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A WEB-BASED GEOGRAPHICAL INFORMATION SYSTEM PROTOTYPE ON PORTUGUESE TRADITIONAL FOOD PRODUCTS

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A WEB-BASED GEOGRAPHICAL INFORMATION SYSTEM PROTOTYPE ON PORTUGUESE TRADITIONAL FOOD PRODUCTS

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ABSTRACT

Portuguese traditional food products use certification labels from EU quality schemes to distinguish from other food products. With the number of traditional food products increasing every year, how to manage the information more efficiently and how to spread the information to the public more clearly and interactively become the challenges. Considering the geographic distribution is one of the key features of the traditional food products, the web-based GIS is a potential system to manage and share the information. In this thesis, the prototype of web-based GIS is designed as three tiered software architecture comprising of web application, web service and spatial database. The prototype provides the possibility to integrate with the information from other sources. For the information managers, the prototype takes advantage of the web, open specifications and open source software. Therefore, it minimizes the barrier of the migration from original information system, and the information management is easy to be done in the web browser. For the public, the web map is easy to use and user-friendly. In the end, the potential improvement in the management web interface is discussed, and the further development such as introducing more roles into the system and having the usability test are pointed out.

KEYWORDS

Open source software

Open specifications

Traditional food products

Web-based GIS

ACRONYMS

API - Application Programming Interface

CAOP - Carta Administrativa Oficial de Portugal

EPSG - European Petroleum Survey Group

EU - European Union

GIS - Geographic Information System

GPP - Gabinete de Planeamento e Políticas

OPC - Organismo Privado de Controlo e Certificação

OGC - Open Geospatial Consortium, Inc.

PDO - Protected Designation of Origin

PGI - Protected Geographical Indication

SRS ID - Spatial Reference System Identifier

TSG - Traditional Speciality Guaranteed

WCS - Web Coverage Service

WFS - Web Feature Service

WKT - Well-known text

WMS - Web Map Service

WWW – World Wide Web

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1. Introduction

There are many Portuguese traditional food products that throughout decades, if not centuries, by the local, loyal and permanent way they are produced, have been given such a reputation that they are actually known by their brand names. Meanwhile those products are facing series of offences, not so much against their brand names, but especially against the consumer, making him/her believe that the products without any characteristics of quality associated to a origin or a production process, are the “good”, “genuine” or “real” ones. In order to make a distinction between fraudulent and genuine traditional food products, the quality schemes using different labels are introduced in European Union (EU).

As the success of the EU quality schemes, the number of traditional food products is increasing every year. How to make the management of the information efficiently and how to share the information smoothly between EU members are the challenges for the organization. At the same time, another challenge is that how to make the consumer to be aware of such good quality traditional food products and their quality schemes, so that when consumers make their purchases, the traditional food product could be easily distinguished from other food products.

With the development of World Wide Web (WWW or the web), one good way is to use the web as platform to manage and present the traditional food product information. Also using open specifications and open source software could make the interoperation among systems go smoothly. In principle, the traditional food product is associated with the specific area, either by its origin or production. In other words, geographic information is one of the key characters of those products. Therefore, the web-based Geographic Information System (GIS) may be an efficient system to gather, integrate and manage Portuguese traditional food product information, and to present the information to consumers using web map, one of components from the system.

1.1 Objectives of thesis

The overall objective of the thesis is to use open specifications and open source software to set up a web-based GIS prototype for managing and spreading the information of Portuguese traditional food products.

Firstly the user requirements from the organization, which will deploy this web-based GIS, need to be studied. Then it is necessary to study and refine the original information system of Portuguese traditional food products to be accessible by the web-based management interface and extendable to introduce the geographic information. Thirdly, the geographic information from other sources will be integrated into the system. Fourthly, the web interfaces for managing the information need be provided. Finally, the web map for presenting the Portuguese traditional food products information will be designed in the thesis.

The expected result will be the web-based GIS prototype using open specifications and open source software to manage the information by the web interface, and to present the information by a user-friendly web map so that the staff could manage information efficiently and the public could get interested in and be aware of Portuguese traditional food products.

1.2 Thesis structure

There are five chapters in the thesis. *Chapter one* introduces the thesis in general, and descriptions of other chapters are listed as below:

Chapter two talks about the knowledge used in the thesis, including the background and challenges of traditional food product in EU and in Portugal, the development of web-based GIS, and the introduction of relevant web technologies, open specifications and open source software.

In *chapter three*, the original information system is studied in the beginning. Then different end users of the prototype are defined, and their requirements are listed. Based on the user requirements, the structure of the prototype is designed. Lastly the general development environment is described.

Chapter four provides the details of the implementation of the prototype, including refining database, importing geographical information, publishing information to web server and designing web interfaces.

At the end, *chapter five* draws the conclusions by discussing the advantages and the limitations of the prototype. The suggestions for further development of the prototype are presented too.

2. Traditional food products & web-based GIS

The quality schemes on traditional food products in EU and Portugal are described, and the challenges are studied to better understand the original information system and user requirements. The development of web-based GIS, web technologies, open specifications and open source software are reviewed in this chapter.

2.1 EU Quality schemes on traditional food products

In order to meet global competition from producers with lower costs outside the EU, and to meet consumer demand, European farmers and agro-industry must build quality into their strategy (Boel 2008). Therefore, in 1992, the agricultural policy focus shifted from increasing food quantity towards increasing food quality. Three regulations were adopted in 1991 and 1992, namely Regulation (EEC) No. 2081/92 on the protection of geographical indications and designations of origin for agricultural products and foodstuffs, Regulation (EEC) No. 2082/92 on certificates of specific character for agricultural products and foodstuffs, and Regulation (EEC) No. 2092/91 on organic production of agricultural products (Becker and Staus 2008). These three regulations are the cornerstones of EU agriculture and food quality policy. Products protected by these EU quality schemes have a privileged position, not only with respect to the legal protection, but also with respect to EU financial aid and the eligibility of Member State financial aid for the promotion of these products (Becker and Benner 2000).

Based on those EU quality schemes, there are three main certification labels, Protected Designation of Origin (PDO), Protected Geographical Indication (PGI), and Traditional Speciality Guaranteed (TSG). Both PDO and PGI are geographical indications, which are names describing an agricultural product or foodstuff that owes its characteristics or its reputation to the geographical area from which it originates (2008), and are considered to be a valuable tool to "institutionalize reputation", i.e. to protect an established reputation (Bramley and Kirsten 2007).

For a name to qualify as a PDO, all the steps of production must in principle take place in the geographical area and the product's characteristics must be exclusively or essentially due to its geographical origin. For a name to qualify as PGI at least one step of production has to take place in the area, and the link to the area concerned can be justified by reason of a specific quality, reputation or other characteristic linked to the geographical area (2008).

The geographical indications schemes of PDO and PGI are clearly a tremendous success. In the wine sector, geographical indications are an essential marketing tool, adding value to quality wines associated with origin and specifically with the terroir where the grapes are grown (Boel 2008). And in addition to nearly 4000 geographical indications for wines and spirits, now there are 818 registered names for agricultural products and foodstuffs under the PDO and PGI Regulation – and hundreds of applications in the pipeline (Boel 2008).

2.2 Certification system of traditional food products in Portugal

Portugal is one of countries with high number of traditional food products registered as PDO and PGI, compared to other EU countries (Table 1). For example, a high number of meat products are registered in Portugal (Becker and Staus 2008). Overall, there are 104 Portuguese traditional food products that have been registered in 2007.

There are several roles highly associated with certification of Portuguese traditional food products. One of the basic roles is the producer or processor of the food. Without them, the food could not be available in the market. There are many associations of producers and/or processors in different kinds of legal form or compositions. In general, each of association deals with one specific product, and wants to promote it. Therefore, the association takes the responsibility to request and register the certification labels, such as PDO, PGI or TSG. Such kind of association or group is named as "Agrupamento de Produtores" in Portuguese. During and after the registration, the independent private third party named "Organismo Privado de Controlo e Certificação" (OPC) in Portuguese will carry

out the inspection and certification throughout. These two organizations are the fundamental units for promoting Portuguese traditional food products, using label certifications. More details of the process flow for registering the certification label is described in Appendix.

	Total	Cheese	Meat-Based	Breads and Bakery	Oils	Fish	Beer	Other Drinks	Fruits and Vegetables	Fresh Meat	Other Animal Product	Olives	Other
Italy	159	32	28	3	38				47	2	2	2	5
France	155	45	4	2	9	2		5	26	51	6	3	2
Spain	105	19	10	7	20				30	13	3		3
Portugal	104	12	28		6				21	26	10	1	
Greece	84	20		1	25	1			22		1	10	4
Germany	67	4	8	4	1	2	12	31	2	3			
United Kingdom	28	11				3	2	3	1	7	1		
Austria	12	6	2		1				3				
Czech Republic	6			1		1	3		1				
Netherlands	6	4							2				
Belgium	5	1	2	1	1								
Ireland	4	1	1			1				1			
Luxemburg	4		1		1					1	1		
Denmark	3	2							1				
Sweden	2	1		1									
Finland	1								1				
Poland	1	1											
Slovenia	1				1								
Total	747	159	84	20	103	10	17	39	157	104	24	16	14

Table 1: Number of PDO and PGI products in the EU
(Source: Moschini, G.C., Menapace L. & Pick D., 2008. Geographical indications and the competitive provision of quality in agricultural markets. *Amer. J. Agr. Econ*, 90(3): 794-812)

The basic administrative unit for defining the geographical area of traditional food product in Portugal is “freguesia” in Portuguese. Though the administrative division of Portugal is undergoing changes, freguesia is the same administrative level as civil parishes, while “concelho” in Portuguese meaning municipality usually consists of several freguesia.

Direcção de Serviços das Fileiras Agro Alimentares, Gabinete de Planeamento e Políticas (GPP) do Ministério da Agricultura, do Desenvolvimento Rural e das Pescas in Portugal is the office who manages all the information about Portuguese traditional food products, including information of products, Agrupamento de Produtores and OPC. It is this office who provides the information and shows the need for the web-based GIS to manage and spread the information on traditional food products.

2.3 Challenges of traditional food products information system

The number of traditional food products registered under the EU quality schemes is steadily increasing every year. It shows the success of geographical indications schemes, but also means more and more information related with those traditional food products need to be collected, managed, and published. So how to manage the information more efficiently becomes an essential issue.

The geographical indications schemes have a great success because the geographical feature is considered as one of key features of the traditional food products. If this geographical feature could still be considered as one of key features in the management system, other non-geographical information may be organized and managed more efficiently around geographical information. GIS is such kind of system considering the geographical information as the most important feature in the system. Therefore, GIS could be an alternative to manage the information of traditional food products.

Moreover, different EU members have their own agencies using different systems to manage the information. There are needs for exchanging information among those systems. So using open specifications and open source software to make sure of the open of the system is meaningful, and it could make the system more flexible and the information more exchangeable.

Another challenge is that how to make the consumer to be aware of the good quality traditional food products and their quality schemes, so that when consumers make their purchases, the traditional food product could be easily distinguished from other food products. A user-friendly web map could attract public's attention, and the information could be spread clearly.

One of the attempts to build the information system on traditional food products is QualiGeo from Italy (Figure 1). It is a project supported by Qualivita Foundation. It provides the information on traditional food products from Italy and Spain. The information includes non-geographical information like the introduction of the products, and the geographical information, the distribution of the selected

product. The website presents the distribution of food products as the atlas without many options to interact in the map.

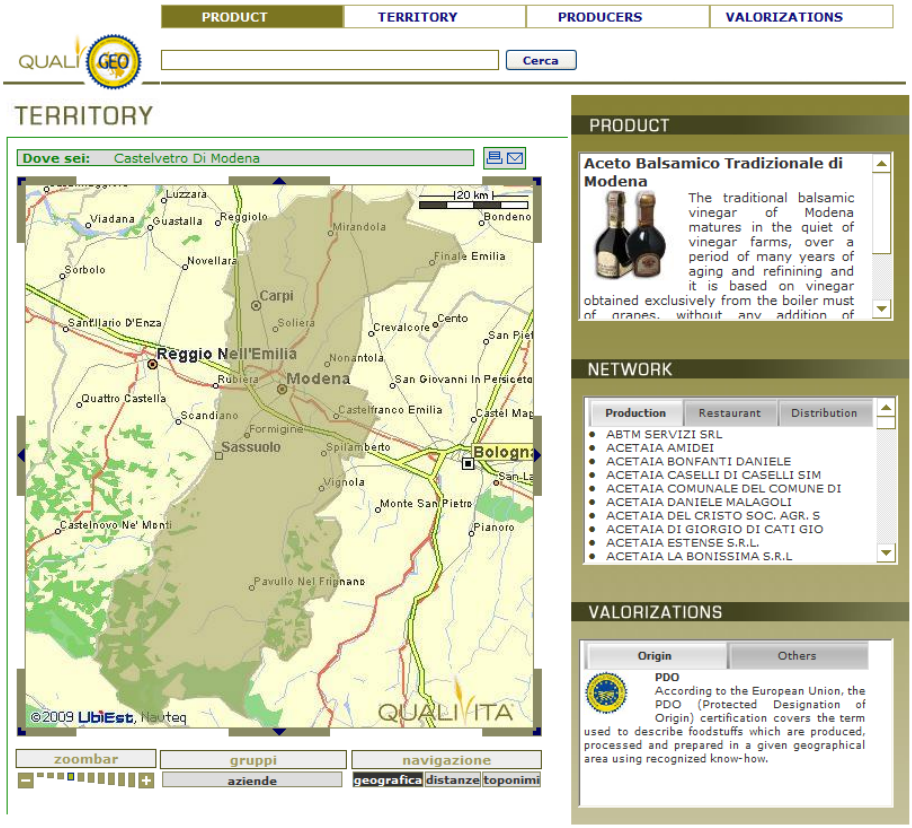

Figure 1: Webpage on the information of food product from QualiGeo.
(Source: www.qualigeo.it Retrieved February 19, 2009)

2.4 Web-based GIS

As is universally recognized in the literature, GIS supports complex spatial decisions through advanced visualization, interactive modeling, and analysis environments (Densham and Armstrong 1994, Densham 1996). GIS is thus far utilized to help with perception and understanding of spatially distributed phenomena in many areas of decision making and evaluating problems (Sakamoto and Fukui 2004).

Meanwhile, the WWW is becoming the core medium for distributed computing in IT generally and in the geo-processing domain specifically (Hecht 2002a). In other words, GIS once focused on data and tools implemented with client-server

architecture, now are evolving to a web services model (Dangermond 2002). In this new architecture, the web is used for delivering not just data, but geo-processing functionality that can be wrapped in interoperable software components called web services (Anderson and Moreno-Sanchez 2003). These components can be plugged together to build larger, more comprehensive services and/or applications (Hecht 2002b). The web could provide the platform meeting the need for ubiquity, ease of access, flexibility, and reducing risk of isolation and obsolescence. Therefore, the benefits of GIS could widely spread in the web.

The web-based GIS provide basic GIS functions to users with browsers. The ability to pan, zoom, turn data layers on and off and, more importantly, to query and view attribute data linked to mapped objects, is widely available (Drummond and French 2008). More sophisticated techniques such as routing and point-in-polygon analysis are becoming available. This type of online mapping technology has been used to support local comprehensive planning efforts and interactive mapping of neighborhood indicators (Sawicki and Craig 1996, Craig 1998).

The development of the web-based GIS is consistent with changes in the Web. Web 2.0, a new generation of Internet services and technology or the second wave of the WWW (Deshpande and Jada 2006), encourages significantly more interaction between users (Boulos and Wheeler 2007, Schuurman *et al.* 2008). This evolution leads GIS away from data browsing, analyzing and managing for individual decisions, and more towards group participating and communicating on social decision issues (Carver 1999). As Craig et al. (1999) describes the Public Participation GIS principles as accessibility, understandability, and accountability, Web GIS continues to draw attention as a public participation tool (Sakamoto and Fukui 2004).

Recently, many websites or application such as Google Maps, Google Earth, OpenStreetMap, Yahoo Maps and Microsoft's Live Search Maps provide many kinds of geographical related information such as detailed maps, satellite images and terrain maps all over the world. Several of these sites provide Application Programming Interface (API) that allow sophisticated users to add their own data

and functions (Drummond and French 2008). Those websites offer a GIS interface for displaying and combining geographically related data (Cheung *et al.* 2008), while the APIs allow users to produce mashups, or applications that display user-generated content on top of the commercial site's data and take advantage of the site's display and query capabilities (Drummond and French 2008).

There are many case studies and applications on web-based GIS in various areas. Carver (1999) shows an example of a web GIS-based social decision support system by means of a site selection problem for radioactive waste disposal. Gao (2008) developed a service oriented architecture for online disease mapping, which can enhance the efficiency and effectiveness of public health surveillance. Wikimapia.com allows users to post location-specific notes and comments onto Google Earth, much as users provide the content for Wikipedia. This creates an opportunity for users to provide input about features or conditions at particular locations (Drummond and French 2008).

Overall, the web-based GIS is a great platform to share and manage the geographical related information in a ubiquity, visualization and interactive way. These kinds of characteristics in web-based GIS meet the needs for managing and presenting the Portuguese traditional food products which are closely associated with their geographic distributions.

2.5 Web technologies for web-based GIS

Following is a brief introduction of some web technologies which are used in the prototype.

2.5.1 Web server

Web server is the server that accepts HTTP requests from clients, and serves them HTTP responses along with optional data contents, which usually are web pages such as HTML documents and linked objects such as images. The most popular web server software is Apache based on Netcraft survey in January 2009. Apache HTTP Server is the open source software and available for a wide variety of

operating systems, including Microsoft Windows, UNIX, and Linux. It supports many programming languages like PHP, Perl, Python and Ruby.

PHP is a widely-used general-purpose scripting language that is especially suited for web development and can be embedded into HTML. It generally runs on a web server, taking PHP code as its input and creating web pages as output. It can be deployed on most web servers and on almost every operating system and platform free of charge. The advantage of PHP is that it could generate the dynamic webpage retrieving information from database in the server side.

2.5.2 JavaScript

JavaScript is a scripting language widely used for client-side web development. It was the originating dialect of the ECMAScript standard. JavaScript was influenced by many languages and was designed to look like Java, but is easier for non-programmers to work with. As used in client side, it is a dynamic, weakly typed, prototype-based language with first-class functions, and helps to reduce the request to the server.

2.5.3 API

API is a set of routines, data structures, object classes and/or protocols provided by libraries and/or operating system services in order to support the building of applications. An API may be:

- Language-dependent, that is, only available in a particular programming language, utilizing the particular syntax and elements of the programming language to make the API convenient to use in this particular context.
- Language-independent, that is, written in a way that means they can be called from several programming languages (typically an assembly/C-level interface). This is a desired feature for a service-style API which is not bound to a particular process or system and is available as a remote procedure call.

The API itself is largely abstract in that it specifies an interface and the behavior of the objects specified in that interface. The API acronym may sometimes be used as a reference not only to the full interface but also to a single function or even a set of multiple APIs provided by an organization. Thus the scope is usually determined by the person or document that communicates the information. Based on the API documents, the user could learn and combine exist functions in the application more easily and efficiently.

2.6 Open specifications for web-based GIS

The open specification provides information about a given specification as well as specific programming rules and advice for implementing the interfaces and/or protocols that enable interoperability between systems (Moreno-Sanchez *et al.* 2007).

The Open Geospatial Consortium, Inc. (OGC) is a non-profit, international, voluntary consensus standards organization that is leading the development of standards for geospatial and location based services. OpenGIS is a Registered Trademark of the OGC and is the brand name associated with the Specifications and documents produced by the OGC. OpenGIS Specifications support interoperable solutions that "geo-enable" the Web, wireless and location-based services, and mainstream IT. The specifications empower technology developers to make complex spatial information and services accessible and useful with all kinds of applications.

Most of the OGC standards are based on a generalized architecture captured in a set of documents collectively called the Abstract Specification, which describes a basic data model for geographic features to be represented. Atop the Abstract Specification are a growing number of specifications, or standards, that have been (or are being) developed to serve specific needs for interoperable location and geospatial technology, including GIS. Most of well-known specifications are the Web Map Service (WMS), the Web Feature Service (WFS), and the Web

Coverage Service (WCS). Figure 2 indicates the relationships among some specifications provided by OGC.

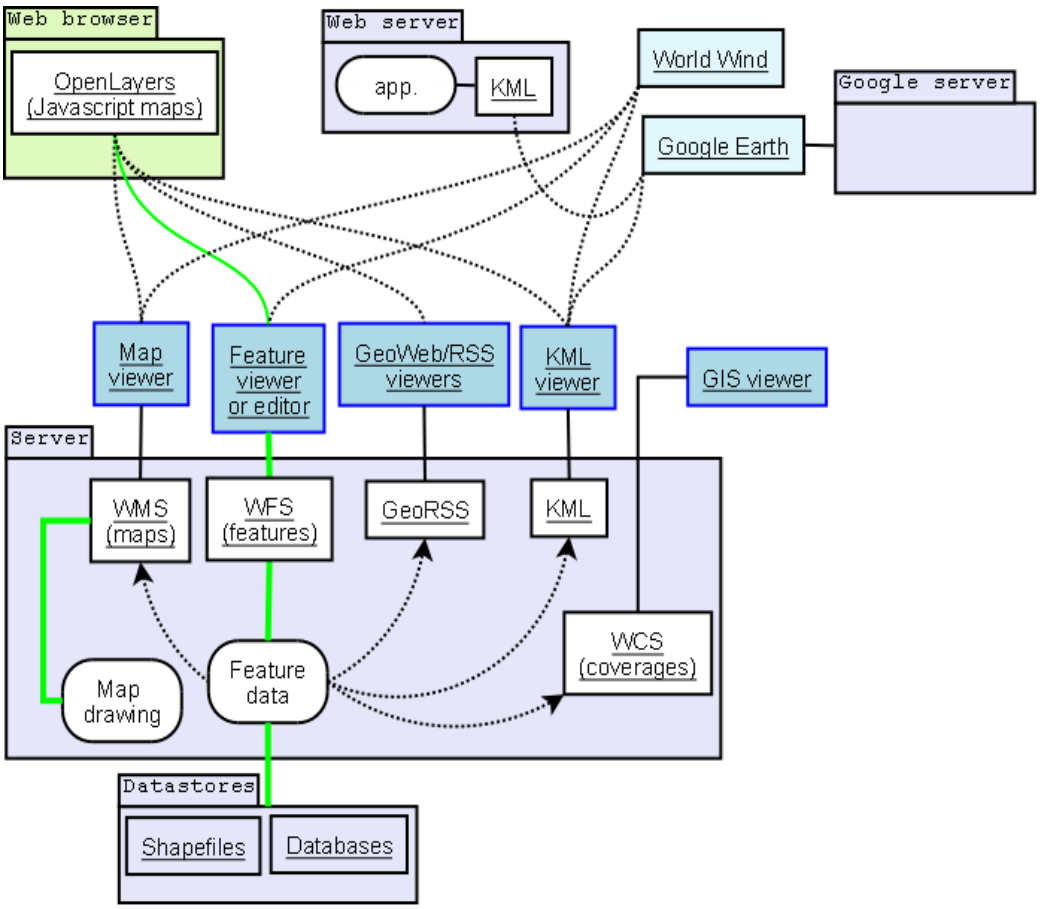

Figure 2: Geoservices server with interfaces and applications sketch.
(Green represents read and write paths. Dotted arrowed line indicates mostly read-only data flow)
(Source: http://en.wikipedia.org/wiki/Open_Geospatial_Consortium Retrieved February 19, 2009)

WMS provides a simple HTTP interface for requesting geo-registered map images from one or more distributed geospatial databases. A WMS request defines the geographic layer(s) and area of interest to be processed. The response to the request is one or more geo-registered map images (returned as JPEG, PNG, etc) that can be displayed in a browser application. The interface also supports the ability to specify whether the returned images should be transparent so that layers from multiple servers can be combined or not. Therefore, it allows for a smooth integration of different (raster or vector) maps in web mapping applications over the Internet (Schütze 2007).

2.7 Open source software for web-based GIS

Open source software are programs whose licenses give users the freedom to run the program for any purpose, to modify the program, and to freely redistribute either the original or modified program without further limitations or royalty payments. There are many open source software available to develop the web-based GIS. The descriptions on software below are some of them selected to be used in the prototype.

2.7.1 PostGIS/PostgreSQL

Spatial databases are an extension of general purpose databases, and they provide spatial indexing and support spatial queries. These features improve performance for geospatial applications. In this prototype, since the open source database PostgreSQL with PostGIS extension could support spatial features very well, they are used for the spatial database.

PostgreSQL is a powerful, open source object-relational database system. It has more than 15 years of active development and a proven architecture that has earned it a strong reputation for reliability, data integrity, and correctness. It runs on all major operating systems, including Linux, UNIX and Windows. It has full support for foreign keys, joins, views, triggers, and stored procedures (in multiple languages). It includes most SQL92 and SQL99 data types. It also supports storage of binary large objects, including pictures, sounds, or video. It has native programming interfaces for C/C++, Java, .Net, PHP, Perl, Python, Ruby, Tcl, ODBC, among others, and exceptional documentation.

PostGIS is a project which adds support for geographic objects in PostgreSQL, allowing it to be used as a spatial database for GIS, much like ESRI's SDE or Oracle's Spatial extension. It implements the OGC standard (Simple Features Specification for SQL) for spatial extensions to the SQL language, and is widely supported by other GIS software. PostGIS also allows the creation and use of R-Tree spatial indices (Guttman 1984) based on the GiST indexing method inherent

in PostgreSQL. This can provide significant performance gains when making spatial queries (WALDRON *et al.* 2006).

2.7.2 GeoServer

GeoServer is an open source 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 open standards. GeoServer is the reference implementation of the WFS and WCS standards, as well as a high performance certified compliant WMS. GeoServer forms a core component of the Geospatial Web. Compared to the MapServer, GeoServer supports the most of GIS functions rather than only publish spatial data. In order to make sure the extendibility of the prototype, the GeoServer is preferred, though limited GIS functions are needed now.

2.7.3 GeoWebCache

Maps are relatively static, and do not change very often. As most mapping clients render WMS data every time they are queried, this can result in unnecessary processing and increased waiting time. GeoWebCache optimizes this experience by caching map tiles as they are requested, in effect acting as a proxy between client such as OpenLayers and server such as GeoServer, or any WMS-compliant server. As new maps and tiles are requested, GeoWebCache intercepts these calls and returns pre-rendered tiles if stored, or calls the server to render new tiles as necessary. Thus, once tiles are stored, the speed of map rendering increases many times, making for a more seamless user experience. The primary purpose to use GeoWebCache is to reduce the response time of the prototype.

2.7.4 JavaScript libraries

Many JavaScript libraries have been developed for GIS nowadays. OpenLayers is a fundamental one, while MapFish has more user-friendly interface.

OpenLayers is an open source JavaScript library released under a BSD-style License for displaying a dynamic map in web browsers. It provides an API for building rich web-based geographic applications similar to Google Maps and MSN Virtual Earth. The library includes components from the Rico JavaScript library and the Prototype JavaScript Framework.

Ext JS is a JavaScript library for building interactive web applications using techniques such as AJAX, DHTML and DOM scripting. It includes high performance with customizable UI widgets, well designed and extensible component model, an intuitive, and an easy to use API. Both commercial and Open Source licenses are available.

MapFish is an easy-to-use and extensible web 2.0 mapping application framework. It is composed of two parts: MapFish Client and MapFish Server. MapFish Client is a JavaScript framework based on OpenLayers for the mapping part and Ext JS for the widgets part. MapFish Server is responsible for server side treatments and composed of several modules which can be implemented in several languages such as Python, Java, and PHP.

MapFish is intended to be easy to use either as a standalone application or as an add-on to an already existing web application. As a standalone application, MapFish offers ways to simply configure some parameters and quickly have a working web mapping application. As a framework, MapFish lets you develop advanced and customized web mapping applications. MapFish API also allows maps to be simply included in an already existing website such as component content management or information system oriented applications.

The strengths of MapFish reside in the integration of several components and the support of the latest Web 2.0 technology. This allows the creation of advanced Mapping solutions.

GeoExt is a JavaScript library providing the groundwork for creating web-mapping applications based on OpenLayers and Ext. Though GeoExt is still in the initial development, its codes are herniated from Mapfish and have not been

released yet, some new features targeted for its first release really get the attention. GeoExt and Mapfish are going to cooperate closely throughout, and Mapfish will import the new features from GeoExt in future, so it could be considered as GeoExt is one of the components in Mapfish.

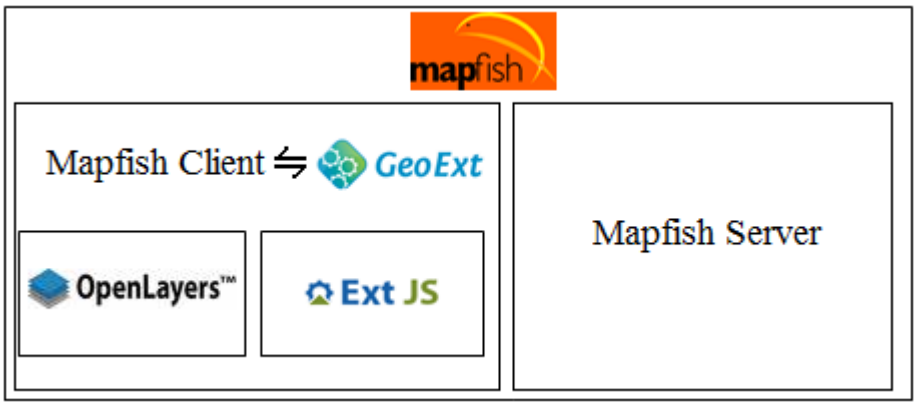

Figure 3: Relationship among OpenLayers, Ext JS, GeoExt and Mapfish.

Overall, Mapfish successfully aggregates the most of JavaScript which will be used in the prototype for web-based GIS, though APIs from different libraries may have been used when doing some specific functions. The general relationship between four JavaScript libraries for GIS is shown in the figure 3.

2.8 Conclusion

Certification labels, especially geographical indications like PDO and PGI are the very important components for building quality into the traditional food products. While Portugal has a high number of traditional food products compared to other EU members. So there are needs to have the information management system, which could interoperate with other systems, and to get attention from public to spread the information on Portuguese traditional food products. The web-based GIS have been developed into a comprehensive and interactive GIS platform, and may provide an efficient way to manage the information considering one of its key information is geographic information. Open specifications and open source software such as WMS and Mapfish are available to make building a web-based GIS possible.

3. Methodology

The original information system on traditional food products is described in the beginning. Then end users of web-based GIS are defined, and their requirements are documented. Based on those requirements, the architecture of the web-based GIS is designed. At the end of the chapter, the system environment for developing and testing the web-based GIS prototype is described in detail.

3.1 Original information system

The original system for Portuguese traditional food products uses Microsoft Office Access 2003 to manage the information. The size of the single Access file is around 126MB, with 33 tables to store the information, and 34 queries, 36 forms and 15 reports to input and retrieve the information. There is no spatial information in the system.

3.2 User requirements

The general requirement is the information management system which could show the information of Portuguese traditional food products by web map.

There are two types of end users: the staff and the public. The staff are working in GPP, and using the original information system to manage the information. They have the training in how to use the system, and the efficiency is their main concern. While the public do not receive any training for the system and their technical skills vary greatly. So the user-friendly interface is very important.

For the staff, considered introducing geographic information, a new database may be required. If so, it needs to be compatible with the original database as much as possible. The information can also be managed by the web interface efficiently.

For the public, the web map showing the information should be easy to use and the interface should be user-friendly. The web map should meet following requirements:

- Basic web map components: zoom bar, navigate bar, zoom in/out tools, map history, legends;
- The switch among two islands and continent is easy and efficient;
- Different base maps such as satellite maps, road maps and terrain maps;
- Provide the distribution of Portuguese traditional food products;
- Provide other information of Portuguese traditional food products, such as product pictures, certification logo, its Agrupamento and OPC addresses and so on;
- Provide the information of freguesia, like the name and the list of products distributed in that region;
- Provide the information of Agrupamento de Produtores, such as the detail address information and the list of products related to it;
- Provide the information of OPC, such as the detail address information and the list of products regulated by it.

3.3 System architecture

The system is designed as a three tiered software architecture comprising of Web Application, Web Service and Spatial Database (Figure 4).

In web application, there are the website using JavaScript libraries to show the information with some basic GIS functions and several web interfaces for the management.

In web service, there is the web server using Apache, which supports PHP script to generate the webpage dynamically. The web server also supports GeoWebCache by Tomcat extension. GeoServer provides WMS directly or through GeoWebCache.

In spatial database, PostgreSQL database with PostGIS extension are used to store spatial and non-spatial information. Meanwhile, Google Map Server provides the external map services.

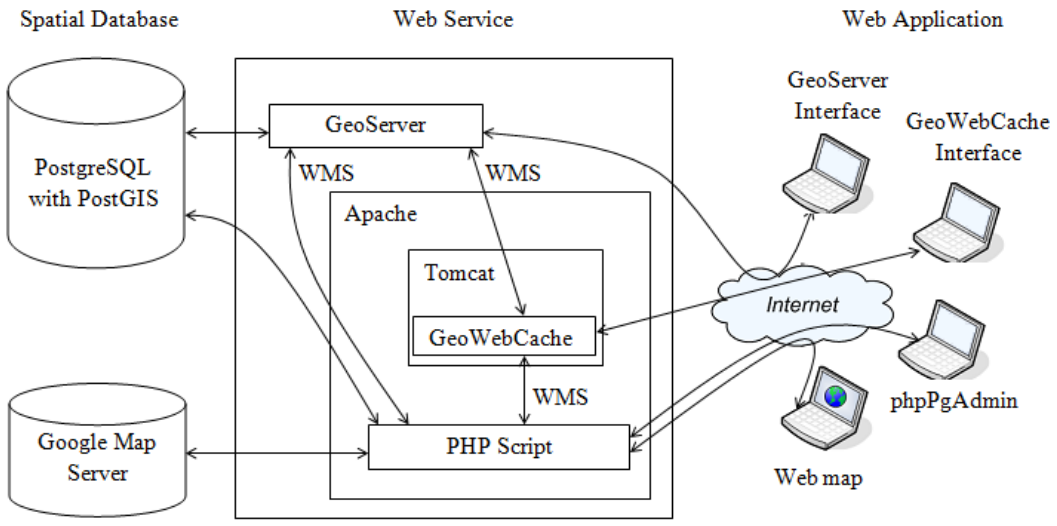

Figure 4: System architecture for the web-based GIS prototype.

A typical route for retrieving information is that the client sends the requests to the web server. Through the PHP module, the web server sends the requests to the PostgreSQL database, which usually are SQL sentences, to get the non-spatial information. Then the database returns the results to the web server. For spatial information, the web server sends WMS requests to the GeoServer or the GeoWebCache. For GeoWebCache, it will check if it has the request image in the cache. If so, it will send the results to the web server directly, otherwise, it will send the WMS request to GeoServer. After getting the request, GeoServer will fetch geographic information from database, and then GeoServer sends the results back to either the GeoWebCache or the web server. GeoWebCache sends the results to the web server. In the end, web server returns the results to the client side.

3.4 System environment

The web-based GIS prototype is developed and tested in a HP laptop, with Intel Core Duo CUP T7300, Mobile Intel 965 Express Chipset Family and 2GB RAM. Microsoft Windows XP Professional with Service Pack 3 is used as the operating system. The web server is using Apache HTTP Server 2.2.9 with PHP 5.2.6 support. The database uses PostgreSQL 8.3.5 with extension of PostGIS 1.3.4.

phpPgAdmin 4.2.1 is used for the web interface for the database. The GeoServer 1.7.1 is installed. Apache Tomcat 6.0.18 is installed to support the GeoWebCache 1.0.1. The Apache HTTP Server and GeoServer are using the default port 80 and 8080 respectively, while GeoWebCache is using 8888 port. Notepad++ 5.1.4 is used as the editor for the website, and Firefox 3.0.6 is used as web browser.

3.5 Conclusion

The original information system on Portuguese traditional food products uses the Microsoft Office Access 2003, without any spatial information. There are two types of end users for the web-based GIS prototype: the staff and the public. Based on their requirements, the system architecture is designed as a three tiered software architecture comprising of Web Application, Web Service and Spatial Database. At the end, the detail of the system environment is described.

4. System implementation

In this chapter, the descriptions of system implementation are divided into three parts: spatial database, web server and web application, based on the system architecture designed in the previous chapter.

4.1 Spatial Database

The structure of the original database is shown in Figure 5. Because the prototype will focus on the traditional food products in Portugal, the traditional food products from other EU countries will not be considered in the prototype. Thus the tables which only contain information on traditional food products from other EU countries are removed, and the database structure is simplified as Figure 6.

The simplified database structure consists of several aspects on traditional food products. One of them is the information about food product itself, including the regulation, the statue of certification, the category it belongs, and so on. Another aspect is the information about participants in the traditional food products, such as producer, agrupamento and OPC. But the information about producer is not collected completely yet, so it will not be well considered in this prototype at the moment. Last one is the distribution of each Portuguese traditional food products.

In order to be compatible with original database as much as possible, only few changes have been made (Figure 7). The original table named “lexeuropeia_old” is divided into two tables, which are “produto_lex” and “lex”, because of the duplication of values of “lex” in the records. The key “regulamento” from table of “classificacao” is separated as a table named “regulamento”. The relationship between tables of “apresentacomercial”, “tipoproduto” and “apresenta_categoria” could be improved, but the prototype does not need much information from those tables based on the user requirement. So there is no change for their relationship. In addition, some names of tables have been changed to clear their meaning. For example, the table named “produto” is changed to “categoria”, which contains the information of product category.

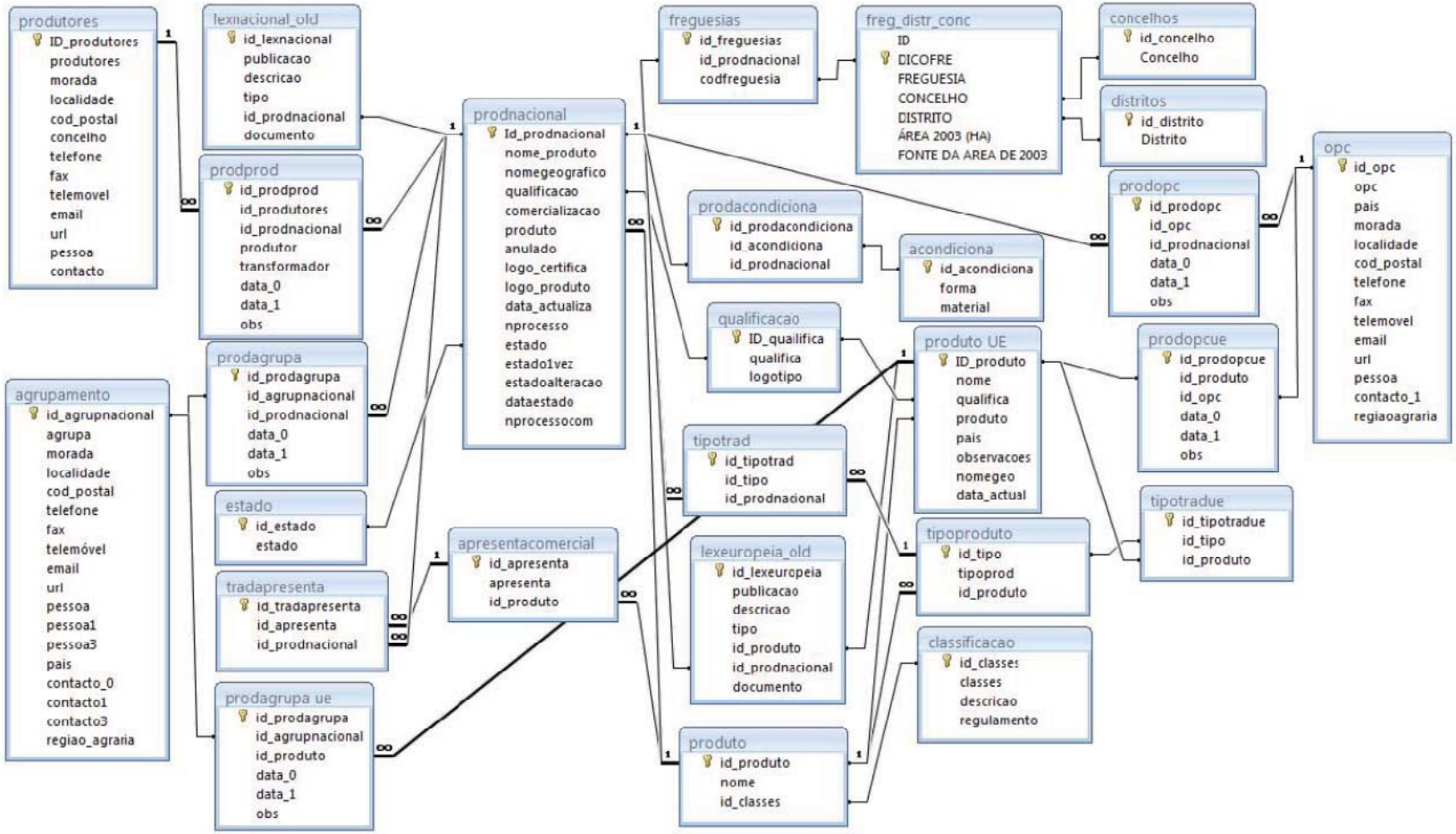

Figure 5: Database structure in original information system.

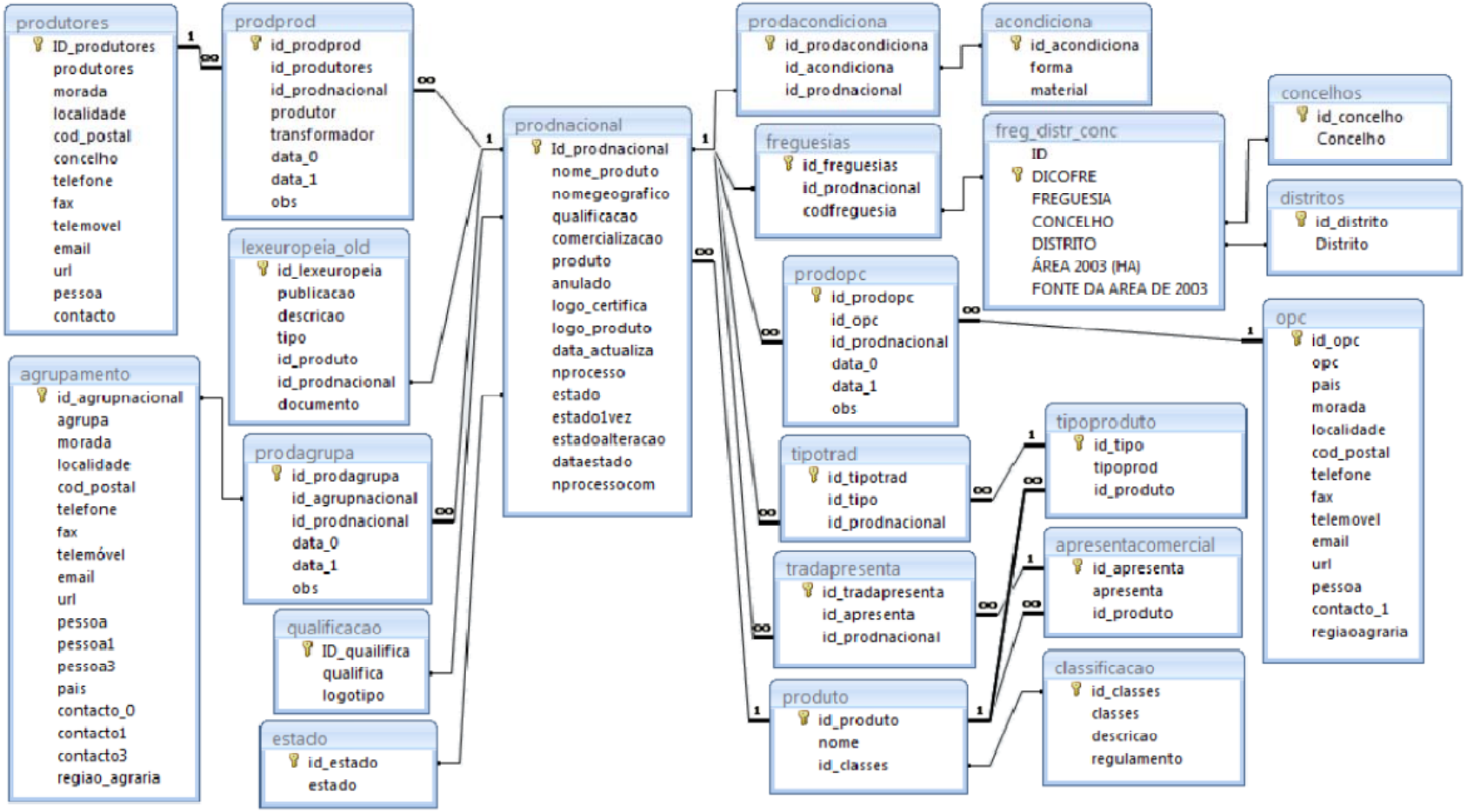

Figure 6: Simplified database structure in original information system.

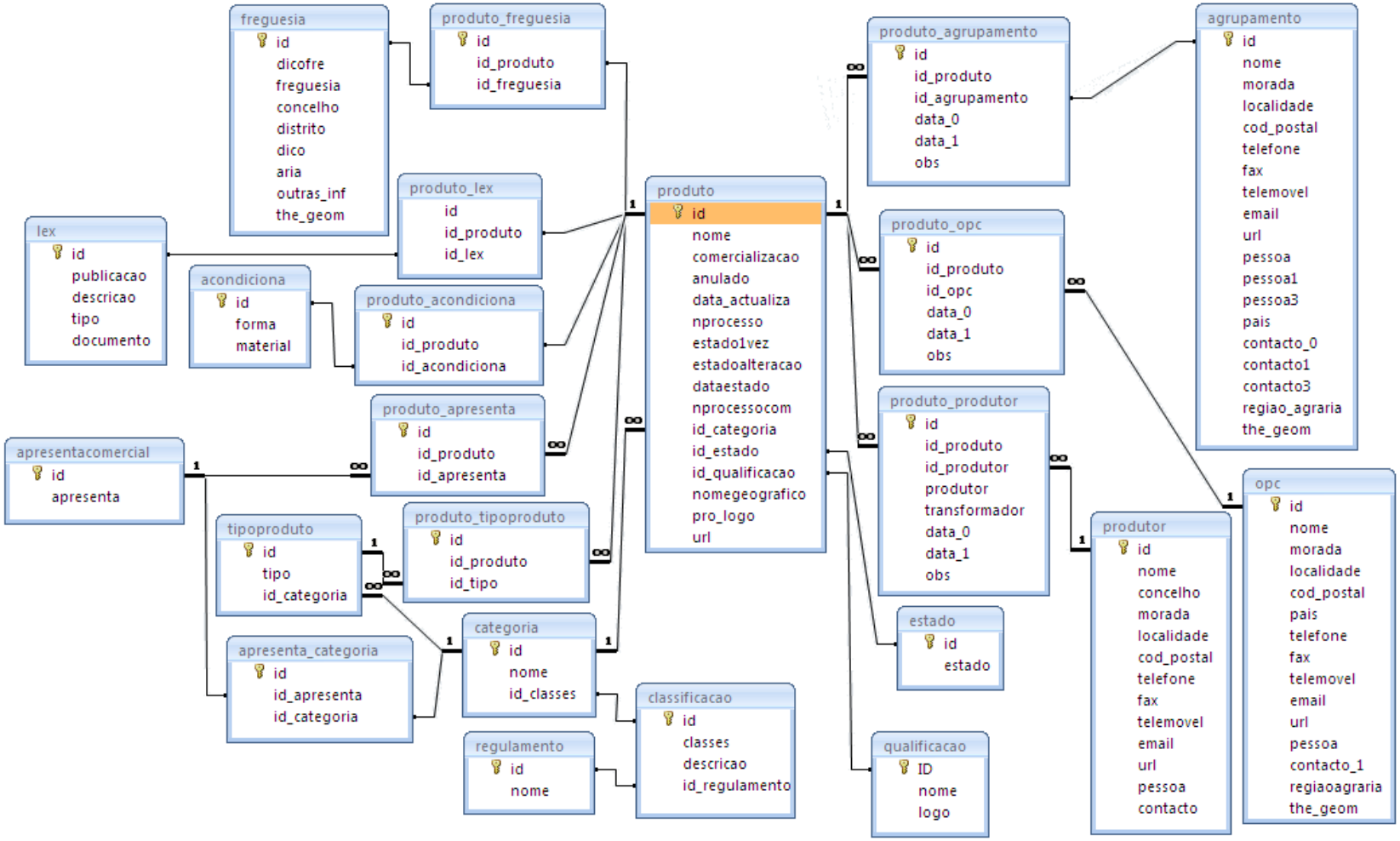

Figure 7: Refined database structure for web-based GIS prototype.

The refined database does not contain any geographic information yet. But there are some information related with locations, such as the distribution of products in the table of “freguesia”, and the address in the tables of “agrupamento”, “opc” and “produtor”.

The information of table “freguesia” is updated using Carta Administrativa Oficial de Portugal (CAOP) version 2008.1 from Instituto Geográfico Português. CAOP version 2008.1 includes 5 shapefiles with different spatial reference systems, which are for Continent, Madeira and Açores (eastern, central, western). Shapefiles for Madeira and Açores (eastern, central and western) are converted to the same spatial reference system as Continent, using AcrGIS 9.2. After that, all the shapefiles are converted into PostgreSQL database supported with PostGIS extension using the command provided by PostgreSQL “shp2pgsql”. In the original database, though there is a key named “dicofre”, it is different from the key of “dicofre” in shapefiles of CAOP version 2008.1. Therefore the name of “freguesia”, “concelho” and “distrito” are used to identify each entity, and then update information of the attributes. Thus, the new column named “the_geom” is introduced. The shape of freguesia is polygon.

The addresses of “agrupamento”, “OPC” and “produtor” are related with location. The information of “produtor” is not considered in the prototype, so the geographic information is only introduced to tables of “agrupamento” and “OPC” with additional key named “the_geom”. The key of “the_geom” is point. It could be updated by Well-known text (WKT). WKT is a text markup language for representing vector geometry objects on a map, spatial reference systems of spatial objects and transformations between spatial reference systems, using longitude/latitude coordinates. The coordinates are supposed to be gathered later.

Overall, the original database are refined to simply the database structure and three geographic attributes are introduced into the database, one of them is polygon, other two are points, for representing the shapes of “freguesia”, the locations of “agrupamento” and “OPC” respectively.

4.2 Web Server

The spatial reference system has to be defined in GeoServer beforehand, in order to use the geographic information of COAP. It could be defined in epsg.properties file in user projection folder. The EPSG number is defined as 900914 in this prototype, with following EPSG WKT definition:

```
PROJCS["ETRS_1989_TM06-Portugal",
  GEOGCS["GCS_ETRS_1989",
    DATUM["D_ETRS_1989",
      SPHEROID["GRS_1980", 6378137.0, 298.257222101]],
    PRIMEM["Greenwich", 0.0],
    UNIT["degree", 0.017453292519943295],
    AXIS["Longitude", EAST],
    AXIS["Latitude", NORTH]],
  PROJECTION["Transverse_Mercator"],
  PARAMETER["central_meridian", -8.13310833333333],
  PARAMETER["latitude_of_origin", 39.66825833333333],
  PARAMETER["scale_factor", 1.0],
  PARAMETER["false_easting", 0.0],
  PARAMETER["false_northing", 0.0],
  UNIT["m", 1.0],
  AXIS["x", EAST],
  AXIS["y", NORTH],
  AUTHORITY["EPSG","900914"]]
```

The spatial reference system used for locations of “agrupamento” and “OPC” is WGS84, so the standard EPSG number, 4326, is used.

After defining the spatial reference system, GeoServer is connected with PostgreSQL database. The database name is “produto”. The setting could be done in Config-Data-DataStores-New in GeoServer web interface.

Next step is publishing the distributions of products and the locations of “agrupamento” and “OPC” in GeoServer.

There are two main ways to publish the distribution of products. One is using geometry from table of “freguesia” as one layer, and displaying the distributions of different traditional food products by filters. The advantage is that the distribution of products could generate automatically. But in this case, GeoServer

will request the whole geometries from table of “freguesia” in the database, and then do the filters instead of parsing the filter to the database, and get the filtered geometries. Therefore, the performance will be the disadvantage. The other way is to generate the view in the database for each product, and publish each view to GeoServer. The advantage is the performance compared to the previous way, because GeoServer will only request the geometries it needs to display. The disadvantage is that the distribution of each product has to be published to GeoServer manually.

For the distribution of the products, the performance is the priority. The whole geometry of “freguesia” is over 60MB. While the total number of products is about 110, and do not increase rapidly each year. So in this prototype, we choose the second way to publish the distributions of the products. Each view of distribution of food products includes dicofre, name of freguesia, concelho, and distrito, area, the extra links and the geometry. The Spatial Reference System Identifier (SRS ID) of geometry in database is not defined since there is no standard SRS ID for it. Each view is published in Config-Data-FeatureTypes-New. The SRS ID is using 900914 which is defined as user projection previously.

For the locations of “agrupamento” and “OPC”, there are two ways to publish it to GeoServer too, similar to the ways of publishing the food products distributions. Considering the geometries of location is points and relatively small. The first way, as using geometries from two tables as two layers, and displaying the individual location of office by the filter, is used. The spatial reference system of geometries from two tables is WGS84, thus the SRS ID is 4326.

There is no need to configure after default installation for GeoWebCache, because the domain for GeoServer is localhost:8080 in the prototype. Otherwise, the configuration can be done in the file of geowebcache-servlet.xml, so that GeoWebCache could configure itself automatically against the WMS GetCapabilities document, and EPSG:4326 and EPSG:900913 are available, which meet the web application request.

The GeoWebCache is used for the distribution of food products, but not for the locations of “agrupamento” and “OPC”, because the GeoWebCache does not support filter parameters in WMS yet.

The performance of the prototype is improved obviously after using GeoWebCache. Before using GeoWebCache, the response time for requesting the distribution of one product will take around 3 seconds, and the user could feel the obvious delay. After using GeoWebCache, the response time for requesting the same distribution reduces to less than 1 second, and no delay could be felt.

4.3 Web Application

After the web services are setting up and running properly, the user from GPP can manage the database by the web interface provided by phpPgAdmin without much modification. The web services, such as GeoServer and GeoWebCache, have their own web interfaces to manage. So there is no extra web interface designed for managing the information.

The next step is designed a user-friendly web interface for the public to show the map on Portuguese traditional food products. The website use APIs from Mapfish and GeoExt to set up the map and provide some basic GIS functions. The Mapfish 1.0.1 has been used without any modification. While in GeoExt part, the LegendPanel.js downloaded from https://geoext.org/trac/geoext/attachment/ticket/2/LegendPanel.js is imported and modified to be able to use in the prototype.

The layout of the default webpage is show in Figure 8. There are four sections in this webpage. In the top, it is the title of the website. The main map panel is shown in the center of the webpage, with a toolbar panel attached under the title of the panel, and the control panels in the left of map. Next to the map panel, it is the panel including two sub-panels which are for layers and legends in the left side, while in the right side it is the panel providing information based on querying.

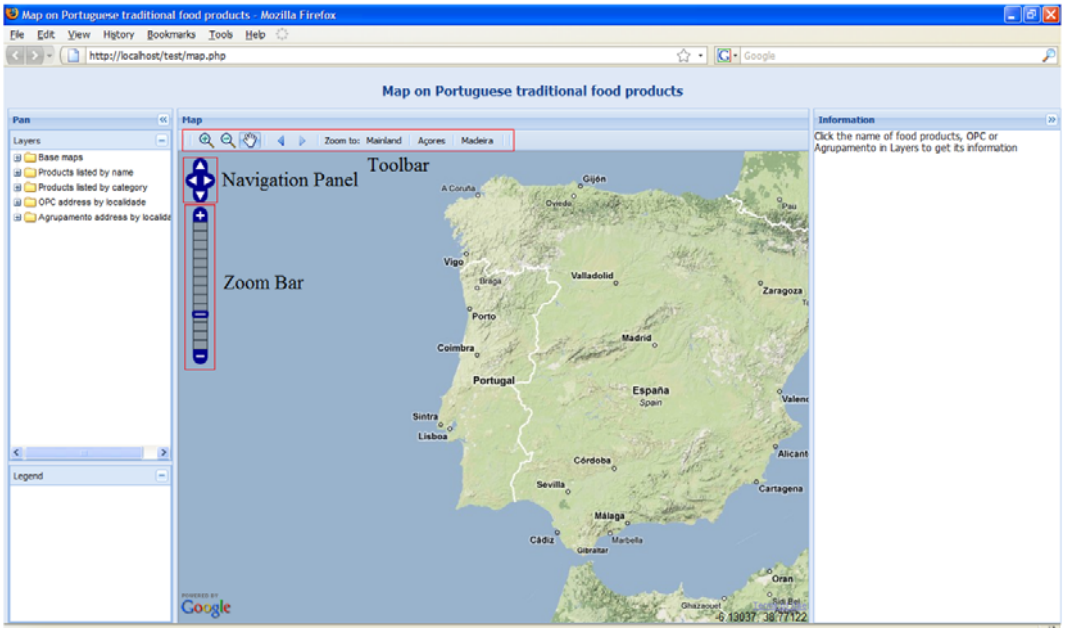

Figure 8: Layout of the web map

The components in the website are described in details as following:

Main map: It is located in the center of the webpage, and is the main componenet to show the geogrpahic information and link non-geographic information of Portuguese traditional food products. Its size could be adjusted by the left and right edges.

Zoom bar: It provides the buttons of zoom in and out on the top and bottom of the bar respectively. In the middle of the bar, it shows the current zoom level in a good visual indicator, and is able to zoom to specific zoom level in just one click.

Navigation Panel: It offers intuitive and precise panning. The functions from Zoom bar and Navigation Panel could be made simpler and quicker by rolling or moving mouse.

Toolbar: In the toolbar, the first three buttons provide the functions related with zooming and moving. One advantage of zooming buttons is that it could zoom in or out either by one simple left click to zoom one level up or down, or by drawing the box to zoom in or out to the selected areas. The left and right arrow offer going back or forward the history of main map. It is designed to save time for user

to get the map from history whenever they want. Another user-friendly design is the shortcuts to the specific geographic area. The two islands in Portugal, Açores and Madeira, are far away from the mainland. These shortcuts help user to quickly navigate among three locations without dragging for a long time in the map.

The left panel next to the main map includes layers and legends, and its width could be adjusted by the edge or hidden by the arrow button on the top.

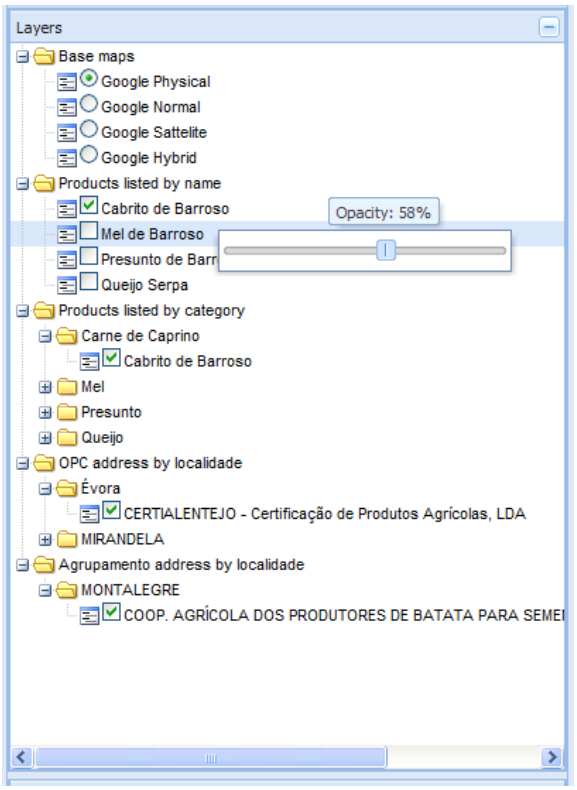

Figure 9: Layer tree panel.

Layers: It is the place to list available layers in the map. Considering the list of layers is long, the list is grouped by their characteristics (Figure 9).

Four types of Google maps are provided to be the base map. Only one of base map can be selected.

The layers related with products are grouped by two ways, listed by their names or by their category, while the layers related with OPC and Agrupamento locations are grouped only by their locations. These grouping are done by PHP code, and

the information needed for grouping are retrieved from database. These layers could be chosen multiple in the clickable box. Lefting click the name of the layer will get the more information related with clicked layer, while righting click the name will provide the operation to change the opacity of clicked layer.

Legends: The panel of legends will automatically generate the name and the legend for the layers, except base maps (Figure 10).

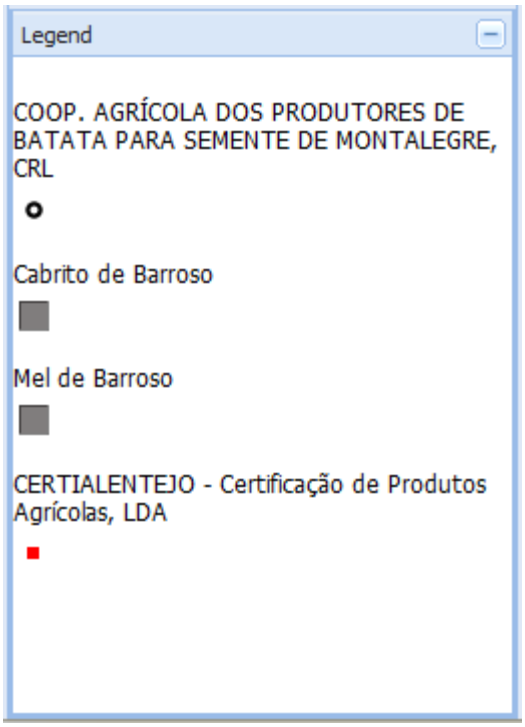

Figure 10: Legend panel.

Information: The purpose of this panel is to provide the non-geographic information. The tip in the panel is to help user easily learn what function is available.

After the product name in panel of layers is clicked, it will provide some introduction of the products including the product name, picture, regulations, certification logos, Agrupamento and OPC locations, extra links and some tips (Figure 11). All of these non-geographical information are retrieved from database, while the tip is trying to help user to quickly know the functions provided by the website.

Figure 11: Information panel showing information on traditional food products.

Based on the tip, click one region in the product distribution, the name, dicofre and extra link are provided (Figure 12). Below these, the list of products produced in that region is listed as layer tree. If the product layer is available in the map, it will give the clickable box to be able to show its distribution in the map.

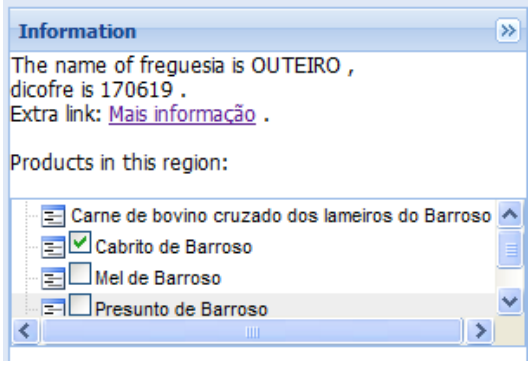

Figure 12: Information panel showing information on region.

Similar to clicking the product name, clicking OPC or Agrupamento name will provide its address details. Meanwhile it also provides the list of product layers order by alphabet. If the product layer is available in the map, it will give the clickable box to be able to show its distribution in the map (Figure 13).

The layer tree in information panel helps the geographical and non-geographic information to be closely related.

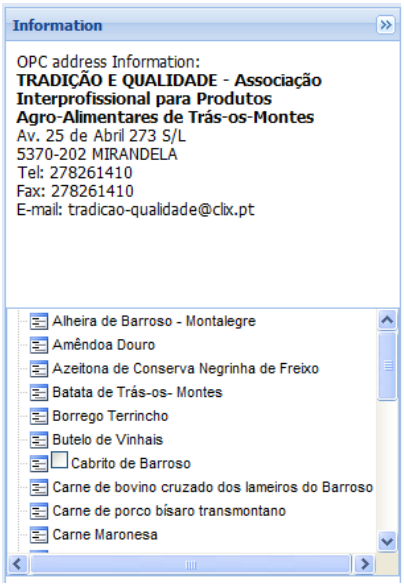

Figure 13: Information panel showing information on OPC location.

4.4 Conclusion

The original database has been studied, and modified to introduce the geographic attributes for tables of Freguesia, Agrupamento and OPC. The customized spatial reference system is defined in the GeoServer, in order to be able to publish the geographic information from COAP. The different choices are made to publish the distribution of Portuguese traditional food products and the locations of Agrupamento and OPC. Beside the web interface provided by phpPgAdmin, GeoServer and GeoWebCache, there is no extra web interface designed to manage the information of the products. Then the user-friendly web interface to show the information on Portuguese traditional food products is designed.

5. Conclusions

The need for the web-based GIS comes from the situations faced by the Portuguese traditional food products. In order to distinguish from other food products, EU quality schemes are introduced to make traditional food products more competitively. In quality schemes, the certification labels named PDO and PGI become tremendous successful in the past years, because those labels clearly indicate an important feature of traditional food products, geographical distribution of the products. With the number of Portuguese traditional food products increasing every year, the management of the information is the challenge. Plus sharing the information with other EU members and spreading the information to the public are important for the promotion of the products. Thus the information system such as the web-based GIS, which considers geographic information as the main feature and uses open specifications and open source software, could be a good choice, and has been proved in the thesis.

In the thesis, two main types of end users are defined as the staff and the public. The staff needs the web interface to manage the information efficiently while the public needs the user-friendly web interface to get the information easily. Based on user requirements, three tiered software architecture are designed for the prototype. PostgreSQL database with PostGIS extensions is used for spatial database. For the web service, the prototype uses GeoServer and GeoWebCache to provide WMS. The Apache HTTP server with PHP and Tomcat is set up to support GeoWebCache. APIs from JavaScript libraries like Mapfish and GeoExt are used to implement the web map for the web application. In addition, the web interfaces for managing database, GeoServer and GeoWebCache are provided.

5.1 Advantages of the prototype

Compared to the original information system, the geographic information have been introduced in the prototype. The prototype use open specification, WMS, to publish the distribution of the products. Therefore, it provides the possibility to integrate with the distribution of the products from other countries, and to

interoperate with other geographical information like soil type distribution to do further analysis and research on the products.

From the information management point of view, in order to make the prototype possible to be deployed later, the smooth migration from original system is critical. In the development of prototype, the changes in database are considered carefully. Only three tables changed the structures. Two of them are divided into two tables, considering the duplication. The attribute in another table, “produto_freguesia”, has to be updated because of the change of “dicofre” code. Some table names are changed to make them meaningful. In general, most of these changes could be skipped if improving the performance of database is unnecessary. These kinds of attentions minimize the barrier of the migration.

In addition, the information in the map is easy to manage and could be done in the web browser. All the non-geographic information which are from the database could be up-to-date without any further work as long as updating the information in the database regularly. For geographic information, updating information is not just about database, but also GeoServer and GeoWebCache. After updating the information in the database, the GeoServer has to be updated to generate the new bounds of the distribution or to add the new distribution as feature type. Then GeoWebCache need to be reloaded once to update the list of cache layer. All of those procedures could be done in the web interface provided by software (Figure 14). The advantage of using web browser to manage the information is that it provides the options to work under any system from anywhere as long as there is the web browser. Plus, there is no need to install any extra plugin, and the user with basic web knowledge could manage it without additional training on the system.

The prototype is built completely based on the open source GIS software, which means that it is free to use and modify. The budget for buying the software could be used in the further development and the employees’ training. Though the commercial GIS software may provide more GI functions compared to the open

source GIS software, the prototype meet the user requirement completely using open source GIS software, since the user only require some basic GI functions.

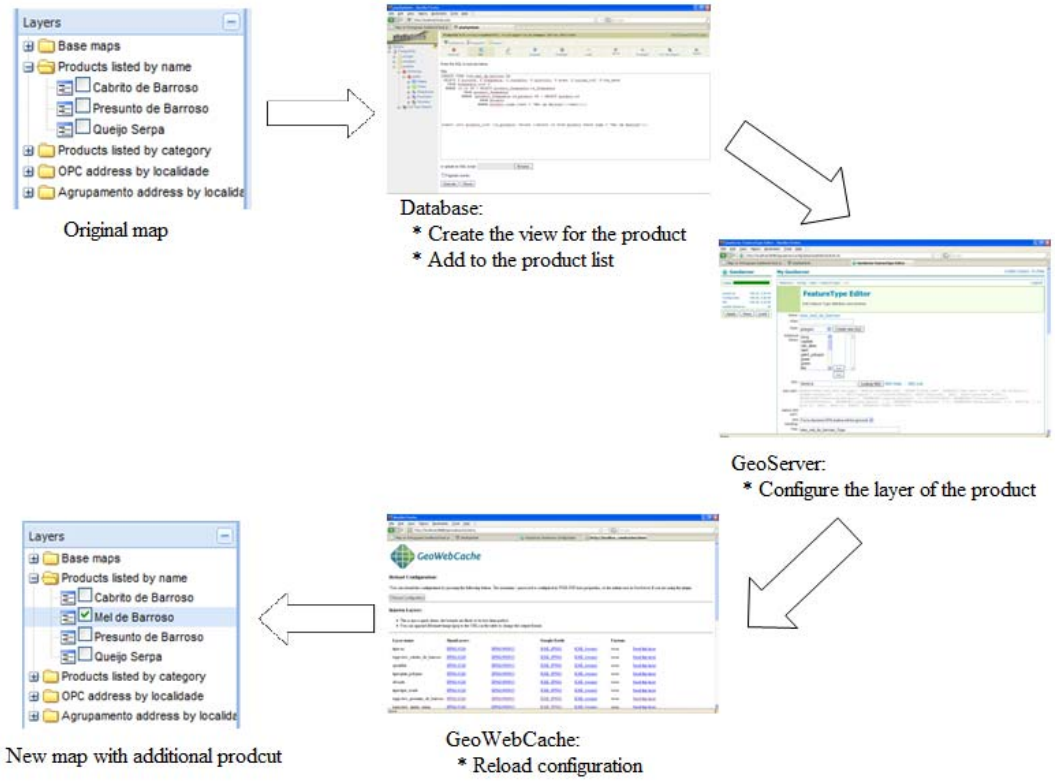

Figure 14: Work flow for adding the product into the web map.

Meanwhile, the freedom to modify the code is very important for the development of prototype. For instance, the API provides by GeoExt to achieve the function of legend do generate the legends automatically. But after testing the prototype, it has been found this API affects the function of changing layers in base map, since base map is not the layer provided by WMS, and therefore, could not pass the right parameter to the API. To solve the problem, the code for generating legends in GeoExt has been studied, and figured out that adding one condition checking in internal function named “changeLayer” could avoid trying to generate the legend for the base map. Such kind of freedom is only available from open source software, and it helps the prototype to better meet the user requirements.

For the public, the web map is interactive, and presents the information clearly. The geographic information such as distribution of traditional food products,

locations of OPC and Agrupamento de Produtores help the public to know the non-geographic information like the product names and certification labels.

5.2 Limitations and further development

Though the management of information could be done by the web browser, the management interfaces from different components are quite different. This could increase the time and cost for manager to be familiar with different interfaces. It can be improved by designing a uniform web interface to manage the components such as PostgreSQL database, GeoServer and GeoWebCache. For the PostgreSQL database, the interface could be done using PHP script. It can provide the functions such as inserting, updating and deleting records in different tables, similar to phpPgAdmin, but in a more user-friendly interface. For the GeoServer, there is a developing API named “REST configuration API” to configure the GeoServer, and it is expected to be published recently. Based on this API, a simplified interface for user to regenerate the bounds of layers and add new product layers will be possible. For GeoWebCache, considering that the only function required for managing the information is reloading the caches and it does not provide the API in the foreseeable future, it is not really necessary to design another webpage to achieve the same function.

The public could be segmented into several roles in the future, so that more functions could be provided in the prototype. The prototype presented in this thesis is designed to show the information of Portuguese traditional food products to the public. So the interactions between users and the system are limited. More roles such as producers and consumers could be introduced into the system in future. The producers could provide the details of their own farms, by editing the attributes of the cadastre in the map through WFS, while the consumers could make comments on the products, and the producers. If so, the authenticate system will be required to restrict the users’ access to the specific functions in the map.

In addition, the usability test is a very important step for developing the system. The reason for skipping usability test in the prototype is that the layout used in the

prototype is from Mapfish, and it could be considered as a mature, user-friendly interface. It will be necessary to do the usability test before deploying the system, especially if the uniform web interface for managing is included or more participators are introduced in the system.

In general, the prototype takes advantage of the web, open specifications and open source software to meet the needs from different users, though it could improve in some aspects. More important is that the prototype is extendable and open. So the web-based GIS prototype is suitable for managing and spreading the information of Portuguese traditional food products.

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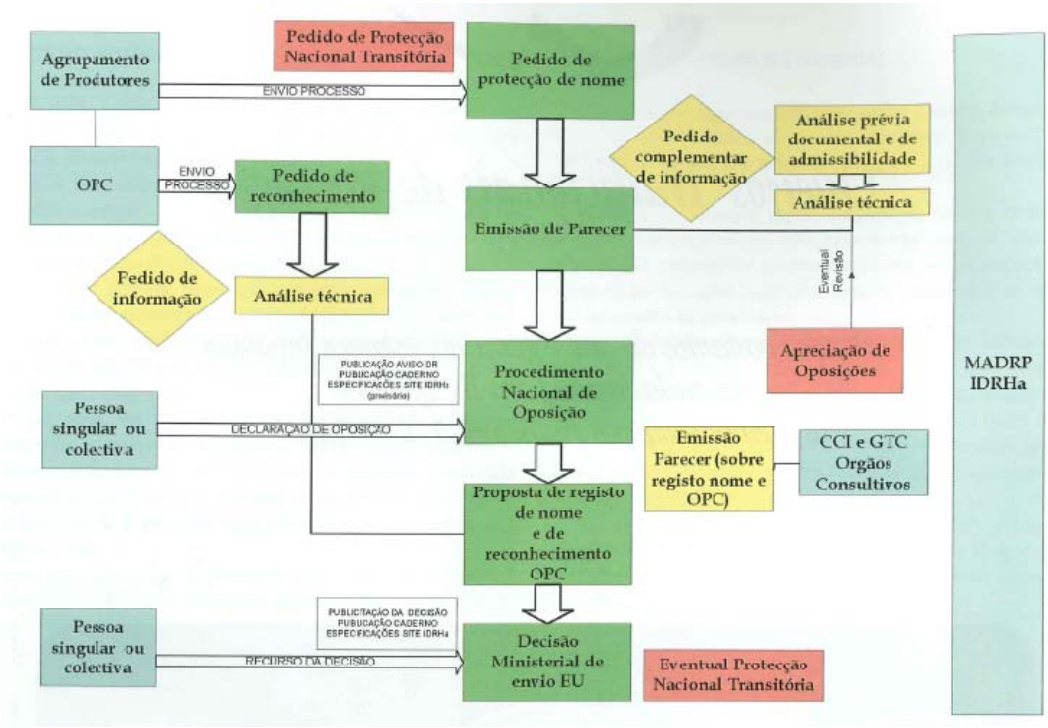
APPENDIX

1. The flow chart for registering traditional food products certification in Portugal



(Source: Guia dos produtos de qualidade 2007)