Universidade Nova de Lisboa
Faculdade de Ciências e Tecnologia
Departamento de Informática

MSC Dissertation in Computer Engineering
1st Semester, 2008/2009

Spatial Operators for Collaborative Map Handling

Renato Rodrigues
No. 26146

Supervisor
Prof.^a Doutora Maria Armanda Simenta Rodrigues Grueau

February the 20th, 2009

No. Of the student: 26146

Name: Renato de Lemos Mendes Severino Rodrigues

Title of the Dissertation:

Spatial Operators for Collaborative Map Handling

Keywords:

- Online Mapping
- GeoCollaboration
- Geographic Information Systems
- Spatial Operators
- Spatial Decision-Making

Acknowledgments

First and foremost, I want to thank Prof. Armanda Rodrigues, for her, supervision, guidance and opportunity to accomplish this work.

I would also like to thank all my friends and colleagues, who have been by my side throughout my academic journey.

I am grateful to the CIVITAS group for all the valuable knowledge shared and the suggestions provided.

I would also like to express my thanks to Prof. Teresa Romão for her help elaborating the usability tests.

My thanks and appreciation goes to the members of the Town Council of Oeiras, especially to Eng. Cristina Garret for her help in organizing usability tests.

Finally, I owe special gratitude to my family for continuous and unconditional support. Without them I would not have concluded this work

Resumo

A recente evolução de tecnologias de mapas baseados na Web, permitiram o acesso a dados geográficos digitais a pessoas a que originalmente não utilizam este tipo de dados. Além disso, com a ampla disponibilidade de ferramentas de mapas on-line, estão reunidas as condições perfeitas para o desenvolvimento de ferramentas espaciais que permitam a colaboração no processo de tomada de decisão com base em informação espacial.

Nesta dissertação, diferentes abordagens para a colaboração espacial foram analisadas a nível conceptual e técnico. As diferentes técnicas estudadas para suportar a colaboração e tomada de decisão espacial, revelaram potencial para suportar colaboração espacial através da internet. Previamente à implementação, foi feito um estudo conceptual e tecnológico, sobre os requisitos envolvidos na colaboração espacial entre utilizadores fisicamente distribuídos. Estudo este que valida os operadores espaciais escolhidos para permitirem colaboração espacial, através de um sistema desenvolvido com as actuais tecnologias de mapas on-line.

A primeira contribuição deste trabalho resulta da abordagem conceptual e consiste num modelo genérico de actividades para apoiar diferentes tipos de tomada de decisão, em que o espaço é um factor e simultaneamente existe a envolvência do público. Após a definição do modelo, foi implementado um sistema que através da colaboração espacial permite a tomada de decisão com base em informação geográfica.

Abstract

With recent developments in Web-based Mapping technologies, the use of digital spatial data has become accessible to people that would not originally use this type of data. Moreover, with the widespread availability of online mapping tools, the perfect stage is set for the development of spatial tools to enable collaboration in spatial decision-making.

In this dissertation, different approaches to spatial collaboration are examined, both from a conceptual and technical point of view. The analysis of existing efforts into collaboration and spatial decision-making, supported by different techniques, revealed potential for spatial collaboration over the Internet.

Before pursuing its implementation, a technological and conceptual study had to be realized, on the needs that distributed users will have, when collaboration spatially. This study supports the choice of spatial operators to facilitate collaboration through space, to compose a distributed work environment developed using currently available online mapping services.

The first contribution of this work results from the conceptual approach, and it consists on a generic activity model for public participation to support different types of spatial decision-making where the public is involved. Following the definition of the model, a generic collaborative Spatial decision support system was developed, containing the necessary structures to enable the application of the model in different spatial decision making contexts.

Index

1	Introduction	1
1.1.	Motivation	1
1.2.	Objectives	3
1.3.	Structure of the dissertation.....	4
2	Related Work.....	7
2.1.	Collaborative systems.....	7
2.1.1.	Computer-Supported Cooperative Work (CSCW).....	7
2.1.2.	Group Decision Support Systems (GDSS).....	9
2.1.2.1.	Benefits and problems of Collaboration.....	11
2.1.3.	Collaborative Software: Examples	13
2.2.	Spatial Collaboration	13
2.2.1.	General Overview	13
2.2.2.	Same place collaboration.....	16
2.2.3.	Different Place Collaboration.....	17
2.2.3.1.	Synchronous Collaboration	18
	Description	18
	Applications examples.....	19
2.2.3.2.	Asynchronous collaboration.....	21
	Description	21
	Applications examples.....	23
2.2.3.3.	PPGIS	26

Description	26
Applications examples.....	28
2.3. Discussion.....	33
3 Methodology.....	35
3.1. Definition of an Activity Model for Public Participation.....	35
3.2. Design.....	35
3.3. Implementation.....	36
3.4. Usability tests	36
3.5. Discussion.....	36
4 Activity Model for Public Participation	37
4.1. Discussion.....	39
5 Design.....	41
5.1. Actors	41
5.2. Cartography	43
5.2.1. Cartography technologies	43
5.2.2. Chosen Cartography	45
5.3. Architecture and technologies	45
5.3.1. Database Management System.....	47
5.3.2. Asynchronous Javascript and XML (AJAX)	48
5.3.3. Keyhole Markup Language (KML).....	48
5.4. Database design.....	49
5.5. Discussion.....	50
6 Proof of Concept.....	51
6.1. Agenda21 Local.....	51
6.2. Features.....	54
6.2.1. Moderator Tools	54
6.2.1.1. Installation and management of system information	54

6.2.1.2.	Define territorial domain	55
6.2.1.3.	Define set of available tools	56
6.2.1.4.	Define/manage categories	56
6.2.1.5.	Add news	56
6.2.1.6.	Add polls	56
6.2.1.7.	GeoRSS Feed	57
6.2.1.8.	Show all Opinions	58
6.2.1.9.	Export Data	59
6.2.1.10.	Erase system	59
6.2.2.	Publicly Available Tools	59
6.2.2.1.	Submit Opinion	59
6.2.2.2.	Submit Expert Opinion.....	61
6.2.2.3.	Define Area of Interest.....	62
6.2.2.4.	Search in Area of Interest.....	63
6.2.2.5.	Read comments on my opinions	63
6.2.2.6.	Other types of search.....	64
6.2.2.7.	Other types of tools	64
6.3.	Discussion.....	64
7	Evaluation.....	67
7.1.	Moderator usability tests	68
7.1.1.	Participants	68
7.1.2.	Questionnaire.....	69
7.1.3.	Results	69
7.2.	Public Usability Tests.....	72
7.2.1.	First Test (Non-expert users).....	72
7.2.1.1.	Participants.....	72
7.2.1.2.	Questionnaire	73

7.2.1.3. Results	73
7.2.2. Second Test (Technical Board of Oeiras).....	75
7.2.2.1. Participants	75
7.2.2.2. Questionnaire	75
7.2.2.3. Results	76
7.3. Discussion.....	78
8 Conclusions and Future work.....	79
References	83
Appendix	87
Appendix A – Moderator Usability Test	87
A.1. Introductory Questionnaire	87
A.2. Briefing	87
A.3. Proposed Tasks	88
A.4. Final Questionnaire.....	91
Appendix B – Public Usability Test	91
B.1. Introductory Questionnaire	91
B.2. Briefing	92
B.3. Proposed Tasks	93
B.4. Final Questionnaire.....	94

List of Figures and Tables

Figures

Figure 1: Crisis Scenario (Cai 2005)	20
Figure 2: Image of the GeoCollaborative application developed by Hopfer (2007) to support spatial planning dialogue.	22
Figure 3: Kebler's (2004), Argumentation Maps. Map View of the Prototype.....	24
Figure 4: CSD (Dragicevic et al. 2004).....	25
Figure 5: Slaithwaite Virtual Decision-Making System (Kingston 1999)	29
Figure 6: Environment on Call Mapping Interface	31
Figure 7: Public participation aggregated into polygons (Park, et al. 2008).....	32
Figure 8: Steps of the activity model for public participation.....	38
Figure 9: Use case Diagram.....	42
Figure 10: System architecture of a web site that uses the Maps APIs (Chow, 2008).....	46
Figure 11: Architecture of the system. Based on Chow (2008)	47
Figure 12: Class Diagram of the system.....	49
Figure 13 : Local Agenda21 Process.....	52
Figure 14: The two different ways to define the territorial domain.	55
Figure 15: Example of geo-referenced Poll.....	57
Figure 16: In green markers it is possible to see the users' addresses acquired through geocoding, and in red the users' opinions.....	58
Figure 17: An example of a opinion submitted by an user.....	60
Figure 18: Submit Expert Opinion.	61

Figure 19: The process of defining an area of interest..	62
Figure 20: Display of “search in area of interest” tool..	63
Figure 21: Results of the moderator usability tests	71
Figure 22: Results from the usability tests with non-expert users.....	74
Figure 23: Results from the usability tests with members of the Oeiras Town Council...	77

Tables

Table 1: CSCW Quadrants (Rama 2006)	8
Table 2: Results of the usability test for the moderators.	70
Table 3: Results of the usability test for non-expert users.	73
Table 4: Results of the usability test for the technical board of Oeiras.....	76

Glossary

GIS	Geographic Information Systems
CSCW	Computer-Supported Cooperative Work
GDSS	Group Decision Support Systems
PPGIS	Public Participation Geographic Information Systems
EMS	Electronic Meeting Systems
R&D	Research and Development
Group-SDSS	Group Spatial Decision Support System
NCGIA	National Center for Geographic Information and Analysis
GCCM	GeoCollaborative Crisis Management
CSDM	Computer-Supported Decision-Making
GUI	Graphical User Interface
KML	Keyhole Markup Language
API	Application Programming Interface
CSD	Collaborative Spatial Delphi
RSS	Really Simple Syndication
XML	Extensible Markup Language
AJAX	Asynchronous Javascript and XML
UML	Unified Modeling Language
OGC	Open Geospatial Consortium
HTML	HyperText Markup Language

1 Introduction

1.1. Motivation

In the decision-making process, individual knowledge and skill is frequently scarce to face the complex decisions that decision makers have to face. Therefore, a group approach may be all that is needed to achieve an optimal solution.

The use of computers can provide significant support for decision-making. It was thus that an area of research was born in the 1980's, addressing collaboration enabled by computing, with various perspectives. These perspectives came from the researchers' different backgrounds including Economics, Social Psychology, Anthropology and Education (Grudin, 1994). The two major research areas in computer collaboration were Computer-Supported Cooperative Work (CSCW) (Grudin, 1994) and Group Decision Support Systems (GDSS) (Desanctis, 1987), each of these with ramifications.

Research into computer-based collaboration gained strength with the Internet boom in the mid 1990's, due to new tools, which emerged to facilitate distributed collaboration.

It is important to study early research into collaboration in a generic way, despite the relevant limitations in the technology which have been overcome, because some of the social and technological requirements for a group decision-making system are still valid.

It was also in the mid 90's that work into spatial decision-making support started to develop. Initially, Geographic Information Systems (GIS) did not support spatial collaboration, although maps and GIS are inherently well suited to support humans in their communication towards spatial decision making about the geographic environment (MacEachren M. A., 2000).

Geographic decision-making is, more than ever, a group activity, and is of relevance in multifaceted situations including natural crisis managements, urban planning and public

participation. However, original GIS methods and tools have been developed for individual use.

This limitation started to be addressed, with an initial approach towards extending existing GIS with collaborative features, with the following examples: (Armstrong, 1994), (Jankowski, Nyerges, Smith, Moore, & Horvath, 1997). These projects aimed at providing tools for distributed users to spatially collaborate over the existing Internet.

Recent developments in online mapping set the perfect stage for the implementation of collaboration in spatial decision-making. GIS was considered an elitist technology, although, with current widely available geographic technology, a shift in the expertise of the user is occurring. With the widespread use of Web mapping technology, offering easy access to geographic data, facilitating geographic data handling through intuitive interfaces, easily manipulated by everyone, the usage of geographic information by the public is bound to increase even more.

This new found utility of mapping has led to the recognition that maps can be useful in many online applications. A new trend in web-based mapping is growing at a fast pace, with “many new tools (...) being built on the back of open standards and free APIs from the likes of Google and Microsoft, and application frameworks like Mapstraction and GeoDjango”.¹

New easy to use and access web-based mapping tools can help increase the level of participation in spatial decision making processes, often restricted to expertise in GIS. Many spatial decision-making processes can benefit from an increase in participation from the general public. One in particular would be Public Participation GIS (PPGIS), which aims at involving the public in the decision of future changes to the citizens’ environment. Decision processes related to our surroundings and the way we interact with them have a strong spatial component, thus making a map-centered system highly beneficial in helping decision-makers to represent and, in the future, engage these problems. Moreover, local people may provide different insights into local phenomena, leading to different solutions that otherwise would not have been reached (Carver S. , 2001).

---

¹ Where 2.0 O’Reilly Conference 2008 - <http://en.oreilly.com/where2008/public/content/home>

Providing better support for public participation is always a goal in PPGIS. For that reason, web-based public participation is increasing in importance in public participation processes. Its advantages over the traditional approach (which can be greatly explored by future PPGIS) such as the freedom in time and location for participation, asynchronous meetings and the convenience and flexibility of anonymous participation, can greatly improve public participation.

1.2. Objectives

The aim of this thesis is to investigate and define the type of tools to be built, using features provided by online mapping technology, which can be useful for people involved in a spatial decision-making process, specifically one that involves the participation of the public, and needing, at some point, to collaborate with each other. Collaboration, in this context, may involve the sharing of information, ideas and events with a geographic footprint (GoodChild, 1998).

As said before, and this will thoroughly be explored in the next chapter, existing tools and frameworks for collaborative computer assisted decision-making still suffer from technological limitations. However, with the general availability of web-based mapping technologies (Chow, 2008), these limitations may be tackled with.

The focus of this work is not solely on the technological approach regarding tools but, most importantly, on the development of a conceptual approach to evaluate digitally supported spatial decision-making. This includes the study of the most adequate spatial operators to help distributed users collaborate towards a decision on spatial issues, and on how current web mapping technology can be used to handle problems with a strong spatial component.

After thoroughly studying existing spatial decision-support systems, it is clear that most of the existing applications only support a limited type of collaboration, that is, applications are designed with the aim of resolving one specific problem. A lack of a working environment that supports different types of collaboration, flexible to different circumstances and supporting the inherently dynamic human-human interaction is clear.

Therefore, to develop a collaborative spatial environment that enables distributed users, experts or laymen, to work collaboratively in a spatial problem, it is necessary to evaluate

in which situations spatial data can facilitate group decision-making and which spatial operators are most adequate for providing this support.

As a result of the analysis made on collaborative decision processes involving spatial issues, an activity model for public participation is proposed based on a generic process of spatial decision-making. The model's goal is to support different types of spatial decision-making where the public is involved.

Another contribution resulting from the conducted analysis is a generic collaborative spatial decision support system, supporting a few operations and tools to enable the application of the model to different spatial decision making contexts. This system supports spatial collaboration for users with minimal experience in working with the Internet, and it is available online, requiring only a computer browser to access.

Usability tests to the system were conducted to analyze the ease of use of the application, as well as, its' potential to support a spatial decision-making process where the public is involved.

1.3. Structure of the dissertation

This dissertation has total of eight chapters:

In Chapter 1 (Introduction) the motivation underlying this work is explained, as well as, its' objectives.

Chapter 2 (Related Work) describes the study of related work in collaboration from a generic perspective and later on, in spatial decision-making.

Chapter 3 (

Methodology) presents the work methodology applied throughout the entire work.

Chapter 4 (Activity Model for Public Participation) describes the activity model for public participation defined through the conceptual approach.

The design of the generic decision support system that enables the application of the model to different spatial decision-making contexts is explained in Chapter 5 (Design).

In Chapter 6 (Proof of Concept) it is described how the resulting system was customized to fit the public participation process of Agenda21 Local.

To evaluate the model and the implemented system, usability tests were made. The results from the tests are depicted in Chapter 7 (Evaluation).

Finally, Chapter 8 (Conclusions and Future work) concludes the dissertation by making a summary of the initial goals of the work and the main results and contributions that were achieved. Future improvements to this work are also debated.

2 Related Work

2.1. Collaborative systems

The main topic of this work is to evaluate collaborative tools to be used in decision-making based on spatial information, in collaborative sessions. This type of computer collaboration is supported by a relatively new body of research. However, the study of computer collaboration has been evolving since the 1980's in two different fields of investigation, Computer-Supported Cooperative Work (CSCW) (Grudin, 1994), relying on a highly technological background and Group Decision Support Systems (GDSS) (Desanctis, 1987) with a focus on management. Sometimes, the term Electronic Meeting Systems (EMS) (Nunamaker, 1991) is also used to describe computer collaboration. It is important to study how computer collaboration has evolved, and in what areas of Research and Development (R&D) it has been used, in order to understand some of the concepts, features, ideas and examples that can also be used in the area of spatial collaboration. To do so some older articles have to be explored, since this area has been developing in several directions and more recently in a more commercial direction, with large companies investing great sums of money in it.

2.1.1. Computer-Supported Cooperative Work (CSCW)

The designation of Computer-Supported Cooperative Work first appeared in 1984, in a workshop organized by Iran Greif of MIT and Paul Cashman of Digital Equipment Corporation. The aim of the workshop was to explore the role of technology in the work environment (Grudin, 1994).

In the beginning, CSCW was an effort led by computer scientists to learn from experienced professionals in group activities like economists, social psychologists, anthropologists and educators (Grudin, 1994). CSCW has become a research area where

people study how to use technology in order to collaborate at a given time in a given place.

The taxonomy of groupware projects suggested by Ellis (1991) had two dimensions: space and time. These dimensions combined represent the different possible types of collaboration in a collaborative project. Rama (2006) presents a four quadrant table, illustrating these combinations (Table 1).

		TIME	
		Same Time (Synchronous)	Different Time (Asynchronous)
SPACE	Same Space	1st Quadrant Spontaneous collaborations, formal meetings, classrooms	2nd Quadrant Design rooms, Project scheduling
	Distributed	3rd Quadrant Video conferencing, net meetings, phone calls	4th Quadrant Emails, blogging, authoring, voice mails, fax

Table 1: CSCW Quadrants (Rama 2006)

Collaborative meetings can vary in time, depending on the way collaborators share and access information. If collaborators share and access information in real time they share the same time, also known as synchronous collaboration. If one of the collaborators shares his/her information and the others only access that information at a later time, time is not shared, and this is known as asynchronous collaboration.

Space also has an important role in collaborative meetings. Collaborators can share the same room and talk face to face or they may be at different/distributed locations, anywhere in the world. When collaborators have different locations, they need to share communication media, like telephones or in most cases, use the Internet.

In Table 1, the first two quadrants cover examples of collaboration at the same location. The first quadrant considers meetings where collaborators share time and place, like a

scheduled meeting between staff in a conference room. Rooms with a whiteboard, or a notice board, to share ideas fall in the category of the second quadrant, since collaborators do not have to be in the same room, at the same time, to share their ideas.

The latter two quadrants cover remote collaboration. One example of the third quadrant is a groupware system, enabling video conferencing meetings over the internet, where spatially distributed collaborators exchange ideas in real time. Communication through e-mail and blogging, where authors make their ideas available through documents for others to read later, are examples of collaboration of the fourth quadrant.

The difference between CSCW and groupware is thin. Moreover, different authors have used these terms with different meanings over the years, describing respectively the research and the technology (Grudin, 1994). Investigation into groupware focuses on commercial technologies be it software, hardware and/or techniques that enable people to collaborate, while in CSCW research is concentrated on tools and technologies for groupware as well as on the nature of workplaces and organizations.

With the growing interest in collaboration, vendors are improving their single-user applications to support groupware features. However, when implementing these enhancements in their programs, they encounter new social, motivational and political issues that have to be taken into account when developing groupware systems.

New issues that emerge with the addition of groupware technology for general computer applications are mainly related to the size of the collaborating groups. Small group research focuses on communication issues, since these groups are formed to enable communication between people who usually share goals, and easily cooperate to accomplish the task at hand with minimal problems. In large groups or in organizational systems support, the aim is to improve coordination between collaborators, because the main problem in such environments is to coordinate a large number of people with conflicting goals, interests and opinions, which always exist in organizations.

2.1.2. Group Decision Support Systems (GDSS)

As said before, the GDSS area has evolved since the early 1980s, with several relevant papers being published on the subject. One of these is Desanctis' "A foundation for the study of group decision support systems." (Desanctis, 1987). Most of the concepts presented in this section were taken from this paper.

Desanctis defines a decision-making group as two or more people, responsible for detecting a problem, generating possible solutions, analysing the proposed solutions and defining implementation strategies.

Group Decision Support Systems evolved from their Decision Support System counterparts to support group decision-making. These systems were originally conceived for face-to-face meetings in so-called decision rooms, whereas nowadays, GDSS enable distributed meetings and provide many different electronic tools to facilitate decision-making.

The goal of GDSS is to enhance the process of group decision-making by improving communication in the group, using techniques for structuring decision analysis. For the author, GDSS should alter the communication pattern within a group, since group decision-making changes the way that interpersonal exchange occurs, as a group analyses and ultimately solves a problem. Desanctis suggests that the design of GDSS should take into account three factors: the size of the group, the presence or absence of face-to-face interaction, and the task confronting the group.

With a wide variety of GDSS applications within the information-exchange view of group decision-making, the author describes three different approaches to support group work:

- Level 1 - GDSS improves the decision process by removing communication barriers and improving information exchange among group members. Features like voting or anonymous input of member ideas facilitate the communication;
- Level 2 - provides decision modelling and group decision techniques to reduce uncertainty for the group decision-making process. Decision trees and planning models are examples of features that improve decision-making;
- Level 3 - systems include machine-induced group communication patterns and can include expert advice and guidance for rules to be applied during a meeting.

In 1987, Desanctis proposed the GDSS shell, which aimed at providing an array of features potentially useful to a variety of decision-making groups. This was an important concept, since behaviour and support needs across groups tend to highly vary. Thus, for the author, the most appropriate starting point in GDSS design was to build an array of

features from which a group could select the ones that better suited their needs during the course of a meeting.

The multi-dimensional taxonomy suggested by Desanctis is supported by three factors: group size (smaller to larger), group members' location (face-to-face to disperse) and the task confronting the group. GDSS design will be somewhat different when group members are remotely collaborating as opposed to when meeting face-to-face. For example, remote group communication may be useful when members cannot meet face-to-face. However, in some circumstances, face-to-face meetings may be inadequate such as, in creativity tasks where individuals work better alone. Moreover, the size of the group also impacts on the design. A small group may need an anonymous message exchange feature whereas, in a large group, a voting system may be more adequate.

2.1.2.1. Benefits and problems of Collaboration

Group decision support systems can improve the decision-making process in many ways, providing several advantages over traditional group meetings (Nunamaker, 1991), as listed:

- Enabling all members to work simultaneously, in order to complete a common task;
- Facilitating equal participation from all members, since GDSS provides an “air time” for each member to contribute ideas, which prevents the monopolization of the group time by some members;
- Enabling larger group meetings that provide additional information, knowledge and skills to accomplish one common goal;
- Encouraging anonymous participation if it is possible, because it will prevent group members from feeling vulnerable to group censorship;
- A GDSS can record all information exchanged during a meeting, providing means for future consultation of past meetings information.

Nevertheless, the use of GDSS may lead to difficulties, which need to be taken into account when choosing to implement these systems (Fjermestad & Hiltz, 1999) (Nunamaker, 1991):

- Trust and confidence issues can happen in a collaborative group, if group members are not willing to share their information with others. Some face-to-face meetings before the implementation of the GDSS can help solve this problem;
- Cultural barriers represent a problem in a collaborative meeting, since, sometimes, it is necessary to integrate many diverse cultures in collaborative sessions. This problem has to be solved by including support for different cultures or through the negotiation, by the group members, of a common ground of understanding for communication;
- One of the major issues in GDSS is its adaptability to the task at hand. A situation where communication is one-to-many, for example, a leader lecturing a group, would not benefit from a GDSS. Only the tasks that require all members to exchange ideas and preferences equally would profit from this.

Questions have come into view concerning the improvements in quality and timeliness of decisions taken with a GDSS (Fjermestad & Hiltz, 1999). Results from experiments did not meet the expectations, since only a slight improvement in quality and timeliness of decisions was achieved.

Nevertheless, the quoted studies on the effectiveness of GDSS were developed at the end of the 1990s and did not take into account recently developed group systems, integrating the ease of use of the “point and click” web based interfaces and multimedia features (Fjermestad & Hiltz, 1999). Group decisions can highly benefit from all the features provided by the currently available Internet technology. Nowadays, transfer speeds allow for the use of improved multimedia handling tools to support group decision-making, lessening the impersonal side of early GDSS. Probably, the most important factor is that the web allows for distributed access anywhere and at anytime. This frees members of a collaborative group from concerns about their location when collaborating.

2.1.3. Collaborative Software: Examples

As said before, computer collaboration highly evolved with recent Internet technology, with new applications becoming available every day. Many of the applications supporting distributed collaboration are made available by large companies, like Microsoft or Google, proving the potential of computer collaboration.

Google's main collaboration software is GoogleDocs², which provides tools for distributed users to create, share and edit documents, using a collaborative approach. The system keeps a log of all the changes made to the documents and provides a chat for user communication.

Microsoft provides a very similar tool called Microsoft Office Live Workspace³, which allows distributed users to work together using Microsoft Office documents, no matter their geographic location. Microsoft Shared View⁴ extends the offers provided by Microsoft Office Live by enabling users to share screen views.

Still with the aim of enhancing computer collaboration, Microsoft Office Groove⁵ offers a large range of tools, from which users can select the ones that better suit their collaborative goal. This approach is quite similar to DeSanctis (1987) concept of shell, providing thus a collaborative environment adaptable to variable group meeting conditions.

2.2. Spatial Collaboration

2.2.1. General Overview

Geographic Information Systems (GIS) are “a computer-based information system that enables capture, modeling, storage, retrieval, sharing, manipulation, and presentation of geographically referenced data” (Worboys & Duckham, 2004). They enable users to make spatial queries, analyze spatial information, edit spatial data and present the results of all these operations.

---

² <http://docs.google.com>

³ <http://workspace.officelive.com/>

⁴ <http://www.connect.microsoft.com/content/content.aspx?SiteID=94&ContentID=6415>

⁵ <http://office.microsoft.com/en-us/groove/>

GIS have had a paradigm shift since the emergence of the Internet “from an isolated architecture to an interoperable framework, from a standalone solution to a distributed approach, from individual proprietary data formats to open specifications exchange of data, from a desktop platform to an Internet environment” (Chow, 2008). With these changes in all aspects of GIS, the circumstances for its use are also changing.

GIS are being used, more than ever, in complex social and environmental problems. Crisis management, urban planning, and environmental policy making are some examples of tasks which can benefit from the geographic approach to decision-making that GIS provides (Cai, 2005). These decision-making processes are often group activities, since professionals from different areas have to work collaboratively to achieve a common goal and individual knowledge and skills are no longer sufficient. Nevertheless, the methods and tools used for creating cartography and working with GIS have been developed for individual use. A good indicator of this approach is Mike Worboys’ definition of GIS, first written in 1995 but still present in his 2004 book that was cited in the beginning of this section. In this definition there is no mention to collaboration or cooperation, showing that supporting collaboration in GIS was not a major topic in geographic systems, as it ought to be, until very recently. Nowadays, Geocollaboration is emerging as a vital topic in GIS and its importance in GIS literature is increasing (Longley, Goodchild, Maguire, & Rhind, 2005).

The spatial collaboration research area, as an extension to existing GIS is also known as Geocollaboration. “Geocollaboration is a special type of collaborative activities that involve a committed effort on the part of two or more people to collectively frame and address a task that requires the use of geospatial information.” (MacEachren & Brewer, 2004).

Geographic information technologies hold huge potential to mediate communication and collaborative activities. However, until very recently, the lack of proper tools and infrastructures to support spatial collaborative sessions was an obstacle for the development of GeoCollaborative Systems (Cai, MacEachren, Sharma, Brewer, Fuhrmann, & McNeese, 2005).

Geocollaboration started to develop in the mid 1990’s, with early work from Armstrong (1994), where he identified the requirements for a Group Spatial Decision Support System (Group-SDSS) and outlined important links to ongoing CSCW research, and on a

more practical approach, the Group-SDDS developed by Jankowski (1997). The main goal of this area of research was to overcome the lack of decision-making tools and group support in GIS systems. One of the first stimuli for the development of group support for GIS was The National Center for Geographic Information and Analysis (NCGIA) Initiative 17 on Collaborative Spatial Decision-Making (Densham, Armstrong, & Kemp, 1995), which was the first conference where collaboration in GIS was the main topic.

The implementation of GeoCollaborative systems faces two types of difficulties: Sociological and Technological. The first problem is to understand how groups behave with GIS and other related technologies and the latter is the lack of technological tools to support computer mediated Geocollaboration (Cai, 2005). To deal with the former, efforts have to be made to understand the role of maps in Geocollaboration. To address the technological barrier, new GIS have to take into account collaborative spatial activities and distributed users. This barrier has had a significant breakthrough with the currently public and freely available Geographic technology: Google maps⁶, Google Earth⁷, Microsoft Virtual Earth⁸, Yahoo Maps⁹, etc. With this new technology era, GIS are losing its elitist fame and online mapping tools are now available for everyone who desires to access geographic information, as long as they have internet access. While not supporting all the spatial features that a classic GIS supports, it is expected that the new online geographic technology will soon reduce the technological gap between them and classic GIS (Chow, 2008).

Initially, GIS did not support decision-making, despite its potential to support complex location-based decision-making, for at least three reasons (MacEachren M. A., 2000): GIS were designed to address structured problems¹⁰, GIS lacked tools for decision support and they did not support group work. Initially, some individual researchers' efforts were made to overcome this lack of support for decision-making. However, it was not until this issue was addressed in a collectively way, that Group-SDSS was born (Armstrong, 1994), (Densham, Armstrong, & Kemp, 1995).

---

⁶ <http://maps.google.com/>

⁷ <http://earth.google.com/>

⁸ <http://www.microsoft.com/virtualearth/>

⁹ <http://maps.yahoo.com/>

¹⁰ Structured problems are problems that can be cleanly formulated using formal methods of analysis

GeoCollaboration has two different ramifications, depending on the context in which collaboration might occur. The first area, Group-SDSS, addresses expert decision-making, while the second one focuses on decision-making with public participation, known as Public Participation GIS (PPGIS) (MacEachren M. A., 2000).

Most of the research efforts in Group-SDSS were on developing better decision support tools. The typical approach, mostly taken individually, with a research focus on geographic information technology, was in developing a conceptual framework and associated tools and operators that extended existing GIS and SDSS to support group work (MacEachren M. A., 2000).

The same author further states that research on PPGIS focuses, not only on the development of tools and methods but also, on the social and political processes which determine who is going to use GIS and how, in public policy decisions. Thus, PPGIS research can be divided in two groups: those that focus on public participation as a social-political phenomenon, and those who aim at enhancing participation through the development and implementation of technology that facilitates it.

One of the main differences between PPGIS and Group-SDSS are the profiles of people studying or developing these systems. While in Group-SDSS researchers are almost exclusively experts in GIS, in PPGIS researchers are as likely to be from other fields of science.

In comparison to Group-SDSS, in PPGIS most of the time is spent, in the early stages, explaining the problems' context to new users, and on the follow up as well, since frequent PPGIS users are not GIS experts and require extra effort to adapt to a new situation and understand the problem at end.

2.2.2. Same place collaboration

Same place collaboration research addresses spatial collaboration when all members of a meeting share a physical space. An overview of this topic and of different place collaboration was made by M. A. MacEachren. He wrote two different reports in consecutive years, 2000 (MacEachren M. A., 2000) and 2001 (MacEachren M. A., 2001) where he presented an overview of the different areas of R&D in spatial collaboration. The first report (MacEachren M. A., 2000), focused on same place collaboration, considering its potentials and challenges.

In this report, MacEachren addressed new software and display forms to facilitate group work in same place collaboration (MacEachren M. A., 2000). In this area of research, three specific problems were considered:

- Representing multiple forms of information in group settings and allowing group members to interact with, and change, representations;
- Adapting and applying electronic meeting software, designed to facilitate both individual and collective decision-making, to spatial issues;
- Improving expert knowledge sharing with non-experts in an information retrieval context.

Another topic analyzed in MacEachren's first report was the understanding of group decisions and groupware use. The author focused on the lack of studies on the process underlying spatial decision-making, at the time when the report was made, and on which tools to use, to facilitate spatial collaboration. In the author's opinion, the complexity of group decision-making and of integrated tools environments for collaboration, made the study of group work with geospatial tools a challenging task and one that deserved a concerted effort.

2.2.3. Different Place Collaboration

With distributed users, new difficulties emerge in GeoCollaboration. Like in Same Place Collaboration, most of the difficulties in different place collaboration are technological and social however, they take a different form due to the physical separation of the users. New technological difficulties, associated with a distributed setting, include implementing visual geospatial data analysis methods and the development of representation and interaction concepts that can facilitate group work (MacEachren M. A., 2001). Social difficulties include the mediation of group work through visual interfaces and human-human interaction between distributed users.

As said in section 2.2.2, a second report was written by MacEachren on Different Place Collaboration (MacEachren M. A., 2001). In this report, three different topics are explored. The first topic was building support for Different Place Geocollaboration, with Same Time Collaboration and Different Time Collaboration considered as sub-topics. The second issue was the human aspects of collaboration at a distance, where three aspects were considered: support for multiple perspectives and negotiation among

alternatives, representing participants (both human and agent¹¹) and facilitating their joint behavior in distributed work and usability of tools and collaborative environments. The final topic addressed a conceptual framework for future geographic visualization environments with six components: problem context, collaboration tasks, commonality of perspective, spatial and temporal context, interaction characteristics and environment as a mediator.

Specific requirements were needed for systems to support Different Place group work, in particular a mechanism to share data and ideas at a distance (MacEachren M. A., 2001). The main difference today, from early synchronous and asynchronous collaboration is that previously, it was not possible to exchange geospatial data and other multimedia features (images, voices, text and video), which is currently considered essential for Different Place Geocollaboration.

2.2.3.1. Synchronous Collaboration

Description

Developments of applications for synchronous Different Place collaboration address two different research topics: Spatial group decision support and support for science. (MacEachren M. A., 2001).

Research and development in synchronous collaboration with Different Place spatial group decision support systems, complements that on asynchronous PPGIS environments. The main issues in synchronous and asynchronous collaboration are similar: facilitating information access, negotiation, providing means to improve human-human communication mediated by technology and decision support. However, there are issues that are not common between synchronous and asynchronous collaboration (MacEachren M. A., 2001). Technological issues differ, since the complexity of the infrastructure needed to support real time collaboration is highly increased by the added multimedia support requirement.

---

¹¹ “An agent is any entity ‘living’ in the environment that is able to modify both the environment and itself. An agent can ‘perceive’ and represent its environment, communicate with other agents (and perhaps with human actors) and exhibit autonomous behavior based on its knowledge, perceptions, and interactions” (MacEachren M. A., Cartography and GIS: extending collaborative tools to support virtual teams, 2001).

Most developments in synchronous collaboration focus on problems that require a fast response. Crisis events, like the terrorist attack on the twin towers in the United States in 2001, or the tsunami in South Asia, are good examples where geographic information and intelligence play a key role (Cai, MacEachren, Sharma, Brewer, Fuhrmann, & McNeese, 2005).

In these events, the availability of maps and GIS technology may play a fundamental role in helping the management of all the simultaneous activities that have to be addressed, in order to help resolve or lessen the problems. Crisis management can highly profit from spatial information support, since it is easy to point out the location of human victims or infrastructure damage on a map and ultimately decide what actions ought to be taken and where should resources be allocated.

Nowadays, GIS are used in all stages of crisis management, allowing immediate response, facilitating recovery, mitigation of human and financial damages and preparedness for further disasters (Cai, MacEachren, Sharma, Brewer, Fuhrmann, & McNeese, 2005).

Applications examples

An interdisciplinary team from Penn State University (comprised of Geoscientists, information scientist and computer scientists) is part of a research group named GeoVista¹². This team is developing a GIS-mediated collaborative environment to support GeoCollaborative Crisis Management named GCCM¹³ (Cai, MacEachren, Sharma, Brewer, Fuhrmann, & McNeese, 2005).

This GeoCollaborative system was designed to mediate collaborative activities between different emergencies' agencies. The system offers support to emergency managers in emergency operation centers and to response personnel in the field.

According to the developers, the most important features in their project are: the ability to interact with the system using spoken language and hand gestures; the joint manipulation – by the participants of a collaborative meeting – of the shared map workspace; the management of mixed-initiative dialogues for cooperative decision-making; and the

---

¹² <http://www.geovista.psu.edu/index.jsp>

¹³ <http://www.geovista.psu.edu/grants/GCCM/>

access to existing data and services from an enterprise spatial information structure (Cai, MacEachren, Sharma, Brewer, Fuhrmann, & McNeese, 2005).

The GeoVista team defends that GCCM can facilitate cooperation between emergency operation centers, with the teams of field responders improving the communication and coordination of actions. Moreover, they claim that maps serve as mediators to facilitate the construction of team knowledge, improving the decision-making process (Cai, MacEachren, Sharma, Brewer, Fuhrmann, & McNeese, 2005).

To demonstrate the utility of the GCCM, they use two crisis scenarios: a hurricane and a gas leak. In their 2005 article (Cai, MacEachren, Sharma, Brewer, Fuhrmann, & McNeese, 2005) and in an individual paper by Cai, the case study used was a hypothetical accident in a nuclear power plant (Figure 1) (Cai, 2005).

Figure 1: Crisis Scenario (Cai 2005)

Although this new application is still under development, some theoretical and technical issues were already raised by the team. Supporting collaboration requires interoperability among potentially different and incompatible semantic processing systems. Contextual factors, like device characteristics, physical environment, team structure and organization norms are important to the design of the system's behavior. Moreover, human interaction is inherently dynamic making it harder to define a structured approach to these problems.

Cai believes that technical advances in distributed computing and in GIS must be complemented with a study of the theoretical area of Geocollaboration (Cai, 2005).

Until now, the area of support for Different Place collaborative science work has not been a priority for geographers. However, it has been considered by others in the form of collaborative visualization. One example of this research is a prototype of a collaborative geovisualization environment that enables multiple users to view and manipulate multivariate climatic data simultaneously, in order to identify space-time patterns and processes (Brewer, MacEachren, Hadi, Gundrum, & Otto, 2000).

The prototype presented by Brewer (Brewer, MacEachren, Hadi, Gundrum, & Otto, 2000), provides a map view for collaborators to manipulate a 3-D depiction of precipitation and temperatures, across different terrains. Users can change the color scheme used to represent the data and can also change the parameters of a time series animation. Furthermore, the prototype supports communication between different computers to enable users to see animations parameterized by other users.

2.2.3.2. Asynchronous collaboration

Description

As stated above, collaboration when members do not share time is called asynchronous collaboration. This area of research has a smaller focus on instant response, thus enabling members of a collaborative session to think thoroughly on the task at hand and take a pondered decision.

MacEachren (MacEachren M. A., 2001) identified three map types specific to geospatial computer-supported decision-making (CSDM) when asynchronous collaboration was involved. Annotation Maps, Argumentation Maps, and Alternative Maps. Annotation Maps enable users to attach annotations to a location in a map, supplying information or recording an opinion about a decision concerning that location. Argumentation Maps support the discursive element in geospatial CSDM by incorporating information and arguments in a map-based display. Finally, Alternative Maps depict possible outcomes in a geospatial decision-making problem.

Map-based displays require spatial-decision support tools, to enable productive group work. Geospatial annotations play an important role in displaying and analyzing group information (Hopfer & Maceachren, 2007). Annotations take different forms depending on the task at hand, including: geo-located text notes, direct drawing on maps, geographically anchored photographs, annotations with fading properties and place-based aural annotations.

Map annotations in a web-based map display have been studied in detail, as tools to maximize the potential of collaborative efforts, by Hopfer (2007). In his study, a framework is proposed, the CIS bias framework, which suggests key goals for developing such tools. The goals proposed are: (a) the harnessing of a group's collective knowledge (b) reducing the repetition of information presented to the group. Resulting from this study a GeoCollaborative application was implemented to support spatial planning dialogue (Figure 2) through the use of geographic annotations.

Figure 2: Image of the GeoCollaborative application developed by Hopfer (2007) to support spatial planning dialogue. Geographic information is displayed using Google Earth.

In Hopfer's work (2007), design recommendations are also presented for the development of annotation tools, which include facilitating access to and recall of geographically referenced discussion contributions, the documentation of ideas for private as well as public discussion spaces, and encouraging all group members to contribute with information in a given collaborative effort.

Collaboration almost imperatively entails argumentation, and most of the spatial collaboration applications lack the support needed for an asynchronous debate between users. Argumentation Maps provide that support. The purpose of Argumentation Maps is to support geographically referenced discussions and to provide visual access to debates. Rinner (2006), suggests a cooperative map where users are able to insert messages, and retrieve messages from a discussion forum. Users visualize the existence of annotations that represent a discussion related to a specific map location. In Argumentation Maps, when a discussion is linked to a map, references will be associated with arguments and geographic objects. A many-to-many relation is established between arguments and geographic objects, that is, an argument in a discussion can reference several geographical objects, and a geographical object can be referenced in several arguments.

Argumentation Maps are generic tools to support the collaborative decision-making process, and they are expected to be useful in discussions between experts as well as in mainstream community participations. Their purpose is not only to support the planning process but any spatial collaborative problem.

Applications examples

A good example of a system that supports spatial discourse is the one being developed by Voss (2004) and their colleagues, at the Spatial Decision support team of Fraunhofer Institute for Autonomous Intelligent Systems. By linking two existing software tools, originated in previous work, the Zeno Discussion Forum and the Descartes Thematic Mapper, they were able to design a system to support many-to-many relations between user comments and geographic objects. The authors establish the requirements for possible annotations relationships as well as the graphical user interface (GUI) requirements, concerning the user interface. Four conceptual requirements (regarding annotations) are suggested: users should be able to create annotations relating different types of objects; many-to-many relation between comments and geographic objects are possible; different groups of actors should be able to annotate the same map in different discussions/contexts and, finally, discussions may be manipulated in both applications (Zeno and Descartes). GUI requirements include, for example, an annotation layer which users may choose to display.

Another example of an implementation of argumentation maps with an asynchronous approach is presented in Keßler (2004), contemplating a prototype to support both end users (participants in a discussion) and content providers (e.g. a planning agency). Users can browse the map and the discussions separately (Figure 3), read and respond to individual messages or start new forum threads. From the perspective of the content provider, important functions are available, including user management and security features, such as authentication. With respect to mapping, users are able to highlight arguments by clicking on related geo-objects, highlight geographic objects, by clicking on discussion messages, and submit geographically referenced messages.

Figure 3: Keßler's (2004), Argumentation Maps. Map View of the Prototype

A more structured example of a Web GIS, supporting collaboration, is the Web GIS Collaborative Spatial Delphi (CSD) framework (Dragicevic & Balram, 2004). This framework aims to improve equity and access in the planning processes on the Web. The Web GIS CSD framework uses argumentation, the Delphi method, digital maps and GIS exploration tools on the Internet, to help the decision-making process. The main difference of this project relative to others is the Delphi method, which is used to define goals, agenda settings, and rank alternatives in a collaborative environment.

As said before, the CSD method is used to give structure to the planning process and improve the participation experience of the stakeholders. This is done in several stages (Figure 4): the first stage is an initial scope, elaborated by the project managers, to explore the facets of the problem. This leads to a workshop, where participants start by defining the goals of the collaboration, followed by the analysis of spatial data in a collaborative way, where priorities are defined. Finally, after deliberation on the spatial data, a consensus is achieved.

Figure 4: CSD (Dragicevic et al. 2004)

In the presented study, there were four different face-to-face planning workshops to address issues around problems in natural resource management, allocation and cultural preservation (Dragicevic & Balram, 2004). According to the authors, the Web GIS CSD enables remote users to collaborate synchronously or asynchronously with local participants. The communication media available is real-time video chat software. The map interface is based on collaborative tools of the ESRI ArcIMS software. The ESRI software tools include two sets of collaborative tools: MapNotes and EditNotes. MapNotes enables users to annotate maps and share text comments. EditNotes tools allow users to draw points, lines and polygons to point out areas of interest.

In the report, evaluations and comments are given by the workshop participants. Some considered the tools too complex to work with, while others considered that they needed more sophisticated tools for their deliberations. This indicates that the system should provide a range of tools that the expert or casual users could choose from, in order to

support the decision of a specific problem and not a static set of tools for all problems, in a similar approach as the Desancits (1987) shell concept. It is however, a good example of a collaborative framework, its tools and potential to support collaborative planning.

2.2.3.3. PPGIS

Description

The concept Public Participation Geographic Information System (PPGIS) is originated different research topics raised by the intersection of community interests and GIS technology. PPGIS's debated issues, usually, do not require the urgency to use real-time spatial collaboration. Therefore, they fall into the research area of asynchronous spatial collaborative activities (MacEachren M. A., 2001).

Many decision problems concerning local areas and the way the public interacts with them, have a strong spatial component. Therefore, despite its limitations, a system that enables decision-makers to organize their point of view and the way to engage the problem, should be centered on a map, since it is the best option for organizing and interacting with spatial information (Carver S. , 2001).

PPGIS are essentially about how people understand, manipulate and interact with geographic representations of the real world (Longley, Goodchild, Maguire, & Rhind, 2005). Moreover, they facilitate public participation in the following ways (Longley, Goodchild, Maguire, & Rhind, 2005), (Carver S. , 2001):

- Making the increasing complexity of urban planning and resource management comprehensible to the public and different government agencies;
- Handle spatial information and communicate it to interested stakeholders, and in turn, accept, organize and reflect inputs (spatial or otherwise) that users provide during the participation process;
- Drastically changing the planning process, all the way through, with the use of new tools for community design and decision-making;
- Enabling the use of many digital data sources that are collected, but not used, at the local level;

- Allowing land use decisions to evolve from a regulatory process to a more practical method;
- Improving community knowledge about local environment and social issues;
- Allowing for new solutions to be reached, other than the ones achieved by expert knowledge and GIS, thanks to the availability of local knowledge.

When comparing online public participation with the traditional participation methods, online participation has the advantage of allowing people to make their comments in an anonymous way, reducing the embarrassment of speaking in front of a group, the probability of a personal conflict and allowing citizens to participate when and where it is convenient for them (Carver S. , 2001).

The growth of Internet GIS has started nearly ten years ago and even then, with the limited existing technology, it was obvious that it was going to provide important tools and methods to increase public participation in decision-making (Kingston, Carver, Evans, & Turton, 1999). At the time, one of PPGIS developer's most significant concerns was the fact that, due to the recent nature of the Internet's availability, it was definitely not widespread. This could eventually reduce the public's participation in their applications. Nowadays, this concern has disappeared.

Until now, most of the work in PPGIS has concentrated on the development of web-based tools to facilitate and enhance public participation in geographic decision-making (MacEachren M. A., 2001), since original GIS were not fit to support public participation.

However, this development of new web-based tools is not an easy task. The main challenge in designing PPGIS and its' tools is the fact that they are used by experts and occasional users, people with different computer literacy, knowledge, and cultural backgrounds. Thus, increasing the difficulty for the designers to foresee how multifaceted users will use the system (Haklay & Tobón, 2003).

To overcome this intrinsic design difficulty Haklay (2003) called for a user-centred design approach to develop PPGIS. User-centred design approaches consist on involving, from an early stage, target users and experts to influence the design of the system. In this approach, usability evaluation is crucial to ensuring that the design meets the user requirements (Haklay & Tobón, 2003).

In addition users of a web-based mapping application face more difficulties than other online systems' users, such as e-commerce (Warren & Bonaguro, 2003). These increased difficulties are due to the inherent complexity of web mapping applications "(...) in terms of the specialized functionality that supports online GIS, the amount of content available and the skills required to interpret this content"(ibid).

Therefore, an approach which involves users and experts, since the beginning of the development, enables designers to take into account fundamental issues, like usability and acceptability, making it an adequate approach to develop PPGIS and their tools.

Applications examples

One of pioneers of web-based GIS to enhance public participation in decision-making was the Centre for Computational Geography at the University of Leeds¹⁴. Their emphasis has been on decision support systems providing both public access to data and involvement in the decision-making process (Kingston, Carver, Evans, & Turton, 1999) .

The Leeds group implemented one of the first and most referenced online geographic information systems to allow public interaction with geographic features. Their project was a parallel online exercise to the 'Planning for Real'®. The Planning for Real exercise objective was to closely involve local people in local environmental planning problems and decision-making.

It consisted on a three dimensional model of a predetermined area of a village, in this case study, the Slaithwaite village. Local habitants were encouraged to register their opinions and views about particular issues on the model, by placing flags containing written comments on the geographic location of their choice. This exercise shares a common benefit with internet GIS: the anonymous placing of flags with opinions. In this way, conflict is inexistent, since a flag in a model has no attachment to an individual, thus preventing the association of a person to an idea.

This case study provided the perfect opportunity to test the new methods and tools developed by the group in Leeds University, in the case study of the Slaithwaite village. The virtual Slaithwaite system was one of the first online GIS that supported two-way

---

¹⁴ <http://www.ccg.leeds.ac.uk/>

flow of information, the system provided information to the users and the users could post information on the system.

The Slaithwaite system is based on a Java map application called GeoTools¹⁵, and it allows the user to perform simple spatial queries and attribute input operations (Kingston, Carver, Evans, & Turton, 1999). The system provides several tools to facilitate public participation. It all revolves around a map of Slaithwaite village, where users can perform zoom and pan operations to control visualization and navigation. Users can execute spatial queries such as asking which building or road is represented at a particular location on the map, and then give their opinion about specific features identified from the map. All the data inserted by the users is stored in the web access log so it can be later analyzed, when making planning decisions about the village.

In Figure 5, it is possible to see how the system works, in the right we can see the map of Slaithwaite with yellow dots representing the comments made by the users, and the red dot is the selected comment that can be read in the left window. When an object is selected in the map the left windows displays a form that can be filled with the comments and suggestions about the selected feature.

Figure 5: Slaithwaite Virtual Decision-Making System (Kingston 1999) - On the right, the map of Slaithwaite with yellow dots representing the comments made by the users, the red dot being the selected comment that can

¹⁵ <http://geotools.codehaus.org/>

be read in the left window. When an object is selected on the map, the left window displays a form that can be filled in with comments and suggestions about the selected feature.

According to the authors of the Slaithwaite system, their application enables the resolution of the issue at hand to prevail over the usual personal confrontations that involves traditional methods of public participation, due to anonymity that the system provides. The authors also point out the fact that most traditional public participation meetings take place at a specific time and place, restricting the number of people that can attend them. Therefore, an online approach can suppress this problem with its intrinsic ability to provide access, independently of time or place. The system, with its two-way flow of information, reduces the time that it takes to make the information inserted by the public available, in comparison with the original Planning for Real exercise, since there is no need to collect flags and manually insert them into a database.

Nevertheless, the Slaithwaite system had some problems and limitations, some due to the lack of tools available at the time the project was being developed, others by choice of the developers. The system lacked the ability for people to give feedback about other people's opinion. Users were restrained to signaling interesting features with a dot, they could not insert an area of interest as a polygon through a free sketch tool. Moreover, they could not submit other types of information, besides text comments.

The two most relevant problems, elicited by the authors, were the lack of internet access in the United Kingdom at the time, and the policy problems of displaying geographic information in a public website. Notwithstanding, they rated the experience as very positive and, in their opinion, this type of system as having a lot of potential (Kingston, Carver, Evans, & Turton, 1999). Nowadays, their two most significant problems are outdated, with the widespread use of the Internet, and with the increasing availability of free of cost spatial tools, which enables the online creation of geo-content, increasing even more the potential of public participation systems.

Another example of web-based public participation GIS, from one of the authors of the virtual Slaithwaite system, Richard Kingston (at the University of Manchester), is a web site called Environment on Call for the City of Manchester (Kingston, 2007). The Environment on Call application provides online tools to facilitate the report of local issues related to environmental and social problems. The report is made by selecting the

location of the problem on a map, and filling in a form with related information (Figure 6).

Figure 6: Environment on Call Mapping Interface

A similar system to the previous described is the mySociety project, developed in 2007 (King & Brown, 2007). MySociety was an UK project, government funded, which allows people to report, view or discuss local problems in their council by locating them on a map, on the project's website. The system distinguishes itself from others by allowing users to submit photos about the reported problem. It supports comments on other people's reports, so that a discussion about a particular topic can be initiated. All the reports can be accessed and viewed by other users. The developers chose to display the reported problems by local council and, for each council, to classify problems as new, old, old with state unknown, old and fixed, and recently fixed.

In a different and more recent approach, Web 2.0 technologies are being used, specifically maps APIs, as an important platform to develop PPGIS (Park, Lee, Choi, & Nam, 2008), (Nuojua & Kuuti, 2008).

Web 2.0 is a novel concept used to describe applications that take full advantage of the recent developments of the web and its' network nature. These kinds of applications are

inherently social and open and their value increases the more people are using it. In contrast to a traditional static Web site that does not improve when visited by large amount of users, since its content is unaffected (O'Reilly, 2007). Examples of such technologies include, Wikipedia¹⁶, Youtube¹⁷, Really Simple Syndication (RSS), Asynchronous Javascript and XML (AJAX) and Blogs all technologies that take advantage of individual participation to enrich the content provided to rest of the community.

Web 2.0 technologies, where the public can directly generate different types of content (spatial, media) to share with other user's can promote participation and social interaction (Nuojuua & Kuuti, 2008), key factors for any PPGIS. Therefore, these technological developments have the potential to improve spatial collaboration, specifically when it involves the public's participation.

Using these recent developments, Park (2008) developed a system to support decision making by providing zone analysis (Figure 7). To provide rapid response to queries, the author implemented a polygon approach to store data. That is, the user's opinion is aggregated into a polygon, which can later be used to access available data.

Figure 7: public participation aggregated into polygons (Park, Lee, Choi, & Nam, 2008).

For the development of this system, the authors have managed to integrate the ArcGIS Server API¹⁸ with the Google Maps API. This combination of technologies was chosen because the ArcGIS Server API provides GIS spatial analysis tools that other Maps APIs like Google's, do not offer.

¹⁶ <http://www.wikipedia.org/>

¹⁷ <http://youtube.com/>

¹⁸ <http://www.esri.com/software/arcgis/arcgisserver/>

In another attempt to involve the public in the decision-making process, a system was developed to improve the acquisition of local knowledge for urban planning (Nuojuua & Kuuti, 2008). This system is very similar in concept to the one implemented by Kingston (1999), allowing users to submit opinions on a map. Users could submit a marker, using different colors, depending on their agreement of the discussion. The novelty is the usage of web 2.0 technologies, like the Google Maps API, to display geographic information and the possibility to add photos to the discussion, so participants can better express their opinions. The system also provided Really Simple Syndication (RSS) feeds for their users.

The authors had good results with their system, concluding that web mapping technologies can be used to improve the traditional, and sometimes still current, methods of public participation. They registered a good level of participation with many users contributing regularly at the site. From these results, they noted that the contributions were mainly submitted on weekdays during office hours, proving that some people want to participate but cannot do so, due to restrictions in time and place. Moreover, most of the participants were under 30 years old, contrasting with the traditional approach where contributors are mostly over 50 years old.

Another important insight was that users prefer to comment other users' opinions, rather than planning sketches or other more technical information, proving that combining local knowledge with planning knowledge is still an important challenge.

2.3. Discussion

This chapter presented an historical overview of computer collaboration, since its beginning to the birth of GeoCollaboration. Two factors defined the type of existing GeoCollaboration: contributors' location and the time at which the collaboration is realized.

The types of the spatial problems in need of a group approach also affect the decision of the better suited collaboration type. As said before, while emergency management needs a synchronous approach, for example, in PPGIS, an asynchronous approach may be appropriate.

Particular emphasis is given to PPGIS and its application examples, since this is a promising area of spatial collaboration, to be explored in this work. Recent developments

in Web 2.0 technologies, specifically on online mapping technology, promise to provide news means for the public to express their opinion, and consequently improve the decision-making process.

From what has been studied in this chapter, a conclusion can be made, as to the relevant issues to be addressed in Spatial decision support system , including: lack of generic tools to support geographic related discussion, lack of a set of configurable tools for different types of meetings, limited interaction with other users and their opinions and GeoVisualization issues. The expectation is that some of these problems can now be tackled with, through the association of available online mapping technology with the study of collaborative operators for spatial decision making. A technological approach is important to develop new spatial collaborative tools, but ultimately, it is insufficient to considerably improve GeoCollaborative applications. A complementary theoretical approach is also needed in spatial group decision-making, in order to decide which tools and methods are better suited for GeoCollaboration.

3 Methodology

In this chapter, the work methodology adopted for this work is explained. Due to the complex nature of collaboration, an effort was made to involve experts in the subject and target-users, from the beginning of the development of the work. The different steps taken to develop the system are explained below.

3.1. Definition of an Activity Model for Public Participation

The first step was a conceptual approach towards the definition of tools that could generically support different processes of spatial decision-making. This step was done in collaboration with the CIVITAS¹⁹ group, from the New University of Lisbon, Department of Sciences and Environmental Engineering. CIVITAS has a large experience in spatial decision-making processes where the public is involved in the decision. Therefore, they had the important role of sharing their knowledge on how people collaborate in different decision-making processes.

Based on their insights and the presented study of related work, an activity model for Public Participation as a generic process of spatial decision-making was defined.

3.2. Design

After defining the conceptual approach, it was possible to move forward to the design of the spatial decision support system. In this step the main concern was to develop a generic architecture that allowed different types of spatial decision-making. The system had to be flexible, in order to allow users with different knowledge and backgrounds, to collaborate spatially in different scenarios.

---

¹⁹ <http://civitas.dcea.fct.unl.pt/>

The system features, architecture, database and cartography were all topics that had to be designed in this step.

3.3. Implementation

After designing the system, the next logic step was to implement it. Implementation was initiated by the development of an empty (“mock-up”) prototype, to visually represent the different features of the system. To confirm if the developed features were according to what was debated in the first meeting, another discussion was arranged with CIVITAS.

To further improve the system, a meeting was held with staff members from the Town Council of Oeiras. These were professionals who usually work with spatial data (environmental and civil engineers, architects), thus providing an important expert perspective over the already defined features.

From the feedback offered by these two groups of professionals, some modifications were made to initially proposed features. After these modifications, the focus was on developing a fully functional system.

3.4. Usability tests

To evaluate if the developed system was easy to use and could successfully support a spatial decision-making process, usability tests were realized. Three distinct usability tests were conducted involving target-users. The first test involved the general public, followed by a test with CIVITAS and finally a test with the members of the Town Council of Oeiras.

From the results in each usability tests some final improvements were made to the system.

3.5. Discussion

As stated above, the goal of involving expert and target-users in the system was successful. In the initial stage, experts in spatial collaboration provided important insights on how people participate in a decision-making process, and how spatial data can help improve these processes. Later on, target-users and experts were involved in testing the developed system, contributing to its improvement.

4 Activity Model for Public Participation

The input provided by CIVITAS and by the study of the related work enabled the development of an activity model for Public Participation. This model is based on a generic process of spatial decision-making. The model's goal is to support different types of spatial decision-making where the public is involved.

The model can be implemented to specific decision-making processes like, the report of local issues related to environmental and social problems, as in the city of Manchester (Kingston, 2007) or provide support for a public discussion on a new road path that will cross the entire county.

CIVITAS input was a very important aspect of the development, since they have provided support to local governments in different decision-making processes including: Agenda 21 Local, Environment Municipal plans and regional planning. Their methodologies in these processes consist on identifying the problems that need to be addressed, encouraging collaboration between different actors and defining strategies to overcome these problems. Their approach has one common denominator: the involvement of the public in local decision-making to achieve innovative proposals.

The approach taken by CIVITAS in these decision-making processes is to conduct workshops to gather the participants' (e.g. general public, staff of the Town Council) opinions about different subjects. CIVITAS moderates these workshops by encouraging participants to express their opinions, making sure that the debates are on relevant topics, and registering the results from these meetings.

The conceptual approach underlying the proposed activity model for public participation is very similar to the workshop approach. Two types of actors are present in the model: a moderator and (one or several) participants. The roles taken from workshops are maintained, the moderator manages the decision-making process and participants express their opinion.

However, there are some differences. The most important is the addition of space as a central elemental in the decision-making process. For example, the opinions provided by the participants will be geo-referenced.

This approach was chosen since, local decision-making problems involving the environment the public lives in and interacts with, have a strong spatial component. Therefore, by defining space as a key element in addressing these problems, an improvement can be achieved in the way we understand and engage these problems.

Another important aspect of the proposed model is that the opportunity to participate in the decision-making process will be made publicly available, on the Internet. By allowing users to participate when and where it is convenient to them, an option that is not available in the workshop approach, public participation can be improved. Furthermore, the intrinsic Internet's anonymity can help overcome the usual personal confrontations that occur in traditional methods of public participation.

In the developed activity model for public participation, the moderator is responsible for configuring the system for the current decision-making process. His/her first task is to select the territorial domain (e.g. a county, a neighborhood) for collaborative activities, followed by the selection of the tools that better suit the current decision-making process (Figure 8).

Figure 8: Steps of the activity model for public participation. First the moderator defines the area and the tools and then the spatial decision-making process can begin. During the process, the moderator manages the participants' collaboration.

Participants can thus take part in the spatial decision-making process. The moderator is still responsible for managing the process by stimulating collaboration (e.g. create polls, news, etc.) but the main contribution now comes from the public.

Participants are invited to take part in the decision-making process through the submission of geo-referenced opinions, with different media associated (video, image and text). Comments can be made to the other participants' opinions, thus encouraging debate between participants. They are informed each time their topics are commented on. However, if the goal of the moderator is to enhance creativity in the submitted opinions, he can disable the ability of participants to interact with each other's opinions.

Nevertheless, if the focus is to stimulate debate between the different participants, different search parameters are available for them to find the topics they wish to collaborate on. Searches by category (e.g. urban planning), by a participant's name and by spatial interests are available.

Participants are encouraged to define their spatial interests (e.g. an area around their workplace) and, henceforward, are notified each time there are new developments (opinions) in their area of interest. This enables a user to keep track of relevant subjects being discussed and contribute when needed. Moreover, with this feature, when participants share the same spatial interests, a forum-like community is created.

4.1. Discussion

In this chapter an Activity Model for Public Participation was described. The definition was achieved with the help of CIVITAS, using their knowledge of current public participation processes.

An explanation of the different stages and features, involved in the Activity Model for Public Participation are presented.

Following the model's definition, a generic collaborative Spatial decision support system was developed, containing the necessary structures to enable the application of the model to different spatial decision making contexts. In the next chapter, the design of this system is described. The resulting system was customized to fit the public participation process of Agenda21 Local, which is described in chapter 6.

5 Design

In this chapter, the design of the system is presented. The primary concern in the design of the system was the possibility of asynchronous spatial collaboration including different features involving different users and the scenarios. Thus, flexibility was one of the main pre-requisites.

Therefore, spatial collaboration is provided through the use of a web browser, which enables users to participate in a decision-making process, involving public participation.

This chapter discusses the provided features and their availability to users. An overview of the database is provided, in order to facilitate the understanding of the system's capability to store the information resulting from the decision-making process.

Finally, the underlying cartography is also described.

5.1. Actors

As said before, the proposed system relies on two different types of users: participants and moderators. Moderators are responsible for configuring and monitoring the decision-making process occurring in the system, while Participants are contributors to the collaborative process. In the use cases diagram (Figure 9), Participants actors are divided in two types of user: Participant and Unregistered User. This separation exists because some of the system's core features are only available to registered users. The moderator inherits the Participant's behavior, enabling him/her to be an active voice in the debates, providing an expert's opinion on the discussed subject if needed.

Figure 9: Use case Diagram

Registration is compulsory for participants to actively participate in the group work. Only when, registered can they access the features that enable them to spatially collaborate including submitting opinion, comments, voting, etc.

Unregistered users can only read news, have a quick guided tour of the system and access the available GeoRSS²⁰ Feed.

The registration and login features are important for the decision-making process at different levels. First of all, participants associate opinions to their profile, thus keeping

²⁰ The GeoRSS enables for typical RSS feed be extended by allowing the encoding of location on the feeds. <http://georss.org/>

track of his/her topics/opinions and enabling other users to initiate contacts, when interested in the topic. Registration also enables the moderator to take important secondary information from the decision-making process, like the age or sex of the participants and the time of day the user access the system. Finally, compulsory registration also discourages passing by users to submit off-topic opinions just because they can and because it is easy.

The system's moderator must be knowledgeable of spatial collaboration and public participation processes, someone who may support users with difficulty in participating electronically. He/she will be in charge of selecting the geographic area where the spatial decision-making process will occur, selecting the best tools to support the current process, inserting news and polls, etc. Essentially, the moderator prepares the system to support spatial collaboration for one specific scenario and users, which the current decision-making problem/process requires. Furthermore, this person is in charge of exporting the data originated from the decision-making process (opinions, polls, spatial interests) for further analysis. Finally, he/she may also erase all the data from the system (executing backups if needed), so a new decision-making process can start.

5.2. Cartography

With a map-centered system, the choice of the base cartography was an important part of this work.

5.2.1. Cartography technologies

Recent developments in web services, 3-dimensional (3D) visualization tools and Maps Application Programming Interfaces (APIs) have helped to facilitate the access, management and interaction with geographical content for both users and developers (Chow, 2008).

Maps APIs in particular, have helped developers to implement systems that enable users with different backgrounds to work with geographic data. This represents a paradigm shift since, prior to the emergence of Maps APIs, access to detailed geographic information was restricted to GIS experts.

A Maps API is a source code interface that allows its users access to a programming library, which enables them to visualize a server generated map, over the Internet. As will be in detail in section 5.3, the web application submits requests of Geographic Information Services from the Maps API, and in that case the Google Maps' web server returns the requested spatial data.

Recent developments in Maps Application Programming Interfaces (APIs) include the Google Maps AP, the Yahoo Maps Developer API, and Microsoft Virtual Earth API. Each one has different characteristics, which are adequate to different tasks. However, they all provide the possibility for developers to combine custom data and functionality with the APIs' built-in features.

From a developer's point of view, the Maps APIs built-in Geographic Information Services, such as zoom in/out, pan and the ease with which custom data can be added to the visualized area are all important factors. They enable applications developers to concentrate on specific tasks at hand, like improving the implementation of collaborative tools, rather than have to implement base cartography handling and visualization tools, as part of their work.

From a users' perspective, applications based on maps APIs enable access to detailed geographic content through an easy to use interface, allowing them to concentrate on their specific task. The fact that there is no need to install any content to display geographic information also helps users with different levels of expertise to access geographic content, an important factor for public participation with spatial support.

Another example of the increasing importance of maps APIs is the recent technologies developed by GIS companies, which allow an easy channel to exchange information between maps APIs and GIS technologies. A good example is the ArcGIS JavaScript Extension²¹ that provides developers with an easy way to display GIS datasets over a Google Maps base map.

Presently, Maps APIs still show some limitations in providing GIS analysis tools. However, the ever-growing demand for more GIS-like functionality by the developer community is answered with frequent updates and extensions to the APIs, which promises great potential for further development and improvement of future versions

---

²¹ http://resources.esri.com/help/9.3/arcgisserver/apis/javascript/gmaps/help/google_start.htm

(Chow, 2008). Moreover, the APIs ability to be combined with other APIs, creating customized tools, can also enable developers with the ability to provide other GIS-like features, which were not initially available through one specific API.

5.2.2. Chosen Cartography

To decide the best API for the development of the system, the comparison between existing online Maps APIs presented by Chow (2008) was an important source. An extensive comparison of existing Maps APIs and its features (Imagery, Map Data, Custom GIS data Overlay, GeoRSS Overlay, GeoCoding, Routing, support for AJAX, the need for a plug-in, etc.) is presented, helping developers to choose the API that best suits their needs.

The chosen Map API for the development of the system was the Google Maps API, since it does not require any type of browser plug-in installation, it offers a good level of detail all throughout Portugal, it has reached a stage (version 2.141) where it is already a robust API and it is in constant development with new features being added to the API regularly, making it adequate to develop a web-based mapping system. The deciding factors were the fact that it requires no installation of a plug-in, increasing the system's availability and ease of use, and it has very good online support.

The information presented on the map will include markers representing opinions, polygons representing areas of interest, and polylines representing polygonal paths. The markers have associated information, which will represent opinions submitted by the users.

5.3. Architecture and technologies

The developed architecture is based on the one proposed by Chow (2008), which is presented in Figure 10, as the conceptual architecture for a Web application relying on a Maps API.

Chow (2008) defines the architecture of a web application, using built-in functionality and data provided by one Maps API, as an application that is hosted on a web server, returning Hypertext Markup Language (HTML) files and associated images (e.g. GIF, JPG, PNG), upon request of the clients' web browsers. JavaScript is used to connect to

the API, providing the web application with access to the API provider. The application can thus request Geographic Information Services, such as zoom and pan. The API provider returns the requested spatial data as web-compatible graphics formats (e.g. GIF, JPG, and PNG).

Figure 10: System architecture of a web site that uses the Maps APIs (Chow, 2008).

The built-in features and data provided by Maps APIs were extended to provide the features required for spatial collaboration, involving changes into Chow's (2008) architecture.

In Figure 11 it is possible to observe the chosen architecture for the developed system. While similar, in many aspects, to a typical web system architecture, relying on a maps API, there are some significant differences. A database was implemented to support persistence in data (geographic and non-geographic).

Figure 11: Architecture of the system. Based on Chow (2008).

5.3.1. Database Management System

The platform chosen to implement the database was MySQL²². MySQL is an Open Source Standard Query Language (SQL) database, reliable, easy to use and, when combined with the script language PHP²³, it can become a powerful tool. For these reasons, and because of its capability to support the generation, storage and analysis of geographic features through its spatial extension²⁴, it was the selected database for this work.

The MySQL spatial extension follows the specification provided by the Open Geospatial Consortium (OGC)²⁵. It uses a set of geometry types, to allow the storage of spatial data,

²² <http://www.mysql.com/>

²³ <http://www.php.net/>

²⁴ <http://dev.mysql.com/doc/refman/5.0/en/spatial-extensions.html>

²⁵ The Open Geospatial Consortium, Inc.® (OGC) is a non-profit, international, voluntary consensus standards organization, which is leading the development of standards for geospatial and location based services. <http://www.opengeospatial.org/>

based on the OpenGIS Geometry Model (e.g. Points, LineStrings and Polygons, among others)²⁶ and provides a set of functions to perform varied operations on spatial data (e.g. Contains, Distance). PHP was used to connect and communicate with the database.

5.3.2. Asynchronous Javascript and XML (AJAX)

In order to improve user interaction with the system, a web development technique, named Asynchronous Javascript and XML (AJAX), was adopted when developing the system. AJAX is neither a new technology nor even a new programming language, it is just a combination of several, already existing, technologies that, when combined in a specific way, offers new possibilities to web developers (Garret, 2005).

It consists of eliminating the start-stop-start-stop nature of traditional web interaction, where the user was left waiting for the response of the server, by introducing an AJAX engine between the user and the server.

The AJAX engine allows for the exchange of information to happen asynchronously, usually small bits of information, so the user is never left staring at a blank page. Essentially the user can request and receive the data from the server without reloading the page by just using the XMLHttpRequest JavaScript object.

For this work, the object used to enable AJAX was the GXMLHttpRequest object, provided by the Google Maps API, allowing users to request spatial data to the server, and the result being displayed on the map, without the need of reloading the page.

5.3.3. Keyhole Markup Language (KML)

The system allows for Keyhole Markup Language (KMLs)²⁷ files to be imported to the system and exported from the system. This format was first introduced by Google, for their Google Maps and Google Earth products, but is now an OGC standard language, which enables the visualization/presentation of geographic information.

---

²⁶ <http://dev.mysql.com/doc/refman/5.0/en/ogis-geometry-model.html>

²⁷ <http://www.opengeospatial.org/standards/kml/>

5.4. Database design

As said before, persistent data is stored on a MySQL database. In Figure 12 we can see a Unified Modeling Language (UML) class diagram of the database. Data, spatial and non-spatial, resulting from spatial collaboration is stored here, making it possible for users to collaborate asynchronously.

Figure 12: Class Diagram of the system

The database will store the user information, enabling a login system to be implemented, among other features. The Last Login field in the User table is of significant importance, enabling the system to notify users of the recent relevant changes (since he was last logged on).

Users can contribute with their opinion in the decision-making process. These opinions are stored in the table opinions. It is clear who the author of which opinion is since both tables are related. Topic stores non-geographic information (e.g. description, link, pictures) and geographic information (e.g. polygon, marker, polyline). The field that enables users to store geographic information related to a topic is of type Geometry,

which is the base class in the spatial data in the MySQL spatial extension. This allows for the topic to be represented on the map by a Point, a Polyline or a Polygon. The submitted topics can be commented on by other participants, providing a way to debate the current topic. The opinions table will also store expert opinions due the similarities between both opinions. The KML and file fields enable the associating of information to an opinion that is not possible in the regular submit opinion feature. Opinion types are distinguished by the field type in the opinions table.

The topics can be associated with a category (e.g. urban planning, environment) by the user, when submitting an opinion. These categories/themes will be the main subjects of the decision-making process and are created by the moderator. This will enable the user to search for the topics that most interest him/her, based on other interests besides space.

Users can define areas of interest on a map. These areas are polygons, representing the spatial interests of collaborative users. The Points field, on the Areas table, will represent a set of points defining the polygon. The areas will be associated to the users.

The moderator can create polls to allow collaborators to vote and enhance the decision-making process. Each answer to the poll can be associated with a topic, giving the moderator the chance to spatially present the different options.

5.5. Discussion

In this chapter the design of the system was discussed. An overview of the features available to support spatial decision-making was presented, as well as, the type of users that will participate.

The cartography of the system was discussed, with a brief explanation on why Maps APIs were chosen for the development of the system, and specifically the Google Maps API choice.

The generic system architecture was described, focusing on its ability to support different types of spatial collaboration using different spatial operators.

Finally, the relational database and how the data is stored were also addressed, so it can become clearer how the spatial collaboration works asynchronously.

6 Proof of Concept

The system, whose design is presented in chapter 5, was implemented and customized to be applied to a specific application domain, as proof of concept for the tools defined in the Activity Model for Public Participation, proposed in this thesis. This system includes all the features described in chapter 4 and is supported by the generic architecture presented in chapter 5.

The system was developed to support spatial collaboration, especially one that involves the public. The included tools aim to support a public participation process, like the Local Agenda21²⁸ process.

In this chapter, a brief overview of what is Local Agenda21 is presented, to support the decision of applying the proposed tools to a process of public participation. In addition, an outline of the implemented tools is provided, including a thorough exposition of what they are capable of and how they work.

6.1. Agenda21 Local

The Local Agenda21 is based on a United Nations initiative, proposed at the World Earth Summit (Rio de Janeiro, 1992), to implement a plan of action for strategic local development, using the natural resources necessary to sustain the present generations, without compromising the capacity of future generations, which is known as sustainable development. It is important to note that Local Agenda21 approach towards sustainability is not uniquely an environmental approach, but it also aims at affecting the economical and social aspects of, in this case, a municipality or a group of municipalities.

The Local Agenda21 is implemented through a complex process that includes several steps and actors. The main novelty of this work, comparing to other projects for

---

²⁸ <http://www.un.org/esa/sustdev/documents/agenda21/english/agenda21toc.htm>

implementing sustainable development, is the importance that public participation has in the process. Public participation is a relevant part of the Local Agenda21 process, offering crucial local knowledge that enables the finding of the most relevant problems in a municipality. They offer a different perspective from the one usually considered when decision needs to be taken, the political perspective.

The Local Agenda21 process comprises four distinct phases that are usually sequential but which can, occasionally, happen simultaneously: the first phase is to Prepare Local Agenda21; followed by the implementation of the Local Agenda21 process; the third step is an evaluation to the Local Agenda 21 process; and the last phase is to increase capacity and knowledge of Local Agenda21 (Figure 13).

Figure 13: Local Agenda21 Process. Adapted from Agenda 21 Local: Guia Metodológico de Apoio em Contextos Rurais e de Forte Interioridade. http://www.amde.pt/pagegen.asp?SYS_PAGE_ID=453274 (accessed last 20/02/09)

The first phase (Prepare Local Agenda21) consists mainly in preparing the necessary components for the Local Agenda21 process. A management structure has to be created for the process, and the plans for participation and communication have to be outlined. Following this initial stage, a preliminary diagnosis, containing the main issues referring to the local sustainable development, will be made. The diagnosis is based on a series of questions made to local inhabitants, interviews to key stakeholders and direct observation of reality. Using the collected information, the main relevant issues are identified and later analyzed in detail. Finally, issues with higher priority are defined and a plan of action is delineated to address them.

The second phase of the Local Agenda21 process is its implementation. In this phase, strategic decisions towards implementation are taken and the previously proposed actions are employed in the field.

In the third phase the process of Local Agenda21 is evaluated. The results are measured and monitored, so they can be compared to the goals and objectives that were defined in the first phase.

The final phase of the process is where the numerous actors in the process increase their knowledge and enhance their ability, regarding the Local Agenda21 process. By learning with mistakes and successes in the process, the return to the beginning of the cycle (Prepare Local Agenda21) can improve the process.

The most relevant stage of the Local Agenda21 process, for this work, is the first stage, where public participation and interaction with spatial information, are most present. In this stage in particular, spatial collaboration can improve the way people collaborate and participate in the process. However, the system can also be useful for the different phases due to its flexible nature. For example, the system can offer support for the citizens to provide information on what are the ramifications of the actions employed in the field or use polls to support a strategic decision debate.

As said above, users with different backgrounds have to work together in different scenarios and areas, meaning that the implemented system has to be customizable to support this multifaceted collaboration.

The Local Agenda21 process presents itself as a perfect example to explore the positive aspects of spatial collaboration, implemented digitally. The computational availability of collaborative tools to facilitate public participation in Local Agenda21 may improve even more, this already good example of group decision-making.

In this context, the CIVITAS²⁹ group has been helping several communities on the process of Local Agenda21 in Portugal, holding valuable knowledge about the process and how it can be improved.

Although the system could not be tested in the first stage of a Local Agenda21 process, as it would be ideal, due to the lack of opportunity given the established deadlines for both

---

²⁹ <http://civitas.dcea.fct.unl.pt/>

this thesis and the ongoing processes, it was still tested with the different actors that take part in this process, which provided major feedback to evaluate if the system could be used to support such a process.

6.2. Features

In this section the defined set of tools to support spatial collaboration are presented. As said before, the system is available online to support asynchronous spatial collaboration. The only system requirements are an internet connection and an internet browser.

The implemented set of tools aims to support public participation GIS, providing means for the public to actively participate in a decision-making process, involving geographically-referenced information.

This section will be divided in two sections, one explaining the features available to the moderator of the process and one explaining the features that can be made available to the public.

The system is available online at, <http://img.di.fct.unl.pt/mapas/>.

6.2.1. Moderator Tools

As previously mentioned, the moderator is responsible for configuring the system, and choosing the appropriate set of tools to support a specific spatial decision-making process. The features that enable him to do so are presented next.

6.2.1.1. Installation and management of system information

The system allows for a simple installation if such is required. The installation is similar to the one that precedes the creation of a blog. The moderator defines the name of the website, its description, keywords, contact data for the process's moderator, server information, e-mail information and database information. After this information is submitted without errors, the SQL code will be executed. A moderator user login is created so the participative process can begin.

The system information may be altered by the administrator, allowing flexibility to different processes. Due to the possibility of combining the capability of altering the system's information (e.g. name of the process) with the ability to erase all data from the

system (discussed further in this chapter), enables the starting of new processes with little effort.

6.2.1.2. Define territorial domain

One of the first tasks that a moderator has to accomplish is the selection of the relevant geographical area, where the public will be allowed to collaborate spatially. This prevents users' opinions from scattering across the map, allowing users to focus on areas where their opinions can contribute to enhance decision-making.

Two options are provided for the moderator to accomplish this task: to choose from a list of Portuguese counties (the Agenda21 Local is frequently applied to a county) on the left of Figure 14, or to draw a polygon defining the area of collaboration on the right of Figure 14, ideal for situations where the area to participate is smaller than an existing administrative boundary.

Figure 14: The two different ways to define the territorial domain. On the left by choosing a county and on the right by defining it manually.

6.2.1.3. Define set of available tools

In this feature the moderator will choose from the defined set of tools, the ones which better suit the needs of the current decision-making process. The selected tools will be made available for the users to participate.

These tools include: submit opinion (private or public), submit expert opinion, define area of interest, search in area of interest, search for user, search by category and consult discussions on the users' submitted opinions.

6.2.1.4. Define/manage categories

The moderator will be responsible for creating the categories of the system. Categories will represent subjects like urban planning, environmental awareness, recycling. These categories will be associated with opinions and news, providing the users with an easy way to search for content related to these topics.

6.2.1.5. Add news

The moderator has the ability to create geo-referenced news. By doing so he may disclose important information to the public. Each news instance has a title, description, image, external hyperlinks, videos, a category and as said before, a geo-reference. It can be a location for a new urbanization or the path of a new road, informing users about the latest changes and novelties in the decision-making process. Moreover, it is possible for users to comment on the news, creating an additional channel to exchange information between the people in charge of taking the decisions and the public.

6.2.1.6. Add polls

An additional medium of expressing an opinion in this system is through a poll. The moderator is responsible for creating polls. These polls may have geographic information associated to each voting option (e.g. different proposals for a road's route). With this geographic representation, participants can have a visual representation of the different options. Furthermore, participants may comment the different options, providing the moderator with a more detailed view of the reasons behind the final results of a poll. An

example is shown in Figure 15, with the graphics being provided by the Google Chart API³⁰.

Figure 15: Example of geo-referenced Poll

6.2.1.7. GeoRSS Feed

The GeoRSS feed allows a number of ways to encode location in RSS feeds. RSS feeds allow users to keep up to date with recent developments in the decision-making process, without much effort. As RSS feeds are increasing in importance as a new media to publish and share information, it is important to provide this new technology to users.

The GeoRSS feed of the system is updated automatically each time the moderator inserts the latest news, making it an easy task for the user to read the most recent changes. To access the feed, the user may use a browser or the Google Maps webpage. The latter enables him to read the topics of the most recent news and at the same time observe where they are located on the map. When a user selects one of the news of the feed he will be redirected to the chosen news webpage.

³⁰ <http://code.google.com/apis/chart/>

6.2.1.8. Show all Opinions

This feature provides the moderator with an easy way to analyze if there is a relationship between the location of the users' opinion and the location of their residence. The map will show users' opinions in red markers, and green markers will represent the address, through GeoCoding³¹, associated to the user profile (Figure 16).

This feature can be especially important in a public participation process, to analyze if people only participate when their immediate surroundings are involved, the NIMBY (Not in my backyard) phenomenon, or if they participate indiscriminately.

Figure 16: In green markers it is possible to see the users' addresses acquired through GeoCoding and in red the users' opinions.

³¹ Geocoding- the process of turning a street address into a latitude and longitude

6.2.1.9. Export Data

To overcome the intrinsic limitations of Maps API regarding GIS analysis tools, the moderator has access to a tool which facilitates exporting data from the system. The data is exported in KML, an OGC standard language, enabling the further study and analysis of the data resulting from the decision-making process.

This tool provides filters to enable the moderator to choose specific ranges of the users' submitted opinions. It enables the moderator to choose opinions depending on their category, on a certain time frame and on the user's data (sex and age). Finally, he/she may export data from a certain area by drawing a polygon.

6.2.1.10. Erase system

Finally, a tool is provided for the moderator to erase all the data generated from the decision-making process. The moderator can thus, through a simple tool, restart the system and start a new decision-making process from scratch.

When a moderator erases the system, a KML file with all the geographic and non-geographic data may be exported, so the data generated from the decision-making system can be preserved and analyzed at a later date.

6.2.2. Publicly Available Tools

In this section the tools available to the public are discussed. It is important to underline that the tools that will be available to the public in a specific decision-making process depend on the set of tools the moderator chose for that occasion.

An effort was made to develop tools that are easy to use, due to the possible different user levels of expertise but nevertheless, still retaining the ability to represent several scenarios and proposals.

6.2.2.1. Submit Opinion

The set of tools available to users depends on the configuration chosen by the moderator for the current decision-making process. However, the possibility of submitting an opinion is compulsory in this system.

This tool enables users to submit a geographically referenced opinion (Figure 17). Users choose the category that is relevant to their opinion. Additional information can be associated to an opinion, to further explain the user's point of view, including images, external hyperlinks, videos and a text description. When submitting an opinion, the system will display previously submitted opinions, made available on a 1km radius, encouraging him/her to only create a new topic when there are no other related topics nearby, thus promoting debate between users with similar geographic interests.

Parque dos Poetas

Autor [rodrigues](#)

Morada R. de São Salvador da Baía, Oeiras 2780, Portugal

Descrição
25,5 hectares de espaço verde numa homenagem a 20 poetas do século XX. O Parque dos Poetas implementa um conceito moderno de lazer de qualidade. Conta com um anfiteatro ao ar livre (com a exibição de ciclos de cinema no Verão), um campo de futebol, fonte luminosa e muita animação aos fins de semana.

Categorias Espacos Verdes

Link
Imagem

Comentários

Figure 17: An example of an opinion submitted by a user. It contains the author's name, the address (through reverse GeoCoding³²) of the submitted opinion, a description, the categories of the opinion, a hyperlink, an image and on the bottom of the Figure the comments of the users will be presented.

³² Reverse Geocoding – the processo of transforming a latitude and longitude into a street address.

To allow further debate between participants, it is possible to comment other users' opinion. This encourages a healthy debate to take place between public participants. A user may also e-mail other users, if there is a need for further debate on the subject.

However, if the moderator's intention is to promote creativity over debate, he/she can prevent users from viewing and making comments on other people's opinion. This prevents users from copying or taking "inspiration" on other users' opinions and forces them to submit their own original thoughts.

6.2.2.2. Submit Expert Opinion

If the moderator wants to provide users with a more elaborated tool for submitting opinions he/she can provide them with the "submit expert opinion". This tool offers all the features that the normal submit opinion provides and, additionally, it enables the users to draw polygons and polylines on the map, associate KML files to the opinion (which will be displayed when the opinion is read) and finally, it allows users to upload files to the server (Figure 18). These files will be available to download when the opinion is read, and are especially useful when it is necessary to represent information that cannot be displayed on a map.

Só pode guardar um marcador ou uma recta ou um poligno. Para começar a desenhar carrega uma vez no mapa e duas para parar.

Navegar
Desenhar ponto
Desenhar recta
Desenhar poligno

Nome do tópico*
Nova urbanização junto ao Estádio Nacional

Morada
Av. Pierre de Coubertin

Categoria
☒ Planeamento Urbanístico ☐ Espacos Verdes

Kml (Link para um ficheiro KML, ficheiro do google maps)
mg.di.fct.unl.pt/planos de urbanização.kml

Figure 18: Submit Expert Opinion. On right of the map the users' drawing tools are displayed and, below the picture, is the form with the opinion's title, address and category. A hyperlink to a KML file is shown.

6.2.2.3. Define Area of Interest

The system offers users the possibility of defining their spatial interests. In this feature a user may define an area where he/she is most willing to participate (e.g. an area around his/her house or his/her children's school). The definition of the area is very similar to the manual definition of the territorial domain area represented on the right in Figure 14. The user inserts the address of the center of the area, its name and its radius and with that data a circular polygon is drawn on the map, as can be seen on the left of Figure 19. Before saving the area, he/she can correct the defined area by dragging the markers in each vertices of the polygon (right of Figure 19). Once the area is defined, the user will be noted whenever another user submits an opinion on his/her area of interest. This enables a user to keep track of relevant subjects being discussed and facilitates contributions when needed, creating a forum-like community when different people have similar spatial interests.

The areas can be changed by the user all throughout the decision-making process, enabling users to change their spatial interests according to their fluctuating personal concerns.

Figure 19: The process of defining an area of interest. On the left we can see the area generated from the data inserted by the user and on the right we can see the area already adapted to the user's interests.

6.2.2.4. Search in Area of Interest

As said before, after the user defines his/her spatial interest, he/she will be noted on new spatially relevant contributions since their last login on to the system. These new opinions can be accessed on the tool “Search in Area of Interest”.

In Figure 20 it is possible to observe, on the map, the area of interest defined by the user and the opinions submitted on his/her area. The green markers represent new opinions, submitted since the user last logged on to the system, and the red markers represent the remaining opinions. This distinction is also present on the right sidebar of the website, with new opinions on top and old ones on the bottom of the sidebar.

Figure 20: Display of “search in area of interest” tool. In the map, it is possible to observe the defined area of interest and the opinions that are contained in it. In green markers, the most recent opinions and in red, the older opinions. On the right sidebar this distinction is also clear.

6.2.2.5. Read comments on my opinions

This tool enables users to access their submitted opinions and their recent comments. In a similar approach to that of the “Search in Area of Interest” tool, this tool will distinguish opinions submitted by the user which have been commented since he last logged on to the system. The opinions’ representation on the map will vary between red and green markers, representing opinions with no recent comments and opinions which have recently been commented on respectively. The opinions are also represented on the sidebar of the website, where they are organized into two separate rows depending on the recent comments made by other users.

6.2.2.6. Other types of search

A user can search for all the opinions submitted by another user. This can be particularly interesting if an expert user (e.g. member of the Town Council) is participating in the decision-making process, making it easy for users to check what topics he/she is debating and giving his/her expert point of view.

A user can also search by category that most interest him/her. This enables a user to search for opinions with other interests than just his spatial interests. For example, he can search for all urban planning related opinions thus, facilitating access to information on one particular topic.

6.2.2.7. Other types of tools

As mentioned in the moderator features, the system supports the creation of news. News may be read by users, making it a good media of communication to divulge important information about the decision-making process. Users can comment on the submitted news in the same way they comment on users' opinions.

Another tool that is available for the moderator, are geo-referenced polls. Users can vote on a poll inserted by the moderator. In addition to regular polls, users can learn about the different voting options by accessing detailed geo-referenced information about them. Furthermore, chosen options may be justified through a comment on the chosen option.

6.3. Discussion

In this chapter the different designed tools which compose the developed system were presented. Moreover, a brief explanation of a public participation process which served as proof of concept in this thesis was also given.

The brief overview on all the implemented features facilitates understanding on how they work, and how they can support a spatial decision-making system is presented. Moderator's tools enable creation and management of a decision-making process. On the other hand, users' tools enable submission of opinions and interaction with other users' opinions, through searches using available information on (spatial and non-spatial) interests.

The developed tools suffered an evaluation process, which is described in the next chapter. The aim of this evaluation was to assess if the designed tools provide users, with different backgrounds and knowledge, a successful platform to collaborate spatially.

7 Evaluation

To understand if the activity model for public participation, specifically the set of implemented tools, were easy to use and enabled users to successfully participate in a spatial decision-making system, an evaluation of the system was realized through usability testing.

As in the previous chapter, the tests were separated depending on user role. Different usability tests were made to evaluate the moderator features and the features available to the public. Therefore, this chapter is divided in two sections, presenting the results of the conducted tests.

Different evaluation techniques can be used, depending on the users and on what are the designers' intentions. The aim was to use a technique that did not require much time spent by both users and the developer, due to the lack of available time, but still gave detailed information of the system's usability, strengths and weaknesses. As a source of information related to the appropriate evaluation and observation techniques, the classification of evaluation techniques presented by Dix (2004) was used.

Introductory and final questionnaires were used, since they are evaluation techniques that require a small amount of time, are not intrusive, do not require a lot of equipment and yield a high level of information (Dix, Finlay, Abowd, & Beale, 2004).

The observation technique used was the *Think Aloud Approach*, where users are encouraged to think aloud while they perform the different tasks which were asked to them (Dix, Finlay, Abowd, & Beale, 2004). In this approach, time is needed for users to explain their difficulties while they are using the system. However, this is time well spent because it enables developers to identify the problem areas and their reasons.

The realized usability tests consisted on four parts:

1. An introductory questionnaire to acquire data from the participants. Gender, age, area of expertise, experience with computers, were all featured questions. Also, questions about their experience using digital maps and their previous knowledge of public participation were made;
2. The second part of the test consisted on handing over a briefing document to the users, explaining the system's goals and features, to provide some context to perform the next step;
3. This step was used to evaluate how the users interacted with the system. They were asked to try to execute a small number of tasks (5-8). The difficulties and successes of the users were registered so they could be later analyzed;
4. The final step was to fill in an evaluation questionnaire. The questionnaire included three questions using Likert's scale to evaluate the usefulness of the system, as well as its potential. Finally, some open-ended questions were made to allow users to express their likes and dislikes about the application and their suggestions on how to improve it.

7.1. Moderator usability tests

A moderator usability test was conducted to test the moderator side of the application (Appendix A – Moderator Usability Test).

7.1.1. Participants

The usability tests to evaluate the moderator features were made with the help of CIVITAS. As previously mentioned, they have provided support to local governments in different public participation processes like Local Agenda21, Environment Municipals plans and regional planning.

As they frequently serve as moderators in these types of processes, they could make an efficient evaluation of the usefulness of this application to support these processes. Moreover, they were asked to evaluate if the features developed, for the moderator, to create and manage a spatial decision-making process were easy to use.

The moderator's side of the application was tested in four usability tests. Two of the participants were males and the other two females. Regarding age, two of the testers were between thirty-five and forty-five, one over 45 years old and the other was between 25 and 35 years old. They all had college education.

7.1.2. Questionnaire

Besides personal data, questions were asked regarding their experience with computers and specifically if they had used digital maps before. As expected, due to their background, all had already used digital maps including, Google Maps, Google Earth and interactive maps from different Portuguese counties.

The final questionnaire consisted on eight questions. The first three used Likert's scale between one (Totally disagree) and five (Totally Agree) where a sentence about the system was provided and they had to circle their accordance. The sentences addressed how easy to use and to learn the application was, and if, in their expert opinion, they thought that this application could be an important complement to existing public participation processes.

The remaining questions were open-ended and addressed their favorite aspects of the system and their least liked quality. Suggestions and commentaries on how the system could be improved were also asked.

7.1.3. Results

Regarding the evaluation of how users performed the different tasks, users were asked to perform eight different tasks. The tasks consisted on preparing a system to support a spatial decision-making process and to add geographic related content to the system. The first task was simply to enter the moderator area of the application. After completing the previous task, the moderator had to change the information related to process (name of the process, moderator contact information, etc.), followed by selection of the territorial domain for the spatial decision-making process. The next task involved the moderator choosing, from the available array of tools, which best suited the current decision-making problem. The moderator had also to add categories to the discussion. This concluded the configuration of the system and spatial collaboration could begin.

Meanwhile, the moderator may also add geo-referenced content to the system. Hence, the next two tasks consist on the tester inserting geo-referenced news and a poll. Finally, the export data feature was tested, to understand its ease of use.

The results of this part of the tests can be observed in Table 2 where 0, 1, 2 and 3 corresponded to, not completed tasks, incorrectly completed tasks, tasks completed with help or not easily completed and easily completed tasks respectively. The results were ordered by tasks where each user had a value from 0 to 3, depending on how well they executed the task.

	0	1	2	3
Login	0	0	1	3
Change System Info	0	0	2	2
Define territorial domain	0	0	0	4
Define Categories	0	0	0	4
Choose tools	0	0	0	4
Insert a news instance	0	0	1	3
Insert a poll	1	1	2	0
Export Data	0	0	0	4
Total	1	1	6	24

Table 2: Results of the usability test for the moderators. 0- Not completed tasks, 1- Incorrectly completed tasks, 2- Tasks completed with help or not easily completed and 3 - Easily completed tasks

The results of the test were quite satisfactory (Mean = 2.66, Standard deviation =0.50), with the moderators accomplishing most (24 in 32) tasks without any help, which is an indication that the system is easy to use. To better analyze the results a graphic is presented in Figure 21 below, which illustrates the results gathered during the moderator usability tests.

Figure 21: Results of the moderator usability tests

The task that generated more difficulties to the user was the creation of a geo-referenced poll. This could be due to novelty in this function where each option had to have geographic information associated. However, after explaining the tool in detail all the users found it very useful and stated that if they performed it a second time they would be successful.

Regarding the final questionnaire, the participants said that the system was easy to use (Mean = 5.00, Standard Deviation = 0.00), it was easy to learn how to use the system (Mean = 5.00, Standard Deviation = 0.00) and in a question specifically oriented to possible future moderators for this system, they all found that this system could be an important complement for existing public participants processes (Mean = 5.00, Standard Deviation = 0.00). This discrepancy between the final questionnaire and the results of the tasks can be a result of the assistance provided to the testers, after their initial difficulties in a specific task, which resulted on the vast majority (30 on 32) of the tasks to be accomplished. In the end, after a few explanations on how to use the system, all the testers thought it was easy to use.

From the open-ended question it was possible to see that the most praised aspect was the addition of a spatial component to public participation processes. The choice of Google Maps, a tool easy to use and already experimented by many, was also congratulated.

Users were asked to give suggestions for the improvement of the system, and the most mentioned was to enable moderators to add files to the system. This feature was later incorporated to the system.

7.2. Public Usability Tests

Two different usability tests were conducted to test the defined tools (Appendix B – Public Usability Test). One with users who are not experts in the subject and usually do not work with spatial information. The other tests involved the technical board of the Oeiras county, people who deal with spatial-decision making problems on a regular basis. Testing with two groups with different backgrounds is important since collaboration in public participation processes usually involves people with different levels of knowledge and expertise. Moreover, the type of feedback provided by the two groups also allows for different improvements on the system, given their naturally different points of view.

The structure of the tests was the same as the moderator usability tests, with an introductory questionnaire, a briefing, followed by task analysis and a final questionnaire.

7.2.1. First Test (Non-expert users)

7.2.1.1. Participants

As the system is intended to support public participation, usability tests of non-experts users had to be realized, to understand whether the system's features were easy to use for the general public. The goal was to gather people from different areas, with some experience with computers but without any link to public participation or spatial collaboration.

The tests were conducted by six users, four between 25 and 34 years old and the other two between 18 and 24 years old. Five of the users were male and one female. Users came from different areas like law, design, finances and computer engineering.

A question was made regarding their previous knowledge of public participation and only half of the users (3) had heard about this process, although without great detail. An indicator that many people have yet to participate in public participation processes due to lack of interest or opportunities.

7.2.1.2. Questionnaire

From the introductory questionnaire it was possible to observe that, as expected, all participants were regular users of computers. An important indication of the widespread use of web mapping technology is that all the users had already used digital maps, evidence that this technology is being used by the public. Once again, Google Maps was the most referenced digital map application.

The final questionnaire was, once again, based on eight questions, the first three to analyze the ease of use, easiness to learn how to use the system and usefulness of the system and the final five questions aimed at encouraging participants to give suggestions and commentaries that could help improve the system.

7.2.1.3. Results

Users were asked to perform six different tasks. The proposed tasks were: registering on the website, submitting an opinion, defining their spatial interests, search in their area of interest and comment one opinion contained in it, read and comment news inserted by the moderator and finally participate in one of the available polls.

Using same approach as the one in Table 2, the results from this test were organized by task, where each one had a classification between 0 and 3 (0- Not completed tasks, 1- Incorrectly completed tasks, 2- Tasks completed with help or not easily completed and 3 - Easily completed tasks), depending on how the user executed the proposed task. The results from this usability test can be seen below in Table 3.

	0	1	2	3
Register	0	0	0	6
Submit Opinion	0	0	3	3
Define Area	0	0	2	4
Search in Area	0	0	0	6
Read News	1	0	0	5
Participate in a Poll	0	0	0	6
Total	1	0	5	30

Table 3: Results of the usability test for non-expert users. 0- Not completed tasks, 1- Incorrectly completed tasks, 2- Tasks completed with help or not easily completed and 3 - Easily completed tasks

Once again the results were quite satisfactory (Mean = 2.78, Standard deviation =0.58), even with users with little to no experience using this kind of tool. The main problems encountered by the users were due to some errors that were present in the system at the time, that which have now been corrected. A graphic is shown with the results from this test, in Figure 22.

Figure 22: Results from the usability tests with non-expert users

From the final questionnaire some relevant data can be analyzed. The first three points of the questionnaire were statements to which users had to agree or disagree, according to a Likert scale. The first question was if the system was easy to use and the general opinion was a yes (Mean = 4.50, Standard deviation =0.50). In the next question, users were asked if it was easy to learn how to use the different features and once again the answer was a clear agreement (Mean = 4.67, Standard deviation =0.47). The final question regarded the users' openness to use a system like and to participate, which, in general, the participants agreed (Mean = 4.00 Standard deviation =0.00).

From the last five questions involving the likes, dislikes, comments and suggestions of the participants, it was possible to observe that the most praised aspect of the system was the simplicity and ease of use involved in the realization of the proposed tasks. This was an important factor since the system had to be easy to use by both experts and non-experts. When asked about what feature they liked the most, the most popular choice was the possibility to define their spatial interests and conduct searches according to them.

In terms of the problems and improvements suggested, there were some navigation problems which have now been solved. The possibility to better keep track of the comments a user makes in other topics and not just the topics he created was also mentioned.

7.2.2. Second Test (Technical Board of Oeiras)

7.2.2.1. Participants

The aim of this test was to evaluate the system with people whose work involve dealing with spatial information on a daily basis.

Five users were tested: all female, three between 35 and 45 years old and the other two between 25 and 34. Three were engineers, one architect and one judge.

7.2.2.2. Questionnaire

From the introductory questionnaire it was also possible to observe that all but one user had previous experience in dealing with digital maps. Google Maps was again the top choice, with three people claiming that they have already used it. Only one of the users also mentioned using different Web GIS, an indication that even between experts this type of technology has a potential to grow.

A question was made to understand if the participants had already been acquainted with public participation processes and the answer was always yes, a clear indicator that this kind of processes has been used in different occasions.

A final questionnaire was presented to the users after the realization of the proposed tasks, which included three statements to evaluate according to a Likert's scale and five open-ended questions. The first question asked was if the application is easy to use, followed by a request to define how easy it was to learn how to use the system and, finally, a question was made on whether they would use a system like this as a mean of giving their opinion, in a public participation process.

The open-ended questions consisted on asking about the likes and dislikes of the testers, as well as requesting any comments or suggestions, which can help improve the system.

7.2.2.3. Results

The tasks presented to the users were five. Although more tasks with more users would be ideal, this could not be done due to lack of time on the part of the users.

Their tasks consisted on registering on the site, submitting an opinion, defining their spatial interests, search in their area of interest, commenting one opinion contained in it and, finally, participating in one of the available polls.

The results from this test can be observed in Table 4. The table is organized in the same way as in the moderator and non-expert usability tests. Each task has a classification between 0 and 3 (0- Not completed tasks, 1- Incorrectly completed tasks, 2- Tasks completed with help or not easily completed and 3 - Easily completed tasks) depending on how the user executed the proposed task.

	0	1	2	3
Register	0	0	1	4
Submit Opinion	0	0	0	5
Define Area	0	0	2	3
Search in Area	0	0	0	5
Participate in Poll	0	0	0	5
Total	0	0	3	22

Table 4: Results of the usability test for the technical board of Oeiras. 0- Not completed tasks, 1- Incorrectly completed tasks, 2- Tasks completed with help or not easily completed and 3 - Easily completed tasks

As can be seen above in Table 4, the results were very good (Mean = 2.88, Standard deviation = 0.33), with most of the tasks being accomplished easily without any help (22 out of 25). The results are also presented below in a bar chart in Figure 23.

Figure 23: Results from the usability tests with members of the Oeiras Town Council

From the results in Table 4, it can be observed that the task users had more problems with was the definition of their spatial interests. This can be due to the different approach taken in this work, regarding the definition of users' interests. Whereas, in the studied systems, users could only search by categories (urban planning, green spaces, etc.), in this system, they can define their spatial interests, which provides them with better search capabilities. However, this concept can, at first, escape their grasp.

From the first three questions/statements of the final questionnaire it can be observed that users found the system user-friendly (Mean = 4.20, Standard deviation = 0.40) and easy to learn to work with (Mean = 4.20, Standard deviation = 0.40). The majority stated that they would use a system like this to submit their opinions (Mean = 4.40, Standard deviation = 0.49).

From the open-ended questions, it was possible to distinguish that the main concern of the participants was the need of an introduction or help manual. In their opinion such a feature could help future users understand what is the system's goals and features, so they could benefit from all that the system has to offer. Although this feature was planned from the beginning, a low priority was attributed to it. Hence, at the time of the delivery of this thesis, it was not yet concluded. However, the goal is to finish it prior to the dissertation's Viva.

Three out of five users also expressed their appreciation regarding the ease of use and the graphical content. Concerns were raised, by two testers, on how users could receive information on whether their opinion was really taken in consideration, in the current decision-making processes.

7.3. Discussion

The overall results from the usability tests can be considered quite satisfactory (Mean = 2.76 Standard, deviation = 0.41) with the different users being able to perform most (79 out of 99) of the task without any help. Regarding the tasks that were not easily completed or were completed with help (16 out of 99), as well as, the incorrectly completed and the non completed, the belief is that, given an introductory feature explaining the goal and the rest of the features of the system, these initial difficulties can be overcome.

Nevertheless, overall, the users found the system easy to use (Mean = 4.87, Standard deviation = 0.60) which indicates that, although the users had some initial difficulties, with support, they understood most of the features and what was expected from them, considering, in the end, the system easy to use. An important factor was that the geographic data was represented using Google Maps, the tool most referenced by users when asked if they had already used a digital map (12 out of 15), suggesting that this platform was a wise choice.

These results were important in proving that the system can be effectively used by users with diverse knowledge and cultural backgrounds. This is a very important factor, due to the fact that in decision-making, especially one that involves public participation, the users are multifaceted.

8 Conclusions and Future work

Although spatial decision-making is, more than ever, a group activity, original GIS methods and tools have been developed for individual use. This situation has recently changed, with spatial decision-making becoming an important aspect of GIS research. Indicating this recent interest is the work done recently in areas like PPGIS and GeoCollaborative crisis management, where despite some technological limitations interesting results were achieved.

With the recent democratization of web mapping and the increasing availability of online mapping tools, the stage is set for the development of productive tools, enabling people to collaboratively work with all these data. The increased access to geographic information by the general public and the potential to reduce existing technological limitations, are motivating factors to improve the current spatial operators that enable spatial decision-making processes, towards facilitating collaborative activities with a geographic reference.

The goal of the work described in this thesis is to define a set of tools, using recent features provided by online mapping technology, which can facilitate collaboration between people involved in a spatial decision-making process, specifically one that involves the participation of the public.

The approach to the problem was first of all, a conceptual approach. Related work was analyzed and meetings with experts in spatial decision-making and public participation were conducted to gather relevant information. The study of related work consisted on analyzing existing efforts into collaboration and spatial decision-making. The meetings with experts provided important input on how people collaborate in different decision-making processes. By combining the insights provided by bibliography research and by meetings with experts, it was possible to clearly define the contributions of this work.

An activity model for public participation is proposed as a generic spatial decision-making process involving the public. The concepts underlying this contribution are integrated in a model which can be used in different scenarios where the public is involved, in a spatial decision-making with process. The different actors involved in the process, as well as their roles, are explained in detail.

Following the model's definition, a generic system to support decision-making was designed and developed. The system is available on the Internet, to increase its availability. Recent online mapping technologies were used in order to generate an easy to use interface with geographic information. The online mapping technology used to represent geographic information was the Google Maps API. The usage of this online mapping technology shows promise, since from the answers provided on user questionnaires it was the most used digital maps application by the different testers. Due to the fact that the target users are multifaceted, with different knowledge and backgrounds, the goal was to implement an easy to use system, allowing the representation of different scenarios in a spatial decision-making process.

Usability tests were conducted to evaluate if the designed tools could successfully support a spatial decision-making process and if they were easy to use. The test consisted on users, representing the different actors, performing different tasks. Meanwhile, the results of their interaction with the system were being registered for further analysis. At the end of the tests, participants were encouraged to give suggestions and commentaries on how to improve the system.

Three different tests were organized. The goal was to test the different roles of the model with their respective target users. A test for the moderator role, and two participants' tests, one realized with experts and the other with non-experts, were conducted.

The results of the moderator tests were quite satisfactory, with the users being successful in accomplishing most of the required tasks, without needing help. The moderator usability test was conducted with the CIVITAS staff, people who usually serve as moderators for public participation processes. A question was made to the participants, on the potential of this application to support spatial decision-making with public participation, and the general opinion was that this new approach can improve current processes.

Since the application is going to be used by the general public, a usability test was realized with users with different levels of expertise. Once again, users were successful in completing the majority of the tasks, without any help. The participants found the system easy to use and felt that they could use this application to participate in a spatial decision-making process.

The final tests involved members of the Town Council of Oeiras. They provided an expert view over the spatial collaboration, possible in the application. The participants were able to perform nearly all the tasks without any assistance. The users found the system easy to use, and considered it had potential for them to express their opinions, in a spatial decision-making process.

The users suggested, as an improvement to the application, a more extensive help feature. They also showed concerns on how users could receive information on the impact of their contribution to the discussion.

Overall, the results from the tests were encouraging, as to the potential of the model to support spatial decision-making processes, where the public is involved. The application's ability to provide easy to use and simple features to participate in a geo-referenced discussion was also praised.

A logic next step is to implement some of the features suggested by the users in the usability tests. A priority will be the development of an introductory help to the system, a kind of "guided tour" of the different features. This feature was planned since the start, although, due to lack of time, it was not possible to implement it. The goal is to develop it before this dissertation's Viva.

After performing usability tests, the next level will be to use the system as a parallel medium to a public participation meeting, organized by a local government in public participation processes. As mentioned in Chapter 6, the goal is to implement the system in an Agenda 21 Local process.

In order to provide a system that is secure to ill-intentioned users, some system vulnerabilities have to be addressed. An example is the technique called "SQL injection", where the security of the database can be compromised.

Another possibility for future developments is the extensions of both the model and the application to support collaborative synchronous tools, enabling users to participate in online meetings with a common geographic interest.

References

- Armstrong, M. P. (1994). Requirements for the development of GIS-based group decision-support systems. *Journal of the American Society for Information Science*. Vol. 45 , 668-677.
- Brewer, I., MacEachren, A. M., Hadi, A., Gundrum, J., & Otto, G. (2000). Collaborative Geographic Visualization: Enabling Shared Understanding of Environmental Processes. *Proceedings of the IEEE Symposium on Information Visualization 2000* (pp. 137-141). Salt Lake City, UT, USA: IEEE Computer Society.
- Cai, G. (2005). Extending Distributed GIS to support Geo-Collaborative Crisis Management. *Geographic Information Science. Special issue on distributed GIS11(1)* , 4-14.
- Cai, G., MacEachren, A. M., Sharma, R., Brewer, I., Fuhrmann, S., & McNeese, M. (2005). Enabling GeoCollaborative crisis management through advanced geoinformation technologies. *Proceedings of the 2005 national conference on Digital government research* (pp. 227-288). Atlanta,Georgia: Digital Government Society of North America.
- Carver, S. (2001). Participation and Geographical Information: a position paper. *ESF-NSF Workshop on Access to Geographic Information and Participatory Approaches Using Geographic Information*. Vol.4 , 6-8.
- Carver, S., Evans, A., & Kingston, A. (2001). Public participation, GIS, and cyberdemocracy: evaluating on-line spatial decision support systems. *Environment and Planning B: Planning and Design*. Vol. 28, Issue 6 , 907-921.
- Chow, E. (2008). The Potential of Maps APIs for Internet GIS applications. *Transactions in GIS*. Vol.12, Issue 2 , 179–191.

- Densham, P. J., Armstrong, M. P., & Kemp, K. K. (1995). *NCGIA Initiative 17 on Collaborative Spatial Decision-Making*. Retrieved 2 17, 2009, from System Design Methodologies To Support Collaborative Spatial Decision-Making : <http://ncgia.ucsb.edu/research/i17/htmlpapers/golay/Golay.html>
- Desanctis, G. a. (1987). A foundation for the study of group decision support systems. *Manage science*. Vol.33, Issue 5 , 589-609.
- Dix, A., Finlay, J., Abowd, G. D., & Beale, R. (2004). *Human-Computer Interaction*. Essex, England: Pearson - Prentice Hall.
- Dragicevic, S., & Balram, S. (2004). A Web GIS collaborative framework to structure and manage distributed planning processes. *Journal of Geographic Systems*. Vol.6, Issue 2 , 133-153.
- Ellis, A. C., Gibbs, S. J., & Rein, G. (1991). Groupware: some issues and experiences. *Communications of the ACM*. Vol.34 , Issue 1 , 39-58.
- Fjermestad, J., & Hiltz, S. R. (1999). An assessment of group support systems research: results. *Proceedings of the Thirty-Second Annual Hawaii International Conference on System Sciences-Volume 1 - Volume 1* (p. 1021). Hawaii: IEEE Computer Society .
- Garret, J. J. (2005, February 18). *Ajax: A New Approach to Web Applications*. Retrieved 2 20, 2009, from Adaptive Path: <http://www.adaptivepath.com/ideas/essays/archives/000385.php>
- GoodChild, M. F. (1998). The Geolibrary. *Innovations in GIS 5: Selected Papers from the Fifth National Conference on GIS Research UK (GISRUK)* (pp. 59-68). London: Taylor and Francis.
- Grudin, J. (1994). Computer-supported cooperative work: history and focus. *Computer*. Vol. 27, Issue 5 , 19-26.
- Haklay, M., & Tobón, C. (2003). Usability evaluation and PPGIS: towards a user-centered design approach. *Geographic Information Science*. Vol.17, Issue 6 , 577-592.

- Hopfer, S., & Maceachren, A. M. (2007). Leveraging the potential of geospatial annotations for collaboration: a communication theory perspective. *International Journal of Geographic Information Science*. Vol 21, Issue 8 , 921-934.
- Jankowski, P., Nyerges, T. L., Smith, A., Moore, T. J., & Horvath, E. (1997). Spatial group choice: a SDSS tool for collaborative spatial decisionmaking. *International Journal of Geographical Information Science*. Vol. 11, Issue 6 , 577-602.
- Keßler, C. (2004). *Design and Implementation of Argumentation Maps*. Münster, Germany: Institute for Geoinformatics, Westfälische Wilhelms-Universität Münster.
- King, F. S., & Brown, P. (2007). Fix my street or else: using the internet to voice local public service concerns. *Proceedings of the 1st international conference on Theory and practice of electronic governance* (pp. 72-80). Macao, China: ACM.
- Kingston, R. (2007). Public Participation in Local Policy Decision-making: The Role of Web-based Mapping. *The Cartographic Journal*. Vol. 44, Issue 2 , 138-144.
- Kingston, R., Carver, S., Evans, A., & Turton, I. (1999, April). *A GIS for the public: enhancing participation in local decision making*. Retrieved 2 19, 2009, from PPGIS - GISRUK '99: <http://www.geog.leeds.ac.uk/papers/99-7/>
- Longley, P., Goodchild, M., Maguire, D., & Rhind, D. (2005). *Geographic Information Systems and Science*. Chichester, New York: Wiley.
- MacEachren, A. M., & Brewer, I. (2004). Developing a conceptual framework for visually-enabled geocollaboration. *International Journal of Geographical Information Science*. Vol.18, Issue 1 , 1-34.
- MacEachren, M. A. (2001). Cartography and GIS: extending collaborative tools to support virtual teams. *Progress in Human Geography*. Vol.25, Issue 3 , 431-444.
- MacEachren, M. A. (2000). Cartography and GIS: facilitating collaboration. *Progress in Human Geography*. Vol.24, Issue 3 , 445-456.
- Muntz, R. R., Barclay, T., Dozier, J., Faloutsos, C., Maceachren, A. M., Martin, J. L., et al. (2003). *IT Roadmap to Geospatial Future, report of the Commitee on Intersections Between Geospatial Information and Information Technology*. Washington DC: National Academy of Sciences Press.

- Nunamaker, J. A. (1991). Electronic meeting systems to support group work. *Communications of the ACM. Vol.34, Issue 7* , 40-61.
- Nuojua, J., & Kuuti, K. (2008). Communication based web mapping: a new approach for acquisition of local knowledge for urban planning. *Proceedings of the 12th international conference on Entertainment and media in the ubiquitous era* (pp. 136-140). Tampere,Finland: ACM.
- O'Reilly, T. (2007). What Is Web 2.0: Design Patterns and Business Models for the Next Generation of Software. *Communications and Strategies. Vol.65* , 17-38.
- Park, S., Lee, J., Choi, Y., & Nam, J. Y. (2008). To improve a public participation decision support system based on web 2.0 technology. *Proceedings of the Twenty-Eighth Annual ESRI User Conference*. San Diego, California: ESRI.
- Rama, J., & Bishop, J. (2006). A survey and comparison of CSCW groupware applications. *Proceedings of the 2006 annual research conference of the South African institute of computer scientists and information technologists on IT research in developing countries* (pp. 198-205). Somerset West, South Africa: South African Institute for Computer Scientists and Information Technologists.
- Rinner, C. (2006). Argumentation mapping in collaborative spatial decision making. In S. Dragicevic, & S. Balram, *Collaborative GIS* (pp. 85-102). Hershey,PA: Idea Group Publishing.
- Voss, A., Denishovich, I., Gatalsky, P., Gavouchidis, K., Klotz, A., Roeder, S., et al. (2004). Evolution of a participatory GIS. *Computers, Environment and Urban Systems. Vol 28, Issue 6* , 635-651.
- Warren, D., & Bonaguro, J. (2003). Usability Testing of Community Data and Mapping Systems. *2nd Annual URISA 2003 Public Participation GIS (PPGIS) Conference*. Portland, Oregon, USA: <http://www.gnocdc.org/usability/usabilitytesting.html>.
- Worboys, M., & Duckham, M. (2004). *GIS: A Computing Perspective, Second Edition*. Boca Raton, FL, USA: CRC Press, Inc.

Appendix

Appendix A – Moderator Usability Test

A.1. Introductory Questionnaire

1. Sexo: M ☐ F ☐
2. Idade: 18-24 ☐ 25-34 ☐ 35-45 ☐ >45 ☐
3. Nível de ensino: Básico – 1o ciclo ☐ Básico – 2o ciclo ☐
Básico – 3o ciclo ☐ Secundário ☐ Superior ☐
4. Profissão _____
5. Já alguma vez consultou informação num mapa na Internet? Sim Não
a. Se sim quais _____
6. Usa regularmente computadores ? Sim Não
7. Já utilizou programas para colaborar com outras pessoas através da Internet? Sim Não
Se sim quais _____

A.2. Briefing

O objectivo deste teste é a configuração de uma aplicação que permita criar e gerir um processo de participação pública com componente espacial através de uma página Web. Um processo de participação pública é um procedimento que assegura a intervenção dos cidadãos interessados no processo de decisão, através de consulta pública (recolha de opiniões e sugestões). Este sistema procura complementar os processos de participação pública existentes, oferecendo ao utilizador meios de participar que antes não estavam ao seu alcance. Nomeadamente, o facto de a grande maioria da interacção que o utilizador

tem com a aplicação ser através de um mapa e ainda a liberdade de participar quando e onde quiser na tomada de decisão.

A sua tarefa como moderador do processo passará por definir o domínio territorial onde decorrerá o processo de participação pública (e.g. um concelho, um município, uma cidade, etc.), definir os dados do sistema (nome, contactos para ajuda, etc.), adicionar notícias e votações, escolher as ferramentas que melhor se adequam ao processo participativo que vai decorrer e poderá ainda exportar informação para consultar noutros programas.

A.3. Proposed Tasks

Tarefa 1

A primeira tarefa consiste em entrar na zona de administração (fazer login). Com o nome de utilizador: admin e a palavra-chave: 123456.

Tarefa 2

Defina agora os dados que estarão associados ao processo. Isto permitirá dar o nome ao site, e definir as palavras-chave do site. Vá à funcionalidade “Gerir Info Sistema” e mude o nome do sítio para “Agenda 21 Local Oeiras”, as palavras-chave para Agenda 21 Local, participação pública, desenvolvimento sustentável e escreva uma pequena descrição (não é necessário alterar o resto dos campos). Guarde as alterações

Tarefa 3

Agora defina a área em que o processo de participação pública decorrerá, também denominada como domínio territorial. A área definida para este processo é o concelho de Oeiras. Para realizar esta tarefa use a funcionalidade “Definir domínio territorial”.

Tarefa 4

Define as funcionalidades que vão estar á disponibilidade do utilizador na funcionalidade “Gerir ferramentas”. Escolha as que acha que mais se adequam a um processo de participação pública em que os utilizadores, sem serem especialistas, possam exprimir a sua opinião e definir os seus interesses (espaciais).

Tarefa 5

Defina as seguintes categorias/tópicos para os quais os utilizadores poderão associar as suas opiniões (Não é preciso definir o icon).

- Requalificação da orla costeira
- Outros

Tarefa 6

Insira uma notícia associada a uma das categorias que criou. Esta notícia terá de ter a seguinte informação:

- **Título:** Praia Velha de Paço de Arcos requalificada
- **Descrição:** A criação de uma praça e a construção de um edifício de apoio à actividade piscatória são algumas das novidades daquele espaço público, agora à disposição tanto dos pescadores como do público em geral.
- **Link:** <http://www.cm-oeiras.pt/default.aspx?Conteudo=Conteudo/Conteudo.ascx&idObj=34864&idCls=25>
- **Imagem:** http://www.cm-oeiras.pt/Ciberstore_backoffice/output_efile.aspx?sid=3e65dac9-248d-45c8-9c20-b66b8f85cf47&cntx=71xvrpy%2FyLWDhtUkYVS6X%2BpcxK1FxALoBUnHzzV1yBZy0lUZ0qJCL8yzd%2BVKIbl6f%2Bw%2F9OkMC%2F15sHAq%2BLfW7w%3D%3D&idf=17282
- **Categoria:** Associe à categoria correspondente.
- Carregue em Paço de Arcos no Mapa
- Guarde a Notícia

Tarefa 7

Insira uma nova votação. Para definir a votação tem de definir a pergunta e as 4 respostas possíveis. Para que seja possível que as respostas estejam representadas num mapa e possibilitem comentários tem de associar um tópico a cada uma delas.

Pergunta: Na sua opinião qual seria a próxima praia do concelho de Oeiras que deveria ser requalificada?

- De seguida estão as 4 respostas. Os tópicos correspondentes estão com o mesmo nome na lista:
  - Praia da Torre
  - Praia de Carcavelos
  - Praia de Santo Amaro de Oeiras
  - Nenhuma destas

Tarefa 8

Exporte todas as opiniões que foram feitas por indivíduos entre os 20 e 30 anos de idade, em que os temas das suas opiniões foram na área de Espaços Verdes e que estejam englobados dentro de uma área que englobe a grande maioria do concelho de Oeiras.

A.4. Final Questionnaire

1. É simples usar esta aplicação

Discordo Totalmente				Concordo Totalmente
1	2	3	4	5

2. É simples aprender a utilizar esta aplicação

Discordo Totalmente				Concordo Totalmente
1	2	3	4	5

3. Esta aplicação poderá ser um complemento importante para os processos de participação pública

Discordo Totalmente				Concordo Totalmente
1	2	3	4	5

4. O que gostou mais no sistema?
5. O que gostou menos no sistema?
6. Houve alguma funcionalidade que não percebeu a sua utilidade? Qual?
7. O que acha que faz mais falta a este sistema que ainda não esteja presente?
8. Alguns comentários ou notas finais?

Appendix B – Public Usability Test

B.1. Introductory Questionnaire

1. Sexo: M ☐ F ☐
2. Idade: 18-24 ☐ 25-34 ☐ 35-45 ☐ >45 ☐

3. Nível de ensino: Básico – ☐ ciclo Básico ☐ 2º ciclo
 Básico – 3º ciclo ☐ Secundário ☐ Superior
4. Profissão _____
5. Já alguma vez ouviu falar de processos de participação pública? ☐ ☐m
 Não
6. Já alguma vez consultou informação num mapa na Internet? ☐m ☐ão
7. Se sim quais _____
8. É um utilizador regular de computadores? ☐im ☐ão
9. Já utilizou programas para colaborar com outras pessoas através da Internet? ☐
☐ Sim Não
10. Se sim quais _____

B.2. Briefing

O objectivo deste teste é participar num processo de participação pública, utilizando um sistema informático desenvolvido para apoiar este método. Um processo de participação pública consiste em envolver o público na tomada de decisão através da recolha de opiniões e sugestões. Este sistema procura complementar os processos de participação pública existentes, retirando ao utilizador a obrigatoriedade temporal e física de comparecer numa reunião para poder participar na tomada de decisão.

Como em todos os processos de participação pública será dada a oportunidade ao público de manifestar a sua opinião, com a diferença que, com este sistema, ela será submetida através de um mapa na Internet. Os utilizadores escolherão, no mapa, a zona sobre a qual incidirá a opinião manifestada e poderão discutir entre si as várias opiniões submetidas.

Você poderá submeter a sua opinião e associada a um local e esta poderá ter informação associada como uma descrição e uma imagem. Estará também encarregue de definir uma área de interesse num mapa. Esta área será definida através da construção de um polígono, e representará a zona sobre a qual você estará mais interessado em participar. Sempre que outro utilizador emita uma opinião nessa área previamente definida, você será avisado para, se assim o desejar, poder participar nas discussões mais relevantes para si. Toda a informação que adicionar ao mapa estará sempre restrita à área que o moderador definiu para o processo de participação pública (e.g. um concelho, um município, uma cidade, etc.).

B.3. Proposed Tasks

Tarefa 1

A primeira tarefa consiste em se registar no website.

Tarefa 2

Começando a sua participação: a sua primeira tarefa, agora que está registado, é submeter uma opinião. Submeta uma opinião na biblioteca municipal de Oeiras. Para encontrar a biblioteca de Oeiras pode ir através do mapa ou inserindo a morada (Av. Dr. Francisco Sá Carneiro, Oeiras, Portugal), assinale a biblioteca com umas das 3 hipóteses disponibilizadas (ponto, polígono e recta). Depois preencha os campos abaixo dando um título uma breve descrição e uma imagem (pode adicionar a seguinte imagem <http://image.wetpaint.com/wiki/bibliotecas/image/1bnypcM8zz3IpLL9vfevNOw==69822/GW450H266>) à sua opinião e associe esta a um dos temas disponíveis. Os campos não referidos não são necessários de preencher.

Tarefa 3

Defina a sua área de interesse. Defina-a como uma área que englobe a biblioteca municipal de Oeiras. A Morada da biblioteca é Av. Dr. Francisco Sá Carneiro, Oeiras, Portugal.

Tarefa 4

Procure por opiniões de outros utilizadores na sua área de interesse. Comente uma destas opiniões.

Tarefa 5 (Only in non-expert usability tests)

Leia uma notícia que pertença à categoria planeamento urbanístico e comente-a.

Tarefa 6

Participe numa votação consultando a opção em que for votar, em pormenor.

B.4. Final Questionnaire

1. É simples usar esta aplicação

Discordo totalmente				Concordo totalmente
1	2	3	4	5

2. Usaria um sistema como este para transmitir a sua opinião?

Nunca				Sempre
1	2	3	4	5

3. É simples aprender a utilizar esta aplicação

Discordo totalmente				Concordo totalmente
1	2	3	4	5

4. O que gostou mais no sistema?

5. O que gostou menos no sistema?

6. Houve alguma funcionalidade que não percebeu a sua utilidade? Qual?

7. O que acha que faz mais falta a este sistema que ainda não esteja presente?

8. Alguns comentários ou notas finais?