

# Masters Program in **Geospatial Technologies**



***Geospatial technologies for public participation:  
Better decisions for smarter cities?***

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for the Degree of *Master of Science in Geospatial Technologies*

**Geospatial technologies for public participation:**

**Better decisions for smarter cities?**

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# **Geospatial technologies for public participation: Better decisions for smarter cities?**

## **ABSTRACT**

In recent years society has undergone a process of modernization and with it, there has been increased citizen participation in decision-making and public policy development. This is due to, in part, the use of Information and Communication Technology (ICT) together with Geographic Information Systems (GIS) in the development of channels of participation. This rapprochement between citizens and institutions through technology, has encouraged the development and evolution of the smart city concept in a broad sense and smart campus, applied to the university context, as test area.

The goal of this thesis is study the relation between the three components of a smart city (human, institution, technology) through the introduction of an improvement in the technology component that allows interrelate the human and institutional component in a closer way, and analyze its potential impact on them. To this end, public participation has been enabled at the Universitat Jaume I (UJI) by implementing a Web mapping application that, on the one hand allows users to report campus incidents (illegally parked vehicles, accumulation of garbage, etc.) in a more accessible way to the administrative institution of the campus, and on the other hand allows to this institution to receive the incidents in a structured and organized visually way, useful for decision-making regarding the management of campus resources.

## **Geospatial technologies for public participation: Better decisions for smarter cities?**

### **ABSTRACT (Spanish)**

Durante los últimos años la sociedad ha sufrido un proceso de modernización y, con ella, se ha producido una mayor participación ciudadana en la toma de decisiones y en la elaboración de políticas públicas. Esto es debido, en parte, al uso de las Tecnologías de la Información y la Comunicación (TIC) junto con los Sistemas de Información Geográfica (SIG) en el desarrollo de canales de participación. Este acercamiento entre la ciudadanía y las instituciones por medio de la tecnología, ha fomentado el desarrollo y evolución del concepto smart city en un sentido amplio y el de smart campus, aplicado al contexto universitario, como área de prueba.

El objetivo de esta tesis es el estudio de la relación entre los tres componentes de una smart city (humano, institución, tecnología) a través de la introducción de una mejora en el componente tecnológico que permita interrelacionar los componentes humano e institucional de una manera más cercana, y analizar su impacto potencial en ellos. Para ello, se ha habilitado la participación pública en la Universitat Jaume I (UJI) mediante la implementación de una Web mapping application que, por una parte permita a los usuarios del campus reportar incidencias (vehículos mal estacionados, acumulación de basura, etc.) de una forma más accesible a la institución administrativa del campus, y por otra parte permita a esta institución recibir las incidencias de una forma estructurada y organizada visualmente, útil para la toma de decisiones en cuanto a la gestión de los recursos del campus.

## **KEYWORDS**

*Crowdsourcing*

*Decision-making*

*Geographical Information Systems*

*Human component*

*Institucional component*

*Public participation*

*Smart city*

*Spatial Decision Support Systems*

*Technological component*

*Volunteered Geographic Information*

*Web mapping application*

## ACRONYMS

- AJAX** – Asynchronous JavaScript and XML
- API** – Application Programming Interface
- CGI** – Common Gateway Interface
- CSS** – Cascading Style Sheets
- CSW** – Catalog Service for the Web
- DSS** – Decision Support Systems
- ESRI** – Environmental Systems Research Institute
- FTP** – File Transfer Protocol
- GEOTEC** – Geospatial Technologies group
- GIS** – Geospatial Information Systems/Science
- GPS** – Global Positioning System
- HTML** – HyperText Markup Language
- HTTP** – Hypertext Transfer Protocol
- HTTPS** – Hypertext Transfer Protocol Secure
- ICF** – Intelligent Community Forum
- ICT** – Information and Communication Technology
- IIS** – Internet Information Services
- INIT** – Institute of New Imaging Technologies
- ISO/TC 24** – International Organization for Standardization the International Technical Committee 24
- IT** – Information Technology
- JSON** – JavaScript Object Notation
- ODC** – Open Data Cities
- OECD** – Organization for Economic Co-operation and Development
- OGC** – Open Geospatial Consortium
- OpenLS** – OpenGIS Location Services
- OTOP** – Oficina Técnica de Obras y Proyectos (Technical Office of Works and Projects)
- PARC** – Palo Alto Research Center
- PAS** – Personal de Administración y Servicios (Management and Services Staff)

**PDI** – Personal Docente y de Investigación (Teaching and Research Staff)  
**PGIS** – Participatory GIS  
**PPGIS** – Public Participation GIS  
**QR** – Quick Response  
**RDBMS** – Relational Database Management System  
**SaaS** – Software as a Service  
**SDSS** – Spatial Decision Support Systems  
**SHM** – Sanitary Hot Water  
**SMTP** – Simple Mail Transfer Protocol  
**SWE** – Sensor Web Enablement  
**UJI** – Universitat Jaume I (Jaume I University)  
**URL** – Uniform Resource Locator  
**XML** – Extensible Markup Language  
**VGI** – Volunteered Geographic Information  
**W3C** – World Wide Web Consortium  
**WCS** – Web Coverage Service  
**WFS** – Web Feature Services  
**WMS** – Web Map Service  
**WPS** – Web Processing Service  
**WWW** – World Wide Web



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# 1. INTRODUCTION

## 1.1. Theoretical framework

A smart city is composed of three linked core factors: people (creativity, diversity, and education), institution (governance, policy and administration), and technology (hardware and software infrastructures) (Nam, T. & Pardo, T. A., 2011). Given this connection (Fig. 1), a city is smart when by means of participatory governance, investments in human capital and IT infrastructure encourage sustainable growth and improves the quality of life (Caragliu, A., Del Bo, C. & Nijkamp, P., 2009).

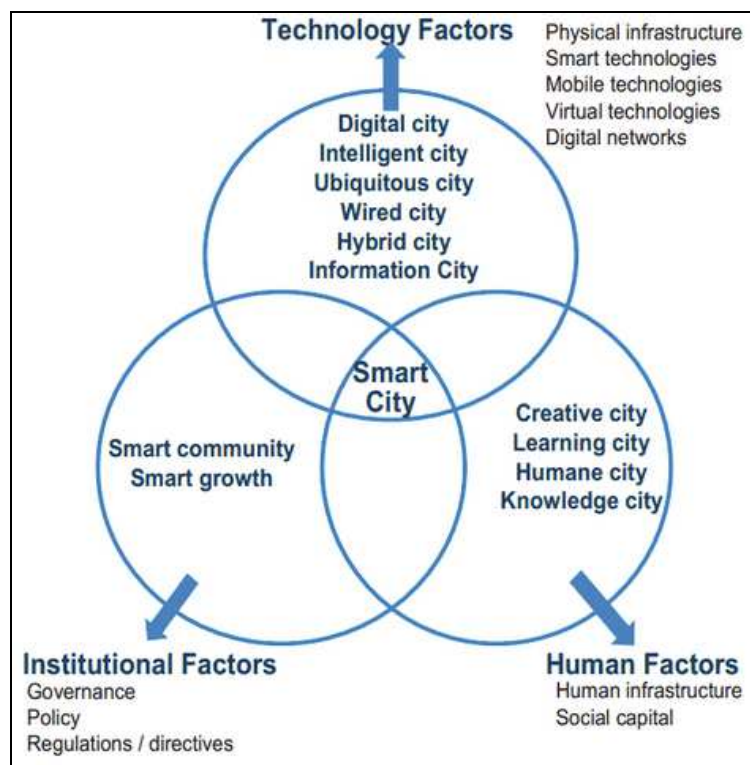


Figure 1. Fundamental Components of Smart Cities (Nam, T. & Pardo, T. A., 2011)

Next, each of the three components of a smart city and certain closely related concepts are described. Should be noted that these three dimensions are not independent of each other, but there is a relationship between them, so that they can take advantage of the synergy.

### **1.1.1. Human component**

According to Nam, T. & Pardo, T. A. (2011), the human component refers to elements related to people living in a smart city such as affinity to lifelong, learning, social and ethnic plurality/urban diversity, flexibility, creativity, cosmopolitanism, open-mindedness, and participation in public life. Moreover, the authors introduce two concepts related, learning/knowledge city and creative city. The first one implies focusing on the creation of a skilled workforce in order to improve urban competitiveness in a context where knowledge is the basis of the economy, and the second concept, creative city, is based on creating a suitable climate for the creative class due to creativity is considered the most important element for smart cities by influencing human infrastructure.

Winters, J. V. (2008) exposes that businesses, organizations, and individuals are attracted to environments with these items, so a smart city is a center of higher education and smart workforce. In this regard, the author introduces the concept of humane city, which refers to the possibility of exploiting human creativity and potential in a smart city, where the workforce and qualified industry migrate to smart places that act as a magnet for creative people and workers, making these places are getting more attractive and smarter, while others increasingly less

Apart from the characteristics of this component and focusing on the role played by citizens in it, technological developments have led to a change in the role of the users with respect to the information, from being mere consumers of content on the Web 1.0, to become users generators of content on the Web 2.0, this being a more participatory process and usually with a geospatial component (Rinner, C., Keßler, C. & Andrulis, S., 2008).

### **1.1.2. Institutional component**

The institutional component is in charge of designing and implementing policies to promote a smart city as well as creating a suitable environment for its development).

A key feature of this environment is a transparent governance, integrated and accountable, which is achieved, among other reasons, strengthening relations between citizens and institutions in the sense of participation and information of citizens in developing policies that affect them (OECD, 2001).

This component interconnects dynamically with citizens, communities, and businesses in real time to promote growth, innovation, and progress, through the integration of services and enabling communication through the use of the Web (Nam, T. & Pardo, T. A., 2011). In this sense, the concept of e-governance appears, which refers to the use of electronic means to communicate with the public in an interactive and bidirectional way (Marche, S. & McNiven, J. D., 2003).

Although there are different ways to define the role that institutions play in the creation and development of smart cities, most authors agree that it is necessary and essential to consider the citizens and to involve them actively. In summary, the key to a smarter government is playing a broad management truly citizen-centric (Nam, T. & Pardo, T. A., 2011).

Given the importance of participation for institutions, a major existing tools that have been developed in recent years, are interactive applications between the administration and citizens, which enable the participation of citizens in certain parts of the management of cities. Thus, the institutions get implement a joint management and thereby provide better service.

Under this component, two concepts focused on form of governance can be highlighted. Smart community, according to the California Institute for Smart Communities (2001), is "a community in which government, business, and residents understand the potential of information technology, and make a conscious decision to use that technology to transform life and work in their region in significant and positive ways". This concept encourage information technology as an engine to solve the social and business needs and as mean to achieve a city significant evolution in terms of economy and society (Eger, J. M., 2000). The second one is smart growth,



emerged as a reaction of the community and the government to the worsening of certain social conditions. This concept includes mainly the urban growth as an alternative to territorial expansion and it is closely related to the above concept, in the sense that the smart growth is the main objective for the creation and planning of a smart community (Freilich, R., 2000).

### **1.1.3. Technological component**

The technology component is an important part to consider a smart city as such, because of the use of ICT transforms life and work within a city in a significant and fundamental form, and performs the connecting link function between the other components, allowing communication between them (Hollands, R. G., 2008). However, the existence of the technological component is not enough, but it is also necessary the existence of institutions and individuals who intend and desire to progress in it.

This component is primarily concerned with the technological infrastructure available, the technology that prioritizes its accessibility and availability in everyday urban life (Giffinger, R., Fertner, C., Kramar, H. & Meijers, E., 2007). Among other things are included network equipments, public access points, and service-oriented information systems, control systems, and database resources.

Having technology, as explain Fu, P. & Sun, J. (2010), makes possible the further development of new technologies, as has been the case of Web 2.0, that with its features has enabled Geographical Information Systems (GIS) and Spatial Decision Support Systems to use Web technology (Web GIS and Web SDSS).

Washburn, D. & Sindhu, U. (2010) define a smart city as the use of smart computing technologies for make critical infrastructure components and services more intelligent, interconnected, and efficient. The same authors define smart computing as “a new generation of integrated hardware, software, and network technologies that provide IT systems with real-time awareness of the real world and

advanced analytics to help people make more intelligent decisions about alternatives and actions that will optimize business processes and business balance sheet results”.

Lastly, Nam, T. & Pardo, T. A. (2011) explain some concepts close to smart city, especially as regards the technological component. Digital city means a city connected through broadband communication infrastructures to satisfy the needs of its members. More focused on information and communication is the intelligent city which offers the latest technology in telecommunications, electronics and mechanics, and offers all the infrastructure and infostructure of the information technology. With a virtual element two concepts are developed, virtual city, whose functionality is implemented in the virtual space known as cyberspace and hybrid city that combines real entities and residents with a parallel virtual city. Finally, with a more general meaning, ubiquitous city, which aims to create an environment where any member can get any service anywhere and anytime through any device.

## ***1.2. Context***

From smart city concept, increasingly initiatives are emerging to integrate ICT in the resources management of cities with the aim of providing new and better services and achieve economic and social development.

University campuses, where many people live daily and which are provided with infrastructure and services, can be compared to small cities and therefore can be considered a testbed for smart cities (Klein, C. & Kaefer, G., 2008).

In the Jaume I University (UJI, in its Catalan acronym) in Castellón (Spain), the Geospatial Technologies research group (GEOTEC), composed of members of the geographic information section of the Institute of New Imaging Technologies (INIT), is working on a project called SmartUJI<sup>1</sup> which aims to improve the monitoring and management of campus resources, integrating in a single application all the relevant information concerning to UJI.

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<sup>1</sup> <http://smart.uji.es/>

The SmartUJI application is a Web based viewer maps, that uses Environmental Systems Research Institute (ESRI) technology and incorporates features such as the location of points of interest (view on the map of the different services offered, parking areas, waste containers, buildings, restaurants and shops, etc.) and information query, as well as get the path to follow between two points on campus. This application uses a homogeneous and unified database, and integrates it with a geodatabase, so the information is current and consistent (Benedito-Bordinau, M. et al., 2013).

Furthermore, in the UJI, there is a department called Technical Office of Works and Projects (OTOP, in its Spanish acronym) which is responsible for coordinating and managing new constructions, maintenance and energy management of buildings and campus outdoor, assigning logical locations through codes to physical locations, and addressing the users services requests. The thesis falls into the services and procedures provided by this department.

### ***1.3. Problem statement***

OTOP informs about the low participation of campus users in reporting incidents, and its attempt to counter this low participation by simplifying the reporting mechanism. This simplification, which has affected the spatial component of incidents, has led to a loss of useful information on incidents in which locations is not well defined (where it is not possible to assign a logical location), because location must be described when people report.

With this, it becomes clear the case in which a member of the university (student, teacher and others users) wants to report an incident, such as when the car of an able-bodied person has been parked on a disabled parking, but the process sometimes is unknown, long, tedious and not always is easy to report to the OTOP where they occur, so they are not reporting. As consequence of this "not report", it

may be that people behavior is not right, increasing passivity, indifference and the number of incidents.

Moreover, this has consequences for the institution, such as a waste of resources at its disposal, as well as inefficiency in its operation. The institution is forced to decision-making with a lot of misinformation about it, for example, it must plan recognition rounds in the area looking for incidents whose implementation is carried out by maintenance workers.

So then, in the UJI there are certain difficulties or obstacles related with the human component, in principle, outside the organization control, that hinder active participation of users in certain situations. Some of these factors include ignorance or time to invest in participation. These have negative consequences for the organization that brings to think weaknesses of this community.

#### ***1.4. Motivation***

The XXI Century has been called the century of cities, in fact, according to the World Bank (n.d.), more than 90 per cent of population growth in developing countries takes place in cities. Furthermore, according to the Global Report on Human Settlements published by the United Nations (2009), says that more than half of the world's population lives in cities and by 2050 this quantity will have risen to 70 per cent. In part, this is motivated by the search for a better quality of life, influential factor in the location decisions of business activities (particularly high value added). Thus, there has been a notable increase in the rivalry between cities in attracting residents and businesses, using quality of life as a crucial factor in urban marketing (Rogerson, R. J., 1999).

Annually, since 2006, the Intelligent Community Forum (ICF) selects 21 cities in the world (The Smart 21) based on five indicators as "smarter" cities (ICF, 2011): knowledge, innovation, marketing and advocacy, digital inclusion, and

broadband. Since that year, only has been selected in 2012 a Spanish city, Barcelona, at the tail of countries like France or England.

Key indicators used by the ICF are related to the three components of a smart city, belonging knowledge and innovation to the human component, marketing and advocacy to the institutional component, and broadband and digital inclusion to the technological component. From this, can be deduced that the future of cities goes through to become smart cities.

According to Pelton, J. N. & Singh, I. (2009) the fundamental component of cities, whether or not smart cities, is the human component and therefore, the future of cities goes through fostering the development of its three components, but with emphasis on citizens, according to Geraci, J. (2009), asking them about the supply of services, how to make them better, more efficient and how to make them work at a much lower cost than the current, i.e., making cities open innovation, crowdsourced and participatory.

Inevitably the structure and organization of cities will change, regardless of the speed with which it does and powered largely by the citizens themselves. Undoubtedly there will be a lot of new applications that provide citizens and institutions all sorts of information and full accessibility to it, in a way that decisions will be made from a better position (Geraci, J., 2009).

### ***1.5. Objectives***

To address the posed problem in this thesis, an improvement in the technological component was proposed jointly with OTOP. The choice of component to change has been largely determined by current trends and the context, as in the university prevails using technology as a means of communication between the institution and users and, given the perspective of the problem, is the most suitable for the introduction of changes.

This technological improvement consists of an accessible and easy incident report system for users, and a tool able to collect data accurately, emphasizing its spatial component, for the administration. That is, a tool that provides information precisely about what is happening and where.

For the purposes of the study, a preliminary analysis of the UJI context as smart campus (the three components) was proposed to detect other possible latent problems in it (causing, among other things, low participation), and to analyze in what sense the technological improvement has led an improvement in users participation and in potential problems identified. For this purpose, GEOTEC provides all the necessary information and tools to carry out this thesis study.

The aim of the thesis is assessing new technology enabling crowdsourcing as an institutional decision-making support for smarter cities. To achieve it the following individual objectives are proposed:

1. Analyze the current status of the three components of a Smart City in the context of the UJI.
2. Introduction of a technological improvement: Web mapping application enabling crowdsourcing to help decision-making.
3. Analyze the possible effects of technological improvement on the human component of the UJI.
4. Analyze the possible effects of technological improvement on the institutional component of the UJI.
5. Compare decisions making with and without the technological improvement.

## ***1.6. Methodology***

The study begins with a literature review in some depth of aspects related to the thesis, such as the elements discussed in the State of art section.

Secondly, an analysis of the UJI context as a smart city is performed in order to detect possible weaknesses causing low participation. The means for this analysis are a first round of surveys/interview to different groups of users of the university, as well as the own observation. From this information, and as can be seen in chapter 4, other weaknesses are detected that encourage this participation problem.

Third, an analysis, design and implementation of the technological improve (Web mapping application), based on the previous analysis, called UJI Service Request is performed. Although the application is finished, for reasons beyond my control, it was not possible to collect data for analysis. Therefore, three case studies, based on random data, are proposed to demonstrate the functionality of the application and the analysis it allows to do.

Finally, a second round of surveys/interview takes place to the same group of people to assess the effects of this improvement on the three components and to determine to what extent the implementation of these features would solve the initial problem and the problems identified in the previous analysis.

### ***1.7. Thesis Structure***

This thesis is divided into five chapters. The first chapter, Introduction, is an overview of the theoretical framework, context, problem statement, motivation, objectives, and methodology used in the development of the thesis.

The second chapter, State of art, is an overview through some related elements with the three components of a smart city. In the human component, how Web second generation made possible the users as content generators and its contribution to Volunteered Geographic Information (VGI). In the institutional component, the reason for enable the public participation in decision-making, and crowdsourcing as a problem solving model. Finally, in the technological component, it is described the origins of Web GIS and Web Spatial Decision Support Systems (Web SDSS), both used to enable the public participation in decision-making.

The third chapter, UJI Service Request, describes the process followed to develop the application into three stages: analysis, design and implementation.

The fourth chapter, Analysis, describes the previous context analysis, the analysis of study cases to demonstrate the functionality of the application, and a posterior context analysis.

In the fifth and final chapter, Conclusions, based on the information obtained in the analysis, components of a smart city and their relationships are examined. Besides, it is focused on the learnt lessons and on the future work.



## **2. STATE OF ART**

### ***2.1. Human Component***

The human component requires a specific environment based on learning, knowledge, creativity and human potential. One way to achieve this context is through the public participation. However, active participation does not always go hand in hand with the institution, but there are initiatives outside the institutions that enable participation by developing tools, that are offered to institutions as a link.

These tools for governance, although are related to the three components, with the human component because are used by citizens, with the institutional component because are enabled by the institution and with the technological component because they are a technological development, are clear examples of how people can voluntarily participate and generate content.

#### **2.1.1. Volunteered Geographic Information**

Participatory GIS (PGIS) is a concept emerged in response to a change of orientation of GIS technology to a critical evaluation of its uses in society in the mid-1990s (Harris, T. M., Weiner, D., Warner, T. & Levin, R., 1995). A variant of this term that arises in the same period is Public Participation GIS (PPGIS), which describes the use of GIS and other tools for spatial decision to make them accessible to all those who have an interest in official decisions (Obermeyer, N. J., 1998).

As explained in Rinner, C. et al. (2008), second generation technologies of World Wide Web (WWW) applications, known as Web 2.0, lead to a change in which users not only play the role of content consumers, but are the centerpiece for new services, users become content generators. This user-generated content, usually has an implicit geospatial component in its metadata, enabling content to be displayed on a map. Goodchild M. F. (2007) uses the term Volunteered Geographic

Information in GIS to define the user-generated geospatial content to satisfy the needs of the institutions (government, industry, and other communities).

Nowadays there are four different contexts in which individuals voluntarily contribute spatial information: mapping and navigation, social networks, civic/governmental, and emergency reporting (Coleman, D. J., Georgiadou, Y. & Labonte, J. (2009).

The same authors explain that there are research which state that a significant proportion of the contributions comes from contributors called good Samaritans, and characterize them by: humanity, frequency, type and degree of a contributor's edit operations, quality and veracity of a contributor's operations and the individual's reputation for reliability in terms of past contributions.

Furthermore, these authors consolidating and summarizing the following list of motivators to make constructive contributions: altruism, professional or personal interest, intellectual stimulation, protection or enhancement of a personal investment, social reward, enhanced personal reputation, provides an outlet for creative and independent self-expression, and pride of place.

Coleman, D. J. et al., (2009) explain that in terms of motivation the context does not matter and that cultural theory literature suggests that there are alternative ways of perceiving the reality by humans and this is what does matter: individualism, hierarchism, and egalitarianism. Each of these ways of perceiving reality has its own social relationships, values, motivations, and beliefs about human nature. Relating this to the motivators, individualists believe that other humans are selfish and looking to maximize their benefit, so they value efficiency and independence and are motivated by intellectual stimulation and the protection of personal investments. Hierarchists believe that other humans are malleable, so they value reliability and resilience and are motivated by professionalism. Finally, egalitarians believe that other humans are caring and cooperative, so they value mutuality and reciprocity, and are motivated by social rewards and altruism.

### **2.1.2. VGI for participatory GIS applications**

Applications that incorporate VGI, among which are those that enable citizen participation, take into account the following aspects, according to Coleman, D. J. et al. (2009), being the first three the most related to the human component:

- VGI need not necessarily be new graphical information but desirable.
- Volunteer contributors desire some recognition of their contribution.
- Contributors want to see their contribution used and quickly.
- Assess contributor credibility through spatio-temporal considerations.
- Quality control or filtering the contributions done by many people that have access to inexpensive means of production such as keyboard, mobile camera, Global Positioning System (GPS), etc.

Repara Ciudad (Fig. 2), in Barcelona, is a clear example of this kind of applications. According Turiera, T. & Cros, S. (2013) it is an Open Data Cities (ODC) free platform for display on desktop, tablet, and smartphone devices, that allows citizens the service of report street-related damage incidents to the local authorities anonymously or providing personal information. Its objectives are to promote environmental responsibility of the city between institutions and citizens and create a participatory, transparent and efficient public administration. This service is used by more than 250 municipalities in Spain and it is available in Catalan, Spanish and English.

This application allows to report incidents related to nine categories: cleaning, traffic lights and road signs, vehicles, lighting, street equipment, public roads, trees, furniture pick-up, animals or noise, public transport. Besides, it allows to prioritize incidents through a support system by using votes from other users. The application also has a point system to rank users as more active users and give them priority, in order to encourage participation. Once the incident is reported, an email is sent informing about it to the city hall. Meanwhile, city hall can report the status and resolution of the incident to users.



Figure 2. Reparaciudad application<sup>2</sup>

Similar example is SeeClickFix (Fig. 3), which is a Web application that allows citizens to report non-emergency issues, and governments to track, manage, and reply displaying user comments, videos or pictures (Pleasant, D., 2010). According to Sifry, M. L., (2009) it is used in more than 25,000 cities, but especially in the United States, using anonymity as a way to encourage participation. It aims to facilitate community volunteering.

According to its policy, open and transparent, any user can read and add comments on the map and receive alerts based on geographical areas or keyword filtering by email. There are two states for topics:

- Open: whether next of the topic appears the word "open", indicates that it is active.
- Closed: whether next of the topic appears the word "closed", indicates that there is an unresolved problem.

<sup>2</sup> <http://reparaciudad.com>

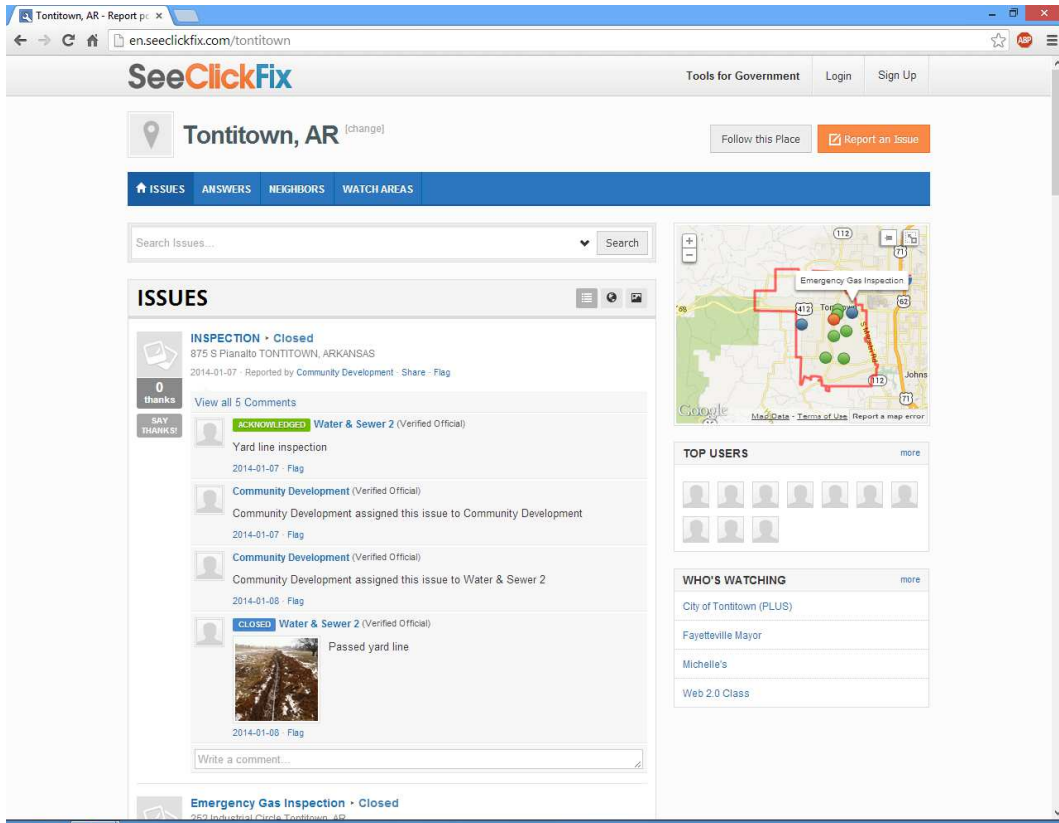


Figure 3. See Click Fix application<sup>3</sup>

In both applications, although users can provide their contact details which facilitates the understanding of the problem (being this confidential information), they may also choose to report anonymously. This presents the problem of incorrect or invalid reports. Both applications allow to exploit the camera and GPS in reporting incidents.

## 2.2. Institutional Component

The goal of institutional component is manage the process of building a better environment. To achieve this, it must incorporate VGI as well as use a model which is able to add the talent of the citizens, and deal with the advantages and

<sup>3</sup> <http://en.seeclickfix.com/>

disadvantages of both. For this, in this section, is included reasons for enable public participation and a brief explanation about VGI and crowdsourcing.

### **2.2.1. Why enable public participation in decision-making?**

According to the report of Organization for Economic Co-operation and Development (OECD) (2001), there are three main reasons why it is necessary and advisable to strengthen the institutions-citizen relations.

The first one is based on the creation of higher quality policies by the administration. This is because by enabling participation, citizens are motivated to spend time and effort on these issues. In turn, the active participation provides a better basis for the development of public policies, allowing it to become a learning organization, and thus ensure more effective implementation of policies to the extent that citizens are familiar with them, to participate in its development.

Second, the deposited confidence of citizens in the institutions increases, since they grant the opportunity for citizens to learn about projects, provide feedback and contribute to the final decision. Because of this, the acceptance of these policies also increased and the image of institutions becomes more reliable before the eyes of citizens.

Last, transparency of public administration increases and become it responsible. And under these conditions, the strengthening of relations between government and citizens encourages active citizenship and promotes their roots in society.

According to this report, active involvement of citizens require resources (time, experience and money), but these resources are well spent if they generate useful effects improving institution-citizen relationship. Taking into account the problems caused by poor development or implementation of public policy, public institutions find that it is worth investing in strengthening its relations with the

public. Therefore, citizen participation is no longer seen as a cost to the detriment of administrative efficiency, but as a necessary cost to achieve efficiency (Ganuza, E., 2004)

Coleman, D. J. et al. (2009), state that institutions wishing to incorporate VGI should consider several considerations. First, institutions should consider the problem or goal to be solved, the reason for using VGI in this context, the VGI extent to be adopted, how to distinguish credible VGI contributors from who are not, the extent which willing to relinquish control over VGI content and quality and who decides that VGI fit with them, and the extent which individuals are interested in making contributions.

Second, if institutions want to harness geospatial data of VGI, they must understand the process and culture of the contributor community, so institutions must accept and respect community rules, consent that community values be above traditional policies and practices (heterarchy), accept that the geographic information provided is not complete, and introduce new rules which take into account the rights of contributors.

And third, the institutions have to consider whether people will participate in the same way as in other places like social networks or industry, how to use VGI provided by producers assessing its risks and benefits, how to assess the credibility and confidence of producers, and how to attract new producers.

### **2.2.2. Crowdsourcing as institutional solution**

Crowdsourcing was coined by Jeff Howe and Mark Robinson in 2006 as a business model, that uses the solutions of the individuals in the open calls via Web, i.e., a online and distributed problem-solving model, in other words, “a company posts a problem online, a vast number of individuals offer solutions to the problem, the winning ideas are awarded some form of a bounty, and the company mass produces the idea for its own gain”, by Brabham, D. C. (2008).

This author describes some successful crowdsourcing examples. First, Threadless.com, a web-based t-shirt company which uses crowdsourcing through contests to the design process of their shirts. Anyone can participate in this process by voting or submitting new designs after registering on the website community. To submit a design, it is necessary to download the company template and follows the company guidelines. The designs are rated on a scale of zero to five, and the winners receive a cash prize, which is a very low price comparing with design services and with the produced high profits.

Second, another similar example is iStockphoto.com, which sells royalty-free stock photography, animations, and video clips. To become a iStockphoto photographer, it is needed to register in the community and submit three photographs to be judged by iStockphoto staff. Once admitted as a photographer, it is possible now send pictures which can be purchased by customers, and will be received between 20 and 40 per cent of sale.

Third, another example is InnoCentive.com, but this is in the field of research and development R&D for scientific problems. The challenges of the applicant companies are published in the InnoCentive community, and the solvers, who do not need to be scientists or professional solvers, can offer solutions and obtain a cash reward. This allows solvers to receive professional recognition and financial reward for solving R&D challenges, while companies harness the talents of a scientific community.

As a final example, Goldcorp, a Canadian gold mining company, launched the challenge 'Goldcorp Challenge' in 2000, in order to the participants submit their proposals for possible targets where large amounts of gold can be found on his property in Ontario, Canada. The large sum of money offered as a prize attracted many participants. Numerous solutions from the crowd confirmed many of the deposits of Goldcorp and identify new ones.



These examples show that the aggregation of individual solutions is very useful for troubleshooting, therefore, institutions should make the most of the people using crowdsourcing through Web technology, which is presented as ideal, since it allows users to not only communicate, but also interact.

Public Information Center (Fig. 4), according to ESRI (2013a), it is a desktop configurable application which allows the institution enable citizens participation to review activities published by the local government, submit requests for service in their community, and review social media feeds to see what is happening in their community.

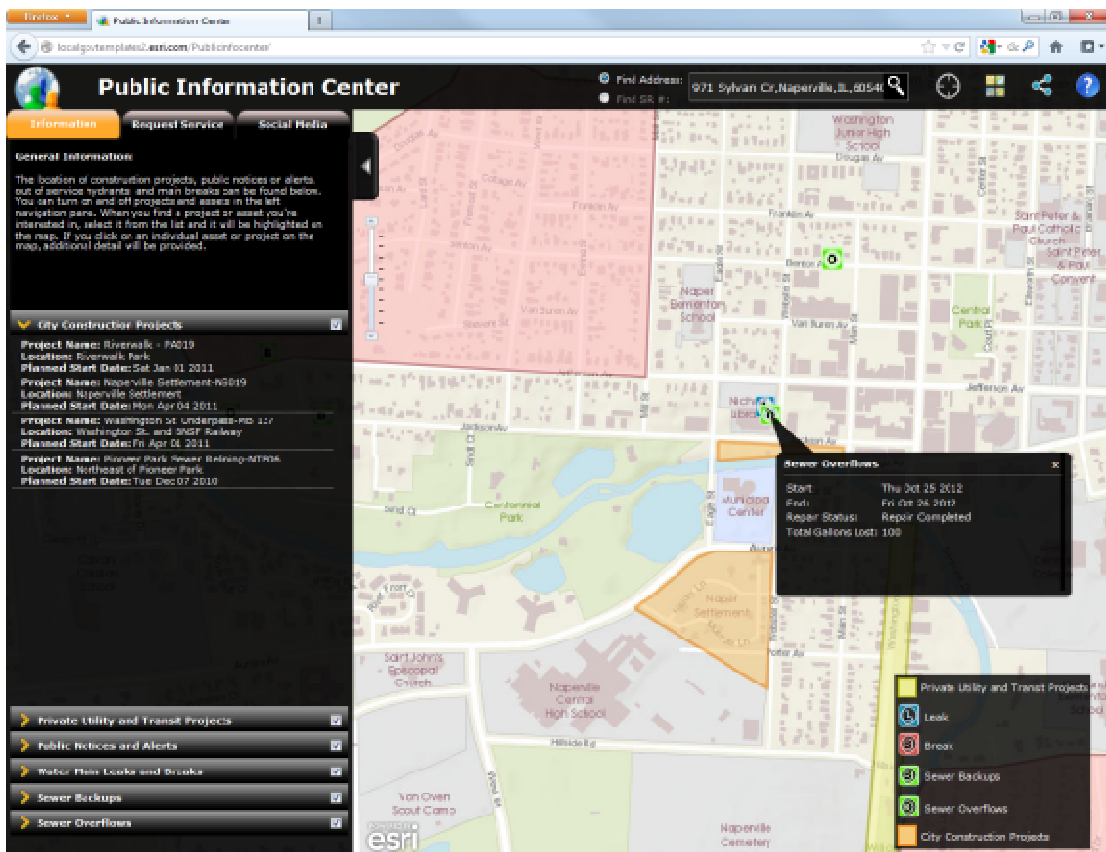


Figure 4. Public Information Center application<sup>4</sup>

Citizen Service Request (Fig. 5), it is another ESRI application similar to the previous one but optimized for display on desktop, tablet, and smartphone devices

<sup>4</sup> <http://www.arcgis.com/home/item.html?id=10ee7568bbf746ebbaa5f6d1219285d8>

(ESRI, 2013b). These two applications are examples that institutions could implement which are related to the problem addressed in this thesis.

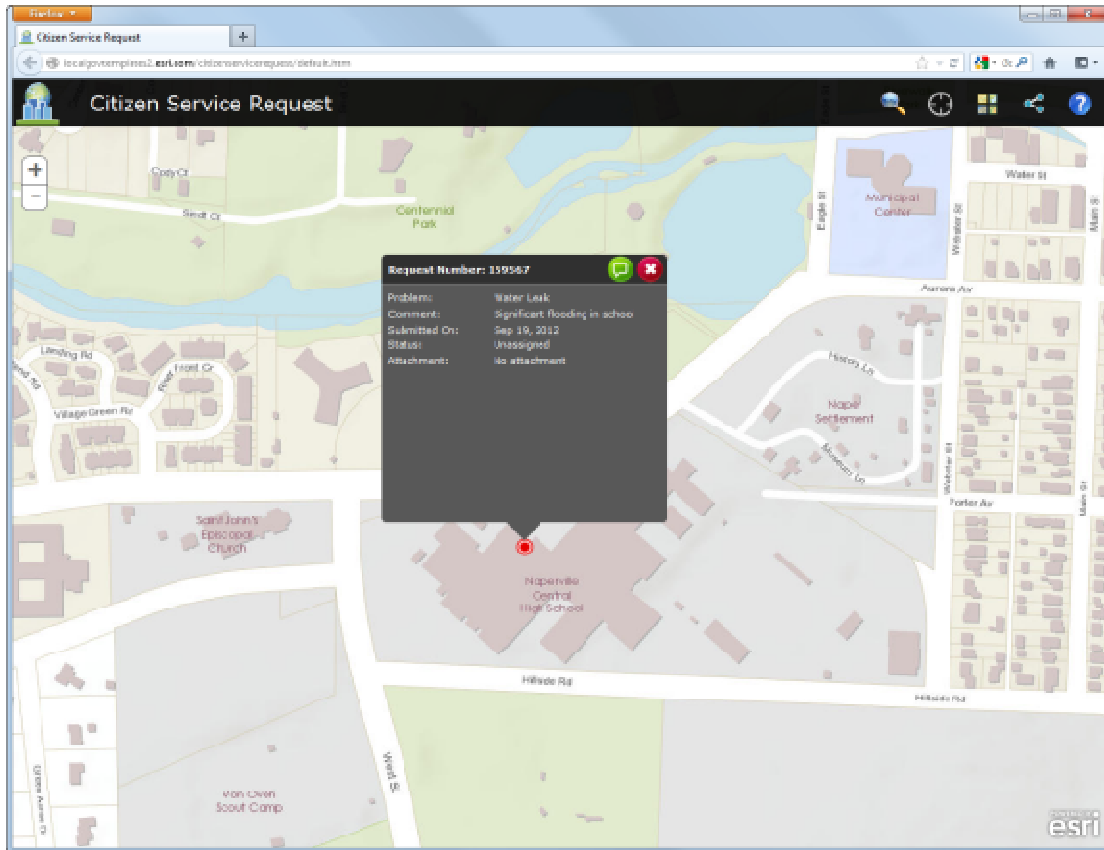


Figure 5. Citizen Service Request application<sup>5</sup>

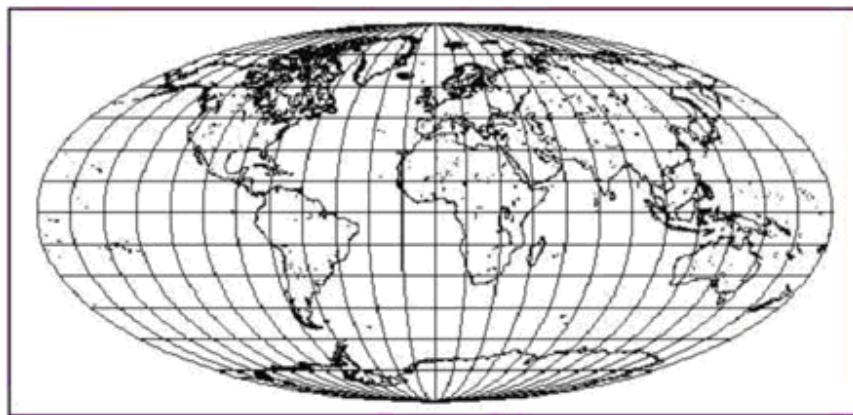
### 2.3. Technology Component

The technological component performs the connecting link function between the other components, allowing communication between them. The ideal technology to perform this communication task is the Web since it is capable of aggregating millions of disparate and independent ideas, providing the means to join in a single environment, enabling a certain kind of thinking, and stimulating a certain kind of innovation (Brabham, D.C., 2008). Therefore, this section refers to Web GIS and Web SDSS.

<sup>5</sup> <http://www.arcgis.com/home/item.html?id=b4756cb6d25e43b995c5fef887b1d5e8>

### 2.3.1. Web GIS

According to Fu, P. & Sun, J. (2010) the concept of Web GIS, which quickly evolved thanks to the era of Web 2.0, represents a significant milestone in the history of GIS as it has changed the way that geospatial information is treated. Its origin dates back to 1993, when Xerox Corporation Palo Alto Research Center (PARC) developed a Web-based map viewer (Fig. 6), providing simple operations zoom, layer selection and projection conversions. This application showed that users anywhere on the Web can use GIS without having it installed locally, with an advantage over the traditional desktop GIS. Given its benefits, the use of GIS functions in web browsers, and its subsequent applications were and are quickly adopted and implemented.



Select a point on the map to zoom in (by 2), or select an option below. Please read [About the Map Viewer](#), [FAQ](#) and [Details](#). To find a U.S. location by name, see the [Geographic Name Server](#).

**Options:**

- Zoom In: (2), (5), (10), (25); Zoom Out: (1/2), (1/5), (1/10), (1/25)
- Features: [Default](#), [All](#); [+borders](#), [+rivers](#)
- Display: [color](#); Projection: [elliptical](#), [rectangular](#), [sinusoidal](#); [Narrow](#), [Square](#)
- Change Database to [USA only \(more detail\)](#)
- [Hide Map Image](#), [Retrieve Map Image Only](#), [No Zoom on Select](#),
- [Place mark at \(0.00N 0.00E\)](#), [Reset All Options](#)

Figure 6. Xerox PARC Map viewer (Fu, P. & Sun, J., 2010)

These authors explain a set of features and benefits of Web GIS, that are described below.

The main advantage, contrary to the Web 1.0 which contents were only read and an unidirectional information flow from top to bottom, is that Web 2.0 is a read-write information flow, so that, users generate and share large amount of content.

Web 2.0 is also considered as a platform for software and computers development, which can be combined and be available for new application development and its implementation. One example is Software as a Service (SaaS) where software capabilities are delivered as Web services or Web applications.

The evolution of Web technologies have allowed to move from the complex and costly architectures Web services, to easy and free online Web 2.0 services (generation, addition and distribution of content) via the lightweight Application Programming Interfaces (APIs). The API easy handling is possible thanks to AJAX (Asynchronous JavaScript and XML), which combines JavaScript for functionality, and XML (Extensible Markup Language) and JavaScript Object Notation (JSON) for data transfer.

The functionality of these services with their APIs is limited and insufficient for users with professional purposes and geospatial data beyond the reach of non-professional users, who will have to turn to traditional desktop GIS. However, for the rest of users with non commercial purposes and with geospatial data available, they offer enough functionality, and hence its success.

Web GIS is a distributed system whose server is a Web application server and whose client can be a Web browser, a desktop application or mobile device (mostly offer a graphical user interface that is easy to use, very intuitive). Its operation is very simple (Fig. 7). The client sends a request for GIS operation via HTTP (Hypertext Transfer Protocol) to the server that is accessible via a URL (Uniform Resource Locator). Once the request is received by the server, it performs the operation and sent the response to the client via HTTP. The format of the response may vary, HTML (HyperText Markup Language), XML or JSON.

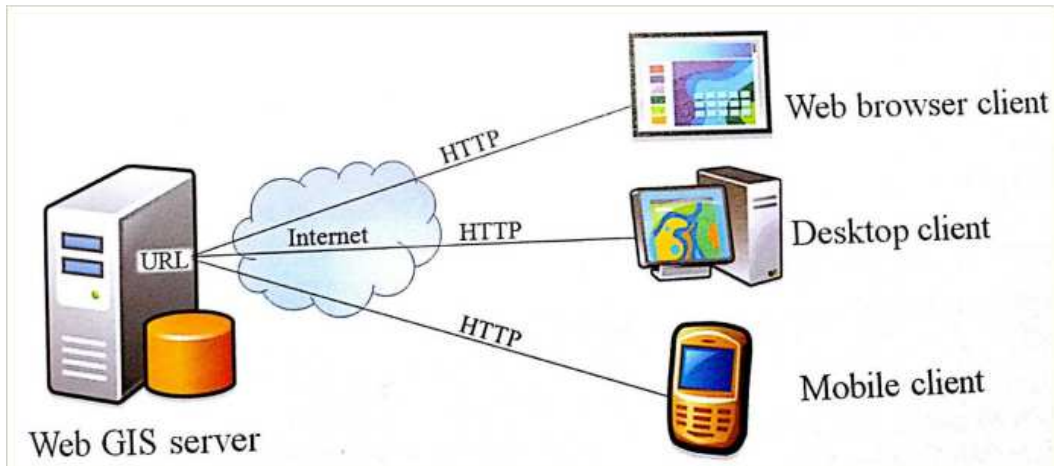


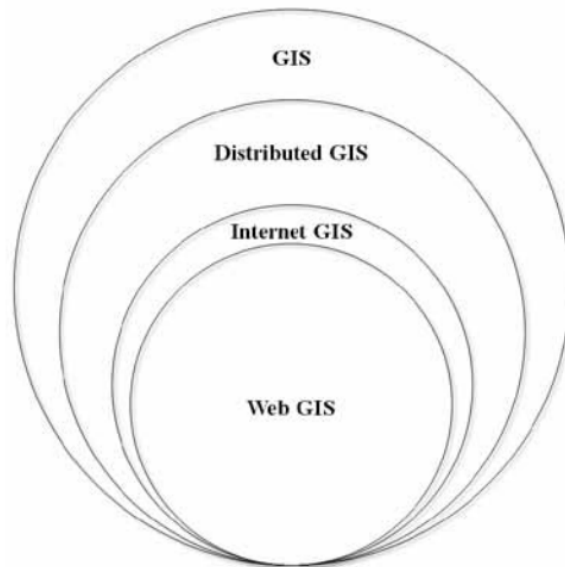
Figure 7. Web GIS server architecture (Fu, P. & Sun, J., 2010)

Web GIS has the following characteristics: global reach, large number of users, better cross-platform capability, low cost as averaged by the number of users, easy to use for end users, unified update, and diverse applications.

Also, Web GIS has the next functions: mapping and query, collection of geospatial information, dissemination of geospatial information, and geospatial analysis.

The next figure (Fig. 8) shows some concepts related to Web GIS that requires distinguish:

- Web GIS: GIS that uses Web (e.g. HTTP, HTTPS).
- Internet GIS: GIS that uses any Internet services (e.g. HTTP, FTP, SMTP). HTTP is the primary form.
- Distributed GIS: pieces of GIS systems distributed over a network (e.g. Internet, Intranet).



**Figure 8. Web GIS in relation to other related GIS terms (Fu, P. & Sun, J., 2010)**

Thus, the use of Web 2.0 technology in GIS facilitates collaborative spatial decision-making (communication) among all participants (public, planners and decision-makers), highlighting this advantage when decision-making requires a more intense involvement of these participants (Rinner C. et al., 2008).

### **2.3.2. Web Spatial Decision Support Systems**

As Rinner, C. (2003) explains, although there is some controversy about the definition of Spatial Decision Support Systems (SDSS) and about how to delimit them from geographic information, they are understood as application-specific software solutions. Moreover, GIS are described as generators for SDSS, being its basic function to support users in solving complex and semi-structured decision problems (Densham, P. J., 1991).

Although the development of SDSS began in the 1970s by advances in the non-spatial Decision Support Systems (DSS), since the early 90's, SDSS has had a significant and growing importance in terms of geographic information, and since the emergence of the WWW both roots of SDSS (DSS and GIS) have been linked to the Internet techniques, and are used for online applications (Keenan, P., 1996).

Peng, Z. R. & Tsou, M. H. (2003) describe GIS Internet as a client-server systems which basic functions (user interface for presentation and input, model base for program logic, and database for data management) are divided between the client and the server and is categorized into three types depending on program logic for SDSS:

- Server-side Web SDSS: while in the client is presented a user interface based on HTML to collect user data, static maps present the results of processing decision support operations that are performed on the server.
- Mixed client-side and server-side Web SDSS: in comparison with server-side, Java applets are used because allow greater interactivity used. Its purpose is to make available the SDSS to support group decision-making.
- Client-side Web SDSS: it involves advanced visualization and methods of multi-criteria evaluation.

In addition, these authors suggest the next evolution of Web mapping technology (Fig. 9):

- Static map publishing: users can not modify or interact with the maps, as they are distributed as static map images.
- Static Web mapping: HTML forms and Common Gateway Interface (CGI) are used to relate the user input in the Web browser with GIS programs on the servers. The performance is limited and can not be edited on the image maps.
- Interactive Web mapping: more interactivity in Web client side by using scripts. Some queries can be processed on the client side without sending requests to servers, but still requires HTTP connections and Web servers to act between the client side and the servers.
- Distributed geographic information services: client side components can directly communicate with other components on the server without going through an HTTP server.

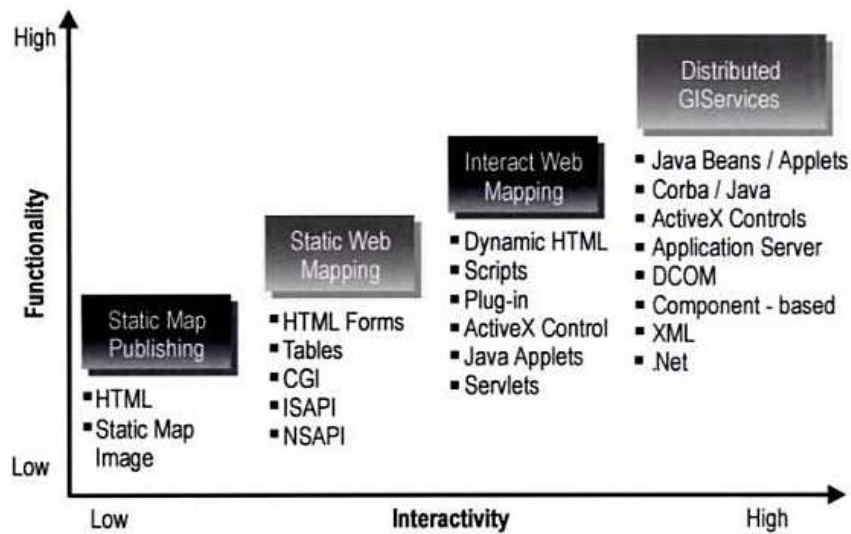


Figure 9. Evolution of distributed GIS (Peng, Z. R. & Tsou, M. H., 2003)

As an example provided by Rinner, C. (2003), Virtual Slaithwaite which is a model application for public participation in urban planning based on the open source Java mapping toolkit GeoTools, with a Java applet and HTML forms user interface which are processed by server side PERL scripts. It consists of an online city map that offers the ability to view and post notes, represented by points in the planning areas. Thus, decision support offered by this application consists of methods for visualization and communication of opinions on desired urban development and aim at increasing and improving the involvement of citizens in planning processes (Kingston, R., Carver, S., Evans, A. & Turton, I., 2000).



### **3. UJI SERVICE REQUEST APPLICATION**

The system has been developed in three stages. An initial phase of analysis, where the architecture, requirements and scopes of the system are defined. A second stage of design, where a first visual aspect (interfaces) and the storage of the system are defined. And a third phase of implementation, where the technology is chosen to develop the system, and then it is developed and tested.

The development process of the application has been adapted to the way of working of the OTOP in their way of classifying infrastructure or services offered at the university.

#### ***3.1. Analysis***

Analyzed the previous context of the UJI (see chapter 4), the technological improvement to develop must meet with certain requirements, being a Web mapping application the most suited to them.

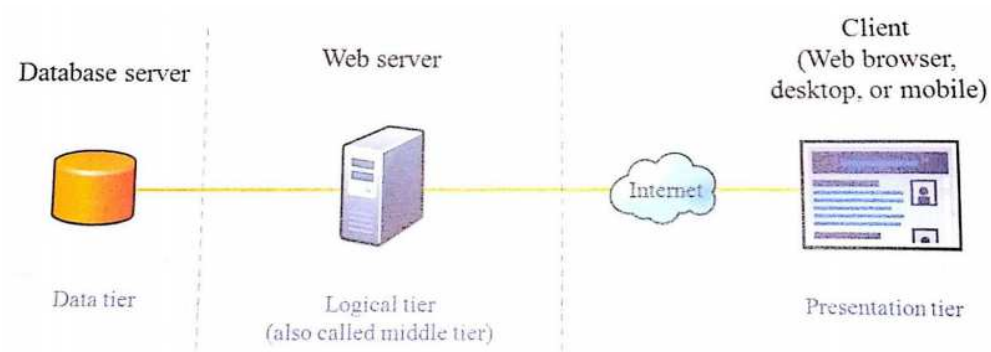
Taking into account the nature of the roles that this system has to cover, for roles which their main function is to report, the application is available for a mobile device, while for the role which its main function is to decision-making, the application is available for managing from a desktop Web browser.

So then, a Web Mapping Application that integrates all actors, services and data flows has been implemented to support spatial decision-making, to respond the needs of the university, in particular, of the OTOP, through enabling the public participation.

The system operation is very simple, consisting of a client-server architecture. On the client side the functionality has to be implemented. On the server side, provided by the INIT, only is required to create services and database to store the data for later use by these services.

Therefore, the used architecture is the three-tier architecture which is a client-server architecture, developed by John Donovan, composed of three tiers that are implemented in separate modules (Fig. 10) (Eckerson, W. W., 1995):

- **Data tier:** is responsible for storing and retrieving information in the database and provide it to the logic tier.
- **Logic tier:** is responsible for the functionality of the application (coordinates, processes, evaluation and logic decision making, perform calculations), and to move and process data between the two tiers.
- **Presentation tier:** is responsible for performing the tasks and understandable results to the user, i.e., the user interface.



**Figure 10. Three-tier architecture (Fu, P. & Sun, J., 2010)**

In Web applications, client requests a Web page, Web server receives the request, executes the code and renders HTML back to client. Finally, client displays the Web page received.

Similarly, the following figure (Fig. 11) shows the three-tier architecture in GIS, where the GIS server will handle delivery of maps, spatial analysis (querying, routing, etc.), spatial processing (GIS models, reprojection, etc.) and data management (replication, etc.).

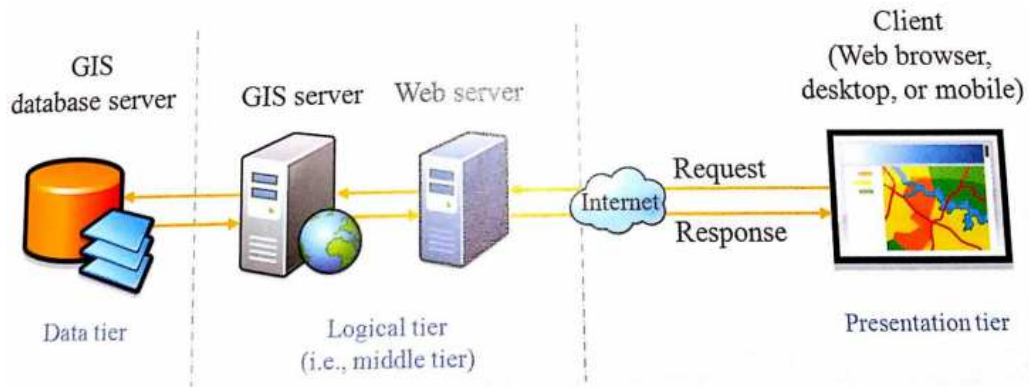


Figure 11. GIS three-tier architecture (Fu, P. & Sun, J., 2010)

After analyzing the system architecture, the first step is to create the use case diagram (Fig. 12) to identify tasks (known as use cases) and actors needed in the system. In the system four types of users are distinguished:

- Student: corresponds to university students.
- PDI: corresponds to research and teaching staff.
- PAS: corresponds to services and management staff.
- Manager: corresponds to the resource management staff.

The main function of the first three types are to report incidents and the main function of the last type is to perform decision-making.

Regarding to the use cases, the system allows all users to report and to check incidents, but only to modify these incidents to the manager. The purpose of modifying the incident is, either to assign a worker to an incident or to close an incident (i.e., change the incident state), or modify any of its parameters. Also, the system must allow the manager to perform some analysis to help with the decision-making. So then, the system allows to perform four tasks:

- Check incident.
- Create incident.
- Modify incident.
- Analyze results.

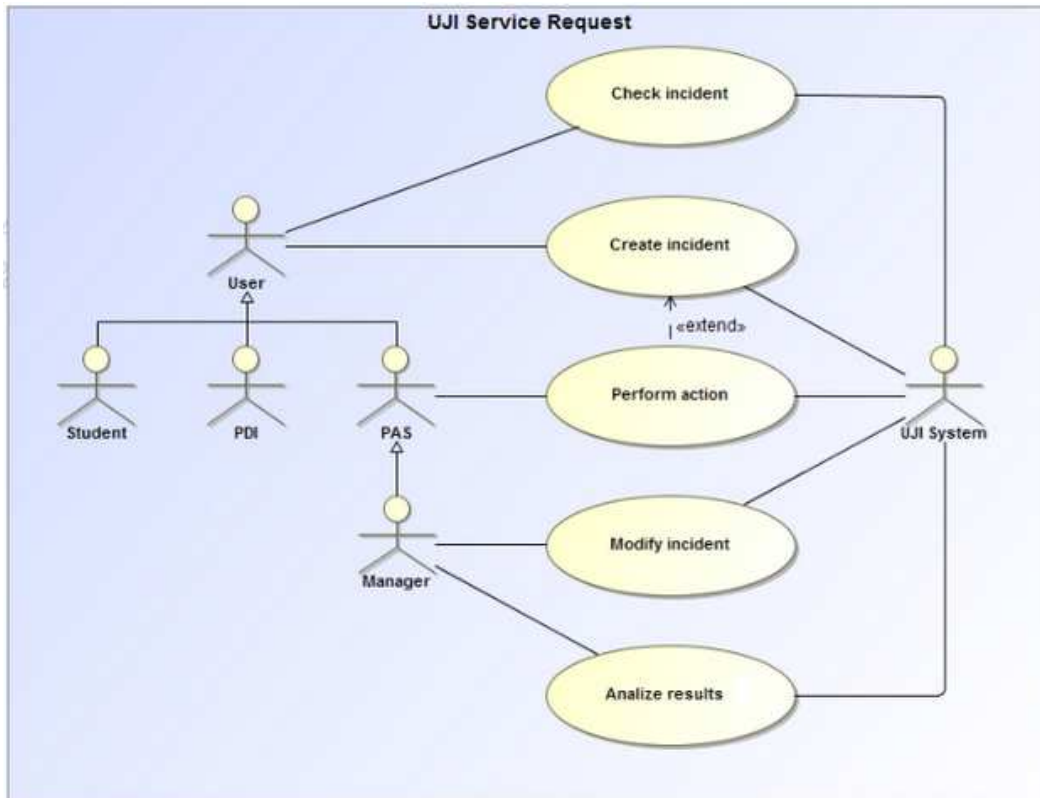


Figure 12. Use case diagram

As regards to incidents, must be distinguish two modes to operate with them. The first one, by the status of the incident: unassigned, assigned and closed. The second one, by the type of incident, whose classification is determined by the OTOP, which manages several UJI infrastructures and services (Annex V). These, benefit from the geospatial component and allow users to interact with the campus.

The second step of the analysis stage is to define the system requirements of each use case that compose the system. Below are the tables that describe the requirements of these use cases (Table 1-4).

Use Case Specification	
<b>Identifier</b>	CU01
<b>Name</b>	<b>Create incident</b>
<b>Version</b>	V1.0
<b>Autors</b>	Juan López Roca
<b>Sources</b>	INIT
<b>Description</b>	The system must allow to register a new incident when the user reports
<b>Scope</b>	Since the user inserts the incident until it is registered in the system
<b>Level</b>	Main task

<b>Main actor</b>	Student
<b>Secondary actors</b>	User
<b>Relations</b>	Modify incident, Check incident, Analyze results
<b>Precondition</b>	Incidents codes created
<b>End condition successfully</b>	New incident registered
<b>End condition failed</b>	It has not been able to register the new incident
<b>Trigger</b>	The user detects a new incident
<b>Normal sequence</b>	<b>Action</b>
	1 Introduce the incident data
	2 Save the data
<b>Exception</b>	<b>Action</b>
	1 Introduce comments concerning the action
	2 Save action
<b>Expected frequency</b>	15 times a day
<b>Importance</b>	Necessary
<b>priority</b>	Short term
<b>Comments</b>	The student uses this use case anytime to report an incident to the university administration, filling in all required fields

**Table 1. Requirements table of Create incident**

Use Case Specification	
<b>Identifier</b>	CU02
<b>Name</b>	<b>Modify incident</b>
<b>Version</b>	V1.0
<b>Autors</b>	Juan López Roca
<b>Sources</b>	INIT
<b>Description</b>	The system must allow update the information of an existing incident
<b>Scope</b>	Since the user selects a problem to change until it is saved modified
<b>Level</b>	Main task
<b>Main actor</b>	Manager
<b>Secondary actors</b>	None
<b>Relations</b>	Create incident, Check incident, Analyze results
<b>Precondition</b>	Incident registered in the system
<b>End condition successfully</b>	Incident updated or modified
<b>End condition failed</b>	Do not upgrade or modify the incident
<b>Trigger</b>	The user wants to modify an incident
<b>Normal sequence</b>	<b>Action</b>
	1 Select the incident
	2 Modify the incident
	3 Save the incident
<b>Expected frequency</b>	10 times a day
<b>Importance</b>	Necessary
<b>priority</b>	Short term
<b>Comments</b>	The manager uses this use case to update the incident status (unassigned, assigned and closed) and modify some incident parameter of the incident

**Table 2. Requirements table of Modify incident**

Use Case Specification	
<b>Identifier</b>	CU03
<b>Name</b>	<b>Check incident</b>
<b>Version</b>	V1.0
<b>Autors</b>	Juan López Roca

<b>Sources</b>	INIT
<b>Description</b>	The system must display events and their attributes and allow searching for some filter incidents
<b>Scope</b>	Since a type of query is selected until the results are displayed on screen
<b>Level</b>	Main task
<b>Main actor</b>	User
<b>Secondary actors</b>	None
<b>Relations</b>	Create incident, Modify incident, Analyze results
<b>Precondition</b>	Incident registered in the system
<b>End condition successfully</b>	Incident is shown for the selected parameters
<b>End condition failed</b>	Incident is not displayed
<b>Trigger</b>	The user wants to perform a query to see the incident status of incidents
<b>Normal sequence</b>	<b>Action</b>
	<b>1</b> Introduce the query parameters
	<b>2</b> Show the query
<b>Expected frequency</b>	30 times a day
<b>Importance</b>	Necessary
<b>priority</b>	Short term
<b>Comments</b>	Users use this use case to check the incident status (unassigned, assigned and closed) and to check some incident parameter of the incident

**Table 3. Requirements table of Check incident**

Use Case Specification	
<b>Identifier</b>	CU04
<b>Name</b>	<b>Analyze results</b>
<b>Version</b>	V1.0
<b>Autors</b>	Juan López Roca
<b>Sources</b>	INIT
<b>Description</b>	The system should allow a data analysis to make them useful information for decision-making
<b>Scope</b>	Since the type of analysis is selected until the screen shows the analysis result
<b>Level</b>	Main task
<b>Main actor</b>	Manager
<b>Secondary actors</b>	None
<b>Relations</b>	Create incident, Modify incident, Check incident
<b>Precondition</b>	Incident registered in the system
<b>End condition successfully</b>	Show the analysis results
<b>End condition failed</b>	Results are not shown
<b>Trigger</b>	The manager wants to perform an analysis that will help to make a decision
<b>Normal sequence</b>	<b>Action</b>
	<b>1</b> Introduce the query parameters
	<b>2</b> Show the query
<b>Expected frequency</b>	10 times a day
<b>Importance</b>	Necessary
<b>priority</b>	Short term
<b>Comments</b>	The manager uses this use case to analyze incident data and obtain useful information for decision-making

**Table 4. Requirements table of Analyze results**

The third and final step of the analysis is to create the class diagram of the system without attributes (Fig. 13), to define by what entities the system is composed and how they are related.

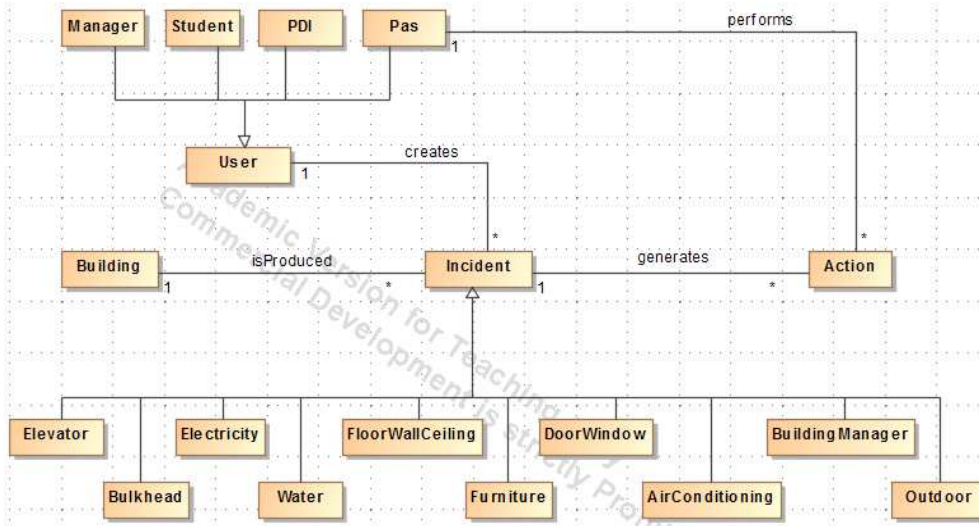


Figure 13. Class diagram

### 3.2. Design

The first step of this stage is to define the attributes and methods of classes defined in the analysis stage (Fig. 14a & Fig. 14b), in order to know what data will be needed and how they will be treated for the system information flow.

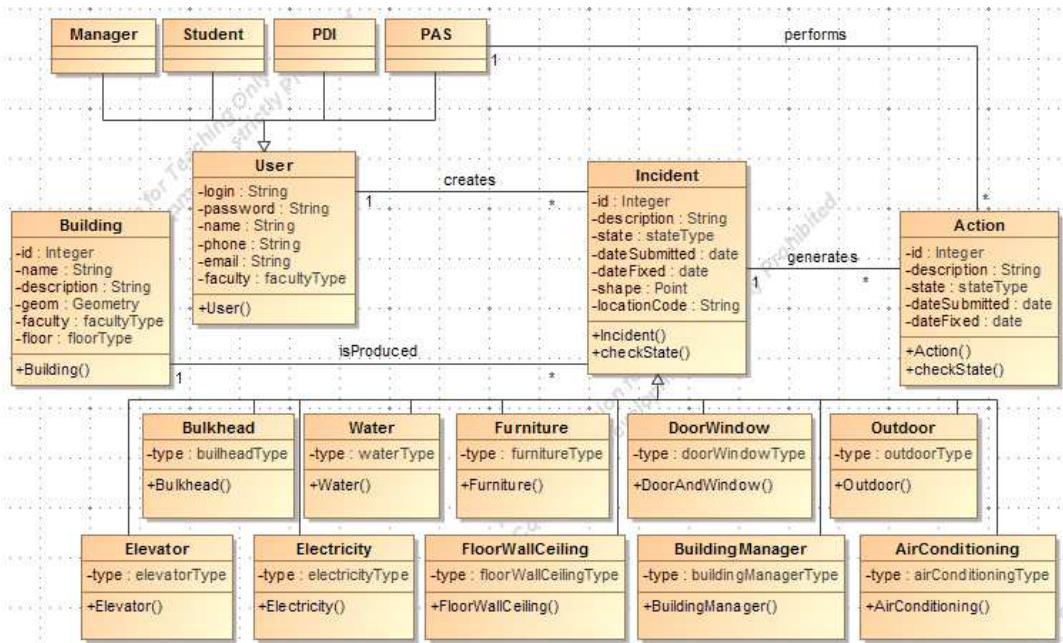


Figure 14a. Complet class diagram

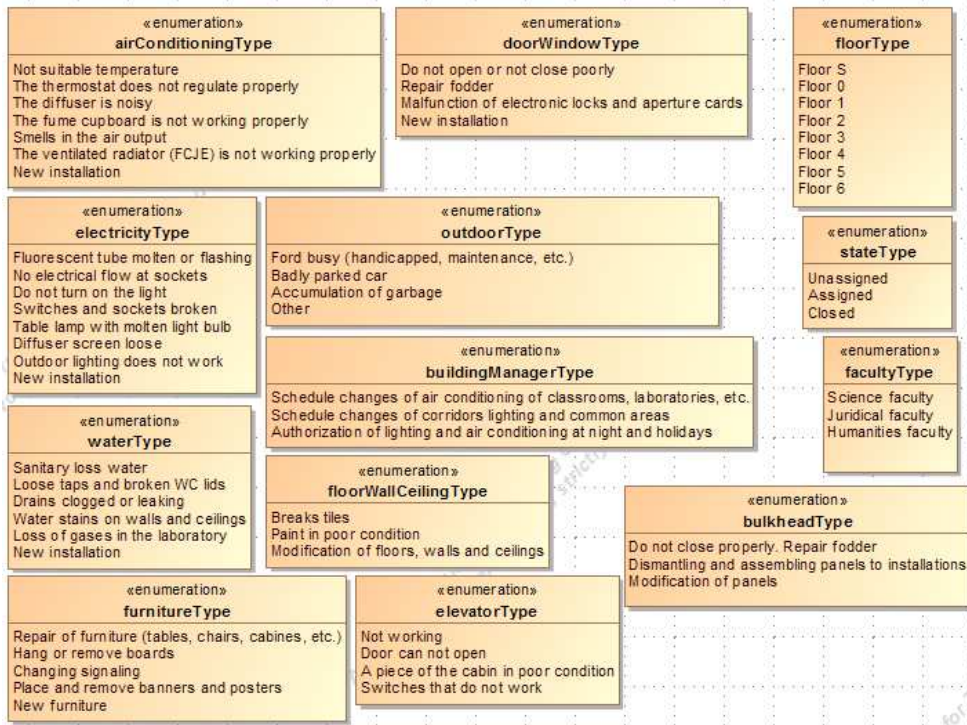


Figure 14b. Class diagram enumerations

The second step is to define a visual appearance or user interface with which the user can communicate with the system, the prototype. The following three figures of the designed prototype summarize the client functionality. The first of them (Fig. 15) corresponds with the check incident functionality by status.

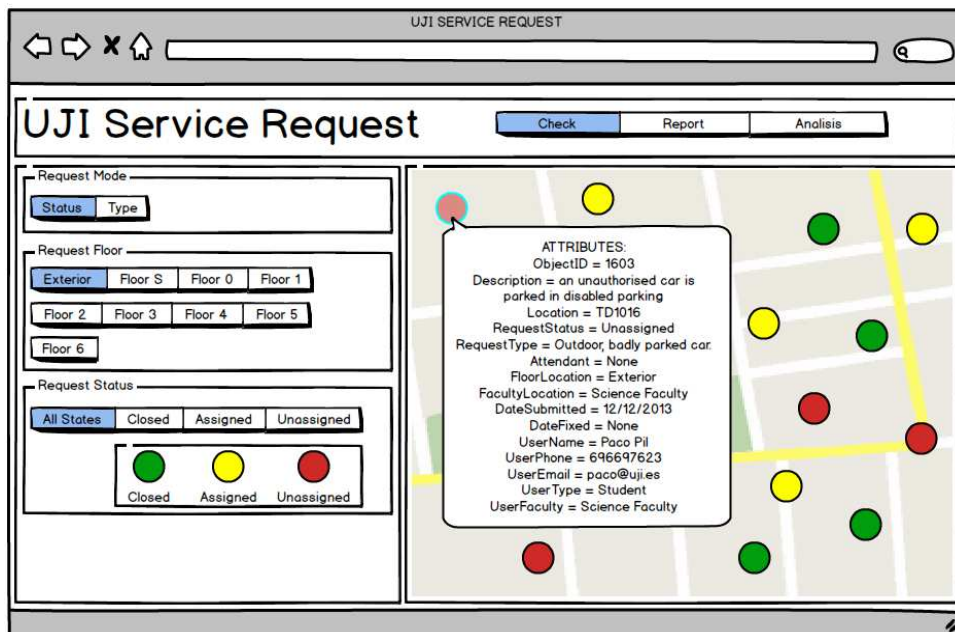


Figure 15. Check status interface prototype



The second figure (Fig. 16) corresponds with the report functionality and by type.

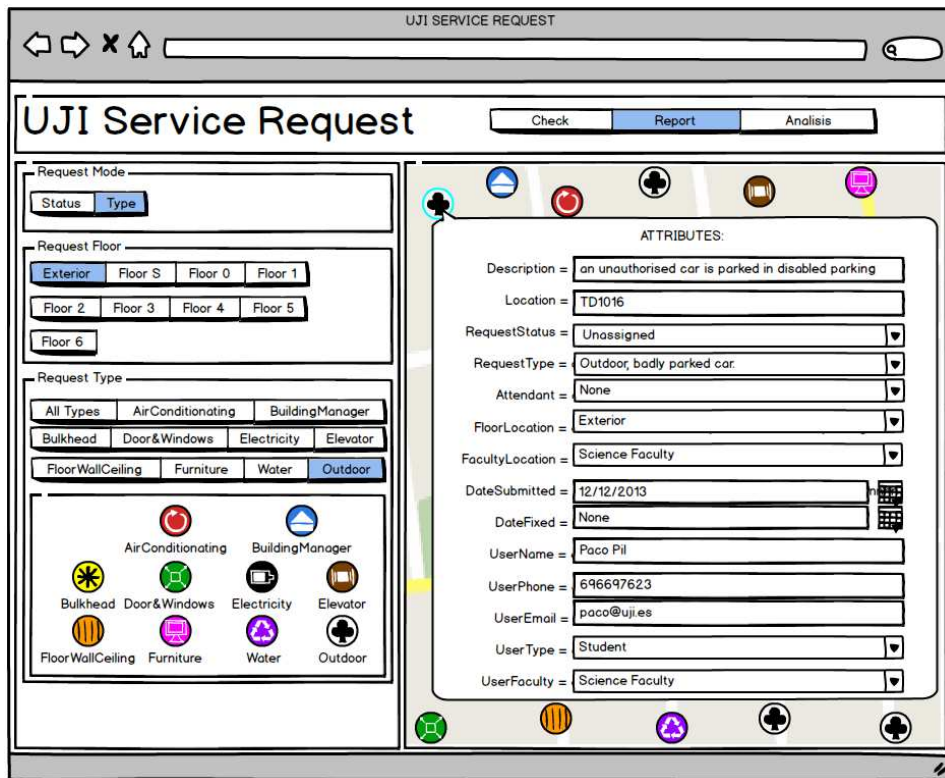


Figure 16. Report type interface prototype

The data analysis functionality (Fig. 17) is useful for decision-making management.

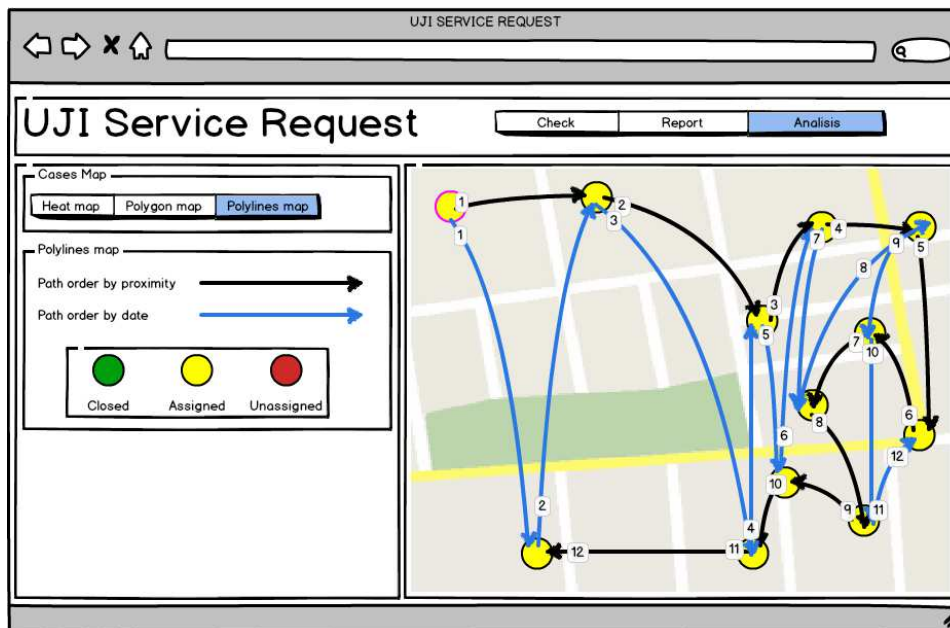


Figure 17. Polylines analysis interface prototype

The third and final step of the design is to define how and where the data needed by the system will be stored, the geodatabase. This step determines, in part, the next stage of implementation, where the technology used by the system must be chosen. This is because depending on the method used to store data, one or another technology will be used in other parts of the system.

Given the technology available and that the university has an ArcGIS server, the storage system is a ArcGIS server geodatabase. Based on the class diagram defined in the first step of this stage (Fig. 13), the following figures show the storage system. Figure 18 shows the geodatabase fields used in the system.

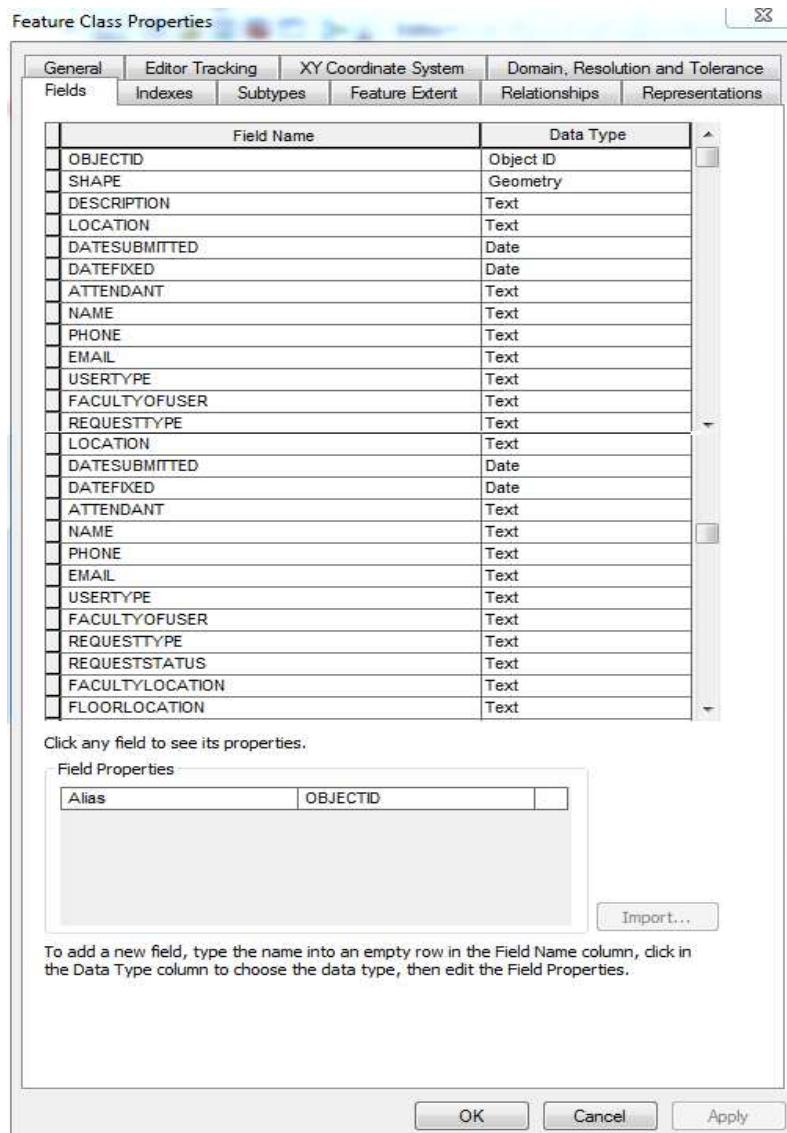


Figure 18. Database fields

To restrict values in those fields of the geodatabase where it is necessary, ArcGIS domains are used. Figure 19 shows one of the domains of one of this geodatabase fields.

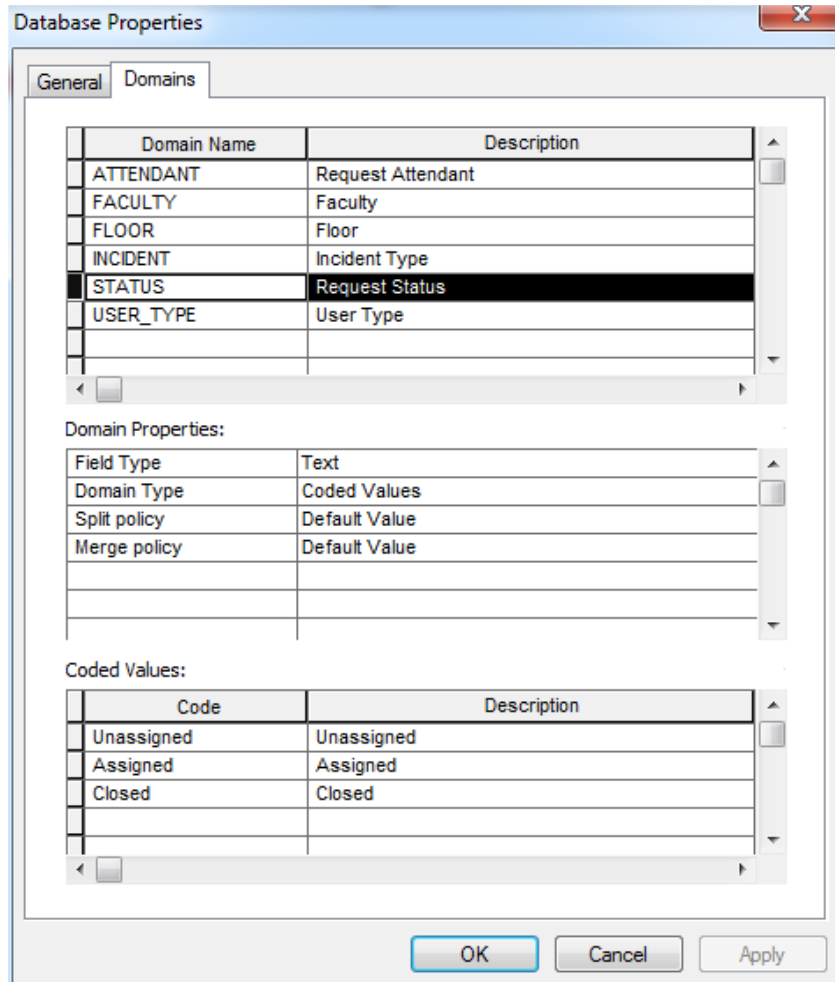


Figure 19. Database fields domains

### 3.3. Implementation

The first step in this stage is to make the choice of technology to implement the parts of the system (Table 5). To do this, available alternatives must be detected, and then select the one that best suited. Then, as in the previous stage we have selected the data storage system, it scores in some way what technology to use. Based on the three-tier system architecture defined in the analysis phase, the following figure (Fig. 20) shows the technology that is commonly used in each of the parts of this architecture.

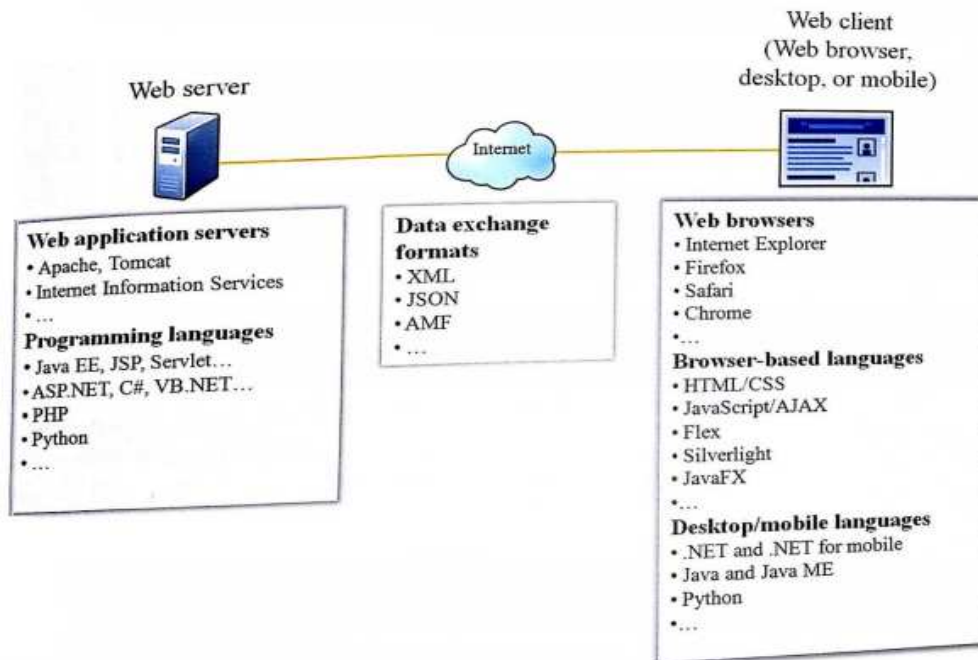


Figure 20. Technology of three-tier architecture (Fu, P. & Sun, J., 2010)

So then, as the server functionality is based on ESRI technology, it is more appropriate to use on the client side a technology to interact properly with the server side. Therefore, to develop the functionality of the client side, is used ArcGIS API for JavaScript which facilitates an already implemented functionality that simplify the process. Finally, for the development of client interfaces, HTML and CSS (Cascading Style Sheets) are used as a programming language.

Part of the system	Technology chosen
Server	Arcgis Server
Database	ArcGIS geodatabase
Client functionality programming language	ArcGIS API for JavaScript
Client interfaces programming language	HTML and CSS

Table 5. Summary of the technology used to implement the system

Before proceeding to explain the implementation of the system is necessary to explain some concepts to understand the implementation later. ArcGIS server can be defined as an application that allows to publish GIS resources to the Internet. Its architecture (Fig. 21) has the following components:

- Data Server:
  - Data Storage.
  - Geodatabase implementation in a Relational Database Management System (RDBMS) (e.g. SQL Server, PostGreSql).
  
- GIS Server:
  - Provides the foundation for the GIS services.
  - Draws maps, runs tools, queries data, and performs other GIS actions.
  
- Web Adaptor:
  - Used to integrate with an existing Web application server (e.g. IIS, Apache).
  - Receives request from Web and redirects them to GIS Server.
  
- Web Server: seen previously.

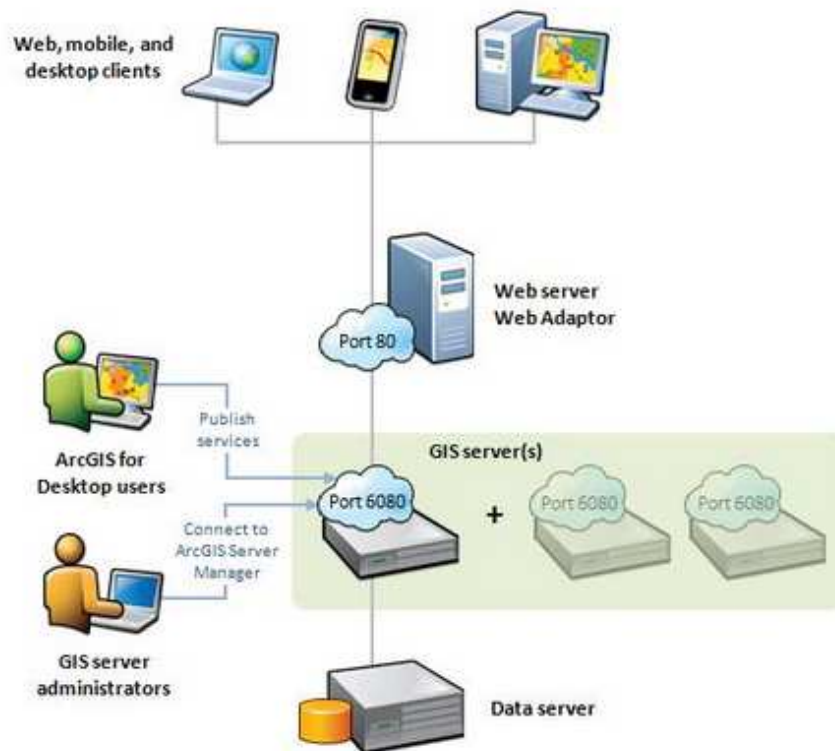


Figure 21. ArcGIS Server architecture (Fu, P. & Sun, J., 2010)

A Web service is a program that runs on a Web server and exposes programming interfaces to other programs on the Web. It has the follow three roles:

- Provider: hosts the functionality.
- Consumer: uses the functionality from the provider.
- Registry: acts as a broker between provider and consumer and stores the metadata about the functionality.

An important concept for Web services is the interoperability, defined as the ability to communicate, execute programs, or transfer data over various functional units in which the user does not need to have knowledge of the unique characteristics of the unit. To carry out this, it is necessary interoperability Web service standards that specify the format of HTTP requests and responses (required parameters, name of parameter, type of value, responses, etc.). Some organizations that are dedicated to this are the Open Geospatial Consortium (OGC), the International Organization for Standardization technical committee 24 (ISO/TC 24), or the World Wide Web Consortium (W3C). Some interoperability services are Web Map Service (WMS), Web Feature Services (WFS), Web Coverage Service (WCS), Catalog Service for the Web (CSW), OpenGIS Location Services (OpenLS), Web Processing Service (WPS), Sensor Web Enablement (SWE).

The second step of this phase is the development of system parts. While on the server is only necessary to create the services and its geodatabase, on the client must be developed the interface for the client to communicate with the server. Below are listed the steps followed to establish the service and its database on the server side:

1. Create a geodatabase.
2. Create a point feature layer.
3. Create fields of points features layer.
4. Create fields domains.
5. Create the symbology of the layer for the two modes (status and type).

6. Import the geodatabase to the server.
7. Publish the point feature layer as a service in the server.

The following two figures (Fig. 22 & Fig. 23) are the final result corresponding to the last step. By publishing a point feature layer as a service, two services are created automatically, WFS (allows edition features) and WMS (allows viewing features). That is why in the next figure (Fig. 22) there are four services, the first two services correspond to status symbology and the following two services correspond to type symbology.

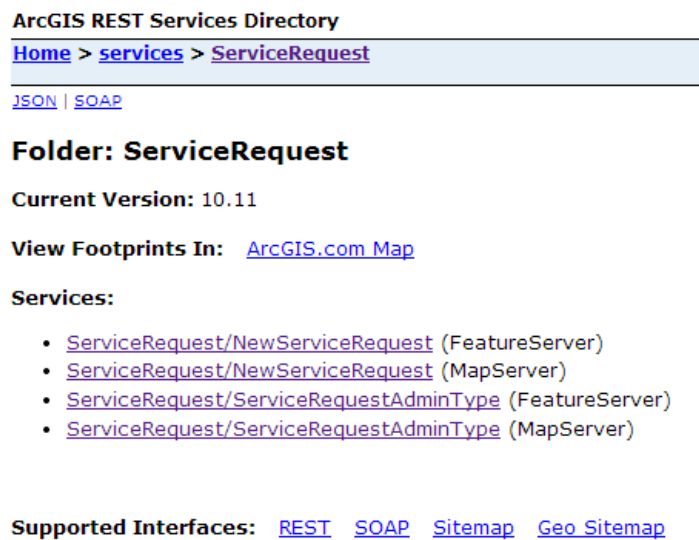


Figure 22. Service directory of the ArcGIS server

The next figure (Fig. 23) shows WFS of the status mode where is described all the features of this service.

```

Default Label: null
UniqueValueInfos:
  Value: Closed
  Label: Closed
  Description:
  Symbol:
  Value: Assigned
  Label: Assigned
  Description:
  Symbol:
  Value: Unassigned
  Label: Unassigned
  Description:
  Symbol:
Transparency: 0
Labeling Info:

HasZ: false
HasM: false
Has Attachments: false
HTML Popup Type: esriServerHTMLPopupTypeAsHTMLText
Type ID Field: REQUESTSTATUS
Fields:
  OBJECTID ( type: esriFieldTypeOID , alias: OBJECTID , editable: false , nullable: false )
  DESCRIPTION ( type: esriFieldTypeString , alias: Request Description , editable: true , nullable: false , length: 150 )
  LOCATION ( type: esriFieldTypeString , alias: Request Location , editable: true , nullable: false , length: 50 )
  DATESUBMITTED ( type: esriFieldTypeDate , alias: Date Submitted , editable: true , nullable: false , length: 36 )
  DATEFIXED ( type: esriFieldTypeDate , alias: Date Fixed , editable: true , nullable: true , length: 36 )
  ATTENDANT ( type: esriFieldTypeString , alias: Request Attendant , editable: true , nullable: false , length: 50 , Coded Values
Puerta: Juan la Puerta , [Florentino Peris: Florentino Peris] , ...1 more... )
  NAME ( type: esriFieldTypeString , alias: Name , editable: true , nullable: false , length: 50 )

```

Figure 23. Feature server details from status mode of ArcGIS server

The following two figures show the user interfaces developed using ArcGIS API for JavaScript. The first one (Fig. 24) shows a piece of HTML and CSS code corresponding to the basic structure of the interface (Fig. 25).

```

index.html
1 |<!DOCTYPE html |
2 |<html>
3 |  <head>
4 |    <meta http-equiv="Content-Type" content="text/html; charset=utf-8">
5 |    <meta http-equiv="X-UA-Compatible" content="IE=7, IE=9">
6 |    <meta name="viewport" content="initial-scale=1, maximum-scale=1, user-scalable=no">
7 |    <title>Service Request</title>
8 |
9 |    <script type="text/javascript" src="http://serverapi.arcgisonline.com/jsapi/arcgis/?v=1"></script>
10 |    <link rel="stylesheet" href="http://serverapi.arcgisonline.com/jsapi/arcgis/3.3/js/dojo/dijit/themes/claro/claro.css">
11 |    <link rel="stylesheet" href="http://serverapi.arcgisonline.com/jsapi/arcgis/3.3/js/esri/css/esri.css">
12 |    <link rel="stylesheet" href="css/myStyle.css">
13 |    <script>var dojoConfig = {parseOnLoad: true}</script>
14 |    <script src="http://serverapi.arcgisonline.com/jsapi/arcgis/3.3/"></script>
15 |
16 |    <script src="js/url.js"></script>
17 |    <script src="js/var.js"></script>
18 |    <script src="js/map.js"></script>
19 |    <script src="js/floor.js"></script>
20 |    <script src="js/query.js"></script>
21 |    <script src="js/check.js"></script>
22 |    <script src="js/report.js"></script>
23 |    <script src="js/mode.js"></script>
24 |    <script src="js/analysis.js"></script>
25 |    <script src="src/heatmap.js"></script>
26 |    <script src="src/heatmap-arcgis.js"></script>
27 |
28 |    dojo.require("dijit.layout.BorderContainer");
29 |    dojo.require("dijit.layout.ContentPane");
30 |    dojo.require("esri.dijit.editing.Editor-all");
31 |    dojo.require("esri.SnappingManager");
32 |    dojo.require("esri.map");
33 |    dojo.require("esri.arcgis.utils");
34 |    dojo.require("esri.layers.FeatureLayer");
35 |    dojo.require("esri.tasks.geometry");
36 |    dojo.require("esri.tasks.query");
37 |    dojo.require("dijit.form.Button");
38 |    dojo.require("esri.dijit.BaseMapGallery");

```

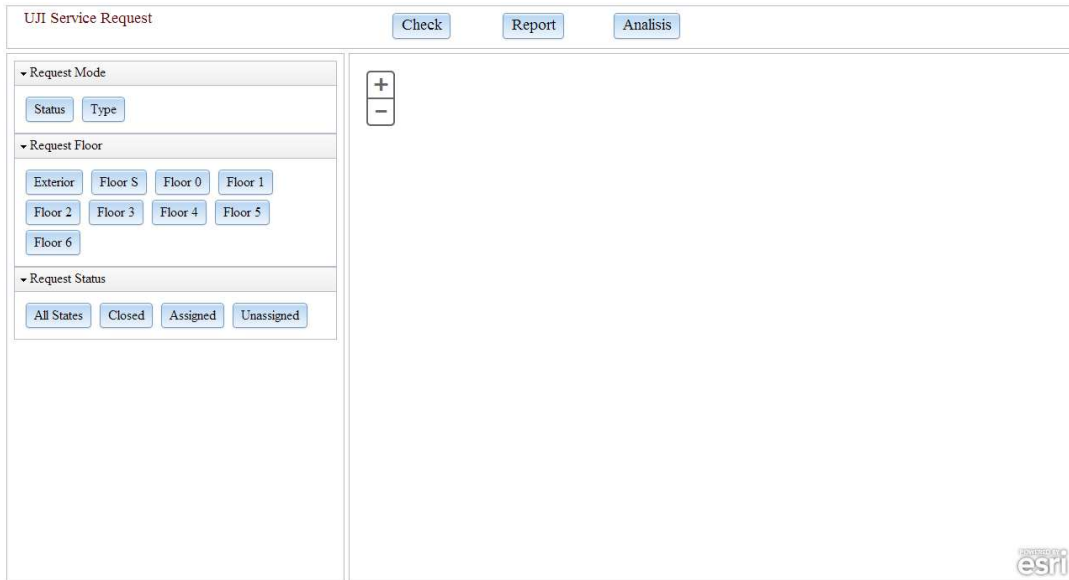
```

*myStyle.css
1 |html,body{
2 |  height:100%;
3 |  width:100%;
4 |  margin:0;
5 |  overflow:hidden;
6 |  background-color:transparent;
7 |
8 |
9 |
10 |#main{
11 |  height:100%;
12 |  width:100%;
13 |
14 |#header{
15 |  font-size:14pt;
16 |  padding-left:20px;
17 |  padding-top:4px;
18 |  color:#660000;
19 |
20 |
21 |#menu{
22 |  width:30%;
23 |
24 |
25 |
26 |#map{
27 |  width:100%;
28 |  padding:0;
29 |
30 |
31 |
32 |.dj_ie .infowindow .window .top .right .user .content { position: relative; }
33 |.dj_ie .simpleInfoWindow .content {position: relative;}

```

Figure 24. HTML and CSS code of interface framework





**Figure 25. Interface framework**

The next figures correspond to examples of JavaScript code functions, along with their corresponding visual result. The first one (Fig. 26) corresponds to the initialization of the interface function, whose steps are:

1. Load interface framework.
2. Load menus of section Check.
3. Connect to the server.
4. Load basemaps.
5. Create different layers.
6. Load the service.
7. Display incidents.

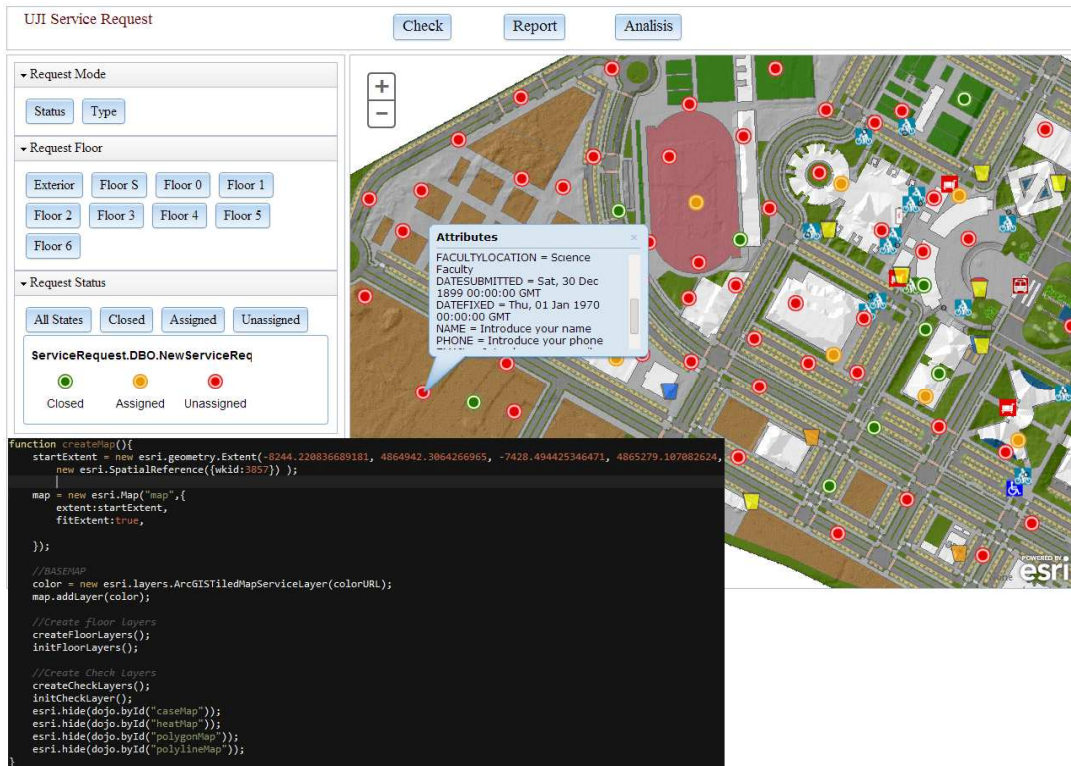


Figure 26. Code and result of initialization of the interface

The second one (Fig. 27) corresponds to the function of reporting the incident, whose steps are:

1. Load menus of section Report.
2. Create the different editing layers.
3. Load the default menu Report Status.

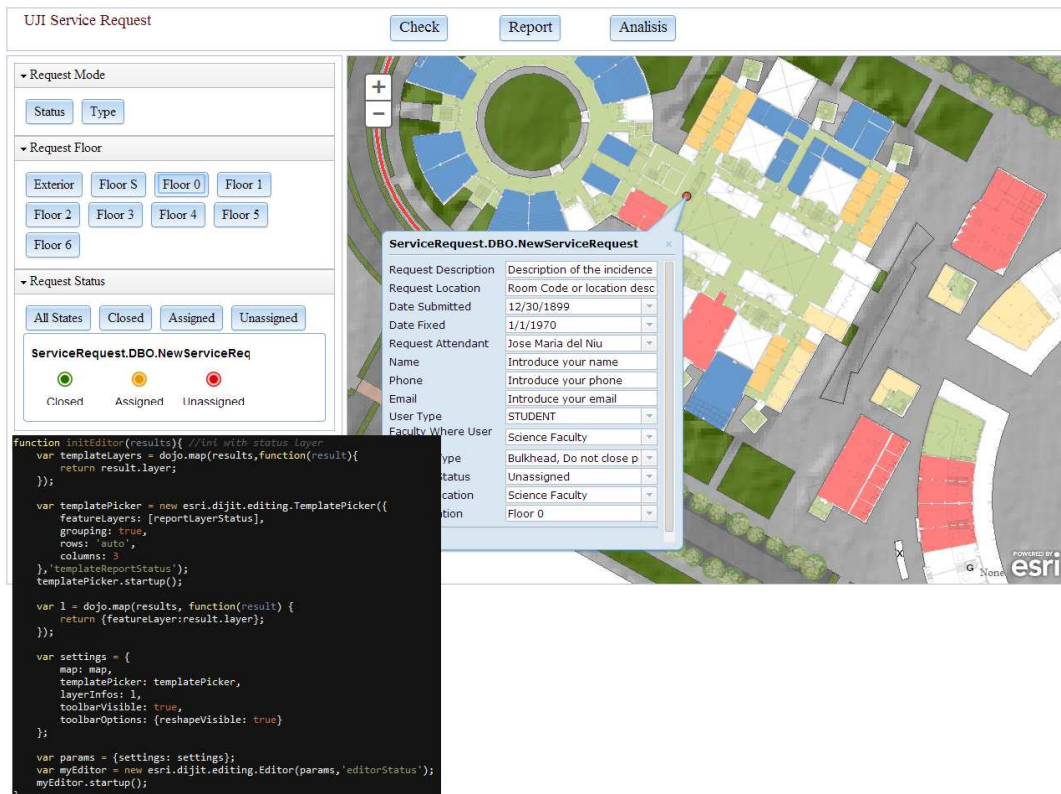
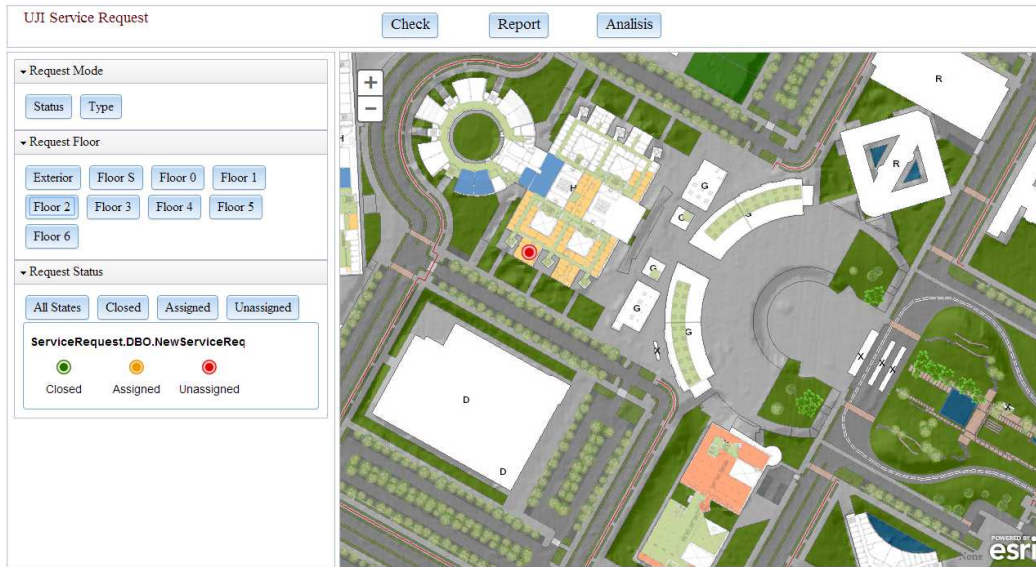


Figure 27. Code and result of the report incident function

Then, once observed the interfaces, the steps to be followed to report incidents are:

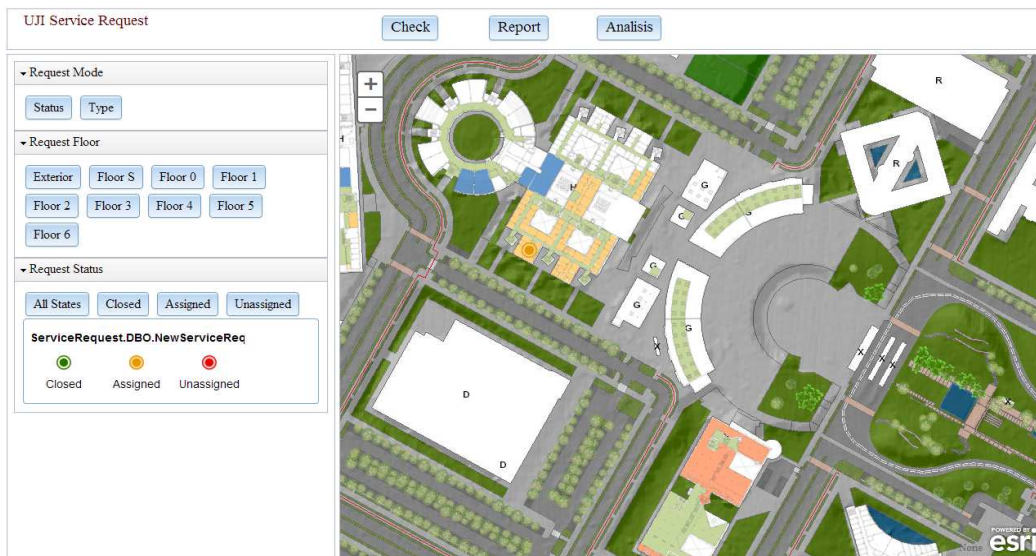
1. Select the Report Mode (Status or Type) button (in the figure Status mode is shown).
2. Select the Report Floor button (floor where the incident occurred).
3. Select the type of incident by clicking on the legend on the left menu.
4. Click on the map where the incident occurred.
5. Fill the incident form.

The third and final step of the implementation phase is to test the implemented functionality. The following figures show an example of one of the functions implemented, change the status of the incident. In the first of them (Fig. 28), the status value of the incident is Unassigned.



**Figure 28. Interface showing an unassigned status incident**

In the second one (Fig. 29) the incident status value has been changed to Assigned.



**Figure 29. Interface showing an assigned status incident**

In the third figure (Fig. 30), the incident status value has been changed to Closed.

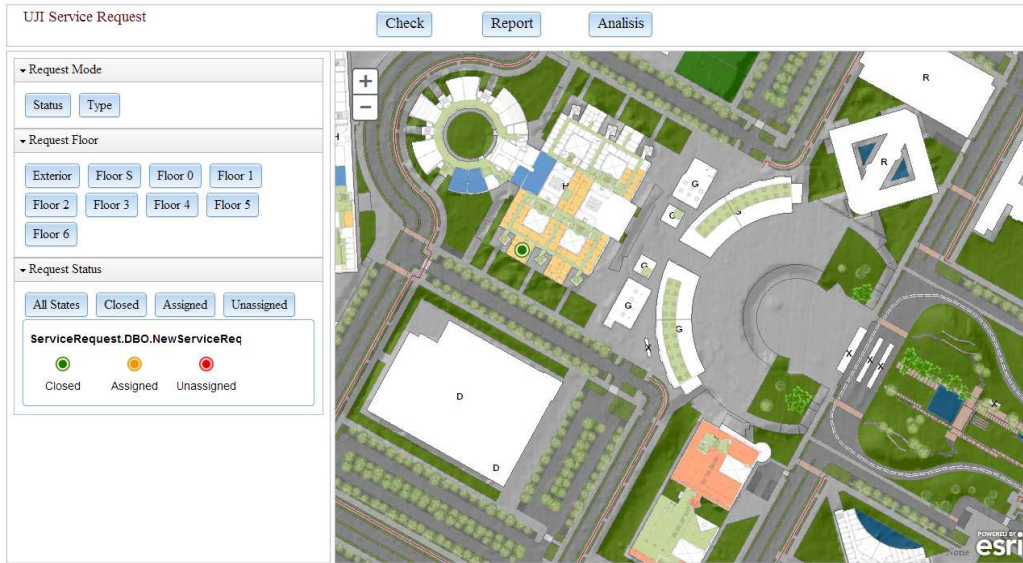


Figure 30. Interface showing a closed status incident

Finally, has been created the deployment diagram to summarize the architecture of the implemented system the (Fig. 31).

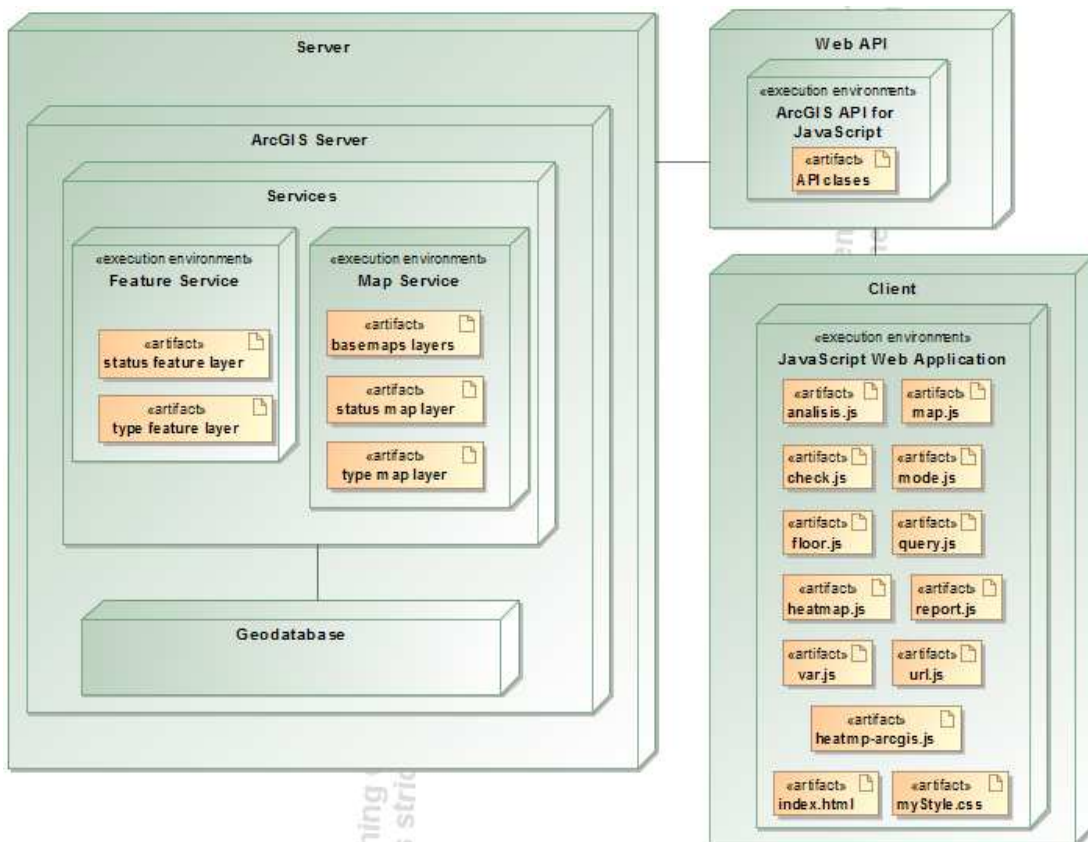


Figure 31. Deployment diagram

## 4. ANALYSIS

This chapter focuses on the previous analysis of the UJI context as smart city, the proposed study cases, and a posterior analysis of the UJI context after the potential introduction of the technological improvement. The before and after situation are studied by observation and through interviews and surveys conducted specifically for each user group of the university. Regarding the implementation of the application, its development was successfully completed and it was available to the university community, but study cases have been developed with random data, for the reasons explained in section 2 of this chapter.

### *4.1. Previous context analysis*

This section analyzes the current status of the three components of a smart city in the UJI context, i.e., the actual situation of the human, institutional and technological component in the UJI.

Regarding human component, at the university coexist people with different roles and needs: students, PID, PAS, and manager (see chapter 3).

With regard to students, who are the role with the most basic function, with fewer needs but the largest group, there is a tendency to believe that they are not sufficiently involved in the coexistence on the campus. One thing that could justify their low participation is the already mentioned problem of not reporting incidents.

In the PDI group, who forms the second largest role but with greater functionality and needs, as well as students, there is a tendency to believe that they are involved but not enough.

PAS, is the role responsible for everything that makes possible for people of the university to satisfy their needs and fulfill their duties. Within this role, there is a more specific role, the manager, who is in charge of decision-making on the

university resources management, i.e., the central component of the institution. Therefore, these two roles have important functions and needs that they have to satisfy for the current and future benefit of the university.

The institutional component of the UJI has a pyramidal structure in which its maximum exponent is the rector, who delegates responsibilities among several institutions. The rectorate, apart from having and using certain technology also promotes the development of technology for the use and benefit of the university, for example, SmartUJI project.

One of these institutions mentioned above is the OTOP, which is responsible for managing the resources of the campus, so it is considered the main institution in this study. For the purposes of the study, although there is personnel who should be included in the role of PAS (concierge, management, etc.), only are considered as PAS personnel who belongs to the OTOP. This institution is interested in promoting that the human component of the UJI helps manage the resources using for it an improved technology that on the one hand, facilitates the participation of users, and on the other hand, facilitates its decision-making.

Regarding the technological component, the UJI has infrastructures, services and applications that allow the development of projects like SmartUJI or the development of applications as the system implemented in this thesis. It should be noted, that the technology used by the OTOP to collect data incidents is through a form via Web (Fig. 33).

Requests for intervention failure, new facilities and equipment - Google Chrome  
 https://e-ujer.uji.es/pls/www/gri\_www.euji21347?p\_tab=1

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 Requests for intervention failure, new facilities and equipment

Link Print Close

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Applicant Juan Lopez Rock  
 Date request 01/30/2014  
 Type of file  
 Location

Fault location  
 Phone contact  
 Description  
 Type of request Electricity

Send request

Information and queries: [Suggestion Box](#) | [General policy on data protection](#)  
 Jaume I University ID: Q-6250003-H Av. Vicent Sos Baynat, s/n 12071 Castellón, Spain Tel: +34964 72 80 00 Fax: +34964 72 90 16

**Figure 32. OTOP form**

At this point, data obtained from the surveys which include questions to assess the three components are analyzed.

For students and PDI roles, were carried questions about participation and reporting of incidents (Annex I) because of they are the largest group and they have not responsibilities on these incidents.

The entire sample states that observe or have observed incidents, being the most frequents illegally parked cars, as well as problems with the air conditioning.

As for students, 15 of the 20 students surveyed say that they have ever generated incidents. Reasons are lack of reprisals, indifference or argue that it is not their role. Furthermore, none of the 20 respondents know the current system, so they do not use it.

As for PDI, 4 of the 10 surveyed claim to have ever generated incidents. The reasons are similar to the students case. Moreover, 8 of the 10 surveyed know the system, 6 of them report or have ever reported any incident. Reasons are mainly because incidents directly affected them, and who do not report, do not do it because



they have not had the need. This group knows the system by information provided from OTOP, by their need of use or by coworkers. As for their perception of the current system, they have no problems to report as in offices is very easy to say where the incident occurred.

Finally, having explained the operation of the current system to students, surveyed from both roles do not like the current way to do it mainly because they have to describe explicitly the location of the incident, being this sometimes a difficult task (students also noted the difficulty in some cases of having a computer). So, they would change the current mode of report by a visual tool that would allow them to report the incident directly on a map, or through a mobile application that allows them to report using a photo, or using the GPS location. Mostly students, by their nature, say that a mobile app would be useful, since they all have smartphones and they would not have to move.

Moreover, PDI is in general, happy with the resolution of incidents because the incidents are solved, but suggest that the resolution time is high.

About the question of what elements and functions should have the application, both of them, students and PDI, have focused mainly on the reporting process becomes a fast and simple process, and does not require the introduction of many data (personal or concerning the incidence). Additional feature named by PDI surveyed, is the possibility to keep under constant review the status of the incident.

As for PAS (Annex II), is the group that reports most. The totality of the 5 surveyed, usually report a range of 0 to 3 incidents daily. The reasons are due for maintenance, rounds of recognition to detect incidents and incidents related to the incident that is being fixed.

A member of the PAS is assigned between 1 to 3 incidents daily. Regarding its resolution, they indicate that all incidents are solved within a period of one to two

days, so the amount of incidents solved daily depends on the number of pending incidents from the previous day and the complexity of incidents assigned that day.

About the way to assign the incidents, these are arranged in chronological order by the manager, however, workers do not always follow this order in their resolution. It was noted that, in certain cases, the worker who knows the area orders the incidents using the proximity criteria. In general, they indicate that the incidents organization, at least for everyday incidents or low importance incidents, proximity would be more appropriate, as there are situations in which the worker must walk significant distances, returning later to nearby places to previous incidents in the same day, so they lose time.

With regard to the way of work, they indicate that the information for each incident is presented on paper and any type of digital format is used, except when they deliver the final report to the institution, which is done manually. Regarding content, the information is adequate, but not its quality because it is inaccurate. This happens in cases where the incident occurs in places that are not offices or classrooms (which have codes that identify the location), since the report implies the description of the place where it occurred, and this description is not generally easy to locate.

They have been asked about their opinion on whether they believe that a tool that presents data in a visual way would help in performing their function. The answer in all cases was affirmative, and they have further indicated that the main elements that should have this tool would be a map, since the location of the incident is the basis of all their work, as well as colors to identify the different states of incidents. With regard to its functions, the necessary basic ones would be have the proper information about the incidence (so that the paper support would be eliminated), ability to report, change information and change the status of the incident.

With regard to the interview that was performed to a manager (Annex III), he indicates that on average are assigned daily 16 incidents, and that over a period of between one and two days, all of them are solved. Of these incidents, most are reported by PAS, followed by PDI. Besides assigning operators incidents chronologically, the manager makes a preorganization of the incidents by specialty (type of incident).

In relation to knowledge of the current system, a mailing was performed to PAS and PDI groups to inform of its existence and procedure. However, the manager assumes that practically mostly members of PAS and PDI know the system and its operation, not students that practically do not report.

As for the way of working, workers formalize their reports when they finish the day and arrive at the central office, so the same time and place of occurrence are assigned to all incidents to avoid wasting time on bureaucracy. In addition, incidents which occurred outdoor are not included within their classification, by the difficulty of locating and, according to the manager, because of the low relative importance with respect to incidents that occur in the indoors although they are within its competence.

About the format used to work with the data, the manager notes that incidents data are printed and they work with a physical format. Also, he notes that incidents data is stored in a database, which shows the data in tables, so the data are untapped, as they have not the necessary tools to work with them such as a visual tool.

Regarding how to improve participation, manager response was that it would improve through a mobile application that makes the report easy and accurate. In addition to the ideas provided by the workers, the manager stands out above all, the importance of the existence of intuitive elements to easily identify the application functions, and intuitive and easy use of the application to not be necessary to teach courses for know how use it. Besides, the manager is interested in an analysis functionality of the information that allows them, for example, to assign the optimal

route by proximity, to know what type of incident occurs more in what building, or to know where there are more incidents.

Based on the information provided by the manager of the number of incidents reported in 2013, around 6,000, and considering that in the UJI coexist around 15,000 people, then a person uses the service once every two or three years. This agrees in some way with the result of the survey, in which we can see, the low participation of students and PDI. These minimum levels of service utilization of existing service, contrast significantly with the fact that absolutely all surveyed confirm that they observe incidences frequently.

In conclusion, it is confirmed that the human component has a weakness in their commitment to the campus. Everyone observe incidents, and a considerable part of the community causes them, either as we have seen in the survey for lack of interest, information or features of the current reporting system. However, there are other reasons for it.

It has been detected that students have access to the UJI intranet, but with limited services (book or join activities), in addition they do not have an infrastructure provided by UJI as PDI (office, computer, etc.). So then, the technological improvement must fit the situation, and allows them to use their own infrastructure (i.e., smartphone). In the PDI case, when dealing with their own infrastructure, they do not have the problem to report the location, since the offices are identified, however, to report external incidents, they are in the same case that students (they have to describe the location) and also they have to report from their own infrastructure. Hence, the new system must allow to report the incidents outside of the offices and classrooms, without having to describe the location of the incident. From the information provided by the manager, the system must allow PAS to report incidents where they occur in an easy way, when these are detected and identify precisely the time elapsed until the solution, so that reliable information on the response time is obtained. Finally, as to the needs identified by the manager, the

application should include classifications of external incidents (such as water service, gardening, cleaning, etc.).

With the current system with database and tables, performing any type of analysis is difficult and unintuitive, and it is not possible to perform any analysis in some depth. Therefore, the developed application should allow collecting geospatial data, and make a spatial analysis of them, which enable the possibility of an analysis that can not be done by tables, as proximity or overlap.

As for the institutional component, although is interested in enabling participation, there is a weakness in terms of disinformation of the campus users, as there has not been given sufficient publicity nor sufficient efforts have been made to convert the current system into a common use system. The institutional problem is especially important for students. In addition, there is no solid basis regarding decision-making on issues related to the incidents, since the institution does not have the necessary information to do it (data are insufficient and incorrect).

Finally, in terms of technological component, there is also a weakness in the method used to collect incidents data and the method for using these data in decision-making, i.e., they have a comprehensive database but the tools (information presented in tables) do not allow to use them at all. The community does not feel comfortable with the current system, we have seen that even PAS sometimes does not follow the rules of its own system. Therefore, the new application should also facilitate the use of data.

#### ***4.2. Study cases***

As has been detected in the previous context analysis, the way of working of the institution responsible for the management of resources (OTOP) is to store all the incidents data in a database and then obtain it using queries to obtain the tables and printing it in a physical format (paper). This means that this way of working does not use the potential of the incident data. For example, to make a decision as to the most

optimal path to be followed by the worker, the possible solution would be to order the incidents by date, and this option could be viable on a campus, but if we extrapolate to larger area as a city, it is inviable.

Following with the example, the manager can sort the incidents by date and by type to calculate the path. However, the handicap if we compare it by using a visual tool to represent data spatially is obvious. The manager can observe which building is near of each building and what things are inside of each building.

Another example, is the traditional allocating of more funds for heating to the older building, but it can be the case that it is wasting money in a building that does not require it. Although this information can be obtained from the data in table form, it can not be compared with the display potential of a visual tool.

Since, the data collection sessions could not be concluded for the reasons explained below, and given the existing analytical gaps, three study cases have been developed with random data to demonstrate different types of analysis that the application allows to perform, and which would be available to the institution and the manager.

Apart from having a limited time to obtain a significant data sample (given the nature of the application), the application did not have the required diffusion because it should have been publicized by the available UJI communication channels such as the institutional Web, or through students mailing, etc., with the aim of a first contact between the application and final users.

One of the weakness that was detected in the previous analysis of the context was that the institution was not provided with a visual tool that would allow them to use all the incidents data stored. The technological improvement makes a change in the shape of the reception, organization and presentation of data to a more visual style of interpretation.

The development of the case studies has been adapted to the way of working of the OTOP in their way of classifying infrastructure or services offered at the university.

#### 4.2.1. Where is there more participation?

The first study case consists in find out in which parts of the campus there are more user participation. To do this, the data that have been used are all incidents regardless of any of his attributes (status, type, date, etc.).

To represent it visually it has been used a heat map (Fig. 33). Heat maps are two-dimensional representations of data in which values are represented by colors, providing a visual summary of the information immediately. That is, it uses color to communicate the relationship between the values of the data, making easier to understand it than a numerical representation in a spreadsheet. On this map the number of reported incidents is counted and displayed using a default color gradient that sets the lowest value for a dark blue color, for the highest value bright red, and the average values for light gray with a transition between the extremes.

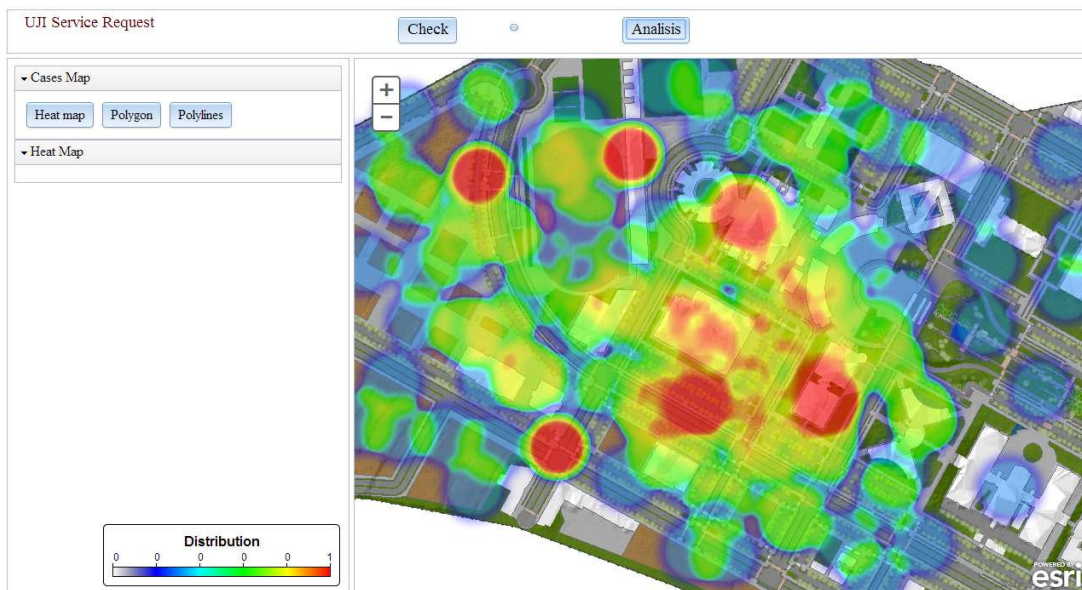


Figura 33. Heat map

This visual tool is useful for administration, as to the naked eye can detect where there is greater participation of users, being useful, for example, for making decisions on where to spend more resources to encourage and promote the participation of users UJI (posters, participation programs, etc.).

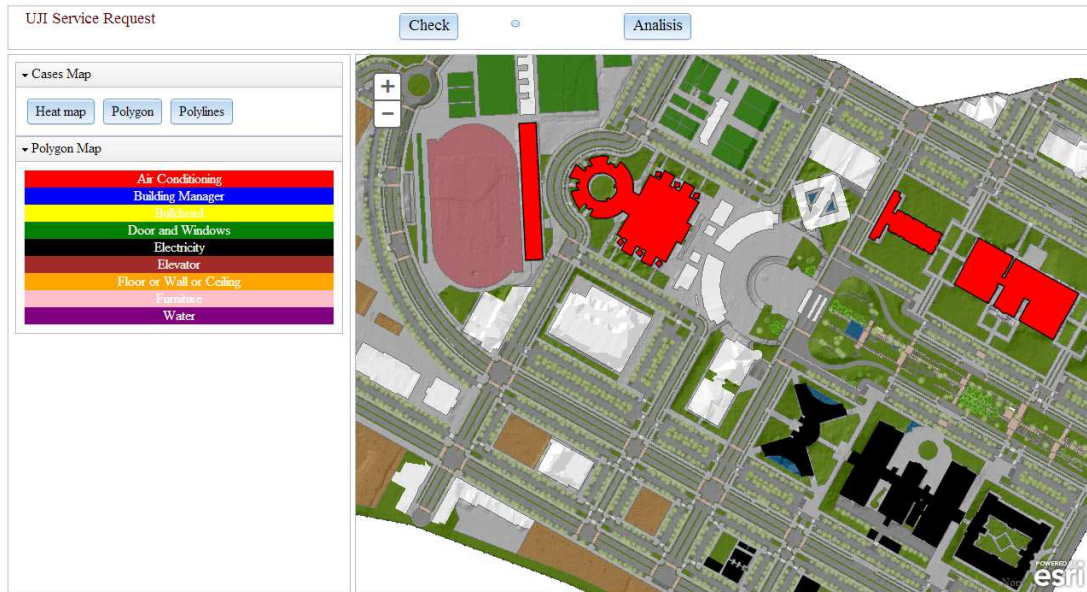
A possible improvement of this study case could be achieved by filtering the types of incidents by the type of user who reports, allowing, for example, if students are those who are less reporting, encourage them by placing posters in frequented places, or organizing more specific participation programs.

#### **4.2.2. What kind of incident occurs more in each of the three faculties?**

The second study case involves knowing what type of incident occurs more in each of the three faculties. To do this, the data used are all incidents but in this case taking into account some attributes, since it is necessary to know the total number of each incident in each faculty of each type.

To represent it visually, it has been used a colored polygon map (Fig. 34). On this map the number of occurrences of each type of incidents in each faculty are counted and the color corresponding to the most frequent occurrence in each faculty is assigned to the polygon that represents each of them.





**Figura 34. Polygon map**

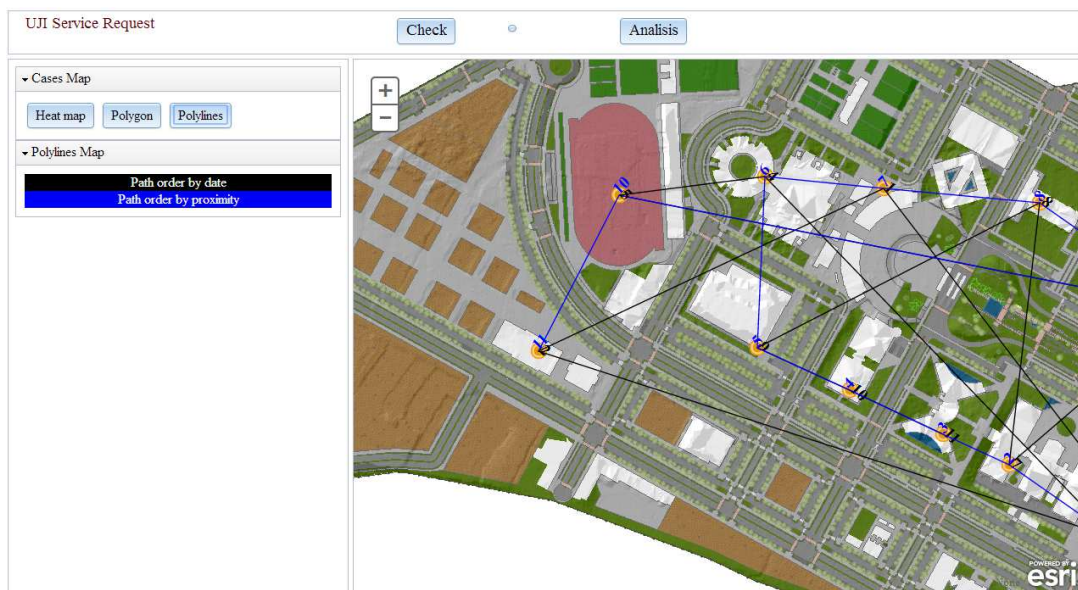
This visual tool is useful for the administration as it can help, for example, to know the functioning or performance of facilities, to prioritize maintenance activities in each faculty and/or assess the quality of maintenance companies responsible for each resource.

The analysis of this study case could be refined including also certain attributes such as age of the building, its uses, number of floors, etc. For example, a building without elevator (one floor) have fewer incidents of elevators than a building does have elevator (more than one floor), an older building has more incidents of climatization than a new one (or should in theory, so if not, something is wrong at this facility), or a sports building (with changing rooms) seems like it should have more incidents of SHM (Sanitary Hot Water) than a classrooms building or offices.

#### **4.2.3. In what order the incidents are solved?**

The third study case consists of deciding in what order resolving incidents. For this, the data used are the assigned incidents to a certain worker, as well as its coordinates.

To represent it visually, it has been used a color map of polylines (Fig. 35). On this map have been identified the incidents assigned to a given worker, established an incident as a starting point, sorted the remaining incidents by proximity based on the starting point (using the coordinates attribute), and drawn the polyline following this order. In addition, the date attribute is used to represent, as an object of comparison, the resulting polyline if the incidents have been sorted by this attribute. Both polylines are represented by two different colors.



**Figura 35. Polylines map**

This visual tool is useful for administration because quickly can make better decisions about the optimal routes to be followed by workers (maintenance, cleaning, etc.), and thereby optimizing the management of their resources (time, working hours, fuel, money, etc.).

A possible improvement would be to combine date with proximity (coordinates) because it may be the case that an incident that is away never get fixed. The introduction of new and closer incidents (highest priority) would cause that the previous farthest incident has a lower priority. Another option is to add a priority attribute, so that the institution can give different levels of importance to the incidents so that this will influence in the solution order of them.

### ***4.3. Posterior context***

In this section, the context of the three components once developed the application is analyzed, through observation, surveys and an interview with the same users as in the previous context. In them, the developed application is shown to users, its different interfaces and in a general way, how it works.

The responses of students and PDI were very similar and favorable. In general, argue that an improved system for reporting incidents as thr introduced, would be very useful, mainly for two rehazos. First because they do not have to move when they need to report a problem (since both roles are on campus with very specific tasks and have no time to lose) and secondly, because they believe that granting this facility will encourage a better campus, since people would use the application to report incidents.

Both, in the survey and in the specific question about whether they think the application is intuitive and easy to use, especially students say they would not have any problem to use it because it is simple and clear.

About the elements they like most, they have pointed to the map because it is clear and easy to select the place where the incident occurs, the extensive use of symbols to represent different things as well as the ability to monitor the incidence, especially when the issue affect them.

As items to add, they have indicated elements such as contact information in case of questions or problems with the application, to upload a photo (as can already done with other applications) or automatic location where they are by GPS.

The entire sample say that would use the application regularly, especially when an incident affects them or the importance of it is considerable, and they also would recommend it.

According to the PDI responses of surveyed who know the current system, say that this new application introduce a great improvement in terms of accessibility and flexibility, allowing them to report incidents anywhere, and in a very easy way.

PAS workers were asked if they believed that this application provides enough information to resolve incidents and the work performance. Their answer was yes in all cases. There are several reasons among we find that, although it provides the same information to the worker, it does it in a more organized way, or because the incidence appears lying on a map and not described, so that in places without logical location is very helpful. They were also asked whether in their opinion the elements of this application are sufficient. Although they said yes, they named certain additional elements as elements that reflect the level of difficulty of repairing the incident, or the percentage of work already done.

About the functions that allows this new system, although these are sufficient to do the tasks, they have highlighted a very important function that could be added, one that allows communication between the worker and the control center, either to send reports, to ask for material requirements or other kinds of needs.

Because any change should carry an acceptance, it was wondered about their opinion on replacing the physical support they are currently using. The answers regarding this issue were very favorable, being mainly young people. A response that would represent all of them would be "evolution is always favorable".

About the aspects they like most, they highlighted the map display, since it allows them to get better orientation in the campus and distinguish perfectly the entire campus. Other highlighted aspect was that with this new system they would avoid to carry with the incidents documents. Furthermore, they say that it is accessible, flexible, intuitive and easy to use. Finally, they were asked for their perception of the current reporting system with respect to the improvement made. Their perception is that the Web mapping application is better than the current system.

The second interview with the manager provides very useful information. The first question asked was if he think this new application would encourage an increased in participation. His response was positive, arguing first that the fact that it is a new element may implicitly encourage its use, and secondly because it transforms the reporting procedure, treatment and repair of incidents to a current, modern and adapted to the needs system.

As in the PAS case, the manager was asked for his opinion about the reaction of the workers to the change in the case of replacing the current working system. According to the manager, workers would be satisfied with this change, as it has received some complaints about the current system and suggestions for change by employees.

One of the functions primarily intended for the use of manager is the analysis of the data for searching information. Regarding the question about the usefulness of these analyzes, the manager stressed its importance and convenience, as it allows use the database to perform data analysis, so it is useful for decision-making, resource management, and it allows to observe details quickly.

The manager also indicates that it is an intuitive tool that can save resources by providing information, especially in location of incidents, where time can be saved, as well as money. As to the stood out element, the manager showed interest in the analysis that the application allows, and therefore he believes that this tool would help him to do his job.

As regards the elements that make up the application, the manager indicates that they are sufficient and that the application contains all the key elements to develop all tasks, but everything could be improved. About the functions to add, the manager has indicated the possibility to track the worker, either at its location while is resolving incidents, or performance statistics.

When the manager was asked to compare this application with the current system, he ended with the superiority of the system proposed in this thesis, arguing that it introduces key elements and functions that would place the reporting system at a higher level.

Finally the last question was about if the institution would be interested in having a permanent tool of this type. The manager replied affirmatively and, in fact, the OTOP is very interested in the application and in the fructification of this project.

In conclusion, can be appreciated that it has created an opportunity to resolve the issue of participation of the human component, adapting to their needs and trends. In principle, providing users, especially students, a mobile application that makes it easy to report through its own infrastructure, there is a willingness of users to accept new ways and to use them. However, the change in the human component will only be useful with a change in the institutional component.

Making easier the collection of geospatial data about location and time of the incident (including all of them regardless if they occur indoor or outdoor), possible thanks to the ease of the new system to track incidents, it is obtained information more precise, real, broad and, therefore, useful to develop valuable analysis for the institution as proximity or overlap, which are not possible with the current system.

As has been seen in the study cases, the manager would be in a position to make certain analysis and get for example, an improvement in route planning, identify weak points in facilities or features of buildings and outdoor environments (e.g., to locate the air conditioning fails more in a certain type of building). With data from the current database these analyzes would be impossible, would give a wrong perspective because all information about the location of incidents is totally wrong.

Additionally, with new tools, more advanced and practices that improve resource management and decision-making, there is no reason for the institution does not encourage its implementation and therefore, change.

Finally, an evolution would occur in technological component, a progress (determined by the improvement in the processing time of the data, the time for interpretation, and by the change in the way of representing data using a visual depiction), by solving in this case, the weakness detected in the previous analysis.

Encourage users to use the application as a tool at their disposal is a fundamental part for its progressive diffusion. To do this, it is possible to use a system commonly performed in UJI such as some kind of monetary compensation, or through games.

To finish the analysis, note that the results of the surveys and interviews are generally what were expected from the own observation.

## 5. CONCLUSIONS

Geographic information plays an important role in the evolution of society, as the spatial component is increasingly important. The scope and uses of GIS are very wide, and its effects on the components system built around the concept of smart city is huge. In the context of this thesis, to know what is happening and where, location-based information, is the key.

Although it was assumed that the components of a smart city are connected, it was found that the relationship between them is very strong and can not be isolated, since as we have seen, a weakness in one of them, directly affects other. So we could say that the three work as a whole.

Therefore, there must be a bidirectional communication between the institutional component and the human component by the technological component for the smart concept makes sense in a city.

This strong interrelationship, is determined by a particular component. People are behind the actions and changes in each of the three components, therefore, are the central axis of a smart city.

As it was possible to verify, without institutional support there is a problem of misinformation and commitment of people. If the human component does not know that participatory tools are available, it will not use them, and if we add the lack of promotion or use programs, or lack of knowledge of them, the result is an environment with problems as discussed in this thesis.

People need communication and information, to know their chances of participation, their place in the government (in this case, their ability to report incidents), to know that their action is good for something, and all of this is determined by the performance of the institutional component.



The institutional component is which first should provide solutions to the problems for the benefit of all. If not, there may be movements from the human component (to promote evolution and change) that attempt to provide solutions to problems (the common good).

The institution must not lose the connection with the human component, because if this happens, the institution is not doing its job. Thus, it must equip itself with the technology component that allows it to promote the participation and involvement of the human component and not promoting isolation between them.

In order to exist communication through the technological component between the institutional component and the human component, the institutional component has to properly disseminate the existence of the technological component on the human component, since a tool to solve a problem if it is not used, it is like it does not exist.

It has also been observed as the wrong choice of instruments or technology to deal with the data may produce negative effects, being unable to visualize and interpret these data properly, and therefore, its transformation into information is not ideal (resources are available but are not exploited).

Another important aspect are the technology trends which people become customs or ways of doing things. Currently, has taken and is taking place a change towards the computerization and automation of many aspects surrounding the lives of people. People like technology that allows them to solve problems in a quick, accessible and visual way. Therefore, changes must to live up to the expectations of the users.

Nowadays, we can see that GIS are essential, especially in the evolution that is taking in the concept of city or similar environments. The geospatial component, in this regard, is key information, since things happen in specific places, which have an

implicit information component. Currently, and increasingly, the running of smart cities is not possible without GIS.

### ***5.1. Learnt lessons***

Within my role as student, many things are observed either concerning the institution and their behavior, or in terms of technology and infrastructure available. A challenge was to set aside this perception of the environment that I had and to focus on a little more objective information. In this sense, surveys proved to be a source of very useful, extensive and detailed information, providing even more information than I originally expected.

Initially was designed a strategy based on the previous analysis in order to know the status of the environment, their characteristics and their needs. This proved to be a very good idea, because, apart from demonstrating that a mobile application was the best way to address the problem of accessibility, could also be detected because of the characteristics of the role of manager, that for him in particular, the mobile application was not an option.

Moreover, it could be seen that work relating to the detection, communication and resolution of incidents, has an important underlying spatial component. Therefore, incorporating a map so that the information becomes visual and spatial information, is a complete success when compared to manual registration.

Finally, initially raised an analysis function as essential, since having a large database with different data types, is useless if we do not have a tool to interpret and transform it into meaningful information for decision-making. Even though decide key aspects of the project before considering the environment is not recommended, in this case the immediate need for this function was evident, as currently data can not be used, either by format or by quality because they are incorrect and, therefore, useless.

## ***5.2. Future work***

Throughout the development of this thesis, have arisen ideas, either own or as the result of research, to improve diverse aspects.

The most obvious is, without doubt, to analyze the real impact that the application would have on the factors and in particular on participation. That is, it would be necessary the implementation of the application of an appropriate form, so that data could be collected.

In relation to the study cases, various modifications can be added. For example, in the generation of the optimum route, automatically select a starting point from the location of the worker (by GPS). Also, consider what other useful study cases could be implemented for decision-making of the institution.

Improving the way or the mode of reporting the geographic component, either through a Quick Response (QR) code reader, barcode reader (way to assign logical locations by OTOP) or by indoor positioning.

Other possible changes of the system would be to introduce the functionality to send a photo when reporting an incident, a communication system through the application between workers and the control center, and location of individuals by GPS (either the users when reporting, as workers while fixing). Furthermore, introducing a more complete analysis including statistical information, that provides further information, so that decisions could be taken from a better position.

It should be noted future work regarding the administration of the university. Encouraging users to use the application as a tool at their disposal is a fundamental part for its progressive diffusion.

Finally, the implemented system is considered as a prototype, so would be necessary to meet with the OTOP and other stakeholders, and lay the foundations for its design and implementation, as well as media, to carry it out.

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## **ANNEXES**



### *I. Student and PDI surveys for context analysis*

<b>Survey for previous analysis of the context</b>	
<b>User type (student or PDI)</b>	<b>Number of interview</b>
<b>Question</b>	<b>Answer</b>
Do you observe incidents? Which?	
Do you generate incidents? Why?	
Do you know about the incident report service? How do you know about it?	
Do you report the incidents? Why?	
Do you like the system to report the incidents? Why?	
Would you change something of the system? What?	
Are you happy with the incidents resolution? Why?	
What do you think is the problem?	
Do you think that a mobile application to report incidents would be useful? Why?	
What elements should have?	
What functions should have?	

<b>Survey for posterior analysis of the context</b>	
<b>User type (PDI or student)</b>	<b>Number of interview</b>
<b>Question</b>	<b>Answer</b>
Do you think that a mobile application to report incidents like this would be useful? Why?	
Does this application seems intuitive and easy to use? Why?	
What do you like most about the application? Why?	
What would you improve? Why? What elements do you think are missing?	
Would you use the application regularly? Why?	
Would you recommend its use?	
Do you think this application is better than the current system? Why?	

## II. PAS surveys for context analysis

Survey for previous analysis of the context	
User type (PAS)	Number of interview
Question	Answer
How many incidents are assigned to you daily?	
How many incidents you report daily?	
How many incidents can you fix daily?	
Are the incidents assigned to you in a certain order? Do you follow it? Why?	
Do you think that you should receive the incidents ordered to fix them? Ordered by which criteria?	
Do you have to walk a big distance between incidents? Do you have to move to places that are near from previous incidents?	
Do you think that you lose time following the pre assigned order?	
What is the data format used to transmit to you the data of the incidents?	
Is the transmitted information enough to solve the incident? Is it difficult to detect the exact location of the incident? Why?	
Do you think that the presentation of data using a visual tool is useful?	
What elements should this visual tool have?	
What functions should this visual tool allows you to do?	

<b>Survey for posterior analysis of the context</b>	
<b>User type (PDI)</b>	<b>Number of interview</b>
<b>Question</b>	<b>Answer</b>
Do you think this application would help you to do your job giving the enough information to detect the incidents location? Why?	
Do you think the application elements are enough? What elements do you think are missing?	
Do you think the application functions are enough? What functions do you think are missing?	
Do you think that a mobile application to report incidents like this would be useful? Why?	
Does this application seems intuitive and easy to use? Why?	
Do you think this application is better than the current system? Why?	
What do you like most about the application? Why?	
What do you like to improve about the application? Why?	

### *III. Manager interview for previous context analysis*

<b>J:</b>	Juan López Roca
<b>M:</b>	Manager

<b>J:</b>	Focusing on the topic at hand, let´s fully enter into the questions.
<b>M:</b>	Go ahead, ask me whatever you need.
<b>J:</b>	Approximately how many incidents are usually assigned daily?
<b>M:</b>	Since last year we had approximately 6,000 incidents (Annex VI), I could say the average would be about 16 daily.
<b>J:</b>	And of those 16 incidents assigned daily, how many of them are repaired?
<b>M:</b>	Incidents that occur on campus are all fixed as soon as possible, this is generally between one or two days, depending on its magnitude or the necessary personnel and material requirements.
<b>J:</b>	As for who reports, would you say that most of the reports come from students?
<b>M:</b>	No, no, quite the opposite. The vast majority of the reports are made by PAS workers. Teachers also reported, although to a lesser extent, and usually when the incident affects them directly, especially in offices that they use.
<b>J:</b>	So, what could you comment in general about the levels of knowledge of UJI users on the report system that OTOP uses?
<b>M:</b>	Beginning with students, certainly they do not know as they do not use it. The PDI know the system for their needs, working in university facilities, most of them have used it, but as I said before, they just use it to solve problems affecting them when performing work or teaching in determined classrooms. Finally, the PAS needless to say we all know it.
<b>J:</b>	Knowing this information, have promotion campaigns to promote use been developed and implemented? Is it intended to make better use of this service?
<b>M:</b>	In this sense it has not been done in the best way. The administration, and particularly the OTOP, seeks to improve participation, particularly students.

For this, the process has been simplified to the maximum, to facilitate users its use but still there were no changes. So the only thing I could talk to you about was a mailing which was sent to all employees of the university. About students I can not comment much as they do not show interest in this.

**J:** Focusing on the way to work, how the reporting system of the PAS is done?

**M:** Operators report incidents they see during the day, however, these reports are all officially recorded as reported in the same moment, in the moment they arrive at the office with all instances of incidents and they are introduced into the system. Moreover, these incidents are reported as occurred in the same building, the building of facilities, although they have occurred elsewhere. All this is done to save operator time with bureaucracy at the time of detection and repair.

**J:** I found information on the classification of incidents, is it real and updated?

**M:** Yes.

**J:** I have seen that external incidence are not included in such classification. Is there a reason? i.e., are they outside the competence of OTOP? or no incidents occur outdoor?

**M:** Incidents occur outdoor, and they are also the responsibility of the OTOP, however, their relative importance with respect to incidents that occur inside, is low. They are also more difficult to treat and report as the OTOP work is based on the codification of locations and outside that is very complicated.

**J:** Focusing on the way to work, when incidents are known, are they assigned to operators in a certain order? or is each operator who manages them?

**M:** Initially all the incidents are grouped by type, i.e. those related to issues of electricity, plumbing, etc. Once we have these groups, incidents are assigned to specialized workers chronologically.

**J:** And how data relating to all incidents are treated?

**M:** Though I can not tell you the reasons, we still work with paper sheets. At the start of the day for each incident a sheet is printed with all the necessary information and they are distributed to the corresponding operators.

**J:** And how are data from previous years stored?

**M:** Data is stored in a database that displays information in tables. This is a problem because it is often not useful for forecasting or other uses, the information is, among other things, disorganized.

**J:** Then, do you think that a visual tool would help you do your job and improve decision-making?

**M:** Yes, without a doubt.

**J:** What would be a good way, in your opinion, to encourage student participation?

**M:** I think a mobile application, because everyone has a smartphone. It should allow easily report incidents, requiring little time for it. For us, the most important is to be precise, as I said before, visual. A tool that provides useful information to analyze the incidents, to understand where they occur and why, and to decide basic issues of this work such as the best path to follow.

**J:** What do you mean by the term visual?

**M:** Mainly a map. Please note that in addition to repairing damage caused and incidents in general, our work is based on the self-detection and location of incidents reported, which can become very complicated in certain cases. So, I think in summary map and accuracy would be indispensable.

**J:** What elements would be key to its success?

**M:** I could name many, as we have long been behind an improvement of this type, but without doubt, I should prioritize the existence of intuitive elements that relate quickly with the functions they perform, both in its use for users and for operators, sparing us training costs.

#### *IV. Manager interview for posterior context analysis*

<b>J:</b>	Juan López Roca
<b>M:</b>	Manager

<b>J:</b>	Do you think this new application would encourage an increase in participation?
<b>M:</b>	As I mentioned at the previous meeting, I think it is the proper support to promote an increase in participation, especially students. It transforms the act of reporting incidents in a contemporary and modern process, adapted to the needs of the university community.
<b>J:</b>	And do you think the team of workers would be in accordance with a change of this type?
<b>M:</b>	Of course, the OTOP team really believe that is a good start and the right way. In fact I have received complaints from workers about problems on the way of working and suggestions for change towards a more modern way than the current. I must also say that new developments like people, and just for this, it may already lead to an improvement.
<b>J:</b>	Once seen analyzes that this particular application would allow to do with data collected, do you think they would be helpful?
<b>M:</b>	If I remember correctly, some of these analyzes or information it provides coincide with a functionality discussed in the previous meeting, in particular, the optimal path. I believe this is possible and would be very beneficial. And about the usefulness of the analysis as a whole, I think if they allow the leverage data that are available, they are useful.
<b>J:</b>	Would you say that the analyzes allow to save resources?
<b>M:</b>	Sure. More information allows for better decisions in general and in terms of resources. With more information, especially regarding issues of location, details could be observe details quickly, and save time, which definitely is money.
<b>J:</b>	If you should highlight an item, what would it be?
<b>M:</b>	If I had to choose one I think that in my position, I would stay with the analysis, the most important for my charge.



**J:** In general, do you think the elements offered by the application are sufficient?

**M:** From what I have seen, elements are sufficient for each user, for students and for PDI to report, for PAS to locate and fix, and for me to manage. In fact, it incorporates some additional elements to the current system. However, all accept improvements.

**J:** So, what features would you add?

**M:** Some interesting features would be to track operators, where they are, what incident they are solving, or at what stage, and statistics, for example, individual or group performance.

**J:** Would you rate the application as intuitive and easy system?

**M:** Definitely yes.

**J:** Could you make a brief comparison between the application and the current system?

**M:** From everything said in the other questions, I could say that your application introduces key elements and functions that would raise the incident reporting system of the university to the next level.

**J:** Finally, do you think the university administration would be interested in permanently implanted a system like this?

**M:** I truly believe that under normal conditions, the administration would be interested. No doubt, I am very interested in the application, and on progress in this sense, first, because evolution is inevitable, and secondly because many of the problems we have been discussing in the meetings would be solved. From this office you will have all the support you need for the prototype that you taught us today, can become a part of the university system.

## *V. Infrastructures and services classification by the OTOP*

Type	Subtype
<b>Air Conditioning</b>	<p>Not suitable temperature.</p> <p>The thermostat does not regulate properly.</p> <p>The diffuser is noisy.</p> <p>The fume cupboard is not working properly.</p> <p>Smells in the air output.</p> <p>The ventilated radiator is not working properly.</p> <p>New installation.</p>
<b>Building Manager</b>	<p>Schedule changes of air conditioning of classrooms, laboratories, etc.</p> <p>Schedule changes of corridors lighting and common areas.</p> <p>Authorization of lighting and air conditioning at night and holidays.</p>
<b>Bulkhead</b>	<p>Do not close properly. Repair fodder.</p> <p>Dismantling and assembling panels to installations.</p> <p>Modification of panels.</p>
<b>Door and Windows</b>	<p>Do not open or not close poorly.</p> <p>Repair fodder.</p> <p>Malfunction of electronic locks and aperture cards.</p> <p>New installation.</p>
<b>Electricity</b>	<p>Fluorescent tube molten or flashing.</p> <p>No electrical flow at sockets.</p> <p>Do not turn on the light (office, classroom, seminar, lab, etc.).</p> <p>Switches and sockets broken.</p> <p>Table lamp with molten light bulb.</p> <p>Diffuser screen loose.</p> <p>Outdoor lighting does not work.</p>

	New installation.
<b>Elevator</b>	Not working. Door can not open. A piece of the cabin in poor condition. Switches that do not work. No light in the cabin.
<b>Floor or Wall or Ceiling</b>	Breaks tiles. Paint in poor condition. Modification of floors, walls and ceilings.
<b>Furniture</b>	Repair of furniture (tables, chairs, cabinets, etc.). Hang or remove boards. Changing signaling. Place and remove banners and posters. New furniture.
<b>Water</b>	Sanitary loses water. Loose taps and broken WC lids. Drains clogged or leaking. Water stains on walls and ceilings. Loss of gases in the laboratory. New installation.
<b>Outdoor</b> <sup>6</sup>	Vehicles (ford busy, illegally parked car, etc.). Gardening. Cleaning (accumulation of garbage, etc.). Street equipment. Other.

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<sup>6</sup> New category created with the consensus of the OTOP.

*VI. Incidents data provided in the manager interview*

Type	Number of
Air Conditioning	576
Building Manager	359
Bulkhead	61
Door and Windows	124
Electricity	1097
Elevator	837
Floor or Wall or Ceiling	106
Furniture	2356
Water	100
Others	352
<b>Incidents reported</b>	<b>5,968</b>

# Masters Program in **Geospatial Technologies**



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Dissertation submitted in partial fulfilment of the requirements  
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