



Frederico Guilherme Galvøeira Ramos Moura Borges

Internet of Things and Android Applications: a case study of InterRail Guide.

Master thesis dissertation in Physics Engineering, in the instrumentation area of expertise, oriented by Professors Jorge Sá Silva and André Rodrigues. Presented in the Physics Department of the Faculty of Sciences and Technologies of the University of Coimbra

2015



UNIVERSIDADE DE COIMBRA

Internet of Things and Android Applications: a case study of InterRail Guide.

Frederico Guilherme Galvøeira Ramos Moura Borges
Masters in Physics Engineering
Physics Department
Faculty of Science and Technologies
University of Coimbra

Supervisor: Professor Jorge Sá Silva
Department of Informatics Engineering

Supervisor: Professor André Rodrigues
Centre for Informatics and Systems of the University of Coimbra

Jury:

President: Professor José Paulo Pires Domingues
Department: Physics Department

Name: Professor Jorge Sá Silva
Department: Department of Informatics Engineering

Name: Professor Alberto Cardoso
Department: Department of Informatics Engineering

*É nesta fase derradeira
Que encaro a realidade
Tenho uma oportunidade
Já penso de outra maneira
Se houver alguém que não queira
Deste ângulo a vida ver
Posso desde já dizer
Está enganado esse alguém
Se pensa que já não tem
Nada mais a aprender*

October 31st, 1982

João Romão Borges

Acknowledgments

It was the best of times, it was the worst of times.

Charles Dickens

What better quote to describe the College Experience, and probably life itself.

Over my academic education, I had the opportunity to learn from great teachers and supervisors who endured me and allowed me to start my own projects and ideas. University is a world of opportunities and personal discovery and Coimbra is the right place to do it.

The person I am today is a product of the interaction of all the experiences I have had during my life, and I only hope that the knowledge of all the professors and supervisors can one day reflect on my work and my future projects.

To all of them I give them my sincere acknowledgment.

- To my parents who paid my college formation. Parents, Sister, Grandparents and Cousins who will be on my side no matter what. Their lives are an intrinsic part of who I am, and I would like to make them proud one day.
- To Andreia Fernandes and Raquel Monteiro who despite my mistakes, were always there when I needed them so. I would like to someday repay them in any way possible.
- Joana Faria that put up with me for four years, and reminds me of Charles Dickens every day.
- To Professor Jorge Sá Silva and Professor André Rodrigues, my supervisors, as well as Eng. Duarte Raposo, for availability and understanding, and for the essential knowledge that enabled this project to be successful.
- To the colleagues who helped me in the InterRail Guide: Andreia Fernandes, Diniz Sá, Francisco Carvalho, Gabriel Salvador, Mariana Briz and Tiago Aryan.
- To Nuno Lopes and Ângela Guerra, who remember that life is a chess game with death and we need to try to make the best of it while we can.
- To Pedro Bala, Peter Pan and Le Petit Prince, my literary heroes who lead the way of my future. *On ne voit bien qu'avec le Cœur. L'essentiel est invisible pour les yeux.*
- To God, for making me an atheist.

Summary

The InterRail Guide solution is an Android based Mobile Application and a Web Platform designed for InterRail travellers across Europe. It was developed to help InterRail travellers in the route preparation process and during the journey itself.

To this purpose, the solution presents maps of the main cities in Europe with a selection of unique points of interest per city. Each city has a maximum of 80 points of interest, divided into 9 categories, carefully chosen to provide the best travelling experience for those who are looking to get to know a city like a local.

In addition, the InterRail Guide solution presents information about villages and small cities that can be addressed by train from a main city. With thousands of years of history, the Old Continent has countless jewels to visit and this application helps travellers to do so.

Finally, to serve travellers on a budget, the application also presents information about night trains across Europe that are available from a selected main city. In this manner, when a main city is selected, the user can search for places to visit by train, either in regular or night trains, and train information (train station and travel duration) is provided.

The application works in conjunction with a Web Platform also developed in this project. The reason for this approach lies in the importance of simplifying the application interface and, at the same time, have flexibility in managing of the databases. The application is designed for traveller, and must be intuitive so the users can easily obtain the information they need. It is also important to continuously update the information available to the users. This information includes images, descriptions, GPS Locations for every point of interest and cities, as well as, all the train information.

Prior to the development, a business plan, possible technologies needed to development and an analyse of similar applications was carried to understand the best way to approach this project and the subsequent commercial viability The Business Plan was also important to define the requirements for the Android Application and to the Web platform. This work was mostly done at the beginning of the project, being refined and updated over time.

Afterwards was the definition of the platforms architecture, the development of the Android Application and the Web Platform and finally a test phase to verify the compliance with the requirements.

There are plenty of applications developed to the travel industry but there is none particularly dedicated to trains; this application tries to approach this market opportunity. Therefore, The InterRail Guide solution was developed according to understand if the travel applications can create value that users are willing to pay. However, in the first release of the application, it will be totally free to users because the goal is to understand their interaction with the application.

As future work, it is required to integrate the InterRail Guide solution with the Internet of Things in order to customize the information presented to the user. Also, based on user experience data, the InterRail Guide solution will be able to adapt and present the information according to the user preferences.

Sumário

A solução InterRail Guide é uma aplicação móvel desenvolvida em Android e uma plataforma Web para portadores de um bilhete de InterRail que viajam pela Europa. Esta aplicação foi desenvolvida para ajudar os viajantes no processo de preparação da viagem de InterRail e durante a viagem em si.

Com este propósito, a solução possui mapas das principais cidades da Europa com uma seleção única de pontos de interesse em cada das cidades. Cada cidade possui cerca de 80 pontos de interesse, divididos em 9 categorias diferentes, cuidadosamente escolhidas para proporcionar uma excelente experiência de para aqueles que gostam de viajar numa cidade como um local.

Adicionalmente, o InterRail Guide possui informação sobre as vilas e pequenas cidades, que vale a pena visitar perto das grandes cidades. Com milhares de anos de história, o Velho Continente possui inúmeras joias para visitar e esta aplicação permite que o viajante as visite.

Para servir os viajantes com baixo orçamento, a aplicação também possui informação sobre os comboios noturnos existentes a partir das grandes cidades europeias. Desta forma, quando uma cidade é selecionada o utilizador pode pesquisar locais para visitar de comboio, em comboios normais ou noturnos sendo que a informação dos comboios (estações e duração) é fornecida.

A aplicação trabalha conjuntamente com a plataforma Web que também foi desenvolvida neste projeto. Esta abordagem reside na importância de simplificar a interface da aplicação e, ao mesmo tempo, permitir uma maior flexibilidade na gestão na base de dados. Uma vez que a aplicação foi desenvolvida para viajantes, esta deve ser intuitiva para permitir que os utilizadores facilmente acedam à informação. É bastante importante que a informação existente seja atualizada continuamente que inclui imagens, descrições, localização GPS para cada ponto de interesse e cada cidade, e informações dos comboios.

Antes do desenvolvimento, o Plano de Negócios, possíveis tecnologias a utilizar e uma análise de plataformas Android similares foram desenvolvidas para perceber a melhor forma de abordar este projeto e a sua consequente viabilidade económica. O Plano de Negócios foi importante para definir os requisitos para a aplicação Android e a plataforma Web. Este trabalho foi maioritariamente feito no início tendo sido atualizado ao longo do desenvolvimento.

De seguida foi definido a arquitetura das plataformas, foi desenvolvida a aplicação Android e a plataforma Web. Para terminar foram testados todos os requisitos para certificar se estavam em conformidade.

Existem inúmeras aplicações desenvolvidas na indústria de viagens mas nenhuma se foca nas viagens de comboio, e esta aplicação tenta captar esta oportunidade. Desta forma, a solução InterRail Guide foi desenvolvida para perceber se as aplicações de viagens conseguem criar valor que os utilizadores estejam dispostos a pagar. Contudo, a primeira versão lançada será totalmente gratuita para perceber a interação dos utilizadores com a solução InterRail Guide.

Como trabalho futuro, é importante integrar a solução InterRail Guide com a Internet das Coisas de forma a personalizar a informação apresentada aos utilizadores.

*It matters not how strait the gate,
How charged with punishment the scroll,
I am the master of my fate,
I am the captain of my soul.*

William Ernest Henley

Table of Contents

Acknowledgments	v
Summary	vii
Figure Index	xiii
Table Index	xvii
Acronyms	xix
Introduction	1
1.1 Motivation	1
1.2 Objectives	2
1.3 Methodologies	2
1.4 Structure of the Document	3
2. State of the Art	5
2.1 Technologies	5
2.2 Similar Platforms	7
3 Requirements	23
3.1 Actors	23
3.2 Functional Requirements	23
3.3 Use Case Diagrams	36
3.5 Non-Functional Requirements	37
3.6 Technical Restrictions	39
4 Architecture	41
4.1 Product View	41
4.2 High Level View	53
4.3 Mobile Application	54
4.4 Web application	55
4.5 REST Server	56
4.6 Data Model	57
5 Tests	61
5.1 Unit Tests	61

5.2	Integration Testing	62
5.3	System Testing	63
5.4	User Acceptance Testing.....	63
6	<i>Business Plan</i>	65
6.1	Product and Services	65
6.2	Marketing Plan.....	67
6.3	Operation Plan	77
6.4	Start-up Expenses and Capitalization	77
6.5	Financial Plan	78
7	<i>Conclusion</i>	81
7.1	InterRail Guide solution.....	81
7.2	Future Work.....	81
7.3	Final Consideration.....	83
	<i>Annex</i>	85
	Annex A: Sales Forecasts	87
	Annex B: Internet of Things	93
	<i>Bibliography</i>	109

Figure Index

<i>Figure 1 - Foursquare Logo [20]</i>	8
<i>Figure 2 - Manhattan's points of Interest [20]</i>	8
<i>Figure 3 - Foursquare: on the left user's recent activity, on the right user tip on a point of interest [20]</i>	9
<i>Figure 4 - Yelp Logo [20]</i>	9
<i>Figure 5 - San Francisco's Points of Interest [20]</i>	10
<i>Figure 6 - Yelp: on the left Thai restaurants according to user location, on the right points of interest categories [20]</i>	10
<i>Figure 7 - TripAdvisor Logo [23]</i>	11
<i>Figure 8 - TripAdvisor: on the left TripAdvisor home page, on the right hotel list according to their evaluation [23]</i>	11
<i>Figure 9 - TripAdvisor: on the left page a selected city, on the right a flight list between New York City and Rio de Janeiro [23]</i>	12
<i>Figure 10 - Rail Planner Eurail/InterRail [23]</i>	12
<i>Figure 11 - Rail Planner: on the left Planner menu, on the right train information [23]</i>	13
<i>Figure 12 - Europe Travel Guide Offline [23]</i>	14
<i>Figure 13 - Europe Travel Guide Offline: on the left Europe map with icon, on the right detailed information about Paris [23]</i>	15
<i>Figure 14 - Europe Travel Guide Offline: on the left photo and information of Paris, on the right suggestions to visit [23]</i>	15
<i>Figure 15 - Europe Travel Guide logo [23]</i>	16
<i>Figure 16 - Europe Travel Guide: on the left home menu, on the right information about a selected country [23]</i>	16
<i>Figure 17 - Europe Travel Guide: on the left information about a selected country, on the right list of selectable city [23]</i>	17
<i>Figure 18 - Voyager: Trip Planner Logo [23]</i>	17
<i>Figure 19 - Voyager: on the left settings menu, on the right menu the user selects a trip in a city [23]</i>	18

<i>Figure 20 - Voyager: on the left traced route requested in figure 19, on the right direction menu between locations [23]</i>	<i>18</i>
<i>Figure 21 - RoadTrippers Logo [23].....</i>	<i>19</i>
<i>Figure 22 - RoadTrippers: on the left travel details, on the right information, photograph and evaluation of a location [23].....</i>	<i>19</i>
<i>Figure 23 - RoadTrippers: on the left itinerary with the travel stops, on the Right Route 66 with different icons [23].....</i>	<i>20</i>
<i>Figure 24 - Use Case Diagram for the Mobile Application</i>	<i>36</i>
<i>Figure 25 - Use Case Diagram for the Web platform.....</i>	<i>37</i>
<i>Figure 26 - InterRail Guide Icon</i>	<i>41</i>
<i>Figure 27 - Splash Screen</i>	<i>42</i>
<i>Figure 28 - Downloading the data in the Welcome activity.....</i>	<i>42</i>
<i>Figure 29 - Europe Fragment. On the Right Coimbra is selected</i>	<i>43</i>
<i>Figure 30 - Pop up Window in the Europe Fragment.....</i>	<i>43</i>
<i>Figure 31 - On the Left is the Settings Fragment and on the Right the Pedometer</i>	<i>44</i>
<i>Figure 32 - Cities List view Fragment</i>	<i>45</i>
<i>Figure 33 - Map Fragment and the Map Details Pop Up</i>	<i>45</i>
<i>Figure 34 - Regular Train Fragment.....</i>	<i>46</i>
<i>Figure 35 - City Information Fragment</i>	<i>46</i>
<i>Figure 36 - Login page in the Web Application</i>	<i>47</i>
<i>Figure 37 - Web Application Home Page</i>	<i>48</i>
<i>Figure 38 - Cities with Points of Interest Home Page in the Web Application</i>	<i>48</i>
<i>Figure 39 - Create a new the city in the Web Application.....</i>	<i>49</i>
<i>Figure 40 - Edit a City in the Web Application</i>	<i>49</i>
<i>Figure 41 - Cities with Map in the Web Application</i>	<i>50</i>
<i>Figure 42 - Train Information about the selected city in the Web Application</i>	<i>50</i>
<i>Figure 43 - Add a new Point of Interest in the Web Application</i>	<i>51</i>

<i>Figure 44 - Edit the Information about a Point of Interest in the Web Application</i>	51
<i>Figure 45 - Nearby City in the Web Application</i>	52
<i>Figure 46 - Edit Train Information in the Web Application</i>	52
<i>Figure 47 - High Level Architecture</i>	53
<i>Figure 48 - High Level Architecture with external services</i>	54
<i>Figure 49 - Mobile Application Architecture</i>	55
<i>Figure 50 - Web Application Architecture, according to the MVC model</i>	56
<i>Figure 51 - REST Server Architecture</i>	57
<i>Figure 52 - Entity Relationship for the Mobile Application</i>	58
<i>Figure 53 - InterRail most popular routes [35]</i>	66
<i>Figure 54 - Mobile Phone Users Worldwide [42]</i>	67
<i>Figure 55 - Global Smartphone Market Share by Platform [43]</i>	67
<i>Figure 56 - Worldwide Smartphone Forecast [43]</i>	68
<i>Figure 57 - Travel Mobile APP Quality Index [41]</i>	69
<i>Figure 58 - Different revenue models for apps, where they are frequently used on, and the revenues from it [47]</i>	70
<i>Figure 59 - Number of mobile-phone subscription compared to the World Population [35]</i>	94
<i>Figure 60 - Things connected to the Internet of Things by 2020 [38]</i>	95
<i>Figure 61 - A 4-slot slotframe and timeslot diagram of an acknowledgment transmission [50]</i>	100
<i>Figure 62 - Example network topology and the associated schedule [50]</i>	100
<i>Figure 63 - CoAP Architecture [50]</i>	107

Table Index

<i>Table 1 - Comparative Analyses</i>	22
<i>Table 2 - Requirement Parameters [32]</i>	23
<i>Table 3 - Unit Testing</i>	61
<i>Table 4 - Integration Testing</i>	62
<i>Table 5 - System Requirements</i>	63
<i>Table 6 - InterRail Guide Analysis</i>	73
<i>Table 7 - Foursquare, Yelp and TripAdvisor analyses</i>	73
<i>Table 8 - Competitive Rail Planner, Europe Travel Guide Offline and Europe Travel Guide Analyses</i>	74
<i>Table 9 - Voyager: Trip Planner and RoadTrippers Analysis</i>	75
<i>Table 10 - Annual Subscription Costs</i>	77
<i>Table 11 - First Year Costs in €</i>	78
<i>Table 12 - Following Years Costs in €</i>	78
<i>Table 13 - Twelve Month Profit Loss Projection</i>	79
<i>Table 14 - Four Year Profit Projection</i>	79
<i>Table 15 - Standard communicating technologies</i>	97

Acronyms

ADT – Android Development Tools

ARQ – Automatic Repeat Request

API – Application Programming Interface

APK – Android Application Package

ASN – Absolute Slot Number

CoAP – Constrained Application Protocol

CORE – Constrained RESTful Environment

CSMA – Carrier Sense Multiple Access

CSS – Cascading Style Sheets

DAO – Data Access Object

DIOC – DODAG Information Option

DPI – Dots per Inch

HTML – Hypertext Markup Language

HTTP – Hypertext Transfer Protocol

IDE – Integrated Development Environment

IEEE – Institute of Electrical and Electronics Engineers

IETF – Internet Engineering Task Force

IoT – Internet of Things

IP - Internet Protocol

JSON – JavaScript Object Notation

LLN - Low Power and Lossy Network

MVC – Model-view-controller

P2MP – Point to Multipoint

P2P – Point to Point

PHP – Hypertext Preprocessor

PHY – Physical Layer

RDBMS – Relational Database Management System

REST – Representational State Transfer

ROLL – Routing over Low Power and Lossy networks

SDK – Software Development Kit

SOAP – Simple Object Access Protocol

SFD – Start of the Frame Delimiter

SQL – Structured Query Language

TCP – Transmission Control Protocol

TSCH – Time Synchronized Channel Hopping

UDP – User Datagram Protocol

UI – User Interface

URL – Uniform Resource Locator

WSN – Wireless Sensor Networks

XML – Extensible Markup Language

Introduction

1.1 Motivation

Ever since I can remember, travelling has been part of my life, by the age of fifteen I had been on four Continents. I grew up hearing stories from my parents throughout Europe (my father did five InterRails and my mother three), so I always dreamed of having that same experience. Fortunately, I was able to do five InterRails.

In these journeys I met fellow travellers and I realized that most of times travellers do not know where to go next. Travellers want to visit more than just the main cities and the majority of them have guidebooks to help them discover Europe. Nowadays, there are numerous guidebooks with all the information that a traveller needs, but most InterRail travellers have a backpack on their shoulders and, as easily imagined, carrying a library of guidebooks for a month is not an option. Besides, most guidebooks only provide information about the best locations to visit and InterRail travellers are looking for the best sites accessible by train, since you can travel by train mainly for free with the InterRail ticket.

For instance, in Krakow, the majority of travellers want to go to Auschwitz and every guidebook and website informs the traveller to go by bus. What most travellers do not know is that Auschwitz can also be reached by train, it takes an extra half an hour but, with an InterRail ticket, it is a free trip.

Therefore, I started thinking about developing a mobile application for InterRail travellers and in November of 2014, I had the opportunity to enter in a Start-up Weekend by Google with this idea and a team to work on it. This idea did not win the competition, nevertheless there were some investors that told us that they thought there is a market opportunity for it.

Talking with my thesis supervisors, the opportunity emerged to work in this project as my thesis and integrate this solution to the Internet of Things (IoT) and Wireless Sensor Networks (WSN). The Internet of Things will connect people to everyday objects like smartphones, cars, trains, fridges, buildings, etc. This thesis enabled to continue to work on this project while applying the opportunities aroused by the Internet of Things that will revolutionize the way humans interact with technology, making the InterRail Guide solution an innovative application in the Mobile Market. In [Annex B](#) it is presented a study about the Internet of Things, and analysed one of the major efforts in defining standards for enabling IoT devices to communicate (i.e. the Open WSN initiative). This study allowed us to realize the importance of the Internet of Things in the near future and its implementation in mobile applications.

The InterRail Guide solution was developed as an academic project designed to release an application for the end user to understand how the Mobile market works. This project combines two worlds: the development and the business which will be a very important experience for my life after college. It is an amazing feeling, typing these words knowing that after all the work in this project, the InterRail Guide solution, will be launched in the Play Store where Android users around the world can download it. User's reviews and number of downloads will be an important metric to evaluate the InterRail Guide success.

1.2 Objectives

The objectives of this thesis are the following:

- The development of a solution for InterRail travellers prepared for the mobile market. The solution needs to have:
 - A good usability
 - A Revenue Model
 - Market Study
- Perceive how to implement customized information for each user in the IoT environment

The scientific objective of this project resides in the development of a solution based on a mobile application and a web platform that collaborate to provide an innovative service taking advantage of smartphone sensors, Internet services, and prepared, in the future, to integrate the Internet of Things through the OpenWSN solution.

- The Internet of Things will enable the customization of the information presented according to the user preferences and needs.

The InterRail Guide solution must be ready to be released in Play Store and the number of users by the start of summer of 2015 will be the main success metric.

1.3 Methodologies

The software development process was based on SCRUM methodologies that are based on the Agile Manifesto.

The Agile Manifesto, was written on 2001 as an alternative to the waterfall project management [1]. Instead of flowing through the different phases of conception one at a time, the Agile implement sprints, where each team responds over incremental and iterative work cadence according to project workflow and client opinions. This implies that the needs are adapted as the projects evolves [2].

Using the Agile framework, SCRUM was originally developed for software development projects but is also applied in other complex and innovative projects. The director of the project need to create a list of requirements and prioritize them according to their importance. The top requirement is taken from the list and the team needs to develop it in a certain amount of time. This is called a sprint. After the sprint is finished, the requirement is reviewed and tested in order to be implemented.

SCRUM works in loop and after a sprint is completed the team takes the top requirement from the list until the list ends [3].

I developed the application through weekly meetings with the thesis supervisors and the development progressed steadily according to the SCUM methodology where I developed and tested the requirements. The supervisors performed a second test of each requirement.

1.4 Structure of the Document

This thesis is divided in seven chapters, according to the work developed.

In the initial chapter it is presented the objectives and methodologies of the InterRail Guide solutions as well as the personal interest and knowledge that enabled the idea to mature during the last InterRails.

The second chapter introduces the technologies used in the InterRail Guide solution development. Similar platforms in the mobile market were analysed to develop the InterRail with the best features existing in the market. Guide. This analysis compares the technical view of the market and the information presented from each application.

The third chapter presents the technological requirements for the InterRail Guide solution. Requirements are established in the beginning of the project to be implemented in the InterRail Guide solution. The requirements changed during the development due to technical restrictions and examples taken from the analysed platforms.

In the following chapter it is introduced the architecture of the InterRail Guide solution and the characterization of the several components developed.

The fifth chapter introduces the tests performed to the InterRail Guide requirements. This chapter suffered constants updates because requirements were introduced during development, and the reviews from the implemented requirements lead to improvement.

The next chapter details the Business Model, where is analysed the market and the potential users. How can the user be addressed? Which is the best revenue model for InterRail Guide? In this chapter it is analysed the competition and how our project can distinguish our application in the market, as well as the marketing used to reach our potential users.

In the final chapter it is presented a conclusion of the work and the future improvements to enable the application to be released.

In annex it is displayed the sales forecast for the InterRail Guide, the Agile Manifesto, the Internet of Things economic perspective, and study the protocols stacks and Open WSN.

2. State of the Art

This chapter is divided in two sections. The first section presents the best-suited technologies for the InterRail Guide solution. The second section analyses similar platforms to verify the features and the quality of the analysed platforms. Further analysis of these platforms is presented in the Business Model.

2.1 Technologies

The technologies used in the development of the InterRail Guide solution were:

Android Platform

The Android Platform is a mobile operating system based on the Linux Kernel and is designed mainly for touchscreen devices, such as smartphones and tablets. As of July 2015 the Google Play store has over 1.6 million applications [4] and over 50 billion apps downloaded [5] The Mobile Platform was developed in Android instead of iOS or Windows Phone because it has the biggest market share of the Mobile device, market analyses in the [Business Plan](#), the development is free and the APK (Android Application Package) can be easily installed on devices with multiple screen sizes.

Android Studio (Integrated Development Environment)

An Integrated Development Environment (IDE) is a software application that provides comprehensive facilities to software developers. For the Android Platform development it was utilized the Android Studio developed by Google and is written in Java. The Android Studio was presented at May 16st, 2013, and since then it replaced the Eclipse Android Development Tools (ADT) as the main native Android application development [6].

Web Service

Web Services are standardized approach used in system integration and communication between different applications. Using the HTTP protocol, software applications written in different programming languages and running on multiple platforms use Web Services to exchange information between them. [7]

PHP

PHP (Hypertext Preprocessor) is an HTML-embedded scripting language which allows developers to easily write dynamically generated pages. When the PHP code is executed, the web server sends the resulting output to the client, normally in the form of a web page [8]. In January of 2013, PHP was installed in more than 240 million websites and 2.1 million web servers, and is one of the mostly used server side scripting language [9].

HTML

The HTML (HyperText Markup Language) is a Markup language, a system for marking a document in a way that is syntactically distinguishable from the text [10] mostly utilized in web pages creation. Web browsers can interpret HTML files and compose them into visible or audible web pages. HTML tags and scripts interpret the content and allow images and objects to be embedded which can create interactive forms [11].

CSS

CSS (Cascading Style Sheets) is a sheet language, a language that expresses the presentation of structured documents meaning that the content can be applied in many contexts and presented in various ways to produce different presentations [12]. CSS is utilized for describing the look and format of a markup language document, and can be applied to any kind of XML document [13].

MySQL

MySQL is an open source relational database management system (RDBMS) based on SQL (Structured Query Language). MySQL runs on almost all platforms like Linux, UNIX and Windows and can be used in multiple applications. However, it is mostly used with web-based applications and online publishing [14]. MySQL was chosen rather than other solutions because it is easy to use, enables a reliable protection for data-access, its flexibility (runs well in Web-sites and Web-applications), its rich configuration settings and operation modes (enabling a highly specific and extremely custom solution) [15].

REST

REST (Representational State Transfer) is an architectural style approach often used in development of Web services and usually communicates with HTTP verbs. REST replaced the SOAP style because it does not consumes as much bandwidth, which is best suited for Internet communications. REST consists of a set of constraints applied to the different elements within the architecture, where it is possible to identify the properties from the Web constraints [16].

JSON

JSON (JavaScript Object Notation) is a lightweight data-interchange format widely used in development to ease the reading and writing of information. JSON is easy to parse so that different languages can interact with the same information [17].

XML

XML (Extensible Markup Language) is a markup language which defines the rules for encoded documents in both human-readable formats as well as machine-readable. The XML design goals emphasize simplicity, generality and usability across the Internet [18]. XML provides constraints on the storage layout and logical structure and can contain parsed or unparsed data [19].

2.2 Similar Platforms

Similar Platforms on the Android Market were analysed in to understand what solutions are available to the user and how the information is presented. Since the InterRail Guide approaches different elements, the similar platforms analysed were divided in three groups:

- Location based application – those are applications based on the user location and on the characterization of points of interest;
- Information applications – applications that are developed to present user information relevant to travel (ex: train schedules);
- Guide applications - provide travel information and advices to the user. Some applications offers offer routes according to the user preferences and choices;

Along this chapter, it is presented a comparative study between the InterRail Guide and the applications analysed. As an initial observation, all the applications analysed have some functionality in common with the InterRail Guide.

2.2.1 Location-based Applications

Location-based applications features points of interest in a map where the community can create, evaluate and comment those points. Most of these applications evolved into social networks where users can respond to comments, add pictures and advices about the points. These applications presents custom information to each user depending on the user likes and dislikes, and its current location.

2.2.1.1 Foursquare



Figure 1 - Foursquare Logo [20]

Foursquare is a local search and discovery service mobile application, founded in 2008, that encourages its users to promote points of interest to the community. Since the application knows the user location and the points of interest that the user liked and commented upon, Foursquare delivers personalized recommendations to places to visit that are around the user's current location. This application detects the user position through GPS or Wi-Fi. In April 2015 Foursquare had 55 million users, more 30 million than in 2012 [21], and more than 6 billion points of interest check-ins [22]. It can be utilized in Android [23], iOS [24], WindowsPhone [25], Blackberry [26] and Symbian [27].

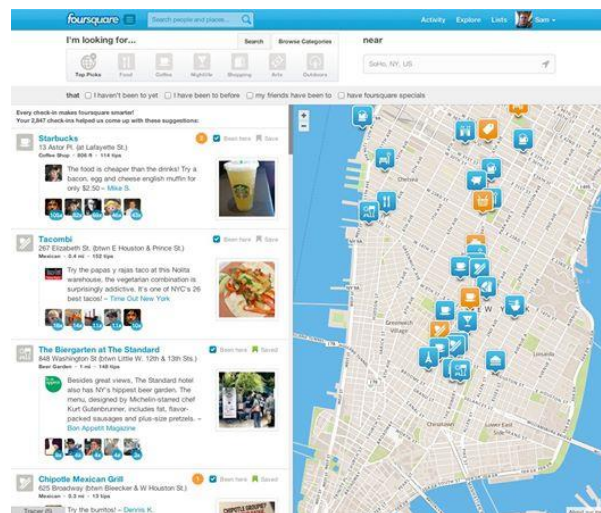


Figure 2 - Manhattan's points of Interest [20]

Foursquare encourages the users to create points of interest as followed:

- Each user can create a check-in in a new point of interest, provided that it is in the vicinity;
- Each check-in assigns points to the user, and depending on the action upon the point of interest, it can attributed badges.
- The badges are attributed if the user performs certain actions in the point of interest, such as frequently updating their check-ins or do check-ins at a certain time.
- In a certain point of interest, if the user makes more check-ins than other users on the last 60 days, it becomes mayor of the point of interest.

By giving points Foursquare promotes customer loyalty and allow the application to improve its content. Foursquare managed to have more than 6 million check-ins.

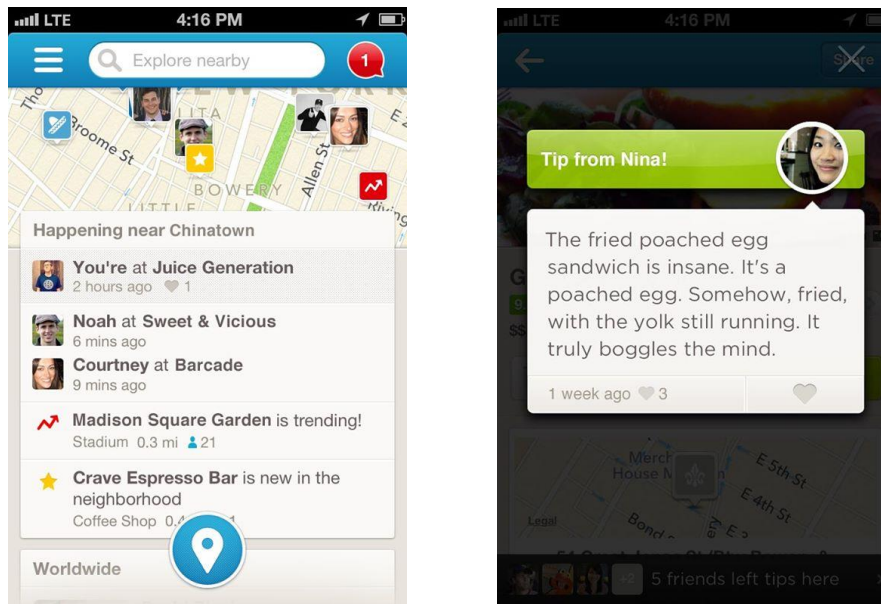


Figure 3 - Foursquare: on the left user's recent activity, on the right user tip on a point of interest [20]

2.2.1.2 Yelp



Figure 4 - Yelp Logo [20]

Yelp is a platform to help the user find the nearest businesses, like dentists, hair stylists, mechanics, restaurants, etc, where the services have operating details. Users can comment about the businesses and describe the establishments on a certain city and there are over 71 million points of interest reviews and has an average of approximately 125 million monthly unique visitors by the Q4, 2014 [28]. Businesses can create a free account where they can put all the information that they consider appropriate as well as photographs of the establishment. Yelp allows users to add further information provided that it is approved by the businesses.

The points of interest are created by the businesses and the costumers only review those points of interest, creating a dynamic yellow pages mobile application with a huge database.



Figure 5 - San Francisco's Points of Interest [20]

To promote customer loyalty and ensure that the application is utilized regularly Yelp assign badges when users conclude proposed objectives and allow the addition of friends allowing the users to exchange messages and visualize comments about the points of interest [28]. To encourage users to contribute to the content, Yelp highlights the first business description as well as the most detailed review, to promote a competition between users to reach prominent positions [29]. Yelp is a dynamic and a customized application where the users likes and comments on businesses influences the score of the establishment. The more likes and reviews the business has, the more time it will be shown to other users. When a user likes the same location as another user, Yelp suggests the first user other businesses that the second user also liked. Business owners can answer to the comments either in the comment section or in a private message. Besides the Web browser, Yelp also offers native application for iOS [24], Android [23], and Blackberry [26].

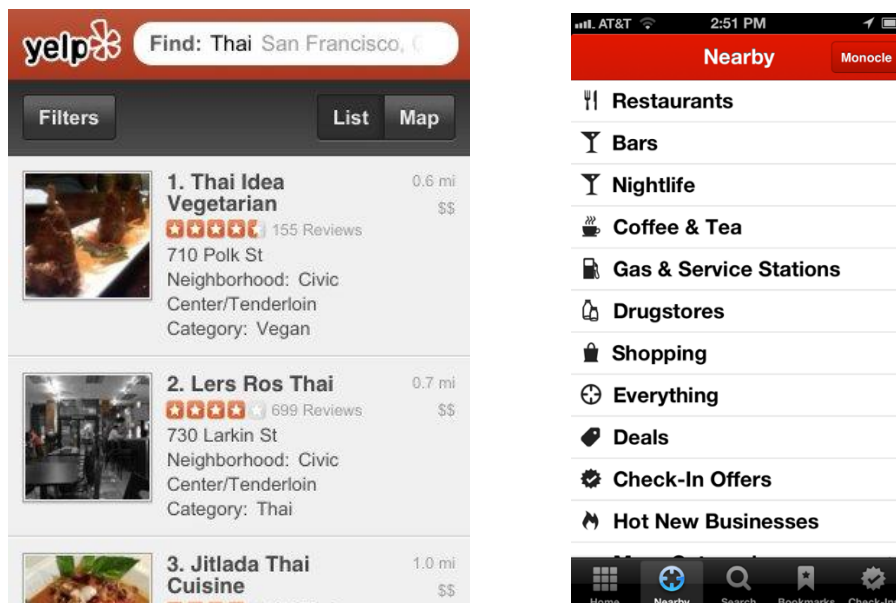


Figure 6 - Yelp: on the left Thai restaurants according to user location, on the right points of interest categories [20]

2.2.1.3 Trip Advisor



Figure 7 - TripAdvisor Logo [23]

TripAdvisor is a travel website, founded in 2000, who provides reviews and travel-related content as well as interactive travel forums to allow a stronger interaction between users. TripAdvisor was an early adopter of user-generated content, where users create points of interests, and then comment and evaluate those locations. It covers businesses like bars, restaurants and shops, but also sightseeing locations. In other words, everything that might have some interest for a tourist. TripAdvisor has more than 200 million reviews and comments around the world; more than 4.5 million businesses including 2.4 million restaurants; 915 thousand hotels, hostels, and B&B; and 500 thousand attractions [30]. TripAdvisor earned such notoriety that businesses exhibit the TripAdvisor evaluation at the front door so that the establishment can be seen as a quality one. In October 2011 TripAdvisor launched the Android mobile application [31], and since then has launched the iOS [24], Symbian [27], and Windows Phone [25] applications.

TripAdvisor has focused on business instead of sightseeing locations because the revenues are higher in this market, but as still managed to become the biggest travel website of the world and transformed the Site and the Applications into a geosocial network.

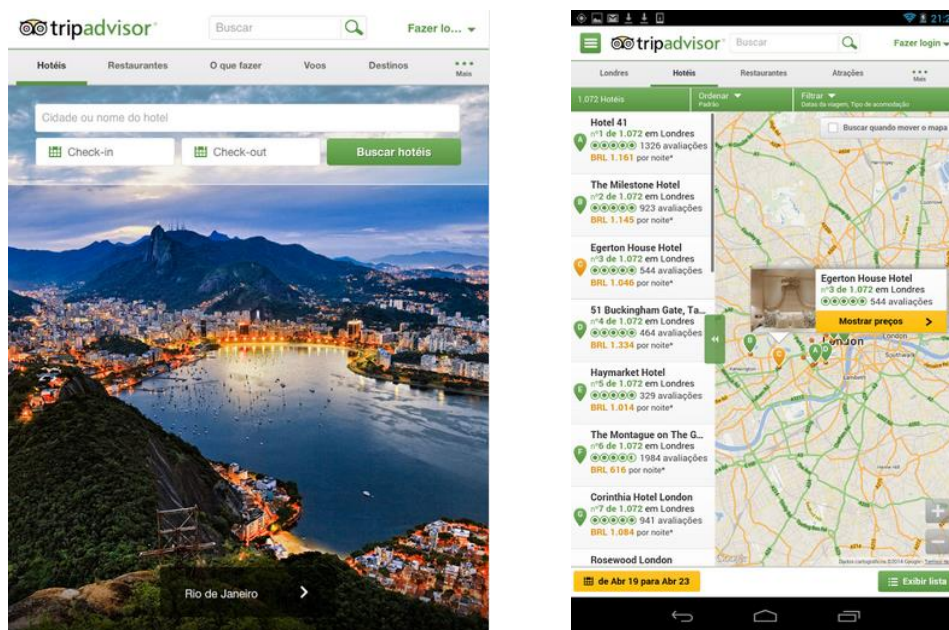


Figure 8 - TripAdvisor: on the left TripAdvisor home page, on the right hotel list according to their evaluation [23]

In the website, TripAdvisor offers points of interest in the whole world, either in cities or villages. However, in the mobile application it only offers the possibility of 30 Europe cities and 50 cities outside Europe [23]. TripAdvisor focuses on tourists that usually travels by aeroplane to only one city.

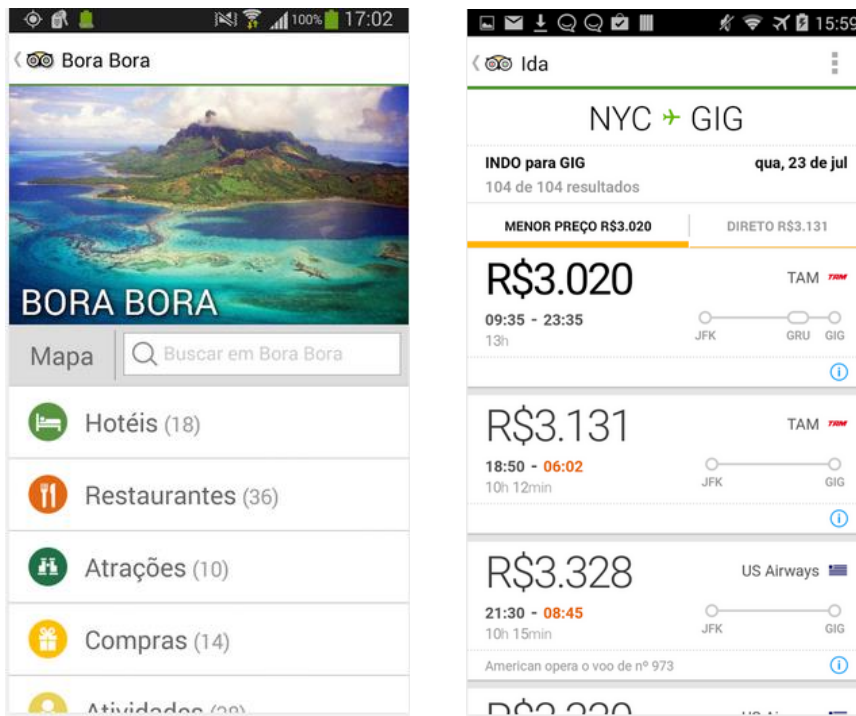


Figure 9 - TripAdvisor: on the left page a selected city, on the right a flight list between New York City and Rio de Janeiro [23]

2.2.2 Information Applications

Information applications provides useful content to its users, and focus only on delivering the content in an easy and intuitive manner despite having huge data.

2.2.2.1 Rail Planner



Figure 10 - Rail Planner EuRail/InterRail [23]

The Rail Planner is an application developed by the EuRail/InterRail group to provide train information through Europe. It is important to mention that the EuRail and InterRail are the same ticket, however

InterRail is sold to travellers residing in Europe and EuRail is sold to non-Europe residents. The price of the EuRail is higher than the InterRail.



Figure 11 - Rail Planner: on the left Planner menu, on the right train information [23]

The Rail Planner is divided in four menus, the Planner menu which provides the train schedules throughout Europe, the Timetable menu which presents train schedules of direct train connections, the Nearby menu shows the nearest train stations according to the user current location (the device must have an Internet connection), and the More menu has other InterRail information such as maps locating the train stations in Europe's main cities, detailed information of every country and ticket details.

The ten maps of the Rail Planner platform are design to show the geographical position of the train station in those cities, and are not touristic maps. This application is mostly utilized by the InterRail travellers because of the Planner menu, where the user discovers how to get from station A to station B, and if necessary, which station the user needs to change trains. The Rail Planner has such a big database that it is possible to have all the information from Lagos train station in southern Portugal to Narvik train station, north of the Arctic Circle in Norway, with the between stations that the user need to change trains.

To better serve users, Rail Planner allows the user to choose the starting time of the trip, on the day he is doing the search or on the following days. The user can also choose the next train departing from a selected station. The Rail Planner is very useful since it helps the traveller to plan the train travel ahead of time. This is a static application where the train information is updated quarterly to remove obsolete routes and add new ones [23].

The Rail Planner database cannot be used in the InterRail Guide since it is property of the European railway companies. The Deutsche Bahn, the German train company, has this data in their website and

the Rail Planner uses their database to present the train schedule. Unfortunately, the InterRail Guide was not able to establish a partnership to utilize this database. Using the Rail Planner the user will not discover new places to visit. This application only allow the user to plan a trip to a city that he intends to visit.

2.2.3 Guide Applications

Guide Applications are developed to help travellers plan the trip, providing advices and evaluations to the users. Some guide applications offer the possibility to make routes to aid the traveller to discover new places. This area of applications is the one that best fits the InterRail Guide.

2.2.3.1 Europe Travel Guide Offline



Figure 12 - Europe Travel Guide Offline [23]

The Europe Travel Guide Offline was launched in January 2015 and has detailed information of 45 countries and regions, and 10 cities, of a total of 6000 travel destinations and businesses [23]. This application is designed as a combination between a mobile guidebook and the Wikipedia website, where the user can access information about the city, places to visit in the country and a few suggestions of business to experience, like hotels, bars, restaurants, nightlife, etc.

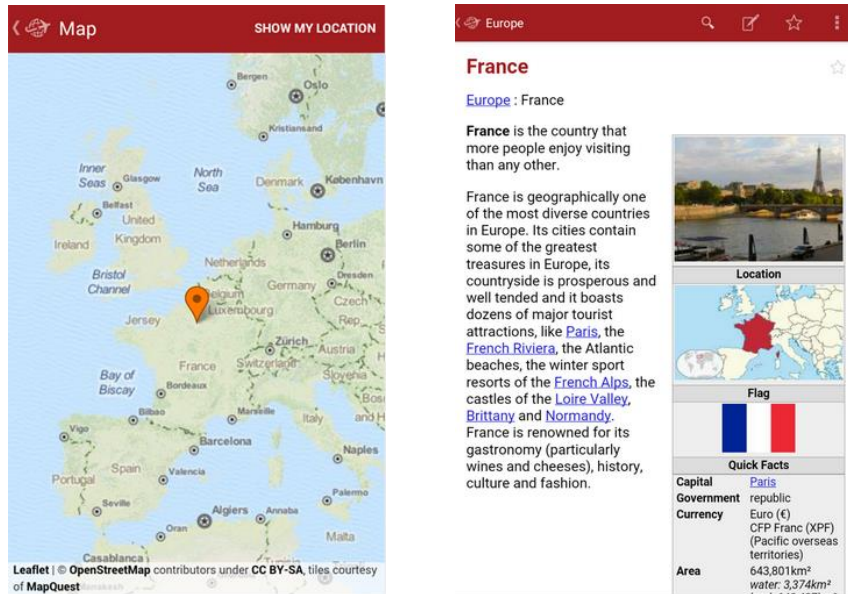


Figure 13 - Europe Travel Guide Offline: on the left Europe map with icon, on the right detailed information about Paris [23]

This is a static application to inform the user of the main touristic locations around Europe. It has a primitive design and the only interactive option a user has is the possibility of saving a list of favourite destinations to enable an easy access during the trip [23].

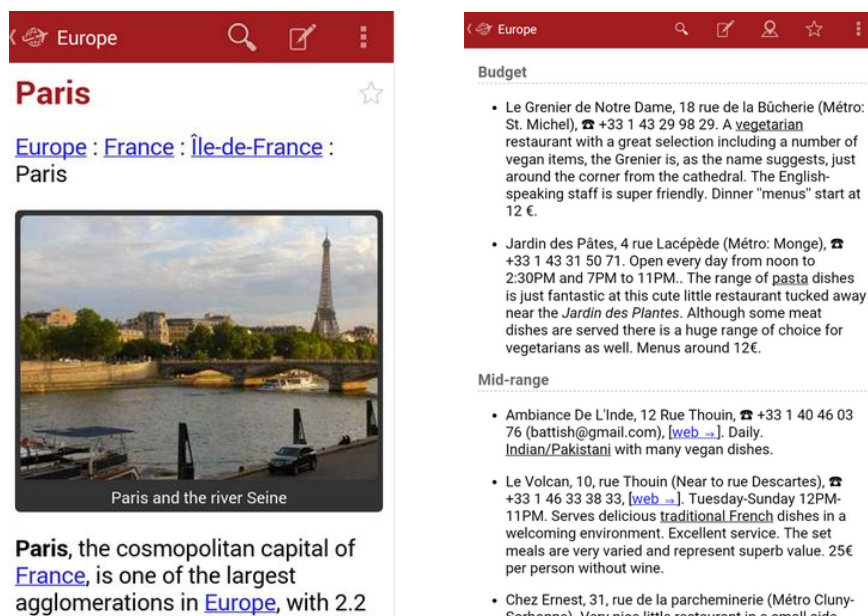


Figure 14 - Europe Travel Guide Offline: on the left photo and information of Paris, on the right suggestions to visit [23]

The Europe Travel Guide Offline has been designed to focus on a general trip, whether on a backpacking adventure or a luxury vacation. This means that the information and advices presented are very wallet distinctive, as in location based applications.

The main disadvantages of the Europe Travel Guide Offline is the confusing navigation interface and the fact that the information presented is downloaded from the Wikipedia website. Information in Wikipedia is general purposed and do not have touristic interest.

2.2.3.2 Europe Travel Guide



Figure 15 - Europe Travel Guide logo [23]

The Europe Travel Guide is a static application last updated in June of 2011 and is the original idea developed by the Europe Travel Guide Offline, the previous application analysed. The objective of this application is the same of the previous one, however the navigation of this application is very different and has much less information. The main menu of this application is the list of countries and the application is branched through clicking on buttons until the user arrives at specific information about regions, cities or other destinations. This application has very little information about location, but presenting information about restaurants, shops and sightseeing locations [23].

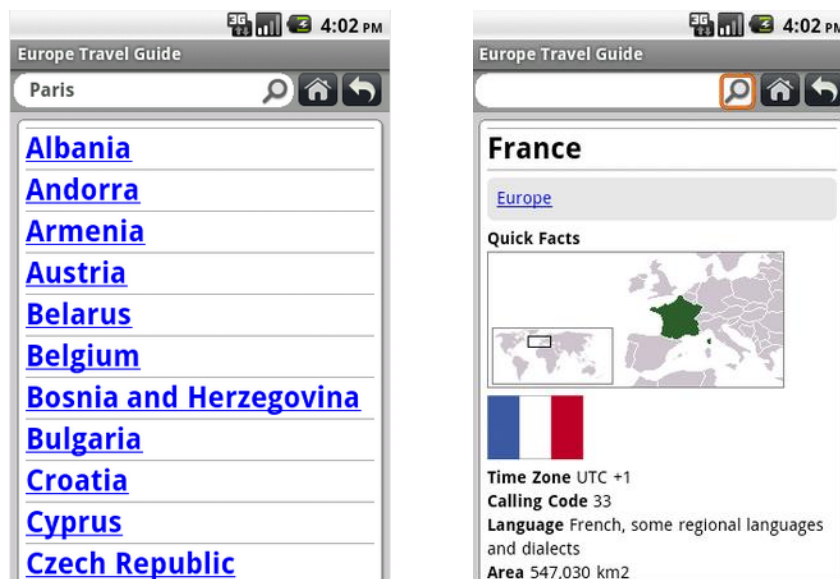


Figure 16 - Europe Travel Guide: on the left home menu, on the right information about a selected country [23]

The Europe Travel Guide offers a general view of touristic information such as the Europe Travel Guide Offline and has most of the same problems as the previous application.

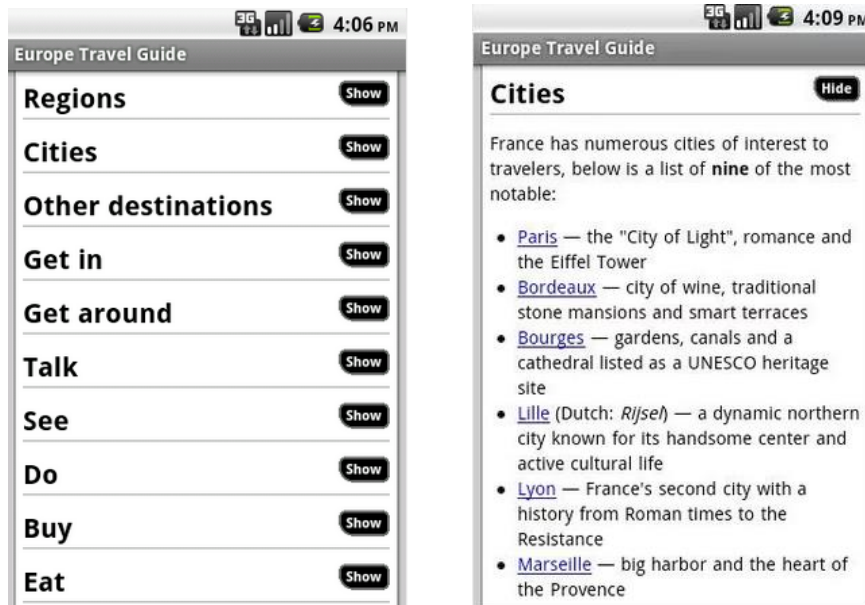


Figure 17 - Europe Travel Guide: on the left information about a selected country, on the right list of selectable city [23]

2.2.3.3 Voyager: Trip Planner

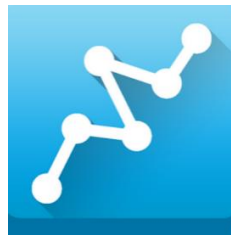


Figure 18 - Voyager: Trip Planner Logo [23]

Voyager: Trip Planner is an application that helps to plan the optimal (fastest) route to visit multiple locations. The user selects the starting, the end point and the number of stops, then the application provides the route automatically selecting the stops. This application requires Internet access to plan the route since it uses the Google Maps API to trace the routes, however the route can be saved and can be accessed offline later. Voyager uses two methods to calculate the optimal route, the brute force approach when the number of destinations is small, and a set of approximation algorithms when the number is large.

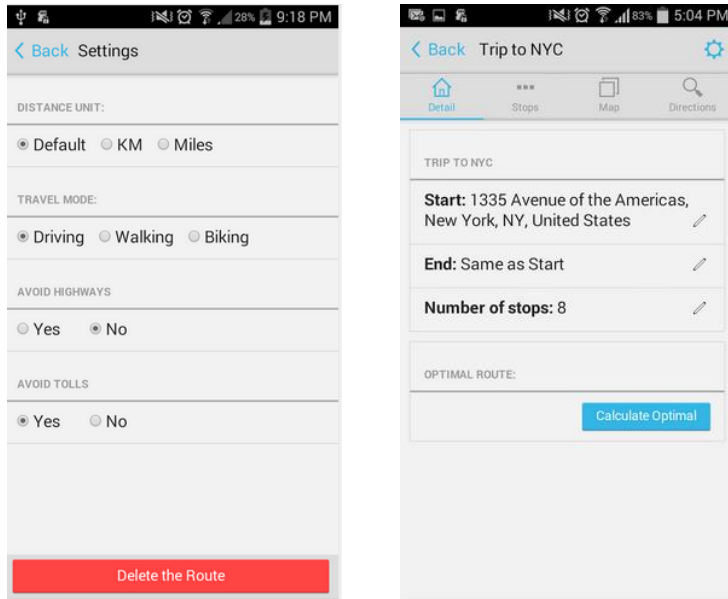


Figure 19 - Voyager: on the left settings menu, on the right menu the user selects a trip in a city [23]

The Voyager can plan routes in three travel modes: driving, walking and biking, providing an approximate travel distance between locations once the route is traced. In driving travel mode option, the user can choose to avoid highways and toll roads. Although, this application can be used to trace routes worldwide, either inside cities or long distances, it is mainly designed to be optimal in city routes of shorter distance. The Voyager has a direction menu, where the user first select a starting point and the end point, either by typing the name or the address of those points, and the number of stops along the route, then the application calculates and presents the optimal route. The route defines automatically the stops but the user can select where it wants to stop by writing the name of the location or its address [23].

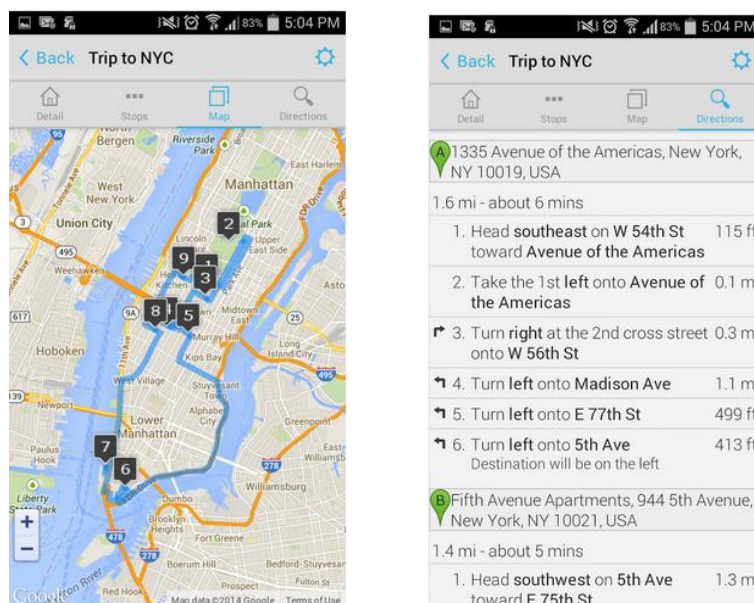


Figure 20 - Voyager: on the left traced route requested in figure 19, on the right direction menu between locations [23]

2.2.3.4 RoadTrippers – Trip Planner



Figure 21 - RoadTrippers Logo [23]

RoadTrippers is an application developed for long road trips where the user has the opportunity to discover dinners, scenic spots, attraction, hotels, etc. It has over a million locations to visit, in the application database. With this application, the user can complete itineraries and synchronize them with the RoadTrippers website or other mobile platforms. To trace the itinerary, the user needs to be connected to the Internet, although the itinerary can be saved so it can be viewed offline later. The user can trace the itinerary according to different topics, such as the top rated, accommodation, attractions, entertainment, food & drink, history, nature, shopping and sports, where each topic has a different icon associated with it. Each location has a description, a photo and an evaluation. This helps the user decide whether to travel next. The evaluation of the location in the RoadTrippers is set by the developers. Until April 2015, RoadTrippers only had content related to the USA [23].

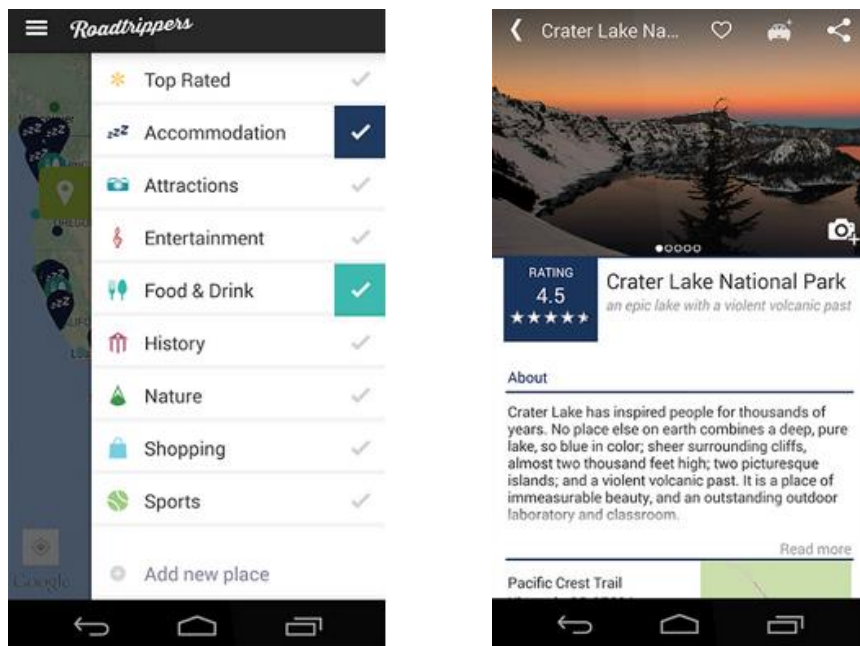


Figure 22 - RoadTrippers: on the left travel details, on the right information, photograph and evaluation of a location [23]

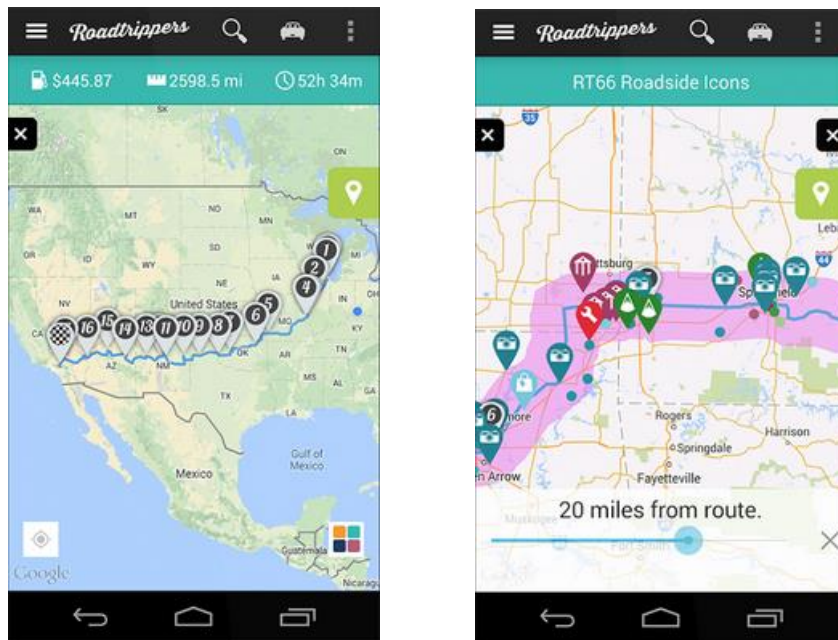


Figure 23 - RoadTrippers: on the left itinerary with the travel stops, on the Right Route 66 with different icons [23]

2.2.4 Comparative Analysis

By comparison, the InterRail Guide fits better into the guide application. However, it incorporates elements from several different applications such as information and location-based applications. The InterRail Guide shares the same target audience as the Rail Planner because they are both directed to InterRail travellers.

All the applications analysed are free and all of them use advertisements as their revenue model. Guide and information applications are static platforms where the application does not take into account the user preferences. On the other hand, location-based applications are evolving into geosocial networks, the platforms are dynamic and present personalized information to the user.

Both guide applications with routes and location-based applications require Internet connection to be fully functional, they still function offline but they lack the main features. For example, guide platforms can only trace routes with Internet connection, however the user can save those routes and check them offline. Location based applications in offline disables the geosocial network and the user need to download the maps to access them offline. When GPS or Wi-Fi are enabled, Location-based applications recomend the nearest existing points of interest according to the user likes.

Guide Applications without routes have far fewer users than the other applications, mainly because of navigation and information flaws such as not intuitive, several clicks to reach the desired page, general purposed information and not very useful.

This suggests that the InterRail Guide may have more users if the route options is featured. In addition, it would be very beneficial if the application could be integrated with the Rail Planner or Deutsche Bahn database. Unfortunately, it was not authorized to use that database and the InterRail Guide can only

provide basic train information, such as duration, number of changes and travel advices. It is hoped that, in case of achieving high number of users, the InterRail Guide will have the proper authorization to use that database.

The InterRail Guide and the Rail Planner can work as a guide packet that every traveller with an InterRail ticket should have installed in the smartphone.

Since the InterRail Guide will be used by travellers outside their country of residence, it is important to assume that users only have limited Internet access. Therefore, the platform needs to be less reliant from the Internet, to the possible extent, so users can access the main features while offline.

In Table 1 it is presented the comparative analyses between the platforms analysed and the InterRail Guide. Each application was analysed by myself in a 0 to 5 system, where 5 is an excellent feature and 0 is a poor feature. The last column, also evaluated in 0 to 5 system, presents the importance of each factor to the costumer. In the Installations factor, it is presented the number of downloads from the Play store, and k represent thousands of installations while m represent millions.

This table is explained in further detail, in the [Business Plan](#).

FACTOR	InterRail Guide	Foursquare	Yelp	TripAdvisor	Rail Planner	Europe Travel Guide Offline	Europe Travel Guide	Voyager: Trip Planner	RoadTrippers	Importance to Costumer
Product	4	4	4	5	5	3	3	2	3	5
Price	5	5	5	5	5	5	5	5	5	4
Quality	4	4	4	4	5	3	2	2	3	5
Expertise	0	5	5	5	5	1	1	2	3	3
Company Reputation	0	4	5	5	5	1	0	1	2	2
Appearance	4	4	4	4	3	2	1	2	3	4
Advertising	0	3	2	5	2	0	0	0	0	3
Image	0	4	5	5	5	2	1	1	2	4
Installation	0	10 m - 50 m	10 m - 50 m	100 m - 500 m	100 k - 500 k	1k - 5k	10 k - 50 k	10 k - 50 k	100 k - 500 k	2

Table 1 - Surveyed applications comparative analyses

3 Requirements

This chapter addresses the InterRail Guide solution functional and non-functional requirements, the use case diagrams and the technical restrictions of the platform.

3.1 Actors

Actors are the elements who interact in a direct or indirect way with the InterRail Guide solution. They include:

- Developers;
- Application Managers (the support and the finance teams);
- Final Users;

3.2 Functional Requirements

Priority [32]	Must Requirements are mandatory
	Should Requirements should be implemented, however if they are not implemented, the InterRail Guide has to work
	Could Requirements are only implemented if they do not affect the most important requirements
	Won't Requirements are not implemented during the project, considered as future work
Description	Overall exposal of the requirements and expected result with the requirement implementation
Actors	Elements who interact with the InterRail Guide
Pre-Conditions	System state before the action realization
Event Flow	Description of the actions needed to achieve to the expected result
Released Version	The system version that will support the requirement. Requirements with the 0.9 Beta version are fully implemented and requirements with the 1.0 version are future work

Table 2 - Requirement Parameters [32]

In this chapter the functional requirements are presented and classified as user stories that are written in non-technical language to be understood by every actor. It is defined a development time for each requirement to be implemented in the InterRail Guide and this time is estimated based on the existing features. The estimated time for each requirement is not presented in this thesis.

3.2.1 List of requirements for the Mobile Application

The requirements defined to the Mobile application are the following:

- *Tab Menu - Access different fragments in the application from the top menu (Req. 1)*
- *Europe Fragment Online Maps - Europe map with the Google Maps API (Req. 2)*
- *Europe Fragment Offline Maps - Europe map with the Open Street Map API (Req. 3)*
- *Europe Map Icon - Icons in the europe map marking the cities with map location (Req. 4)*
- *Cities List view Fragment - List view of the cities of map (Req. 5)*
- *Welcome Activity - Activity that only appears the first time the application opens (Req. 6)*
- *Settings Fragment - Fragment with additional information and activities (Req. 7)*
- *Application Database Update - Button to update the application database (Req. 8)*
- *GPS - Enable or disable the GPS (Req. 9)*
- *Pedometer - Features of the Pedomete (Req. 10)*
- *Map Fragment with Online Maps - City map with the Google Maps API (Req. 11)*
- *Map Fragment with Offline Maps - City map with the Open Street Map API (Req. 12)*
- *Map Detail - Pop up to select the city icons to be presented (Req. 13)*
- *Train Fragments - Three different train fragments that change between them (Req. 14)*
- *Regular Train Fragment - Fragment with the regular trains departing from the selected city map (Req. 15)*
- *Night Train Fragment - Fragment with the night trains departing from the selected city map (Req. 16)*
- *City Information Fragment - Fragment with city and train information from the selected city (Req. 17)*
- *Evaluate Locations in a Star Rating System - Evaluate the cities and points of interest in a star rating system (Req. 18)*
- *Associate an email or social network account to login in the Mobile Platform - Connect the InterRail Guide to an network platform (Req. 19)*
- *Remove an email or social network account to login in the Mobile Platform - Remove the network account (Req. 20)*
- *Routes Planning - Plan a train route troughout Europe (Req. 21)*

3.2.1.1 Tab Menu

Name:	Tab Menu				
Priority:	Must	Actors:	User	Release Version:	0.9 Beta
Description:	The application has a top menu tab to select different fragments ¹ in the application. These fragments will change as the user navigates and open other fragments. The Europe Fragment will always be on the left side of the tab. The central tab features the Cities List view Fragment when a city is not selected and the Map Fragment otherwise. The right tab presents the Settings Fragment when the city is not selected and the Trains Fragments otherwise.				
Pre-Conditions:	Application Initialized				
Event Flow:	The Tab Menu will exist throughout the application.				

Mobile Application Requirement 1 - Tab Menu

3.2.1.2 Europe Fragment Online Maps

Name:	Europe Fragment Online Maps				
Priority:	Must	Actors:	User	Release Version:	0.9 Beta
Description:	The Europe Fragment presents the Europe Map, using the Google Maps API, where the user can select icons of the cities with map in the database. Once the icon is clicked, a pop up appears with information and photographs about the clicked city. If the city has a map, the pop up includes a button that, when clicked, opens the Map Fragment with the map of the selected city.				
Pre-Conditions:	Application Initialized				
	Internet Connection Enabled				
Event Flow:	Select the left tab and the Europe Fragment is showed				

Mobile Application Requirement 2 - Europe Fragment Online Maps

3.2.1.3 Europe Fragment Offline Maps

Name:	Europe Fragment Offline Maps				
Priority:	Won't	Actors:	User	Release Version:	1.0
Description:	The Europe Fragment presents the Europe Map, using the Open Street Map API, where the user can select icons of the cities with map in the database. Once the icon is clicked, a pop up appears with information and photographs about the clicked city. If the city has a map, the pop up includes a button that, when clicked, opens the Map Fragment with the map of the selected city.				
Pre-Conditions:	Application Initialized				
Event Flow:	Select the left tab and the Europe Fragment is showed				

Mobile Application Requirement 3 - Europe Fragment Offline Maps

¹ A Fragment is a portion of user interface in an Activity. Fragments can be combined in a single Activity to build a multi-panel UI [33].

3.2.1.4 Europe Map Icon

Name:	Europe Map Icon				
Priority:	Must	Actors:	User	Release Version:	0.9 Beta
Description:	The Europe map shows three different icon. A yellow icon when the city has a map in the database, a white icon when the map is not available and a pink icon when the user has selected the city.				
Pre-Conditions:	Application Initialized				
Event Flow:	Select the left tab and the Europe Fragment is showed				

Mobile Application Requirement 4 - Europe Map Icon

3.2.1.5 Cities List view Fragment

Name:	Cities List view Fragment				
Priority:	Must	Actors:	User	Release Version:	0.9 Beta
Description:	A list view of the cities with maps appears in the central tab when a city has not been selected.				
Pre-Conditions:	Application Initialized				
Event Flow:	Select the central tab when no city has been selected				

Mobile Application Requirement 5 - Cities List view Fragment

3.2.1.6 Welcome Activity

Name:	Welcome Activity				
Priority:	Should	Actors:	User	Release Version:	0.9 Beta
Description:	The first time the application opens after the installation, a Welcome Activity informs the user with the basic steps of navigation. The user can select the "Next" button to proceed to the application. This activity only appears the first time the application is opened.				
Pre-Conditions:	First time the Application is installed				
Event Flow:	Install the Application				

Mobile Application Requirement 6 - Welcome Activity

3.2.1.7 Settings Fragment

Name:	Settings Fragment				
Priority:	Must	Actors:	User	Release Version:	0.9 Beta
Description:	Settings Fragment presents five buttons. The enable GPS button , the Pedometer button , the Update Application button and the About button. The About Button opens a fragment that features information about the developers.				
Pre-Conditions:	Application Initialized				
Event Flow:	Select the right tab when a city is not selected				

Mobile Application Requirement 7 - Settings Fragment

3.2.1.8 Application Database Update

Name:	Application Database Update				
Priority:	Could	Actors:	User	Release Version:	0.9 Beta
Description:	The user can choose to update the application database. If the application has Internet connection the server will update the database. If the application is not connected to the Internet a pop up will appear informing the user that the update cannot be completed.				
Pre-Conditions:	Application Initialized				
	Internet Connection Enabled				
Event Flow:	Select the right tab when a city is not selected				
	Click on "Update APP" button in the Settings Fragment				

Mobile Application Requirement 8 - Application Database Update

3.2.1.9 GPS

Name:	GPS				
Priority:	Should	Actors:	User	Release Version:	0.9 Beta
Description:	Once the GPS button is clicked the device menu that manages the GPS opens so the user can enable or disable the GPS. If the GPS is enabled a blue icon appears in the Map Fragment on the user current location.				
Pre-Conditions:	Application Initialized				
	GPS enabled				
Event Flow:	Select the right tab when a city is not selected				
	Select the "GPS" button in the Settings Fragment				

Mobile Application Requirement 9 - GPS

3.2.1.10 Pedometer

Name:	Pedometer				
Priority:	Should	Actors:	User	Release Version:	0.9 Beta
Description:	When the Pedometer button is clicked, a new activity ² opens starting the pedometer. It can measure the kilometres covered and the steps taken by the user. This activity has three buttons. A button to pause the pedometer, a button to restart the pedometer and a button to return to the Settings Fragment .				
Pre-Conditions:	Application Initialized				
	Accelerometers sensors on the device				
Event Flow:	Select the right tab when a city is not selected				
	Select the "Pedometer" button in the Settings Fragment				

Mobile Application Requirement 10 – Pedometer

² The Activity Class creates a window that the user can interact with. The Activities are an important part of the application life cycle and the way the platform is launched [33].

3.2.1.11 Map Fragment with Online Maps

Name:	Map Fragment with Online Maps				
Priority:	Must	Actors:	User	Release Version:	0.9 Beta
Description:	The Map Fragment presents the city map with the points of interests on the Google Maps API. The points of interest are divided in nine categories: Train Stations, Sightseeing, Culturama, Night Life, Food, Supermarket, Hostel, Shops and Utilities. Each category has a custom icon addressed to it. Once an icon is selected a Pop Up button opens with the point of interest information and photographs. The Map Fragment has a "Change City" button that leads to the City List view Fragment and a "Map Detail" button .				
Pre-Conditions:	Application Initialized				
	Internet Connection Enabled				
	A city with a map is selected				
Event Flow:	Or, select a City in the City List view Fragment				
	Or, Click on the "Open Map" button, on the Pop Up in the Europe Fragment of a yellow icon.				
	Select the central tab when a city has been selected				

Mobile Application Requirement 11 - Map Fragment with Online Maps

3.2.1.12 Map Fragment with Offline Maps

Name:	Map Fragment with Offline Maps				
Priority:	Must	Actors:	User	Release Version:	0.9 Beta
Description:	The Map Fragment presents the city map with the points of interests on the Open Street Maps API. The points of interest are divided in nine categories: Train Stations, Sightseeing, Culturama, Night Life, Food, Supermarket, Hostel, Shops and Utilities. Each category has a custom icon addressed to it. Once an icon is selected a Pop Up button opens with the point of interest information and photographs. The Map Fragment has a "Change City" button that leads to the City List view Fragment and a "Map Detail" button .				
Pre-Conditions:	Application Initialized				
	A city with a map is selected				
Event Flow:	Select a City in the City List view Fragment				
	Or, Click on the "Open Map" button, on the Pop Up in the Europe Fragment of a yellow icon.				
	Select the central tab when a city has been selected				

Mobile Application Requirement 12 - Map Fragment with Offline Maps

3.2.1.13 Map Detail

Name:	Map Detail				
Priority:	Could	Actors:	User	Release Version:	0.9 Beta
Description:	The "Map Details" button opens a Pop Up with the icons and their respective category. Each category is a checkbox button ³ , where the user can enable or disable the category. After closing the Pop Up, the Map Fragment will only present the selected categories.				
Pre-Conditions:	Application Initialized				
	A city with a map is selected				
Event Flow:	Or, select a City in the City List view Fragment				
	Or, click on the "Open Map" button, on the Pop Up in the Europe Fragment of a yellow icon.				
	Select the central tab when a city has been selected				
	Click the "Map Details" button in the Map Fragment				

Mobile Application Requirement 13 - Map Detail

3.2.1.14 Train Fragments

Name:	Train Fragments				
Priority:	Must	Actors:	User	Release Version:	0.9 Beta
Description:	The Train Information is composed by three fragments: Regular Train Fragment , the Night Train Fragment and the City Information Fragment . These fragments can be browsed between them and appear on the right tab .				
Pre-Conditions:	Application Initialized				
	A city with a map is selected				
Event Flow:	Or, select a City in the City List view Fragment				
	Or, click on the "Open Map" button, on the Pop Up in the Europe Fragment of a yellow icon.				
	Select the right tab when a city has been selected				

Mobile Application Requirement 14 - Train Fragments

³ Checkboxes enable the user to select one or more options from a set [33].

3.2.1.15 Regular Train Fragment

Name:	Regular Train Fragment				
Priority:	Must	Actors:	User	Release Version:	0.9 Beta
Description:	This is the first fragment that appears once the Train Information opens. It presents a list view ⁴ of the day time trains departing from the selecting city. If an item on the list view is selected the City Information Fragment opens. This Fragment has two buttons, the "Change City" button which lead to the City List view Fragment and the "Night Train" button who open the Night Train Fragment .				
Pre-Conditions:	Application Initialized				
	A city with a map is selected				
Event Flow:	Or, select a City in the City List view Fragment				
	Or, click on the "Open Map" button, on the Pop Up in the Europe Fragment of a yellow icon.				
	Select the right tab when a city has been selected				

Mobile Application Requirement 15 - Regular Train Fragment

3.2.1.16 Night Train Fragment

Name:	Night Train Fragment				
Priority:	Must	Actors:	User	Release Version:	0.9 Beta
Description:	The Night Train Fragment presents a list view of the night trains departing from the selecting city. If an item on the list view is selected the City Information Fragment opens. This Fragment has two buttons, the "Change City" button which lead to the City List view Fragment and the "Regular Train" button who open the Regular Train Fragment .				
Pre-Conditions:	Application Initialized				
	A city with a map is selected				
Event Flow:	Or, select a City in the City List view Fragment				
	Or, click on the "Open Map" button, on the Pop Up in the Europe Fragment of a yellow icon.				
	Click on the "Night Train" button on the Regular Train Fragment.				
	Select the right tab when a city has been selected				

Mobile Application Requirement 16 - Night Train Fragment

⁴ List view is a view group that displays a list of scrollable items [33]

3.2.1.17 City Information Fragment

Name:	City Information Fragment				
Priority:	Must	Actors:	User	Release Version:	0.9 Beta
Description:	The City Information Fragment presents the description and photographs of the city selected in the Train Fragments List views. It is intended to give the user a general touristic overview of the city. At the bottom of the fragment, a list view of detailed train information is presented. There is a button that lead to the previous fragment.				
Pre-Conditions:	Application Initialized				
	A city with a map is selected				
Event Flow:	Or, select a City in the List view Fragment, RER				
	Or, click on the "Open Map" button, on the Pop Up in the Europe Fragment of a yellow icon.				
	Click on an item in the List view, either from the Regular Train Fragment or the Night Train Fragment .				
	Select the right tab when a city has been selected				

Mobile Application Requirement 17 - City Information Fragment

3.2.1.18 Evaluate Locations in a Star Rating System

Name:	Evaluate Locations in the Star Rating System				
Priority:	Won't	Actors:	User	Release Version:	1.0
Description:	The user can click on the star rating to evaluate the location on a 5 star basis. The application saves the vote, and once there is Internet connection it sends this information to the server. The server will save the vote, and send back the average vote of the location automatically to the user.				
Pre-Conditions:	Application Initialized				
	Or, a Pop Up opened in the Europe Fragment				
	Or, a Pop Up opened in the Map Fragment				
	Or, the City Information Fragment opened				
Event Flow:	Or, click an icon in the Europe Fragment				
	Or, click an icon in the Map Fragment				
	Or, click on an item in the List view, either from the Regular Train Fragment or the Night Train Fragment .				

Mobile Application Requirement 18 - Evaluate Locations in a Star Rating System

3.2.1.19 Associate an email or social network account to login in the Mobile Application

Name:	Associate an email or social network account to login in the Mobile Platform				
Priority:	Won't	Actors:	User	Release Version:	1.0
Description:	This requirement is intended to enable the user to vote on the locations presented in the app. To ensure that each user can only vote once at each location, it is necessary to associate an account of a social network or an email account (Google). This will also enable to post photos and information directly into the social network.				
Pre-Conditions:	Settings Fragment				
	Application Initialized				
Event Flow:	Select the right tab when a city is not selected				

Mobile Application Requirement 19 - Associate an email or social network account to login in the Mobile Platform

3.2.1.20 Remove an email or social network account used to login in the Mobile Application

Name:	Remove an email or social network account used to login in the Mobile Platform				
Priority:	Won't	Actors:	User	Release Version:	1.0
Description:	If the user wants to remove the social network or e-mail account from the application, it should be possible to do it. ⁵				
Pre-Conditions:	Settings Fragment				
	Application Initialized				
Event Flow:	Select the right tab when a city is not selected				

Mobile Application Requirement 20 - Remove an email or social network account to login in the Mobile Platform

3.2.1.21 Routes Planning

Name:	Europe Fragment				
Priority:	Won't	Actors:	User	Release Version:	1.0
Description:	The user can plan a train route through Europe by choosing the departed and arrival train station, and the number of days of the trip. This will present a main route but the user can choose intermediate cities that the route go through, and the application will present another route passing through the intermediate cities.				
Pre-Conditions:	Routes Fragment				
	Application Initialized				
Event Flow:	Select the left tab				

Mobile Application Requirement 21 - Routes Planning

⁵ If the InterRail Guide does not have an email or social network account associated with, the application functions normally without the account features.

3.2.2 List of requirements for the Web Platform

The Web Platform was developed to support the database used in the InterRail Guide and the requirements defined are the following:

- *Web Platform Login - Only users with an account can access the Web Platform (Req. 1)*
- *Web Platform Home Page - Home Page with buttons leading to different information pages (Req. 2)*
- *Maps with Points of Interest Home Page - Page with the cities with map (Req. 3)*
- *City with Points of Interest Page - Create the points of interest of the cities with map (Req. 4)*
- *Nearby Cities Pages - Information about the cities without map (Req. 5)*
- *Train Information Page - Train Information between the created cities (Req. 6)*

3.2.2.1 Web Platform Login

Name:	Web Platform Login				
Priority:	Must	Actors:	Application Manager	Release Version:	0.9 Beta
Description:	To access the information in the database the Application Manager need to have an account with name and password. The implementation of the Login is due to security concerns of the database. If the Application Manager has a valid account the Web Platform Home Page opens.				
Pre-Conditions:	Web Platform Initialized				
	Internet Connection				
Event Flow:	Browse the Web Platform on the Internet				

Web Platform Requirement 1 - Web Platform Login

3.2.2.2 Web Platform Home Page

Name:	Web Platform Home Page				
Priority:	Must	Actors:	Application Manager	Release Version:	0.9 Beta
Description:	To access the different pages the Home Page of the Web Platform features three buttons. The Maps with Points of Interest button, the Nearby Cities Page button, and the Train Information button.				
Pre-Conditions:	Web Platform Initialized				
	Internet Connection				
Event Flow:	Browse the Web Platform on the Internet				
	The Application Manager needs a valid account				

Web Platform Requirement 2 - Web Platform Home Page

3.2.2.3 Maps with Points of Interest Home Page

Name:	Maps with Points of Interest Home Page				
Priority:	Must	Actors:	Application Manager	Release Version:	0.9 Beta
Description:	This page presents the cities that have maps with points of interest. Each city has four photographs, GPS coordinates, an evaluation and a description, existing an "Edit Button" to edit this information. If the Application Manager clicks on the city name the City with Points of Interest Page opens. This page has a "Create" button to create a new city.				
Pre-Conditions:	Web Platform Initialized				
	Internet Connection				
Event Flow:	Browse the Web Platform on the Internet				
	Select the Maps with points of interest button in the Web Platform Home Page				
	The Application Manager needs a valid account				

Web Platform Requirement 3 - Maps with Points of Interest Home Page

3.2.2.4 City with Points of Interest Page

Name:	City with Points of Interest Page				
Priority:	Must	Actors:	Application Manager	Release Version:	0.9 Beta
Description:	This page features the points of interest existed on the selected city. Each point of interest has a single photograph, a description, the GPS coordinate, an evaluation and a category addressed. An "Edit" button enables the Application Manager to edit the information. Once the point of interest is created, a marker is placed in a Google Map existing in this page to ensure that the GPS coordinates are correct. The user can create a new point of interest by clicking the "Create" button.				
Pre-Conditions:	Web Platform Initialized				
	Internet Connection				
Event Flow:	Browse the Web Platform on the Internet				
	Select the City in the City with Points of Interest Page				
	The Application Manager needs a valid account				

Web Platform Requirement 4 - City with Points of Interest Page

3.2.2.5 Nearby Cities Page

Name:	Nearby City Page				
Priority:	Must	Actors:	Application Manager	Release Version:	0.9 Beta
Description:	This page presents the cities without maps. Each city has four photographs, GPS coordinates, an evaluation and a description. An "Edit" button to edit this information. If the Application Manager clicks on the nearby city name a page identical to the City with Points of Interest Page opens where the Application Manager can create the nearby city main train stations. These stations are required for the train information. This page has a "Create a new city button" button to create a new nearby city.				
Pre-Conditions:	Web Platform Initialized				
	Internet Connection				
Event Flow:	Browse the Web Platform on the Internet				
	Select the Nearby Cities button in the Web Platform Home Page				
	The Application Manager needs a valid account				

Web Platform Requirement 5 - Nearby Cities Pages

3.2.2.6 Train Information Page

Name:	Train Information Page				
Priority:	Must	Actors:	Application Manager	Release Version:	0.9 Beta
Description:	The Train Information Page features the train information between the created cities, either selecting a regular train or a night train. The Application Manager needs to select the departing and arrival city, and their respective train station.				
Pre-Conditions:	Web Platform Initialized				
	Internet Connection				
Event Flow:	Browse the Web Platform on the Internet				
	Select the Train Information button in the Web Platform Home Page				
	The Application Manager needs a valid account				

Web Platform Requirement 6 - Train Information Page

3.3 Use Case Diagrams

Use Case Diagrams are utilized to explain the features of the product. For the InterRail Guide solution two diagrams were created.

3.4.1 Use Case Diagram for the Mobile Application

The first diagram represented is the use case diagram for the mobile application and presents the interactions between the user and the different use cases in which it is involved when using the mobile application. In this diagram only the final user will interact with the application.

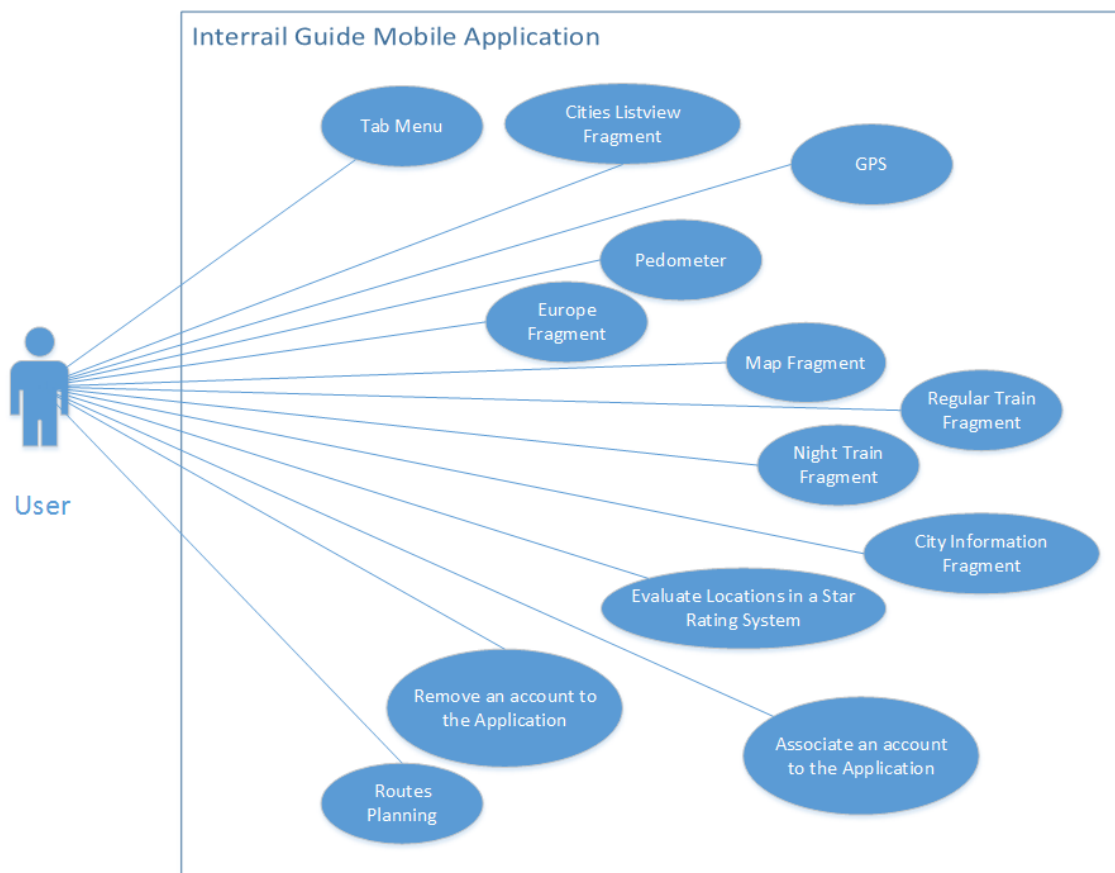


Figure 24 - Use Case Diagram for the Mobile Application

3.4.2 Use Case Diagram for the Web Platform

The second use case diagram presented is designed for the Web Platform. In this use case diagram only the application managers will interact with the Web Platform to add, delete, or edit the database information.

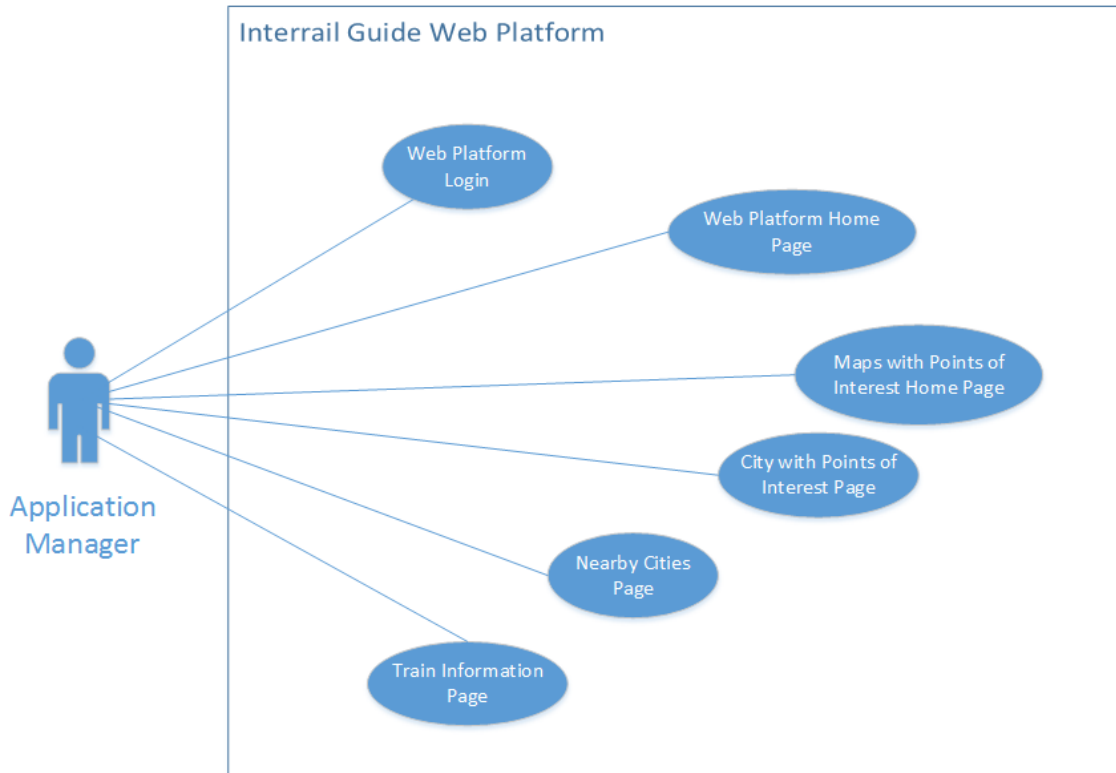


Figure 25 - Use Case Diagram for the Web platform

3.5 Non-Functional Requirements

The non-functional requirements are identified and categorized according to these categories:

- Usability – Determine the aesthetics interface from the users point of view
- Confidence – availability of the applications and the capacity to recover from failures
- Performance – Response time from interfaces
- Support – Determines characteristics as compatibility, test capacity, configuration, durability and others.

The Confidence and Performance categories were not analysed in the non-functional requirements because it was not possible to evaluate the capacity to recover from failures and a response time from interfaces. These requirements depended deeply on the device tested. Although early devices had longer response periods and lower capacity to recover from failures than the latter Android versions, this should be done as future work

3.5.1 Compatibility (Support category)

Name:	Compatibility				
Priority:	Must	Type	Support	Release Version:	0.9 Beta
Description:	The InterRail Guide must be compatible with Android 3.2, with an API 13: (Honeycomb), and with versions that are more recent. This ensures a compatibility with 87.9% of all Android users' devices [33].				

3.5.2 User Friendly (Usability group)

Name:	User Friendly				
Priority:	Must	Type	Usability	Release Version:	0.9 Beta
Description:	<p>Application content (mobile and web) should be available to the user in a practical and intuitive form. Therefore, the user must be able, without any aid, to fully function with the application. The user must realize instantly that the InterRail Guide has three main fragment. The user must realize that the Europe Fragment has interactive icons that will lead to the maps and through the Cities List view Fragment the user can also achieve that. Once the city is selected the Map Fragment will be open in the central tab and the Train Fragments with train information from the selected city will be open in the right tab replacing the Settings Fragment. The left tab will maintain the Europe Fragment throughout the navigation. Lastly, the user needs to understand that he can enable or disable the GPS and the Pedometer in the Settings Fragment. The InterRail Guide must be very intuitive, and once the user understand how the application works, the user must reach the desired page in a matter of 5 seconds. To test this requirement the test group should be able to reach the pages in the 5 second window.</p>				

3.5.3 Maintenance (Support group)

Name:	Maintenance				
Priority:	Must	Type	Support	Release Version:	0.9 Beta
Description:	The source code, the system configurations and the development configuration must be documented for further improvement of the work.				

3.6 Technical Restrictions

The technical restrictions of the project are parameters which restrict the development of the various platforms.

The Mobile application **must be** developed to the Android platform, and the smartphones should have the following characteristics:

- **Should** have GPS to present the user its current location;
- **Should** have Accelerometer sensor, to enable the measurement the distance covered;
- **Should** enable the option to restrict the database update in environments where the WI-FI connection is not possible;

4 Architecture

In this chapter it is presented the InterRail Guide architecture resulting from the developed work. In the first section it will be analysed the InterRail Guide solution through the user perspective. In the second section it is presented the high level view of the architecture. On the last section it is presented the InterRail Guide data model.

4.1 Product View

4.1.1 Mobile Application



Figure 26 - InterRail Guide Icon

Installation:

Once the InterRail Guide is installed a splash screen opens with the InterRail Guide logo on the screen. This action lasts about 3 seconds and occurs every time the application is initialized.

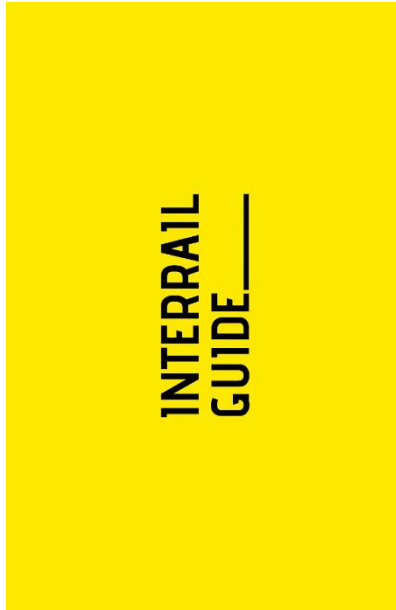


Figure 27 - Splash Screen

The first time that the application is initialized it is performed the data transfer from the database and a pop up appears informing the user that the download is occurring. Once the download is finished a Welcome Activity will be shown informing the user about the overall design and usability. Once the “Next” button is clicked the user enters the application. This action only occurs the first time the application is started after installation; the next time the application is initialized it will go straight to the application (Figure 32).

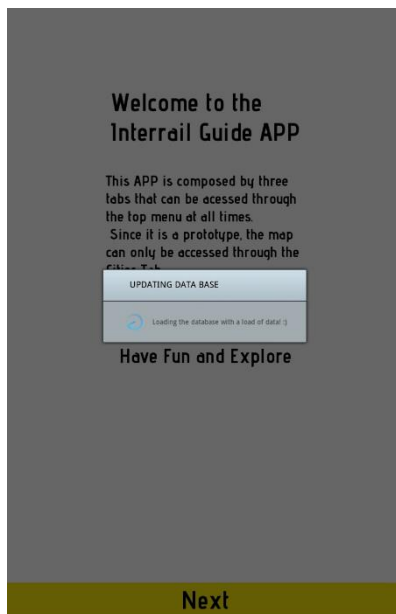


Figure 28 - Downloading the data in the Welcome activity

The InterRail Guide has five main fragments: the Europe Fragment (Figure 29), the Cities List view Fragment (Figure 32), the Settings Fragment (Figure 31), the Map Fragment (Figure 33) and the Train Fragments (Figure 34). The application is developed with different fragments accessed through the top tab menu.

Europe Fragment:

The Europe Fragment contains the Europe map. In the beta version, the Europe map is presented using the Google Maps API. However, in a future version, the purpose is to design a personalized Europe map to improve the user experience.

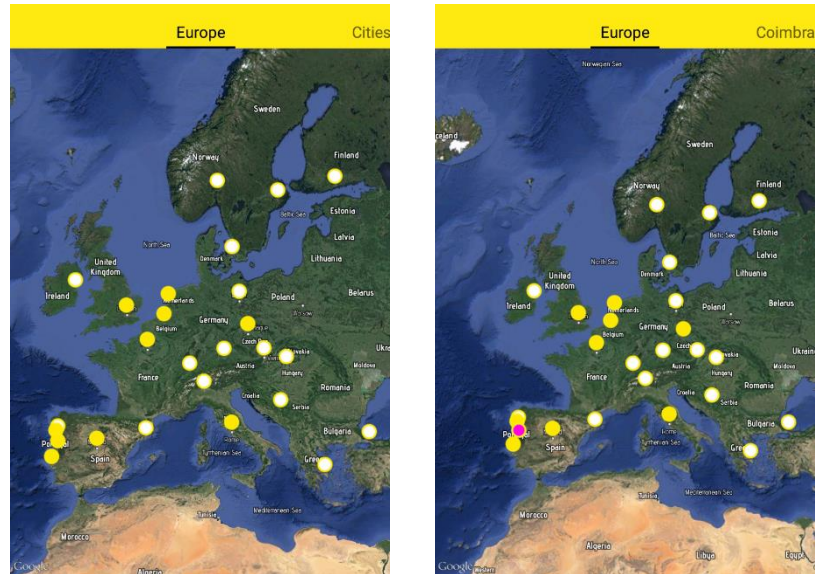


Figure 29 - Europe Fragment. On the Right Coimbra is selected

Cities with maps can be accessed from the Europe map by clicking on the icon on top of the geographical location of the city. There are three different colours for the icons in the Europe map: a yellow icon that represents a city with map and train information, a white icon for cities maps in development and a pink icon if a city is selected. When a city icon is clicked a pop up appears presenting a city description, an evaluation and photographs (Figure 30). If it is a yellow icon the pop up includes an “Open Map” button to open the respective map. The Europe Map is the only fragment that is always accessible in the left side of the tab menu, so the user can easily select a new city to explore.

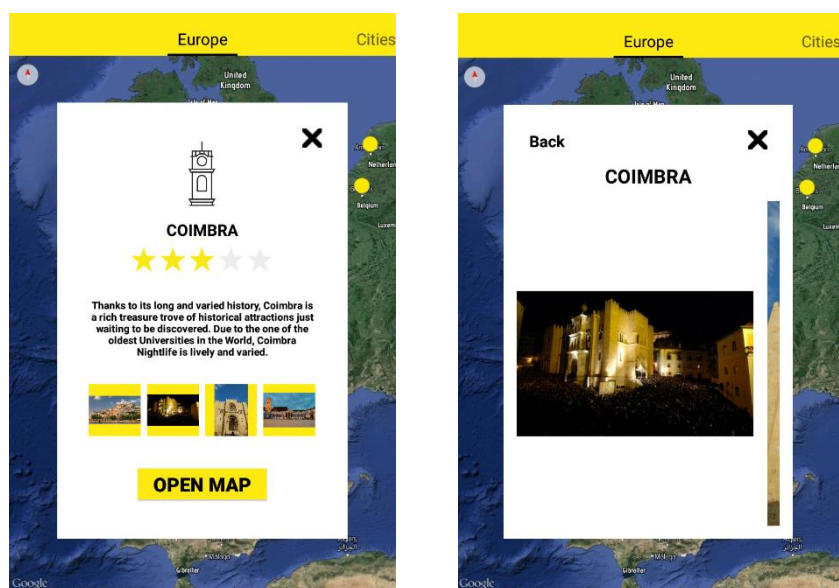


Figure 30 - Pop up Window in the Europe Fragment

The Europe fragment will offer, in a future upgrade, the possibility to trace train itineraries throughout Europe. The user selects the button “Define My Route”, and a popup window appears where the user can introduce the departure city, the arrival city and the duration of the trip. Depending on the duration, the application will trace different itineraries, and the itineraries will pass by different cities and advise the traveller to stay different numbers of days in each city. The user will also have an optional button to include other cities in the itinerary.

The Settings Fragment:

The fragment on the right is the Settings, where the user can enable the GPS and the Pedometer; update the information database and check information about the InterRail Guide. The GPS and the Pedometer are features that can help the user visiting a city, especially if the city has an InterRail Guide map because the user can always know their exact location. The Pedometer calculates the average distance travelled daily, how many steps have been taken on a single day and the distance travelled. The Pedometer only takes into account the steps given while the pedometer is enabled.

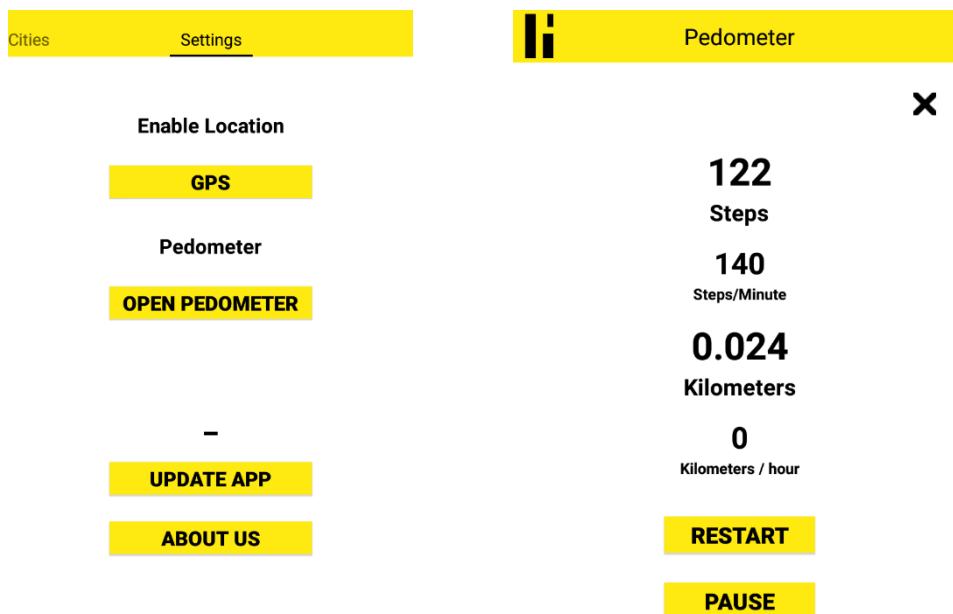


Figure 31 - On the Left is the Settings Fragment and on the Right the Pedometer

The Cities List view Fragment:

The central fragment is the Cities List view Fragment and it is the first fragment presented once the application is opened. This fragment presents a list view of the cities with maps, so the user can easily select the city. The List view enables to scroll the list to present more information. The cities presented are the same cities that have a yellow icon in the Europe Fragment. The cities with a white icon are not presented.

When the user selects a city, either in the Europe Fragment (Figure 29) or in the Cities List view Fragment (Figure 32), the fragments shown changes. Replacing the Cities List view Fragment in the central tab appears the Map Fragment (Figure 33) with the map of the selected city using the Google Maps API and the Train Fragments (Figure 34) replacing the Settings Fragment (Figure 31) on the right tab. The Europe fragment, like stated before, is kept on the left fragment throughout the application.

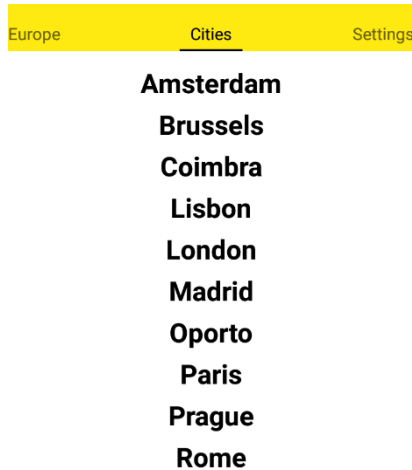


Figure 32 - Cities List view Fragment

The Map Fragment:

The map fragment presents the map with points of interest chosen by administrators rather than the community, so the map displays the unique places that the city has to offer directed for low budget travellers – The points of interest are divided in 9 groups: *Train Station, Sightseeing, Culturama, Night Life, Food, Supermarkets, Hostels, Shops and Utilities*. Each icon is personalized with a different image so the user can easily associate each location to a group. When the user clicks the “Map Details” button a pop-up appears enabling the user to select the icons to appear in the map.

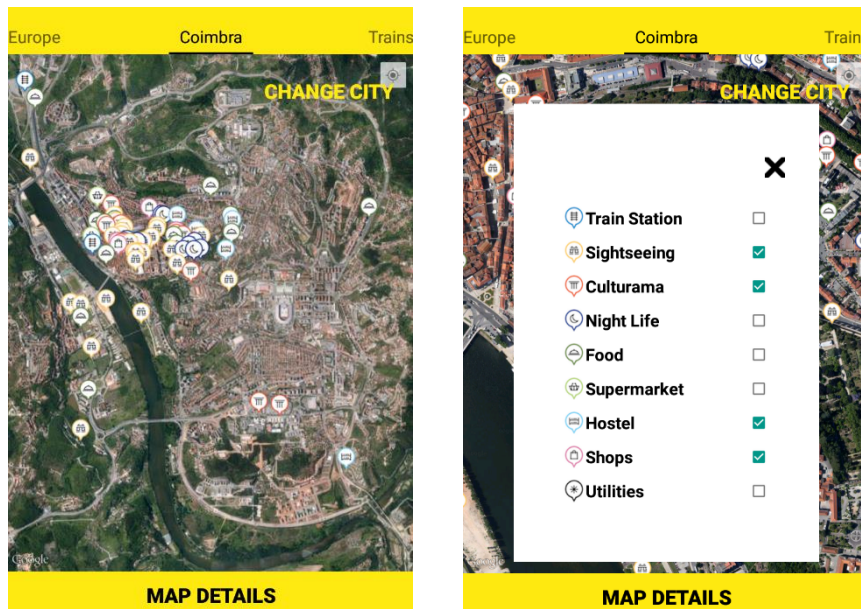


Figure 33 - Map Fragment and the Map Details Pop Up

The Train Fragment:

The Train Fragment is shown on the right tab containing information about the nearby sightseeing villages and cities accessible by train from the selected city (Figure 33). A location is considered nearby when it takes less than 4 hours to reach it. By default, the information for Regular Trains is shown, namely the trains running during day time. However, there is a button at the bottom of the fragment that allows the user to access the information about night trains departing from the selected city (Figure 33). In both the Regular Trains and Night Trains fragments, the information is presented in a list view with the name of the city and the journey time (Figure 34).

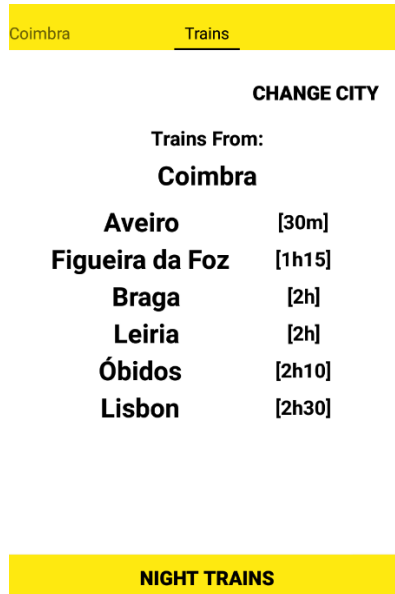


Figure 34 - Regular Train Fragment

Once a destination city is selected, it is presented the detailed train information and the city description, evaluation and photographs. If the city has a map, the map can be accessed from this fragment.

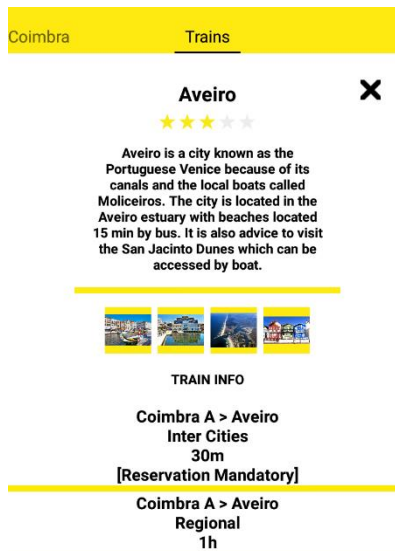


Figure 35 - City Information Fragment

4.1.2 Web Applications

The Web Application was developed to build and maintain the database, it is possible to insert or edit information about the points of interest, the cities with map or nearby cities, and the train information. Information should be added or updated periodically to provide the best up-to-date service possible.

The Web Application is constructed using three languages: PHP, HTML and CSS. HTML defines the layout of the Web Application, CSS the styles used in HTML and PHP processes the information and communicate with the Database, which is stored in MySQL.

The Web Application is constructed with six PHP type files.

Login Page:

The *inter.php* file states the first page (Figure 36). It is required a login and password to access the Web Application to guarantee that only administrators with authenticated credentials can access and manage the data.

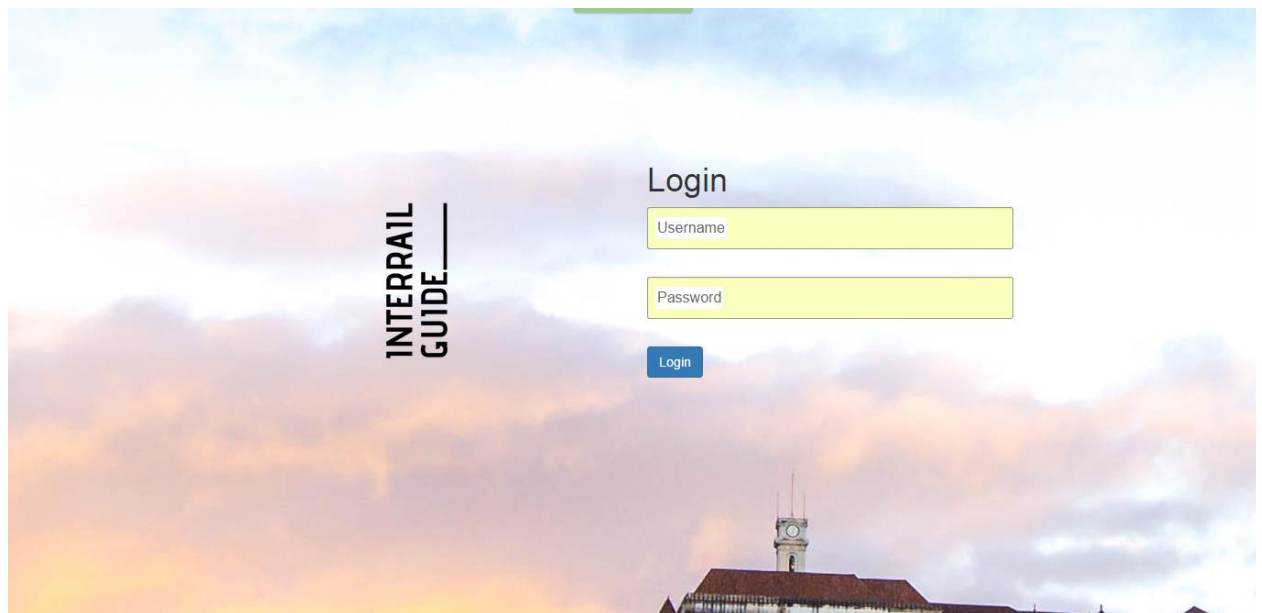


Figure 36 - Login page in the Web Application

Home Page:

An authenticated administrator sees the Web Application Home Page (Figure 37). The available links redirect the user to the management pages.

The first link sends the user to the *Cities with points of interest Page* (Figure 38), the second link refers the user to *Nearby Cities & Cities Without Map Page* (Figure 45) and the third link forwards the user to *Train Information Page* (Figure 42).

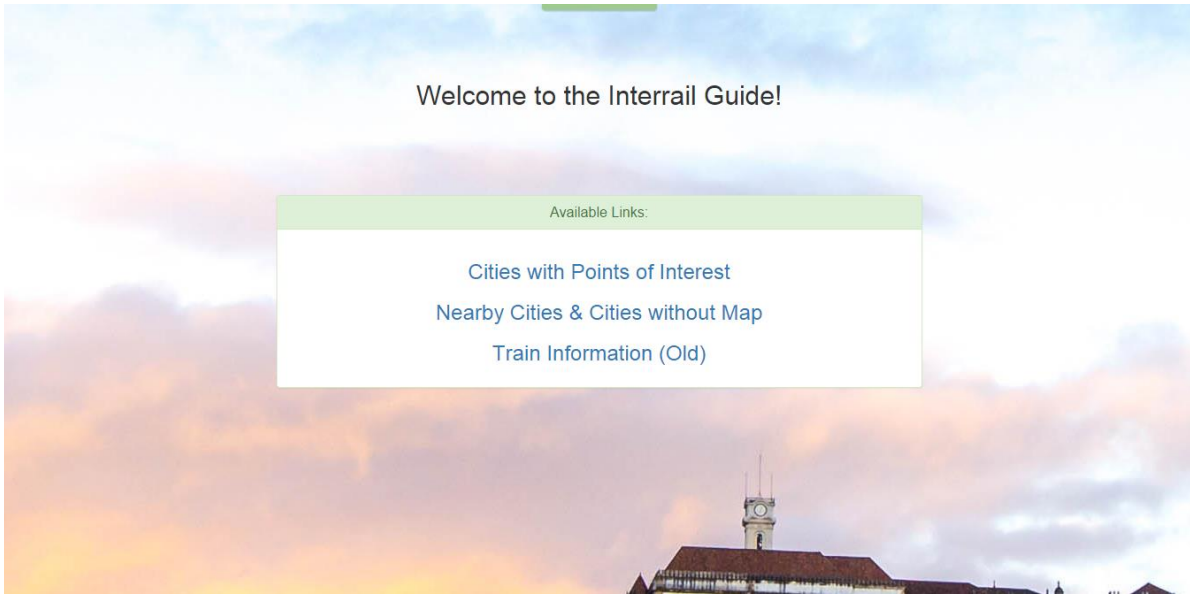


Figure 37 - Web Application Home Page

Cities with points of interest Page:

By clicking the “Add a new City” button (on the top of the screen) that redirects the operator to the page shown in Figure 39. The administrator is able to create the new city and later complement it by adding points of interest.

Trough clicking the pencil button in the upper right corner of each city square the administrator is able to edit the information about the cities (Figure 40). By clicking in the City name the page forwards the user to the page that manages this city points of interest (Figure 41).

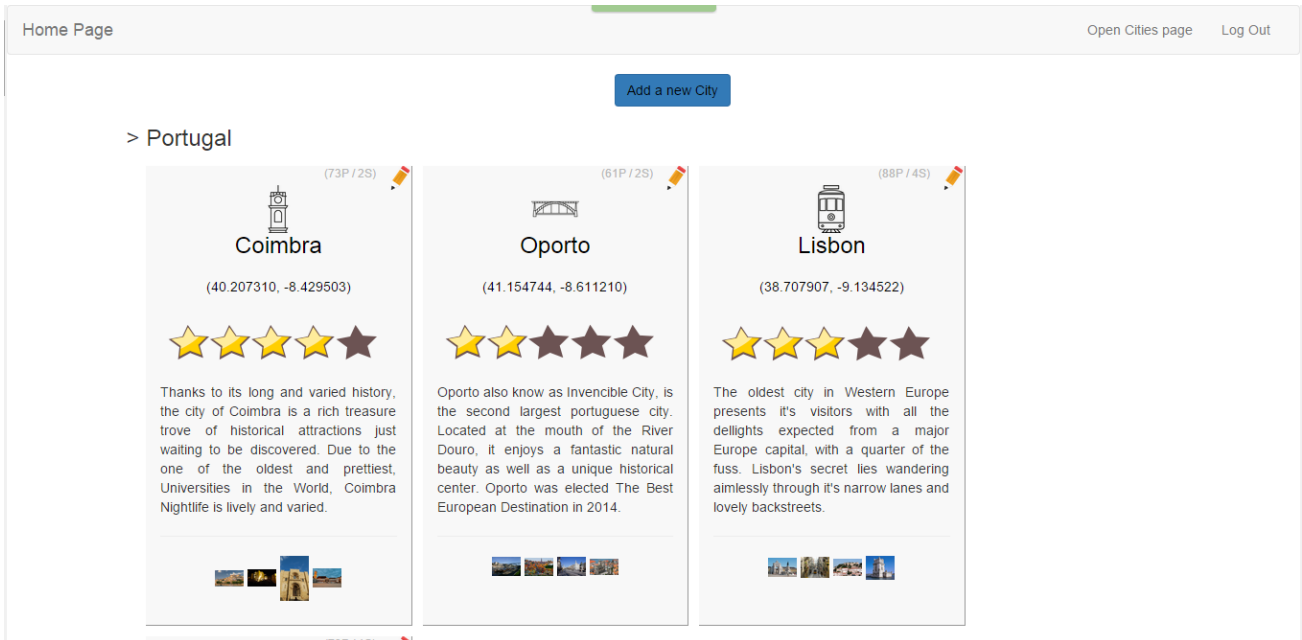


Figure 38 - Cities with Points of Interest Home Page in the Web Application

Create a new City

City Name :	<input type="text"/>
City Country:	Portugal ▼
City Description :	<div style="border: 1px solid gray; height: 40px;"></div>
City Latitude :	<input type="text"/>
City Longitude :	<input type="text"/>
Map Zoom :	<input type="text"/>
City Image_1 :	<input type="text"/>
City Image_2 :	<input type="text"/>
City Image_3 :	<input type="text"/>
City Image_4 :	<input type="text"/>

Figure 39 - Create a new the city in the Web Application

It is worth noticing that the upper bar remains constant during navigation. The “Home page” button, as the name suggests, readdresses the user to the Home Page (Figure 37). The “Open Cities page” redirects to the Cities with Points of Interest Page (Figure 38). Finally, the “Log Out” button closes the Web Application and opens the page depicted in Figure 36.

Edit Coimbra City

City Description:	<div style="border: 1px solid gray; padding: 5px;">Thanks to its long and varied history, Coimbra is a rich treasure trove of historical attractions just waiting to be discovered. Due to the one of the oldest Universities in the World, Coimbra Nightlife is lively and varied.</div>
Map Option:	YES ▼
City Latitude:	40.203176
City Longitude:	-8.416962
Map Zoom:	14
City Star Rating:	3
City Image_1:	https://images.booking-channel.com/synergy/HTL00108/images
City Image_2:	http://www.serenatahostel.com/img/coimbra/tosee/Se%20Velha
City Image_3:	http://upload.wikimedia.org/wikipedia/commons/f/f2/S%C3%A9
City Image_4:	http://visit.uc.pt/files/ficha/1357926788_13.jpg

Figure 40 - Edit a City in the Web Application

Cities with map Information Page:

In the *Cities with map Info Page* the administrator can manage the points of interest of a determined city by placing markers on each point of interest geographical location. This Page uses the Google Maps API to ensure that each icon is placed correctly. The page have three buttons: the “Add a new Train” button opens the train information page (Figure 42), the “Add a Point of Interest” button creates a new point of interest (Figure 43) and each name of the point of interest is a button that opens a page to edit the information about the clicked point of interest (Figure 44).



Figure 41 - Cities with Map in the Web Application

Train Information Page departing from a selected city:

The Train Information page displays information of the trains departing from the selected city in Figure 38. The last row (Figure 42) offers the possibility of adding new trains to the list. Cities can have more than one Train Station, so the administrator has to select the departed and arrival station.

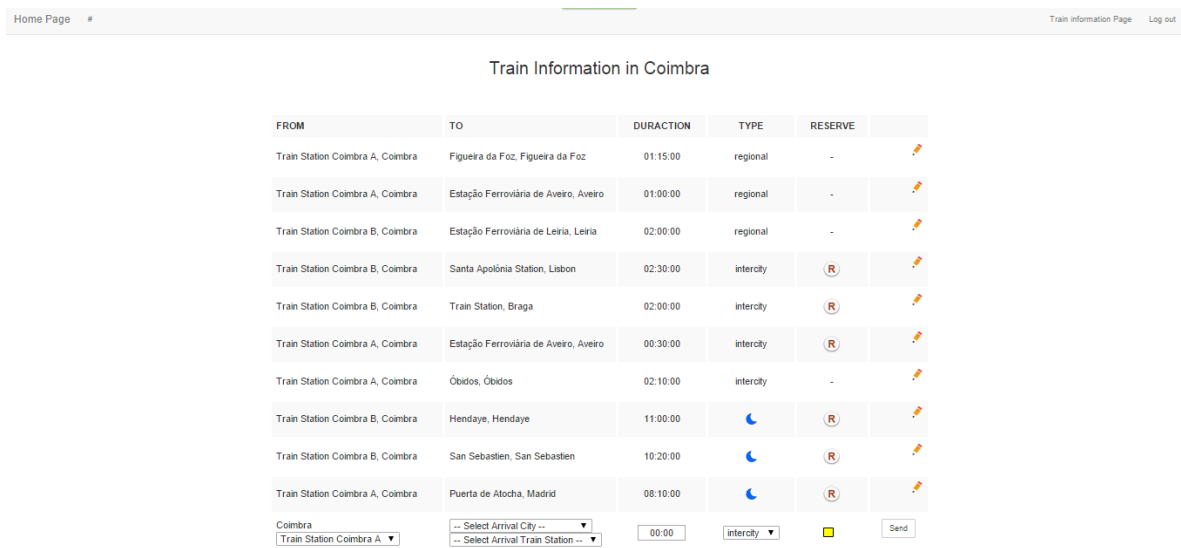



Figure 42 - Train Information about the selected city in the Web Application

Point of Interest Page:

The New Point of Interest Page (Figure 43) and the Edit a Point of Interest Page (Figure 44) are identical. The administrator can write the point of interest name, description, the Image URL link, GPS coordinates and the Point of Interest Type. Just like the City with Map Page, this pages use the Google Maps API so the user can attest the location of the point of interest.

Home Page Open Cities page Log Out

New Point of Interest

Point of Interest Name :	<input type="text"/>
Point of Interest Description :	<input type="text"/>
Point of Interest Image :	<input type="text"/>
Point of Interest Latitude :	<input type="text"/>
Point of Interest Longitude :	<input type="text"/>
Set Location (Drag Marker)	
Point of Interest Type :	Train stations ▼


[Enviar](#)

Figure 43 - Add a new Point of Interest in the Web Application

Home Page Open Cities page Log Out

Edit Point of Interest

[Eliminar Point of interest !](#)

Point of Interest Name :	University of Coimbra
Point of Interest City :	Coimbra ▼
Point of Interest Description :	The history of the University of Coimbra dates back to the century subsequent to the very foundation of the Portuguese nation, since the University was established in the 13th century, in 1290. It is one of the oldest universities in continuous operation in the world and the oldest university of Portugal. It is organized into eight different faculties according to a wide range of fields
Point of Interest Image :	http://www.uc.pt/bric/slideshow/UC_patrimonio_mundial
Point of Interest Latitude :	40.207850
Point of Interest Longitude :	-8.429669
Set Location (Drag Marker)	
Point of Interest Type :	Sightseeing ▼

[Atualiza](#)

Figure 44 - Edit the Information about a Point of Interest in the Web Application

Nearby Cities Page:

The Nearby Cities Page (Figure 45) is opened from the Home Page (Figure 37) and is similar to the Cities with Points of Interest Page (Figure 38), but each city only have train stations points of interest to enable the creation of departing and arrival stations. Once a city in the Nearby City Page is selected, the page equal to the Cities with Points of Interest Page (Figure 37) with the same buttons.

Add a new Nearby City

> NearbyCities

> Portugal

(0P / 1S)

Figueira da Foz

(40.155803, -8.836833)

Figueira da Foz is a coastal city extremely popular in summer thanks to its beach, the widest in Europe, and the summer parties located in Bairro Novo. This City also has one of the most popular Casinos in Portugal. If times allows, visit the Mondego Cape situated north of the city.

(0P / 1S)

Óbidos

(39.364890, -9.159509)

Once the wedding present of a queen, the preserved medieval town of Óbidos lying 100 km north of Lisbon is without doubt one of Portugal's most classic walled settlements. Walking the ramparts, visitors can enjoy views of windmills, vineyards and surrounding farmlands.

(0P / 1S)

Leiria

(39.749521, -8.807707)

Leiria is city that is perhaps best used as a jumping off point to other nearby attractions such as Alcobaca, Batalha, Fátima, and the nearby beaches. However Leiria is also worth a visit since it has an imposing castle and a beautiful city center.

Figure 45 - Nearby City in the Web Application

Train Information Page:

Train information opened through the Home Page (Figure 37) is equal to the shown in the Figure 42, but instead of presenting only the train information departing from the selected city, it presents the train information from all cities. If the user selects the pencil at the right of each train information row he can edit the information (Figure 46).

Edit Train Information

Delete

FROM	TO	DURATION	TYPE	RESERVE
Coimbra <small>Train Station Coimbra A</small>	Figueira da Foz <small>Figueira da Foz</small>	01:15:00	regional	<input type="checkbox"/>

Train Information List

FROM	TO	DURATION	TYPE	RESERVE
Train Station Coimbra A, Coimbra	Figueira da Foz, Figueira da Foz	01:15:00	regional	-

Figure 46 - Edit Train Information in the Web Application

4.2 High Level View

The InterRail Guide architecture is similar to the approach followed by many mobile-based solutions, where a mobile application on the user smartphone interacts with a backend server and a database in order to provide its features. The user interacts with the InterRail Guide solution through the Android platform. There is also a frontend component accessed through the Web to add information to the database, only available for administrators (such as people working on a new map, adding information about the city and its locations, as well as train information).

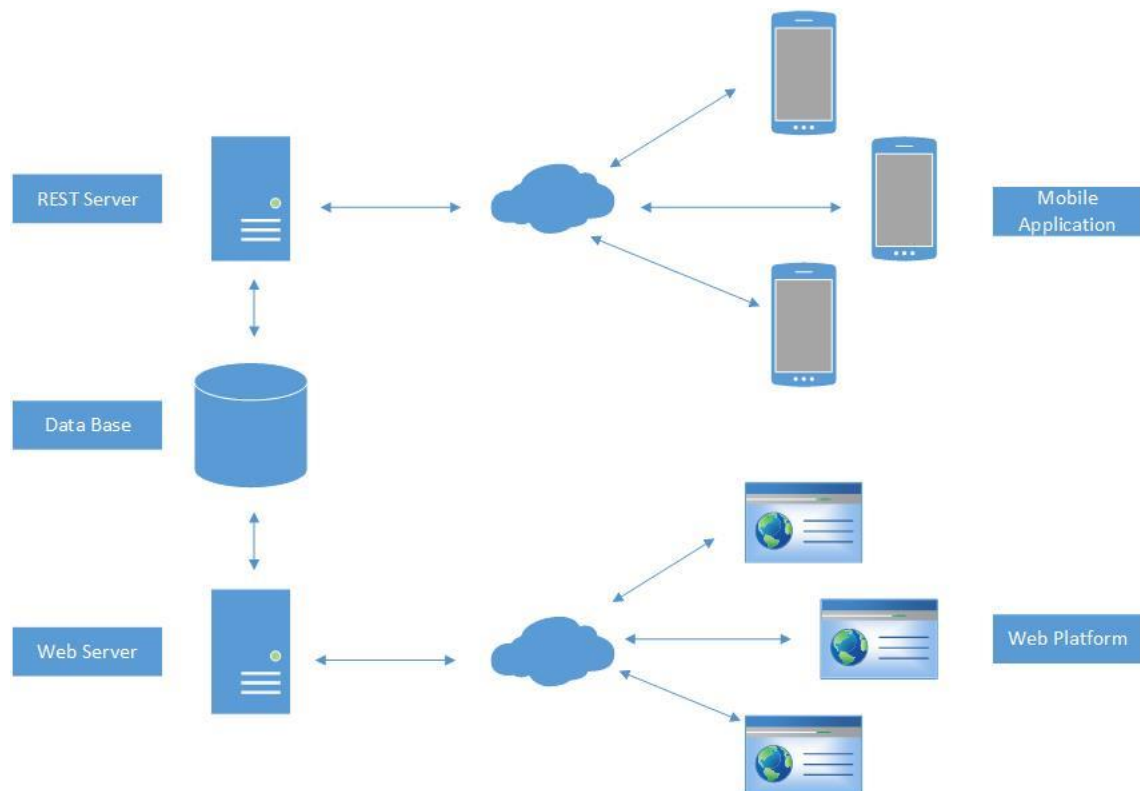


Figure 47 - High Level Architecture

In the Figure 47 it is possible to identify the high level view of the InterRail Guide architecture, where exists a direct connection from the web server to the database since it has the following advantages:

- Simplifies the development of new modules in the Web Platform.
- It enables the REST server to receive only the request from the smartphone, simplifying the process.

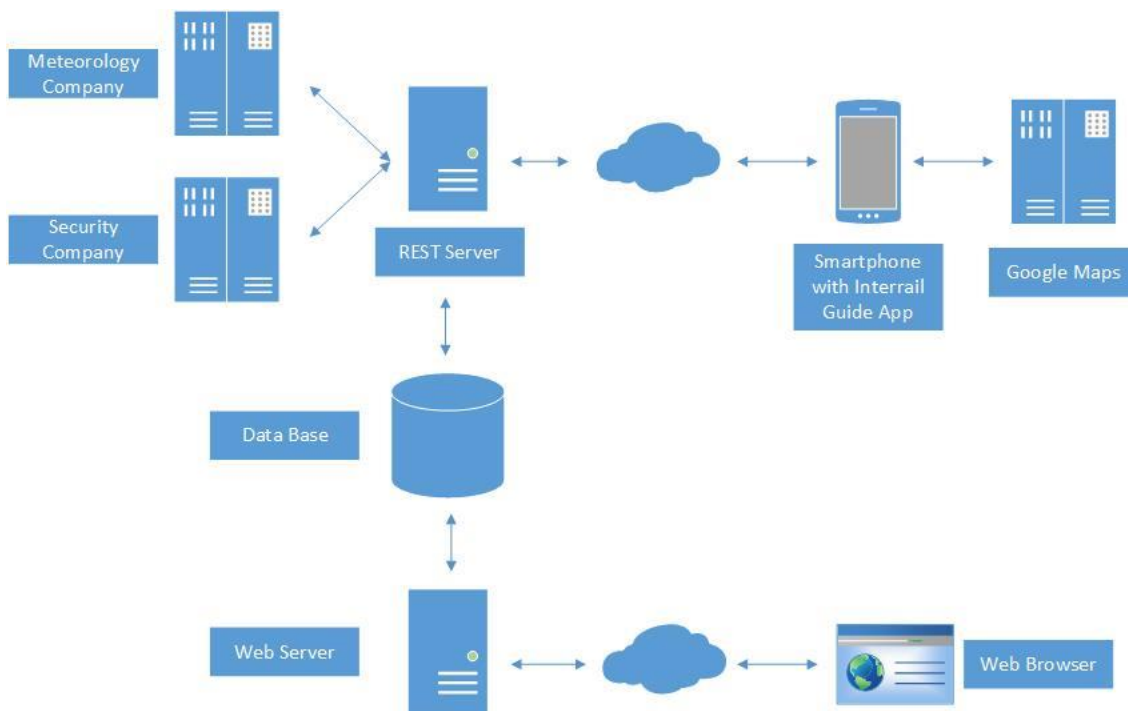


Figure 48 - High Level Architecture with external services

In Figure 48 it is illustrated the high level architecture with possible external services, which are the following:

- A meteorology company supplying information providing the opportunity to trace itineraries in good weather, so the traveller can escape rain and cold regions.
- A security company to ensure that the database used in the InterRail Guide cannot be accessed by others.
- The Google Map API presents the user with online maps.
- The Open Street Maps API presents the user with offline maps.

4.3 Mobile Application

The architecture of the mobile application contains a user interface process and a service. The process is responsible with displaying the interface to the user, but it also as to answer to user actions. The service is a component that processes the background information.

In the cases where points of interest are displayed to the user the interface is constructed using the Google Maps API.

The service, through the GPS and the Pedometer, can determine the position and user movement through sensors and send that information to the REST server. This server is also used to receive information about the cities and points of interest and has the following features:

- It can collect information from the GPS system, from the accelerometer sensor, and from external Web service about meteorology conditions.

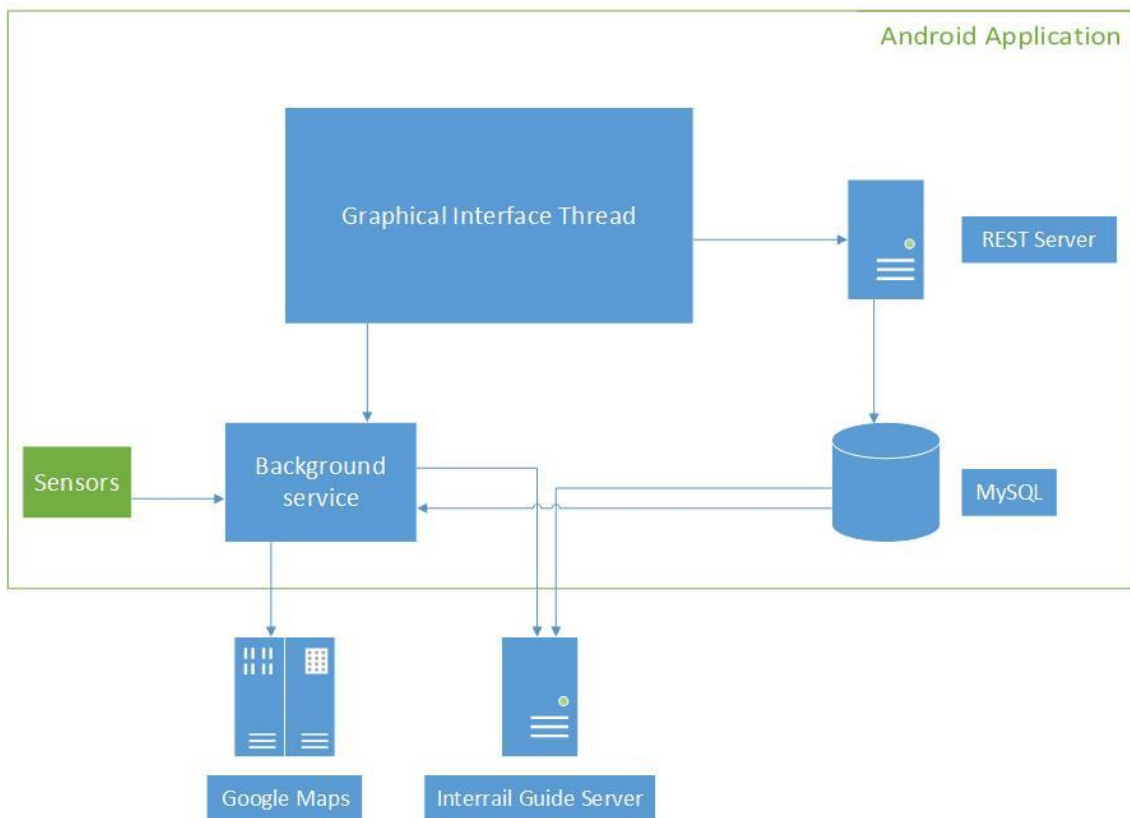


Figure 49 - Mobile Application Architecture

4.4 Web application

The Web application enables an administrator for maintaining the city database. The actions that the administrator can execute are:

- Introduce the city overall information and the respective photographs;
- Introduce information and locations about points of interest;
- Introduce train information around Europe;
- Edit the information previously indicated;

Nowadays, the APIs of the external services suffer constant actualizations because they are open source. So, the InterRail Guide must incorporate there actualizations services in future updates

The Web application was developed according to the MVC model, and when a request is received, the framework interprets the URL to decide which Controller is responsible for processing the request. This method communicates with the database through an abstraction called model.

This model also contains methods which processes the information from the database and validate the data introduced by the administrators.

After obtaining the information from the database, the Controller sends the information to the corresponding interface.

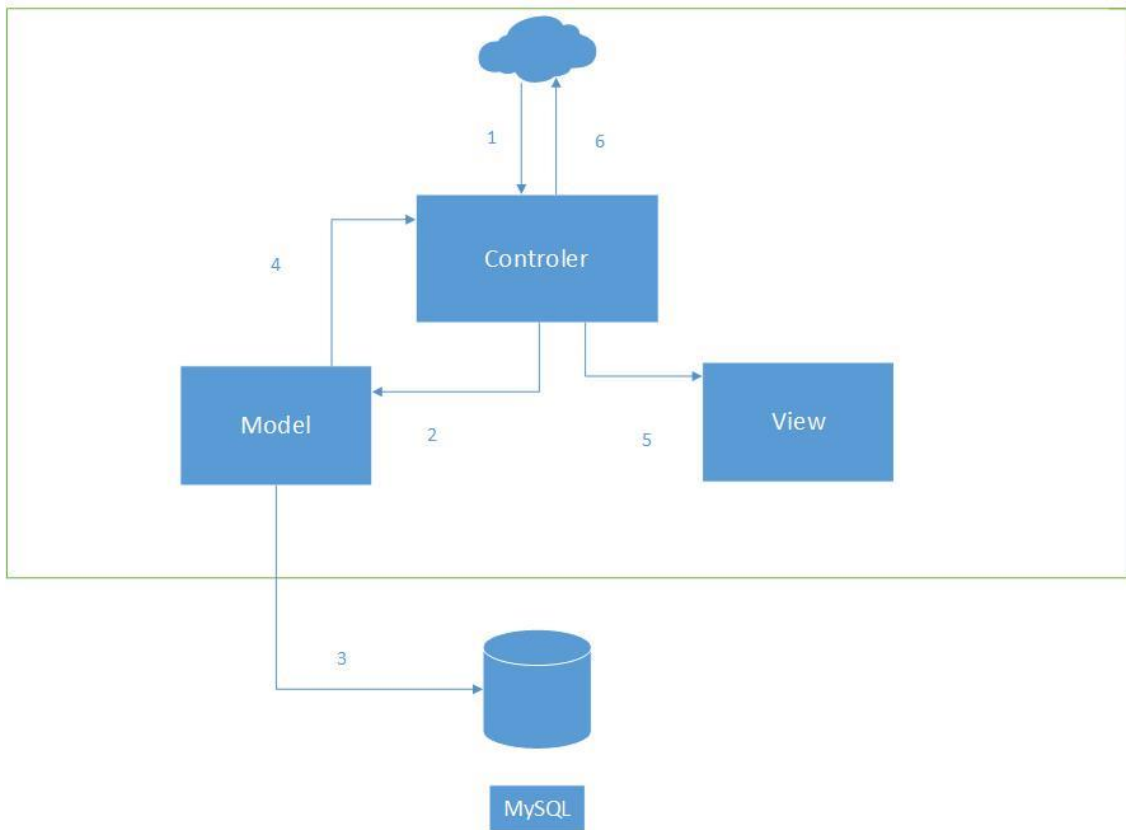


Figure 50 - Web Application Architecture, according to the MVC model

4.5 REST Server

The REST server is the Backend of the InterRail Guide Application, used to provide access to the database. The REST Server has three different components:

- Data access layer is the server component which utilizes Data Access Objects (DAO) to abstract the connection of each table. In this layer, there will also be used classes generated from Hibernate which enable the abstraction the instances of each table.
- Web services layer interacts with the mobile application. The information submitted from the mobile application reaches the service and is converted into a Request Data Object. Depending in the request, data is acquired through the DAO layer. The Implementation layer elaborates an answer, which is then converted into Response Data Object and is sent to the mobile application. It is in this layer that the points of interest are going to be updated.
- The Pooler is the service responsible for processing the evaluation data for each city and the points of interest, and is executed daily. This component interacts only with the DAO objects and the corresponding tables which contains the manipulated information by the DAO.

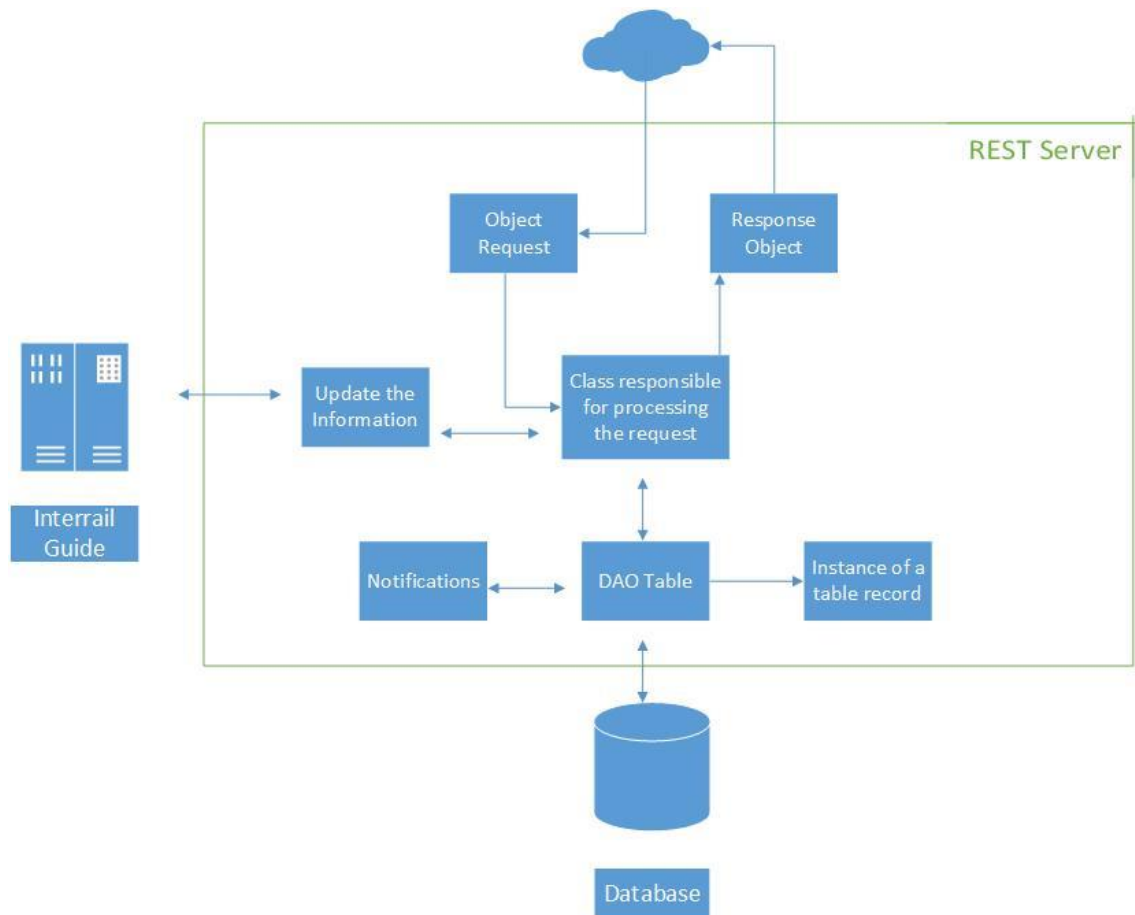


Figure 51 - REST Server Architecture

4.6 Data Model

In the Figure 52 the first class presents the country of each city existed in the database. This class is not presented in the InterRail Guide because there is only 10 cities with maps and each city have a country addressed to it.

This Country class has the following fields:

- The *id* of the Country;
- The name of the Country;

The City Class that will diverge in 3 other classes, the CityPoints Class, the Trains Class and the Nearby Cities Class- This class has the ensuing fields:

- The city *id*;
- The city name;
- The city description;
- The city number of users votes;
- The city average rating of the user's votes;
- The city latitude;
- The city longitude;

- The city Map Zoom
- The city Images link;

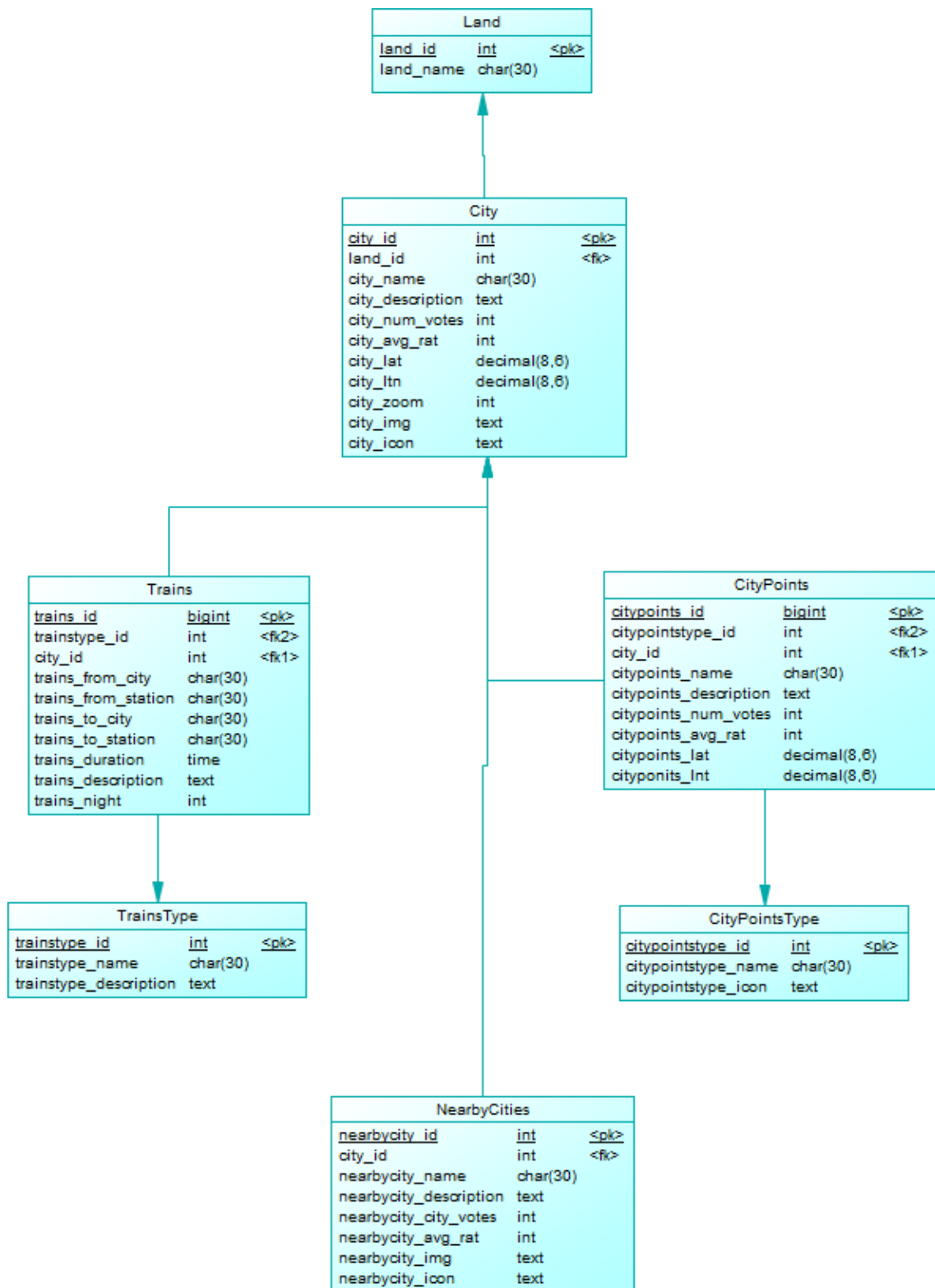


Figure 52 - Entity Relationship for the Mobile Application

The first class diverged from the City Class is the CityPoints Class. In this Class it is presented the associated fields to the points of interest existing in a map such as:

- The citypoints id;
- The citypointstype foreign key;
- The city foreign id;
- The citypoints name;
- The citypoints description;
- The citypoints number of users votes;
- The citypoints average rating of the user's votes;
- The citypoints of interest latitude;
- The citypoints of interest longitude;

Since each point of interest belongs to a type, the CityPointsType Class presents the information of each type of point of interest:

- The CityPointsType ID;
- The CityPointsType name;
- The CityPointsType description;

City Class also diverge to the Trains Class that presents the train information between the created cities and train stations. The fields are the following:

- The Trains ID;
- The TrainsType foreign key;
- The City foreign key;
- The Trains departed city;
- The Trains arrival city;
- The Trains departed station;
- The Trains arrival station;
- The Trains duration;
- The Train description;
- The Train night type;

The TrainsType Class, diverged from the Train Class because each train has a train type. This class has the ensuing fields:

- The TrainsType ID;
- The TrainsType name;
- The TrainsType description;

The last class diverged from the City Class is the NearbyCities Class that has the information about the Europe cities and villages without map. It has the following fields:

- The NearbyCity ID;
- The City foreign key;
- The NearbyCity name;
- The NearbyCity description;

- The NearbyCity number of users votes;
- The NearbyCity average rating of the votes;
- The NearbyCity images link;

5 Tests

In this chapter are presented the results of different tests made to the InterRail Guide. These tests are aimed to perceive the bugs, both from the developer perspective and from the user perspective.

Mobile Application cannot be fully tested because testing it is a never-ending process but every round of tests minimizes the number of bugs and improves the overall application. Four types of tests were performed. They are presented in this chapter.

5.1 Unit Tests

Unit Tests were performed by the developers in each individual unit of code. Each code must be tested isolated from the overall program and should be perform correctly in terms of their requirements.

Description	Result
Tab Menu	Pass
Europe Fragment Online Maps	Pass
Europe Fragment Offline Maps	Pass
Europe Maps Icon	Pass
Cities List view Fragment	Pass
Welcome Activity	Pass
Settings Fragment	Pass
Application Database Update	Pass
GPS	Pass
Pedometer	Not Passed
Map Fragment with Online Maps	Pass
Map Fragment with Offline Maps	Pass
Map Detail	Pass
Train Fragments	Pass
Regular Train Fragment	Pass
Night Train Fragment	Pass
City Information Fragment	Pass
Evaluate Locations in a Star Rating System	Not Passed
Associate an email or social network account to login in the Mobile Application	Not Passed
Remove an email or social network account to login in the Mobile Application	Not Passed
Routes Planning	Not Passed

Table 3 - Unit Testing

The Evaluation Location based in a Star Rating System and the Routes Planning Requirements did not pass the Unit testing. It is intended that the user could vote on the cities and on the points of interest using a Star Rating System but it was not possible that each user could only make one vote per location. In the Routes Unit Testing it has not developed the algorithm that calculated the train routes throughout Europe, which would plan the routes. Since the Evaluation Location in a Star Rating System and the Routes Planning did not pass the Unit Testing they were not tested to the Integration Testing.

The association of an email or social network account to login in the Mobile Application was not implemented because the Evaluation Location based on a Star Rating System was unsuccessful.

The Pedometer has an *orange* evaluation because it did not pass the Unit Testing but it will advance to the Integration Testing. The Pedometer was developed and counted steps based on the sensor accelerometer. However, the sensor accelerometer alone is not enough to count steps because the smartphone movement counted steps even though the user is not moving. An upgrade of the Pedometer is going to be developed in future iterations but despite not being truly accurate, it was decided that the Pedometer was going to be implemented.

5.2 Integration Testing

The units tested were integrated to determine if they function together. To perform the Integration Testing two kinds of tests were conducted: the Bottom-Up Integration and the multiple testing of the application. The Bottom-Up Integration is carried out by progressively adding higher-level combinations of the units previously tested.

Description	Result
Tab Menu	Pass
Europe Fragment Online Maps	Pass
Europe Fragment Offline Maps	Pass
Europe Maps Icon	Pass
Cities List view Fragment	Pass
Welcome Activity	Pass
Settings Fragment	Pass
Application Database Update	Pass
GPS	Pass
Pedometer	Not Passed
Map Fragment with Online Maps	Pass
Map Fragment with Offline Maps	Pass
Map Detail	Pass
Train Fragments	Pass
Regular Train Fragment	Pass
Night Train Fragment	Pass
City Information Fragment	Pass

Table 4 - Integration Testing

The Pedometer has correctly implemented but has the same precision problems described in the Unit Testing. This requirement will advance to System Testing for the same reason given in the previous section.

5.3 System Testing

The System Testing tests the application as a whole, once all the units are implemented. The InterRail Guide was tested to verify functional and technical specifications and the environment tested is similar to the environment where the application will be deployed. The InterRail Guide architecture supported the requirements tested.

Description	Result
Tab Menu	Pass
Europe Fragment Online Maps	Pass
Europe Fragment Offline Maps	Not Passed
Europe Maps Icon	Pass
Cities List view Fragment	Pass
Welcome Activity	Pass
Settings Fragment	Pass
Application Database Update	Pass
GPS	Pass
Pedometer	Not Passed
Map Fragment with Online Maps	Pass
Map Fragment with Offline Maps	Not Passed
Map Detail	Pass
Train Fragments	Pass
Regular Train Fragment	Pass
Night Train Fragment	Pass
City Information Fragment	Pass

Table 5 - System Requirements

The Open Street Map is an offline map alternative to the Google Maps API to let the user navigate the maps while in offline mode. The Open Street Map use did not pass the System Testing because the map sizes were very large (dozens of MB) and it has not been found a way to use the offline maps in order to maintain a decent size application.

5.4 User Acceptance Testing

The User Acceptance Testing evaluates whether the InterRail Guide meets the intended specifications and it is intended to understand if the user think the application is interactive. This testing ensures that the final user can navigate through the application fluidly and bug free. User Acceptance Testing discovers

errors like spelling mistakes, design errors, interface gaps and major bugs that can result in system crashes or major malfunctions.

To perform the User Acceptance Testing three different test groups were created to test the InterRail Guide. First a test group was gathered with people with Android knowledge to test the overall application and requirements. The second test group had people not familiar with Android to test the usability of the application. Finally, a test group with people that already made an InterRail was gathered to test the information presented.

Below it will be presented a few errors uncovered by the User Acceptance Testing:

- Several Layout problems resulting from tests on different screens and different DPI, such as Pop Up's with wrong sizes, non-accessible buttons, etc.
- The User had difficulties sliding between the top tabs when a map fragment was opened because the application applied the slide to the tabs, and the user had difficulties navigating in navigating in the Google Maps API. Ultimately the slide tap functionality was disabled so the user could navigate freely in the map.
- Two fragments had to be fused together because the user could not understand how to navigate between those fragments.
- The Settings Fragment has to be placed only in the Main Activity, when a city was not selected, so the user could navigate more fluidly between the Map Fragment and the Train Fragment.

6 Business Plan

6.1 Product and Services

The InterRail Guide is an application made for young travellers who want to enjoy what Europe has to offer. Everyone knows about the main touristic cities but those places can be visited throughout the lifespan. The InterRail Guide allows the traveller to truly know Europe by train and this project value resides in the opportunity to have a guide for young travellers in a smartphone.

The InterRail Guide has three main elements:

- Cities with points of interest directed for young travellers. There is a Belgium company called USE-IT Maps that designs printed maps specifically for young travellers that is having a huge success. The points of interest are selected by managers and they gather several opinions from local habitants. Similar to the Use It Maps, the InterRail Guide will be supported by several administrators that live on the cities and will show the best points of interest that the city has to offer. This enables the traveller to visit a city as he had a local as a guide.
- Train information between the existing cities in the database cities which allow the traveller to visit less known villages and cities. Imagine you are with an InterRail ticket in Lisbon. What is near to Lisbon that is worth visiting? People from Portugal can easily say Cascais, Sintra, Óbidos, Coimbra and Évora; all places less than 4 hours by train. But how can you discover those locations in Paris, London, Berlin or Vienna? There are numerous platforms that have this sort of information, however the traveller never knows how to get there by train. With the InterRail Guide the user is given information to plan the trip. Additionally, it is given access to information about night trains.
- Route planning where the traveller can plan a trip throughout Europe. The user selects the starting and arrival stations and the number of days he wants to spend between these stations. Then, the application will run an algorithm and presenting the user with the intermediate cities/villages to visit. This is a regular problem between travellers because Europe has so much to offer, that travellers feels confused where to go next. The Routes enables the user the visit unheard locations that were not planned originally.

The main objective of the InterRail Guide is the development of a Mobile Application Guide for InterRail travellers that usually carry heavy backpacks where guidebooks are not welcomed. Since most travellers carry a smartphone, the InterRail Guide could be easily downloaded and explored during the InterRail.

More than 250 thousand people [34] make an InterRail every year, and this number is expected to grow in the following years according to the growth of InterRail tickets sold the past years. The InterRail ticket holders are the main audience; however the InterRail Guide can also be used by other travellers. Most travellers of this kind of trips are from the middle class or higher, and own smartphones which is ideal for this project.



Figure 53 - InterRail most popular routes [35]

The travel industry is a very competitive market, and the number of companies that have invested in Mobile Applications or Web Platforms has grown substantially. Service includes travel planners, travel guides and location-based applications. Due to fierce competition the prices of services have fell and it is hard to obtain profits other than by advertisement. Nevertheless, to obtain substantially profits from advertisement the platforms need thousands of users, which is very difficult to achieve.

Investors usually criticize young entrepreneurs because they develop an idea based on a need they think they have rather than thinking on an idea that the market needs. This is one of the major strengths of this project because it was a need realized through talking with fellow travellers during the InterRails. It does not exist a mobile guide application developed for train travellers and if a user types the word InterRail in the Play Store the result will only present one application for train travellers, the Rail Planner. This means that when the InterRail Guide is released it will automatically appear to every user that searches InterRail in the Play Store and this is a major advantage.

Most InterRail travellers have a tight budget do not want to spend more money than they need to, however they still want to have a good time and are willing to spend money in beer, coffee or a decent meal. If the InterRail Guide could provide a better experience while travelling, users would use the application on a regular basis.

Most travellers get tired of the main touristic cities and want to visit something new, less crowded with a natural mystic. For travellers who want to find these locations the InterRail Guide is the best option on the market.

It can be concluded that this application has market value because the guide applications have thousands of users, and there is demand from InterRail travellers for a guide like this. Application design and usability are very important, because it has a direct relationship with the number of users.

6.2 Marketing Plan

6.2.1 Market Research

6.2.1.1 Mobile Devices Worldwide

According to the eMarketer 1.75 Billion people own a mobile phone worldwide and its growth is expected to remain steady until 2017. According to Figure 54 the mobile phone penetration will rise from 61.1% in 2013 to 69.4% in 2017 [36] (Figure 54). In January of 2014, in the US alone, 90% of adults had a mobile phone, 58% had a smartphone and 42% a tablet [37].

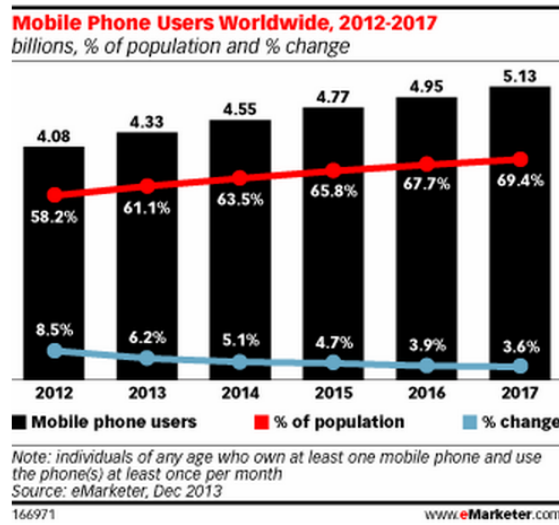


Figure 54 - Mobile Phone Users Worldwide [42]

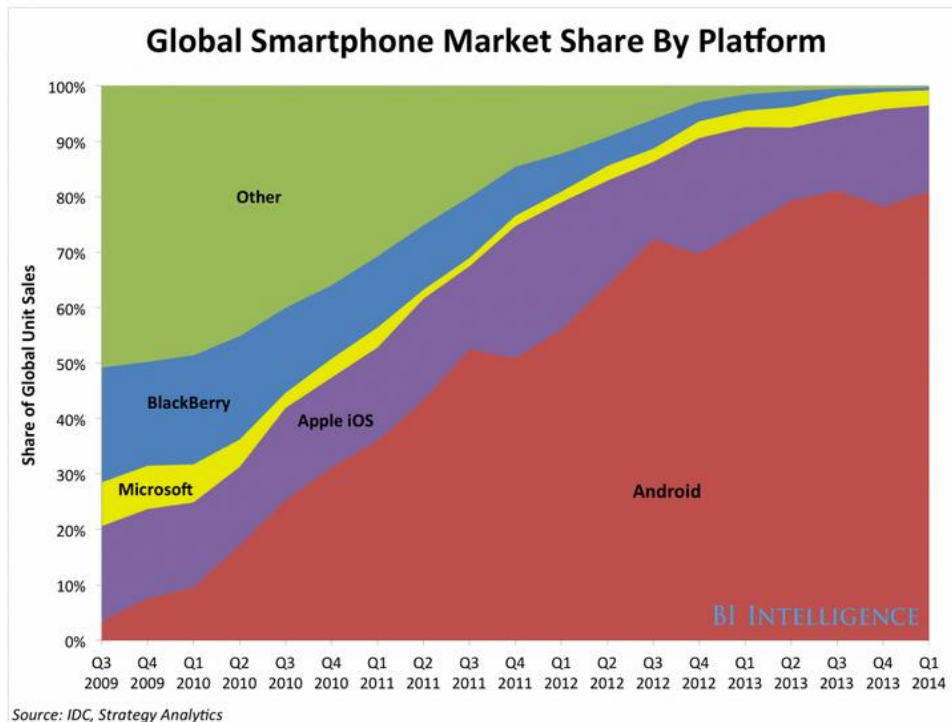


Figure 55 - Global Smartphone Market Share by Platform [43]

Operating System	2014 Shipment Volumes*	2014 Market Share	2018 Shipment Volumes*	2018 Market Share	2013-2018 CAGR
Android	997.7	80.2%	1,401.3	77.6%	12.0%
iOS	184.1	14.8%	247.4	13.7%	10.0%
Windows Phone	43.3	3.5%	115.3	6.4%	28.1%
BlackBerry	9.7	0.8%	4.6	0.3%	-25.0%
Others	9.3	0.7%	37.7	2.1%	31.5%
Total	1,244.1	100%	1,806.3	100%	12.3%

Figure 56 - Worldwide Smartphone Forecast [43]

Analysing the Global Smartphone Market Share by platform (Figure 56) it is noticed that the Android Platform had a Market share of 80.2% in the third quarter of 2014. By 2018 the Market Share of the Android Platform is expected to decrease to 77.6% however the number of shipment volumes of this platform is predicted to increase from 997.7 million devices in 2014 to 1401.3 million devices in 2018.

The smartphone market is anticipated to continue to grow but the remaining operating systems will gain market share relative to the Android, but will continue to dominate the market (Figure 55 and Figure 56) [43].

The number of users that utilize mobile devices with access the Internet is growing [38] but users already spend more time on applications than on the web itself [39]. This means that the search for applications continues to increase and users want useful or entertaining application, that can work both offline and online.

6.2.1.2 Mobile Travel Applications

The Mobile Travel Applications Market is a very competitive market where new applications are released every day. The main areas of the Mobile Travel Market are Travel Booking, Hotels, Airlines, Cruises and Car Rentals. As seen in Figure 57, users do not evaluate positively most of the travel applications with exception of the Travel booking [41]. Despite the quality, users continue to use this types of applications because they serve a costumer need. The lack of quality, from the user perspective implies a market opportunity of improvement in development and design.

APPLAUSE TRAVEL MOBILE APP QUALITY INDEX - MINIMUM, AVERAGE & MAXIMUM SCORE

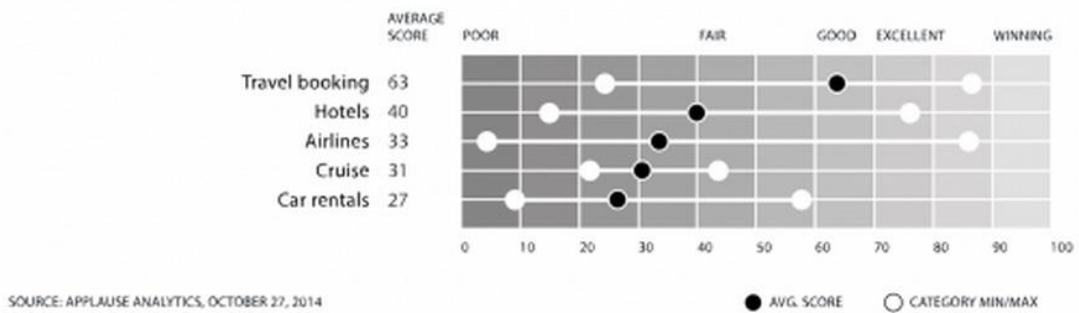


Figure 57 - Travel Mobile APP Quality Index [41]

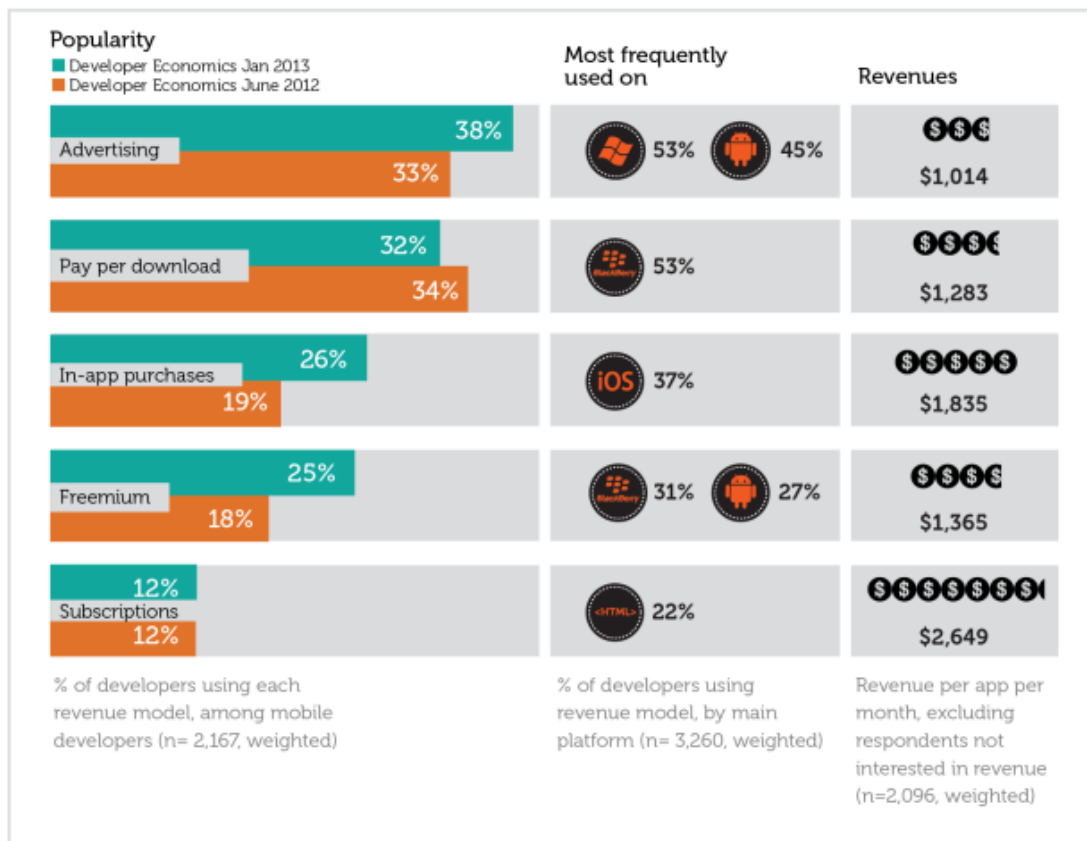
6.2.1.3 Revenue Model in Mobile Platforms

Figure 58 presents information about common revenue models across different Mobile Platforms featuring information about the average revenue per application per month of each revenue model [42]. The sum of the revenue model percentage is bigger than 100% because some applications use more than one revenue model. Only applications with revenue models were analysed.

Advertising is applied to free applications and is the most popular revenue model by June 2013, surpassing the Pay per Download by 6% (38% and 32% respectively), with a growth of 5% from June 2012 (33%) to June 2013. Advertising is mostly implemented by Windows Phone (53%) and Android Platforms (45%), with an average revenue of \$1,014. It is the smallest average revenue model because advertisement needs a massive scale of users to have a decent revenue, but even then it is tricky to implement it [42].

Pay per Download Applications decreased 2% from 2012 (34%) to 2013 (32%) which implies that is losing ground as a revenue model because users cannot experience the application before buying it, which decreases the total number of users. Pay per download is applied on 53% of the Blackberry applications, and has an average revenue of \$1,283 only bigger than the advertisement revenue.

In-App Purchases and Freemium grown 7% on the years featured in Figure 58. In-App purchases are free applications where there is content that can only be accessible through payment. For example, buttons and menus of the application can only be opened if the user pays for those. In June 2013 it was implemented in 26% of the Mobile Platforms and is mostly implemented in the iOS Platform (37%) it has the second higher average revenue of \$1,835.



Source: Developer Economics 2013 | www.DeveloperEconomics.com | January 2013
 Licensed under Creative Commons Attribution 3.0 License



Figure 58 - Different revenue models for apps, where they are frequently used on, and the revenues from it [47]

Freemium Applications are also free but are developed with *action points* where the user earns points every x minutes, and each action in the application needs several action points to be made. After the user spend the *actions points*, he need wait for the *actions points* to be replenished. However, the user can buys of *actions points* to interact with the application. The Freemium revenue is implemented in 25% of the Mobile Applications, more significantly in Blackberry (31%) and Android (27%) Platforms. Freemium has an average revenue of \$1,365.

The least popular revenue model is the subscription and has maintained market share with 12%. Subscription is implemented in HTML Platforms and the user only has access to the information when the subscription is paid. With this revenue model, the application receives a regular income, however, subscription needs to update the content, otherwise the users will stop paying.

The average income is \$2,649, the highest revenue analysed.

6.2.1.4 Location-Based Applications

With the evolution of smartphones and tablets, the printed versions of newspapers, books and magazines are declining and the companies needed to adapt the mobile devices. Lonely Planet, a Giant on travel guides has faced with a rapid decline in the printed guidebooks. In 2007 Lonely Planet sold more than 25 million guidebooks and in 2012 decreased their sales to around 18 million, a drop of 30% [43]. Frommer's travel guides sold almost 35 million guides in 2007 and in 2012 sold 17 million, less than Lonely Planet [43]. Google, the owner of Frommer's, has planned to kill its paper edition and only focus on online content [44].

Apps like Foursquare, Yelp and TripAdvisor have been leading the market in location-based applications where users can place, vote and comment the point of interest such as restaurants, bars and other shops and the community creates the points of interest. Back in 2011 Foursquare had 5 million of users, Yelp 36 million and Facebook an astonishing 200 million [45]. It is almost impossible to enter this market where the companies lead the market with millions of users.

6.2.2 Economics

To perform an economic analysis of the InterRail Guide I have relied on my experience and in the number of EuRail/InterRail tickets sold worldwide. There are two kinds of travellers that buy an InterRail ticket: the travellers who are focused on big cities and parties; and travellers who want to discover new places in Europe. In my experience, 20% of the travellers can be inserted in the first kind described and are not the InterRail Guide main audience.

250 thousand people did InterRail in 2011 [34], and the InterRail Group shows that this number has been increasing in the past years. So, 80% of the 250 thousand [34] people that buy an InterRail ticket are the application target audience.

Equation 1 - Target Audience with InterRail Ticket

$$250,000 * 0.8 = 200,000$$

According to my experience the average person who buys an InterRail ticket belongs to the middle class and have between 18 and 35 years. It is expect that 95% of people in these ages have cell phones, and 70% will have smartphone. Remember that the InterRail Guide is developed in the Android Platform, which has a market share of 80.2% [43]. The number of InterRail travellers bearing the Android Platform devices is 112,280 (Equation 2).

Equation 2 - Target Audience with Android Platform in the first year

$$200,000 * 0.95 * 0.7 = 112,280$$

To calculate the number of travellers with an Android Platform that does the InterRail for the first time it is estimated that 60% of all tickets bought annually are for first time buyers. Hence, in the first year 112.280 are the target audience and on the following years the target audience is 67.368 (Equation 3).

Equation 3 - Target audience with Android Platform after the first year

$$112.280 * 0.6 = 67.368$$

I have discovered during the InterRail that there is a true demand for a guide application directed to the InterRail market because travellers often question themselves where to go next. Since the application also has maps with points of interest, all tourists travelling to those cities are potentially users of the InterRail Guide which will multiply the number of users by thousands.

6.2.3 Costumers

The InterRail Guide costumers have between 18 to 35 years, female and male being equally represented and residing in developed countries (countries of the European Union, USA, Canada, Japan, Australia, etc.) or countries in development like China, Brazil, Argentina, etc. All of these countries have a middle class, representing the average income of the InterRail travellers.

Travelling one month with the InterRail ticket has an average cost of 1,500€ with all costs included such as InterRail ticket, train reservations, Hostels, Food, etc. Most travellers are students or recently employed young adults that take several weeks of vacation for an InterRail.

6.2.4 Competition

There are hundreds of applications for touristic purposes, covering very different areas. This sections deepens the comparative analyses presented in [State of the Art](#). It is pertinent to accentuate that all the application analysed are free and use advertisement as their revenue model.

The analyses presented in this section is based in my own personal experience and duly identified information. The factors presented in the following tables were chosen according to my experience as a mobile application user and the importance of each factor to the user. The factors are the following:

- **Product** – Usefulness of the application
- **Price** – Download cost
- **Quality** – Application usability
- **Expertise** – Number of application released by the company
- **Company Reputation** – Reviews of the applications owned by the company
- **Appearance** – Design of the Application
- **Advertising** – Advertisement investment
- **Image** – Image of the overall company
- **Installations** – Number of installations according to the Play Store

Each application is analysed on a 0 to 5 scale, where 5 is an excellent feature and 0 is a poor feature. The InterRail Guide and the applications described in the [State of the Art](#) (were a summary table was already

presented) are analysed according to the groups they belong. (I.e. Location based applications, Information applications and Guide applications).

FACTOR	InterRail Guide	Importance to Costumer
Product	4	5
Price	5	4
Quality	4	5
Expertise	0	3
Company Reputation	0	2
Appearance	4	4
Advertising	0	3
Image	0	4
Installations	0	2

Table 6 - InterRail Guide Analysis

The InterRail Guide has 4 strengths and 7 weaknesses. The InterRail Guide weaknesses rely in the factors where the first applications struggle such as the expertise, advertising and reputation.

FACTOR	Foursquare	Yelp	TripAdvisor
Product	4	4	5
Price	5	5	5
Quality	4	4	4
Expertise	5	5	5
Company Reputation	4	5	5
Appearance	4	4	4
Advertising	3	2	5
Image	4	5	5
Installations	10 m - 50 m	10 m - 50 m	100 m - 500 m

Table 7 - Foursquare, Yelp and TripAdvisor analyses

Foursquare is in a very competitive market, with *Yelp* and *TripAdvisor*, and is losing market share to both of them. *Foursquare* has presented a new business model turning *Foursquare* in a *Yelp 2.0*. *Foursquare* excels in company expertise and has very good features in quality, appearance and company image.

Yelp is similar to *Foursquare* but with focused in the USA market. *Yelp* competitive analysis is very similar to *Foursquare*, however the company reputation and image are better than *Foursquare*. Both these applications are shifting from being centred on touristic sites to target businesses, because the revenues are higher [46].

Finally, *TripAdvisor* has ten times more downloads than the previous two applications. Touristic sites, shops, restaurants, etc. place at their entrance a sticker with the *TripAdvisor* rating so tourists have an extra incentive to visit. This application has very good rating in all the factors analysed, as well as a fantastic company reputation, being recognized worldwide.

FACTOR	Rail Planner	Europe Travel Guide Offline	Europe Travel Guide
Product	5	3	3
Price	5	5	5
Quality	5	3	2
Expertise	5	1	1
Company Reputation	5	1	0
Appearance	3	2	1
Advertising	2	0	0
Image	5	2	1
Installations	100 k - 500 k	1 k – 5 k	10 k - 50 k

Table 8 - Competitive Rail Planner, Europe Travel Guide Offline and Europe Travel Guide Analyses

Rail Planner is designed by the InterRail group and it is the main application developed for train travellers, presenting train schedules in Europe. Both the Rail Planner and the InterRail Guide focus on the same target audience, so the number of the *Rail Planner* downloads is very important. It has 100 to 500 thousand downloads, which means that train travels applications have a big demand. It has the highest evaluation in six topics such as product, quality, expertise and image. This application goes straight to the user needs. The lowest rating appears in the appearance and advertising because outside train travellers few people know about this application.

The *Europe Travel Guide Offline* and the *Europe Travel Guide* are similar to the InterRail Guide, since they are both guides for Europe travellers. The difference between them and the InterRail Guide resides in the target audience because these applications are not focused on trains, rather as in Europe as a whole.

The *Europe Travel Guide Offline* is a new application, launched in January of 2015, and has managed to get 5 thousand users. This application presents touristic information about countries in Europe, divided by cities. This application does not have high evaluation because although the product is interesting, it does not have an appealing design and the information is not very useful, because it is a summary of online travel guides. Despite this problem, the application managed to get thousands of users in just four months.

The *Europe Travel Guide* is the predecessor of the last application analysed, and it was last updated in June of 2011, which means that the application is not up to date. This application appearance is not very appealing and the information is not complete. The *Europe Travel Guide Offline* is an improvement on development and has updated the information. This application has a competitive analysis very similar to the previous one and had 10 to 50 thousand installations.

Voyager: Trip Planner is an application that draws cities routes in a chosen city. *Voyager* offers walking, bicycle and cars routes focused in city itineraries. The appearance of this application is not very appealing and the routes presented are the same as the ones in Google Maps, which means that there are more helpful in car trips or in small walking trips. *Voyager* product and quality is similar to the Google Maps. *Voyager* application succeeded to get 10 to 50 thousand installations, which is very good for this type of applications.

FACTOR	Voyager: Trip Planner	RoadTrippers
Product	2	3
Price	5	5
Quality	2	3
Expertise	2	3
Company Reputation	1	2
Appearance	2	3
Advertising	0	0
Image	1	2
Installations	10 k - 50 k	100 k - 500 k

Table 9 - Voyager: Trip Planner and RoadTrippers Analysis

The last application analysed is the *RoadTrippers*, an upgraded version of the last one but focused on large-scale car routes trips along the USA. *RoadTrippers* has an average evaluation of 3 points, stressing that the appearance is much better than the Voyager application. This application has 100 to 500 thousand installations it can be drawn from to analyses to *RoadTrippers* and *Voyager* applications that costumers are interested in routes applications that help them travel and enable them to discover new locations to visit.

6.2.5 Strategy

6.2.5.1 Promotion

Once the application is finished, the plan is to disclose it through two possible partners, the Rail Dude and the Use It Maps. The Rail Dude is the most important website for InterRail Travellers which presents their users with travel advises, such as best locations to visit, some night trains, and a forum where travellers can talk to each other. The Use it Maps, is a Belgian company who designs maps for young travellers, and the particularity of these maps is that they are designed by locals, which means the points of interest are decided by managers who live in the city rather the community. The Use it maps are all printed maps, and it will be offered the opportunity to turn their maps from printed to digital.

The name InterRail Guide is a big advantage since the application can be easily found in Play Store which will enable an easy promotion without much investment.

6.2.5.2 Pricing

Initially the InterRail Guide will be free, to obtain the biggest number of possible users. When, and if, the application reaches a big number of users there will be released more cities with maps that can be bought by In-App purchases.

When the user installs the application there will be 10 free cities. Each city has a map with points of interest, nearby cities to visit, and trains departing from that city. If the user wants to access information of more than the 10 free cities, he will need to purchase the non-free cities.

6.2.5.3 Distribution Channel

Since the InterRail Guide is an Android application, Play Store (Google Application Store) will be used as a distribution channel. To use this channel it is necessary an investment of \$25 to create an account on Play Store. If Advertisement is implemented, Google will gain an advertisement percentage since its Google that defines the advertisement that appears on the application.

6.2.5.4 Sales Forecast

For the Sales Forecast it was filled a forecaster spreadsheet to prepare a three year month –by-month projection for two different forecasters. The best scenario, which is the case intended to happen, and the worst case scenario that is the number of downloads that will happen no matter what happens The spreadsheets, based on assumptions from our market knowledge, are presented in the [Annex: A](#).

For both forecasts it was used a gross profit of 60% for advertisement because Google retains 40% of the profit and a gross profit of 90% for In-App Purchases. The percentages were estimated according to the profits of similar platforms. The missing 10% are for the intermediate seller. Google Play does not require a profit for In-App purchases, however these stores have a few rules, and to make a conservative analyses it was calculated a 90% gross profit. For the forecasts, it was divided the Sales in two parts, Advertisement and In-App Purchases. For the Volume of Sales, Google determines the price of the advertisement, and charge accordingly to the number of users. The price increases as the number of users increase. In both forecasts, the InterRail Guide has only In-App purchases in the second year because it will be implemented after the first year. When In-App purchases become available the average price of purchase will be 1€.

For the worst-case scenario, the Gross Profit is 3,750€ on the first year, 15,330€ on the second and a 21,330€ on the third year. The main difference of revenues from the first year to the second is the implementation of the In-app Purchases. Although the InterRail Guide is a seasonal application, in general used during summer it can also be used by the users all year long.

For the best-case scenario, it is expect the InterRail Guide to be heavily used by the travellers. Like stated before, although these numbers represent many users, this can be possible if the market accepts the application. The Gross Profit is 19,620€ in the first year, a 51,210€ in the second and a 97,650€ in the third year. These revenues are very interesting, but in the best-case analysis it was not considered a direct competitor to enter this market, which would decrease the revenues.

6.3 Operation Plan

6.3.1 Production

Since the InterRail Guide comprises mobile and web platforms, i.e. a digital product, inventory is not necessary. To develop an application for Android developers it is only needed a smartphone or a tablet with the Android installed and an Android IDE installed in a computer. The InterRail Guide was developed using the Android Studio, the Google's IDE. Since the Android developer had an Android tablet there was no additional costs associated.

The Quality Control is responsibility of the Quality Manager, which needs to test the application and compare it to other applications on the market. The InterRail Guide needs to be simple and intuitive for every user and should allow a quick access to the information. The Quality Manager gathered a test group to test the application. For the test group, people with little smartphone experience are required in order to test its simplicity, interactivity, and design. To test the information in the InterRail Guide another test group was gathered with people that have done at least two InterRails.

6.4 Start-up Expenses and Capitalization

The IDE is free and several friends had Android devices that enabled to test the InterRail Guide on 10 different devices. To test the application in an emulator, it is not necessary any investment because Android Studio includes an emulator.

To develop a website, a worldwide domain needs to be bought to launch a website for the application and create a forum for the users of the Interracial Guide, two domains need to be purchased, the *interrailguide.com* for the website and the *interrailguide.org* for the forum.

Annually Subscription	Price	Currency
interrailguide.com Domain	10.69	\$
interrailguide.org Domain	11.48	\$

Table 10 - Annual Subscription Costs

The *interrailguide.com* domain has an annually subscription of 10.69\$ and the *interrailguide.org* an annually subscription of 11.48\$.

To release the InterRail Guide in the Play Store it is necessary to by a Play Store account that has a unitary cost of \$25. This account enables the release of several different applications.

With the current size of the database, the InterRail Guide database can be inserted in a free server, which has limited capacity and processing capabilities. However, as the database increases it is fundamental to have a dedicated server. The dedicated server's price depends on the RAM, storage and bandwidth, but for the beginning a server with 2 GB of RAM, storage of 512 GB and bandwidth of 5 TB/month is sufficient. The selected server has an annual subscription of 159.88€.

First Year Costs (€)	Price
Play Store Account	23.28 €
interrailguide.com Domain	9.96 €
interrailguide.org Domain	10.69 €
2 GB Dedicated Server	159.88 €
Total	203.81 €

Table 11 - First Year Costs in €

In the first year, presuming the dedicated server is bought, the costs will be 203.81€. This cost is the investment needed to develop and released the Android application in the market.

Following Years Costs (€)	Price
intertailguide.com Domain	9.96 €
interrailguide.org Domain	10.69 €
2 GB Dedicated Server	159.88 €
Total	180.53 €

Table 12 - Following Years Costs in €

In the following years, the InterRail Guide only need to pay annual subscriptions calculated as 180.53€, which is a reasonable price⁶.

6.5 Financial Plan

6.5.1 Twelve Month Profit and Loss Projection

The results for the 12-Month Profit and Loss projection are calculated based on the Sales Forecast, presented in [Annex A](#), and the [Start-up Expenses](#). These scenarios represent the minimum and maximum plausible gross profit.

The estimated number of users was calculated according to the number of users of the analysed application, especially the Guide Applications. In the worst case scenario, the number of users are considerably smaller than any of the analysed applications while in the best case scenario the number of users is similar.

To calculate the gross profit, it was set an average value to the advertisement that depends on the size of the application, number of clicks, time spend on the application and other factors. Since this value cannot be calculated, the average estimated value is lower than in the analysed application.

⁶ Note that in April 22, 2015, one US dollar was worth 0.931272118€, and the calculations were made according to this value.⁶

12 Month Profit	
Worst Scenario	
Gross Profit	3,750.00 €
Expenses	203.81 €
Total	3,546.19 €
Best Scenario	
Gross Profit	19,620.00 €
Expenses	203.81 €
Total	19,416.19 €

Table 13 - Twelve Month Profit Loss Projection

In the Twelve Month Profit and Loss Projection it is easily noted that the expenses are very small comparing with the sales for both forecasted scenarios, and the InterRail Guide can provide profit because the investment needed for a digital product is minimal. It is worth remembering that in the first year all revenues come from advertisement, and the Inn-App Purchases will only be implemented on the second year.

6.5.2 Four Year Profit Projection

In the Four Year Profit Projection it was performed a similar analysis to on the previous Twelve Month Projection. Since it was made a three year Sales Forecast, the fourth year have identical values to the third year. This will not have a significant importance in the analyses since it implies that in the fourth year there will not growth, which is not plausible.

4 Year Projection					
Worst Scenario					
	First Year	Second Year	Third Year	Fourth Year	4 Year Total
Gross Profit	3,750.00 €	15,330.00 €	21,330.00 €	21,330.00 €	
Expenses	203.81 €	180.53 €	180.53 €	180.53 €	
Total	3,546.19 €	15,149.47 €	21,149.47 €	21,149.47 €	
Best Scenario					
	First Year	Second Year	Third Year	Fourth Year	4 Year Total
Gross Profit	19,620.00 €	51,210.00 €	97,650.00 €	97,650.00 €	
Expenses	203.81 €	180.53 €	180.53 €	180.53 €	
Total	19,416.19 €	51,029.47 €	97,469.47 €	97,469.47 €	

Table 14 - Four Year Profit Projection

Since this analysis was made for four years it implies many conjectures and must be corrected once InterRail Guide is released.

The element that stands out the most is the difference between the worst and the best case scenario. In the worst case scenario the company profit is above 60 thousands euros, while the best case the profit is bigger than 265 thousand euros. The difference between the profits from the first year and the following years lies in the implementation of In-App purchases. The profit growth arises from the growing number of users. Note, the constant expenses continue small, since that after the first year it is only necessary to pay the annual subscription for the dedicated server and the websites domains.

In this analysis there were not considered labour and office costs, which are the main expenses of a company. These expenses will vary deeply according to the InterRail Guide success and future projects. The 4 year profits can seem very optimistic at a glance however the average month profit for the worst case scenario is 1,270.72€ and for the best case scenario is 5,528.85€. In the worst case scenario the average profit is not sufficient to rent an office and no more than two people could work full time in the InterRail Guide.

At the best case scenario the profit is sufficient to create a small start-up of 4 to 5 people, each earning an average of 800€, plus rent and other expenses

7.

⁷ The estimated number of users was calculated according to the number of users of the analysed application, especially the Guide Applications. In the worst case scenario, the number of users are considerably smaller than any of the analysed applications while in the best case scenario the number of users is similar.

To calculate the gross profit, it was set an average value to the advertisement that depends on the size of the application, number of clicks, time spend on the application and other factors. Since this value cannot be calculated, the average estimated value is lower than the analysed application.

7 Conclusion

7.1 InterRail Guide solution

The InterRail Guide was developed to help train travellers to have the best possible experience while travelling throughout Europe, whether visiting main cities or smaller cities and villages.

The InterRail Guide makes use of the GPS and Pedometer to know the user location and their movement pattern. Combining data from these sensors with the user evaluation on the points of interest, the InterRail Guide can present personalized information to each user and improve user experience. However, the customized information is not implemented in the Beta version.

The InterRail Guide is the first guide mobile application developed for train travellers, representing a market untapped. A Business Model was made to understand the mobile market and implement the best revenue model for it.

The whole application is based on providing information that the user needs while traveling. The development needed to understand how to present that information in an easy and intuitive manner.

The opportunity to develop an Android application directed to the end user enriching because I had to understand how users interact with every aspect of the application. For someone concluding an engineer degree this was a dream project.

During my academic experience, I realized how difficult it is to have a product or a service that the market wants; however, students seem to think that a degree ensures that the clients or employers automatically want their services. This is a myth and most students do not realize how businesses work, despite the knowledge acquired.

The InterRail Guide is a thesis designed to approach both the academic and the business sides, where an academic project is developed but directed to market opportunity.

I hope the reader will learn and enjoy this thesis as much as I have enjoyed working on it.

7.2 Future Work

As Future Work I will prepare the InterRail Guide to be released in the Android market because, as seen during tests, new upgrades are needed. The application should be re-thought so all maps can be made available offline, however, offline maps bring memory constraints. Open Street Map API enables the InterRail Guide to present offline maps, each one with dozens of MB, which is very heavy file. The InterRail Guide with online maps, Google Maps API, has an overall memory of 130MB, but 120MB are only used by the photographs. Using the photographs and the Street Map API is not a viable solution due to the final size of the application.

To combine the Open Street Maps and the photograph, a new approach must be taken so the application has a reasonable size. One possible solution is to have Offline maps that need to be downloaded only if the user want to have an offline map. If the map is not downloaded, the InterRail Guide will present the application using the Google Maps API, as it now works.

Since some requirements were not implemented, future work will address these issues. The first requirement to be developed is the evaluation of the location based on a 5 star scale, to enable the user to interact with the InterRail Guide and evaluate the cities and points of interest presented. Once the 5 star scale is implemented, two other requirements will be implemented as well. The association or removal of a social network or e-mail account enables the user to only vote once on each location. The implementation of these two requirements will also incentive the interaction between users and will improve customer loyalty.

The final requirement to be implemented is the Train Routes. To develop this requirement it is necessary that an algorithm that goes through all cities and trains existing in the database. It is going to be a heavy algorithm that will likely have to be run in a dedicated server.

When the described work is implemented the InterRail Guide can be released in the market. However, additional work should be carried on to improve the application. According to the Business Model, the Android Application will need to implement In-App Purchase. When the Application is installed, there will be 10 free cities that the user can explore. However, as more cities are developed, the user will need to buy these cities individually to access the map and the train information. In-App Purchases will be the main revenue model.

To implement more cities it is necessary to introduce more data. That means more points of interest and more villages and cities with train information. As more data is introduced, more cities could be bought and higher revenue could be obtained. The existing database could be improved by making partnerships with specialized websites to ensure a better travelling experience. A key partnership with Deutsche Bahn or the Rail planner application is necessary to present the trains timetables.

To target the Mobile market efficiently it is necessary to develop an iOS application. As explained in the Business Model, the Android and iOS together represent 91.3% of the Mobile Devices market. Developing the InterRail Guide for these two platforms will enhance the possibilities of a successful application.

To guarantee that the application is not duplicated by the competition, there will be necessary to implement data security. The market value of the InterRail Guide resides in the information presented and how it is integrated on each other. By protecting this data, the competition would have to start over the database, and it would take a few months to launch a similar application to the market. By then, it is intended to have a good market share that will greatly hinder competition.

There are two elements that need to be improved to guarantee that the application will be downloaded by the user. These improvements will benefit from an exhaustive User Acceptance Testing procedure that will help to identify the application navigation issues that the user might find. The first element of improvement is the design layout of the application that needs to be improved by an experienced android designer. The second element is the enhancement of the user experience so the user can easily navigate through different fragments and activities.

Lastly, it is necessary to integrate the InterRail Guide solution in the IoT using the OpenWSN library. This will enable the customization of the information presented to the user and makes the InterRail Guide a new member of the IoT environment

7.3 Final Consideration

This project had a tremendous importance in my personal and academic development because allowed me to develop a mobile based solution that will be released in the market.

This journey enabled to upgrade my skills in several technologies, business practices, and market trends.

The knowledge acquired and the overcome difficulties were an excellent preparation for the life after college.

This thesis was an enriching experience.

Annex

Annex A: Sales Forecasts

Sales Forecast Worst Case Scenario year 1

Sales Forecast

	month 1	month 2	month 3	month 4	month 5	month 6	month 7	month 8	month 9	month 10	month 11	month 12	Year 1
	Jul-2015	ago-2015	set-2015	out-2015	nov-2015	dez-2015	Jan-2016	fev-2016	mar-2016	abr-2016	mai-2016	Jun-2016	Total
Volume	500	2 000	1 500	200	200	150	150	150	150	250	400	600	6 250
Regular Users	500	2 000	1 500	200	200	150	150	150	150	250	400	600	6 250
In-app Purchases	-	-	-	-	-	-	-	-	-	-	-	-	-
Selling Price	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00
Advertisement	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00
In-app Purchases	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00
Sales	500	2 000	1 500	200	200	150	150	150	150	250	400	600	6 250
Advertisement	500	2 000	1 500	200	200	150	150	150	150	250	400	600	6 250
In-app Purchases	-	-	-	-	-	-	-	-	-	-	-	-	-
Cost of Sales	200	800	600	80	80	60	60	60	60	100	160	240	2 500
Advertisement	200	800	600	80	80	60	60	60	60	100	160	240	2 500
In-app Purchases	-	-	-	-	-	-	-	-	-	-	-	-	-
Gross Profit	300	1 200	900	120	120	90	90	90	90	150	240	360	3 750
Advertisement	300	1 200	900	120	120	90	90	90	90	150	240	360	3 750
In-app Purchases	-	-	-	-	-	-	-	-	-	-	-	-	-
Gross Profit %	60,0%	60,0%	60,0%	60,0%	60,0%	60,0%	60,0%	60,0%	60,0%	60,0%	60,0%	60,0%	60,0%
Advertisement	60,0%	60,0%	60,0%	60,0%	60,0%	60,0%	60,0%	60,0%	60,0%	60,0%	60,0%	60,0%	60,0%
In-app Purchases	90,0%	90,0%	90,0%	90,0%	90,0%	90,0%	90,0%	90,0%	90,0%	90,0%	90,0%	90,0%	0,0%

Sales Forecast Worst Case Scenario year 2

Sales Forecast

	month 13 jul-2016	month 14 ago-2016	month 15 set-2016	month 16 out-2016	month 17 nov-2016	month 18 dez-2016	month 19 jan-2017	month 20 feb-2017	month 21 mar-2017	month 22 abr-2017	month 23 mai-2017	month 24 jun-2017	year 2 Total
Volume	1 500	4 000	2 250	650	650	450	450	450	550	750	1 000	1 000	13 700
Regular Users	1 000	3 000	1 500	500	500	300	300	300	400	600	800	800	10 000
In-app Purchases	500	1 000	750	150	150	150	150	150	150	150	200	200	3 700
Selling Price	1,67	1,75	1,67	1,77	1,77	1,67	1,67	1,67	1,73	1,80	1,80	1,80	1,73
Advertisement	2,00	2,00	2,00	2,00	2,00	2,00	2,00	2,00	2,00	2,00	2,00	2,00	2,00
In-app Purchases	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00
Sales	2 500	7 000	3 750	1 150	1 150	750	750	750	950	1 350	1 800	1 800	23 700
Advertisement	2 000	6 000	3 000	1 000	1 000	600	600	600	800	1 200	1 600	1 600	20 000
In-app Purchases	500	1 000	750	150	150	150	150	150	150	150	200	200	3 700
Cost of Sales	850	2 500	1 275	415	415	255	255	255	335	495	660	660	8 370
Advertisement	800	2 400	1 200	400	400	240	240	240	320	480	640	640	8 000
In-app Purchases	50	100	75	15	15	15	15	15	15	15	20	20	370
Gross Profit	1 650	4 500	2 475	735	735	495	495	495	615	855	1 140	1 140	15 330
Advertisement	1 200	3 600	1 800	600	600	360	360	360	480	720	960	960	12 000
In-app Purchases	450	900	675	135	135	135	135	135	135	135	180	180	3 330
Gross Profit %	66,0%	64,3%	66,0%	63,9%	63,9%	66,0%	66,0%	66,0%	64,7%	63,3%	63,3%	63,3%	64,7%
Advertisement	60,0%	60,0%	60,0%	60,0%	60,0%	60,0%	60,0%	60,0%	60,0%	60,0%	60,0%	60,0%	60,0%
In-app Purchases	90,0%	90,0%	90,0%	90,0%	90,0%	90,0%	90,0%	90,0%	90,0%	90,0%	90,0%	90,0%	90,0%

Sales Forecast Worst Case Scenario year 3

Sales Forecast

	month 25	month 26	month 27	month 28	month 29	month 30	month 31	month 32	month 33	month 34	month 35	month 36	Year 3
	Jul-2017	ago-2017	set-2017	out-2017	nov-2017	dec-2017	jan-2018	feb-2018	mar-2018	abr-2018	mai-2018	Jun-2018	Total
Volume	1 500	4 000	2 250	650	650	450	450	450	550	750	1 000	1 000	13 700
Regular Users	1 000	3 000	1 500	500	500	300	300	300	400	600	800	800	10 000
In-app Purchases	500	1 000	750	150	150	150	150	150	150	150	200	200	3 700
Selling Price	2.33	2.50	2.33	2.54	2.54	2.33	2.33	2.33	2.45	2.60	2.60	2.60	2.46
Advertisement	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00
In-app Purchases	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Sales	3 500	10 000	5 250	1 650	1 650	1 050	1 050	1 050	1 350	1 950	2 600	2 600	33 700
Advertisement	3 000	9 000	4 500	1 500	1 500	900	900	900	1 200	1 800	2 400	2 400	30 000
In-app Purchases	500	1 000	750	150	150	150	150	150	150	150	200	200	3 700
Cost of Sales	1 250	3 700	1 875	615	615	375	375	375	495	735	980	980	12 370
Advertisement	1 200	3 600	1 800	600	600	360	360	360	480	720	960	960	12 000
In-app Purchases	50	100	75	15	15	15	15	15	15	15	20	20	370
Gross Profit	2 250	6 300	3 375	1 035	1 035	675	675	675	855	1 215	1 620	1 620	21 330
Advertisement	1 800	5 400	2 700	900	900	540	540	540	720	1 080	1 440	1 440	18 000
In-app Purchases	450	900	675	135	135	135	135	135	135	135	180	180	3 330
Gross Profit %	64.3%	63.0%	64.3%	62.7%	62.7%	64.3%	64.3%	64.3%	63.3%	62.3%	62.3%	62.3%	63.3%
Advertisement	60.0%	60.0%	60.0%	60.0%	60.0%	60.0%	60.0%	60.0%	60.0%	60.0%	60.0%	60.0%	60.0%
In-app Purchases	90.0%	90.0%	90.0%	90.0%	90.0%	90.0%	90.0%	90.0%	90.0%	90.0%	90.0%	90.0%	90.0%

Sales Forecast Best Case Scenario year 1

Sales Forecast

	month 1 jul-2015	month 2 ago-2015	month 3 set-2015	month 4 out-2015	month 5 nov-2015	month 6 dez-2015	month 7 jan-2016	month 8 feb-2016	month 9 mar-2016	month 10 abr-2016	month 11 mai-2016	month 12 jun-2016	year 1 Total
Volume	1 000	5 000	4 000	400	400	300	600	600	800	1 000	1 400	1 600	17 100
Regular Users	1 000	5 000	4 000	400	400	300	300	300	300	500	700	900	14 100
In-app Purchases	-	-	-	-	-	-	300	300	500	500	700	700	3 000
Selling Price	2,00	2,00	2,00	2,00	2,00	2,00	1,50	1,50	1,38	1,50	1,50	1,56	1,82
Advertisement	2,00	2,00	2,00	2,00	2,00	2,00	2,00	2,00	2,00	2,00	2,00	2,00	2,00
In-app Purchases	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00
Sales	2 000	10 000	8 000	800	800	600	900	900	1 100	1 500	2 100	2 500	31 200
Advertisement	2 000	10 000	8 000	800	800	600	600	600	600	1 000	1 400	1 800	28 200
In-app Purchases	-	-	-	-	-	-	300	300	500	500	700	700	3 000
Cost of Sales	800	4 000	3 200	320	320	240	270	270	290	450	630	790	11 580
Advertisement	800	4 000	3 200	320	320	240	240	240	240	400	560	720	11 280
In-app Purchases	-	-	-	-	-	-	30	30	50	50	70	70	300
Gross Profit	1 200	6 000	4 800	480	480	360	630	630	810	1 050	1 470	1 710	19 620
Advertisement	1 200	6 000	4 800	480	480	360	360	360	360	600	840	1 080	16 920
In-app Purchases	-	-	-	-	-	-	270	270	450	450	630	630	2 700
Gross Profit %	60,0%	60,0%	60,0%	60,0%	60,0%	60,0%	70,0%	70,0%	73,6%	70,0%	70,0%	68,4%	62,9%
Advertisement	60,0%	60,0%	60,0%	60,0%	60,0%	60,0%	60,0%	60,0%	60,0%	60,0%	60,0%	60,0%	60,0%
In-app Purchases	90,0%	90,0%	90,0%	90,0%	90,0%	90,0%	90,0%	90,0%	90,0%	90,0%	90,0%	90,0%	90,0%

Sales Forecast Best Case Scenario year 2

Sales Forecast

	month 13	month 14	month 15	month 16	month 17	month 18	month 19	month 20	month 21	month 22	month 23	month 24	year 2
	Jul-2016	ago-2016	set-2016	out-2016	nov-2016	dez-2016	Jan-2017	fev-2017	mar-2017	abr-2017	mai-2017	Jun-2017	Total
Volume	3 500	9 000	4 500	1 500	1 500	1 100	1 100	1 100	1 200	1 900	2 000	2 000	30 400
Regular Users	2 000	5 000	2 500	700	700	500	500	500	600	900	1 000	1 000	15 900
In-app Purchases	1 500	4 000	2 000	800	800	600	600	600	600	1 000	1 000	1 000	14 500
Selling Price	2,71	2,67	2,67	2,40	2,40	2,36	2,36	2,36	2,50	2,42	2,50	2,50	2,57
Advertisement	4,00	4,00	4,00	4,00	4,00	4,00	4,00	4,00	4,00	4,00	4,00	4,00	4,00
In-app Purchases	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00
Sales	9 500	24 000	12 000	3 600	3 600	2 600	2 600	2 600	3 000	4 600	5 000	5 000	78 100
Advertisement	8 000	20 000	10 000	2 800	2 800	2 000	2 000	2 000	2 400	3 600	4 000	4 000	63 600
In-app Purchases	1 500	4 000	2 000	800	800	600	600	600	600	1 000	1 000	1 000	14 500
Cost of Sales	3 350	8 400	4 200	1 200	1 200	860	860	860	1 020	1 540	1 700	1 700	26 890
Advertisement	3 200	8 000	4 000	1 120	1 120	800	800	800	960	1 440	1 600	1 600	25 440
In-app Purchases	150	400	200	80	80	60	60	60	60	100	100	100	1 450
Gross Profit	6 150	15 600	7 800	2 400	2 400	1 740	1 740	1 740	1 980	3 060	3 300	3 300	51 210
Advertisement	4 800	12 000	6 000	1 680	1 680	1 200	1 200	1 200	1 440	2 160	2 400	2 400	38 160
In-app Purchases	1 350	3 600	1 800	720	720	540	540	540	540	900	900	900	13 050
Gross Profit %	64,7%	65,0%	65,0%	66,7%	66,7%	66,9%	66,9%	66,9%	66,0%	66,5%	66,0%	66,0%	65,6%
Advertisement	60,0%	60,0%	60,0%	60,0%	60,0%	60,0%	60,0%	60,0%	60,0%	60,0%	60,0%	60,0%	60,0%
In-app Purchases	90,0%	90,0%	90,0%	90,0%	90,0%	90,0%	90,0%	90,0%	90,0%	90,0%	90,0%	90,0%	90,0%

Sales Forecast Best Case Scenario year 3

Sales Forecast

	month 25 Jul-2017	month 26 ago-2017	month 27 set-2017	month 28 out-2017	month 29 nov-2017	month 30 dez-2017	month 31 jan-2018	month 32 feb-2018	month 33 mar-2018	month 34 abr-2018	month 35 mai-2018	month 36 jun-2018	Year 3 Total
Volume	5 000	12 000	6 500	1 300	1 000	900	900	8 700	1 700	1 900	2 200	2 200	44 300
Regular Users	3 000	7 000	4 000	800	700	700	700	700	900	900	1 000	1 000	21 400
In-app Purchases	2 000	5 000	2 500	500	300	200	200	8 000	800	1 000	1 200	1 200	22 900
Selling Price	4,00	3,92	4,08	4,08	4,50	4,89	4,89	1,40	3,65	3,37	3,27	3,27	3,42
Advertisement	6,00	6,00	6,00	6,00	6,00	6,00	6,00	6,00	6,00	6,00	6,00	6,00	6,00
In-app Purchases	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00
Sales	20 000	47 000	26 500	5 300	4 500	4 400	4 400	12 200	6 200	6 400	7 200	7 200	151 300
Advertisement	18 000	42 000	24 000	4 800	4 200	4 200	4 200	4 200	5 400	5 400	6 000	6 000	128 400
In-app Purchases	2 000	5 000	2 500	500	300	200	200	8 000	800	1 000	1 200	1 200	22 900
Cost of Sales	7 400	17 300	9 850	1 970	1 710	1 700	1 700	2 480	2 240	2 260	2 520	2 520	53 650
Advertisement	7 200	16 800	9 600	1 920	1 680	1 680	1 680	1 680	2 160	2 160	2 400	2 400	51 360
In-app Purchases	200	500	250	50	30	20	20	800	80	100	120	120	2 290
Gross Profit	12 600	29 700	16 650	3 330	2 790	2 700	2 700	9 720	3 960	4 140	4 680	4 680	97 650
Advertisement	10 800	25 200	14 400	2 880	2 520	2 520	2 520	2 520	3 240	3 240	3 600	3 600	77 040
In-app Purchases	1 800	4 500	2 250	450	270	180	180	7 200	720	900	1 080	1 080	20 610
Gross Profit %	63,0%	63,2%	62,8%	62,8%	62,0%	61,4%	61,4%	79,7%	63,9%	64,7%	65,0%	65,0%	64,5%
Advertisement	60,0%	60,0%	60,0%	60,0%	60,0%	60,0%	60,0%	60,0%	60,0%	60,0%	60,0%	60,0%	60,0%
In-app Purchases	90,0%	90,0%	90,0%	90,0%	90,0%	90,0%	90,0%	90,0%	90,0%	90,0%	90,0%	90,0%	90,0%

Annex B: Internet of Things

Economic Perspective

In the past years there has been a boom of excitement about the IoT, both in businesses and in major media. However, when we think about the term IoT, it has little meaning because it is not clear what we are talking about. Where is the value in the IoT?

However, if we instead think of *smart, connected products*¹ [47], we realize that the value is not in the Internet, but in the products or *things*. We can now ask ourselves, which are the benefits of connecting the products to the Internet.

There are three main benefits, the first being that companies can service things better if they communicate with these *things* so that companies can understand how costumers interacts with the product, and learn with that interaction.

The second benefit is that users can operate the products better, such as remote operation for reasons of safety, accessibility, etc.

The third benefit is transforming this new information to make the products better, through feedback loops into the engineering and design processes.

These benefits will have a transformative effect on the way things are created, operated and serviced; and thus a tremendous amount of efficiency, differentiation and value will be created as a result. One can be proactive and more efficient in developing the product, because it is possible to learn in first-hand the issues of the product [47].

The IoT is not a new term, it has been developed for the past 20 years, but it took 20 years to connect only 1% of what can be connected in the world. However, the number of people and devices connected will go up exponentially in the next 10 years. [48]

The IoT is transforming the physical world in a sort of information system, via sensors and actuators embedded in physical objects and linked to the Internet protocol [49], and this worldwide information system will lead the fourth industrial revolution (steam engine, the converges belt and the first phase of IT and automation). This revolution will decentralize production and cause a paradigm shift in manufacturing because individual factories will transform into interconnected factories across the world. To enable the interconnection, a complex software architecture is essential to keep the network together through steering algorithms that will link millions of data and will ensure that everything is synchronized.

These algorithms already exist, and mathematics has already solved numerous problems that technology will not encounter in the real world in the next 50 years [49]. All of the information, queries and computing gathered through the IoT needs to be processed filtered, aggregated and data mined for further analysis. This complex software will be sustained by HTTP and by the Internet Protocol (IP) [50].

Nowadays, companies see the physical flows as separate from the information flows and try to coordinate and synchronize both of them individually. After the fourth industrial revolution, there will be no difference between material and information, because products will be inextricably linked to *their* information. [49]

The IoT will change the way we see products, and will revolutionize the value of information. A product will gather data that will service the customer better in the future. In addition, this revolution has started with the globalization of smartphones and tablets, as see in Figure 59, where in 2015 there will be more mobile-phone subscriptions than the world population [51].

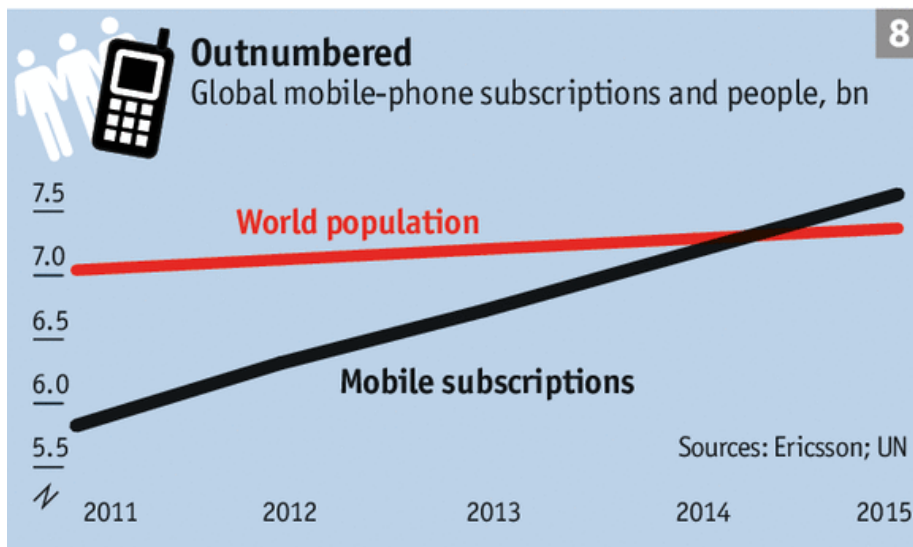


Figure 59 - Number of mobile-phone subscription compared to the World Population [35]

The IoT has two groups of emerging applications: the Information and Analysis, and the Automation and Control [52].

In the Information and Analysis group, we have applications like Tracking behavior (with products embedded with sensors, like a simple smartphone, where products and costumers can have their movements tracked), the Enhanced Situational Awareness (with a large number of sensors placed in infrastructures, decision makers will have real time information for situational awareness), and Sensor-Driven Decisions Analytics (actuators can have complex human planning and decision making, analyzing data from around the world).

The Automation and Control group, has Process Optimization (data analyzed from sensors will send signals to actuators to adjust the processes, creating an automation loop - this being the earliest and best-know application for IoT [53]), Optimized Resource Consumption (Network Sensors and Automated Feedback Mechanism can crate price patterns, including water and energy, which will enable a more dynamic pricing), and Complex Autonomous Systems (with a fast, real-time sensing of unpredictable conditions that can have instantaneous responses from automated systems) [52].

Over the next 10 years, the IoT has a potential financial value of \$300 billion to \$15 trillion [54], and this will mean a big market opportunity for many businesses. As up to 30 billion *things* will be connected to the IoT by 2020 (Figure 60).

Yet, companies need to realize that only 10% of the financial value will be created by the hardware, whilst the other 90% comes from the information gathered by connecting *things* to the Internet [54]. To create additional value, the *things* need to be connected to the cloud.

Each IoT device will require, at a minimum, a microcontroller (MCU) to add intelligence, sensors to collect data, chips to data transmission, and a memory component. This will start a demand of a new class of components created specifically for the IoT [53]. This new class of components must be self-sustained or rely on energy harvesting, have wireless connection and need to be plugged to the Internet [50].

Some 30 billion objects may be connected to the Internet of Things¹ by 2020.

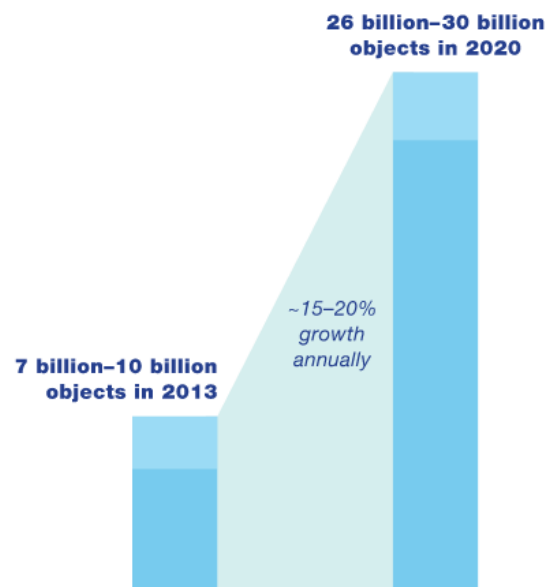


Figure 60 - Things connected to the Internet of Things by 2020 [38]

However, according to a *McKinsey* projection, existing Internet protocols such as HTTP and Transmission Control Protocol (TCP) are not optimized for low power communications due to packet acknowledgment at higher layers. In this area at IEEE and IETF level much work have been done and new efforts are in progress. In addition, because those devices must have optimal power consumption and an outstanding power management, this will favored new technologies that will result in integrated circuits that are one-third smaller than standard chips have 50% lower power consumption, have a bandwidth 8 times higher, and have 50% lower cost compared with traditional systems [53].

The power and network limitation will be a big factor in wireless communication. Wi-Fi, Bluetooth and ZigBee are sufficient to enable most IoT applications. However, for low power and low data rate connectivity of more than 20m, cellular technologies and Wi-Fi fall short.

In these situations, new technologies from the Weightless and Bluetooth groups are emerging [53].

There are still concerns that must be addressed to allow the IoT to flourish in the upcoming years. There is still an interoperability between standards across industrial environments, and new standards that can collect data from various different software and show the data more reliably [53].

The biggest concern, however, remains in the security and privacy issues, mainly in Industrial and medical environments, where hacking must be prevented [53]. Consumers are afraid that personal information can be leaked, and companies of loss of their intellectual propriety.

Companies and governments spent tens of billion dollars annually to protect against hacking, but this is not enough. The Sony hacking in 2014 that cost the company \$200 million. Security problems is getting worse by the year, and 80% of technologies executives say that their companies cannot keep up with the attackers increasing sophistication, and that security could drive as much as 20%-30% of their overall activity costs [55]. Security and privacy is the main obstacle to IoT proliferation, and can materially slow the pace of technology and business innovation.

The future of technology and industry goes through the IoT, and companies and academia must start to solve the problems or risk losing the next industrial revolution.

Protocol Stacks and OpenWSN

There are innumerable sensor networks but nowadays, one of the most common normalized solutions are based in IPv6. The OpenWSN is in the frontline of IPv6 and was developed for industrial environments but it can be implemented in Mobile and Web platforms. To understand the OpenWSN stack and the underlying standards the following study was performed.

To assure that the IoT has the ability to interconnect Internet-connected objects, “things”, machines and users, there are three core requirements that need to be satisfied.

- A Low Power Communication Stack (since energy harvesting cannot be applied in the majority of situations, and changing batteries regularly is not an option, any stack need to exhibit a low average power consumption)
- a Highly Reliable Communication Stack (for the IoT to merge with the Internet, it needs to have the same reliability, with a high efficiency)
- An Internet-Enabled Communication Stack (once the communication is bidirectional, the IoT must be IP enabled, to ensure communication from objects and toward objects).

These three requirements call for a standardized communication [50] stack such as the one presented in table 15...

application	CoAP, HTTP
transport	UDP, TCP
IP/routing	IETF RPL
adaptation	IETF 6LoWPAN
medium access control	IEEE802.15.4e
physical	IEEE802.15.4-2006

Table 15 - Standard communicating technologies

Low-Power PHY Layer (IEEE 802.15.4)

The IEEE 802.15.4 standard defines the physical layer and an energy efficient MAC layer. Both are designed to ensure a low power communication among the IoT [50].

Before presenting the physical layer standard, a few notions on radio communications are provided.

Radio hardware converts bytes of digital information into radiation of an electromagnetic signal through the atmosphere or vacuum. The transmission takes place when bytes of information are modulated into parts of radiation waves, such as amplitude, frequency and phase. The radiation is then amplified before being sent to the antenna. The signal shades its amplitude as it travels through the air, due to fading and shadowing, so when it is picked by the receiver antenna the signal needs to be amplified again to be demodulated.

Since the amplifier in the Radio draws substantial amount of current, Radios are often the most power hungry component on the IoT device, and it consumes almost the same current while in idle listening or transmitting/receiving.

However, the radio does not consume current when turned off, so the secret of a Low-Power Communication Stack is to allow a reliable transmission, whilst having the radio off most of the time. The radio only turns on when has to transmit or receive, and the portion of time the radio is on is called duty cycle. Therefore, optimization of power consumption implies having the lowest radio duty cycle that ensure reliable transmission.

Some typical values for low power radio parameters are: 0 dBm (or 1 mW) for output power, -90dBm for sensitivity (i.e. minimum received signal power to enable signal to be successfully demodulated), and a duty cycle lower than 1%. [50].

PHY of IEEE 802.15.4

The IEEE 802.15.4 PHY manages the physical attributes of the network communication, which have impact in the energy efficiency, the communication range, and the data rate. The current standard defines multiple PHY layers, but the mostly used is the one that operates in the 2.4GHz ISM frequency band, using DSSS modulation, and supporting 250kbps.

The IEEE 802.15.4 layer breaks the bandwidth in smaller chunks, in the case of the 2.4 -2.485 GHz frequency band the IEEE 802.15.4 defines 16 frequency channels each with 5 MHz between 2.405 and 2.480 GHz. However a channel is only 2 MHz wide, the remaining frequencies are used to ensure a reliable communication with the above and below bands by helping to avoid signal interference. The radio can communicate in either of these 16 bandwidths and is able to switch channels in no more than 192 μ s [50].

To send a packet, the radio sends a physical preamble for 123 μ s to allow the receiver to lock the signal [50]. Then, the radio sends the Start of frame Delimiter (SFD) to denote the start of the physical payload. The first byte of the physical payload indicates the physical length of the payload itself, as if to say how much time does the receiver radio needs to be on. After the packet is successfully received, the receiver sends an acknowledgment packet to the transmitter. There are only two requirements from the implementers point of view, the maximum length of the packet must be lower the 128 bytes, and the first byte must indicate the length of the packet.

Power Saving MAC Layer (IEEE 802.15.4e)

The IEEE 802.15.4 also defines the MAC protocol, the layer that stays on top of the Physical layer. This layer defines the format of the MAC header and the procedure a mote must follow in order to have access to the medium (to communicate with another mote(s)).

The most used 802.15.4 MAC mode of operation is based on using a predefined channel and CSMA. This is ill-suited for multi-hop communication because motes hearing for data must be always on, and single channel operation could cause the network to fail because of network instabilities such as shadowing and multi-path fading.

To solve these problems, the IEEE 802.15.4e was created to update the MAC protocol change through time synchronization and channel hopping which will enable high reliability while maintaining low duty cycles. The last generation of highly reliable and low-power MAC protocol is the Time Synchronized Channel Hopping (TSCH) and is part of the IEEE 802.15.4e since 2010 [50] and synchronizes the motes for energy efficiency and channel hopping for reliability.

Slotframe Structure

The TSCH synchronizes the motes according to a slot frame structure, which is a group of slots that repeats itself over time. Each mote has a schedule that defines what each slot has to do. A slot can either, transmit, receive or sleep (in this case the radio is off to save energy). The schedule also indicates which neighbors the mote can communicate with, and on which channel offset it communicates.

A slot has to be long enough to enable to transmit the longest possible packet and for the receiver to send an acknowledgment indicating good reception.

Once the upper layer generates a packet, it sends the packet to the MAC layer which is going to store the packet in the transmit queue. When the schedule has a transmission slot, the MAC layer verifies if it has a packet destined to a neighbor associated with the slot. If there is a packet in the transmit queue, the mote transmits the packet and waits for an acknowledgment. If the mote receives the acknowledgment it removes the packet from the queue, otherwise it keeps the packet for future transmission. For security reasons, there is a maximum number of transmissions for every packet to avoid staleness. If there is not a packet in the transmit queue, the mote goes to sleep, waiting for a transmission slot.

When the schedule has a receiving slot the mote turns the radio on, and waits for a packet. If it receives a packet, the mote sends an acknowledgment to the transmitter and turns the radio off. Then, forwards the packet to the upper layers for processing. If the mote does not receive a packet after the maximum time for the longest possible packet, it turns the radio off. This means that the transmitter mote has nothing to say, or that the packet is lost due to interferences. To ensure the communication the radio starts before it is expected to do so.

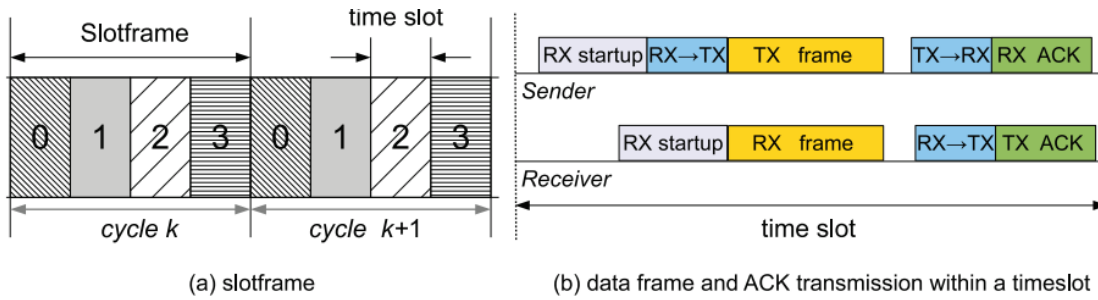


Figure 61 - A 4-slot slotframe and timeslot diagram of an acknowledgment transmission [50]

The Figure 61 shows a 4-slot slotframe, where the schedule is the cycle k and the time slot is long enough to transmit, or receive, the longest possible packet.

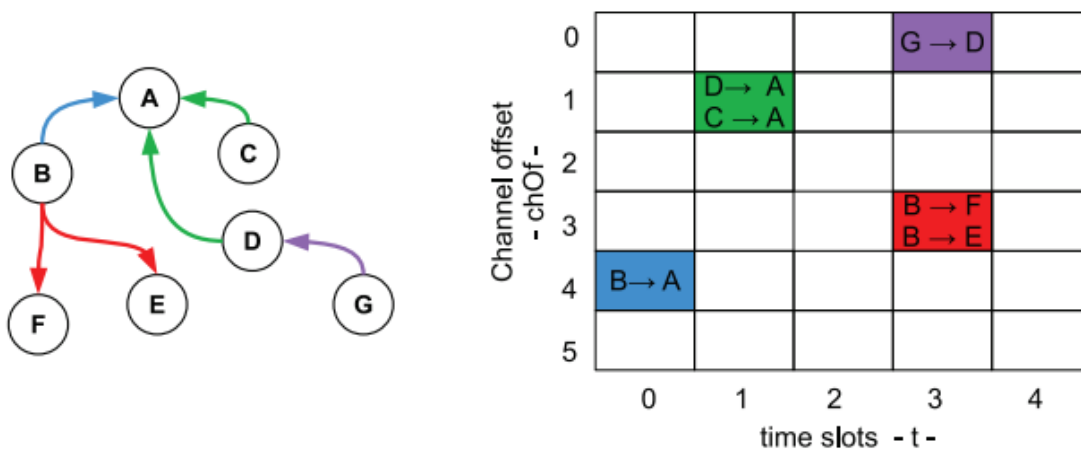


Figure 62 - Example network topology and the associated schedule [50]

The associated schedule in the Figure 62 has a slotframe of 5 slots with 6 channels offset where the communications occur. The channel offset prevents overlapping of communication. For example, B has a packet for A, it waits for slot 0 and sends the packet in the 4 channel offset. If G wants to send a packet for A, it first send the packet to D in the slot 4 and then D send the same packet to A in slot 1. Motes can share channels offset.

If a collision occurs, the IEEE 802.15.4e has a simple backoff scheme for shared cells [50].

Scheduling

The IEEE 802.15.4e only defines how the MAC layer implements the schedule, it does not specifies how the schedule is built. The schedule needs to be assembled accurately so that when the mote A wants to send a packet to mote B, mote B is actually listening to the mote A. Similarly, when mote B is no longer neighbor to mote A, mote B should not listen anymore to the mote A. This shows that the schedule needs to be constantly updated as links come and go in the network.

Scheduling can be mounted either in a centralized or a distributed way:

- Centralized

In the centralized approach, the manager mote is responsible to mount and update the network schedule, while the other motes send information to the manager with the list of the motes that communicate with them and the amount of data it is generating. Through the neighbor information the manager sets the connectivity graph and with the information about the amount of data received by the motes, the manager assigns the slots to the different links in the connectivity graph.

Once the schedule is built, according to the information sent by all the motes in the network, the manager mote reports each mote and links it is participating, the mote simply follows the schedule. When a mote loses a neighbor, the manager updates the schedule and reports to the respective motes.

In the real world, there is a gateway mote in the network that ensures the Internet connection. In the centralized approach, the manager is usually the gateway mote as well.

The centralized approach mounts a very efficient schedule because the manager knows what is the best network according to the motes' needs and it can also apply centralized networks techniques [50].

- Distributed

In cases where the topology is changing constantly, with the motes moving and changing its neighbors, the network is continuously transforming.

In this approach, the motes decide locally which links to schedule with its neighbors, and the easiest solution is that each mote connects directly with its neighbor. This approach has a very challenging solution in multi-hop communication, where multiple motes generate data at a constant rate. The distributed approach is usually used in cases where it is needed many gateway motes to connect to the Internet [50].

Synchronization

The synchronization between motes is fundamental to ensure the communication between neighbors in a slotframe-based network. There are two methods utilized that allow the motes to stay synchronized in the network: the Acknowledgment-Based synchronization and the Frame-Based synchronization. In the Acknowledgment-Based Network, the receiver calculates the delta between the expected time of frame arrival and the actual time of arrival, and sends this information back to the transmitter mote in its acknowledgment. This information allows the transmitter mote to synchronize to the receiver. The Frame-Based synchronization also has the receiver calculating the delta of the difference between expected time and the actual time, but in this case, the receiver adjusts its own clock by the difference, which allows the receiver clock to synchronize with the transmitter clock.

If there is traffic in the network, motes keep synchronizing through communication, however in times with less traffic the motes could lose track of each other's clocks. To avoid this situation, if neighbors do not communicate for some time (30 s), they exchange a keep alive packet (an empty packet just used to re-synchronize the motes).

In the IEEE 802.15.4e TSCH network, time propagates from the manager to all motes in the network, to maintain the clocks at the same time. This allows a unidirectional time propagation and avoid timing loops in the network, as each mote synchronizes its internal clock to the neighbors. The time propagation is independent of data flow in the network [50].

Channel Hopping

Channel Hopping means frequently changing the communication channel used to send information. In this case using each time a different channel from the 16 ones available in the 2.4GHz ISM band. This will mitigate the effects of interference and multipath fading. Using several frequencies also increases the network traffic capacity because different motes can communicate at the same time, using different channels. Additionally, channel hopping combined with slot access policy improves the overall reliability.

The Absolute Slot Number (ASN) is a number shared by all the network that counts the number of slots elapsed since the network was deployed. The ASN is incremented by each slot, and it is the same through the whole network, it allows the network to define which channel the mote will utilize in the communication.

. There is also a translation function that ensure that each link rotates though all the frequency channels and the slotframes cycles, where successive frames over the same link are sent through different frequency channels in successive slotframe cycles [50].

Network Formation

Network formation in TSCH networks have two different components: advertising and joining. If a new mote is implemented in the network it tries to listen for Advertisement command frames and when one of these frames is received this new mote joins the network through sending a Join Request command frame to an advertising device.

If the network has a centralize management system, the Join Request frames are kept by the network manager. In a distributed manager system, the frames are routed locally. When a mote is accepted into the network, the advertiser activates the mote through setting slotframes and link between the new mote and its neighbors.

The TSCH network works in a centralize management system, so the first mote is the manager and it initializes the slotframe to which to whole network will later synchronize. This first mote will also defines the links between motes that allows broadcast and communication in the network. The first two slots in the slotframe are reserved for the Advertising frame and the Join Request frame, respectively.

When all motes have joined the network and the manager did not receive more Join Request frames, the manager can disable the Advertising frame. However, if there are new motes that want to join the network, the Advertising frame can be enabled again.

Connecting to the Internet (IETF 6LoWPAN)

Communication through the Internet need to cross different interconnected networks from the source to the destination, however, the main requirement is the transport of IP packets and the mapping of services by the IP layer [50]. The IETF 6LoWPAN working group has established an adaptation layer for transmitting IPV6 over IEEE 802.15.4 networks.

The low power WPANs are: small packet sizes, support addresses with different lengths, have low bandwidth, work on star or mesh topologies, uses battery supplied devices, low cost, composed by a large number of devices, do not know the motes positions, have low reliability, and have long periods of idle periods when communications are turned off to save energy.

Despite the IPv6 limitations, the IETF 6LoWPAN has been updated to enable the auto-configuration of IPv6 addresses because IPv6 can support any address dimension, which is ideal to the adaptation layer.

6LoWPAN Frame Format

To manage IPv6, the 6LoWPAN established an intermediate adaptation layer between IPv6 and IEEE 802.15.4 MAC levels.

6LoWPAN encapsulates datagrams which are prefixed by a stack of headers, each one identified by a type field. The headers can be logically grouped in four classes, depending on the function of each of the adaptation strategy:

- The NO 6LoWPAN Header.
- The Dispatch Header compresses an IPv6 header or manages link-layer multicast/broadcast
- The Mesh Addressing Header enables the IEEE 802.15.4 frames to be submitted at link-layer, transforming single-hop WSNs in multi-hops.
- The Fragmentation header is used when the datagram does not fit a single IEEE802.15.4e frame.

The NO 6LoWPAN Header specifies that the received packet is not compliant with the 6LoWPAN specifications and has to be discarded, to allow coexistence between motes in the same network.

Since the IEEE802.15.4e standard does not define routing capabilities, it has to rely on functions of upper layers to this task. The routing enables commutation between motes even when they are not neighbors; intermediate motes pass the information between the original transmitting motes to the final receiver mote. This frame delivery uses a unicast communication, the Mesh Addressing Header, and is the first header used in the 6LoWPAN encapsulation.

When there is need to broadcast/multicast communication there needs to be controlled flooding mechanism. The Broadcast header it is a similar to the Dispatch Header includes a 1 byte long sequence number for packet detection to avoid transmitting of duplicated packets.

The Fragmentation Header includes a Datagram Size that is the dimension of the IP packet, before link fragmentation, which is the same for link layer fragments of the IP packet. It also has a Datagram Offset with the fragment in the beginning of the payload.

The Dispatch Header is used for encapsulating and compressing the IPv6 packet, using the 6LoWPAN specifications consider LoWPAN_IPHC encoding scheme.

Routing (IETF ROLL)

Routing is complicated for 6LoWPAN because multiple requirements are needed, like low power, radio links with high loss, battery supplied motes, multi-mesh topologies and the frequent topologies changes. It also has to take in account the Ipv6 behavior and 6LoWPAN mechanism.

An effective solution is the IETF *Routing Over Low power and Lossy (ROLL)* network, used in IPv6 Routing Protocol for Low power and Lossy networks (LLN's), and Recognition of Prior Learning (RPL) based on a gradient-based approach [50]. RPL supports a wide variety of different link layers and it can quickly build up network routes while informing the nodes of the routing, a constructing very efficient topologies. Due to these characteristics, the RPL is advised for smart grid communications.

In a typical RPL setting, the motes of the network communicate through multi-hop paths to a small set of root devices, who are responsible for data collection and coordinate the communications. For each of the deviced root, it is created a Destination Oriented Directed Acyclic Graph (DODAG) that is responsible for links costs, mote attributes/status information, and an Objective Function who will map the optimal root for the intended objective. The network topology is set-up based on a ranking metric, which codifies the distance between motes relative to the to the reference root. The ranking should monotonically decrease along the DODAG and towards the final target. The RPL can also compute different kinds of traffic and signaling the information communicated between motes depended on the traffic data flow.

Multipoint-to-Point (MP2P) is the dominant traffic in the LLN and is routed towards the motes with application relevance, like the LLN gateways that connects the networks to the Internet or core private IP networks. Normally, these destinations are DODAG roots and they function as data collection points for distributing and monitoring the applications. Contrary to the MP2P, the Point-to-Multipoint (P2MP) data streams are used for actuation, through messages, sent from DODAG to the target mote.

Lastly, the Point-to-Point (P2P) traffic enables communication between two motes in the same LLN, like a sensor and an actuator. In P2P communications, the packet flows from the source to the nearest mote between these two motes, and then to the final mote.

To enable these traffic communications, the RPL has to control the upwards routes, from the motes to the DODAG roots, supporting MP2P and P2P communication. To control the downwards routes, DODAG roots to the motes, RPL enables M2MP and P2P flows [50].

RPL Topology Formation

The RPL topology can go from a single DODAG with just one route, to more complicated topologies such as multiple uncoordinated DODAG's with independent roots. A single DODAG with a virtual root can coordinate several LLN and create a sophisticated and flexible configuration. This virtual configuration has the advantage of reducing the limitations on the parent set selection so the nodes in the network can belong in the same DODAG root. It is also possible to construct hybrid topologies, and present a complex topology.

There is the possibility that a network has all the topologies implemented depending on the instant optimal routing objective, such as minimization of the delay or energy consumption. The RPLInstanceID is employed to identify the topologies used at every time in, and the RPL information dissemination mechanism controls the topology to a minimal configuration that operates the nodes autonomously. Since the DODAG Information Option (DIO) has information about the Rank, the Objective Function, the ID's, etc. which is vital to mount the topology, the DODAG works with the RPL to establish the optimal topology for each communication at every time.

To implement network formation and manage the communications, all nodes need to execute an order of operations, such as send and receive DIOs, compute their own Rank, join the DODAG and then choose the neighbors to communicate. A node that receives a DIO analyzes the information and acts to leave or maintain the DODAG, according to the Rank of their neighbors and the Objective Function, and then sets up its own Rank. After this, the node chooses the manager node. Analogously, the nodes advertise their presence, after setting their own Rank, by sending DIO messages to their neighbors.

These procedures are only applied in the upward routes. The Destination Advertisement Object messages from the RPL, create a back-propagating routing information from the end points to the roots, and they are triggered by the DIOs. After a Destination Advertisement Object message is received, the respective node forwards it to its parent creating a downward path [50].

The Objective Function

The Objective Function defines the Rank according to the metrics and constraints in the RPL Control Messages. It computes the node distance from a DODAG root to optimize the network topology efficiently. The Objective Function also allows the node to join the DODAG root and choose its DODAG parents from the neighbor nodes, and this event can be triggered according to several events such as the reception of a DIO message, a timer elapse, DODAG parents becoming unavailable, or a trigger indicating that the state of a candidate neighbor has changed. Once the Objective Function has scanned the nodes interfaces to check if a link can be established in the topology, all the possible neighbors are verified to act as a RPL router. These primary operations are essential to exclude the links and nodes who do not have Objective Function compatibility, such as performance, consumption or security issues. The nodes that have compatibility are tested to see the Rank that would result if each one of them was selected as

the parent, and the one who provides the smaller Rank is selected as parent, provided that this Rank is smaller than the used one [50].

The Objective Function proposed by the IETF are:

1) Objective Function 0

Requiring just the information in the RPL DIO header, the Rank is achieved through normalized scalar, RankIncrease, to Rank the selected parent. The Objective Function 0 is the common denominator of all the generic implementation, because it does not use the metrics to compute link properties. The Rank is obtained only through computation [50].

2) Minimum Rank Objective Function with Hysteresis:

This Objective Function is designed to find the smaller path cost while avoiding excessive traffic in the network. This method uses metrics to achieve the optimal path. It also employs the DODAG parent with one mote, which is the automatically chosen parent from all the motes available [50].

Transport Layer and Above (IETF CoAP)

The LLN uses IPv6 to provide Internet integration enabling the motes to be addressed and able to transfer information through the whole network. However depending on the network requirements, for complete Internet compatibility some features are required. To enable the mote to manage multiple non-interfering requests it is required a specialized application code running at every mote or a multiplexing network layer using the concept of port. To ensure reliability in end-to-end communications it needs to be addressed by upper-networks layers such as transport application in the TCP/IP network stack.

The application layer protocols ease content representations and inter-operability between different applications, such as the HTTP which enables to inter-operate between client/server and content/resource. The main objective is the development of LLN's that can be integrated with existing applications without need of additional updates. The LLN communicate directly with the application layer protocols. Two techniques to compress the application layer protocol are presented:

Transport over LLN's

The Transport layer is responsible for reliable end-to-end communications over the IP based networks, while the TCP provides traffic and congestion control over Automatic Repeat Request (ARQ). To control the traffic on the Internet and ensure reliability, it uses control overhead inserted in every transmitted packet.

The IoT demand energy requirements and reliable communication in LLN's. To this effect, the User Datagram Protocol (UDP) and retransmissions protocols ensure a good relation between energy and

reliability. The UDP is a data oriented protocol mechanism and overhead for communication between applications, where the transaction, delivery or duplicate security is not guaranteed.

Application Layer

To provide inter-operability communication between all the devices addressed by LLN's, using the de-facto standard Internet application, there is necessity to restrict the use of different protocols. Because of LLN's restrictions, RESTful architectures like the client/server model defined by HTTP is not possible, and there is need for a new approach for the application layer.

The IETF Constrained RESTful Environments (CORE) working group has developed the Constrained Application Protocol (CoAP) and translates to HTTP for Internet integration while resolving LLN requirements. The features addressed allowed the CoAP to be the generic protocol for LLN's.

The CoAP is an asynchronous/response protocol over a datagram oriented transport like the UDP, and the CoAP client/server architecture is different because the end-points act both as client and servers. The CoAP architecture is divided in five methods, presented in Figure 63.

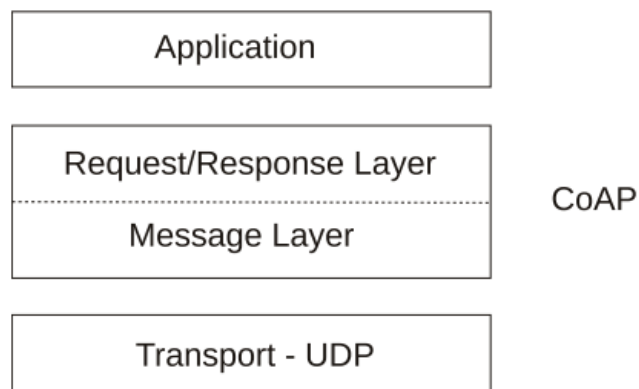


Figure 63 - CoAP Architecture [50]

Bibliography

- [1] Agile Manifesto, "Agile Manifesto," 2001. [Online]. Available: <http://www.agilemanifesto.org/>. [Accessed 24 08 2015].
- [2] "Agile Methodology," 2008. [Online]. Available: <http://agilemethodology.org/>. [Accessed 24 08 2015].
- [3] "Scrum Alliance," [Online]. Available: <https://www.scrumalliance.org/>. [Accessed 24 08 2015].
- [4] "Statista," [Online]. Available: <http://www.statista.com/statistics/276623/number-of-apps-available-in-leading-app-stores/>. [Accessed 28 08 2015].
- [5] V. H., "phoneArena.com," 24 July 2014. [Online]. Available: http://www.phonearena.com/news/Androids-Google-Play-beats-App-Store-with-over-1-million-apps-now-officially-largest_id45680. [Accessed 15 April 2015].
- [6] E. Protalinski, "VB news," 2014 8 2014. [Online]. Available: <http://venturebeat.com/2014/12/08/google-releases-android-studio-1-0-the-first-stable-version-of-its-ide/>. [Accessed 15 April 2015].
- [7] S. R. Leonard Richardson, RESTful Web Services, O'Reilly Media, 2007.
- [8] "php," [Online]. Available: <http://php.net/manual/en/history.php.php>. [Accessed 15 April 2015].
- [9] A. Ide, "Netcraft," 2013 January 2013. [Online]. Available: <http://news.netcraft.com/archives/2013/01/31/php-just-grows-grows.html>. [Accessed 15 April 2015].
- [10] A. H. R. S. J. D. James H. Coombs, "Markup Systems and the Future of Scholarly Text Processing," *Communications of the ACM* 30, 1987.
- [11] "w3," [Online]. Available: <http://www.w3.org/TR/html401/conform.html#deprecated>. [Accessed 15 April 2015].
- [12] H. W. Lie, "Cascading Style Sheets," University of Oslo, Oslo, 2005.
- [13] D. Raggett, "w3," 14 March 1997. [Online]. Available: <http://www.w3.org/TR/WD-script-970314>. [Accessed 15 April 2015].
- [14] "MySQL," [Online]. Available: <http://www.mysql.com/>. [Accessed 06 08 2015].
- [15] "Digital Ocean," [Online]. Available: <https://www.digitalocean.com/community/tutorials/sqlite-vs-mysql-vs-postgresql-a-comparison-of-relational-database-management-systems>. [Accessed 20 08 2015].

- [16] R. T. Fielding, "Representational State Transfer (REST)," in *Architectural Styles and the Design of Network-based Software Architectures*, University of California, 2000.
- [17] "JSON," [Online]. Available: <http://json.org/>. [Accessed 06 08 2015].
- [18] L. A. Cunningham, "Language, Deals and Standards: The Future of XML Contracts," George Washington University, Washington DC, 2006.
- [19] T. Bray, J. Paoli, C. M. Sperberg-McQueen, E. Maler and F. Yergeau, "Extensible Markup Language (XML)," 2008.
- [20] "Facebook," Facebook, [Online]. Available: www.facebook.com. [Accessed 2015 April 2015].
- [21] D. J. C. Silva, "Combinação de Mundos," Universidade de Coimbra, Coimbra, 2013.
- [22] "Foursquare," Foursquare, [Online]. Available: <https://pt.foursquare.com/about>. [Accessed 15 April 2015].
- [23] "Play Store," Play Store, [Online]. Available: www.playstore.com. [Accessed April 15 2015].
- [24] "iTunes," iTunes, [Online]. Available: www.itunes.com. [Accessed 15 April 2015].
- [25] "Windows Phone," Windows Phone, [Online]. Available: <http://www.windowsphone.com/>. [Accessed 15 April 2015].
- [26] "Blackberry," Blackberry, [Online]. Available: <https://appworld.blackberry.com>. [Accessed 2015 April 2015].
- [27] "Symbian Store," Symbian Store, [Online]. Available: <http://symbianstore.net/>. [Accessed 15 April 2015].
- [28] "Yelp," Yelp, [Online]. Available: <http://www.yelp.com/about>. [Accessed 15 April 2015].
- [29] "Yelp," Yelp, [Online]. Available: www.yelp.com/guidelines. [Accessed 15 April 2015].
- [30] "Trip Advisor," Trip Advisor, [Online]. Available: http://www.tripadvisor.com/PressCenter-c4-Fact_Sheet.html. [Accessed 15 April 2015].
- [31] "Trip Advisor," Trip Advisor, 11 October 2011. [Online]. Available: http://www.tripadvisor.com.br/PressCenter-i4869-c1-Press_Releases.html. [Accessed 15 April 2015].
- [32] "A Guide to the Business Analysis Body of Knowledge," International Institute of Business Analysis, 2009.
- [33] "Android Developers," Google, [Online]. Available: <http://developer.android.com/index.html>. [Accessed 20 08 2015].
- [34] L. Orlandi, "West-Info," West-Info, 26 July 2012. [Online]. Available: <http://www.west-info.eu/interral-the-trains-for-young-people/>. [Accessed 18 March 2015].

- [35] "Economist," [Online]. Available: <http://www.economist.com/news/europe/21663256-once-symbol-hope-eu-fails-inspire-its-most-important-constituency-what-europe-means>. [Accessed 05 09 2015].
- [36] 16 January 2014. [Online]. Available: <http://www.emarketer.com/Article/Smartphone-Users-Worldwide-Will-Total-175-Billion-2014/1010536>. [Accessed 19 March 2015].
- [37] "Pew Research Center," [Online]. Available: <http://www.pewinternet.org/fact-sheets/mobile-technology-fact-sheet/>. [Accessed 19 March 2015].
- [38] "Mobilegeddon," *The Economist*, 20 April 2015.
- [39] "Should digital monopolies be broken up?," *The Economist*, 29 November 2014.
- [40] "GSMArena," [Online]. Available: <http://www.gsmarena.com/battery-test.php3>. [Accessed 22 08 2015].
- [41] N. Vivion, "tnooz," Applause, 5 November 2015. [Online]. Available: <http://www.tnooz.com/article/new-analysis-travel-app-ecosystem-benchmarks-quality-across-31-brands/>. [Accessed 3 March 2015].
- [42] A. Pappas, "Developer Economics," Vision Mobile, 14 October 2013. [Online]. Available: <http://www.developereconomics.com/6-tough-questions-app-business-models-strategies/>. [Accessed 3 March 2015].
- [43] J. Clampet, "Skift," 4 March 2013. [Online]. Available: <http://skift.com/2013/03/04/lonely-planet-and-the-rapid-decline-of-the-printed-guidebook/>. [Accessed 3 March 2015].
- [44] V. Kopytoff, "Fortune," 22 March 2013. [Online]. Available: <http://fortune.com/2013/03/22/why-google-is-pulling-the-plug-on-frommers/>. [Accessed 3 March 2013].
- [45] L. Peyton, "Social Fresh," 6 January 2011. [Online]. Available: <http://www.socialfresh.com/a-comparison-guide-for-creating-location-based-offers/>. [Accessed 19 March 2015].
- [46] J. Yarow, "Business Insider," 4 June 2012. [Online]. Available: <http://www.businessinsider.com/foursquare-yelp-public-markets-2012-6>. [Accessed 19 March 2015].
- [47] J. Heppelmann, "How the Internet of Things could transform the value chain," McKinsey & Company, December 2014.
- [48] R. Kirkland, "Connecting everything: A conversation with Cisco's Padmasree Warrior," McKinsey & Company, May 2013.
- [49] M. Löffler, "The Internet of Things and the future of manufacturing," McKinsey & Company, June 2013 .
- [50] N. A. X. V. T. W. L. A. G. G. B. M. D. Maria Rita Palattela, "Standardized Protocol Stack for the Internet of (Important) Things," *IEEE Communications Surveys & Tutorials*, 2013.

[51] K. Cukier, "The World in Transition," *The Economist*, no. The World in 2015, pp. 90-91, 2014.

[52] M. L. a. R. R. Michael Chui, "The Internet of Things," McKinsey & Company, The Internet of Things.

[53] M. P. a. J. V. Harald Bauer, "The Internet of Things: Sizing up the opportunity," McKinsey & Company, December 2014.

[54] M. P. a. J. Veira, "Making connections: An industry perspective on the Internet of Things," McKinsey & Company, December 2014.

[55] J. K. a. A. W. David Chinn, "Risk and responsibility in a hyperconnected world: Implications for enterprises," McKinsey & Company, January 2014 .
