vehicle that transports passengers.

- **Application related concepts**

  Concepts that represent and support the social network's related actions that users are able to execute.

  Comment - Represents the information users share. It is the key concept of this system. User's comments can be of two types, Categorised and Written. Each comment refers to a stop or line, a journey or check-in, allowing users to comment either when they are at the stop or inside the vehicle.

  Written Comment - Allows the user to freely share an opinion or consideration about anything related with the journey or the public transport system.

  Categorised Comment - Represents an easy and structured way for users to share an opinion about one of the existing categories. These categories of information are explained in Chapter 6.

  Categorised Comment Type - Represents the different types of categories that Categorised Comments can assume.

  Rate - Concept that has an active role on the evaluation and reward models. It represents an user's evaluation of a categorised comment made by another user, helping filtering the reliable information.

  Star - Together with the rate entity, supports the reward model and also contributes for the reliability of the information. When a user considers that a certain comment was relevant, can value it with a star. This way the user who created that comment can be rewarded with points.

Network - It is what brings users together, creating an environment where users share information for the sake of the community, contributing with information that can be useful for the other users in the network. As previously said (see section 5.1), these networks are intended to dynamically adapt to the current travellers' location, travel patterns and intentions, in order to join those who have relevant information for each others.

- **Travel related concepts**

  There are two main concepts that represent the travel related actions and that allow the system to track their movements.

  Journey - Represents a travel intention of a user, allowing for the planning of a future journey. This is very important for the system to be able to improve the user's travel profile as well as to provide relevant information on the right time.

  Check-in - Represents the main action that a user does when riding public transport. Every time a traveller starts a journey, has to enter a vehicle or a station and validate the ticket. This validation process can be a way for the system to know where the user is, in order to provide the most valuable information.

5.4 Main functionalities

After an explanation of the general idea of this thesis, the next lines will uncover the main functionalities of the system.

The ability to check-into a vehicle is crucial, this way the system is able to locate the user in order to provide relevant information. When the user enters a vehicle and starts a journey, the check-in has to be done, either automatically, through NFC[2] for example, or through manual input. By checking-in, the system is able to add the user to the networks that might have valuable information for the trip.

Another way of being added to networks, can be done by the system itself, which, recurring to the user's travel profile or travel plans, is able to predict when and where is the traveller going to start a journey. With this functionality, it is intended to reduce as much as possible the user's need to interact with the application to start receiving valuable information.

Moreover, by matching the user's current GPS location with the vehicle's and also recurring to the mobile device accelerometer to analyse if the user is walking , it is possible to identify when and where the user leaves the vehicle, allowing for the automatic check-out to happen.

When checked-into a vehicle, the user must be able to start sharing information with other fellow travellers. In case the user has not checked-in yet but wants to share information about the trip that is going to do, there are two ways of being able to do it. Either the system, based on the travel profile, predicts the trip and asks if the user wants to be added to the networks related to that trip. Or the user itself plans the trip through the journey planner, which triggers the system to ask

[2]Near Field Communication - set of standards that allows for mobile devices to establish radio communication between each other by simply bringing them into close proximity (no more than a few centimeters).

if he or she wants to be added to the relevant networks. From then on, the user is able to also share information among those networks.

This exchange of information is done in a comment format, which means that the user can make a comment about the current trip and share it within his or her networks. Comments can be of two different types, the categorised and the written comments. The later ones are the most common ones in social networks, where the user can freely write something about the trip. This comments have a maximum limit of characters which, similarly to Twitter, is 140.

The first ones are an easier and faster way to share valuable information. These kind of comments are divided in categories related with different travel aspects. The user's opinion about delays, temperature, noise, or even the driver's skills, can be easily shared. These opinions are usually associated to a specific vehicle or stop, which allows for a validation system to enter in action.

When a categorised comment is submitted, the system randomly selects two users that are in the vehicle or network the comment was sent from. Those two users are then in charge of rating their agreement with the comment. That comment is only shared with all the users that might benefit from it if both evaluators positively rate it, otherwise it never gets to the news feed.

Through this data validation process, it is possible to filter the unreliable comments and also put the reward model in practice. Either by rating the comment or by submitting the one that reaches the news feed, the user is positively contributing to maintain the system's flow, being awarded with points for it.

It is important that the users are randomly picked to evaluate the comment and that the system can analyse if they are cheating. If only three users are in the same line, they must not be able to constantly keep rating each others comments, since they could evaluate them wrong only to profit from the points obtained through positive evaluations of their information.

When navigating through users' comments in the news feed, the opportunity to highlight a comment by attributing it a star can also be used to evaluate its relevance. The user who made that comment can also be awarded with points for the value of that information.

During the development of the prototype, it was decided to not implement the star related functionalities, though the database is ready to support them. The reason for this decision was the fact that it would be too easy to cheat the reward system. As an example, two users that know each other can enter the same network and evaluate each others' comments as relevant, even if they are not. Also, the impact on the information reliability could be awful. It was also considered that it would have a negative impact in the easiness of use of the application.

Acquiring points becomes an important part of the user's interaction with the system, since they can later be used to claim for rewards given by the transport operators, such as discounts, or free tickets. It is this goal that makes this application as a potential serious game.

Alike the social networks, all the shared comments are displayed as a list in the application, the news feed, sorted by the submission time. This list aggregates all the comments that somehow might have value, which means, they were sent from travellers within the networks the user is in.

Finally, and as this application's main goal is to improve the experience of the users during their public transport travels, a journey planner is almost a required functionality. Besides providing the user with operational information about the journey, it can also be used to schedule future and non routine trips, allowing the system to act accordingly to when and where they will take place.

5.5 Summary

In this chapter the concept and goals that leveraged this thesis were explained. It was also given a view of the conceptual model that allowed to assimilate the entities that somehow play a role in the system.

Insights about the main features that are meant to be part of the application were also provided.

Application

Chapter 6

Implementation

In this chapter all the application's development and implementation will be explained. The reader will be provided with information about the decisions that were made regarding the prototype's development as well as about its design process and architecture. Sometimes the reader will also be pointed to attachments that provide extra information about implementation details.

6.1 Development model

Being the main goal of this thesis to develop a functional prototype of a smartphone application, a software development process was followed in order to assure a correct implementation. As a relatively large system with several functionalities, the chosen development model was the iterative and incremental development.

As Figure 6.1 shows, this model is characterised for being a cyclic software development process. In each cycle, subsets of the software requirements are developed, tested and evaluated (iterative). After each cycle, modifications are made according to the evaluation results, as well as a new set of functionalities is added for implementation (incremental) [BDRW03].

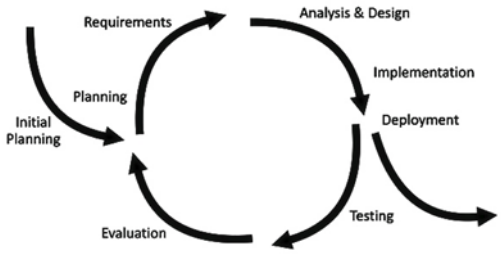


Figure 6.1: Iterative and incremental development.

The main reason that led to the use of this model was the need of having a prototype with the main functionalities implemented in a short period of time. With the iterative and incremental

development, it was possible to assure that in the end there would be at least some functionalities fully implemented and ready to be tested.

Groups of functionalities were developed and tested in an iterative way, allowing for constant analysis and improvement of the prototype. By recurrently testing the functionalities that were being implemented, new ideas and different opinions emerged, contributing for the consistency and evolution of the application's concept.

As the prototype's development took place at the Center for Advanced Studies of IBM[1], there was daily communication with the author of the application concept, Eng. António Nunes. This fact had an important role for the understanding of the application's intended goals and flow.

6.1.1 Interface design model

Regarding the interface design, the followed development process was the *User-Centered Design*. As previously explained in Chapter 4, this process is characterised for involving the user in the product's development. In this case, the application prototype was subjected to three main stages. The first two were mock-ups previously developed for the article *Using social networks for exchanging valuable real time public transport information among travellers* [NGeCP11]. While the third main stage occurred simultaneously with the functional prototype's development and its results can be used for future improvements.

The users were specially involved in the third main stage, although some feedback from other researchers at CAS and brainstorming session participants, was also gathered in the first two stages.

Figure 6.2 shows an example screen from each of the three stages of the interface development.

- **First stage - Article mock-ups**
  The first drafts of the interface design were created on Photoshop[2] to be part of the article *Using social networks for exchanging valuable real time public transport information among travellers* [NGeCP11]. Only the main menu (Figure 6.3), the points and rewards (Figure 6.4) and the comment evaluation (Figure 6.5) screens were made.

- **Second stage - Non-functional prototype**
  In this stage, a non-functional prototype of the application was designed using Balsamic Mockups[3] and Microsoft Power Point. It was possible to understand the application's flow and walk-through drafts of the functionalities' graphical interfaces. More information about this stage can be found in Section 6.5.

- **Third stage - Functional prototype**
  The last stage of the interface design was done after the requirements specification phase

[1] http://paginas.fe.up.pt/~ibmcas/
[2] http://www.photoshop.com/
[3] Balsamic Mockups - an application for the design of interface mock-ups (http://www.balsamiq.com/products/mockups)

Figure 6.2: Interface evolution.

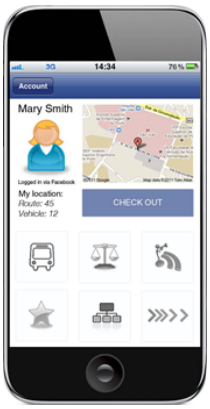


Figure 6.3: Main menu.

Figure 6.4: Comment evaluation.

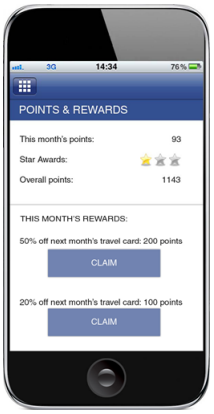


Figure 6.5: Points and rewards.

of the application functional prototype. A large set of modifications were made when comparing to the previous stages results. These changes occurred to better adapt the application to the OS it was going to run in. More information about this stage can be found in Section 6.6.1.

6.1.2 Brainstorming session

During the requirements specification phase, and as a first step to better define the type of information and functionalities that people miss when travelling, a brainstorming session was held.

Brainstorming session [Poh10] is a technique which goal is to generate as much new ideas and solutions as possible for a given topic. A group of people is gathered and asked to contribute with spontaneous thoughts about a problem. During the session the participants' input is not analysed nor judged, only afterwards conclusions can be taken from it. In the beginning of the session, it is important not to give the slightest suggestion of a typical solution for the problem, since it might hind the generation of participants ideas.

Six people with different characteristics regarding public transport use, from different age groups and with different backgrounds, were part of the session, in order to obtain a wider view over the travellers' needs. Table 6.1 shows a detailed view of the participants characteristics.

Table 6.1: Brainstorming session participants' characteristics.

#	Age group	Public transport travel profile	Background
1	30-40	Intermittent, mostly subway	Public transport domain researcher
2	18-30	Frequent subway user	Public transport related Msc. thesis
3	> 60	Regular bus user, sporadic use of subway	Retired
4	18-30	Sporadic in city bus user, regular between cities bus trips	Not relevant
5	30-40	Regular public transport user	Works for *Metro do Porto* in the service offer department
6	18-30	Public transport dependent user	Public transport related Msc. thesis

This group of people guaranteed a broad spectrum of ideas and opinions that allowed to better understand not only what travellers want, but also to see transport provider's perspective. By the end of the session, mock-ups of the application were also shown to the participants.

As it was expected, some of the ideas that came up from the session, were already present in most of the research cited in Chapter 3.1. Nevertheless, new types of information arose that had not been thought before the session, such as security issues or scenery related information.

The ones that were decided to integrate the application, and that emerged from the brainstorming session as well as from previous research, are presented below.

- Atmosphere related information

  Temperature;

  Scent;

  Noise;

  Crowding;

  Seating availability;

Cleanliness;

Scenery;

- Driver related information

  Courtesy;

  Smoothness;

- Progress related information

  Vehicle's speed;

  Vehicle's expected arrival at stop;

  Vehicle's progress;

  Distance of a similar vehicle;

  Incident report;

  Perceived security.

These types of information can be easily shared across the networks through the use of Categorised Comments. They were divided into three different categories, atmosphere, vehicle progress and driver related comments.

More information about the brainstorming session can be found in Appendix A.

6.2 Data model

Taking into account the application requirements, a data model was built to support all the functionalities and data. The conceptual model (Figure 5.3) can be seen as a first draft from where this data model evolved.

In order to better understand it, some important decisions regarding the application concept and the prototype will be presented, since they had a direct impact in the model design.

Network simplified concept

For the sake of this thesis, and due to time constraints, the network's concept had to be simplified in order to have a prototype ready on time and able to simulate the system. It was considered that relevant information comes from users that are in the same line and direction at the same time. This way, there is a network for each line and direction.

This assumption comes with some flaws. In case of lines that cover long distances, a user that only wants to travel between stops in the beginning of the line, will also receive information from users that are on the other end of it and that probably will not provide him or her with relevant information. Also, there are times where valuable information comes from users in lines that the only thing that have in common is the fact that they cross the same crossroad. However, if an accident happens on that crossroad it is important that users on both lines receive that information.

Nevertheless, it was considered that these constraints were not relevant for the simulation of the idea.

Vehicles not considered

An important public transport related concept was left out of the developed prototype. It was decided that representing vehicles would not compensate the effort of doing it. Stops and lines were considered sufficient for the prototype to simulate the idealised system. Also, it would not be practical for users to indicate in which specific vehicle they were checking-into, as they would have to know its identification code.

The ability to check-into a specific vehicle can be studied in a future work, since it introduces the necessity of giving the application means to automatically know in which specific vehicle the user is entering. It would also have an impact in the public transport system itself, since vehicles would have to make the needed information available. This could be done recurring to emergent technologies, such as NFC, that could also be integrated with the trip validation system.

Comment only when checked in

Another feature that was not fully implemented relates with the ability to make a comment without being checked-in. For instance, if a user is waiting for the bus at the stop, even if receiving news from the networks, will not be able to share a comment. In order to do it, the user has to check-into the appropriate line.

Once again, this constraint was not considered relevant for the prototype testing.

The designed data model can be seen as a base start for the concept development. Figure 6.6 shows the data model. As most of the components can be easily related to the ones already stated in the conceptual model 5.3, only some considerations will be made.

Again, it is possible to divide the data model into three main parts, one for the public transport data, which is only needed to query information that stays constant along the time. A second one for the application support, that holds all the data related with the social networks associated functionalities, and a last one to allow the users' interaction with the public transport.

All the information is referenced to a place by the latitude and longitude coordinates. This is very important to help the system forwarding it to the right users, and also to support the creation of their travel profile.

Public transport

This is the part of the data model that is filled with information from public transport, such as lines, stops or vehicle types. Each *Stop* is connected to the lines that pass by through the *StopsLine* table. This is a faster way to know which lines pass by that stop, since the same information could be extracted from the *Link* table through a more complex and time consuming query.

The *Link* table is responsible for storing information about how each route is composed. From this table and for each route (*idLineLink*) it is possible to know where it starts and what is the

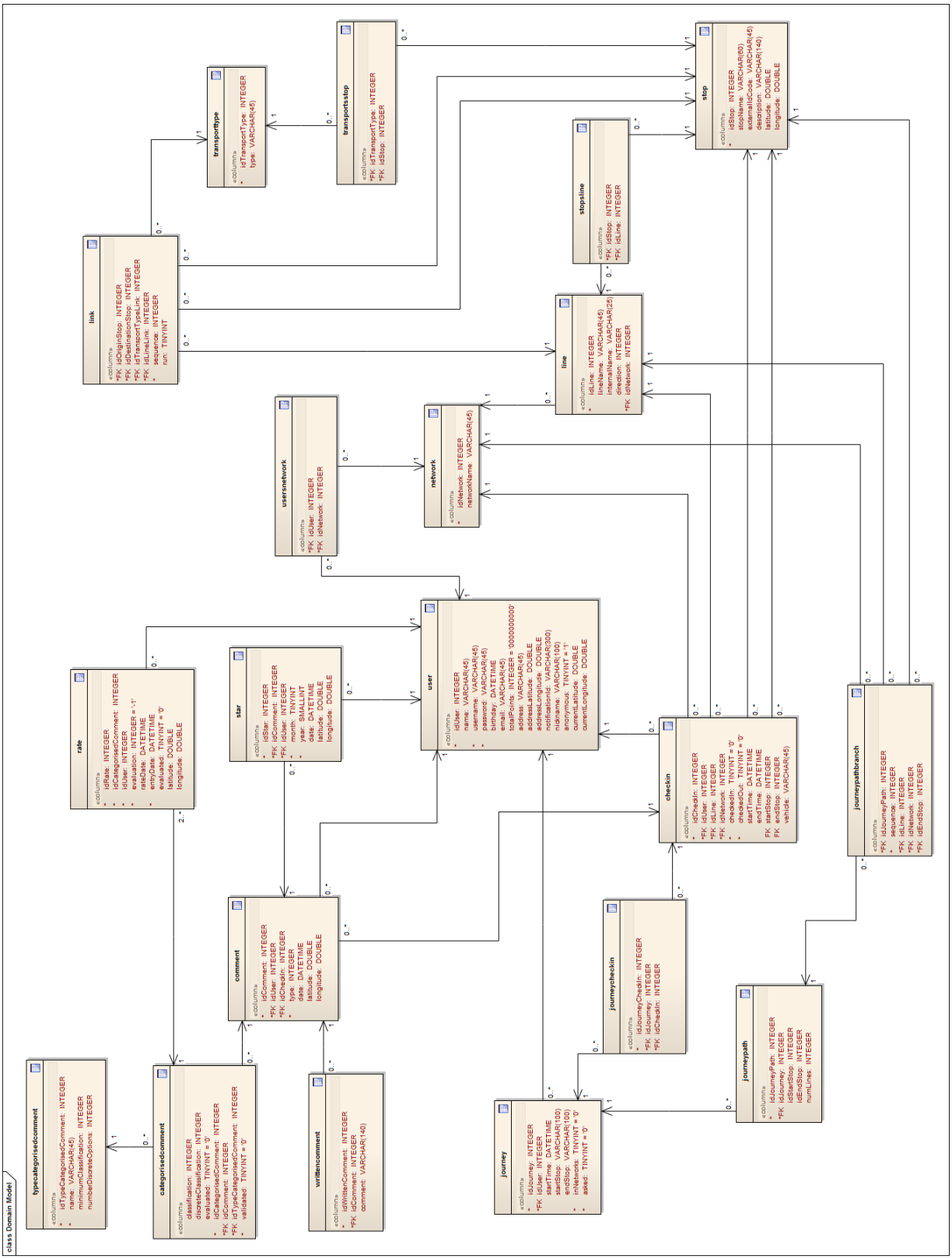


Figure 6.6: Data model.

sequence of stops using the *sequence* field. It is also possible to know which kind of transport does the route (*idTransportType*). The *idTransportType* could also be associated with each Line instead of each Link, but again, for querying purposes it was decided to associate it with each link, moreover, it also gives the ability for the system to support public transport where the same route can have different kinds of transport doing different parts of the path.

Application

Comments are the users' tools to interact with each others. As previously said, these comments can be of two different types, *Categorised* and *Written*. In order for users to validate others' categorised comments, so they can be spread through the networks, a *Rate* table keeps their evaluations of those comments. Only when two users rate positively (over the categorised comment's *minimumClassication*) a certain categorised comment, the *evaluated* and the *validated* fields are set to true, which allows for the comment to appear in the news feed. In case that the comment does not get a positive evaluation, only the *evaluated* field is set to true, in order for the system to know that it was evaluated but not validated.

Since the comments are referenced to a specific time, they must be evaluated as fast as possible, so that the information is still valid when it gets to the news feed. For instance, if a user says that a certain vehicle is crowded, it might not be true after the next stop. To allow for a fast evaluation of the comments, after choosing the users to rate the comment, the system gives them two minutes to do it. In case that they do not do it in those two minutes, then the system selects other users to do it. This is why it is necessary to keep track of when a user has been selected to rate a comment (*entryDate*) and when he or she actually rated it (*rateDate*).

When creating a categorised comment, a continuous scale from 1 to 100 is used to classify a certain trip related aspect (*classification*). However, the comments' rating is done using a discrete classification from 1 to 5 (*evaluation*). The average of both comment's rates is stored in the *discreteClassification* field.

As previously said in Section 5.4, during the prototype's development it was decided not to implement the ability for users to attribute stars to comments that they found relevant since it would be a very easy way to cheat the system. However, this decision was made after designing the system's data model and it was not removed from the design since it can be reconsidered in future work. The month and year of the star assignment would be stored in order to keep track of how many stars the user gave. As a way to prevent cheating, each user could only be allowed to assign a maximum number of stars each month.

Regarding the users' information, and for prototype purposes, privacy issues were taken care in simple way through the use of a nickname (*nickname*) and a profile visibility field (*anonymous*). Each user can set is profile in two different modes, anonymous or public. If in anonymous mode, users' cannot know who are the comments' creators, while when in public mode, the user's nickname appears in the comment's information. The nickname can be changed by the user at any time. Also for prototype purposes, the rewarding system was simulated through the sum of points

(*totalPoints*) whenever each user rates a comment (wins 1 point) or creates a categorised comment that is rated successfully (wins 2 points).

Through *UsersNetwork* it is possible to know which users are in which networks.

It is also possible to see that all the information fed into the system is georeferenced through latitude and longitude coordinates.

Public transport usage

When a user enters in a public transport vehicle, it is important that system is aware of it in order to provide the most suitable information. For that purpose, the check-in has to be done. The travel line, start stop, end stop and times, are the sort of information that needs to be stored. Also, the system must be able to know if the user already checked-out (*checkedOut*). For the prototype, each check-in is associated with only one network (*idNetwork*), though in future developments, it should be related to more, as the user might benefit from information that comes from other lines and directions.

To hold users' travel intentions, the *Journey* table stores from where, to where and when the trip is intended to occur. Since the user introduces the places names, it is necessary for the system to relate those names to the stops' identification codes (*idStop*). In order to do that, a journey planner query is responsible to calculate the possibilities that the user has to travel between the stops that match the given names. The ability for the system to allow the user to introduce the location name instead of the stops is also supported, since each *Journey* can be associated with several *JourneyPath*. This means that if a user only says that wants to go from place A to place B, the system can check all the stops near A and B and plan journeys between all the possible options. Moreover, each *JourneyPath* may carry the need for the user to take several lines. For instance, to go from A to B, it might be needed to stop in C and change to another vehicle. This is possible through the *JourneyPathBranch* that represents each part of the trip.

When a travel intention is actually put into practice, the relation with the correspondent check-ins is done through the *JourneyCheckIn* table. This relation is very important for the creation of the user's travel profile, as it indicates which planned trips are actually made. Otherwise the system would not be able to distinguish which journeys were actually important for the user since some travel intentions could be made only for purposes of user's curiosity about a certain trip. For instance, a father that would like to know information about his son's trip.

The travel intentions are also important for the system to suggest the user to be added to the networks related with the trip. This way, ten minutes before the trip is suppose to be made, the user can start receiving information about it. The *inNetworks* field allows the system to know if the user was added to the networks related with that journey, while the *asked* field tells if the user was already warned about that journey intention.

6.3 Component Model

A smartphone application that demands interaction and exchange of information between users implies the existence of third party components to store and operate the data. Figure 6.7 shows the component model that was implemented for the system.

The database, the web service and the Android application are the three main components that support the core functionalities of the service. There is a fourth component in a form of a Windows application that keeps querying the database and that makes use of an external service, the Android C2DM[4] that allows to dispatch information to the smartphone without the need of a request from it. This service implies the use of an external service provided by Google.

All these components are analysed in the following sections.

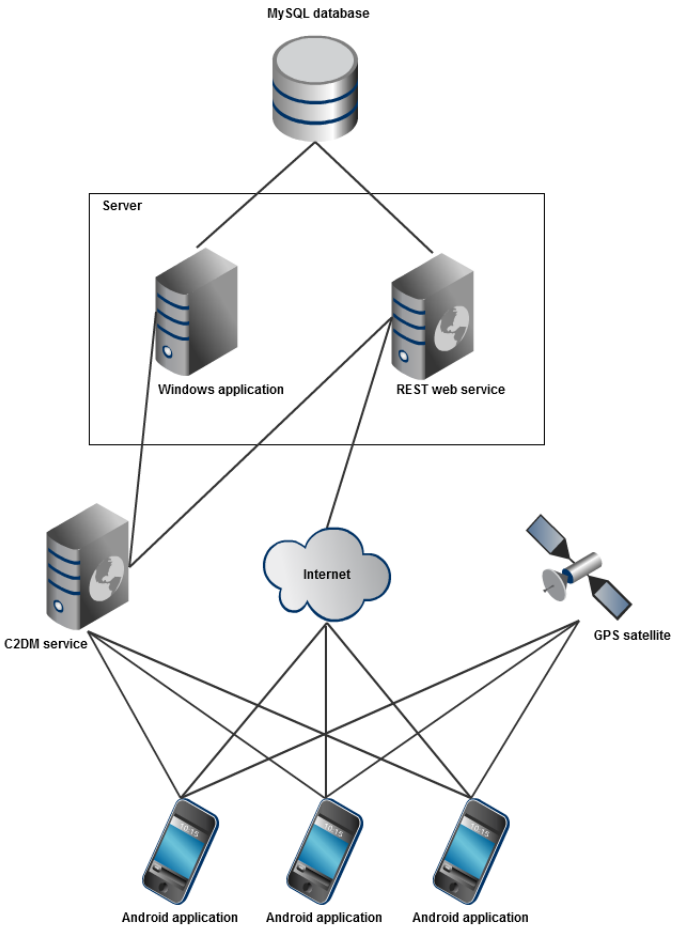


Figure 6.7: Component model.

[4]Cloud to Device Messaging Framework - https://developers.google.com/android/c2dm/

6.3.1 Database

One of the first decisions made was the database technology to use. The chosen one was MySQL, not only because it is an open source technology, but also due to scaling capabilities and being able to support stored procedures. Its portability and compatibility with most programming languages were also factors that contributed for choosing this technology.

Several stored procedures were created to support the system functionalities. Some of the most relevant ones will be presented below.

journeyPlanner(IN startNode INT, IN endNode INT) - as the name suggests, receives two stops' identifications and is responsible for finding a path between them. However, it works only for stops that are part of the same line or that can be reached only by using two different lines. Though it could be done on the web service side, it was decided to implement it as a database procedure because it is faster and the above constraint is not relevant for prototype purposes. Using the web service for this work would imply the importation of huge amounts of data from the database as well as the use of memory resources that could negatively affect its performance. The code below shows the procedure's returned information when both stops can only be reached if the traveller changes line once.

```
...
SELECT startLines.idLineLink AS startOriginLine, startLines.idOriginStop AS
    startOriginStop, startLines.idDestinationStop AS startDestinationStop,
    endLines.idLineLink AS endOriginLine, endLines.idOriginStop AS
    endOriginStop, endLines.idDestinationStop AS endDestinationStop, ((
    startLines.sequence - startLines.originSeq) + (endLines.destinationSeq -
    endLines.sequence)) AS numberStops
...
```

Listing 6.1: journeyPlanner procedure.

newCategorisedComment(IN p_idUser INT, IN type INT, IN p_idCheckIn INT, IN date DATETIME, IN latitude DOUBLE, IN longitude DOUBLE, IN idCategorisedType INT, IN classification INT, IN discreteClassification INT) - is responsible for creating a categorised comment and randomly select the users to rate it. The code below shows how the selection of users is done.

```
...
  -- Selects the first user
  SELECT u.idUser
  INTO userId1
  FROM CheckIn ch, User u
  WHERE idNetwork=v_idNetwork AND checkedIn=TRUE AND checkedOut=FALSE
    AND ch.idUser<>p_idUser
```

```
    AND ch.idUser=u.idUser
  ORDER BY rand()
  LIMIT 1;

  -- Selects the second user
  SELECT u.idUser
  INTO userId2
  FROM CheckIn ch, User u
  WHERE idNetwork=v_idNetwork AND checkedIn=TRUE AND checkedOut=FALSE
    AND ch.idUser<>userId1
    AND ch.idUser<>p_idUser
    AND ch.idUser=u.idUser
  ORDER BY rand()
  LIMIT 1;

  -- Introduces the new rates for the comment
  IF(userId1 IS NOT NULL) THEN
    INSERT INTO Rate(idCategorisedComment, idUser, evaluation, entryDate,
        evaluated) VALUES (v_idCategorisedComment, userId1, -1, date, false);
  END IF;

  IF(userId2 IS NOT NULL) THEN
    INSERT INTO Rate(idCategorisedComment, idUser, evaluation, entryDate,
        evaluated) VALUES (v_idCategorisedComment, userId2, -1, date, false);
  END IF;
...
```

Listing 6.2: newCategorisedComment procedure.

For the prototype, these users are selected randomly from the network the categorised comment is associated with. However, it is important that in a future version the system is able to avoid selecting always the same users as cheating can occur.

closestStopsProcedure(IN dist INT, IN mylat DOUBLE, IN mylon DOUBLE) - is the procedure that enables the check-in using GPS coordinates to occur. It receives the current latitude (*mylat*) and longitude (*mylon*) of the user and returns the five closest stops to that location. The area that is considered for the stops' search is constrained to a square that is centered on the current user's location and has a side of *dist* miles (Figure 6.8)

The code below shows the implemented procedure.

```
CREATE PROCEDURE closestStopsProcedure(IN dist INT, IN mylat DOUBLE, IN mylon
    DOUBLE)
BEGIN
  DECLARE lon1 float;
  DECLARE lon2 float;
  DECLARE lat1 float;
  DECLARE lat2 float;
```

```
  -- Calculate lon and lat for the square:
  SELECT mylon-dist/abs(cos(radians(mylat))*69.0) INTO lon1;
  SELECT mylon+dist/abs(cos(radians(mylat))*69.0) INTO lon2;
  SELECT mylat-(dist/69.0) INTO lat1;
  SELECT mylat+(dist/69.0) INTO lat2;

  -- Select the closest stops
  SELECT *, 3956.0 * 2.0 * ASIN(SQRT( POWER(SIN((mylat - Stop.latitude) * pi
      ()/180.0 / 2.0), 2.0) +COS(mylat * pi()/180.0) * COS(Stop.latitude * pi
      ()/180.0) *POWER(SIN((mylon - Stop.longitude) * pi()/180.0 / 2.0), 2.0)
       )) AS distance
  FROM Stop
  WHERE
    Stop.longitude BETWEEN lon1 AND lon2 AND
    Stop.latitude BETWEEN lat1 AND lat2
  HAVING distance < dist
  ORDER BY distance
  LIMIT 5;
END
```

Listing 6.3: closestStopsProcedure procedure.

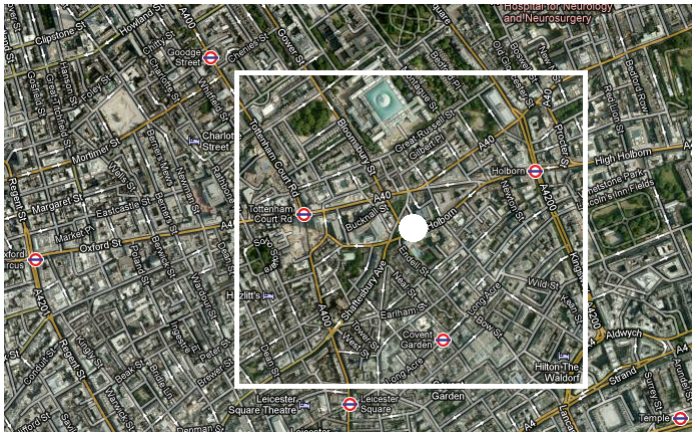


Figure 6.8: Closest stops identification square.

6.3.2 Web service

Following the current trends of most of the large companies' public web services, such as Google, Yahoo or Amazon, the chosen design architecture for the implemented web service was REST.

This architecture is characterised for being a stateless client-server architecture where web services are viewed as resources that can be identified by their URL [RR07]. Meaning that a client requests a web service for a certain resource, that can be any coherent and meaningful concept, which is typically represented by a document that captures the current state of the resource. If the

client wants to update the state of a certain resource, then it send the representation of the intended state of that resource to the web service.

REST is considered to be lighter and simpler than other architectures, such as SOAP. It is also common to use **JSON!** instead of XML, which contributes for lighter messages between the client and server.

The use of **JSON!** together with being a stateless architecture are the main reasons that make REST architecture suited for mobile applications. As mobile connections are prone to network failures, by having a stateless client-server architecture where it is not needed for communication to be constrained to the client context being stored on the web service between requests, problems related with sudden losses of signal are prevented, since each request contains all the necessary information for the web service to process it.

Both the windows application (see Section 6.3.4) and the web service were developed in C# using the .NET framework.

6.3.3 Android application

Regarding the mobile application, it was decided to develop it for the Android platform.

Android is an operative system for mobile devices based on Linux and created by Google. It is one of the most used platforms and the main competitor of iOS[5].

The main reasons that led to this decision were related to the main advantages that characterise Android.

Open-source platform - making it easier to develop applications for smartphones and tablets;

Portability - the programming language for the applications' development is a modified version of Java, that is optimised to save system resources. As Java is not compiled to native code, but to a *bytecode* that is executed by any Java virtual machine, it makes it possible to develop applications in any environment, from Windows to Linux or Mac OS.

Another important feature provided by Google that was important for this decision, is the Android Cloud to Device Messaging Framework (C2DM). This is a service that allows developers to send data from servers to their applications on Android devices without the need of a request from the mobile device to occur. There are several requirements regarding the user's device that need to be fulfilled to use this service.

- Devices must be running Android 2.2 or higher versions
- The Market application must be installed.
- Requires users to set up a Google account on the mobile device.

Another important characteristic of this service, is that it does not require the application to be running for the mobile device to receive messages, which is important when the server needs to notify users about a comment to rate or a scheduled trip to do, that are not using the application.

[5] iOS - mobile operating system developed and distributed by Apple, it is the most popular OS.

6.3.4 Windows application

In order to provide the system with the ability to inform users about planned trips or to select new users to rate a categorised comment whenever the chosen ones do not do it in time, a windows application was created. This application is always running in the server and querying the database, acting accordingly with the information retrieved.

The application is composed of three main methods that are called every fifteen seconds.

checkRate() - it queries the database and checks if there are categorised comments whose rates have already expired and have not been evaluated. Since each selected user as only two minutes to rate a certain categorised comment, this method is responsible for choosing and notifying another user in case the first one exceeds the given time.

checkJourneys() - is responsible for checking and notifying users with scheduled journeys for the next ten minutes, in order for them to accept being added to the relevant networks.

checkRemoveJourneys() - when a user schedules a journey and accepts being added to the relevant networks, he or she might never actually do that journey. This method is then responsible for removing the user from those networks if no check-in is done after five minutes of the journey's intended start time.

All these methods make use of Google's C2DM service to notify the users.

6.4 Main use cases

After the requirements elicitation, a document was created in order to define the mobile application requirements (see Appendix B). Although a total of twenty three use cases were defined, only some of those were actually essential for the concept testing.

In the following lines, these essential use cases will be presented. All the uses cases imply that the user is registered in the system and that is already logged in the android application.

6.4.1 Check-in and check-out use cases

Since the system must know where the user is in order to provide relevant information, the actions of check-in and check-out from a vehicle are very important. As previously said, vehicles were left out of the prototype's development, so instead of checking-into a vehicle, users check-into a certain line and direction.

When a user checks-in, is automatically added to the networks that are relevant for the journey that just started, while when check-out occurs, the user is removed from those exact same networks. Below (see Figure 6.9), the check-in and check-out use cases are presented.

There are several ways for the check-in and the check-out to be done. Both of these actions must be able to be performed through manual input of the user, since the automatic ways might not be supported in all the devices (not all devices possess NFC) or at every time (the GPS signal might not exist).

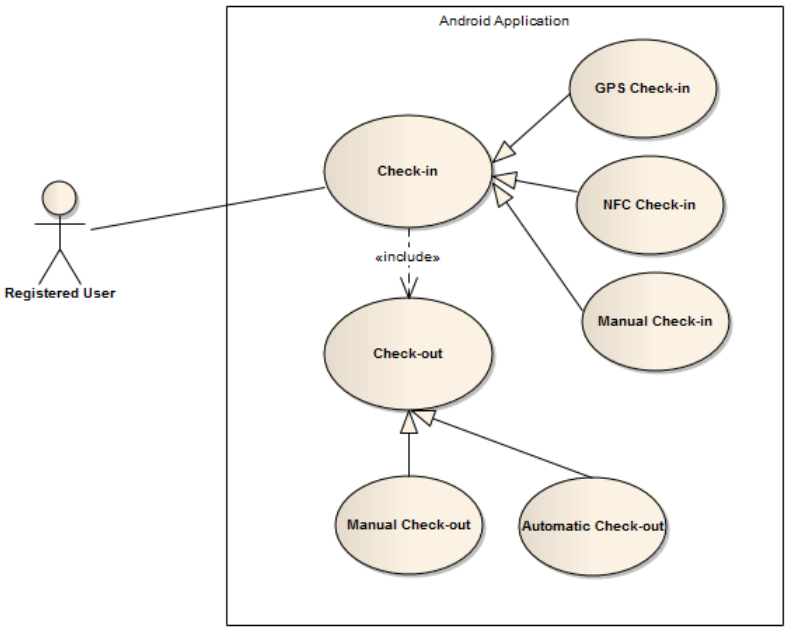


Figure 6.9: Check-in and check-out use cases.

As previously explained (see Section 5.4), by comparing the GPS location provided by the mobile device and the one from the vehicles, it is possible to infer if the user has checked-in or checked-out. Also the use of NFC technology, it can be possible for the user to easily check-into a vehicle.

6.4.2 Comment use cases

This set of use cases are the core of the application. These allow the users to share information between each others and also to rate a categorised comment and evaluate each others comments. Figure 6.10 shows the comments related use cases.

Each Categorised Comment must be validated by two other users in order to get to the news feed. As previously explained (see Section 5.4), the ability for a user to evaluate a comment as relevant when seeing the news feed, was decided not to be implemented.

6.5 Mock-ups (low definition prototype)

In the second stage of the interface design, which was done before this thesis work by Eng. António Nunes, a fully non-functional prototype was created. This prototype allowed for a better understanding of the application flow and its intended functionalities. Below (see Figure 6.11) there is a diagram that represents the application's flow.

The following lines will present some of the designed screens from which there are relevant informations or decisions to address.

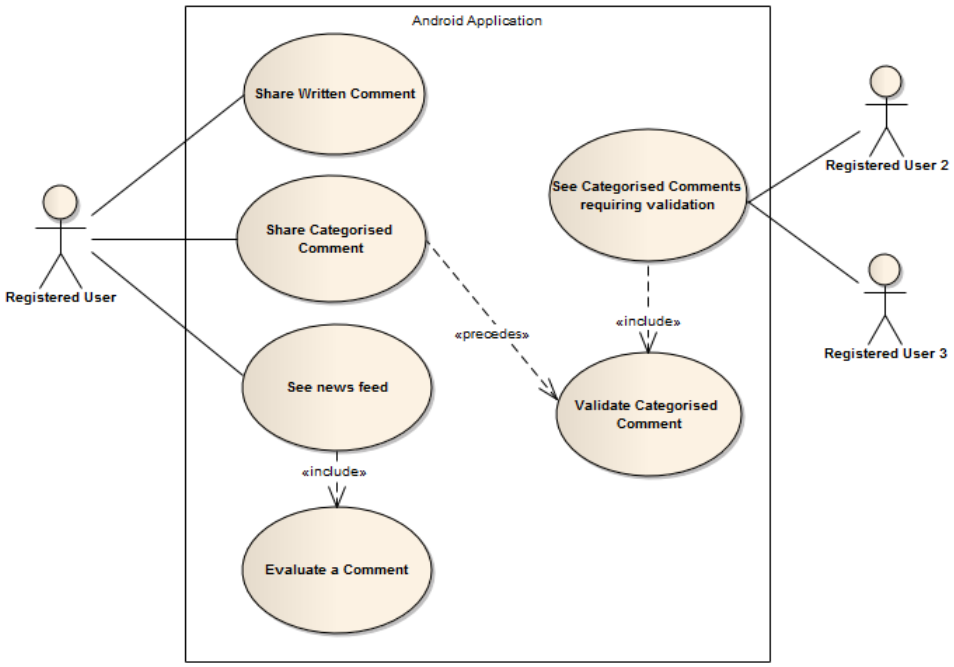


Figure 6.10: Comment related use cases.

6.5.1 Main menu

In this stage of the design, and alike the first one (see Section 6.1.1), the application has a main screen from where it is possible to navigate to all the different parts of it. In this main screen it is also possible to quickly access to information such as the current user's route, vehicle and map location. There is also a button that allows the user to quickly check-into a vehicle (see Figure 6.12).

6.5.2 Comment screen

The comment interface is divided in four different tabs that correspond to the following main categories:

- Atmosphere
- Vehicle Progress
- Driver
- Written Comments

Inside the first three main categories, the user is able to submit a Categorised Comment in an easy way, by using a slide bar to evaluate the chosen category and pressing the submit button (see Figure 6.13). In the last one (Written Comments) the user can share a freely written comment (such as the ones in Twitter or Facebook).

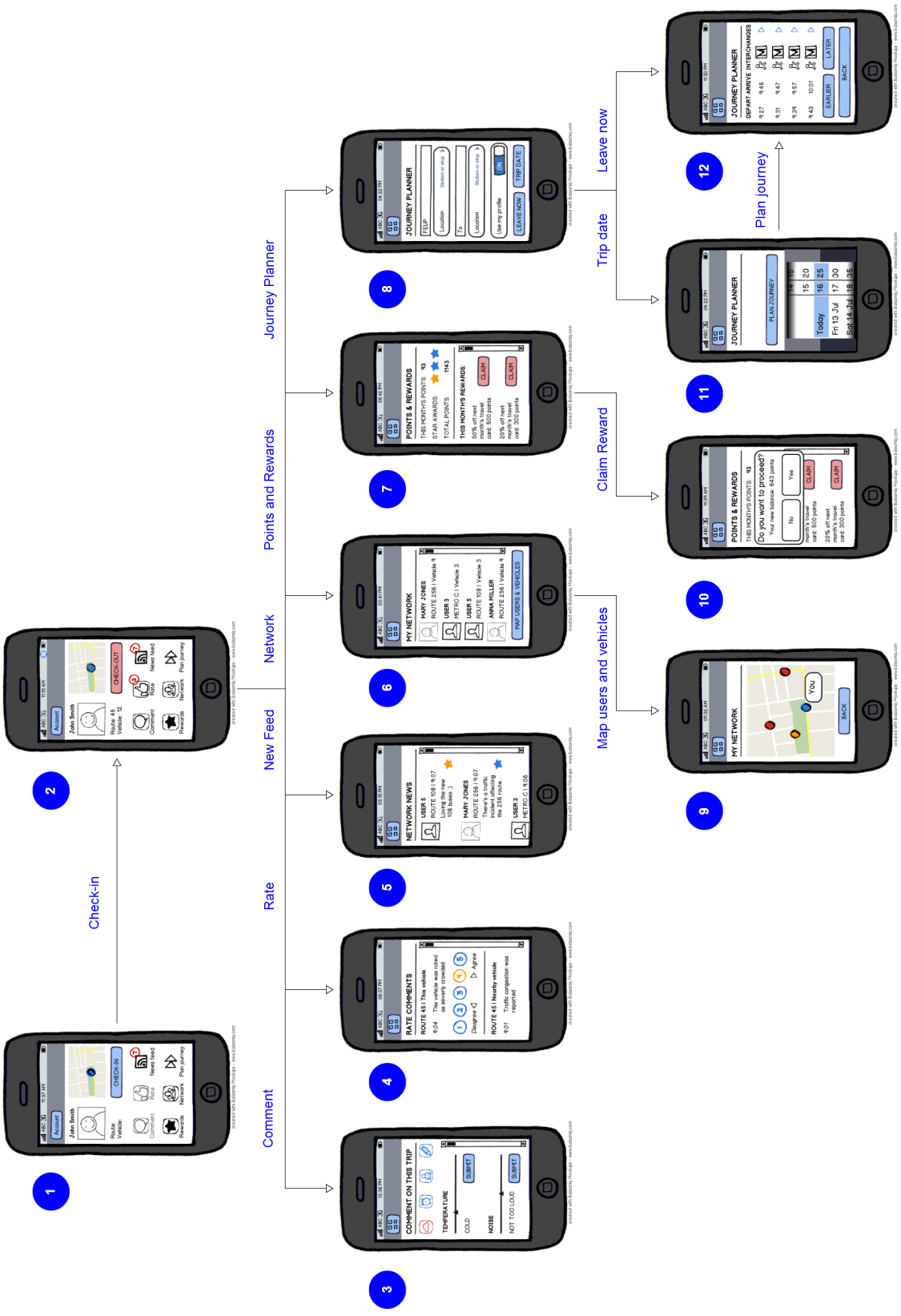


Figure 6.11: Application flow.

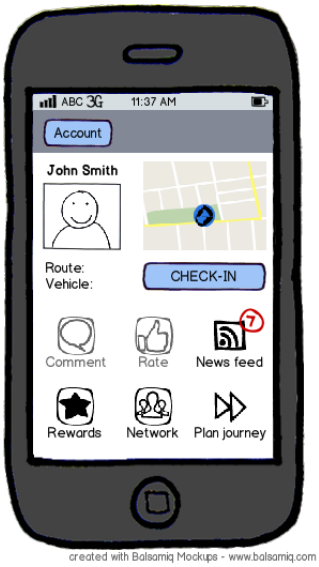


Figure 6.12: Main menu screen.

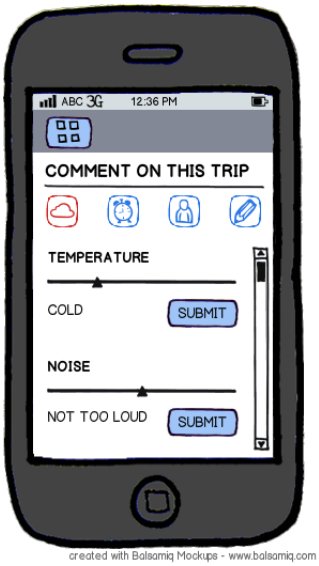


Figure 6.13: Comment screen.

6.5.3 Network screen

In this interface design stage, it was foreseen the existence of a screen where the users could see who and where were the current users in their current networks. Figures 6.14 and 6.15 show those screens that were later excluded from the prototype, since it was not considered to be a fundamental functionality for the prototype testing.

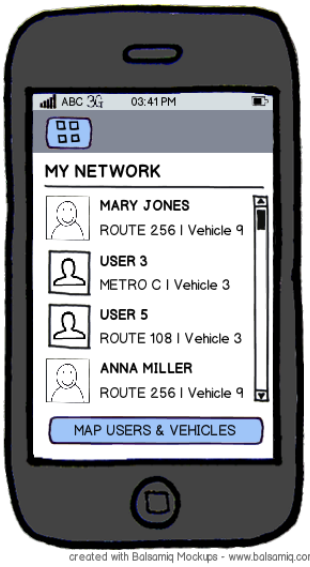


Figure 6.14: Network screen.

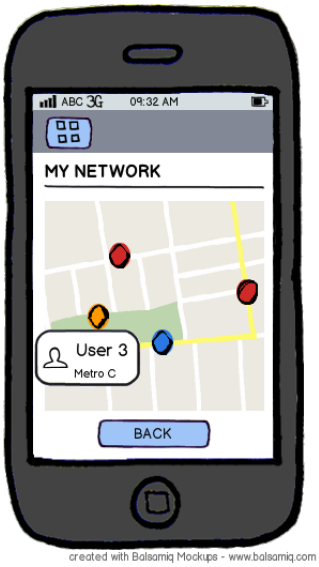


Figure 6.15: Network map screen.

6.6 Functional prototype

A functional prototype of the mobile application was developed and tested. In this section, all the implemented functionalities will be presented, as well as the last stage of the interface design (see Section 6.1.1).

6.6.1 Interface design

In the third stage of the interface design, the application interface suffered several changes.

Major changes were done in order to better adapt and take advantage of the Android resources and capabilities. The first thing that started to have an impact on the new interface design was the existence of the Android Context Menu. With this menu, having an home screen from where the user could reach all the application functionalities and, more important, could quickly check-into a vehicle, was not a necessity any more. The decision of migrating the check-in related functionalities to the Context Menu, allowed the rethinking of the application interface and flow.

Instead of a main screen, it was decided to create a tab based interface. A tab interface transmits a more fluid application flow, since the tabs are visible during all the application usage, which allows the user to easily understand the current application context as well as to easily navigate between the main functionalities without the need to constantly return to the main menu.

Figure 6.16 shows the first draws of the tab based interface. It is possible to distinguish five different tabs, each one leading the user to a different application functionality:

- Comment
- Rate
- News Feed

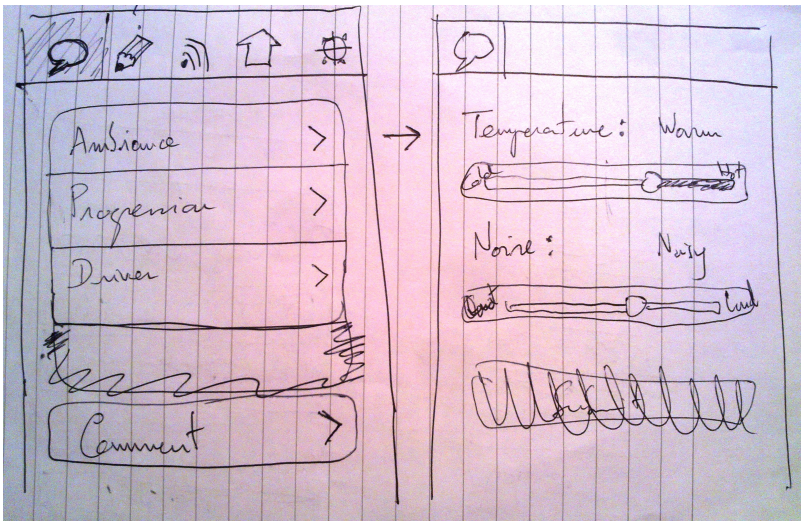


Figure 6.16: Tab interface's first drafts.

- Home
- Journey Planner

On the left side is the first screen of the Comment tab, which has two different sets of buttons. The top set is constituted of three buttons that lead the user to the three main categories of the Categorised Comments, while the button *Comment* allows to create a Written Comment.

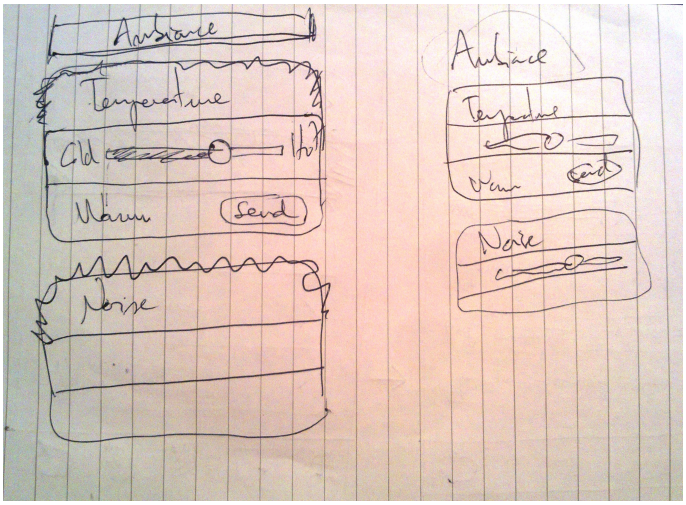


Figure 6.17: Comments interface's first drafts.

A first draw of the categorised comment input format can be seen on the right side of Figure 6.16, it later evolved to what can be seen in Figure 6.17. This evolution was necessary to provide a way for submitting each categorised comment individually and in an easier way. The first draw would only have one button at the end of the screen to submit the categorised comments, which implied the existence of something to allow the user to choose which comment to submit,

such as a check-box. Having an independent button (*send*) for each categorised comment type, the user is able to submit one in only two touches.

Another modification from the second design stage to the third, was the aggregation of the user's account settings with the points and rewards screen. This decision emerged from the fact that having one more tab could dangerously diminish the tabs size, which could be a problem for devices with small screens. Figure 6.18 shows the Home tab that aggregates all the user's personal information as well as the claim rewards functionality.

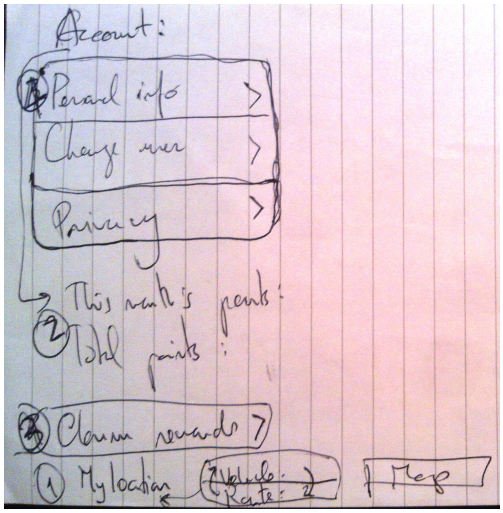


Figure 6.18: Home interface's first drafts.

The prototype's final interfaces will be presented along with the implemented functionalities in Section 6.6.2.

6.6.2 Implemented functionalities

As previously said (see Section 6.4), there were use cases that needed to be implemented in order to enable the test and evaluation of the application concept. Besides the ones presented in Section 6.4, some other use cases were also implemented to enrich the test participants perceived experience of the application.

Each of the following sections presents the flow and functionalities of each tab of the developed prototype. Section 6.6.2.6 presents all the functionalities provided in the Android Context Menu.

6.6.2.1 Comment tab

This tab contains all the functionalities related with the creation of either written or categorised comments.

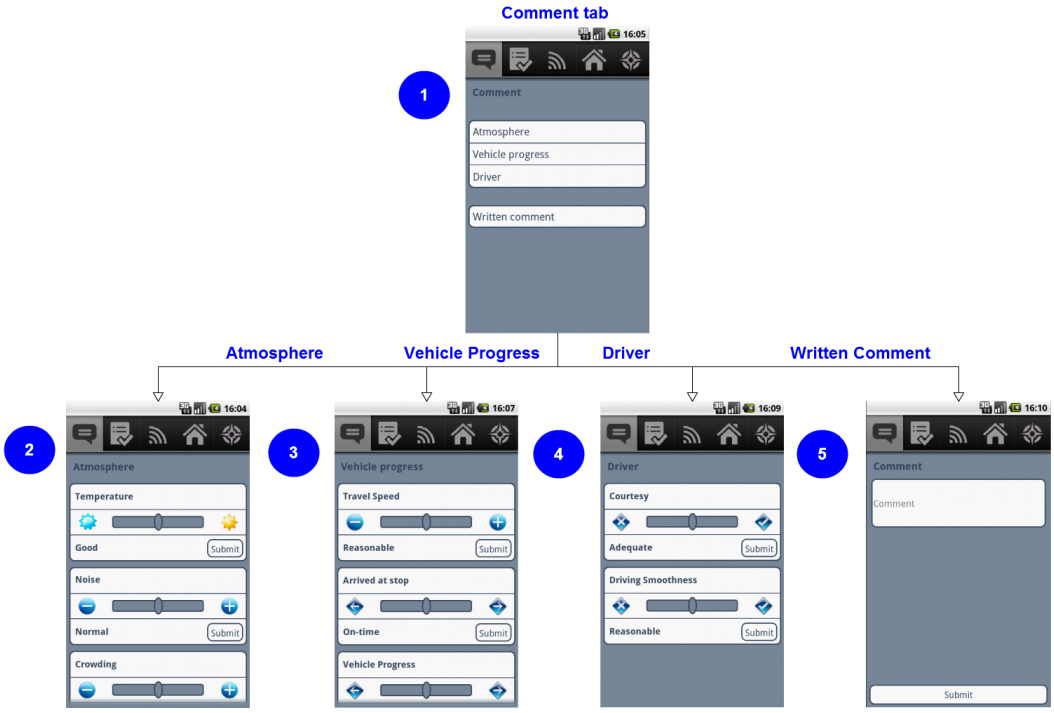


Figure 6.19: Comment tab flow.

1. Main screen of the comment's tab.

2. Allows the user to create atmosphere related categorised comments.

3. Allows the user to create vehicle's progress related categorised comments.

4. Allows the user to create driver related categorised comments.

5. Allows the user to create a written comment.

6.6.2.2 Rate tab

When selected to rate a categorised comment, the user has to go to the Rate tab in order to evaluate the comment. There is only one submit button that only submits the rates that the user actually evaluated. For instance, in the Figure 6.20 case, only the first rate would be submitted.

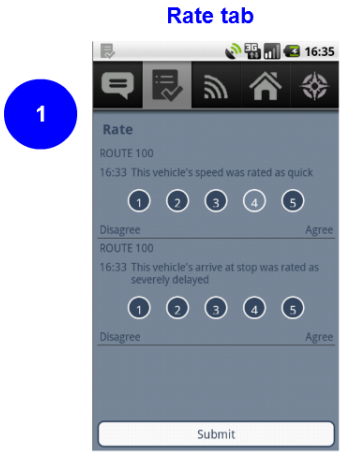


Figure 6.20: Rate tab flow.

1. Main and only screen of the Rate tab that shows all the categorised comments that the user was selected to rate.

6.6.2.3 News feed tab

Alike the Rate tab, the News feed one also has only one screen. It shows a list of all comments made in the networks the user is in, being similar to most of the social networks main screens, such as Facebook's wall or Twitter. Each comment contains information about the time it was created as well as the nickname of the user who did it. If the user's profile is set to anonymous, *UserX* appears instead of the nickname.

Figure 6.21: News feed tab flow.

1. Main and only screen that shows all the comments made in the networks of the user. The first time the user gets to this tab, only the comments from ten minutes before the current time are shown.

6.6.2.4 Home tab

As previously said (see Section 6.6.1), this tab is the result of the aggregation of both user's account settings and the points and rewards related functionalities.

Regarding the reward model presented in Section 5.1, only the points scoring is implemented. If a categorised comment is successfully validated, the user who created it gets two points, while for each categorised comment rated, gets one point. As the reward claiming functionalities are dependent of the public transport managers, they were not considered for the development of this prototype.

For prototype purposes, the user has only two options regarding his or hers public profile. It can be either public or anonymous.

- **Public profile -** the user is represented in the networks by the nickname. This nickname is not related with the username and can be changed at any time.

- **Anonymous profile -** the user is represented as being *UserX*.

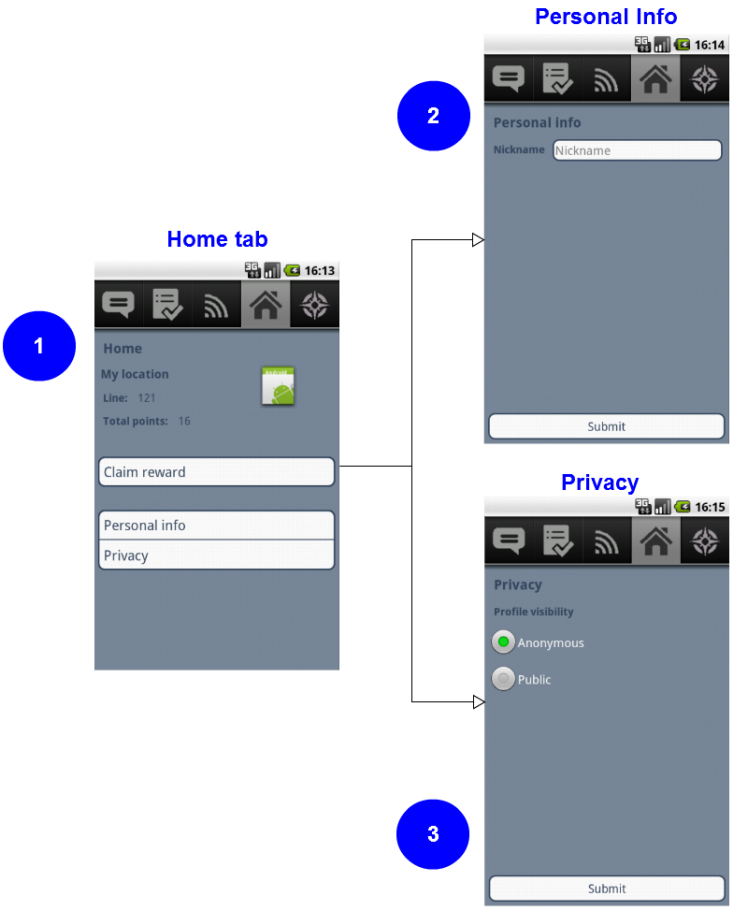


Figure 6.22: Home tab flow.

1. Screen that alike the main menu designed in the early stages of the interface design process, shows the user's current route. In future work, the Android image on the top right side of the screen should be replaced by a map that shows the user current location, just like the Network Maps (see Section 6.5.3) screen of the second stage of the design process.
2. Allows the user to change the nickname
3. Allows the user to change the profile visibility

6.6.2.5 Journey planner tab

Journey planner functionalities are a must in a public transport related application. Though this was not an essential use case for the prototype development, a simple journey planner was implemented. This provided the prototype to be able to handle user's travel intentions and act accordingly.

In this tab, the user can schedule a journey between two stops and choose which of the available paths he or she wants to receive information from. Ten minutes before the scheduled time, the user

is asked if he wants to start receiving information about the trip (see Figure 6.24). If so, the system adds the user to the networks related to the previously chosen paths.

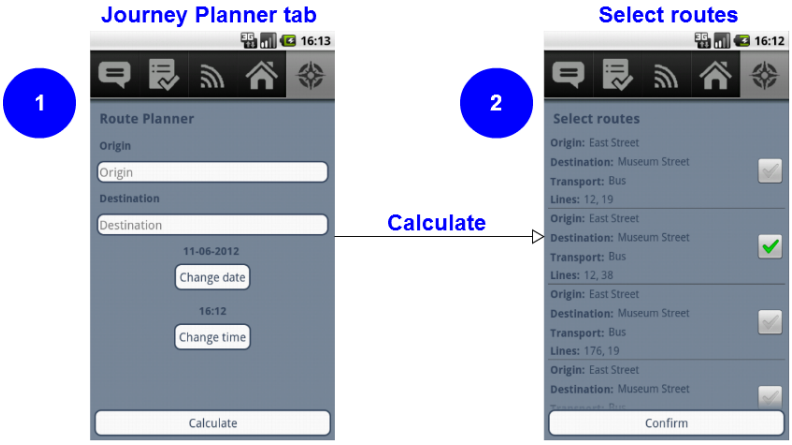


Figure 6.23: Journey planner tab flow.

1. Tab's main screen where the user can schedule a journey between two stops.
2. Informs about the available paths to follow and allows the selection of the ones the user wants to receive information from.

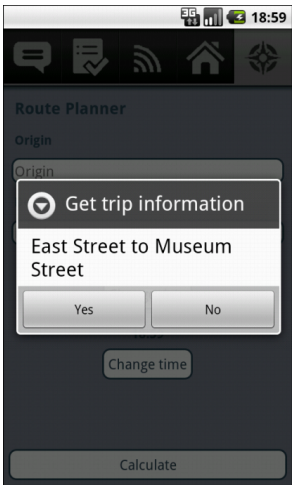


Figure 6.24: Get trip information.

6.6.2.6 Context menu

The context menu was responsible for the biggest changes in the application interface design. This resource incorporates the functionalities that must be available for the user independently of the location in the application, such as the check-in, check-out, refresh and logout.

Regarding the check-in, there are two options available. Check-in can be made, either by making use of the user's current GPS location, or through manual input of the current stop.

The GPS option asks the web service which are the five closest stops to the user. Then the web service provides them, using the *closestStopsProcedure* mentioned in Section 6.3.1, as well as the lines and directions that pass on those stops. The user only has to choose in which route wants to check-in.

By manually checking-in, the user must input the stop name so that the application can request the routes available to the web service. The rest of the process is similar to the GPS check-in.

The refresh button requests the web service for an update of information according to the current selected tab. Below there is a list of its functionality for each tab.

- **Rate** - asks the web service if the user has any categorised comments to rate.
- **News Feed** - gets the comments made in all the users networks since the last request. If it is the first request, then the web service returns the comments made in the last ten minutes.
- **Journey Planner** - asks the web service if the user has journeys scheduled for the next ten minutes.

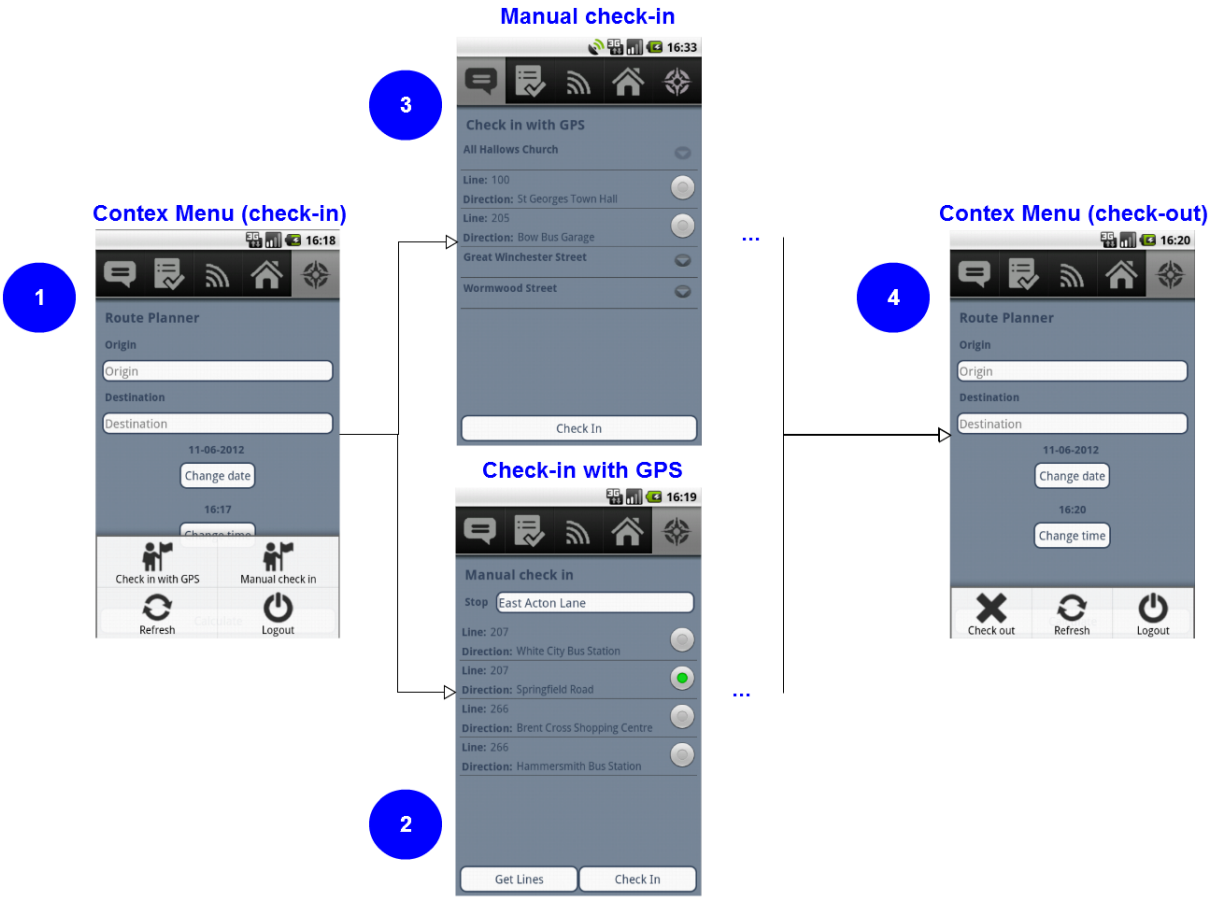


Figure 6.25: Context menu flow.

1. Context menu options that are shown when the user is not checked-into any route. If the current tab was the comments or the home one, the refresh button would not be present.
2. Screen where the user can check-in usign GPS.
3. Screen where the user can manually check-in.
4. Context menu options that are shown when the user is checked-into a route. If the current tab was the comments or the home one, the refresh button would not be present.

6.6.2.7 Android push notifications

One of the main services provided by Google that enriches the Android applications, is the C2DM framework that was already mentioned in Section 6.3. In practical terms, this service allows the Android device to receive small messages, know as notifications, that are usually used by the web servers to ask for the application to communicate with it.

The developed prototype handles three different messages that are sent via the C2DM service from the web service and the windows application, each one related to a different functionality. Table 6.2 shows the notifications handled by the application. The first column shows the message that is sent, the second tells the reason why it was sent and the third shows how the Android application reacts to it.

Table 6.2: Android notifications handled by the prototype.

Message	Reason	Response
new_feed	There is a new comment in one of the user's networks	The News Feed tab is updated with the new comments
new_rate	The user has been selected to rate a new categorised comment	The Rate tab is updated with the new categorised comment to rate
new_journey	The user has a scheduled journey for the next ten minutes	A dialogue asking if the user wants to get information about the scheduled journey (like the one in Figure 6.24) is triggered

Figure 6.26 shows an example of how the user sees each of the three messages.

6.7 Summary

This chapter tries to address all the implementation work that was done, from the development models used, passing by the first steps of the concept and ending with the presentation of the prototype developed.

This document's appendixes provide more details about some parts of the work.

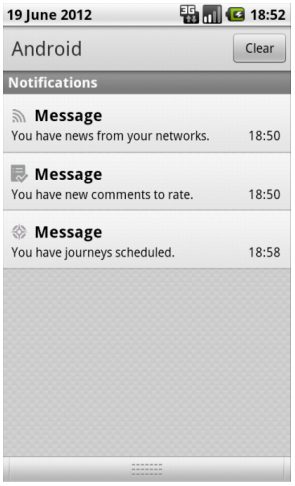


Figure 6.26: Android notifications.

Chapter 7

Final tests

The tests that will be presented in this section aimed to evaluate not only how easily users interact with the application, but also how they perceive the concept when using it in a real context. In order to obtain reality consistent results, the application testing was done while riding a bus.

In the beginning of the development phase, it was decided to use the public transport data provided by TFL[1]. It would be expected to use data from Porto public transport system, but while trying to get the needed information, a new option appeared. TFL's data is publicly available, and they also provide web services from where developers can get real time information about the public transport as well as journey planner functionalities.

The thesis coordinator also agreed to use TFL's data, and provided the funds to test the application in London.

An experiment designed according to the DECIDE framework [SRP07] proposed by Preece, Roger and Sharp and presented in Section 4.4, was conducted as the prototype's evaluation technique.The check list that characterises the DECIDE framework and that acted as a guide for the test is presented below.

1 - Determine the goals As a real time application where users are supposed to share information that usually is only valid for short time frame, it is important that they are provided with an interface that allows them to share it quickly. Moreover, as it will be used in public transport, each task must not require too much time since there might be situations where users will be standing while riding a crowded bus, which is not a pleasant situation to interact with a smartphone. Moreover, evaluate the users' perceived value of the application is also a goal of the tests.

2 - Explore the questions As a test to the developed prototype, there were questions intimately related to its use cases (see Section 6.4). For each task that users' were asked to do, it was evaluated the ease and speed of its conclusion.

[1] local government body responsible for most of aspects of the transport system in Greater London

To analyse users' perceived value of the application, there were five additional questions asked in the end of the participants' interaction with the prototype. The questions were:

1. What is the overall opinion on the usefulness of such an application?
2. Was it easy or difficult to interact with?
3. As a concept, how easy or difficult was it to grasp?
4. How safe would you feel using such an application?
5. How likely would you be using such an application?

There was also a last question where users could suggest other relevant topics that could be encompassed by the categorised comments.

3 - Choose the evaluation paradigm and techniques Being one of the tests' goals to evaluate how long it takes for inexperienced users to accomplish different tasks on the prototype, the evaluation paradigm adopted was usability testing (see Section 4.3). Users' interaction with the application also allows to infer possible changes that might improve it.

As the aim was to make the participants' experience as close to reality as possible, the technique consisted of a test with typical users in a real environment. Participants were asked to complete a set of ordered interaction tasks, defined according to the use cases presented earlier, while riding a real bus.

4 - Identify the practical issues that must be addressed, such as selecting participants Since the tests were done in London and in a real environment, there were several practical issues that needed to be taken care of. Each of these are detailed below.

- **Users -** given the fact that the tests were done in London, the participants selection was restricted to relatives or friends living there. Nine people were contacted with ages ranging from the late 20s to the late 40s and with different backgrounds regarding both the public transport usage and their smartphone's OS. The decision of having more than 5 participants had into account the mathematical model presented by Robert Virzi (see Section 4.3) where 90% of usability problems can be detected by 10 different subjects testing the product.
- **Facilities and equipment -** regarding the facilities, the only requirement was the existence of a bus line. This allowed to facilitate the participants life, as they did not have to go to a certain place to do the test, instead the facilitators met the participants wherever they wanted.

  As for the equipment, two smartphones were needed, one for the participant and a second one to allow one of the facilitators to rate participant's comments and to create categorised comments to be rated. It was also necessary to charge the SIM cards with money to allow for 3G[2] internet usage.

[2]third generation of standards for mobile telecommunication services

An Oyster card with prepaid tickets was also provided, so that participants could ride the bus.

- **Schedule and budget constraints -** given that each test should take around 40 minutes, plus the time needed for facilitators to meet the next participant, it was necessary to stay at least 2 full days in the city just for the tests. To keep the budget as low as possible, the dates were set having in mind the flights' prices.

5 - Decide how to deal with the ethical issues This project was considered not to present any particular ethical issues, yet the identity of the participants will not be revealed. It should be noted that all participants were informed that the experiment was designed to test the system and not the users, so that participation was a pleasant experience for everyone involved.

6 - Evaluate, interpret and present the data The usability test generated both quantitative and qualitative data for analysis. The quantitative data was originated from measuring how much time each participant took to complete each task.

Regarding the qualitative data, it was originated from the perceived ease of completion of each task according to each participant. This was recorded in a scale ranging from 1 (difficult) to 5 (easy) for each task. Moreover, there were also five final questions that intended to evaluate participant's feeling about the application's concept.

7.1 Preparation and execution

A script of tasks was created for the participants to follow in order to attest the prototype's usability. The document that was presented to each participant can be found in Appendix C.

Table 7.1 shows the set of ordered tasks that were asked to perform. It is possible to see that these tasks covered all the prototype's provided functionalities, allowing to take results about the users' interaction with them. Something that is also clear, is that the tasks are ordered in a way that simulates the usage of the application in a real situation.

Some of the tasks required not only the interaction with the application but also with the public transport' environment. Here are the actions that were required simultaneously with the correspondent task:

2 - The participant has to enter a bus.

11 - The participant has to leave the bus.

Tasks three to ten were done inside a real bus.

Two facilitators were present to conduct the tests. One was responsible for guiding the participant through the tasks as well as for taking times, ratings and other relevant comments or considerations. The second facilitator was present to respond to participant's actions that required a second person using the application in another smartphone. This facilitator's tasks were:

Table 7.1: Usability test's script of tasks.

#	Task
1	Login with the following credentials.
2	Through the Android Context Menu, check-into the current line and direction using the GPS check-in functionality.
3	Share a written comment about this trip.
4	Share a driver related categorised comment.
5	Check the news feed.
6	Rate a categorised comment.
7	Check the current number of points in your account.
8	Check the current line of travel.
9	Change your nickname.
10	Change your profile visibility to public.
11	Check-out through the Android Context Menu.
12	Plan a journey between Oxford Circus Station and Victoria Bus Station to start in 2 minutes. Select the first option displayed.
13	Accept being added to the journey you have just planned.
14	Through the Android Context Menu, manually check-in at Oxford Circus Station. Select the first option displayed.
15	Logout through the Android Context Menu.

2 - Check-into the same line and direction of the participant in order to be added to the same network

4 - Validate the participant's categorised comment so that it reached the news feed.

6 - Submit a categorised comment to be rated by the participant.

7.2 Results

From every test that was conducted, the time taken and the difficulty level of each task as perceived by the participant were obtained. The average results for each tasks are presented in Figure 7.1.

Figure 7.2 illustrates the average ease of completion of a task by participants.

Quantitative data that was gathered to qualitatively analyse user's perceived experience and possible future interest in such an application are illustrated in Figure 7.3

Regarding the last question about possible topics to be added to the categorised comments, two suggestions arose.

The first one was pointed by four different participants and was related with scent. This topic had already been addressed in the requirements phase, but it got forgotten when adding the different types to the application.

The second suggestion was to add a categorised comment related with the predicted travel time.

More relevant feedback was also collected and will be addressed in the next Section 7.3.

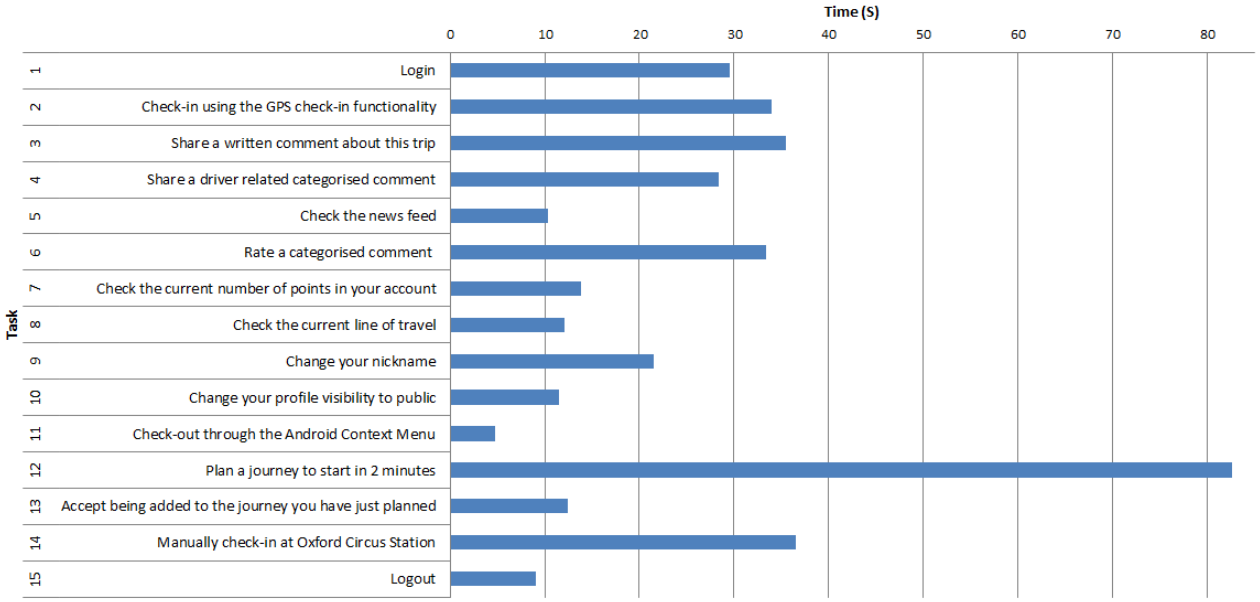


Figure 7.1: Average task's execution time.

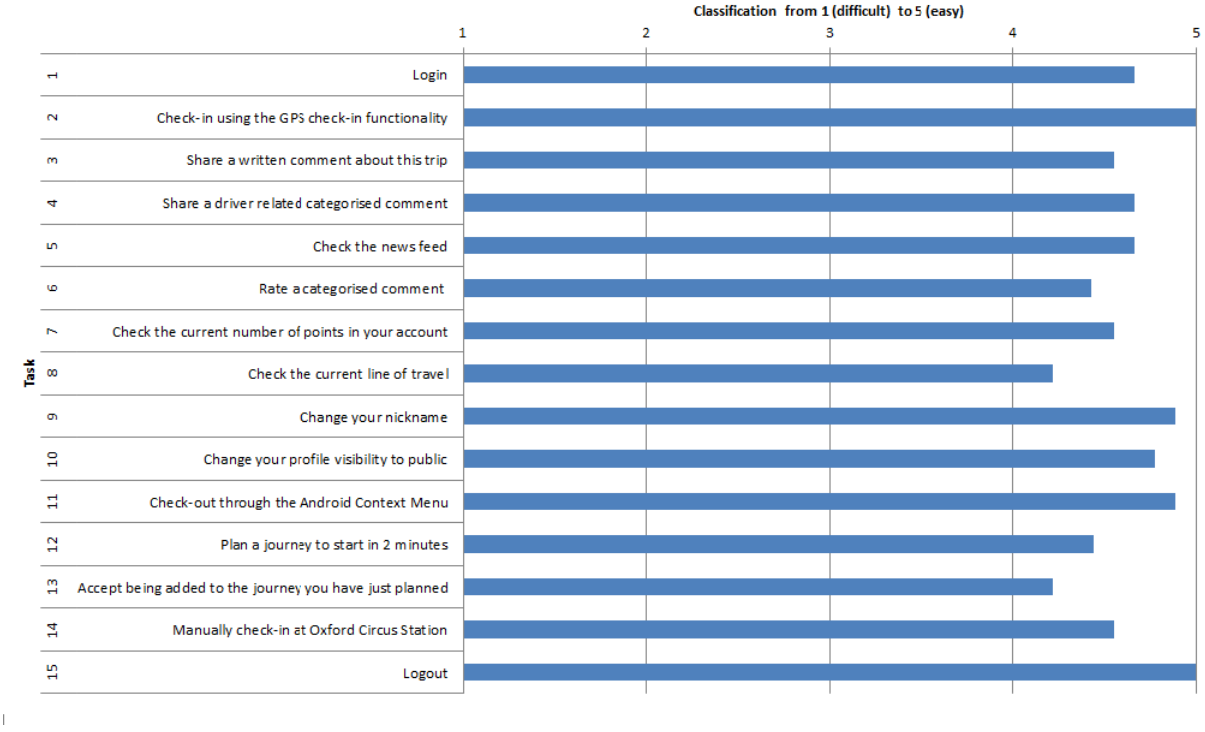


Figure 7.2: Average quantitative appraisal of a task.

7.3 Interpretation

Having into account that none of the participants had any previous contact with the application or even with the concept behind it before doing the test, it was considered that the average times for the completion of the tasks were positive.

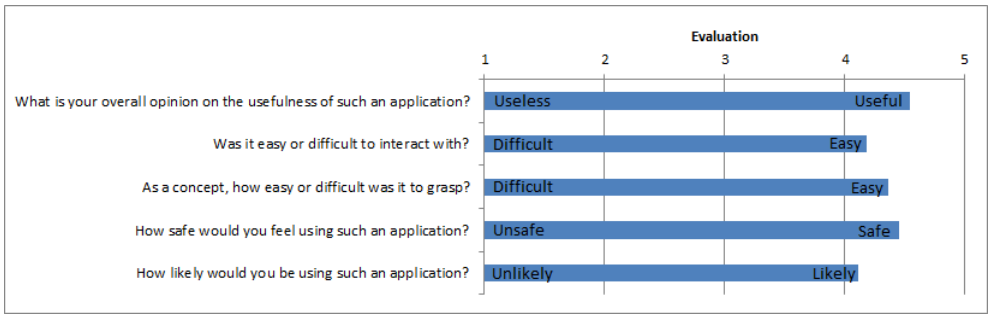


Figure 7.3: Average users' impressions about the concept.

From Figure 7.1 it is easily distinguishable a task that exceeds all the others in terms of time. Plan a journey takes in average more that the double of time than any other task. This results can be explained due to one constraint that the prototype had.

In order to plan a new journey, the user has to make use of two auto-complete text boxes (see Figure 7.4) to introduce the names of the origin and destination stops. Unfortunately there was a problem related with the fact that these text boxes have to make a request to the web service when the user introduces the first two letters of the stop's name in order to get the ones that start with those two same letters.

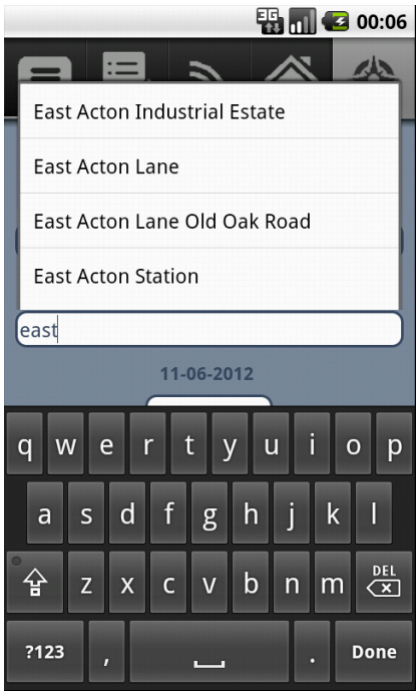


Figure 7.4: Auto-complete text box.

These request is done in a background thread of the Android application that sometimes interferes with the auto-complete feature, leading to the crash of the application. In order to avoid the application to crash, the participants needed to wait for the request to be responded after introducing the first two letters. This waiting together with the fact that in some cases the application

actually crashed and had to be restarted, led to this time disparity when comparing with the other tasks.

Regarding the check-in functionalities, it is noticeable that are requiring too much time (almost half a minute). This action is probably one of the most important functionalities of the application, as it is what allows the system to know where the user is to provide the best information possible.

As it occurs simultaneously with one the most critical parts of the trip, which is entering into a vehicle, the required interaction with the application must be minimal. To address this issue, automatic ways of checking-into a vehicle can be provided by the application through the use of technologies such as NFC or by comparing the GPS of the user's smartphone and the vehicles. However, this amount of time can also be explained by the fact that many of the participants were not familiar with the Android OS, and therefore did not know what the context menu was, leading to the waste of time searching for it.

The first time that users have to interact with the context menu is when checking-in using GPS feature. This might be a reason to explain why there is no big difference when comparing the results of both check-in options, since it was expected that manually it should take longer as users have to input the stop name.

As for the rest of the tasks, the time results of creating and rating comments can be explained by the time spent by the participants reading or writing them.

When looking at the results of the ease of completion of the tasks (see Figure 7.2), it is possible to see that the averages are all above 4.

The tasks that had worst results in this category were the 8th and the 13th.

The first one was not expected to have such results, in fact, it should be very easy to accomplish, since the current line information is right below the one that is part of the previous task (check the current points). This can be explained by the fact that participants started to immediately checking other tabs as they thought it should be a more challenging task. Another reason for this was the fact that the common English word that should be used is *route*, which confused some of the participants as they were not understanding the meaning of line. Using the word *route* can be a solution to solve this problem.

Rating a categorised comment was also one of the tasks that had lower results. Participants justified these results with the fact that it was not easy to understand the concept behind rating comments.

Finally, the results concerned to users' impressions of the application concept were very satisfactory as well. However, there is still work to do regarding the interaction between the user and the application.

Another important point, is the fact that the third question (*As a concept, how easy or difficult was it to grasp?*) presented better results than what was expected. One of the biggest fears was how easy would be for users to understand the application's goals and the underlying concept, which participants' ended up not having major difficulties on.

Most of the participants commented that they would be less willing to use this application if it only allowed for the exchange of information in a close system.

However, it would be much more appealing if it was integrated with social networks, such as Twitter or Facebook, and with already existing applications from public transport operators that provide real time information about delays, and vehicles' status.

This shows that journey planner features are very valued by travellers.

Privacy issues did not seemed to be a problem for the participants, especially due to the fact that they were able to set their profile as public or anonymous and to change the nickname. This brings more relevance for the previously mentioned features to allow users to create avatars (Section 5.1).

The usefulness of the application was undoubtedly valued which is probably one of the most important results that were taken from these tests.

In one of the tests, instead of having a facilitator interacting with the participant through the application, it was possible to put two participants doing the test at the same time. This ended up being a great experience to evaluate the real environment. The participants also ended up enjoying more and easily attesting the potential of the application.

7.4 Summary

Tests and its results over the prototype that was developed were presented in this chapter. The interpretation of the results was also done and shown that the concept developed in this thesis has potential and should be further explored in the future as there was a very positive feedback from the tests' participants.

Chapter 8

Conclusions

Finding new ways of improving public transport users' experience gains more importance as the urban areas are getting larger and crowded.

Article *Using social networks for exchanging valuable real time public transport information among travellers* [NGeCP11] presents a new paradigm for providing information to travellers, where the data is shared and is originated in the users themselves instead of transport managers having to supply it.

In this thesis a prototype of a smartphone application was developed in order to explore new ways of distributing real time public transport information between travellers. Information that has origin in travellers and that can be used by transport managers to improve their quality of service.

Evaluating users receptiveness to such an application as well as attest its usability on a real environment, were aspects that leveraged the development of a functional prototype. The creation of the prototype implied the development of, not only the smartphone application, but also the whole system to support it.

First it was needed to build a data model that could support this interaction between users but also that allowed the spread of information to those who could benefit from it. Integrate the transport' related information was also a requirement, since only that way it could be possible to determine what information would be useful to whom.

It was necessary to acquire data about a public transport system, which was possible through TFL's features for developers. This required understanding how that data was organised and adapt it to the database designed structure.

A web service was built to answer the application's requests and a windows application was also created to allow the server to contact the application without the need to receive a request from it.

As it can be seen in chapter 7 the results obtained for the usability tests as well as for the assess of users' willingness to use such an application were very satisfactory. This is a motivation to keep working on this concept and a reward to the work that was done.

To conclude, the following sections will show that there is still a long way to go to improve the application and the concept itself, as this thesis was only a first step to help understanding its real potential and feasibility.

8.1 Future work

As previously said, this thesis work can be considered as a first approach in the study and evolution of the developed mobile application. There is still a long way to go to exploit the full potential of this concept, and therefore, several features and architectural characteristics that can be object of future works.

Throughout the prototype development, there was a constant feeling that the available time was not enough to correctly implement a sufficiently strong and broad basis to sustain all the features that were intended to be supported by the system. Several times was necessary to constrain the prototype's functionalities in order for the testing and evaluation of the concept to be possible.

The following sections present parts of the work that should be further exploited as they might be fundamental for the success of the mobile application.

8.1.1 Data structure

Covering the first decisions that constrained the prototype's functionalities (see Section 6.2), the system's data model may and should suffer modifications.

Below we present a short list of some of the main requirements that emerged during the data model development but that were not implemented:

- Support vehicle related data as well as use it to improve the accuracy and efficiency of the information dissemination;
- Have a transport related data structure flexible enough to store and handle information from different public transport systems so that it can be used in different cities;
- Support the creation of user's avatars in order to mitigate privacy issues;
- Allow the creation of comments without being necessary to be checked-into a vehicle or line;
- Support data mining techniques for travel patterns deduction and to provide relevant and understandable information to companies;
- Support the reward model.

Some of these are directly connected with some of the features that follow this section.

8.1.2 Travel patterns

One of the main features that might highly influence users' participation and that can have a major impact in the application's flow, is the ability for the system to identify users' travel patterns and create their travel profiles.

These can influence how the application responds to users' needs and how the user interacts with it. With time, the system would start predicting users' intentions, being able to automatically provide relevant and personalised information according with the current time and location. This way the need for user input would be constrained to the generation of information, reducing the probability of quickly getting tired of the application by having to recurrently do the same actions in order to start benefiting from it.

As mentioned in the previous section, the system's data model should be prepared for the application of data mining techniques to infer the users' travel patterns.

8.1.3 Social networks integration

Although for prototype purposes, social network related features were left aside and a closed environment was created, it was one of the main goals of the system to make use of the already existing social networks to disseminate the public transport generated information.

This integration can be a very important mean for users' persuasion, not only because they could use their already existing profiles (instead of creating new ones for the application), but also because the integrated social networks would work has additional environments to promote the application usage.

However, this integration should be carefully handled, since social network users might be suspicious about how the application manages and what is it allowed to do with their data.

8.1.4 Full integration with public transport systems

Integrating travel tickets in the application could highly improve the users' perceived experience from both the mobile application and the public transport.

By taking advantage of emerging technologies such as NFC or QR codes, the application could be linked with public transport' travel passes, saving travellers from having to carry extra cards, and facilitating the implementation of the reward model. Smartphones with embedded travel passes would allow users to easily claim rewards, such as free tickets or discounts, with the application's points and quickly use them through the mobile device.

Moreover, the check-into a vehicle procedure could be done using NFC, which would allow the application to automatically know the exact vehicle the user was entering. This feature would contribute for the decrease of user required input.

Other features that should also be developed are the journey planner related functionalities, that were considered by some of the tests participants as essential for the success of such an application (see Chapter7).

8.1.5 Role and abilities of public transport operators

As one of the main stakeholders of the concept, it is important to define how public transport companies can benefit and interact with the system.

Having a back-end interface that allows them to query for relevant information and make use of data mining techniques to understand how their services can be improved to meet the customers wishes, is one of the possibilities that emerged during the prototype development.

Appendix A

Brainstorming session

In order to understand what information travellers lack or would like to get when using public transport, a brainstorming session was held.

A brainstorming session is a technique that aims at the generation of ideas by a group of people. It can be described as a creative process where participants suggest solutions to a given problem.

The ideas provided must not be a subject of any kind of criticism or participants might feel uncomfortable to continue intervening.

> ”An effective brainstorming session gets a little craze. It should be a safe place for people to have silly ideas because sometimes those silly ideas lead to fantastic ideas. Whatever you do, don’t start critiquing ideas; nothing will squash creativity sooner.” [GC09]

A clear goal for the session must be defined. There are also other practical issues that must be taken care of before the session takes place. The participants selection, the date a place as well as the necessary material are all aspects that one has to handle [Poh10].

During the session there are rules that must be followed and that are essential for the session’s success. These rules can be further explored in Klaus Pohl’ *Requirements Engineering: Fundamentals, Principles, and Techniques* [Poh10].

1. quantity over quality;
2. free association and visionary thinking are explicitly desired;
3. taking on and combining expressed ideas is allowed and desired;
4. criticism is forbidden;
5. question for clarification are allowed;
6. do not abort the brainstorming at the first deadlock;

7. the brainstorming shall come to a natural end.

In the end of the session, the ideas that emerged must processed as some might not even be possible. Three different categories can be used for the ideas' prioritisation:

1. directly usable ideas
2. ideas that need to be worked on to be usable
3. unusable ideas

This process shall be done by the session's group after the idea generation phase [Poh10].

This appendix is divided in sections that present in a simple way all the relevant information about the session .

A.1 Goals and preparation

The first thing to do was to define the goal of the session.

Goal - What are the information needs of public transport users?

In order to better conduct the discussion, three different stages when travelling were defined. These stages were based in the article *The desired quality of integrated multimodal travel information in public transport: Customer needs for time and effort savings* [GWR07], that says:

> "When planning and undertaking a trip, travellers have different purposes to fulfil. These purposes are presumed to affect the tasks and decisions, and hence the information needs of a traveller, and can be assigned to three different stages of a journey, roughly in conformity with three location types: pre-trip, wayside, and on-board." [GWR07]

So the participant's input was divided in three categories:

- Pre-trip
- Wayside
- On-board

There were some dichotomies prepared to stimulate participants' ideas in case the session got to a break point.

- Compare regular trips with occasional ones
- Unknown origin and/or destination

- Information provided by the operators or by other travellers

In the end of the session it was explained to the participants the project's goal, and some pictures of the prototype were also shown. Feedback regarding privacy and security issues of such an application was also taken from the session.

A.1.1 Practical issues

Other practical details regarding the session had to be taken care of. These are presented in the list below.

Place - the place chosen to hold the session was the IBM CAS room at FEUP.

Material - the only material needed was a flip-chart, post-its and pens.

A.1.2 Participants

It was intended to have a group of participants with different backgrounds that could give different insights about public transports. Table A.1 shows the participants' relevant characteristics.

Table A.1: Brainstorming session participants' characteristics.

#	Age group	Public transport travel profile	Background
1	30-40	Intermittent, mostly subway	Public transport domain researcher
2	18-30	Frequent subway user	Public transport related Msc. thesis
3	> 60	Regular bus user, sporadic use of subway	Retired
4	18-30	Sporadic in city bus user, regular between cities bus trips	Not relevant
5	30-40	Regular public transport user	Works for *Metro do Porto* in the service offer department
6	18-30	Public transport dependent user	Public transport related Msc. thesis

This group of people guaranteed a broad spectrum of ideas and opinions about public transport. There were representatives from youngster generations as well as from older age groups.

There was also a participant who also gave important insights from the public transport managers' perspective.

A.2 Results

In the brainstorming session, participants were asked to say every kind of information that came to their minds that they would like to have access to when ridding public transport. Every response

was written in flip-charts and in the end they were asked to evaluate in a scale ranging from 1 to 3, how important that information would be. 1 being important and 3 being less important.

Although the main goal was to understand to what information travellers would like to have access to, later in the session the application concept was explained and some ideas regarding the functionalities also emerged.

Table A.2 shows all the input that was gathered during the session, as well as the priority .

Table A.2: Brainstorming session outcomes.

Input	**Priority**
Vehicle delays	1
Waiting time for the next vehicle	2
Vehicle's seating availability	2
Breakdown information and predicted fixing time Works Route modifications due to works	1
Vehicle's accessibility for people with disabilities	1
Ability to interact with directly with the operator call security report occurrences (such as vandalism) broken equipment (such as ticket machines)	1
Lost & found	3
Find other people	3
Information to share with other users: dirtiness levels temperature scent	3
Information for operators: ability to make questionnaires to travellers regarding the quality of service	3
Faster or emptier vehicle behind the next one	1
Allow users to define levels of info they want to receive	1
Levels of access (not all features are available. For instance, some require registration)	1
Automatic warnings. For instance, if a route suffers changes, then users who often use it are automatically informed	1
Route planning for unfamiliar users (such as tourists) according with:	
travel time	1
scenery	3
modal preferences	1
simplified route information	1

A.3 Considerations

This session brought new ideas for information that could be shared, but most of all, it allowed to understand what users really want.

As it would be expected, participants gave a lot of importance to information regarding schedules, delays and travel times, and also to journey planning functionalities. However, other types of information, despite not being essential, would also add value to the public transport' perceived experience.

Regarding the application concept itself, participants shown some concern about the reliability of the data shared by other users, and also the dangers that could come from this information sharing. For instance, stalkers can use the data to find their victims.

Appendix B

Requirements Specification

B.1 Purpose and scope

The system that is described in this document is part of a MSc thesis in Informatics and Computing Engineering of the Faculty of Engineering of the University of Porto.

With the goal of allowing the exchange of valuable information between public transport users in real-time, a new idea came up, that takes advantage of the new technologies and uses them to improve public transport users' experience. This concept was presented in article *Using social networks for exchanging valuable real time public transport information among travellers* [NGeCP11] and it was what leveraged this thesis work.

Basically, the idea consists of a smartphone application that allows travellers to share and receive information about the public transport in an organised and structured way. It can then be forward to all users to whom it might have value.

This requirements specification document is therefore the result of the requirements elicitation phase and its purpose is to describe precisely the application prototype that is intended to be developed.

B.2 General Description

This section presents a general description of the application that will be developed.

B.2.1 System overview

The system explained in this document is based on the idea of exchanging valuable real-time public transport information among travellers. This means that it is expected that the users are able to share organized and structured information about public transports that might help other travellers to make informed decisions concerning their trips.

As a system that requires mobility, it consists of the following:

- a mobile Android application;

- a web service to which the mobile application communicates, that contains the business logic and also acts as a database access layer;
- a database that supports the application and the public transports' related information, like stops and routes for all transport types.

B.2.2 System functions

Each user is responsible for feeding the system with information that is shared between groups of users (networks) that are assembled according to their on-going or planned trips. These networks, alike social networks, are means of making the information arrive to the users who may actually benefit from it, preventing them from receiving information that they are unlikely to be interested in.

The information that is fed to the system is provided under the form of user comments. These comments can be of two types, they can be 140 characters long text comments that the user writes (written comments), or the user can also use already existing comment templates (categorised comments) that the application provides and enables the user to classify certain pre-categorised aspect of the trip, like:

- Atmosphere related information
  - Temperature;
  - Scent;
  - Noise;
  - Crowding;
  - Seating availability;
  - Cleanliness;
  - Scenery;
- Driver related information
  - Courtesy;
  - Smoothness;
- Progress related information
  - Vehicle's speed;
  - Vehicle's expected arrival at stop;
  - Vehicle's progress;
  - Distance of a similar vehicle;
  - Incident report;
  - Perceived security.

Since the information is provided by users, it is important to have a mechanism to validate its reliability. In order to accomplish this, the users are able to evaluate other users' written and categorised comments. When someone creates a written comment, it is automatically added to the news feed of the users in the corresponding network. After that, the written comments are classified by its relevance, so if a user thinks a certain comment is relevant, he can give it a star which tells other users that that comment is author provided a relevant piece of information.

Regarding the categorised comments, the evaluation and publication systems are more complex, since they first have to be evaluated in order to get to the users is news feed. For each categorised comment created, two users are randomly selected, from the vehicle that the comment is associated with, to evaluate it using a continuous scale. Only after a positive evaluation made by those two users, the comment is added to the news feed of all the users in the network. In case the comment is evaluation is negative, that comment never reaches the news feed of the users, providing a certain level of reliability to the information that the users get. As these comments concern to an environment that is constantly changing (what is true in a metro station might be false on the next one), the evaluation of categorised comments must be as fast as possible, so that the information is still valid when it gets to the users is news feed. This way, each user selected to evaluate a categorised comment has a limit time to do it, that when exceeded triggers the system to choose another user to evaluate it. If none of the selected users evaluates the comment, then it never gets to the users is news feed.

To motivate the users to provide relevant, useful and truthful information, the system also implements a rewarding model where they gather points from the positive feedback their comments receive from other users. These points can be used to claim rewards, like free tickets or discounts, provided by the public transport providers.

As a transport related system, route planning functionalities are highly relevant. These functionalities also have an important role in the users is networks, since each one is added to the network that gathers all the users that are interested in a certain public transport line, at a specific time. This way, when a user uses the route planner, he can be automatically added to the networks related to the lines that are part of the route planner is results in a given time interval.

It is also a goal that the system learns from the users is travel history detecting travel patterns and preferences, in order to suggest the routes that better suit the user is wishes and to automatically assign the user to the networks that might be useful at a given moment. One example of the machine learning goals is to automatically provide the user with information about a trip that he or she usually does with a given frequency (e.g. every weekday or every Tuesday), more or less at the same hour.

Given the social component of this system, users' privacy is an important issue. In order to provide the users with privacy options, they are able to choose which profile details they want other users to have access to. Also, their public profiles can be represented in three different ways, which are as follows:

Public Profile - the user is username and photo (if provided) are mandatory to be public. All the other details are only public if allowed by the user.

Avatar Profile - the user can create a fictitious character that represents the profile. This character has a name and a photo that represent the user. The rest of the users' profile details are not allowed to be public.

Anonymous Profile – the user is represented by a name randomly assigned by the system and a default picture as a photo. All the users' details are not allowed to be public.

As one of the main stakeholders, the public transport operators are also actors in this application. It is intended that they have access to information collected from the users' inputs in order to better understand how they see the provided services and be able to improve them. This interaction may be done through the use of a web application that allows them to access information and also to interact with the costumers. Using a notification system, the operators are able to reach the customers directly by sending messages or links to fill surveys or to promote new services. Operator related functionalities are not a priority for the prototype development.

B.2.3 User Characteristics

Since it is a public transport related application, the users should be people who make use of them either if on a regular or occasionally basis. The users also have to own smartphone phone compatible with the application (Android for the prototype) and be familiar with smartphone applications.

B.3 Requirements

This section describes the functionalities that the final system is expected to provide.

B.3.1 Functional requirements

Since the project is main goal is to prove the concept behind the application through the creation of a prototype, and this document is intended to show all the requirements that the final system is supposed to have, there are some of the functional requirements that will only be implemented if there is time for it, or that will not be implemented at all.

Given this premise, the priority value associated with each User Story can be interpreted as follows:

1. Will be implemented;
2. Might be implemented if there is time for it;
3. Will not be implemented.

The User Stories that are classified with a priority value of 1 are also considered to be essential to prove the system is idea.

The cost values represent an estimate of the difficulty and time spent in each user story. User stories are evaluated using a scale of 1 to 5, being each value associated to the following estimates:

1. 6 hours
2. 8 hours
3. 16 hours
4. 32 hours
5. 48 hours

B.3.1.1 User stories

ID	US1
Name	Register a user
Description	As a user I want to register myself in the system, so that I can access the application functionalities.
Cost	1
Use Cases	UC1
Priority	1

ID	US2
Name	Login and Logout
Description	As a user I want to login and logout from the application using my credentials so that I can access the functionalities provided.
Cost	1
Use Cases	UC2, UC3
Priority	1

ID	US3
Name	Language
Description	As a user I want to change the language of the application.
Cost	2
Use Cases	UC4
Priority	3

ID	US4
Name	Trip information
Description	As a user I want to have access to information that might be useful to my trip so that I can make the best trip related decisions.
Cost	5
Use Cases	UC5, UC6, UC7, UC8
Priority	1

ID	US5
Name	Route planner
Description	As a user I want to plan a trip by giving some trip details, like the origin, destination or time of departure, so that the system provides the possible routes that I can follow.
Cost	5
Use Cases	UC7, UC8
Priority	2

ID	US6
Name	See users in the network
Description	As a user I want to see who and where the users in my network are. The position of the users is available only if they give permission to share it.
Cost	3
Use Cases	UC9, UC10
Priority	2

ID	US7
Name	Share written comments
Description	As a user I want to write a comment about my journey so that I can share it within the users that might benefit from it.
Cost	3
Use Cases	UC11
Priority	1

ID	US8
Name	See written comments and categorised comments.
Description	As a user I want to receive written and categorised comments made by other users in my network, so that I can be informed about important events that may concern my trip.
Cost	4
Use Cases	UC12
Priority	1

ID	US9
Name	Share categorised comments
Description	As a user I want to use the existing categorized comment templates so that I can classify aspects related to the vehicle I am in and share them within the users that might benefit from them. These categories can be: • Atmosphere related information Temperature; Scent; Noise; Crowding; Seating availability; Cleanliness; Scenery; • Driver related information Courtesy; Smoothness; • Progress related information Vehicle's speed; Vehicle's expected arrival at stop; Vehicle's progress; Distance of a similar vehicle; Incident report; Perceived security.
Cost	4
Use Cases	UC13, UC14
Priority	1

ID	US10
Name	Rate categorized comments
Description	As a user I want to rate categorized comments made by other users who are within my network, so that I can contribute for the reliability of the information provided. These evaluations tell the user is level of agreement with the categorized comment. Every time a user creates a categorised comment, two other users in the same vehicle are randomly selected to rate that comment, validating it and making it available for other users.
Cost	4
Use Cases	UC15
Priority	1

ID	US11
Name	Evaluate written and categorised comments
Description	As a user I want to evaluate written and categorized comments made by other users in my network by telling if they are relevant, so that the users who made them are rewarded with points. Also, this way I can contribute for the increase of the reliability of the information provided by the comment is author. This relevance evaluation is made through the attribution of stars, having each user a maximum limit of stars to give each month.
Cost	2
Use Cases	UC16
Priority	1

ID	US12
Name	See the number of written and categorized comments' evaluations left
Description	As a user I want to check how many stars I can still give to other users' written and categorised comments.
Cost	1
Use Cases	UC17
Priority	2

ID	US13
Name	See user is month points
Description	As a user I want to check the points I already collected in the current month. These points are earned through other users' positive evaluations of my comments.
Cost	2
Use Cases	UC18
Priority	3

ID	US14
Name	See user is total points
Description	As a user I want to check the total amount of points I currently have. These points are earned through other users' positive evaluations of my comments.
Cost	2
Use Cases	UC19
Priority	3

ID	US15
Name	Claim rewards
Description	As a user I want to use the collected points to claim for rewards provided by the transport operators.
Cost	5
Use Cases	UC20, UC21
Priority	3

ID	US16
Name	Profile visibility
Description	As a user I want to choose how other users see my profile, so that I can protect my privacy and only share the information I allow.
Cost	3
Use Cases	UC22
Priority	2

B.3.1.2 Actors

This application is intended to be used by registered users. This way, there are two types of users, the visitors and the registered users.

The visitors are users that are not registered in the system and so, do not have a personal profile. These users cannot access the application functionalities, but they are able to install it

in their Android smartphones and freely register themselves in the system, becoming registered users.

The registered users are the ones that can access the full functionalities of the application. In order to do that, they only need to install the application in their Android smartphone and log in using the credentials that are defined in the registration process.

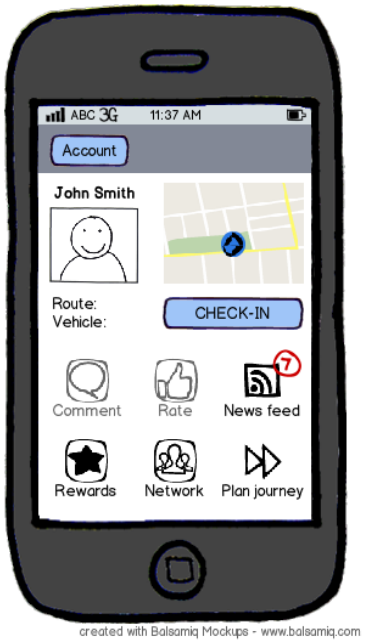
B.3.1.3 Use cases

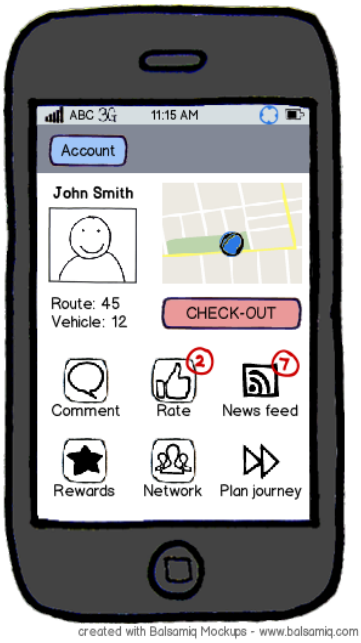
ID	UC1
Name	Visitor registers in the application
Actors	Visitor
Description	An application user who is not registered yet will fill the personal information that the application requires in order to be able to access its full functionalities. The user can either fill the form presented in the application or use the Facebook or Twitter account information to register in the application.
Priority	1
Interface	N/A
User Story	US1

ID	UC2
Name	User logs in the application
Actors	Registered user
Description	The registered user logs in the application in order to start using it and exploit its functionalities.
Priority	1
Interface	N/A
User Story	US2

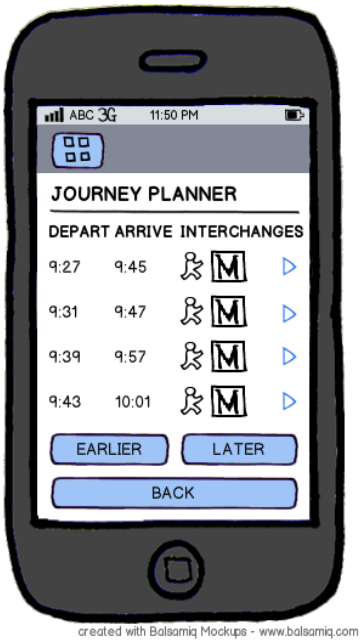
ID	UC3
Name	User logs out the application
Actors	Registered user
Description	The registered user logs out the application when he does not need it anymore.
Priority	1
Interface	N/A
User Story	US2

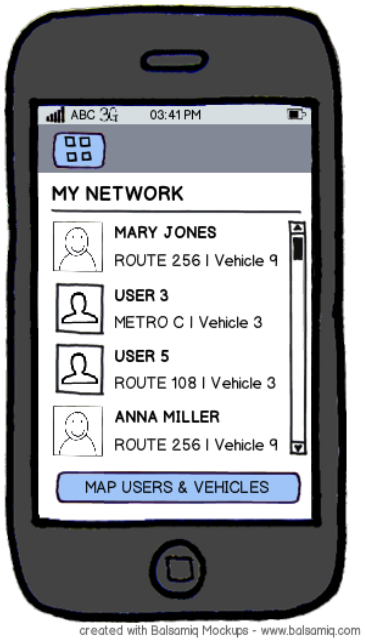
ID	UC4
Name	Change the application language
Actors	Registered user
Description	The registered user changes the applications language in order to better understand it.
Priority	3
Interface	N/A
User Story	US3

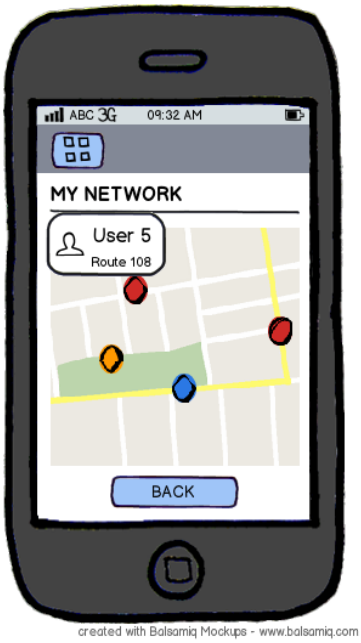
ID	UC5
Name	Check-in on a vehicle
Actors	Registered user
Description	The registered user enters a vehicle, and through manual or automatic (through NFC, or GPS position) input, is added to the networks that might provide relevant information about the vehicle and route the user is in.
Priority	1
Interface	
User Story	US4

ID	UC6
Name	Check-out of a vehicle
Actors	Registered user
Description	The registered user leaves a vehicle, and through manual or automatic (through NFC, or GPS position) input, is removed from the networks that was added to when started the trip.
Priority	1
Interface	
User Story	US4

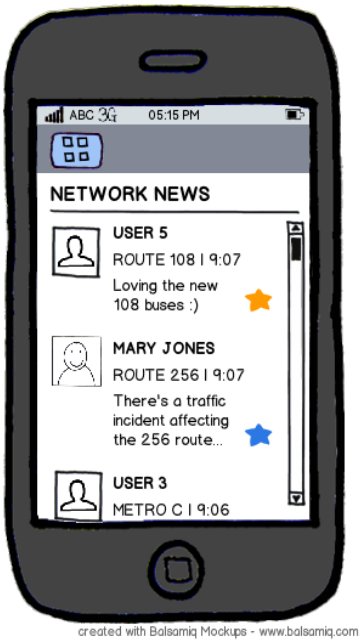
ID	UC7
Name	Plan a trip
Actors	Registered user
Description	The registered user enters the route planner menu and provides the details (origin, destination, time of departure) about the trip he or she wants to do, then the application provides the user with the options available.
Priority	2
Interface	
User Story	US4, US5

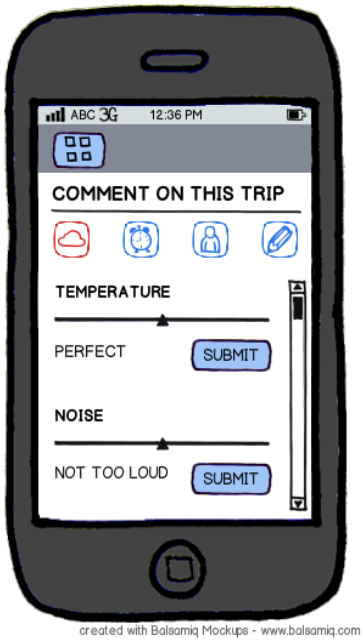
ID	UC8
Name	Choose routes to join
Actors	Registered user
Description	With the available routes given by the route planner, the user can then choose the ones that he or she is interested in and be automatically added to the corresponding network.
Priority	2
Interface	
User Story	US4, US5

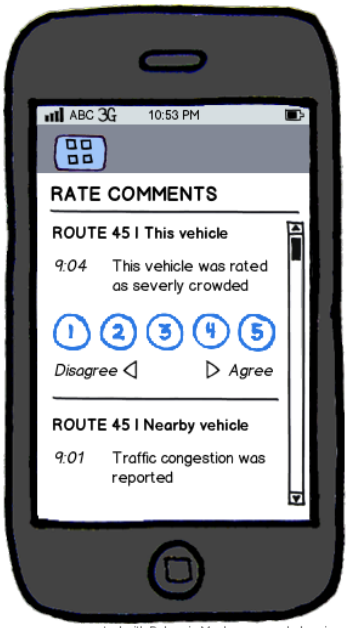
ID	UC9
Name	See users in the network
Actors	Registered user
Description	The user enters the networks' menu and is able to see who is in the user is networks.
Priority	2
Interface	
User Story	US6

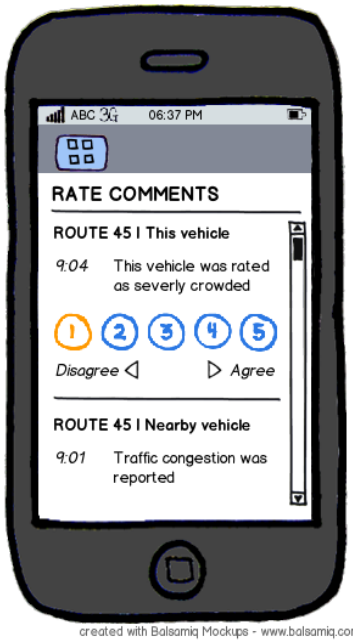
ID	UC10
Name	See the position of the users in the network
Actors	Registered user
Description	The user enters the networks' menu and is able to see the position of who is in the user is networks. Only the position of the users who gave permission to share it is available.
Priority	2
Interface	
User Story	US6

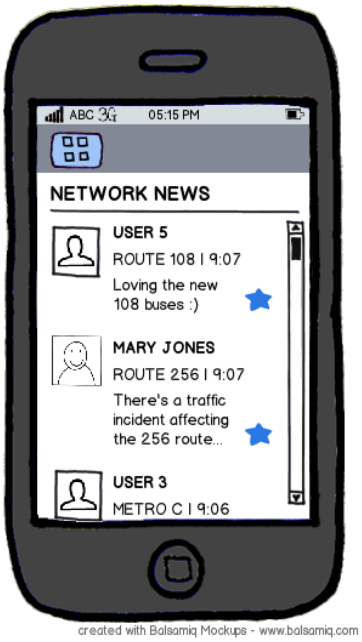
ID	UC11
Name	Share a written comment
Actors	Registered user
Description	When in a network, the user can share a written comment of 140 characters long, within the network the user is in, in order to notify others about an event that might help them defining their journey.
Priority	1
Interface	
User Story	US7

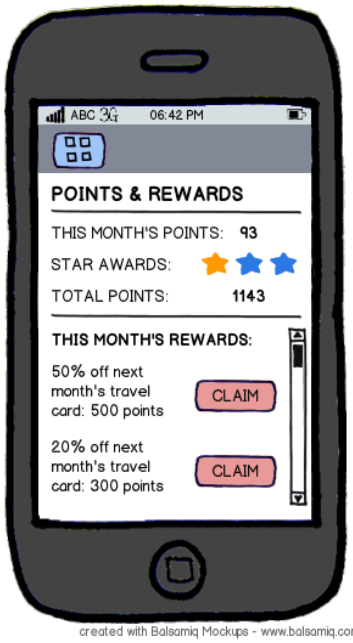
ID	UC12
Name	See comments
Actors	Registered user
Description	The registered user enters the news feed menu in order to see the written and categorised comments that might be useful and that were shared by the others in the user is networks.
Priority	1
Interface	
User Story	US8

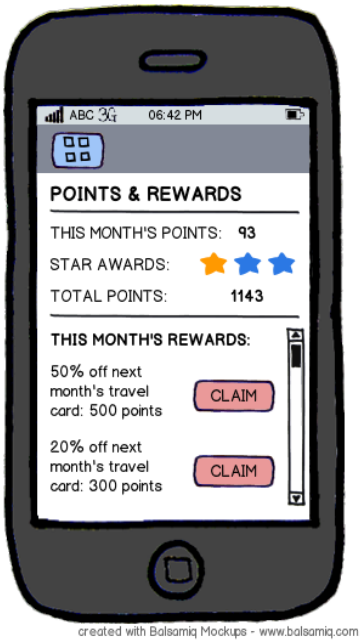
ID	UC13
Name	Share a categorized comment
Actors	Registered user
Description	When in a network, it is possible to share; within the user is network, a categorized comment that evaluates a certain vehicle characteristic. This way, other users in that network are provided with information that might help them choose the transport they want to go in. The categorised comments first have to pass through a validation phase where two other randomly selected users in the same vehicle, evaluate the comment. Only if there is positive feedback to the comment, it is shared with other users in the network.
Priority	1
Interface	
User Story	US9

ID	UC14
Name	See categorised comments that require validation
Actors	Registered user
Description	The registered user enters the categorised comments' screen in order to see if the system asked for the validation of a categorised comment made by a user in the same vehicle. There is a time limit to evaluate a categorised comment that when exceeded the user is no longer able to contribute to that comment is evaluation.
Priority	1
Interface	
User Story	US9

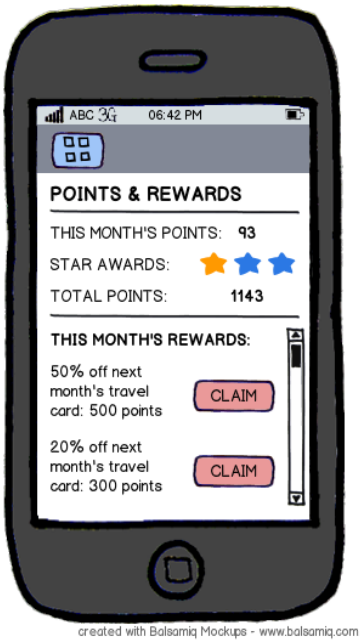
ID	UC15
Name	Validate a categorised comment
Actors	Registered user
Description	For each categorised comment created, two users that are in the vehicle of that comment is author, are randomly selected to rate them according to their level of agreement. The user is notified that there are categorised comments to rate, and has to access the rate comments screen in order to do it. The agreement level is assigned using a continuous scale, for example, from 0 to 100, and only if the average between both opinions is over half of the scale, that comment is sent to other users' news feed. As a real-time time system, it is required that this process of categorised comment evaluation is as fast as possible, so each selected user has a maximum limit of time to rate the comment, otherwise, the system replaces the user for another one.
Priority	1
Interface	
User Story	US10

ID	UC16
Name	Evaluate written and categorised comments
Actors	Registered user
Description	The registered user enters the news feed screen and is able to evaluate as relevant each comment from the networks he is in. This way the user who made the comment is rewarded with points, also, others can then rely more on the information provided by that comment is author. For the purpose of defining a comment as relevant, users assign a star to it, being able to give up to a maximum number of stars each month.
Priority	1
Interface	
User Story	US11

ID	UC17
Name	See the number of written and categorised comments' evaluations left
Actors	Registered user
Description	The registered user enters the points and rewards screen and is able to see how many comments he or she can still rate as relevant in the current month, since each user as a limited number of stars to give per month.
Priority	2
Interface	
User Story	US12

ID	UC18
Name	See user is month points
Actors	Registered user
Description	The registered user enters the points and rewards screen and is able to see how many points already collected in the current month.
Priority	3
Interface	
User Story	US13

ID	UC19
Name	See user is total points
Actors	Registered user
Description	The registered user enters the points and rewards screen and is able to see how many points he currently has in is account.
Priority	3
Interface	
User Story	US14

ID	UC20
Name	Claim a reward
Actors	Registered user
Description	The registered user enters the points and rewards screen and is able to claim a reward that is paid with the points owned. These rewards can be free tickets, discounts, or whatever the transport public providers offer.
Priority	3
Interface	
User Story	US15

ID	UC21
Name	See claimed rewards
Actors	Registered user
Description	The registered user enters the points and rewards screen and is able to see which rewards already claimed.
Priority	3
Interface	
User Story	US15

ID	UC22
Name	Change profile visibility type
Actors	Registered user
Description	The registered user enters is account settings screen and changes the visibility type of the profile. There are three options, it can be Public Profile, Avatar Profile or Anonymous Profile.
Priority	2
Interface	N/A
User Story	US16

ID	UC22
Name	Change profile details' visibility
Actors	Registered user
Description	The registered user enters the account settings screen and changes the details' visibility between public or private.
Priority	2
Interface	N/A
User Story	US16

B.3.1.4 Additional requirements

One of the main goals of this system is the ability to create a unique personal travel profile based on the user is travel history. The system must learn users' preferences and travel patterns in order to provide users with accurate and relevant information that fulfils their needs. This ability brings new function possibilities for the application allowing it to provide the users with a personalized experience and with more suitable information.

Base on the user is travel profile, there are two automatic functionalities that the application must provide, these are:

- Automatic trip adviser
- Route planner results based on users' profile

The automatic trip adviser consists in adding the user to networks that might be useful to him in a given moment. This means that if the user makes always the same trip at approximately the same hour, the application should automatically add the user to relevant networks.

Regarding the route planner, its results should be according with the user is travel preferences. If a user usually selects the paths where metro is the main travel mode, then the results of the route planner should be the ones that make more use of that travel mode.

The system is also responsible for automatically remove users from networks that they no longer need information from. The user can only be added to a network through two ways, either by checking-in on a vehicle, or using the route planner and selecting the results that he or she wants to know information about. In the first case, the user is removed from the networks when checking-out of the vehicle. In the latter, if it is after a certain time of the forecast time of arrival and the user has not checked-in on a vehicle or the current position is not close to the trip origin, the user is automatically removed from the networks.

B.3.2 Non-functional requirements

In order to guarantee the proper functioning of the system, it is important to make sure that aspects like efficiency, reliability or security are not missed. The following list holds non-functional characteristics that the application should ensure.

- Effectiveness
- Reliability
- Robustness
- Portability
- Scalability
- Security
- Usability

Appendix C

Usability test

An increasing number of public transport passengers are connected to social networks through their personal mobile devices. This allows them to share information in real time, related to several aspects of the service they are benefiting from. This type of information can be useful to help other passengers who are making decisions about their trips, as to assist the transportation network managers improving their service. However, the lack of systems able to aggregate and distribute personalized information to passengers and managers means that currently this information is too scattered, reducing its usefulness.

From a general point of view, this project aims to explore possibilities of structuring information on public transport, to generate data that can be useful to various users groups and distribute it through social networks.

The usability test you are about to start is intended to evaluate the usability of a prototype that was created under this project. The way it works is similar to a social network, but the members of your network are not necessarily your friends, but other passengers with similar travel patterns at a given moment in time.

C.1 Pre-test questionnaire

#	Description	Response
1	Age:	
2	Sex (M/F):	
3	Approximate frequency of public transport use (per week):	
4	Smartphone user (Y/N):	
5	Smartphone type:	

C.2 Post-task questionnaire

You will now be asked to follow a set of tasks that will involve most of the prototype's available functionalities. While we go through the script, a facilitator will be at your side to help you and

to take some notes about the tests progress. Keep in mind that this we are not testing you; it is a test of the prototype. So do not worry, take as much time as you want to complete the tasks. Your identity will not be revealed with the results of the test.

#	Activity	Time (s)	Class. **	Comments
1	Login with the following credentials Username: userX Password: test			
2	Through the Android Context Menu, check-into the current line and direction using the GPS check-in functionality			
3	Share a written comment about this trip			
4	Share a driver related categorised comment			
5	Check the news feed *			
6	Rate a categorised comment *			
7	Check the current number of points in your account			
8	Check the current line of travel			
9	Change your nickname			
10	Change your profile visibility to public			
11	Check-out through the Android Context Menu			
12	Plan a journey between Oxford Circus Station and Victoria Bus Station to start in 2 minutes. Select the first option displayed.			
13	Accept being added to the journey you have just planned *			
14	Through the Android Context Menu, manually check-in at Oxford Circus Station. Select the first option displayed.			
15	Logout through the Android Context Menu			

* Make use of the Refresh functionality in the Android Context Menu if you do not receive a notification.

** Classification between 1 (difficult) to 5 (easy)

C.3 Post-test questionnaire

#	Description	Evaluation						
1	What is your overall opinion on the usefulness of such an application	Useless	1	2	3	4	5	Useful
2	Was it easy or difficult to interact with?	Difficult	1	2	3	4	5	Easy
3	As a concept, how easy or difficult was it to grasp?	Difficult	1	2	3	4	5	Easy
4	How safe would you feel using such an application?	Unsafe	1	2	3	4	5	Safe
5	How likely would you be using such an application	Unlikely	1	2	3	4	5	Likely

Would you like to see any other comment categories in the application?

Thank you very much for participating!

References

[Bab11] Eduard Babkin. *Ubiquitous Computing*. Janeza Trdine, 2011.

[BC07] Gabriela Beirão and J.A. Sarsfield Cabral. Understanding attitudes towards public transport and private car: A qualitative study. *Transport Policy*, 14(6):478 – 489, 2007.

[BDRW03] Oddur Benediktsson, Darren Dalcher, Karl Reed, and Mark Woodman. Cocomo-based effort estimation for iterative and incremental software development. *Software Quality Control*, 11(4):265–281, November 2003.

[BE08] Danah M Boyd and Nicole B Ellison. Social network sites: Definition, history, and scholarship. *Journal of Computer-Mediated Communication*, 13(1):210–230, 2008.

[CGC07] Harry J. P. Timmermans Eric J. E. Molin Bert Van Wee Caspar G. Chorus, Theo A. Arentze. Travelers' need for information in traffic and transit: results from a web survey. *Journal of Intelligent Transportation Systems*, pages 57 – 67, 2007.

[Coh10] Arianne Cohen. The connected traveler, Janeiro 2010. http://www.budgettravel.com/bt-dyn/content/article/2009/11/01/AR2009110102119.html?page=1.

[CSV11] Ana P. Chaves, Igor Steinmacher, and Vaninha Vieira. Social networks and collective intelligence applied to public transportation systems: A survey. *VIII Simpósio Brasileiro de Sistemas Colaborativos (SBSC 2011)*, October 2011.

[Del11] Colin Delany. How social media accelerated tunisia's revolution: An inside view, February 2011. http://www.epolitics.com/2011/02/10/how-social-media-accelerated-tunisias-revolution-an-inside-view/.

[GC09] K. Goodwin and A. Cooper. *Designing for the Digital Age: How to Create Human-Centered Products and Services*. John Wiley & Sons, 2009.

[GL83] John D Gould and Clayton Lewis. Designing for usability key principles and what designers think. *CHI83 Proceedings*, pages 50–53, 1983.

[Gui11] Rui Guimarães. Serious games, 2011. Unidade Curricular "Desenvolvimento de Jogos de Computador, Faculdade de Engenharia da Universidade do Porto".

[GWR07] Jan-Willem Grotenhuis, Bart W. Wiegmans, and Piet Rietveld. The desired quality of integrated multimodal travel information in public transport: Customer needs for time and effort savings. *Transport Policy*, 14(1):27 – 38, 2007.

REFERENCES

[HS06] Marc Pallot Wolfgang Prinz Hans Schaffers, Torsten Brodt. *The Future Workspace: Perspectives on Mobile and Collaborative Workin*. Telematica Instituut, The Netherlands, www.telin.nl, 2006.

[Ini] Serious Games Initiative. http://www.seriousgames.org/about2.html.

[Joi08] Adam N. Joinson. Looking at, looking up or keeping up with people?: motives and use of facebook. In *Proceedings of the twenty-sixth annual SIGCHI conference on Human factors in computing systems*, CHI '08, pages 1027–1036. ACM, 2008.

[KP10] Jairo A. Gutiérrez Kevin Park. Basics of ubiquitous networking. *Ubiquitous and Pervasive Computing: Concepts, Methodologies, Tools, and Applications*, pages 156–170, 2010.

[Lév98] P. Lévy. *A inteligência coletiva: por uma antropologia do ciberespaço*. Edições Loyola, 1998.

[Mit69] J.C. Mitchell. *Social networks in urban situations: analyses of personal relationships in Central African towns*. Manchester University Press, 1969.

[NGeCP11] Antonio A. Nunes, Teresa Galvao, João Falcão e Cunha, and Jeremy V. Pitt. Using social networks for exchanging valuable real time public transport information among travellers. In Birgit Hofreiter, Eric Dubois 0001, Kwei-Jay Lin, Thomas Setzer, Claude Godart, Erik Proper, and Lianne Bodenstaff, editors, *CEC*, pages 365–370. IEEE, 2011.

[Nie93a] Jakob Nielsen. Iterative user-interface design. *Computer*, 26:32–41, 1993.

[Nie93b] Jakob Nielsen. *Usability Engineering*, volume 44. Morgan Kaufmann, 1993.

[oESA10] Department of Economic and Population Division Social Affairs. World urbanization prospects. the 2009 revision. Technical report, United Nations, New York, March 2010.

[Poh10] Klaus Pohl. *Requirements Engineering: Fundamentals, Principles, and Techniques*. Springer Publishing Company, Incorporated, 1st edition, 2010.

[Rib11] Susana Almeida Ribeiro. Teoria dos "seis graus de separação" revista para a web 2.0, November 2011. http://www.publico.pt/Tecnologia/teoria-dos-seis-graus-de-separacao-revista-para-a-era-da-web-20-1522195.

[RR07] L. Richardson and S. Ruby. *RESTful Web Services*. Oreilly Series. O'Reilly, 2007.

[SRP07] Helen Sharp, Yvonne Rogers, and Jenny Preece. *Interaction design : beyond human-computer interaction*. Wiley, 2007.

[Sut11] John D. Sutter. The faces of egypt's 'revolution 2.0', February 2011. http://edition.cnn.com/2011/TECH/innovation/02/21/egypt.internet.revolution/index.html.

[TS07] Per Backlund Tarja Susi, Mikael Johannesson. Serious games – an overview. Technical report, School of Humanities and Informatic, University of Skövde, Swede, February 2007.

[Vir92] Robert A Virzi. Refining the test phase of usability evaluation: How many subjects is enough? *Human Factors*, 34(4):457–468, 1992.