ZoomAzores project:
Implementation of a WebGIS for Nature and Adventure Tourism

by

Òscar Vidal Calbet

Dissertation submitted in partial fulfillment of the requirements
for the Degree of Statistics and Information Management

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ABSTRACT

Nowadays, the Web offers new ways to make available information to users. This creates new ways and tools that can be used to make available tourist information and promotion of these destinations. The main objective this work is to develop a Web application for the ZoomAzores project. This web application uses dynamic maps and user-generated content features, which are focused on make available useful information for the tourist and the promotion of Nature and Adventure Tourism (NAT) in the archipelago of Azores. The solutions encountered were always determined by the technologies used and from the point of view of tourists visiting the Azores, which frequently doesn't know about the Azores territory. The ZoomAzores Web application has Geographic Information System (GIS) visualization and navigation capabilities on the Internet, turning it into a WebGIS. It also encompasses the principles of Web 2.0 providing functionalities such as the generation of contents by users. The existing link between the use of dynamic maps and Web 2.0 in the tourism promotion and travel planning tasks seems to be a solid reality putting up new opportunities for the business in tourism.

In this work, the development of the ZoomAzores WebGIS is based on the use of Open Standards (OS) and Free Open Source Software (FOSS). The use of OS is a key to the development of a WebGIS application able to interoperate with other systems and then use and consume Web Services (WS) that other systems can offer, concurrently enriching the data sources used. The FOSS technologies allow creates a more low cost solution without licensing cost software. This document exposes some design aspects in the system development and describes some functional and architectural features about the WebGIS ZoomAzores.

KEY WORDS

Tourism, WebGIS, Web 2.0, Open Standards, Web Services

RESUMO

Atualmente, a Web oferece novas maneiras de tornar as informações disponíveis aos utilizadores. Isso implica novas formas e ferramentas que podem ser usados para tornar as informações turísticas disponíveis e fazer promoção destes destinos turísticos. O objetivo principal deste trabalho é desenvolver uma aplicação Web para o projeto ZoomAzores. Esta aplicação Web utiliza mapas dinâmicos e funcionalidades que permitem a geração de conteúdo por parte dos utilizadores, estes estão focados em tornar a informação disponível para o turista e para a promoção do Turismo de Natureza e Aventura (NAT) no arquipélago dos Açores. As soluções encontradas foram sempre determinadas pelas tecnologias utilizadas e do ponto de vista dos turistas que visitam os Açores, que muitas vezes não sabe sobre o território dos Açores. A aplicação Web tem capacidades próprias dos Sistema de Informação Geográfica (GIS) como a visualização e navegação sobre informação geográfica, sendo isto a traves da Internet, transformando-o em um WebGIS. Também engloba os princípios da Web 2.0 com funcionalidades como a geração de conteúdo pelos usuários. A ligação existente entre o uso de mapas dinâmicos e Web 2.0 na promoção do turismo e as tarefas de planeamento de viagens parece ser uma realidade sólida colocando novas oportunidades para o negócio do turismo.

Neste trabalho, o desenvolvimento do WebGIS ZoomAzores é baseado no uso de padrões abertos (OS) e Software Free Open Source (FOSS). O uso de padrões abertos é a chave para o desenvolvimento de uma aplicação WebGIS capaz de interoperar com outros sistemas e assim usar e consumir Web Services (WS) que outros sistemas podem oferecer, ao mesmo tempo enriquecer a fontes de dados utilizadas. As tecnologias FOSS permitem criar uma solução de custo mais baixo, sem custo de licenciamento de software. Este documento expõe alguns aspectos do projeto no desenvolvimento do sistema e descreve algumas características funcionais e arquitectónicas sobre o WebGIS ZoomAzores.

PALAVRAS-CHAVE

Turismo, WebGIS, Web 2.0, Padrões Abertos, Serviços Web

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ACRONYMS

API	Application Programming Interface
ART	*Associação Regional de Turismo dos Açores*
ASTER	Advanced Spaceborne Thermal Emission and Reflection Radiometer
CAOP	*Carta Administrativa Oficial de Portugal*
DBMS	Database Management System
DEM	Digital Elevation Model
ESHTE	Escola Superior de Hotelaria e Turismo do Estoril
FES	Filter Encoding Standard
FOSS	Free Open Source Software
GDAL	Geospatial Data Abstraction Library
GEBCO	General Bathymetric Chart of the Oceans
GIS	Geographic Information System
GML	Geographic Markup Language
GPS	Global Position System
GSDI	Global Spatial Data Infrastructure Association
HTTP	Hypertext Transfer Protocol
ICT	Information and Communication Technologies
IDE	Integrate Development Environment
IGEO	*Instituto Geográfico Português*
ISEGI	*Instituto Superior de Estatística e Gestão da Informação*
KML	Keyhole Markup Language
LGPL	Lesser General Public License
METI	Ministry of Economy, Trade and Industry
NASA	National Aeronautics and Space Administration
NAT	Nature Adventure Tourism
OASIS	Organization for the Advancement of Structured Information Standards
OGC	Open Geospatial Consortium

OS	Open Standards
OSGeo	Open Source Geospatial Foundation
OSI	Open Source Initiative
OSS	Open Source Software
PHP	Hypertext Preprocessor
PPGIS	Public Participation GIS
RDF	Resource Description Framework
SDI	Spatial Data Infrastructure
SLD	Styled Layer Descriptor
SOA	Service Oriented Architecture
UDDI	Universal Description Discovery Integration
URI	Uniform Resource Identifiers
URL	Uniform Resource Locator
UTM	Universal Transverse Mercator
W3C	World Wide Web Consortium
WCS	Web Coverage Service
WFS	Web Feature Service
WGS	World Geodetic System
WMC	Web Map Context
WMS	Web Map Service
WS	Web Service
WSDL	Web Service Definition Language
XML	Extensible Markup Language

INTRODUCTION

1.1. Overview

The developments in information and communication technologies (ICT) have transformed tourism in multiple ways in areas such as consumer demand and site management (Buhalis & Law, 2008; Guttentag, 2010). Varied inputs of information on destinations may play a major role on tourists' choice and vacation planning (Decrop, 2006; Gursoy & McCleary, 2004) being the Internet a privileged tool for accomplishing this task (Buhalis, 2003; Buhalis & Law, 2008; Gretzel, Yuan, & Fesenmaier, 2000). E-Tourism represents the combined research of ICT and tourism, is changing the tourism sector rapidly calling for a constant adoption and integration of latest ICT developments into the tourism sector (Buhalis & Deimezi, 2004; Buhalis & Law, 2008). Since ICT developments are not developed directly by and for the tourism industry, both tourism researchers and professionals may be unprepared to adequately integrate these technologies into the sector (Guttentag, 2010).

Linking geography to tourism is an emergent field that is progressively gaining its own space in tourism research (Hall & Page, 2006, 2009; Lew, 2001). Many researchers have identified valuable contributions to tourism by applying GIS capabilities such as visualization, spatial analysis and mapping (Butler, 1992; Chen, 2007; Elliot-White & Finn, 1998; Hall & Page, 2009; Nielsen & Liburd, 2008). Nevertheless, GIS utilization has been far from its potential due to the high level of required expertise to deal with this type of systems and to the intensive data requirements (Hall & Page, 2009). The first objective of GIS is give the necessary information to help the decision makers in a decision making process when spatial information is evolved (Cabral, 2001) .

Tourism involves travel to a place where the tourist normally does not work or live (Richmond & Keller, 2003). The traveler, therefore, has limited spatial knowledge of the visited environment, and maps perform an essential function in the acquisition of spatial information about travel destinations. According to (Richmond & Keller, 2003), maps are

recognized as vital tools used throughout the entire tourism experience, from pre-holiday trip planning, through the actual vacation, to post trip analysis and holiday recollection.

In business where to sell experiences is the objective, the user-generated content systems has opened a new area of opportunities for the travel industry (Reactive, 2007). The Web 2.0 is one of the new technologies more used by consumers and are currently changing the traditional marketing methods in tourism business allowing the tourist relate their feedback of a product or experience (Au, 2010).

In this project, a GIS hosted on the Internet is developed, also known as WebGIS[1], with the aim of promoting nature tourism in the Azores. This work is intended as a continuation of the master's thesis in Science and GIS performed by Silva 2008. It is intended that the WebGIS developed reach a broad audience and can show all the geographic information relevant allowing the dynamic maps to locate services and tourist resources more relevant in the Azores archipelago, as well as ancillary information relevant. Web 2.0 functionalities are included allowing the feedback from the users. The system will be directed at any potential tourist who is interested in carrying out activities related to nature, without having specific knowledge of GIS, so that it pursues the implementation of an intuitive and easy to use WebGIS.

This project is being developed by the "*Instituto Superior de Estatística e Gestão da Informação*" (ISEGI) and the " *Escola Superior de Hotelaria e Turismo do Estoril* " (ESHTE) for the "*Associação Regional de Turismo dos Açores*" (ART). The project is funded by the "*Programa Operacional dos Açores para a Convergência*" (PROCONVERGÊNCIA[2]) and has an estimated duration of 2 years (2009-2011).

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[1] Web application that provides specific GIS functions through the Internet allowing the recovery, modification and analysis of geographic information.

[2] The Azores Operational Programme for Convergence is a Reimbursed by the ERDF Operational Programme for the programming period 2007-2013, included in the Community Convergence Objective, with implementation in the Azores, integrated in the Portuguese Strategic Reference Framework.

1.2. Objectives

The mission of the ZoomAzores project is the promotion of tourism in the Azores based on natural resources and NAT, but integrating information about all tourism products and services. According to (Richmond & Keller, 2003), "the purpose of tourism marketing is to create a particular image of the tourism destination in the minds of potential tourists, with the goal of enticing tourists to select the destination for a holiday". Maps are indispensable vehicles for communicating spatial information and creating images of space and place (Zonn, 1990). Thus, the objective of the present work is to develop a WebGIS using Free Open Source Software (FOSS[3]) and Open Specifications (OS), which should carry out the tasks needed for accomplishing the objectives of tourist marketing. The WebGIS should not be dependent of software license cost, minimizing the price of the project and making it independent of license costs along the time and hence, only FOSS technologies are used making it sustainable for the local economy.

The main objective, which is to build a WebGIS to promote the tourism in Azores and the NAT in particular, is decomposed into more specific and functional objectives listed below:

- Create an aesthetically appealing interface;

- Identify and evaluate the FOSS technologies needed to develop a WebGIS;

- Make available useful and updated information for tourist promotion and travel planning for the end-users;

- Create a back office allowing the content management for the administrators' users.

- Optimize performance issues in the WebGIS system;

- Create a Web 2.0 component allowing feedback from users; and

- Identify a way to link dynamically the tourist services with the companies offering these services.

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[3] Free and open-source software (F/OSS, FOSS) or free/libre/open-source software (FLOSS) is liberally licensed to grant the right of users to use, study, change, and improve its design through the availability of its source code (Shephard & Evans, 2005).

1.3. Hypothesis

The formulated hypotheses, which are the basis for this work, are the following:

- It is possible to use the Internet as a channel of communication and promotion of tourism in nature, making use of dynamic and interactive maps to show to the potential tourists what are the possibilities a particular territory offers;

- It is possible to use the user generated content, as text relating previous tourist experiences, for the promotion of tourist destinations.

- It is feasible to use FOSS technologies, respecting the Open Geospatial Consortium (OGC)[4] standards to develop WebGIS application for the promotion of nature activities for tourists.

1.4. General Methodology

One task included in the methodology of the development process is based in analyze the information needs of a potential tourist and implement a data model able to integrate this information needs in a WebGIS.

Analyze what kind the functionalities can help a potential tourist and identify which technologies can be used for the functionalities implementation integrated in a WebGIS.

The development of this project is based on web technologies. Regarding programming languages, the PHP[5] scripting language was used for the server side and the JavaScript[6] language for the client side. For the software web development is used the integrate development environment (IDE) Aptana.

A database with spatial functions is implemented in PostgresSQL-PostGIS DBMS. For the web services, the Apache 2 and GeoServer are running in the server side. GDAL,

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[4] The Open Geospatial Consortium (OGC®) is a non-profit, international, voluntary consensus standards organization that is leading the development of standards for geospatial and location based services (Shephard & Evans, 2005).

[5] PHP is a server side scripting language, designed for web development to produce dynamic web pages.

[6] JavaScript is a scripting language which is interpreted and executed on a web browser in the client side.

Geospatial Data Abstraction Library (GDAL, 2011) was used to process the raster data, create the base maps of the WebGIS. To deal with the spatial data features, to represent the tourist services, Quantum GIS software was used. All the system was developed and is running on Linux environment.

External Web Map Services and Web Services are used, such as the non commercial and collaborative project OpenStreetMaps and commercial maps from Google, Yahoo and Google Earth. The geographic projection used is the Spherical Mercator.

The citations of the thesis are made using the rules of Journal of Tourism Management, which is one of the reference publications in the field of planning and management of travel and tourism.

All the structured diagrams which are illustrated in the form of figures were created using the Dia software.

1.5. Thesis Structure

This thesis is divided into 5 chapters. The first chapter presents an overview and contextualization of the master project outlining the main objectives and hypotheses.

In the second chapter, the application and the potential use of GIS in Tourism is discussed. The chapter presents how the GIS solutions can be an opportunity for Tourism. The importance of the Web 2.0 technologies in a tourism business and how it can be integrated in a WebGIS is addressed.

The third chapter is especially dedicated to Web Services (WS). It illustrates the role that the WS have on the development of an information system and benefits they entail. Also address the importance of defining and using Open Standards (OS) to the use of WS, to finally achieve interoperability between systems. A comparison between WS and Web Map Services (WMS) is done. It is also dedicated to GIS software panorama, describing the best practices to choose FOSS technologies.

The fourth chapter is dedicated to the development and implementation of the ZoomAzores WebGIS. The chapter presents the system architecture, the conceptual data model, some system functionalities are explained. Also explain the process, as a work flow,

to pre-generate some map images to improve the system performance and finally illustrates an interoperability example.

The fifth and final chapter is dedicated to the conclusions, an overview to the problems found, limitations and future works.

The Figure 1.1, illustrates a schema with the thesis structure.

Literature Review

Chapter 1

Introduction
- Project overview
- Objectives
- Hypothesis
- General methodology

Chapter 2

Tourism promotion: WebGIS and Web 2.0
- Tourism
- GIS
- Web 2.0

Chapter 3

Interoperability, Open Standards and Web Services
- Interoperability
- Open Standards
- Web Services & Web Map Services
- Open Source

Application development and deployment

Chapter 4

The case study: WebGIS ZoomAzores
- System Architecture
- System Data Model
- System functionalities

Chapter 5

Main conclusions
- Conclusions
- Problems and limitations
- Future work

Figure 1.1. Thesis structure schema

2. TOURISM PROMOTION: WEBGIS AND WEB 2.0

2.1. Introduction

This chapter discusses the use of spatial information for tourism promotion and how the WebGIS can be a tool to help perform the tourism promotion of a specific geographical area.

The first part defines the Geotourism and NAT niches, which are based on a sustainable model of tourist and are perfectly aligned with the objectives of the Portuguese public authority (Turismo de Portugal, I.P.) and the Regional Government of Azores (ALRA, 2008; Silva, Almeida, Pinto, Carvalho, & Pain, 2007; TP/MEI, 2007).

The second part on the other hand shows a brief GIS software panorama, how the web serves as a tool to spread the use of these GIS technologies, and the opportunity of consuming map services from outside sources and integrate it within a single WebGIS.

The third part discusses the lack of use of GIS technologies for tourism promotion and how these technologies can be integrated in the tourism business area, showing the information for promotion of the desired touristic area. Maps and touristic information are linked in a single web application.

The use of the Web 2.0 in tourism promotion and planning is discussed in the fourth part. Is pretended to show the opportunity that the Web 2.0 technologies are giving for a tourist business, showing some of the technologies underlying the Web 2.0 and how those can be integrated into a WebSIG.

2.2. Geotourism, Nature and Adventure Tourism

New trends in tourism have seen the evolution from mass tourism to sustainable tourism and the recognition of its associated activities, such as Geotourism (Hose, 2005). According to Hose, Geotourism encompasses the examination and understanding of the

physical basis of geosites[7], together with their interpretative media and promotion. Geotourism is defined by (National_Geographic_Society, 2011) as a tourism that sustains or enhances the geographical character of a place, its environment, culture, aesthetics, heritage, and the well-being of its residents. By the above definition, it can be extracted that for the practice of Geotourism, a great knowledge and understanding of the territory at different levels are required.

The NAT, according to Graham (2005), is an activity-based tourism which allows many players to enter what is now a highly specialized and lucrative market characterized by an enormous variety of products, ranging from whale watching trips in the Azores archipelago to guided ascents to the summit of Mount Everest, from cycling trips to surfing holidays, from canoeing to heli-hiking. Wilderness experiences have developed in a way that almost every adventure activity has been capitalized upon to provide some form of tourism experience (Shephard & Evans, 2005).

Geotourism and NAT niches are based on a sustainable model of tourism. Sustainable tourism is a form of tourism attempting to make a low impact on the environment and local culture, while helping to generate future employment for local people (WTO, 1998). Sustainable tourism is aligned with the objectives of The Regional Government of Azores who has assumed an environmental, economical and social sustainability paradigm as the regional tourism development model, which privileges quality in terms of the environment of the touristic destination and also in the facilities and touristic services (Silva, et al., 2007).

According Silva, the territory of the Azores has a strong geographical identity expressed by both the landscape and the natural and cultural heritage. In peripheral regions such as the Azores, recognized by its natural and cultural identity, the expansion of the alternative tourism paradigm is recognized as a contribution to sustainable development. (Silva & Almeida, 2010).

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[7] According Hose (2005), geosites are divided in 2 types: (1) Primary Geosites having geological/geomorphologic features, either naturally or artificially and generally permanently exposed, within a delimited outdoor area that are at least locally significant for their scientific, educational or interpretative value. (2) Secondary Geosites having some feature(s) and/or item(s), within or on a structure or delimited area, of at least local significance to the history, development, presentation or interpretation of geology or geomorphology.

2.3.   GIS and WebGIS Software Panorama

GIS is considered as a tool of excellence for handling spatial data and can be applied to various areas of knowledge (Longley, Goodchild, Maguire, & Rhind, 2005a; McMaster & Craig, 2002). These systems comprise a powerful set of tools for collecting, storing, retrieving at will, transforming and displaying spatial data from the real world (Burrough & McDonnell, 1998). Most of GIS systems, also known as Desktop GIS, run individually on personal computers and are seen as a technology restricted to a limited number of users that, as a rule, work for private or public companies or in research centers. Some well-known proprietary, and costly Desktop GIS are ArcGIS from ESRI (ESRI, 2010), Geomedia from Intergraph (Intergraph, 2010), Idrisi from Clark Labs (ClarkLabs, 2010), MapInfo (PitneyBowes, 2010), etc. Recently, some interesting free OSS (FOSS) solutions that do not require licensing appeared, making Desktop GIS technology more widespread. Examples include software packages such as Quantum GIS (QGIS, 2010), gvSIG (gvSIG, 2010), GRASS (Grass, 2010), uDIG (uDIG, 2010) and many others (Maptools, 2010; OSGEO, 2009). Regardless the type of licensing, all these sophisticated programs vary in their specific capabilities and require a significant investment in data acquisition and in trained professionals with strong background in GIS concepts to run them. Notwithstanding, these tools can be very useful, or even mandatory, for the preprocessing of geographical data to be integrated in the WebGIS.

The Internet development contributed to the growing importance of GIS in various areas opening new perspectives for people who need to use spatial data (Yang, Wong, Yang, Kafatos, & Li, 2004). Straightforward data sharing also became possible for Desktop GIS that can now use remote data services available through the Internet unlike previously where all data was only accessible locally. However, the most significant development has been the dissemination of GIS capabilities in the Internet through WebGIS. This combined technology of GIS and Internet enables the access to geographical data and to a myriad of analytical tools and different GIS services by using a simple web browser (Peng & Tsou,

2003). This synergy facilitates the process of finding and sharing spatial data and analytical tools, reaching a considerably larger number of users (Tang & Selwood, 2003).

WebGIS applications range from providing basic GIS functions, such as the ability to pan, zoom, turn data layers on and off and to query and view attribute data linked to mapped objects, to providing more refined techniques such as routing and point-in-polygon analysis (Drummond & French, 2008). WebGIS is also following latest Web developments like Web 2.0, which is a new generation of Internet services and technology (Deshpande & Jada, 2006; Nielsen & Liburd, 2008), that encourages more interaction between users (Boulos & Wheeler, 2007; Schuurman, Leight, & Berube, 2008). This evolution is leading GIS away from individual to group decisions known as Public Participation GIS (PPGIS) (Carver, 1999; Sakamoto & Fukui, 2004) and is also recognized as having an important impact in destination marketing (Pan, MacLaurin, & Crotts, 2007).

Some web mapping software options in the server side to publish spatial data on internet and concerning FOSS software are GeoServer (GeoServer, 2010), MapServer (MapServer, 2010) and Mapnik (Mapnik, 2011), and as proprietary software the most popular is ArcGIS Server (ESRI, 2010). On the client side and as FOSS projects we can find OpenLayers (OpenLayers, 2011) and GeoEXT (GeoEXT, 2011).

Many websites or applications such as Google Maps (Google, 2010b), Google Earth (Google, 2010a), OpenStreetMap (OpenStreetMap, 2010), Yahoo Maps (Yahoo, 2010) and Bing Maps (Microsoft, 2010) are providing worldwide geographical data such as detailed maps, satellite images and terrain maps. They also provide Application Programming Interfaces (API) that allow sophisticated users to combine their own geographically data and functions to produce mashups (Cheung, Yip, Townsend, & Scotch, 2008). This creates an opportunity for users to provide input about features or conditions at particular locations (Drummond & French, 2008).

2.4.   WebGIS for Tourism Promotion

There are many case studies about WebGIS applications to various fields of studies such as site selection of radioactive waste disposal (Carver, 1999), disease mapping (Gao,

Mioc, Anton, Yi, & Coleman, 2008) and health care allocation (Schuurman, et al., 2008), to assist in the decision-making process to restore and preserve wetlands (Mathiyalagana, Grunwaldb, Reddyb, & Bloom, 2005), to test interoperability issues as means of GIS integration (Vckovsky, 1998), or to post location-specific notes and comments over Google maps similarly to the way users provide the content for Wikipedia (Wikimapia, 2010).

Applications of WebGIS in tourism are very rare, possibly due to the previously mentioned difficulties in using GIS technologies (Table 2.1). Most of them use their own cartography but some of them are already benefiting from Google API, making the interaction of the user easier when familiarized with Google mapping products.

Table 2.1.
Some WebGIS in tourism

Name	Area of interest	Description	URL
Senderos de Aragon	Aragon, Spain	Information about trails. GPS trails.	http://senderos.turismodearagon.com
Lisboa Interactiva	Lisbon, Portugal	Leisure and cultural activities, e.g. restaurants, sport, theatres, etc. Recommended tours.	http://lisboainteractiva.cm-lisboa.pt
The Official Lithuanian Travel Guide	Lithuania	Nature tourism activities and several information about tourism	http://www.travel.lt/turizmas/map.do
Switzer Provincial Park - Map Viewer	Alberta, Canada	Information about nature tourism activities available in the William A. Switzer Provincial Park	http://tpr.alberta.ca/parks/switzer/parkmap_flash.html
Travel Alberta	Alberta, Canada	General tourist information. Activities, lodging, camping, etc.	http://www.travelalberta.com/TripPlanner/Pages/Default.aspx?mrkt=Canada
Germany the travel destination	Germany	Touristic Tours, museums, shopping, events, etc.	http://www.dzt-top50.de/index_neu.html/?lang=en
Barbados Maps	Barbados	Thematic maps based in Google API with touristic information.	http://barbados.org/maps.htm
Places On Line	World	Touristic points of interest such as hotels, restaurants, museums, entertainment, etc.	http://www.placesonline.com/maps.asp

After performing a search of WebGIS sites for tourism promotion, it was noticed that even some web sites from countries where tourism is a major source of income, they make little use of maps, or at the most, very simple and static maps. This reveals the still existing lack of use of WebGIS for the promotion of tourism.

The ZoomAzores idea was first conceptualized by Silva (2008) who detected the lack of information for NAT activities in the Azores archipelago. After compiling relevant datasets, he argued that the use of WebGIS technology would be very important for this type of tourists that require a thorough geographical knowledge of visited areas (Silva, 2008).

Nowadays, the most used channel to promote tourist destinations is the Web (Scottish-Parliament, 2002). However according a statistical study (SEREA, 2007), in 2001 only the 4,3% of tourists that visit the Azores used the Internet as a source of information for planning the journey, and in 2006 was the 14,3%. That denotes that in the case of Azores, the use of internet as source of information for planning the trip is low in the tourist arriving to the Azores. But in general, the use of Internet gives great advantages in the tourism business, enabling the customer from anywhere to have much easier and direct access to a very large amount of up to date information than traditional printed media (Vasiljević, et al., 2009). WebGIS allows showing visual descriptions of desirable location, referencing where are the areas of interest, where to find the services needed linked with all the useful up to date information, which is going to help plan a trip. The ZoomAzores, focused on the adventure tourism niche, is giving the opportunity as well to give information that can be helpful to perform a desired activity on the field.

2.5. Web 2.0 and Tourism

Roland (2008) suggests that the Web 2.0 is becoming an important element in travel planning and buying. The term Web 2.0 is associated with web applications allowing participatory information sharing, interoperability and collaboration on the Internet, providing an opportunity for users to interact and collaborate with each other in a social media dialoged as creators of user-generated content.

Tourists normally try to use the holiday time efficiently, planning and getting information in multiple ways to reduce the risks during the decision process (Schegga, Liebrichb, Scaglionea, & Ahmadc, 2008) . Web 2.0 appears as a new source of information which allows interchange experiences between tourists, transforming the online decision process from an individual into a social activity (Au, 2010), and allowing consumers have more control over their travel decision making process (Cox, Burgess, Sellitto, & Buultjens, 2008). This user-generated content means that marketers have less control over what messages reach their potential clients, but this does not necessarily mean that it will have negative ramifications as user-generated web sites can build brand loyalty and it can be a way of forming a relationship with the traveler (Cox, et al., 2008).

Nowadays traditional forms of marketing where content was created by the marketer co-exist with the trend of the content generated by the consumer (Au, 2010). The former is relatively market-oriented and composed of merely static information. The latter on the other hand are basically opinions and suggestions based on past experiences of tourists, which are opportunities that the Web 2.0 offers to aid on the tasks of tourist promotion and travel planning. In fact, one of the objectives of the present project is to integrate Web 2.0 functionalities, user-generated content and collaborative evaluation, with the WebGIS, allowing sharing knowledge based on a previous experience from other tourists, and linking this knowledge with the services and activities which are located on the interactive map.

2.6.   Conclusions

The NAT and Geotourism niches are sustainable forms of tourism and aligned with the objectives of The Regional Government of Azores (ALRA, 2008; Silva, et al., 2007). These forms of tourism require a good spatial knowledge of the terrain where thematic maps play as mediums of communicating geographic information.

There is a substantial group of software that can process and prepare the spatial information to be integrated within WebGIS. In this project, the WebGIS becomes the gateway for all tourist information related to a specific geographic area. It is possible to

integrate geographic information with the user-generated content and collaborative evaluation, making the WebGIS a Web 2.0 collaborative information platform aimed at the promotion of tourist services and activities in nature. The use of the spatial information linked with the Web 2.0 appears to be a powerful combination of technologies to help in the planning decision process for holidays. It's important to refer that to allow Web 2.0 technologies and functionalities work together with a WebGIS in the same system, the interoperability is needed. To achieve interoperability the use of open standards and the access to the source of the technologies is required.

3. INTEROPERABILITY, OPEN STANDARDS AND WEB SERVICES

3.1. Introduction

This chapter has more technological and technical approach. In the first section, it explains the definition of interoperability. It also discusses the interoperability as an information integration problem and scrutinizes what kind of tasks is needed to solve this common issue in the computer science area. It argues the importance to create and use Open Standards (OS) to integrate systems which are based on different technologies from different vendors, to achieve the much appreciated interoperability. In the second section, the Web Services (WS) are presented showing the role that these are playing to achieve the interoperability in distributed systems over Internet, and noting the WS importance nowadays to build information systems. The third section is focused on the tree most important OS for the launch of the WS, explaining the tasks of these OS and how they are composed. The fourth part of this chapter shows the four basic steps involved in a general process to hire a WS, and showing the tree OS explained before in action. The fifth section is focused on the OS for a Geo-WS and makes a brief comparison with the non spatial WS. The most common OS used in a development of a WebGIS are listed making a brief description. Some server software for spatial data are showed and related with some of the OS that they are implementing. Because this is a project developed using Open Source technologies, in the sixth section is defined what this term means and explains the actually software licensing options. To conclude, the last section remarks the importance to use OS in the development of this project.

3.2. Interoperability and Open Standards

Interoperability refers to the capability of autonomous systems to exchange data and to handle processing request by means of a common understanding of data and requests (Doyle, Han, Weakliam, Bertolotto, & Wilson, 2004). Therefore interoperability allows the

communication between open systems using common communication infrastructures, a public applications programming interfaces, and a common objects definition to transport them across networks (Longley, Goodchild, Maguire, & Rhind, 2005b). Achieving interoperability creates new challenges for many areas of computer science where the concept of information integration is behind (Stuckenschmidt, Wache, Vogele, & Visser, 2000). According Heiner there are three different tasks for the information integration:

1. Syntactic Integration: This problem concerns the level of data types and data structure. To solve this problem, standards are used to integrate different information sources. Standards created using markup languages such as XML[8] are gaining importance allowing the definition of a data structure based on a hierarchy model enabling the representation of any conceptual data model that is coming from other sources as a database system.

2. Structural Integration: This problem appears when there are numerous data sources in the same system and normally solved by mediator systems, defining mapping rules between different information structures. The task of this mediator or middleware is to reformat the different data structures coming from numerous sources to a new homogeneous data structure.

3. Semantic Integration: This is the most complicated task that presents a real challenge. It focuses on the meanings of the data and uses semantic information to aid in the translation of data in one data model to another data model. To solve this problem, there are several approaches from different authors (Heflin & Hendler, 2000; Noy, Doan, & Halevy, 2005; Richard & Geert-Jan, 2001; Stuckenschmidt, et al., 2000; Wang, Lu, Zhang, Miao, & Zhou, 2009) . According to these authors, ontology and Resource Description Framework[9] (RDF) can be used to deal with this problem.

Now, addressing the integration data between independent systems in a web environment, where heterogeneous data is coming from distributed sources and the

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[8] Extensible Markup Language (XML) is a simple, very flexible text format. Originally designed to meet the challenges of large-scale electronic publishing, XML is also playing an increasingly important role in the exchange of a wide variety of data on the Web and elsewhere (W3C, 1998).

[9] RDF is a standard model for data interchange on the Web. RDF has features that facilitate data merging even if the underlying schemas differ, and it specifically supports the evolution of schemas over time without requiring all the data consumers to be changed (W3C, 2004b)

interoperability is needed, the independent systems must be able to use a common and universally available set of web services accessible thought networks communication (Doyle, et al., 2004). The web services must allow exchange data and handle requests between the independent systems (Doyle, et al., 2004). This web services must use a common formal language, XML, and common model representation throw XML schemas. The XML schemas is a standard that provide a means for defining the structure, content and semantics of XML documents (W3C, 2001).

According Becker (Becker, 2007) and concerning interoperability, standards are the key to allow definition of: (1) layered reference architecture and clarifying the boundaries between standards in each layer, (2) generic services for information exchange and (3) profiles for the services and semantics for specific information exchanges between business functions.

Open Standards are programming rules and guidelines for implementing interface and/or protocols that enable interoperability between systems which must be considered in WebGIS application development (Moreno-Sanchez, Anderson, Cruz, & Hayden, 2007). Open Standards arising from the collaboration of interested parties results in a consensus on specifications for implementing common requirements (Sliman, 2002). Sliman emphasizes that Open Standards means openness in both the standards setting process as well as access to the specifications. According Sliman and Schwartz (Schwartz, 2003) the use of Open standards helps to consolidate competing standards, increasing the aggregate pool of resources available for using them without be dependent of a specific vendor.

The World Wide Web Consortium (W3C) was funded in 1994 and is an international community that develops standards to ensure the long-term growth of the Web (W3C, 2011). One of W3C's primary goals is to make available the benefits of the Web, enabling human communication, commerce and opportunities to share knowledge, making it available to all people, whatever their hardware, software, network infrastructure, native language, culture, geographical location, or physical or mental ability.

3.3.   Web Services

The initial success of the Web in the 90s is attributed to the fact of provide distributed and referenced resources, textual information, with a Uniform Resource Identifiers[10] (URI) to interconnect them globally (Figure 3.1. A) (Muschamp, 2004). When the web services emerged, the web resources that are initially limited to be textual or multimedia information can now be a software application providing a specific service (Figure 3.1. B) (Davies, Fensel, & Richardson, 2004; Muschamp, 2004).
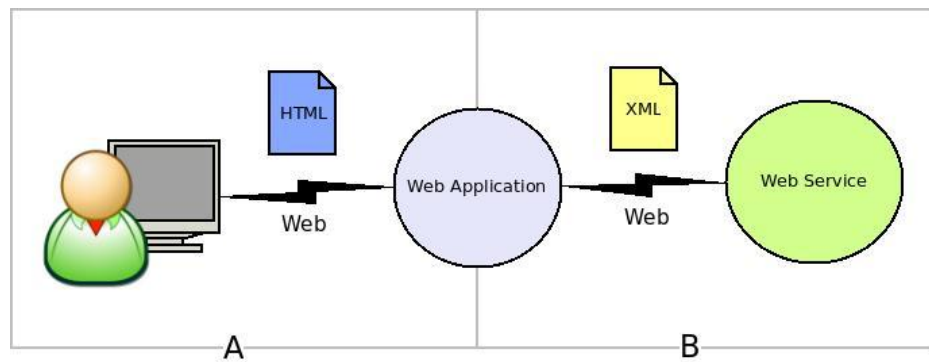
Figure 3.1. (a) User and Web application, (b) Web application and WS

Web Services are software components that can be located through URI address and invoked from others software components, which are allocated over the same network (Muschamp, 2004; Richardson, 2008). Another characteristic of a Web Service is the fact that it can describe it self, allowing other software components understand the functionalities it offers and how to access these functionalities. The principal objective of WS is to provide interoperability between applications that have been built on different systems and can be using different technologies from different vendors (Davies, et al., 2004; Mockford, 2004).

A WS can make available a variety of products, coming from database systems, application servers and standard applications. For example (Figure 3.2.), a WS can be an

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[10] The URI is a single global identification system, providing identification that is common across the Web (W3C, 2004a).

application that when a tourist is in a specific online booking web application allowing make a reserve in different hotels, one WS can have the task to check if the credit card number for this specific user is correct and is still able to be used. Another WS can handle the task to check if there are available rooms in the specific hotel for some specific days and giving back the result of what rooms are available and which are the prices.
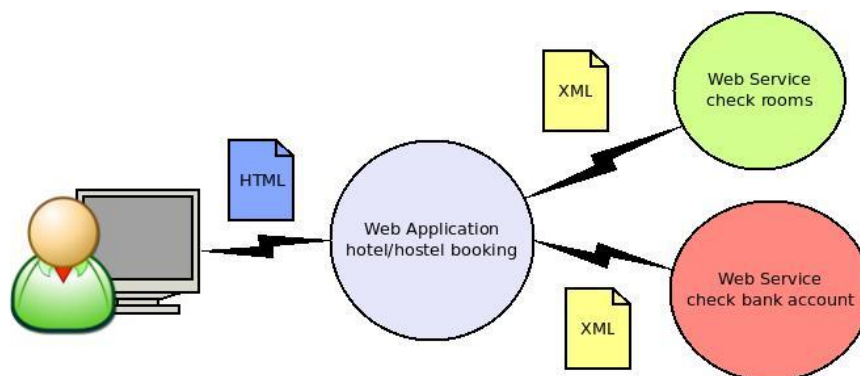
Figure 3.2. Example of Web application consuming WSs.

The WSs are giving a new service-oriented architectural approach, based on the notion of building applications by discovering and orchestrating network-available services (Harrison & Reichardt, 2001) . Daum (Daum & Merten, 2003) refers that the WSs have become an integral aspect of modern system architecture. A system architecture based on services is called SOA (Service Oriented Architecture). It's an architectural style for building software applications that use services available in a network such as the web (Mahmoud, 2005). In SOA systems, a service is an implementation of well-defined business functionality, and it can be consumed by clients in different applications or business processes. A system based on SOA must be focused on resolving pressing business challenges (Marks & Bell, 2006).

At the end of 2000, product from the collaboration and effort of well-known companies such as IBM, BEA Systems, Oracle, Microsoft and HP, to define the standards needed for create and use an interoperable Web Services, and finally this basic standards

and technology appears with SOAP[11], WSDL and UDDI (Harrison & Reichardt, 2001; Muschamp, 2004). The common language for all this technologies is the XML.

3.4.   Standard Protocols for WS: SOAP, WSDL and UDDI.

The present section is dedicated to explain how this three standards works and the roll that these play with the WS. How we saw before, a WS should be able to be invoked, describe itself and be located. Each of these characteristics is directly related with one of these standard technologies in the way that; SOAP allow a service to be invoked, WSDL provides the description of the service and UDDI is the protocol for locate a WS (Muschamp, 2004).

3.4.1. SOAP

SOAP is a standard protocol for accessing and invoking a WS. The SOAP protocol provides the definition rules to create a XML message, it used for exchanging structured information between software components over the internet. A SOAP message is composed by different sections and it can be extended and adapted to define any information that is pretended to transfer. The basic components of a message are the envelope, header/s and body (Figure 3.3). In the header section is where usually is defined the URI that identify the WS which is invoking the message. The SOAP message can use different protocols to be transported, being HTTP the most currently used.
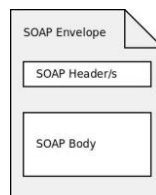
Figure 3.3. SOAP message structure

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[11] SOAP used to stand for "Simple Object Access Protocol" in version 1.1, but with the release of SOAP 1.2 in 2003, its acronym status was revoked.

3.4.2. WSDL

The WS Definition Language WSDL is an XML-based language for describing the functionalities of the WSs and how locates it. The WSDL language gives a detailed description of the WS. This description is divided in two parts, concrete and abstract description:

1. In the concrete description is defined the address of the WS which is typically represented by a HTTP URL and defines the implementation details necessary to access the service. In this description is located the information needed to create a SOAP message.

2. In the abstract description defines the operations that can be performed, the messages that are used to perform the operation and what type of data are used by specifying which XML-schemas is using the WS.

3.4.3. UDDI

The Universal, Description, Discovery and Integration (UDDI) define a standard method for publishing and discovering WS. The functional purpose is the representation of data and metadata about WSs in a service repository. It offers a standards-based mechanism to classify, catalog, and manage WS, so that they can be discovered and consumed by other applications (OASIS, 2006). This standard was created by OASIS (Organization for the Advancement of Structured Information Standards) which is a not-for-profit consortium that drives the development, convergence and adoption of open standards for the global information society. UDDI defines a set of public services that can be used directly by applications and services to interact with UDDI data, using a specific Application Public Interface. This API allows publish, update, discover services and get the information details in automatic way. Actually there are more service repositories available on internet some examples are *webservicelist* and *service-repository*.

3.5.   The General Process of Hiring a Web Service

This section aims to describe the general process of hiring a WS (Figure 3.4) and observing how the three basic standards, that propel the use of WSs, are playing in this process. The content and terminology is based in the document WS Architecture (W3C, 2004c) but making a simplification of the possible cases that the process can be involved. The description is going to show the four required steeps in this process of hiring a WS and using a generalized and simplified model of the process.

1. The requester and provider entities become known to each other. This step can be initiated by the requester or the provider of the WS. In a typical case is the requester who is going to initiate the process. Two scenarios are possible; (1) the requester entity knows already where the service is, if not (2) the requester entity may use a discovery service, like UDDI, to locate a suitable service description via an associated functional description, either through manual discovery or autonomous selection.

2. The requester and provider entities agree on the service description defined in a WSDL document and semantics that will govern the interaction between the requester and provider agents.

3. The service description and semantics are realized by the requester and provider agents. This means create a software component to make the request and interact with the WS provider, using some programming language or other technology. The technology used to interact with the WS is independent with the technologies used to implement the WS.

4. The requester and provider agents exchange SOAP messages, thus performing some task on behalf of the requester and provider entities. The WS is invoked from the requester agent using a SOAP message to the provider agent.
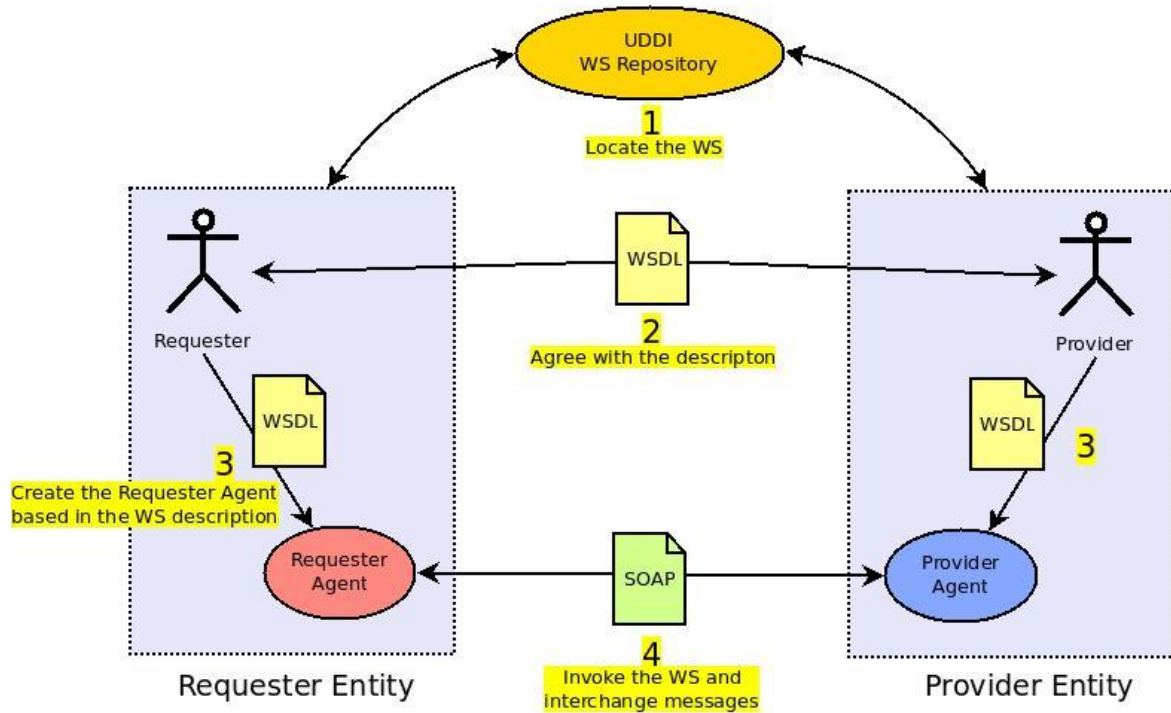
Figure 3.4. General process of hiring a WS. Adapted from (W3C, 2004c)

3.6. Standards for Geo Web Services

Open Standards for geospatial and location based services are defined by the Open Geospatial Consortium (OGC, 2009) and their use is of paramount importance for granting information portability between different applications, i.e., interoperability (Vckovsky, 1998). OGC was founded in 1994 and consists of an international consortium of companies, government agencies and universities that work on concepts and techniques that help to provide the previously mentioned interoperability. This organization has developed implementation specifications for several WSs, i.e. computing processes provided remotely using the Internet, that offer a standardized way for users to search for maps and geoprocessing sources over the Web from different map servers and different vendors.

The definition of Geo-WS standards was previous to the definition of the standards for WS, and because of that the Geo-WS are not based on WSDL, UDDI and SOAP

standards (Araújo, 2005). To invoke a Geo-WS is used the HTTP protocol with GET or POST operations, without need of a SOAP message. To get the description of a Geo-WS is used the common operation *GetCapabilities*, this operation is implemented in all the Geo-WS and is the equivalent of a WSDL description for a non spatial WS. For the discovery and view of Geo-WS there is the Spatial Data Infrastructure (SDI). A SDI is defined by the Global Spatial Data Infrastructure Association[12] (GSDA, 2009) as a "coordinated series of agreements on technology standards, institutional arrangements, and policies that enable the discovery and facilitate the availability of and access to spatial data". A specific SDI initiative always refers to a specific geographic area (Table n) and a hierarchy level (Ex. Local, regional, national...).

Table 3.1.
SDI's examples

SDI name	Geographic area
IDEiA	Azores
SNIG	Portugal
GDI-DE	German
INSPIRE	Europe
ASDI	Australia
NSDI	EEUU
GSDI	Global

In a WS catalogue based on UDDI standard, the WS functionality normally refers a specific business process belonging to some business area, while in a SDI catalogue the Geo-WS can refer a specific thematic data (roads, land use, interest points…) belonging to a specific geographic area.

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[12] The GSDI Association is an inclusive organization of organizations, agencies, firms, and individuals from around the world. The purpose of the organization is to promote international cooperation and collaboration in support of local, national and international spatial data infrastructure developments that will allow nations to better address social, economic, and environmental issues of pressing importance.

The OGC is the institution working in defining new OS to solve the interoperability need for spatial data. In Table 3.2 are identified and described the most important standards concerning WSs for spatial data that can be adopted in WebGIS development.

Table 3.2.
Some OGC standards description (OGC, 2009)

Standard	Description
Web Map Service (WMS)	Defines the rules to request geographic layers of an area of interest, and obtains, as result, one or more geo-registered map images (returned as JPEG, PNG, etc.) that can be displayed in a browser.
Web Feature Service (WFS)	Provides the rules to request some geographic layers of an area of interest, but the response consists of the geographic features themselves as vector data. The transactional Web Feature Service (WFS-T) allows creation, deletion, and updating of features.
Geographic Markup Language (GML)	Extensible Markup Language (XML) grammar for expressing geographical features. Serves as a modeling language for GIS as well as an open interchange format for geographic transactions on the Internet.
Web Map Context (WMC)	Specifies how a specific grouping of one or more maps coming from one or more WMS can be described in a portable format for storage, use and reuse within and between clients
Keyhole Markup Language (KML)	XML standard language for expressing geographic annotation and visualization on existing or future web-based online and mobile maps (2d) and earth browsers (3d).
Web Coverage Service (WCS)	Defines a standard interface and operations that enables interoperable access to geospatial coverages.
Styled Layer Descriptor (SLD)	Defines an encoding that extends the WMS standard to allow user-defined symbolization and coloring of geographic feature.
Filter Encoding Standard (FES)	Defines an XML encoding for filter expressions which logically combines constraints on the properties of a feature in order to identify a particular subset of features to be operated upon.

Currently, there is a wide range of options for WebGIS based on FOSS which are compliant with OGC OS. This is a critical factor of success if one wants to consider interoperability issues. Additionally, standards adoption grants a more flexible evolution of

the application keeping it open to the integration of new features and services. Most important FOSS WebGIS projects have all more than one standard compliancy (Table 3.3).

Table 1.3
Main FOSS WebGIS software and some of the OGC standards supported

Standard / Software	WMS	WFS	WFST	GML	WMC	KML	WCS	SLD	FES
MapGuide (Autodesk, 2010)	X	X							
GeoServer (GeoServer, 2010)	X	X	X	X	X	X	X	X	X
MapServer (MapServer, 2010)	X	X		X	X		X	X	X
Mapfish (MapFish, 2010)	X	X		X	X	X			

In this project is used the software GeoServer to create the Geo-WS. GeoServer is a software server written in Java that allows users to share and edit geospatial data. Designed for interoperability, it publishes data from any major spatial data source using a OGC standards (GeoServer, 2010). GeoServer is an Open Source Geospatial Foundation (OSGeo) project. OSGeo is a not-for-profit organization whose mission is to support and promote the collaborative development of open geospatial technologies and data (OSGEO, 2009). The present project is implemented using only Open Source technologies, being it one of the requisites to guaranty zero license software cost.

3.7. Open Source Software, Free Open Source Software and Proprietary Software

Currently, there are a large number of options concerning WebGIS software that can be applied to the tourism sector. These range from those provided by software vendors to the ones developed by groups dedicated to research and not all of them implement OS

which may compromise interoperability issues. As a result the decision of choosing what software to use may not be easy.

According to the Open Source Initiative (OSI), Open Source Software (OSS) does not mean just access to source code but also full compliance to criteria such as free use and distribution of the program for any purpose, its modification without the need for execution of an additional license, among others (OSI, 2009). This term does not mean exactly the same as free software because some licenses are considered too restrictive (GNU, 2009). The term FOSS refers to "software with permission for anyone to use, copy, and/or distribute, either verbatim or with modifications, either gratis or for a fee" (GNU, 2009). This also means that the source code must be available. The terms "freeware", i.e. software that can be redistributed but not modified, and "shareware", i.e. software that can be redistributed but requires licensing if someone wants to continue using it, should not be confused with free software (GNU, 2009). Examples of FOSS for WebGIS include MapServer (MapServer, 2010), GeoServer (GeoServer, 2010) and many others (Maptools, 2010; OSGEO, 2009)

Non-free, or proprietary, software is any software where any use, redistribution or modification is forbidden or requires authorization (GNU, 2009). Example of proprietary WebGIS software packages include ArcGIS Server (ESRI, 2010), Geomedia WebMap (Intergraph, 2010) and many others. An example of a non-free open source WebGIS software is MapGuide Open Source from Autodesk (Autodesk, 2010) which is licensed under the LGPL (Lesser General Public License). This type of license grants permission to copy and distribute verbatim copies of this license document, but changing it is not allowed (GNU, 2009).

3.8.   Conclusions

Using WS is possible extend functionalities of a system, integrate it with other business areas and increase the flexibility to adapt the information system to a changing business model. The whole system architecture can be based on many WS and named as SOA architecture. The need of creating and using open standards arises from the concept of

interoperability, where the objective is to create a flow of information to get interaction between different systems. The definition of standards comes from neutral organizations and sometimes with the collaboration of different vendors.

The chapter showed some of the technique concepts which are applied in the development of the WebGIS. The use of WSs in the development of this project is used and they play an important role in the system giving the opportunity to get some external collaborative data as the maps from OpenStreetMap project or the several pictures available in the Flickr system. Without the use of OS the ZoomAzores WebGIS will be a close system and lost the opportunity to consume potentially useful external data, which is increasing the value of the system.

4. THE CASE STUDY: WEBGIS ZOOMAZORES

4.1. Introduction

This chapter is dedicated to the description of the ZoomAzores system. The first section gives some context information about the ZoomAzores project development. A justification of why are used FOSS technologies and the OS is discussed in the second section. The third section delineates some general system requirements that define the philosophy of development and conditioning system design decisions to take. The fourth section goes directly to explain the system architecture, revealing that is based on different architectural styles, explaining each of the technologies and parts of the system and how they relate to each other. The fifth section illustrates the conceptual data model that is behind of the system explaining each of the entities of which is composed. The sixth section identifies the principal functionalities of the system, shows a UML context diagram, later is explored the content management related functionalities, discomposing this in some user cases with the interfaces designed for them, also shows what kind of interactions can have a potential tourist with the ZoomAzores. The seventh section exposes some base layers used in the WebGIS and explains how digital elevation model was created and processed as tile cache images to later be used as a one of the base layer in the WebGIS. In the eighth section we can see an interoperability example, between Flickr and ZoomAzores. To conclude, the last section denotes the importance to choose a FOSS technology with an active online community, which can provide the necessary support.

4.2. Development Context

The implementation of ZoomAzores project was initiated in January 2010. With an estimated 2 years time duration, it is still currently being developed at the Institute of Statistics and Information Management (ISEGI) and the School of Hospitality and Tourism Estoril (ESHTE) for the Association of the Azores Regional Tourism (ART). In ISEGI, the

mains tasks are to define the system architecture, develop the WebGIS application and elaborate the final user's manual. In the ESHTE, the mains tasks, as GIS and tourism specialists, are to identify, collect, build and organize the necessary spatial, multimedia and textual information. Both teams have regular meetings to show the results and define the new tasks to execute. This document is focused in the technical aspects of the WebGIS development.

4.3.   Why FOSS and OS?

The decision of using FOSS and OS to develop the ZoomAzores WebGIS was taken considering two vectors: (a) the need of ensuring long-term economic sustainability without depending of software license costs and (b) the need of ensuring a scalable and interoperable solution that is able to communicate with different software platforms and to integrate different data formats. The former is addressed by the use of FOSS that suits the ZoomAzores project that has a limited execution time and economic financial support. The latter is granted by the use of interoperable standards, i.e. OS, that allow the visualization, distribution, and processing of geographic data from different software and devices (Vckovsky, 1998).

In the OSS technologies panorama, there are different alternatives available for each of the module that can be used, hence the first task consists of identifying what modules are available and which can be successfully used. A good practice to choose the right OSS technologies is to use the criteria suggested by in the form of questions (Ramsey, 2007): (a) Is it clear who the core development team is? (b) Is the software modular? (c) How wide is the development community? (d) How wide is the user community? Positive answers to these questions indicate a healthy and mature OSS project which provides a greater degree of confidence in its use (Moreno-Sanchez, et al., 2007).

4.4. General System Requirements.

To develop the WebGIS and accomplish the objectives of tourist promotion, we focused on seven general and initial system requirements:

1. The map information should be clear. Since the web application aims sporadic users looking for a travel destination, it was decided that the cleanness of the interface and the data organization should be a requirement;

2. The map should contain useful information. Because one of the objectives is to support the planning trip process, the information must be useful to allow taking the right decisions;

3. The map should be aesthetically pleasant. For the reason that the main objective is to perform the promotion of the Azores as a tourism destination, the map which is representing the Azores area must be aesthetically appealing, transmitting good sensations and opening the curiosity about the area;

4. The system should be user-friendly. Because the system is designated to sporadic users as the potential tourist and tourism professionals without technologic background required;

5. The system should have long-term economic viability. Since the economic budget for the project is limited and we are looking for long-term durability of the project, we must find a way to not live the project dependent of the licenses payment;

6. The system should allow the interoperability of data and services. Since we need ensuring a scalable and interoperable solution that is able to communicate with different software platforms and to integrate different data formats; and

7. The system should have a great performance. Here is important to refer that the performance in a WebGIS systems is a important issue to overcome (Yang, et al., 2004). To keep the users interested we need improve the system performance to deliver the data in a reasonable time while they are looking between several destinations options.

4.5. Data Input and Pre-processing

This section is focused on the spatial data that the system is using. In this case, it is possible to make the distinction between two different kinds of data. The first are the spatial entities, which are represented by the kind of geometry like point, line or segment. These can symbolize various themes such as tourist services or activities. The second are the background map images which are oriented to give a spatial context, known as base layers in GIS terminology. These maps can show different kinds of contexts focused on for an instance terrain elevation or aerial images.

4.5.1. Base layers from WMS

Some base layers used in this project are coming from WMS. In the Figure 4.1 we can see some examples of base layers coming from a WS used in the ZoomAzores WebGIS. For example the base layer *A* is coming from Google Maps and the *B* is coming from OpenStreetMaps. The Figure 4.1 is representing the same area in the four maps, but each map gives different kind of information. The WebGIS is allows select which base layer we want to see, only one at the same time, depending of what kind of information wee need to use as context.
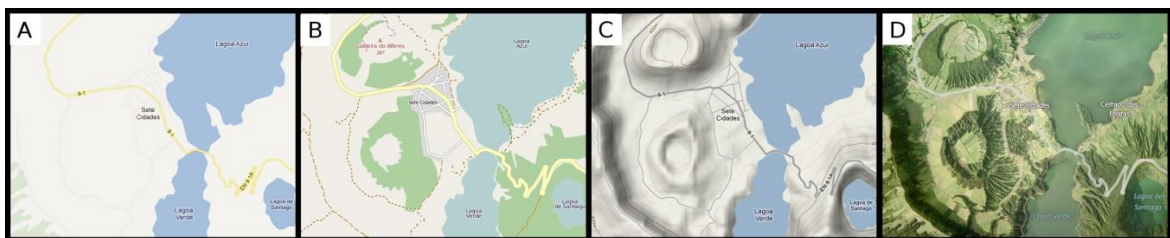

Figure 4.1. Examples of base layers from WMS. A) Google Maps Roads, B) OpenStreetMaps, C) Google Maps Physical and D) Bing Maps Aerial.

The entire base layers coming WMS are using the same projection Spherical Mercator, and the same pre-defined zoom levels. That obliges to use the same projection

for all the spatial data in the WebGIS ZoomAzores. All this WMS are directly accessed from the WebGIS client side, and integrated with the JavaScript code that implements the OpenLayers library.

4.5.2. Pre-processed Base Layers

Two of the base layers used by the ZoomAzores WebGIS are provided by the Apache web server showed in the architecture. The images of these base layers were already pre-processed during the development of the WebGIS. The Figure 4.2 shows both base layers. The *A* represents a Digital Elevation Model (DEM) and *B* is a cartographic map produced by the military army of Portugal. These military maps are very useful for adventure sports, to cause to show the contours lines of the land. The use of these maps will not be possible due to economic limitations.
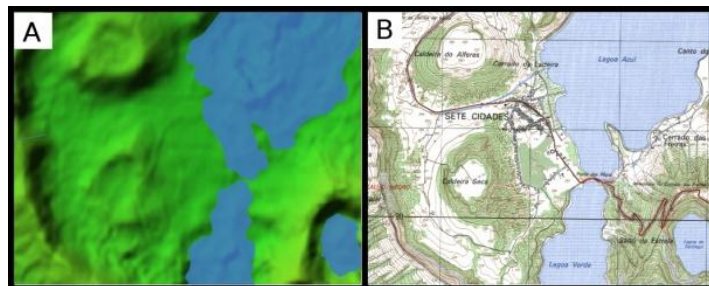
Figure 4.2. Pre-processed base layers. A) DEM and B) cartographic map

The DEM base layer is the first image that the potential tourist is going to receive from the WebGIS, giving an initial and important geographic context idea about the Azores area. In the task to create a DEM the two more important aspects were to create an aesthetically pleasing image having good performance at the moment to delivery this data through the Internet. The first task to create the DEM is get the data illustrated in the Table 4.1.

Table 4.1.
Data sources used for create the DEM base layer.

Data/Source	Format	Coordinate System	Description
ASTER Global Digital Elevation Model 30 meters / https://wist.echo.nasa.gov	GEOtif (*.tif)	WGS 84	Global digital Elevation Model from the earth surface (METI/NASA, 2009)
GEBCO One Minute Grid / http://www.gebco.net	netCDF (*.grd)	Polar stereographic	Continuous digital terrain model for ocean and land (Goodwillie, 2008)
CAOP Carta Administrativa Oficial de Portugal / http://www.igeo.pt	ESRI shapefile (*.shp)	UTM	Administrative borders in Portugal. (IGEO, 2011)

The second task was to process all these spatial data using the Geospatial Data Abstraction Library (GDAL). GDAL is a Open Source library for raster geospatial data formats, which comes with a variety of useful command line utilities for data translation and processing (GDAL, 2011). The Figure 4.3 illustrates a simplified model of the command line workflow followed to create the DEM for the islands.
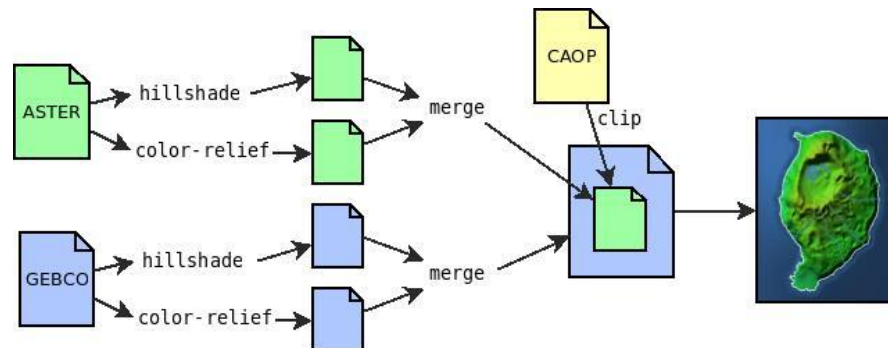
Figure 4.3. Workflow to create a DEM with GDAL

The third task for processing the DEM to make it available for publishing in the Internet was to create a cache. A cache is a set of pre-generated images of the map, according some specific levels of zoom. The objective of creating a cache is to improve the performance when delivering the DEM layer data to the browser in the client side. Because the character of a DEM data is static it was decided to pre-generate all the images for most of the zoom levels present in the WebGIS map. The Figure 4.4 shows a work flow model where we can see the software used to generate the map images.
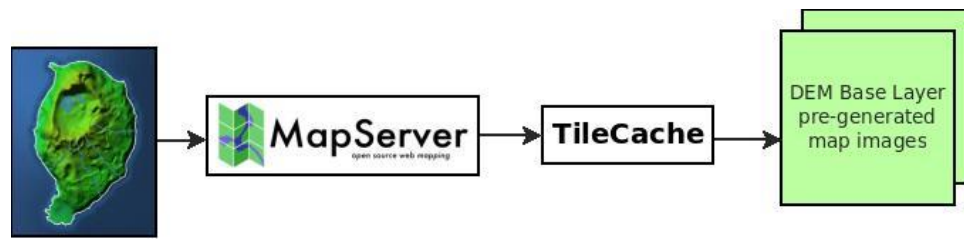
Figure 4.4. Work flow to create a cache.

The MapServer is used to draw the images and TileCache (TileCache, 2011) allows to cache the images for some specified zoom levels, and allocate these images in a specific folder in the file system.

Finally we have a folder where are located all the pre-generated images of the map, in a GIS nomenclature are know as tiles. These tiles can be accessed throw Apache web server by the OpenLayers in the client side.

4.6.   System Architecture

The ZoomAzores WebGIS architecture is hybrid and based on the combination of Client-Server, 3-Tier and SOA architectures styles. A short justification for each of this architecture styles is following.

In essence, it is a client-server application. In a physical server, the data is stored to which it can be accessed through internet by several clients. One of the clients refers to a web browser for public and private use of the system, and the other is the specific client GIS desktop application where the use is restricted to an authenticated user. The big advantage of this architecture is that allows the use of a centralized database and this simplifies the data edition, giving an only one version of the data and solving the data replication problem. The Figure 4.5 illustrates the components looking the ZoomAzores WebGIS as client-server architecture.
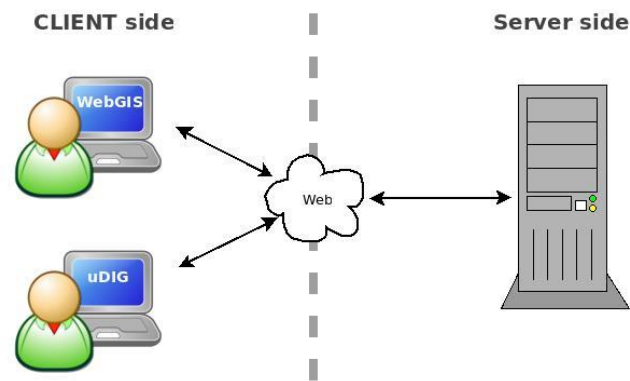
Figure 4.5. ZoomAzores system architecture as Client/Server style.

Approaching the system as 3-Tier architecture it is possible to identify different modules on the system (see Figure 4.6), being possible to separate them in different computers. In the actual architecture of the ZoomAzores WebGIS, the server side is composed by a single Linux server computer, where are located the data tier and server application tier. The third, as presentation tier, can be located in any computer which is accessing the server side system. This approach of separating the system in different logic modules facilitates the maintenance because each module is independent of the other modules, allowing specific updates or changes without affecting the application as a whole. It also improves the scalability, because it becomes easier to assemble new modules giving more flexibility to the system.
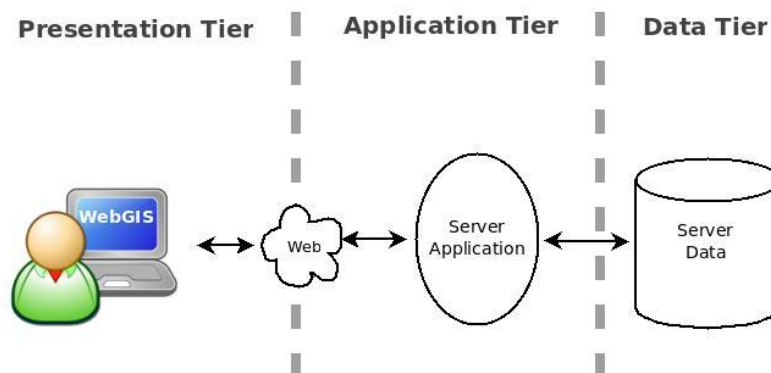
Figure 4.6. ZoomAzores system architecture as 3-Tier style

It's also possible to look the system as SOA architecture (see Figure 4.7), since the system is consuming different WS from different systems as Flickr, OpenStreetMaps or Google Maps. The ZoomAzores WebGIS, as interoperable system, is consuming external WS but at the same time has the capacity to produce its own WS such as the WMS that are coming from the GeoServer.
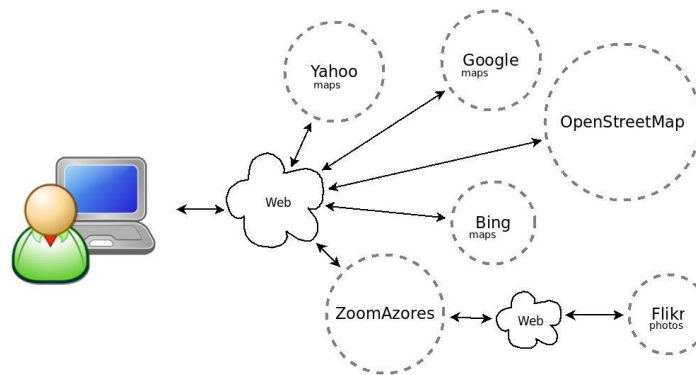
Figure 4.7. ZoomAzores system architecture as SOA style

We can conclude that the whole system is based and built on hybrid architecture. The Figure 4.8 aims to represent graphically the whole system architecture and show how are integrated the three different architecture approaches, resulting in unique hybrid architecture.

In the Figure 4.8 we can observe the core technologies used for the development, where these technologies are located and how those are connected between each other. This Figure 4.8 is identifying as well which are the external WSs used and how those are integrated in with the ZoomAzores system architecture.
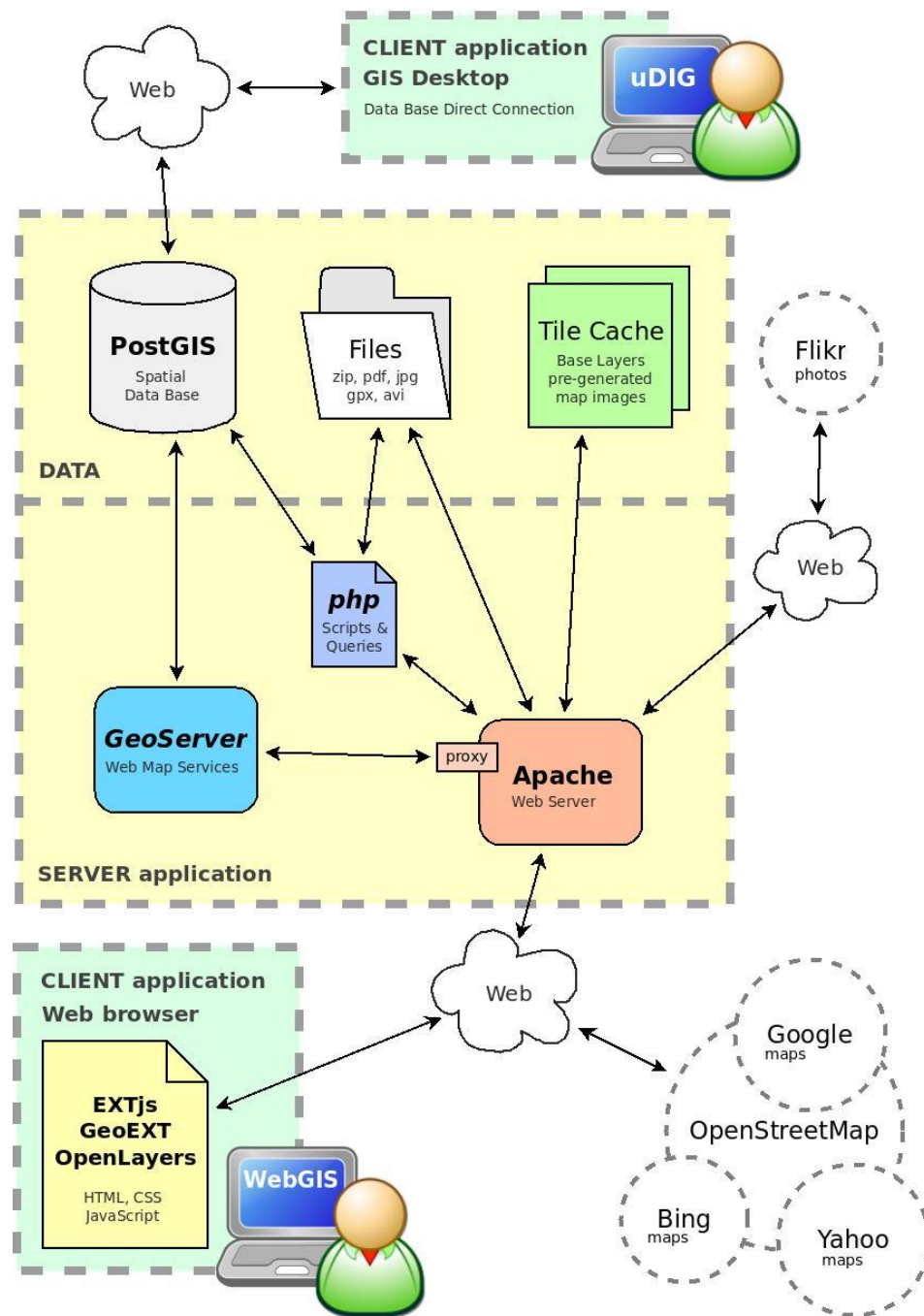
Figure 4.8. Architecture of the ZoomAzores WebGIS

Looking the Figure 4.8 is easier make a description of the system architecture. In first instance we can describe the data server component. Here we can see three different sources of data: the database which is implemented using the PostgreSQL DBMS and

PostGIS to add support to geographic objects. In the section System Data Model (4.7) is described the conceptual data model implemented in the database. Inside the data server component is defined a folder allocated in the file system of the server, where are stored and organized all the files which are related with the tourism services and activities. The third source of data refers the tile cache; in the file system is where the pre-generated map images which are used for the base layers are. These images are accessed directly by the Apache web server, avoiding the high processing cost required to create these images when a client needs them and improve the system performance. The section (4.4) has explained the general process to produce a tile cache images.

In the server application component are the technologies needed to access and publish the data. Apache is the web server used to give the access from and since the internet using the HTTP protocol. PHP programming language is used to interact with the database, performing specific queries, and processing data to be send to the client side through the Internet using the Web Server Apache. PHP also is used to deal with the upload of files and organize them in the file system. GeoServer is used to publish the spatial data stored in the data base in a form of WMS. Apache proxy module is needed to integrate Apache with GeoServer, and keep the access of the system in the same port 80, that solves the asynchronous calls problem from the OpenLayers in the client side.

We can find two different client types. On one hand is a desktop GIS application, uDIG. This application is installed in a specific computer, and allows have authenticated remote access to the spatial database. This connection is made through the Internet using the port *5432*. On the other hand is the WebGIS client side application. This application uses JavaScript libraries as OpenLayers, GeoEXT and EXTjs.

An important component of the architecture is the integration of some WS in the system. The integration of the WMS coming from commercial and non commercial providers was done directly on the client application using the OpenLayers JavaScript library. On the other hand, the WS coming from the Flickr was invoked through the use of PHP in the server side, where is processed and sent throw Apache to the client side.

4.7.   System Data Model

This section aims to describe the data model implemented for the system. Conceptually, the ZoomAzores data model has six well defined entities. The Figure 4.9 defines the conceptual data model and illustrates the entities and the relationships between them.
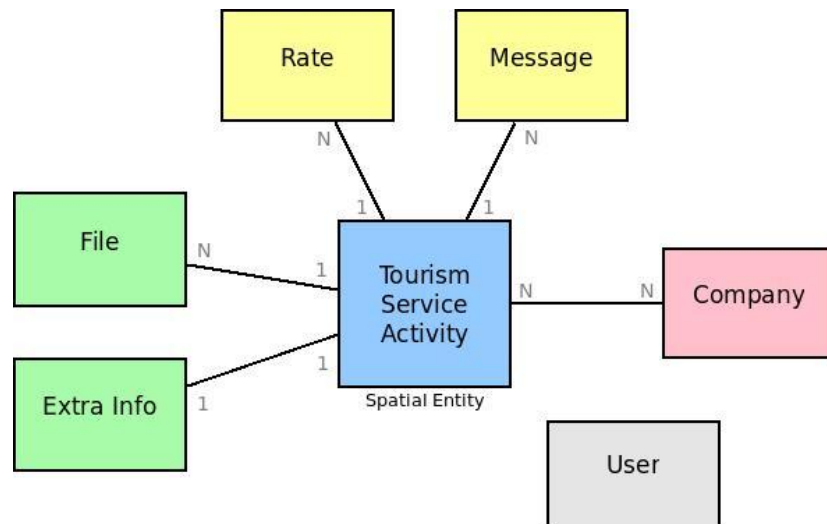
Figure 4.9. Conceptual data model

The diagram has one central entity which represents each one of the activities or services that are georeferenced on the map, consequently this is a spatial entity and by definition for all the objects coming from this entity must have associated geographic coordinates. This entity corresponds to different classes of services (ex. hotel, restaurant …) and different classes of activities (ex. canyoning, hiking ...) .The annex A describes all these classes and attributes.

The green entities, *File* and *Extra Info*, denote the content management component of the system. *File* is the entity which represents all the files that can be associated with tourism elements, where for each tourism element we can associate *N* files. The *Extra Info* entity represents a formatted text which allows associate for each tourism element *one* more detailed textual description.

The yellow entities, *Rate* and *Message*, are illustrating the participative and collaborative component of the system. The *Rate* entity represents each of the rates that were issued by a particular public user and for a given tourism component, where the final rate of a tourism component is represented by the average of all the rates that a given tourism component have. The *Message* entity represents the posts from the public user can make to the tourism component. Each tourism component can have *N* messages.

The *Company* entity represents all the companies that are related with some tourism services or adventure activities in the Azores archipelago. One specific company can be related with different tourism components and one tourism component can be related with different companies. This entity allows find contact information for each company.

The *User* entity represents the registered users in the system. There are two different classes of users, the Administrator and the Manager.

4.8.   System Functionalities

This section aims to describe the functionalities of the system. In first instance is important to define the user's profiles, since the functionalities are designed in function of what kind of user. Basically there are tree well defined user profiles designed as; public, manager and the administrator (Figure 4.10).
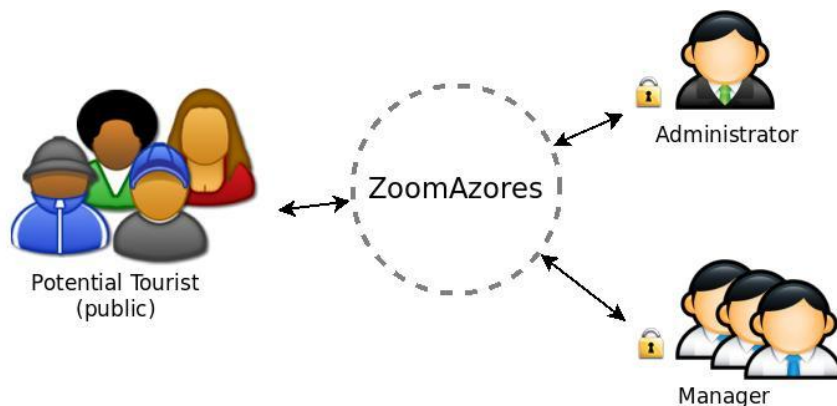
Figure 4.10. Users profiles

It is possible to create a hierarchy with the user profiles according to their permissions. On the top is the administrator, who is able to perform all the functionalities defined in the system. The big difference is that this user profile can register new users in the system and define the role of them. Below the administrator is the manager, who is able to edit the information related with the services and activities. This user can also create and edit company's instances, which later can relate with the services and activities. The last is the public user, who refers the potential tourist. The potential tourist is able to interact and browse in the map, identifying and getting some extra information, such as files from the specific activities and services which the user is interested. The public users are able to rate and post messages about the specific activities and services.

The Figure 4.11 shows a context diagram of the system. The context diagram defines which the general functionalities are in the WebGIS and relates these with the users' profiles. It is possible to explore each of these functionalities deeper. The functionalities are associated with colors, which these are according the entities showed in Figure 4.9 representing the data model.
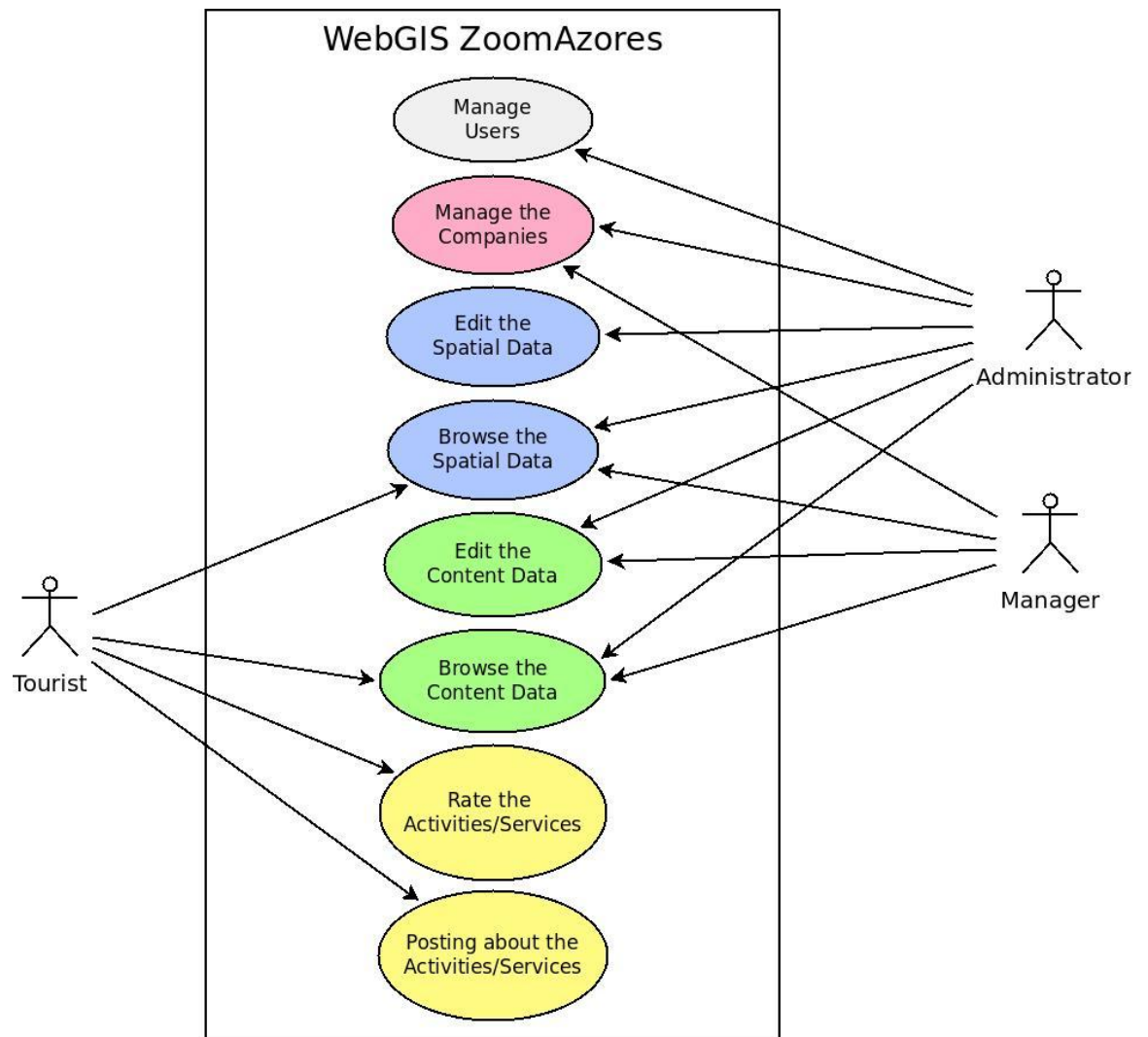
Figure 4.11. Context diagram.

4.9.   Editing data

The functionalities related with content management are the key to keep the system information easily updated, show more reliable information and facilitating the expansion of this. The Figure 4.12 shows a division of functionalities related with the content management.
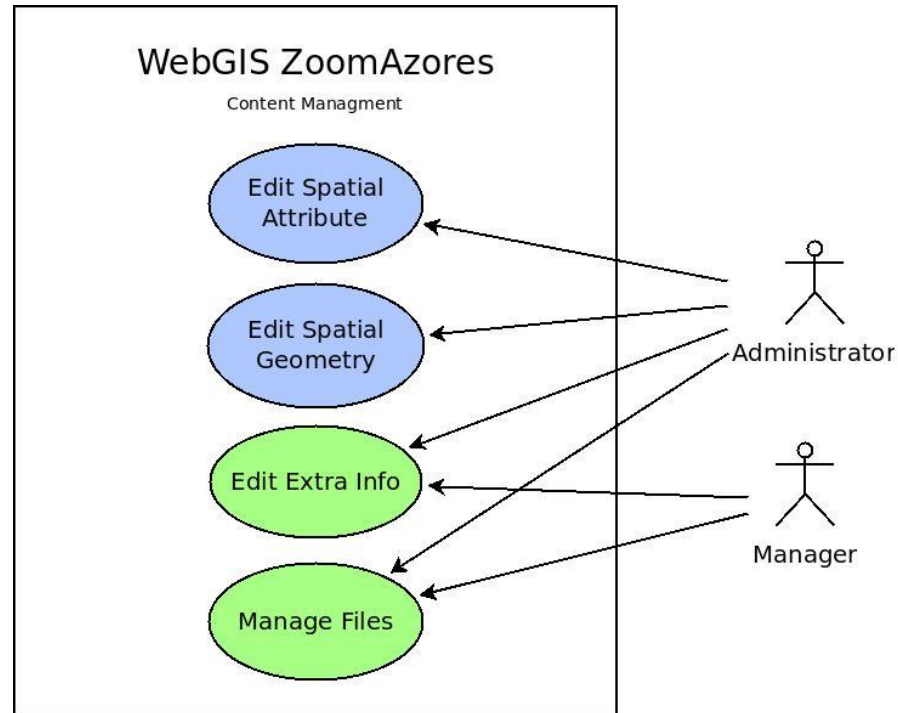
Figure 4.12. Content management functionalities.

To have access all this functionalities is necessary make a user authentication to the system. In the case of editing the spatial geometry is the authentication is directly with the database user. For the others functionalities the authentication is on the WebGIS.

The first of the functionalities refers the edition of the attributes related with a specific service or activity which is represented by a spatial entity. This functionality is restricted to the administrator user. The Figure 4.13 is showing the interface used to perform the edition of the attributes. In the example we can see how the user can indentify a specific activity in throw the map and later click in a button represented by a red pencil, to open the form where are all the attributes related with this activity.

Figure 4.13. Interface to edit the fields from a service or activity

The second functionality refers to spatial geometry edition like moving the position of one point which indicates where is located a specific tourism service or a place where can be performed some activity. It also allows creating a new point to add for example a new tourism service such as a restaurant. To perform these operations some knowledge about GIS is required. The implementation of these operations on the WebGIS involves some extra complexity. Hence it was decided to use a specific GIS application for this purpose. To achieve this purpose, the database that is located on the same computer that the web server was accessed remotely from a GIS desktop application with spatial editing capabilities (Figure 4.14). The GIS application selected to perform this task was uDIG (uDIG, 2010).
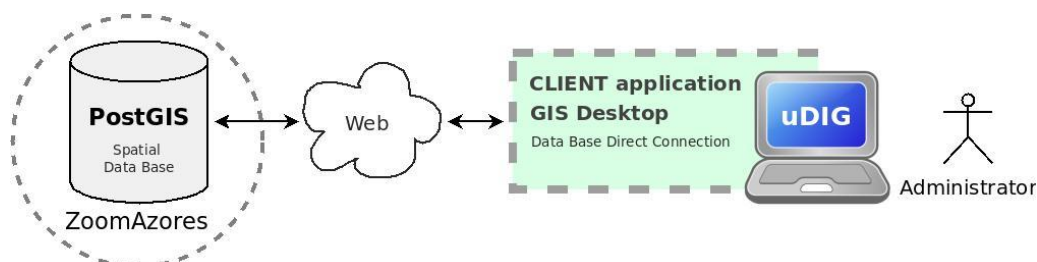
Figure 4.14. Editing spatial data with uDIG

The third functionality refers to the edition of some extra content related with a specific tourism service or activity. This extra information gives more flexibility and fewer limitations that the initial data showed in the popup, which follow the pattern *attribute value*. This extra content allows insert formatted text like in a normal text processor, and gives the opportunity to include external links web sites or online files. This information can be created and edited in English and Portuguese languages. The Figure 4.15 shows the interface used for this functionality.
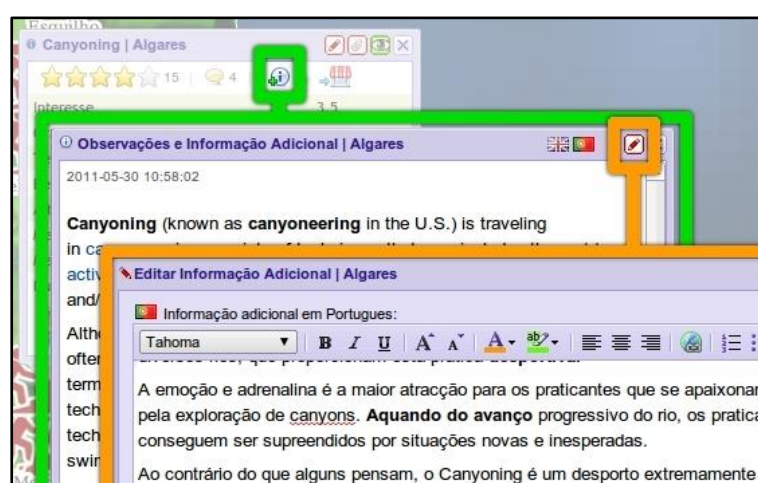
Figure 4.15. Interface to edit the extra information.

The fourth functionality refers the files management. This allows uploading files and associating them to each service or activity. For each file is possible to associate a small description. When a file is uploaded to the server, it is automatically zipped by a PHP script and remains compressed in the server saving some memory space. The Figure 4.16 shows the interface used for this functionality.

Figure 4.16. Interface to manage the files.

4.10. Tourist Interaction Example

This section shows an example of how potential tourists can interact with the ZoomAzores. Fundamentally, the tourists can use the system as illustrated in Figure 4.17. It exemplifies the fourth general interactions the tourists can make with the WebGIS application. The first blue bubble on the right part of the Figure states that the tourists can browse the map and all the spatial data on this. The second green bubble refers the content data browsing, which means the exploration of the information embedded in ZoomAzores. The third yellow bubble on the other hand points out that the application enables them to grade or evaluate the activities and/or services offered in a specific area. Lastly, the third yellow bubble accounts for the functionality of the application to allow the tourists to comment or suggest regarding the activities and services.
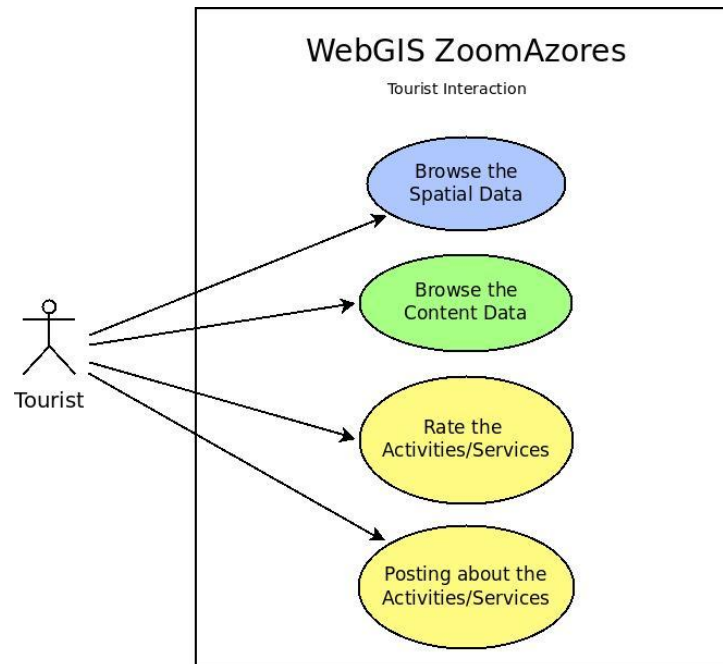
Figure 4.17. Functionalities addressed for the tourist interaction.

For an instance, Part A in Figure 4.18. demonstrates some of the land activities that can be done in Azores. The user can check from the list which activity they want to show in the map; say checking the activity option Canyoning instigates its location visibility on the map as shown in Part B of Figure 4.18. Subsequently, if the user or the tourist is interested to do bird watching, the box next to it can be checked as to visualize the locations where he/she can do the said activity.

Figure 4.18. (A) List which allows select activities, (B) activities showed on the map.

Aside from the functionality to control what kind of activities a tourist want to see in the map, other tools exist in the interface of ZoomAzores, as presented in Figure 4.19. Note that the descriptions of each tool are given in Table 4.2.

To site an example, say Tourist A wants to go to the island Flores to do canyoning. Tourist A can easily click the Island Zoom menu and choose Flores from the selection to center it on the map. If not yet checked, Tourist A can tick the box next to the canyoning option to see the places where he/she can do the activity within Flores. Tourist A can also click the Flickr button to activate and visualize existing photos to get an idea what the environment is like to where the tourist plans to do the activity. Then, Tourist A can use the Zoom In and Pan tools to focus the map on the area of interest.

Figure 4.19. Tool bar to browse on the map.

Table 4.2.
Description of the tool bar functionalities of the map.

Nº	Description
1	When this button is active, the user can click in one entity (tourism service or activity) on the map to get a popup, which will show information and functionalities related to this specific entity.
2	When this button is active, the user can make a zoom in to the selected area on the map.
3	When this button is active, the user can click on the map to make a zoom out.
4	When this button is active, the user can make a pan on the map.
5	When the user clicks this button, a full extent of the map will be provided.
6	This is a menu that allows the user to select a specific island to make a zoom of the island on the map.
7	This tool performs distance measurements on the map.
8	This is a menu which allows the user to select and change the map context.
9	When this button is active, the user can visualize the Flickr pictures on the map.

Other interesting functionalities that the application provides to the users are those given on a pop-up interface. For an instance, if the Identify button is active, Tourist A can

click on a specific canyoning location on the map to visualize the pop-up window as shown in Figure 4.20. Table 4.3 defines each tool's usage.
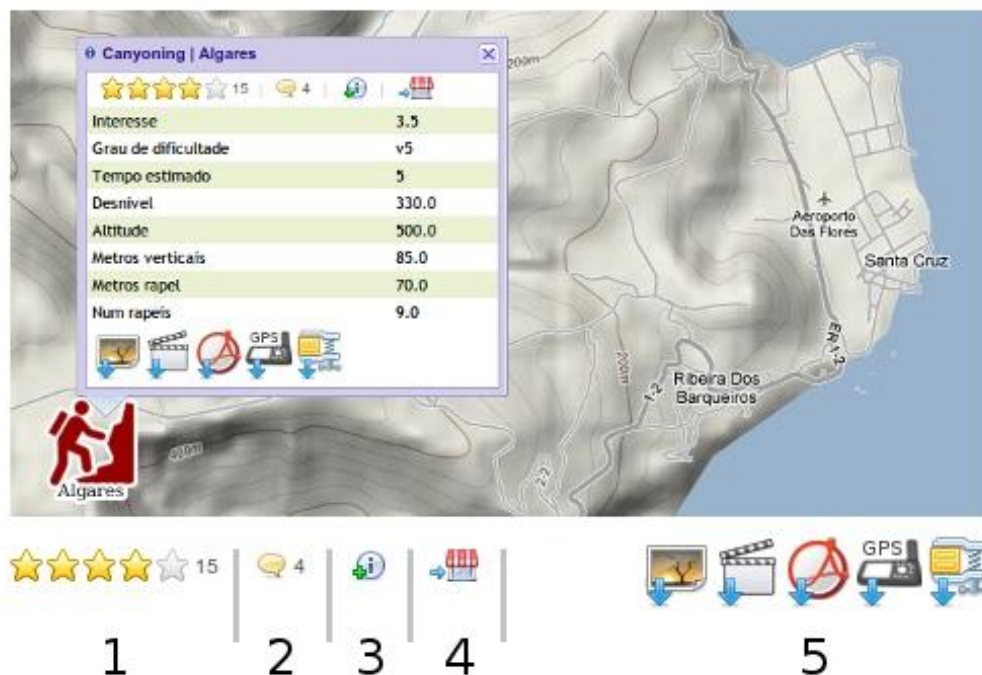
Figure 4.20. Functionalities associated with the popup

If Tourist A say wants to view more information about canyoning on the area of interest, he/she can click on Nº 3 (in Figure 4.20) to access external links or short written materials regarding the said activity. Tourist A can also click one of the buttons under Nº 5 to download related data such as video clips, pictures, pdf files of itinerary or detailed information of the activity, and GPS files. Nº 4 can also be clicked to access contact information of companies that offer canyoning services on that location, so Tourist A can arrange his/her plan with one of them. Finally, once Tourist A has been gone and done the canyoning activity on that place within Flores, he/she can rate it as desired using Nº 1, and add comments using Nº 2 to help next potential tourists.

Table 4.3.
Description of the popup functionalities.

Nº	Description
1	The stars show the rate given by the previous users. To give a new rate, the user only needs to click on the star that represents the rate desired. In the example, 15 users rate this activity (canyoning in Algares) with a total average rate of 4.
2	Clicking to this balloon, the user will have access to the comments submitted by other users and will have the opportunity to add new comments.
3	Clicking to this icon, the user will have access to a new window with more detailed information.
4	Clicking on this store icon, the user will have access to a new window listing all the companies related with this activity.
5	All this icons are linked to various files, which the user can download.

4.11. An Interoperability Example: Flickr and ZoomAzores

Now we pretend to show an example that shows how a WS works. In the second chapter argued the use of geographic information and Web 2.0 technologies to for the promotion of NAT. For the present example we are going to use a WS, which is a mix of user generated Web 2.0 content and spatial data. It possible to find all this in Flickr (Flickr, 2011) using the WSs available in The App Garden of Flickr. The App Garden has an open API that allows anyone access to the Flickr WSs. In the literature related with tourism promotion and Web2.0 we can find various references about Flickr use (Au, 2010; Cox, et al., 2008; Reactive, 2007; Ruiz, 2011; Schegga, et al., 2008).

For the example shown various technical details are omitted to make shorter and easier to understand how the interoperability works. We already know who is going to be the server application which is going to offer the WS, but now is needed another autonomous system, which is going to do the request of the service, this is the ZoomAzores web application (Figure 4.21).
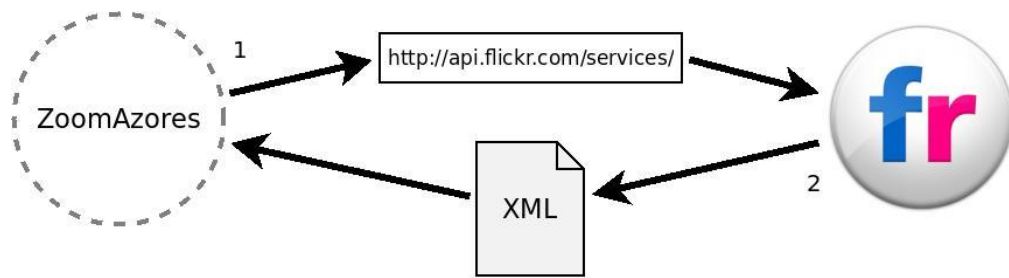
Figure 4.21. Interoperability example

The Figure 4.21 shows in a simple and schematic way how the two systems are going to communicate; (1) first the web application ZoomAzores is going to make a URL request, (2) and Flickr is going to execute the request and send a XML response with the content. We did not specify which technologies are used in each web application, but that does not matter, because we are using a WS that is independent of the technologies of the web applications. What we need to know is how we can make the request. In the documentation of the Flickr API is all that we need to know regarding the description of the WS. The Figure 4.22 is showing one complete example of URL request to call the WS. In this URL it is possible to see the parameter *method* with the value *flickr.photos.search* which is the name of the WS and it returns a list of photos matching some criteria. Only the photos visible to the calling user will be returned. To return private or semi-private photos, the caller must be authenticated with 'read' permissions, and have permission to view the photos. Unauthenticated calls will only return public photos.

```
URL:http://api.flickr.com/services/rest/?method=flickr.photos.sear
ch&api_key=c7a52501dde9a1890d50de1ed2d5df0c&tags=azores%2C+adventu
re%2C+nature&tag_mode=&text=&license=&bbox=-32.217%2C+35.898%2C-
24.168%2C+40.894&has_geo=&extras=geo&format=rest&api_sig=4647385ad
1c3603cfe8cb60b20063693
```

Figure 4.22. Request example for a Flickr WS

On the other hand, we have to know what the response from the WS is and how we can read the content from the XML to later use it in the way that we need. The Figure 4.23

shows a part of the XML content that the WS sent in response. In the XML are all the
photos and the geographic coordinates that were matching the criteria defined in the request
call.

Figure 4.23. XML response example from a Flickr WS

Finally, we have already in our system all the content that the WS provided to us, so
now we can process this content to be presented in a map (Figure 4.24). Our system is able
to process this content because this is represented in an OS language where it does not
matter from which vendor is coming from, because we are using an interoperable system.
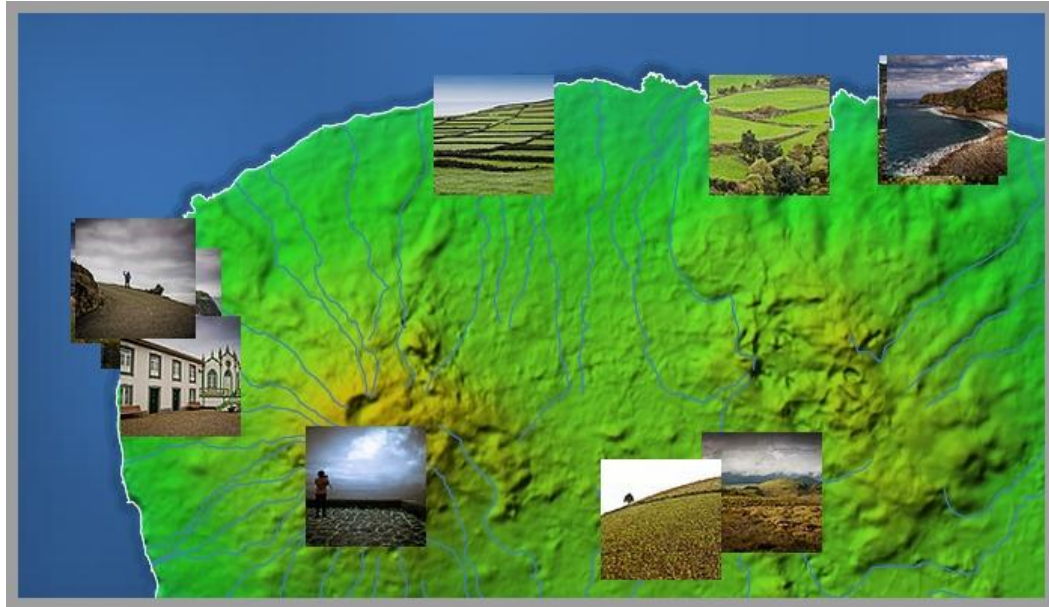
Figure 4.24. Flickr photos in ZoomAzores map.

4.12. Conclusions

It is possible to build a whole WebGIS with FOSS technologies and using OS which allowed the interoperability with other system. The process of developing a WebGIS requires the integration of GIS and Web based technologies, which actually have a good maturity grade, enabling the development of a WebGIS.

The online communities that are behind of an active Open Source project are a great support, and normally in a short time, to overcome specific difficulties of software development. In these online communities, the sharing of knowledge is a volunteer and motivating activity, resulting in a most of the times as the principal source of information in the learning process of the use of a FOSS technology.

5. CONCLUSIONS

5.1. Principal conclusions

The use of internet for marketing promotion of tourist destination gives a great opportunity to apply new tool focused on the search information process. It allows potential tourists to have better decisions about the destinations and for the holiday planning process. Combination of information, maps and stories about past experiences seem to be a good combination to support the decision making process about the travel destination and the selection of related services. The development of a WebGIS allows the integration of interactive maps together with the means to receive posts or comments about previous tourist experiences. The use of dynamics maps on Internet seems to be especially useful for the NAT and Geotourism niches, which are aligned with the sustainable model of tourism in the Azores.

In the development of WebGIS, the use of WS and WMS are a good practice, allowing the increase of functionalities and data sources of the system. To enrich the system with WSs, the use of OS cannot be forgotten, making it the key to achieving interoperability. The use of FOSS technologies is perfectly aligned with the use of OS, considering that these technologies are good choices to develop a customized system without software license cost and long term economic viability. Actually, there are enough FOSS technologies to develop a full WebGIS system. In fact, the process to choose the right FOSS project is not easy, requiring the evaluation of different factors.

5.2. Problems and Limitations

During the development of the present project, some difficulties and intricate decision-making were encountered. For an instance, understanding and choosing from various existing technologies for the WebGIS development have been very tricky, since

pieces of software were needed to identify each one of these pieces to build the system architecture. This part of the process has spent more time than what was expected.

In addition, understanding the tourist needs was crucial in doing some design decisions. It was necessary to depart from the view of the programmer software and step into the shoes of a potential tourist. Help and opinions from other team members that are experts in the area of tourism were also critical since in reality, these professionals have greater knowledge about the specific needs of the tourism business.

5.3. Future Work

The actual ZoomAzores WebGIS development still leaves some aspects to improve and lines where the system may experience an evolution. This section primarily identifies possible improvements for the system as enumerated below:

1. Stronger integration with the social networks since they offer the opportunity to spread information by creating a community or adding the ZoomAzores as part of their profiles. Other benefits of integrating and using Social Networks are the improvement of the results in search engine rankings, the increase of traffic and/or visitors in the website, and the provision of access to new market segments (Au, 2010).

2. Create a customized version to be used for touch screen devices like tablet computers or smart phones.

3. Define clustering strategies to improve the visualization of the spatial entities. When a remote zoom level is used and there are many points near each other, it becomes difficult to identify how many points exist. Applying an adequate clustering strategy will improve the clearness of the data.

4. Integration of 3D visualization. This kind of visualization helps to better understand the terrain. Actually, Google Earth can offer this kind of visualization and GeoEXT has a plug-in that allows this kind of integration.

5. A Street View visualization. Idem as the previous item, it is possible to integrate the Google Street View functionality with the GeoEXT library.

6. Develop a printing module where the user will be able to print for example a part of the map with some selected services or activities and the textual description related to the selected services or activities.

7. Improve the initial loading performance. The time needed when the site is loaded the first time can be improved since mainly, this time is consumed by the loading of JavaScript libraries (EXTjs, GeoEXT and OpenLayers). To achieve this, it is possible to only load the code and functions needed by the system. There are existing software such as JSBuild that can automatically make this task.

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ANNEX A

Tables and attributes for the tourism activities and services

Tourism Activity/Service	Attribute name	Atribute description
Percursos Pedestres Sinalizados	id	N.º de identificação da variável
	ilha	Ilha do percurso
	designacao	Sigla que identifica o percurso (ex: PR1FLO)
	nome	Nome do percurso
	interesse	Interesse do percurso (0-5)
	circular	Se se trata de um percurso circular (S/N)
	dificuldad	Grau de dificuldade do percurso (0-5)
	extensao	Extensão do percurso (Km)
	duracao	Tempo de realização do percurso (h)
	link	URL para mais informação
	visivel	Disponível para visualização.
Percursos Pedestres Aventura	id	N.º de identificação da variável
	ilha	Ilha do percurso
	designacao	Sigla que identifica o percurso (ex: PNSFLO)
	nome	Nome do percurso
	interesse	Interesse do percurso (0-5)
	circular	Se se trata de um percurso circular (S/N)
	dificuldad	Grau de dificuldade do percurso (0-5)
	extensao	Extensão do percurso (Km)
	navegação	Facilidade de Navegação (0-5)
	duracao	Tempo de realização do percurso (h)
	visivel	Disponível para visualização.
Percursos de Bicicleta	id	N.º de identificação da variável
	ilha	Ilha do percurso
	designacao	Sigla que identifica o percurso (ex: PB1FLO)
	nome	Nome do percurso
	interesse	Interesse do percurso (0-5)
	circular	Se se trata de um percurso circular (S/N)
	dificuldad	Grau de dificuldade do percurso (0-5)
	extensao	Extensão do percurso (Km)
	sinalizacao	Percurso Sinalizado (Sim/Não)
	duracao	Tempo de realização do percurso (h)
	visivel	Disponível para visualização.
Actividades Equestres Serviços	id	N.º de identificação da variável
	ilha	Ilha da actividade
	local	Local onde se desenvolve a actividade
	entidade	Nome da Entidade Gestora
	contacto	Contacto telefónico da Unidade
	email	Contacto electrónico da Unidade
	link	Website com mais informações sobre unidade
	rua	Rua da Unidade
	num	N.º da Unidade
	visivel	Disponível para visualização.
Percursos a Cavalo	id	N.º de identificação da variável
	ilha	Ilha do percurso
	designacao	Sigla que identifica o percurso (ex: PC1FLO)
	nome	Nome do percurso

	interesse	Interesse do percurso (0-5)
	circular	Se se trata de um percurso circular (S/N)
	dificuldad	Grau de dificuldade do percurso (0-5)
	sinalizacao	Percurso Sinalizado (Sim/Não)
	extensao	Extensão do percurso (Km)
	duracao	Tempo de realização do percurso (h)
	visivel	Disponível para visualização.
Canyoning Entrada	id	N.º de identificação da variável
	ilha	Ilha respectiva
	designacao	Sigla que identifica o percurso (ex: C1FLO)
	nome	Nome respectivo
	interesse	Interesse do percurso (0-5)
	dificuldad	Grau de dificuldade do percurso (v1-v6)
	duracao	Tempo de realização do percurso (h)
	desnivel	Desnível do percurso (m)
	altitude	Altitude do ponto respectivo (m)
	m_vertical	Maior vertical do percurso (m)
	m_rapel	Maior rapel do percurso (m)
	num_rapeis	N.º total de rapeis do percurso
	link	URL para mais informação
	visivel	Disponível para visualização.
Canyoning Saída	id	N.º de identificação da variável
	ilha	Ilha respectiva
	nome	Nome do troço de Canyoning
	altitude	Altitude do ponto respectivo (m)
	visivel	Disponível para visualização.
Escalada	id	N.º de identificação da variável
	ilha	Ilha respectiva
	nome	Nome da escola de escalada
	local	Local onde se desenvolve a actividade
	tipologia	Tipo de Zona (Orla Costeira; Litoral)
	num_vias	N.º total de vias no local de escalada
	altura	Altura máxima das vias do local de escalada (m)
	tipo_rocha	Tipos de rocha do local de escalada
	dificuldad	Dificuldade mínima e máxima das vias de escalada
	tipo	Tipo de escalada - clássica, desportiva, bloco
	interesse	Interesse da escola (0-5)
	link	Website com mais informação técnica da escola
	visivel	Disponível para visualização.
Parque Aventura	id	N.º de identificação da variável
	ilha	Ilha da actividade
	nome	Nome da variável
	local	Local onde se desenvolve a actividade
	entidade	Nome da Entidade Gestora
	contacto	Contacto telefónico da Unidade
	email	Contacto electrónico da Unidade
	link	Website com mais informações sobre unidade
	rua	Rua da Unidade
	num	N.º da Unidade
	visivel	Disponível para visualização.
Obs. de Aves	id	N.º de identificação da variável

	ilha	Ilha respectiva
	nome	Nome respectivo
	especies	Tipo de espécies observáveis
	habitats	Tipologia de habitats
	epoca	Referência à melhor época para BW
	indicacoes	Indicações adicionais sobre local.
	link	URL para mais informação
	visivel	Disponível para visualização.
Campos de Golfe	id	N.º de identificação da variável
	ilha	Ilha respectiva
	nome	Nome respectivo
	tipologia	Tipologia de serviço oferecido
	local	Local onde se desenvolve a actividade
	entidade	Nome da Entidade Gestora
	contacto	Contacto telefónico da Unidade
	email	Contacto electrónico da Unidade
	link	Website com mais informações sobre unidade
	rua	Rua da Unidade
	num	N.º da Unidade
	visivel	Disponível para visualização.
Golfe Rústico	id	N.º de identificação da variável
	ilha	Ilha respectiva
	nome	Nome respectivo
	tipologia	Tipologia de serviço oferecido
	local	Local onde se desenvolve a actividade
	entidade	Nome da Entidade Gestora
	contacto	Contacto telefónico da Unidade
	email	Contacto electrónico da Unidade
	link	Website com mais informações sobre unidade
	rua	Rua da Unidade
	num	N.º da Unidade
	visivel	Disponível para visualização.
Observação de Cetáceos	id	N.º de identificação da variável
	ilha	Ilha respectiva
	nome	Nome respectivo
	local	Local onde se desenvolve a actividade
	num_empres	N.º de Empresas a Operar no Local
	visivel	Disponível para visualização.
Mergulho - Serviços	id	N.º de identificação da variável
	ilha	Ilha respectiva
	nome	Nome respectivo
	local	Local onde se desenvolve a actividade
	num_empres	N.º de Empresas a Operar no Local
	visivel	Disponível para visualização.
Mergulho - Locais	id	N.º de identificação da variável
	ilha	Ilha a que pertence o local

	designacao	Sigla que identifica o local
	nome	Nome do local
	acesso	Tipo de Acesso ao local (Barco/pedestre)
	profundida	Profundidade Máxima do Local (m)
	tipologia	Tipo de Mergulho (escafandro/apneia)
	interesse	Interesse do local (0-5)
	vida_marin	Interesse da vida marinha do local (0-5)
	fundo	Interesse do fundo do local (0-5)
	class_ambi	Classificações Ambientais que englobam o local
	visivel	Disponível para visualização.
Passeio de Barco	id	N.º de identificação da variável
	ilha	Ilha respectiva
	nome	Nome respectivo
	local	Local onde se desenvolve a actividade
	num_empres	N.º de Empresas a Operar no Local
	visivel	Disponível para visualização.
Pesca Lúdica	id	N.º de identificação da variável
	ilha	Ilha respectiva
	nome	Nome respectivo
	local	Local onde se desenvolve a actividade
	num_empres	N.º de Empresas a Operar no Local
	visivel	Disponível para visualização.
Vela Cruzeiro	id	N.º de identificação da variável
	ilha	Ilha respectiva
	nome	Nome respectivo
	local	Local onde se desenvolve a actividade
	num_empres	N.º de Empresas a Operar no Local
	visivel	Disponível para visualização.
Surf - Serviços	id	N.º de identificação da variável
	ilha	Ilha respectiva
	nome	Nome respectivo
	local	Local onde se desenvolve a actividade
	entidade	Nome da Entidade Gestora
	contacto	Contacto telefónico da Unidade
	email	Contacto electrónico da Unidade
	link	Website com mais informações sobre unidade
	rua	Rua da Unidade
	num	N.º da Unidade
	visivel	Disponível para visualização.
Surf- Locais	id	N.º de identificação da variável
	ilha	Ilha respectiva
	nome	Nome respectivo
	local	Local onde se desenvolve a actividade
	interesse	Interesse do local (0-5)
	vento	Melhor vento para realização da actividade

	ondulacao	Melhor ondulação para a realização da actividade
	dificuldad	Grau de dificuldade do local (0-5)
	visivel	Disponível para visualização.
Caiaque de Mar	id	N.º de identificação da variável
	ilha	Ilha respectiva
	nome	Nome respectivo
	local	Local onde se desenvolve a actividade
	num_empres	N.º de Empresas a Operar no Local
	visivel	Disponível para visualização.
Coasteering	id	N.º de identificação da variável
	ilha	Ilha respectiva
	designacao	Sigla que identifica o percurso (CG1SJO)
	nome	Nome do percurso
	interesse	Interesse do percurso (0-5)
	extensao	Extensão do percurso (Km)
	duracao	Duração do percurso (h)
	orient_costa	Para onde está virada a costa
	visivel	Disponível para visualização.
Parapente	id	N.º de identificação da variável
	ilha	Ilha respectiva
	designacao	Sigla que identifica local (T01)
	nome	Nome da zona de voo
	altitude	Altitude do ponto de descolagem (m)
	desnivel	Desnível entre PD e ponto de aterragem (m)
	quadrante	Azimute de onde o vento deve estar a soprar
	nivel	Nível do suposto praticante
	tipologia	Tipologia do voo em questão
	aterragem	Informações sobre local de aterragem
	indicacoes	Indicações adicionais sobre local
	cuidados	Cuidados a considerar neste local
	visivel	Disponível para visualização.
Hotel	id	N.º de identificação da variável
	ilha	Ilha respectiva
	nome	Nome respectivo
	tipologia	Tipo de estabelecimento
	classificacao	Classificação do Hotel (1 a 5*)
	contacto	Contacto telefónico da Unidade
	email	Contacto electrónico da Unidade
	link	Website com mais informações sobre unidade
	rua	Rua da Unidade
	num	N.º da Unidade
	local	Local respectivo
	piscina	Existência de Piscina (Sim/Não)
	relax	Existência de Serviços para relaxamento
	visivel	Disponível para visualização.
Turismo Rural	id	N.º de identificação da variável

	ilha	Ilha respectiva
	nome	Nome respectivo
	tipologia	Tipologia de Unidade
	contacto	Contacto telefónico da Unidade
	email	Contacto electrónico da Unidade
	link	Website com mais informações sobre unidade
	rua	Rua da Unidade
	num	N.º da Unidade
	local	Local respectivo
	visivel	Disponível para visualização.
Alojamento Local	id	N.º de identificação da variável
	ilha	Ilha respectiva
	nome	Nome respectivo
	tipologia	Tipologia de Unidade
	contacto	Contacto telefónico da Unidade
	email	Contacto electrónico da Unidade
	link	Website com mais informações sobre unidade
	rua	Rua da Unidade
	num	N.º da Unidade
	local	Local respectivo
	visivel	Disponível para visualização.
Parques de Campismo	id	N.º de identificação da variável
	ilha	Ilha respectiva
	nome	Nome respectivo
	tipologia	Tipo - Parque classificado ou Zona de Campismo
	contacto	Contacto telefónico da Unidade
	email	Contacto electrónico da Unidade
	link	Website com mais informações sobre unidade
	rua	Rua da Unidade
	num	N.º da Unidade
	local	Local respectivo
	visivel	Disponível para visualização.
Restaurantes	id	N.º de identificação do restaurante
	ilha	Ilha respectiva
	nome	Nome respectivo
	tipologia	Tipologia de Restaurante
	contacto	Contacto telefónico da Unidade
	email	Contacto electrónico da Unidade
	link	Website com mais informações sobre unidade
	rua	Rua da Unidade
	num	N.º da Unidade
	local	Local respectivo
	preco_medio	Preço médio de uma refeição
	visivel	Disponível para visualização.
Rent-a-Car	id	N.º de identificação da variável
	ilha	Ilha respectiva
	nome	Nome respectivo
	contacto	Contacto telefónico da Unidade
	email	Contacto electrónico da Unidade
	link	Website com mais informações sobre unidade
	rua	Rua da Unidade
	num	N.º da Unidade
	local	Local respectivo
	visivel	Disponível para visualização.

Meeting Industry	id	N.º de identificação da variável
	ilha	Ilha respectiva
	tipologia	Tipologia de Equipamento
	nome	Nome respectivo
	lotacao	Lotação em Plateia do Recurso
	contacto	Contacto telefónico da Unidade
	email	Contacto electrónico da Unidade
	link	Website com mais informações sobre unidade
	rua	Rua da Unidade
	num	N.º da Unidade
	local	Local respectivo
	visivel	Disponível para visualização.
Postos de Turismo	id	N.º de identificação da variável
	ilha	Ilha respectiva
	local	Local respectivo
	nome	Nome respectivo
	entidade	Entidade Gestora do Posto
	contacto	Contacto telefónico do Posto
	rua	Rua da Unidade
	num	N.º da Unidade
	link	URL para mais informação
	visivel	Disponível para visualização.
Praia	id	N.º de identificação da variável
	ilha	Ilha respectiva
	nome	Nome respectivo
	interesse	Interesse turístico do local (0-5)
	bandeira_azul	Classificado como bandeira azul (sim/não)
	visivel	Disponível para visualização.
Piscina Natural	id	N.º de identificação da variável
	ilha	Ilha respectiva
	nome	Nome respectivo
	interesse	Interesse turístico do local (0-5)
	Infra-estruturas	Infra-estruturas como vestiários e WC (Sim/Não)
	visivel	Disponível para visualização.
Geossítios	id	N.º de identificação da variável
	gestao_ambiental	Sistema de Gestão Ambiental em questão
	classificacao	Classificação do sítio
	referencia	Referência /Código do Sítio
	designacao	Designação do Sítio
	ilha_zona	Ilha / Zona
	categoria	Categoria associada ao Sítio
	ano	Ano de selecção
	legislacao	Legislação associada
	link	URL para mais informação
	visivel	Disponível para visualização.
Miradouro	id	N.º de identificação da variável
	ilha	Ilha respectiva
	nome	Nome respectivo
	interesse	Interesse turístico do local (0-5)

	visivel	Disponível para visualização.
Património Mundial	id	N.º de identificação da variável
	ilha	Ilha respectiva
	nome	Nome respectivo
	tipologia	Tipo de Classificação (natural, cultural, mista)
	ano	Ano da classificação
	visivel	Disponível para visualização.
Museu	id	N.º de identificação da variável
	ilha	Ilha respectiva
	nome	Nome respectivo
	tipologia	Tipo de Museu / Entidade em questão
	link	Website da entidade em questão
	visivel	Disponível para visualização.
Vigia de Baleia	id	N.º de identificação da variável
	ilha	Ilha respectiva
	nome	Nome respectivo
	interesse	Interesse turístico do local (0-5)
	estado	Estado de conservação do Local
	visivel	Disponível para visualização.
Farol	id	N.º de identificação da variável
	ilha	Ilha respectiva
	nome	Nome respectivo
	int_paisagistico	Interesse paisagístico do local (0-5)
	int_construcao	Interesse da construção (0-5)
	ano	Ano de Construção
	altura	Altura do Farol (m)
	altitude	Altitude do Farol (m)
	visivel	Disponível para visualização.
Monumentos	id	N.º de identificação da variável
	ilha	Ilha respectiva
	nome	Nome respectivo
	tipologia	Tipo de Ponto de interesse cultural
	interesse	Interesse turístico do local (0-5)
	visivel	Disponível para visualização.
Igrejas	id	N.º de identificação da variável
	ilha	Ilha respectiva
	nome	Nome respectivo
	tipologia	Tipo de Ponto de interesse cultural
	interesse	Interesse turístico do local (0-5)
	visivel	Disponível para visualização.
Arquitectura Popular	id	N.º de identificação da variável
	ilha	Ilha respectiva
	nome	Nome respectivo
	tipologia	Tipo de Ponto de interesse cultural

	interesse	Interesse turístico do local (0-5)
	visivel	Disponível para visualização.
Rede Regional	id	N.º de identificação da variável
	gestao_ambiental	Sistema de Gestão Ambiental em questão
	classificacao	Classificação do sítio
	referencia	Referência /Código do Sítio
	designacao	Designação do Sítio
	ilha_zona	Ilha / Zona
	categoria	Categoria associada ao Sítio
	ano	Ano de selecção
	legislacao	Legislação associada
	link	URL para mais informação
	visivel	Disponível para visualização.
Reserva da Biosfera	id	N.º de identificação da variável
	gestao_ambiental	Sistema de Gestão Ambiental em questão
	classificacao	Classificação do sítio
	referencia	Referência /Código do Sítio
	designacao	Designação do Sítio
	ilha_zona	Ilha / Zona
	categoria	Categoria associada ao Sítio
	ano	Ano de selecção
	legislacao	Legislação associada
	link	URL para mais informação
	visivel	Disponível para visualização.
RAMSAR	id	N.º de identificação da variável
	gestao_ambiental	Sistema de Gestão Ambiental em questão
	classificacao	Classificação do sítio
	referencia	Referência /Código do Sítio
	designacao	Designação do Sítio
	ilha_zona	Ilha / Zona
	categoria	Categoria associada ao Sítio
	ano	Ano de selecção
	legislacao	Legislação associada
	link	URL para mais informação
	visivel	Disponível para visualização.
Rede Natura 2000	id	N.º de identificação da variável
	gestao_ambiental	Sistema de Gestão Ambiental em questão
	classificacao	Classificação do sítio
	referencia	Referência /Código do Sítio
	designacao	Designação do Sítio
	ilha_zona	Ilha / Zona
	categoria	Categoria associada ao Sítio
	ano	Ano de selecção
	legislacao	Legislação associada
	link	URL para mais informação
	visivel	Disponível para visualização.
OSPAR	id	N.º de identificação da variável
	gestao_ambiental	Sistema de Gestão Ambiental em questão
	designacao	Designação do Sítio
	regiao	Região associada ao sítio
	zona	Zona geográfica
	ano	Ano de selecção
	link	URL para mais informação

Aeroporto	id	N.º de identificação da variável
	ilha	Ilha respectiva
	nome	Nome respectivo
	gerencia	Entidade gerente do aeroporto
	tipologia	Aeroporto, aeródromo
	ligacoes	Ligações ext. e int.
	contacto	Contacto telefónico da Unidade
	email	Contacto electrónico da Unidade
	link	Website com mais informações sobre unidade
	rua	Rua da Unidade
	num	N.º da Unidade
	local	Local respectivo
	visivel	Disponível para visualização.
Marina	id	N.º de identificação da variável
	ilha	Ilha respectiva
	nome	Nome respectivo
	canais_vhf	Canais VHF suportados pela Marina
	amarracoes	N.º de Amarrações
	contacto	Contacto telefónico da Marina
	email	Contacto electrónico da Marina
	link	Website com mais informações sobre a marina
	visivel	Disponível para visualização.
Porto de Embarque	id	N.º de identificação da variável
	ilha	Ilha respectiva
	local	Nome do Porto
	entidades	Entidade que operacionam serviços
	visivel	Disponível para visualização.
Ligações	id	N.º de identificação da variável
	idl	ID para linhas de ligação ID_ID (Portos)
	ilha1	Ilha de Partida
	ilha2	Ilha de Chegada
	epoca	Época do Ano
	duracao	Tempo de realização da Viagem (h)
	entidade	Entidade que operaciona o serviço
	visivel	Disponível para visualização.