

Low-cost Solution for Registration and Identification of Rural Properties

Technical and Financial Feasibility Analysis

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Abstract

The private property present great importance in the life of people in a society, in this manner it becomes important to know the characteristics and limitations that they present in order to ensure the organization and respect of the laws. With this, the difficulties and inconsistencies in the process of registration of properties currently used, mainly in the rustic context of Portugal are presented. Also, the issues and the high bureaucracy for the identification and collection of property data is also discussed.

The objective of the work is to develop a low-cost solution to solve the problems of registration and identification of properties. For this, it was opted for the development of a mobile application, since the devices currently present technologies such as GPS and Camera, that if compared with specific equipment, present a great difference of cost. In addition, the paper also proposes a business model that aims to ensure the commercial viability of the solution.

For the development of the solution, it was decided to use current technologies such as Ionic and Apache Cordova that aim at friendly user experience and also enable cross-platform. In addition, it was also developed a web server and its communication between application and database.

Finally, it is concluded that the work done in this dissertation proves the viability of creating a solution that fulfills the defined requirements. It presents a viable business model and presents a tool that can geographically demarcate in order to maintain a persistent and accurate record. Besides, it presents the results of the record in a simple way for different types of users.

Keywords: Registration, Identification, Properties, Application, GPS

Resumo

A propriedade privada apresenta grande importância na vida das pessoas em uma sociedade, desta forma torna-se importante conhecer as características e limitações que elas apresentam para garantir a organização e o respeito às leis. Com isso, são apresentadas as dificuldades e inconsistências no processo de cadastramento dos imóveis atualmente utilizados, principalmente no contexto rústico de Portugal. Além disso, os problemas e a alta burocracia para a identificação e coleta de dados de propriedade também são discutidas.

O objetivo do trabalho é desenvolver uma solução de baixo custo para resolver os problemas de registro e identificação de propriedades. Para isso, optou-se pelo desenvolvimento de uma aplicação móvel, uma vez que os dispositivos atualmente apresentam tecnologias como GPS e Câmera, que se comparadas a equipamentos específicos, apresentam uma grande diferença de custo. Além disso, o trabalho também propõe um modelo de negócios que visa garantir a viabilidade comercial da solução.

Para o desenvolvimento da solução, decidiu-se usar tecnologias atuais, como Ionic e Apache Cordova, que visam uma experiência agradável para o usuário e também permitem o desenvolvimento multiplataforma. Além disso, também foi desenvolvido um servidor web e sua comunicação entre aplicativo e banco de dados.

Finalmente, conclui-se que o trabalho realizado nessa dissertação de mestrado prova a viabilidade de construção de uma solução que cumpre os requisitos definidos, apresentando um modelo de negócio viável e uma ferramenta que pode demarcar uma propriedade geograficamente para manter um registro persistente e preciso. Além disso, a ferramenta apresenta os resultados do registro de maneira simples para diferentes tipos de usuários.

Palavras-chave: Registro, Identificação, Propriedade, Aplicação, GPS

General Index

| | |
|--|------|
| Acknowledgments | iii |
| Abstract..... | v |
| Resumo | vii |
| General Index | ix |
| List of Acronyms..... | xi |
| Figures Index | xiii |
| Listings Index | xv |
| Chapter 1 Introduction | 1 |
| 1.1. Description of the problem | 1 |
| 1.2. Objectives | 2 |
| 1.3. Structure of the thesis | 3 |
| Chapter 2 Contextualization..... | 5 |
| 2.1. Problem description | 5 |
| 2.2. Description of the proposed solution | 7 |
| Chapter 3 State of the Art..... | 9 |
| 3.1. Introduction..... | 9 |
| 3.2. Property registration process | 10 |
| 3.3. Property demarcation process | 10 |
| 3.4. Technological tools and similar solutions | 11 |
| 3.5. Conclusion | 12 |
| Chapter 4 Business Model | 15 |
| 4.1. Introduction..... | 15 |
| 4.2. User types in the Registration process | 16 |
| 4.3. User types in the Visualization and Identification process..... | 18 |
| 4.4. Conclusion | 19 |
| Chapter 5 Architecture | 21 |
| 5.1. Introduction..... | 21 |
| 5.2. Architectural diagram | 21 |
| 5.3. Architectural diagram with technologies | 23 |
| 5.4. Conclusion | 26 |
| Chapter 6 Analysis | 27 |
| 6.1. Introduction..... | 27 |
| 6.2. Stages of the identification process | 28 |
| 6.3. Stages of the registration process..... | 32 |

| | |
|---|----|
| 6.4. Conclusion | 36 |
| Chapter 7 Implementation..... | 37 |
| 7.1. Introduction..... | 37 |
| 7.2. Application development..... | 37 |
| 7.2.1. Identification process development..... | 39 |
| 7.2.1.1. Asynchronous operations | 40 |
| 7.2.1.2. Communication between application and server | 41 |
| 7.2.1.3. Google Maps API functions..... | 41 |
| 7.2.2. Registration process development..... | 42 |
| 7.2.2.1. Geolocation functions | 42 |
| 7.2.2.2. Polygon intersection identification algorithm..... | 43 |
| 7.2.2.3. Camera settings | 44 |
| 7.2.2.4. Storage strategy | 45 |
| 7.3. Server and Data Base development | 45 |
| 7.3.1. Express | 46 |
| 7.3.2. REST API..... | 47 |
| 7.3.3. Sequelize..... | 48 |
| 7.4. Conclusion | 49 |
| Chapter 8 Conclusion..... | 51 |
| 8.1. Discussion of results | 51 |
| 8.2. Application test | 52 |
| 8.3. Future work..... | 55 |
| Bibliography | 57 |
| Annexes | 59 |

List of Acronyms

| | |
|-------|---|
| CSS | Cascading Style Sheets |
| DGT | Directorate General for Territory |
| GPS | Global Positioning System |
| GRRP | Geometric Register of Rustic Property |
| HTTP | Hypertext Transfer Protocol |
| JS | JavaScript |
| MVC | Model-View-Controller |
| NSEMC | National System for the Exploration and Management of Cadastral Information |
| ORM | Object-relational mapping |
| REST | Representational State Transfer |

Figures Index

| | |
|---|----|
| Figure 1: Landmarks that define limits of a property (reproduced from [4])..... | 11 |
| Figure 2: Use case diagram of the registration process | 16 |
| Figure 3: Use case diagram of the identification process | 18 |
| Figure 4: Architectural diagram | 22 |
| Figure 5: Architectural diagram with technologies | 24 |
| Figure 6: Activity diagram of identification process..... | 28 |
| Figure 7: Activity diagram of the map and properties display | 29 |
| Figure 8: Diagram activity of property interaction..... | 30 |
| Figure 9: Activity diagram of registration process | 32 |
| Figure 10: Activity diagram of demarcation stage | 33 |
| Figure 11: Activity diagram of the data saving process | 35 |
| Figure 12: Ionic project structure | 38 |
| Figure 13: Application tabs layout | 39 |
| Figure 14: Server NodeJS Express project structure | 46 |
| Figure 15: Result of the REST API request | 47 |
| Figure 16: Database table file | 48 |
| Figure 17: Charts representing the form answers about the solution | 53 |
| Figure 18: Answers from users regarding the potential of the solution | 54 |
| Figure 19: Application guide part 1..... | 59 |
| Figure 20: Application guide part 2..... | 60 |
| Figure 21: Application guide part 3..... | 60 |
| Figure 22: Application guide part 4..... | 61 |
| Figure 23: Application guide part 5..... | 61 |

Listings Index

| | |
|--|----|
| Listing 1: Code fragment representing the function chaining | 40 |
| Listing 2: Code fragment representing the HTTP request..... | 41 |
| Listing 3: Code fragment representing the retrieve of coordinates from a polygon | 42 |
| Listing 4: Code fragment representing the collect of coordinates..... | 43 |
| Listing 5: Code fragment representing the polygon verification function | 43 |
| Listing 6: Code fragment representing the camera options..... | 44 |
| Listing 7: Code fragment representing the save strategy | 45 |
| Listing 8: Code fragment representing one method of the REST API..... | 47 |
| Listing 9: Code fragment representing the "file" model..... | 48 |

Chapter 1 Introduction

In this chapter, the introduction to dissertation work is made. The chapter is organized into three sections, namely: "Description of the problem", "Objectives" and "Structure of the thesis". In the first one, the contextualization of the problem is presented and the proposed solution is approached. The second section presents the objectives defined for this dissertation. Finally, the third section presents the structure of the thesis, with the description of each step performed.

1.1. Description of the problem

Due to the importance that private property represents for individuals in a society, formal knowledge about geographic areas that are directly related to these individuals, represented by houses, sites, land, and others, becomes important. As generations go by, the geographical boundaries between private property, especially those present in rural areas, become complex to be determined, since often the delimitations are based on simple assumptions or physical indications that can be altered.

The property delimitation can be considered a practice of great importance since it can be used as a way of guaranteeing the law. In addition, it has a direct role in avoiding controversies in legal relationships. When demarcating a property, still seeks to ensure a better relationship between owner and neighbourhood [1].

The bureaucracy involved in obtaining legal information of properties is subject of discussions and studies, as in [2]. With this, it can be considered that the difficulties created can act negatively in the interest of the owners on their properties.

It is in this context that this master's dissertation arises, whose thesis is to prove the technical viability of constructing a low-cost solution for end users, allowing users to search, identify, delimit and advertise geographical areas, namely rural properties. The dissertation presupposes the specification of a business model that also guarantees the financial viability of the constructed solution.

1.2. Objectives

In order to prove the thesis, the following goals were defined:

- The functional and architectural design of the solution, satisfying the defined requirements and constraints and the purpose of the solution, including:
 - The characterization of properties, identifying limits and reference elements;
 - Create and maintain a digital characterization memory that extends beyond individual memory and is more accurate than current building records;
 - Enable the use of the information obtained for the consultation - ensuring legal ways of doing so.
- Design of a business model that enables the use of the developed solution considering the needs of owners, real estate agents, public entities and others;
- Implementation of the solution, ensuring a low cost of development and use.

For the development of the proposed solution, it became necessary the knowledge of different technologies, requiring the academic deepening in each one of the modules necessary for the development of the application, being these:

- Study on mobile platform development;
- Deepening in IONIC and Apache Cordova;
- Study on the development of web services;

- Study of geographic data;
- Deepening the Google Maps API;
- Study on the use of GPS;
- Study on the use of Node.js for the development of a web service.

1.3. Structure of the thesis

This dissertation is composed of 8 chapters, organized as follows:

Chapter 1 – It presents a brief contextualization, the objectives and the structure of the thesis.

Chapter 2 – It presents a deeper understanding of the problems addressed in this work and the proposed solution.

Chapter 3 – It presents the state of the art of the process studied in this work.

Chapter 4 – It presents a business model to ensure the feasibility of the proposed solution.

Chapter 5 – It presents the architecture of the proposed solution as well as the technologies involved in the development.

Chapter 6 – It presents the analysis of the proposed solution in order to observe the functionalities and the methods of development.

Chapter 7 – It presents important aspects of the implementation, as well as the difficulties encountered in the development of the proposed solution.

Chapter 8 – It presents the final conclusion and discusses future works.

Chapter 2 Contextualization

In this chapter a detailed description of the problem is made, focusing on the current situation regarding the registration and descriptive memory of the properties, of the existing limitations, which needs to be solved. Several examples are also presented to owners of properties. Chapter 2 describes in detail the problem being studied in the development of this work, as well as, present the proposed solution.

2.1. Problem description

Geographical boundaries between properties, principally rural properties, are complex to be formally defined. The official records, when they exist, present vague data, such as descriptions of generic geographical confrontations that are directly based on the descriptive memory of people, which is normally an old population that tends to disappear.

These generic descriptions can be exemplified as: "property 'x' confronts at north the property 'y', and is confronted at the south by the property 'z'", although it is the convention used on the official records, it is common knowledge that it consists of imprecise information since it does not present effective ways of defining territorial boundaries, let alone defining existing items (buildings, trees, fountains, wells, etc.).

In the case of rural properties, often acquired by inheritance, the situation becomes even more difficult, since the descriptive memory is lost with the passing of generations and/or owners.

In addition, the current difficulty in acquiring this information makes the process time-consuming and complex, since the records can only be obtained through the public sectors responsible for this subject and by authorized persons.

As a consequence of this inaccuracy and difficulty in obtaining information, there are personal losses, commercial difficulties or even tax fraud. But also, aspects of civil liability, such as property cleaning or eliminating public health threats (elimination of pests or sources of pollution).

The personal losses can also occur due to potential territorial disputes. These owners may be harmed directly by the lack of descriptive memory, or by the lack of witnesses who also have them. Consequently, with the imprecision of formal records, injustices can be committed.

Commercial difficulties and possible fraud can be considered direct results of the difficulty in obtaining the information and the imprecision present in the formal records. As there is a high bureaucracy to obtain the data, the time taken to survey them, can lead to delay possible trade agreements. Already in the context of tax fraud, as taxes are related to the type and size of properties, the inaccurate official data may enable or facilitate possible frauds.

Civilian aspects, in the context of private property, may be related to current discussions, such as the question of the owner's responsibility to his property, in the area of land clearances or health threats. It is known today that forest burners are one of the great agents responsible for the emission of greenhouse gases to the terrestrial atmosphere, in turn, it is correct to suppose that the negligence of owners with their properties contributes directly to that fact.

Therefore, when considering the environment that involves the situations described, the problem of having as the main component of formal registration inaccurate data and descriptions based on a memory described volatile, and the current way of obtaining data related to registration of rural properties, it is understood that there is room for the exploration of a solution with a strong technological component, which aims solving or assisting the process of territorial registration of properties, allowing well defined geographical delimitations and data availability in a formalized and simplified way.

With this, it is possible that this information can be used for personal purposes, for example, to create and maintain a descriptive memory of properties in a persistent way, supported by current technologies; but also, for purposes of public responsibility, such as identifying owners who neglect their properties; and also, for commercial purposes in real estate - helping to identify owners or promote properties.

2.2. Description of the proposed solution

Considering that the current means for the formal property registration are imprecise, as the means for the collection of information are time consuming and bureaucratic, this master's work is based on the possibility of exploring a solution, with a strong technological component, that seeks assist both processes, and present a viable business plan for the solution.

The proposed solution consists of the development of a mobile application that can be used for both processes, characterization, and registration of properties, as well as for identifying and obtaining information, namely contacts or means of contacting owners.

The use of a mobile solution is shown as a good cost-benefit since the mobile platform provides the necessary means such as internet access, camera, GPS, and development is focused on software.

As described previously, two main problems have been described in the context of this work. The first one consists of the inaccuracy of the records of formal properties, and the second consists of the complexity of identifying and obtaining information about formal properties and their owners.

In order to carry out the characterization and registration of properties, the solution proposed in this work allows the user, using GPS, to collect the coordinates that consist of the perimeter of the property. For this, the user physically walks all the extension of the property boundaries, and the mobile solution automatically collects all geographic coordinates in a persistent and precise way. In the end, the route, which consists in the boundary of the property, is made available and graphically presented on the application.

This process can be complemented by the addition of other evidence, such as photos, landmarks or objects that help to realize the concept of border. The photos added during this process are contextualized both temporarily and in terms of geographic location.

In addition, during the registration of this process, the user adds more data, such as the identification of the pseudo owner. With this, the process of registering property is completed.

In order to perform the process of identifying and obtaining data of properties, the user interacts with the solution and the identification can be done by the site itself, using the GPS, or by identifying the position of the properties on the map provided by the application. If the record is associated with the current position, or with the desired position, the solution provides property information and forms of contact with the owner, if these were authorized by the user that was done the registry.

By providing the user with the two processes described above, the solution proposed in this work solves the problems previously pointed out, about the current context of registration and identification of properties.

In addition, in presenting this set of functionalities, the proposed solution allows greater exploitation by different types of users as owners, mediators and even public entities.

For owners, the set of features presented allows maintaining a relevant described memory, which will not get lost for the next generations of owners. For mediators, as well as real estate agents, it may be possible to advertise properties registered in the system. With this, the tool itself, with data recorded by the users, allows mediation between people interested in a particular area and the owner. For public entities, as already explained, the functionalities can allow greater control in the property inspection, allowing the contact with the owner, both for warning purposes and for collecting pertinent information to carry out punishments.

Chapter 3 State of the Art

In this chapter, the state of the art is analysed. Current methods of registering properties are described, as the methods for demarcating an area. Finally, existing applications that somehow aid these processes are exemplified.

3.1. Introduction

As this work proposes the development of a tool that assists in the process of registering, demarcating and identifying properties, focusing on the rural context of Portugal, it is important to know the current methods used for the execution of these processes.

In Portugal, the registration of properties is officially called "Cadastro Predial". Although this is an official tool for registering properties in the rural context, the reality is that the data, when existing, do not reflect the real characteristics of the properties.

This can be observed if it is considered that 20% of the Portuguese territory is constituted of lands whose owners are unknown. This fact can be considered as a result that 74% of the population of Portugal, currently congregate in a small portion of approximately 2.4% of the national territory, which consists of large cities and coastal regions [3]. With this, it is possible to verify that in the last decades most of the population left the rural territory, that already belonged to their ancestors.

Property demarcation processes use physical landmarks, and although the Directorate General for Territory (DGT), presents detailed instructions to support the process [4], it is understood that the method is not very modern.

3.2. Property registration process

The process of registration of properties operative in Portugal since 1995, is called "Cadastral Predial". There is also an old process called the Geometric Register of Rustic Property (GRRP), it is understood that it is in a period of transition to the new process. The main difference between the processes is that the "Cadastral Predial" includes the "Registo Predial" of the property in question, with this, occurs a greater harmonization between the data for legal purposes [3].

The "Cadastral Predial" can be defined as "an appropriate public instrument to identify and demarcate the rustic and urban buildings existing in national territory" [3], also the Directorate General for Territory (DGT) defines that the "Cadastral Predial" is the registry of "prédios" in the country, containing their characterizations. The term "prédios" means both an urban property or a rustic property. It should be noted that it is in this register that information such as geographical and spatial delimitation of property, as well as a land description, are recorded [5].

The objective of this registry is to characterize and identify the properties present in the country, thus creating a unique, organized and modern registry, so that each property contains a real description of the property [6].

3.3. Property demarcation process

The demarcation process used in an official way, consists in the installation of landmarks of different types, within the boundaries of the property, following instructions defined by competent groups. Only with this type of demarcation, that technicians can make the registration of the property, adhering the characterizations of the same [3].

According to the land registry regulations, it is the owner's duty, the demarcation of the property, since it is only he who has the legitimacy to define the limits of his property, that delimitation must be in accordance with the property described in the "Registo Predial" [3] [6].

The current form of demarcation makes use of physical landmarks with the initials of the owners engraved in the stone, as well as a sequential number and a symbol to indicate if that point is an intersection, passage or corner, as shown in Figure 1.



Figure 1: Landmarks that define limits of a property (reproduced from [4])

The current instructions also specify the materials that should be used in the use of the marks, being: stone, concrete, wood, plastic or similar resistant materials [4]. It is only with this type of demarcation, that technicians specialized in the registry of the proprietors, can do the registration of the property [3].

3.4. Technological tools and similar solutions

In Portugal, the National System for the Exploration and Management of Cadastral Information (NSEMC), supports the "Cadastre Predial". It consists of an online platform for data storage, exploitation, processing, communication, and availability of cadastral data as well as geographical data. The system is in operation at the DGT. The system is intended to be more efficient in collecting and registering data, integrating information that previously was in different domains [3].

In addition, articles and tools that make use of similar technologies and assumptions used in the solution proposed for this thesis have been analysed.

In [7], there is a deepening in questions of surveying and a study is made of the characteristics in the form of demarcation of properties in Malaysia, many similar to those described previously, used in Portugal.

Also, in [7], the integration of the existing system with a digital system, supported by GPS and stored in a specific database for these data types, is studied. A system of registration is developed, but without the same particular character that the solution proposed by this work addresses, but rather is aimed at legal entities and with professional equipment such as sensors and dedicated GPS devices.

In [8], it is also proposed an application for area records using GPS and GoogleMaps. The suggested demarcation process presents similarities with the proposal in this work since it also consists of allowing the user to walk the perimeter of property with a device that collects the coordinates. In this, it is concluded that the use of GIS technologies can serve to create robust and fast land management systems.

In [9], the issue of property registration is repeatedly addressed, but in the context of managing inventories related to sports complexes, in the context of Mozambique.

Like the solution proposed in this work, the m-SportGIS application makes use of the data that the users themselves put on the tool, through forms and image uploads. The registration process makes use of geolocation to register the position of the sports complex, so the biggest difference between the solutions is that m-SportGIS does not worry about the demarcation of the property, but only with the records associate with it.

3.5. Conclusion

Based on the facts presented, it is concluded that despite the initiative to maintain a unified register of the rustic properties in Portugal being in progress, the methods used in demarcation processes and the bureaucracy for data registration can be considered a problem.

The online platform previously mentioned still under development, being a confusing navigation system. Adding to this, the method for the delimitation of properties that the official authorities request, needs updates, since they can be easily deceived.

Therefore, it is understood that even with the current official status of the processes of registration, access, and demarcation of properties, there is room for a solution with a simple character, addressing the most urgent concerns and reducing the necessary bureaucracy.

Chapter 4 Business Model

In this chapter, the proposed business model is presented. The use case diagrams for the application are also explained and contextualized with examples. Finally, the viability of the application as a low-cost solution is proven.

4.1. Introduction

The solution proposed in this master thesis, explore two processes: the demarcation and registration of properties; and the identification and visualization of properties. For a better understanding of the solution, use case diagrams were defined for each of the processes. As the processes present different internal activities, each of the activities is explained separately below, in addition, for reasons of visual simplification, the server actor has been omitted but should be considered present in all actions that have data submissions or requests.

The process of demarcation and registration of properties is directly related to the issue of the descriptive memory of the people, a topic previously discussed, so that the owner has the need to maintain a digital record of its property, characterizing it persistently, even without legal nature.

The identification or visualization process is of great importance because it facilitates the existing bureaucratic question of collecting data related to a particular area - if the owner gave permission for it. In addition to providing the representation and the actual position of the area on a map provided by the proposed solution.

4.2. User types in the Registration process

As can be seen in the use case diagram below, Figure 2, the property registration process presents two different types of users.

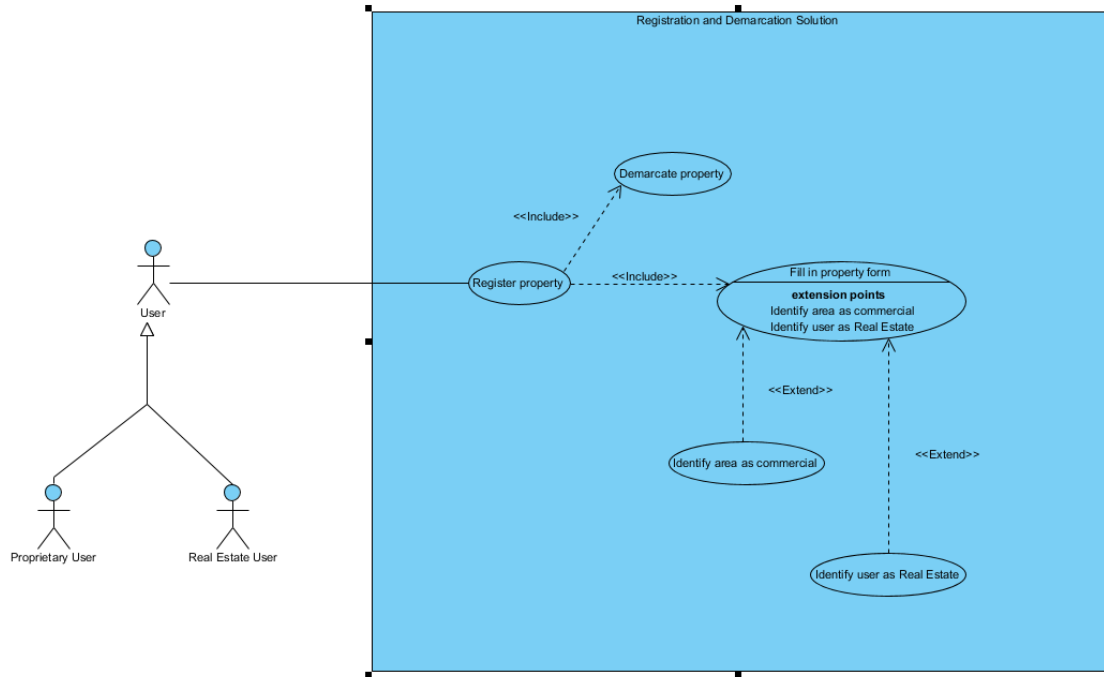


Figure 2: Use case diagram of the registration process

The Proprietary User represents a casual owner, that is, the owner who has the interest of maintaining a digital memory, with the characteristics of his properties recorded in a persistent way so that information is not lost when possible future generations inherit the property. This user can either register properties for personal use or for commercial purposes.

For commercial purposes, the user may choose to identify the registry as commercial, making it understood that the data entered during the registration process may be used by the administration of the application for the provision of commercial services, if so permitted. By not declaring the commercial interest in the registered property, it is understood that the registration was made for personal purposes.

The Real Estate User represents a real estate company responsible for the area registered, with interest in registering the area for advertising and commercial purposes. The registration process, as well as the demarcation, occurs in the same way as with the

Proprietary User. The difference is in completing the property form, there is a need to identify the user as a Real Estate User, this implies that the demarcation was not done directly by the actual owner, but by a representative. Therefore, for this type of user, it is explored to make possible the relationship between the registered property and an existing advertisement, which could be a link to the real estate site.

The commercial viability that the proposed solution intends to exploit in the property registration process, has a focus on the commercial services that could be offered to users and real estate companies that have this interest. However, the importance of the proprietary user who wishes to register their area for personal cannot be overlooked since in agreeing that the data is used by the tool, the information recorded and the data collected may be of great importance for future work or new functionality.

The possibility to advertise the properties, is a profitable factor and a way to build a sustainable business model (one of the main goals of this dissertation). This occurs in the potential of services that can be made available from the information that these users have registered.

For the Proprietary User, who wants to advertise their area to other interested users, it is possible to present a service that highlights their property to other users of the solution. In addition, by registering your personal contact during the registration of the area, it becomes possible to mediate the contact between an interested user and the owner.

Although these services are not the main focus of the tool, the set of functionalities available and the data received by the users makes it possible to use the solution for these purposes.

To the Real Estate User, not only can the same possibilities mentioned above, but also a direct reference, in the form of a redirected link to the real estate site, related to the registered property. In this way, users who use the solution can find a property of their commercial interest and easily get in touch with the company responsible for it.

All of these additional services allow the solution to be used in a commercial environment.

4.3. User types in the Visualization and Identification process

In the use case diagram below, Figure 3, the three types of users that interact with the proposed solution are presented.

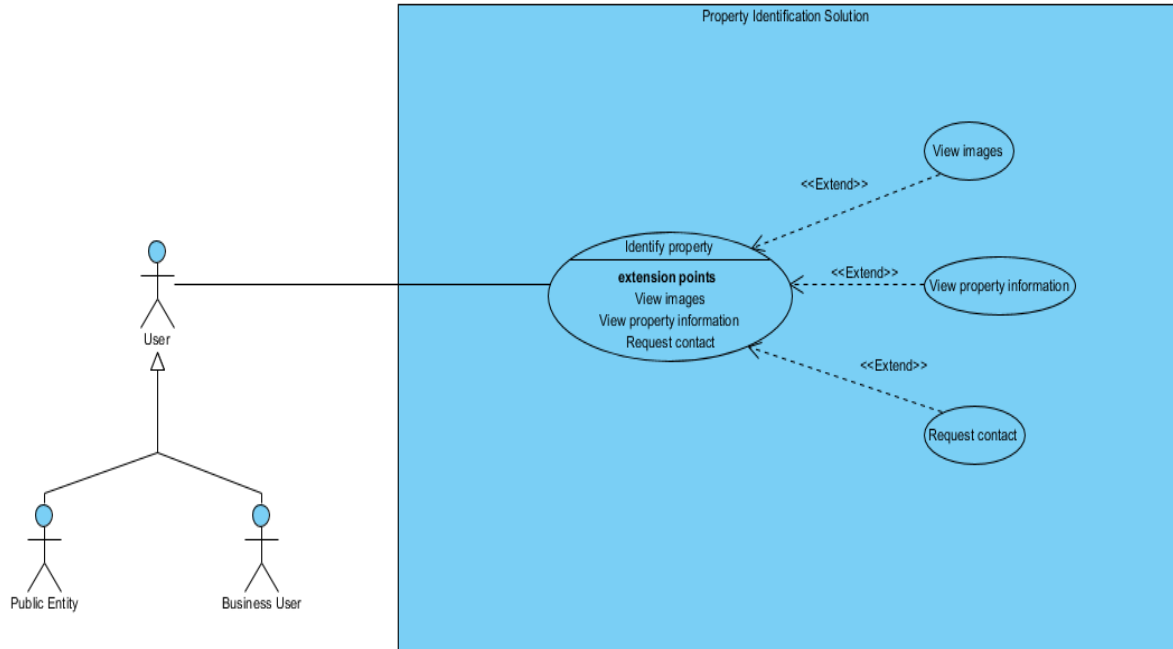


Figure 3: Use case diagram of the identification process

As can be seen, in the processes of identification and visualization of properties, there are three possible users, a generic user who can specialize in two other types of user, the public entity user and the business user.

This process is very important because it is responsible for facilitating the access of information about properties and owners, which today, when available, present a large bureaucracy to be accessed. In addition, this process provides the outline and the actual position of the area on a map provided by the proposed solution.

The Business User represents the casual user of the tool, who may be looking for the property of commercial interest, or just looking at properties registered in the region.

By clicking on the outline that represents the property available in the solution map, the user can observe the available information about it.

It is in this sense, that during the information visualization process, there is the commercial opportunity to be explored. When interested in a demarcated property, the

user can request mediation of contact between him and the owner or real estate, being this, a service that could be made available by the administration of the solution.

The second type of user that interacts with this process is the Public Entity User. The solution could be useful for this type of user because creates the possibility for public agents to use the identification feature to get in touch with owners, or property representatives, to solve urgent matters such as ground cleaning, pest control and the like.

Both types of users have similar characteristics and actions, for this reason, they have been represented as specializations of a generic user.

Therefore, it is understood that there is also space to explore the offer of services that make the contact between interested and owner, making this process profitable as well as the registration and demarcation process.

4.4. Conclusion

It is possible to observe that both the processes of property identification and property registration offer possibilities that can be explored to find profitability in the use of the solution.

Considering the set of functionalities that the proposed tool already presents, there is space for the exploration and adaptation of new services of a profitable character as: a mediation of contact between owner and interested, and the advertisement of properties.

In addition, based on the different types of outstanding users that can interact with the solution, it is understood that its impact is diverse, ranging from simple owners to public entities.

Chapter 5 Architecture

In this chapter, the proposed architecture for the solution is presented and explained in the form of an architectural diagram. After that, the technologies involved with the architecture are presented, as well as their respective functions.

5.1. Introduction

In order to support the development of the solution proposed in this thesis and also to help explain the elements involved, an architectural diagram was created, Figure 4, which aims to present the architecture of the proposed solution, addressing the elements that are necessary for its working and also the actors involved.

In addition, a second architectural diagram was also created, with the technologies chosen to be used, Figure 5. The second diagram aims to assist the understanding of the construction of the solution showing the technologies used in the development of the work and where they relate to the architectural elements already mentioned. With this, the justifications are made regarding the choices of technologies as well as the correct definition of them.

5.2. Architectural diagram

In the architectural diagram below, Figure 4, the necessary elements for the operation of the proposed solution are presented.

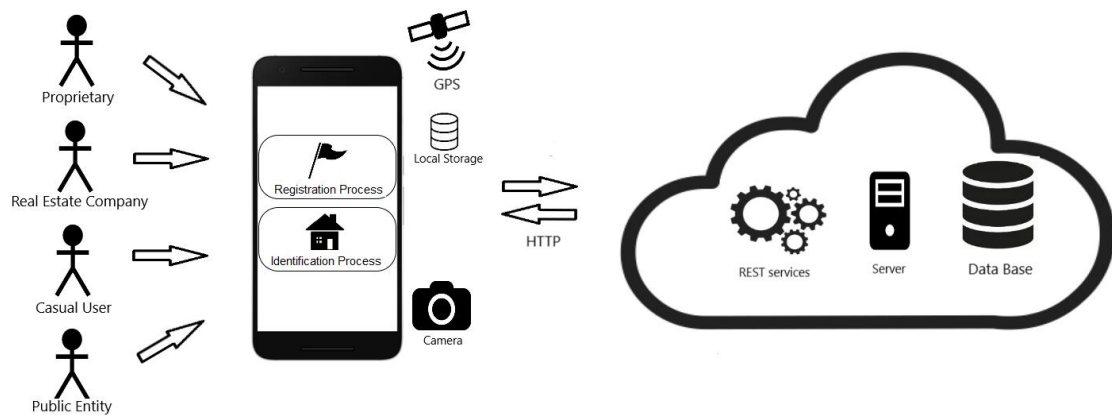


Figure 4: Architectural diagram

As can be seen, on the left are the users that interact with the proposed solution using the mobile application.

The first user represented is the Proprietary, this user interacts directly with the property registration process. As mentioned before, this is used to maintain a descriptive memory or take some commercial option.

The second user represented is the Real Estate Company, this type of user is also directly related to the registration of properties, which seeks to advertise the areas related to the company, as well as promote access to a particular site through a link or service.

The third type of user represented is the Business user, this type can interact in the processes: registration and identification. In the registration process, this user represents someone that wants to advertise its property. In the identification process, this type of user represents someone that requested mediation services, to find a property in a specific area.

And finally, the fourth user represented is the Public entity, who may use the solution in order to identify and contact proprietaries of his interest.

The diagram represents that all types of users interact directly with the solution, and although in the previous explanation have been defined the processes that each type of user interacts, it cannot be left aside the possibility that the users described also interact with another process.

From left to right, after the users, the architectural diagram represents the application on a mobile device held by a user. It is in this mobile application where the user interacts with the two main processes: the registration process, which contains the demarcation and the fulfilment of a form on the property; and the identification process, which consists of finding the properties on a map made available graphically by the application. As can be seen, these two processes are present in the use of the application through a mobile device and both make use of the Global Positioning System (GPS) and photographic camera.

After that, the elements responsible for the actions outside the application are represented inside the cloud. First can be observed. the use of Representational State Transfer (REST) services together with the presence of the server. This combination allows the communication with the application through the Hypertext Transfer Protocol (HTTP) requests, this makes it possible to exchange information in real-time if connected with the network.

Finally, also presented inside the cloud, the last element represented in the diagram is the database, in which the data recorded by the users during the registration process are stored and requested during the identification process. The only element that makes direct contact with the database is the server.

Although not present in the architectural diagram above, it is understood that in order to achieve viable commercial results as raised in the business model, the solution must also contain an area reserved for the administration of the application. This supports to conduct the services provided in an organized and viable manner, as is the case of requesting mediation between owners and interested users.

5.3. Architectural diagram with technologies

In the diagram below, Figure 5, the architectural diagram is presented together with the technologies used to support the development of the proposed solution.

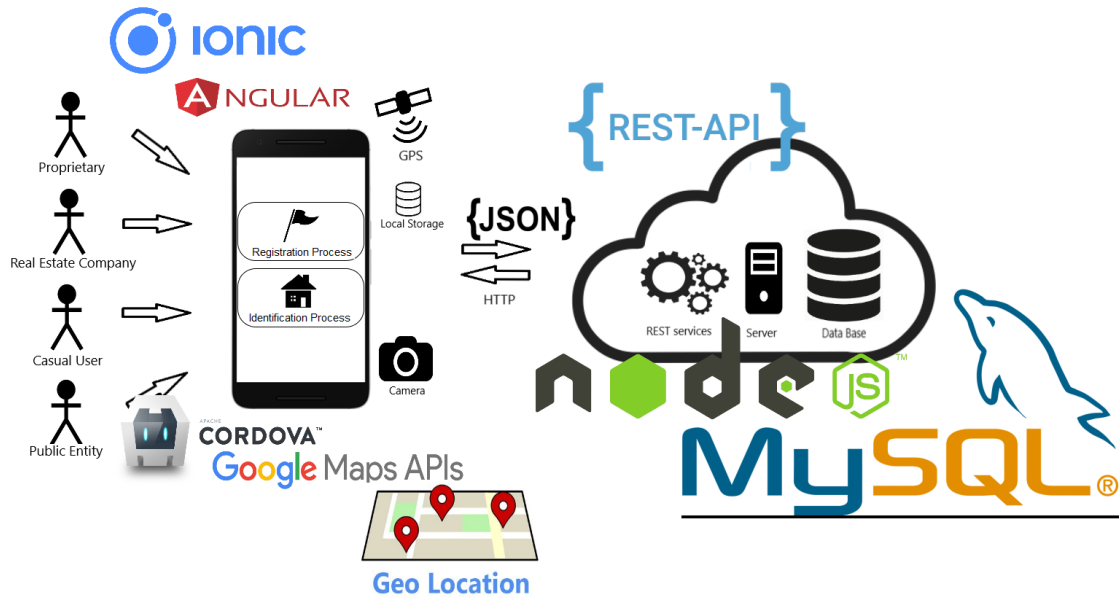


Figure 5: Architectural diagram with technologies

In this new architectural diagram, which presents the technologies related to the elements necessary for the operation of the solution, the main element can be considered the mobile device.

This is due to the fact that today the use of mobile devices has become a human need, which grows along with the increase in population [10]. In addition, important features like internet access, camera, and GPS, are already contained within the smartphones. The provision of these features replaces the need for specific technological devices, consequently the solution presents a low development cost.

When choosing a mobile device as the main element of the solution, it is necessary to consider the variety of operating systems currently present in the market, with this considered, the option to develop a native application for each existing system becomes unfeasible, since the time in the production process also leads to an increase in costs [10].

To overcome the need to develop an application for each system, we made use of Apache Cordova, version 7.0.0. As can be found in the official documentation, Apache Cordova consists of an open source mobile framework that allows the use of technologies such as HyperText Markup Language (HTML), Cascading Style Sheets (CSS) and JavaScript (JS) for cross-platform development [11].

Cross-platform has the objective of enabling the same application to be used on different platforms [12]. In addition, the use of Apache Cordova allows the use of Plugins, which

provide native components such as camera, geolocation and local storage [11]. That was an essential chosen for the correct operation of the application.

As a mobile application that aims to be used by different types of users, as previously mentioned, it became necessary to worry about the visual interface of the application. To supply this point, the Ionic Framework, version 3.9.2, was used. As stated in its official documentation, the Ionic Framework consists of an open source UI toolkit that enables the development of high-quality mobile and desktop applications using HTML 5, CSS 3 and JS, having a focus on user experience in interaction with the interface [13].

The use of the Ionic Framework presents features that make the project easy to maintain [14]. Finally, in sets with these technologies related to user experience, integrated with the Ionic Framework, AngularJS version 5 was used, as represented in the figure above.

AngularJS is responsible for improving the experience of using HTML in the application development [15]. This is due to the fact that it consists of a JS framework developed by Google, recommended for use in mobile applications and that makes use of the Model-View-Controller (MVC) standard, facilitating the modularization of processes [14].

The set of previously mentioned technologies allowed a development environment favourable to the objectives proposed for application since as can be seen represented in the figure above, the use of Geolocation and camera systems is an essential part of the context. Adding to this, still in the context of the mobile application, the Google Maps API, native ionic version 4.15.1, has a prominent role, since it is present in both application processes: Registration and Identification, working together with the Geolocation API.

The Google Maps API is a service provided by Google that provides graphically represented data in the form of maps, as well as functions related to that context. In the development of the application was used with the Geolocation API, which is the technology responsible for making it possible to obtain the data related to the physical location of the used device [16].

In spite of the diversity of the technologies used, it was previously described the part referred to the client of the solution and the technologies involved with the interaction of the final user, but as observed in the figure above, the solution also consists of the part referring to the server that presents its range of different technologies.

The elements represented by the figure of the cloud is related to the server and the services that use Representational State Transfer (REST). For the correct operation of these services in a simple way and still worrying about the scalability, NodeJS, version 10..12.0, was used to treat the responsibilities of the server, since it is responsible for creating a runtime environment [17]. With this, a context of communication with the application is schematized through HTTP requests and a REST API to support the exchange of messages. Being a REST API a set of connected REST resources that provide services through a standardized interface [18].

This environment makes it possible to communicate with the last element present in the diagram, also inside de cloud, which consists of the database. For that was used the MySQL Workbench database, version 8.0.12, which consists of a relational database that presents a faster execution of queries than other similar technologies and is also considered the most used storage method in web applications due to its data read speed and low cost in relation to its implementation, besides being generally free for use in open source projects [19].

5.4. Conclusion

As can be seen, the proposed solution presents a large number of elements and technologies involved in its operation. This makes the development of the present solution a complex and unsustainable project if the chosen technologies are not the most suitable. The chosen technologies allow a high productivity, a low investment on development and maintenance and the possibility of the scalability.

The combination of all the elements and technologies described above is essential for the correct functioning of the proposed solution and a further deepening related to their use within the application and the server will be addressed during the analysis chapter.

Chapter 6 Analysis

In this chapter, the processes of identification and registration are analysed and specified graphically through activity diagrams. Each stage of the processes is explained in detail. A conclusion is also made, highlighting the main points of each step and also additional points aiming future functionalities.

6.1. Introduction

As previously mentioned in this work, the proposed solution consists of the development of a mobile application capable of performing the processes of identification and registration of properties. These two processes are based on solving the problems currently existing in the context of rural properties already included in the introductory chapters.

Both processes are composed of a group of smaller operations that together make the solution viable. For the construction of the solution as a whole, it is necessary to understand the processes, with a detailed analysis of the operations involved, since this is what guarantees the viability of what is proposed to develop.

For better understanding, were developed activities diagrams to help the visualization of the main processes, not with a technological aspect, but with a procedural character. Therefore, each stage is properly explained in order to understand and analyse the operation of the proposed solution.

6.2. Stages of the identification process

The Figure 6 represents the activity diagram for the identification process and its different stages, each explained below.

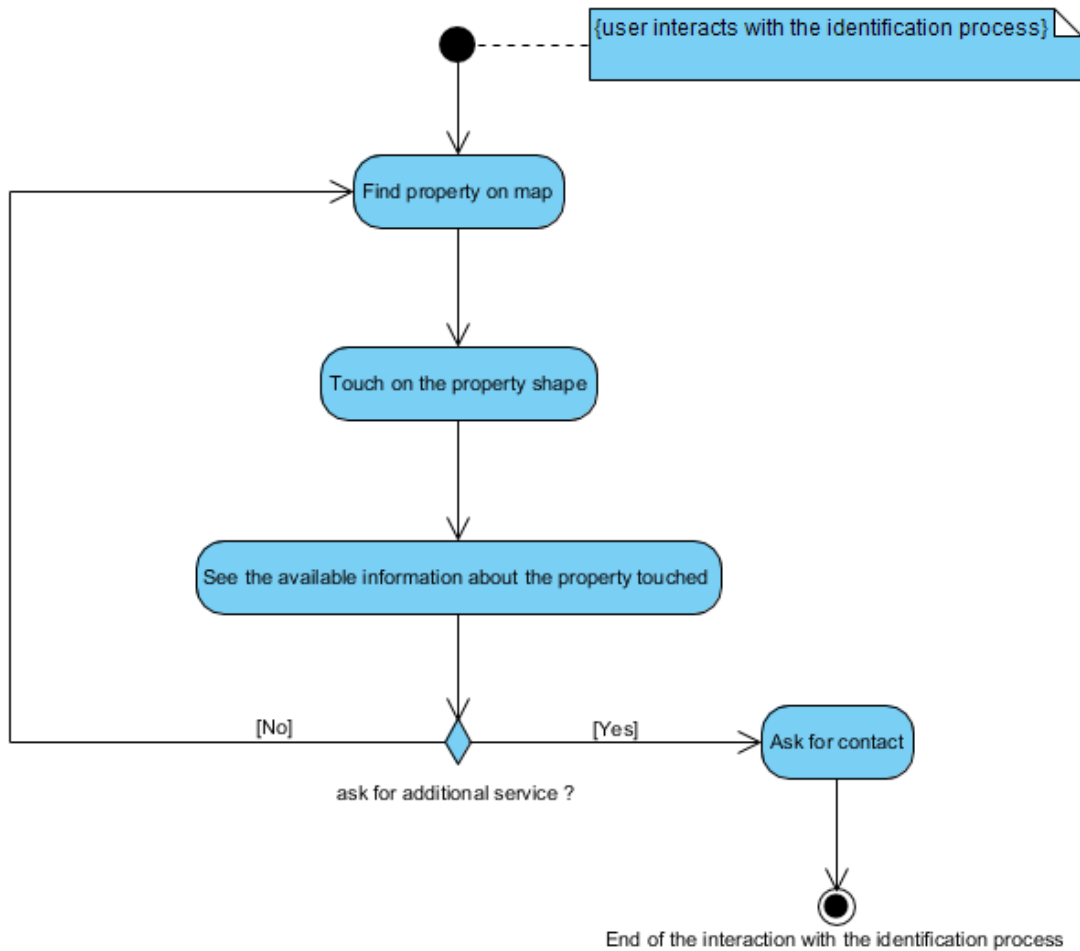


Figure 6: Activity diagram of identification process

When analysing the use of the application in the context of a mobile solution, it is understood that the first action that a user is able to perform is to find a property on the map. This is possible because when initiating the interaction with the identification process, it is presumed that the user will interact with a map graphically displayed on the screen of the device.

The display of the map, as well as the availability of the properties, depends on the use of GPS and the access to the server through the network. These actions occur at the moment the user enters in the page responsible for the process of identification and must be

completed before the user takes the first action. As an important part of the functionality developed, they were represented in the activity diagram Figure 7.

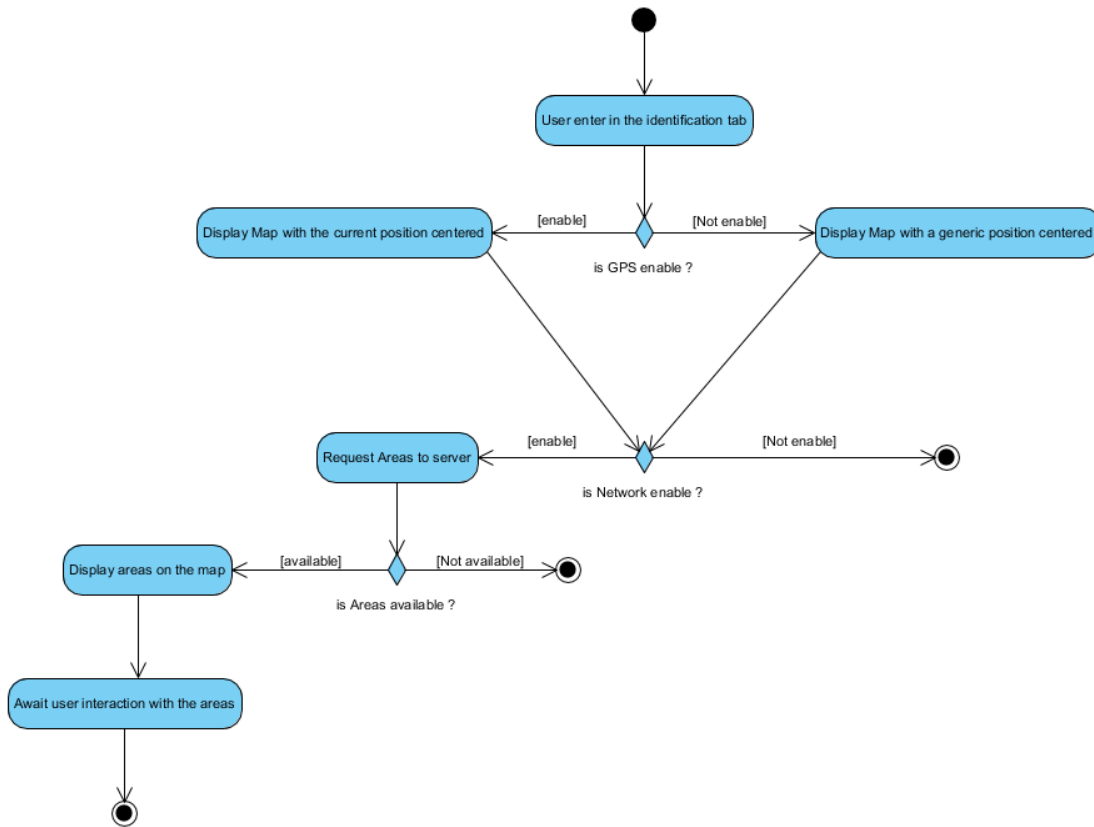


Figure 7: Activity diagram of the map and properties display

As shown in Figure 7, in case the GPS is activated in the mobile device, the map available to the user displays the current location that the user is positioned. If the GPS is not activated the map still available, but in this case, the region shown on the map has no relation to the current position. Also, it is worth mentioning that the application requests the activation of GPS in the actions that make use of it.

It is also possible to observe that after the display of the map, the loading of the areas stored in the database is requested to the server. First, as noticed in the diagram above, the availability of the network is identified. If there is no connection, the request to the server cannot be made and as a result, the areas are not loaded on the map. If the connection is available, it is requested the data of the already registered areas. If there are not available areas the process finish, otherwise the areas are graphically displayed on the map, taking the form of polygons directly related to the delimitations of the properties

registered. As can be seen in the diagram, after the property is made available on the map, the interaction with the user is expected. Therefore, it is understood that the user of the application will observe the map and the properties displayed on it, to choose the one of its interest.

The user can choose one of the areas on the map to see the details of it. This process is performed when the user touches the polygon that represents the property of interest. When the desired polygon is touched, the user is presented with information related to the property chosen, the diagram in Figure 8 represents the interaction process with the chosen area.

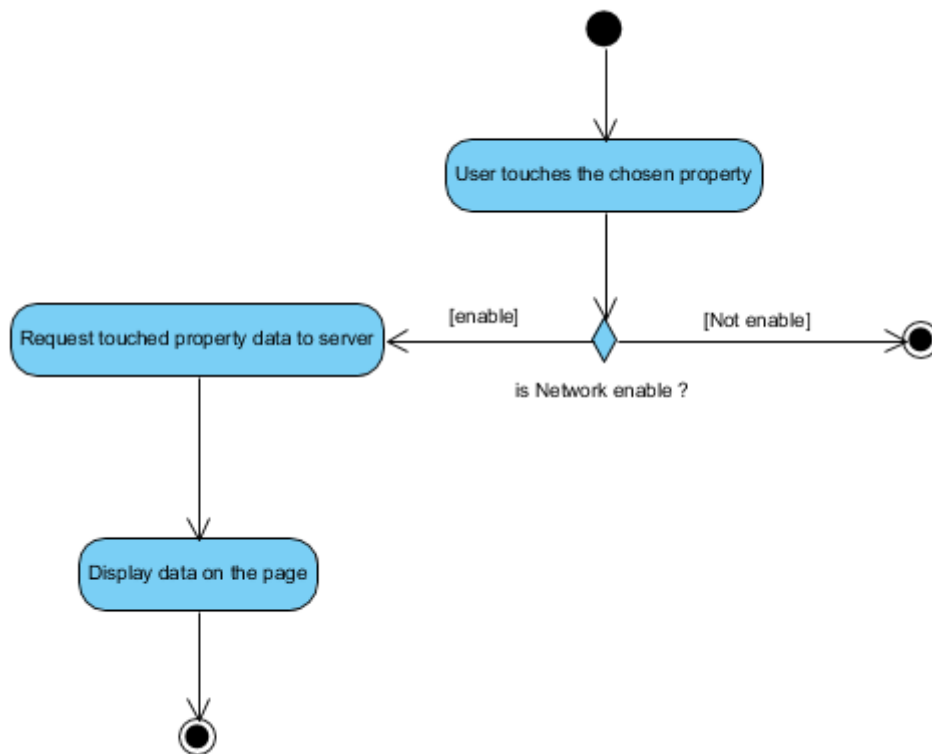


Figure 8: Diagram activity of property interaction

As can be seen in the diagram above, when touching one of the areas, a request is made to the server and it is expected the return of the chosen area data. As in the process described previously, if there is no connection, the action is finished, otherwise the data is made available to the user.

The request to the server is necessary because in the previous process, in order to obtain a better computational advantage, only the coordinates of each stored area are brought

from the data base, being the coordinates, the main data needed for the creation of the polygons that represented the properties.

When touching any other point in the map, which is not a property, the user receives the coordinates of the touched point.

The information about the property is made available to the user in a form, filled with the data registered by the owner or legal representative, if available. The availability of data during this process is related to the permission granted by the owner at the time of the property registration.

In this stage, different types of relevant data can be observed as: the property area in m², descriptions and particular characteristics raised by the owner at the time of registration, images geographically contextualized, representing references or landmarks of the property, the current status of the property as commercial or private, or if the property has any connection with real estate company or advertise.

After observing the available information about the property chosen, there is the possibility of exploring the offer of additional services, as already mentioned. These services would support the commercial viability of the solution as a product.

If the property in question has a commercial character, as indicated by the owner at the moment of the property registration, the user may request contact with the owner or company responsible for the property.

Therefore, it would be offered the service of mediation between interested and owner so that they can discuss commercial matters about the concerning property. It is up to the administration of the application to create this mediation. Finally, if the user don't request any additional service, it is up to the user to return to the property identification stage where he proceeds its search of properties.

The descriptions about each stage of the identification process made previously help to understand the process, showing the importance of each action to be taken and the results from these actions. With this analysis and observing the activity diagrams, it becomes possible to visualize and contextualize the idea in a real scenario.

6.3. Stages of the registration process

The diagram presented below, Figure 9, represents the activity diagram referring to the property registration process.

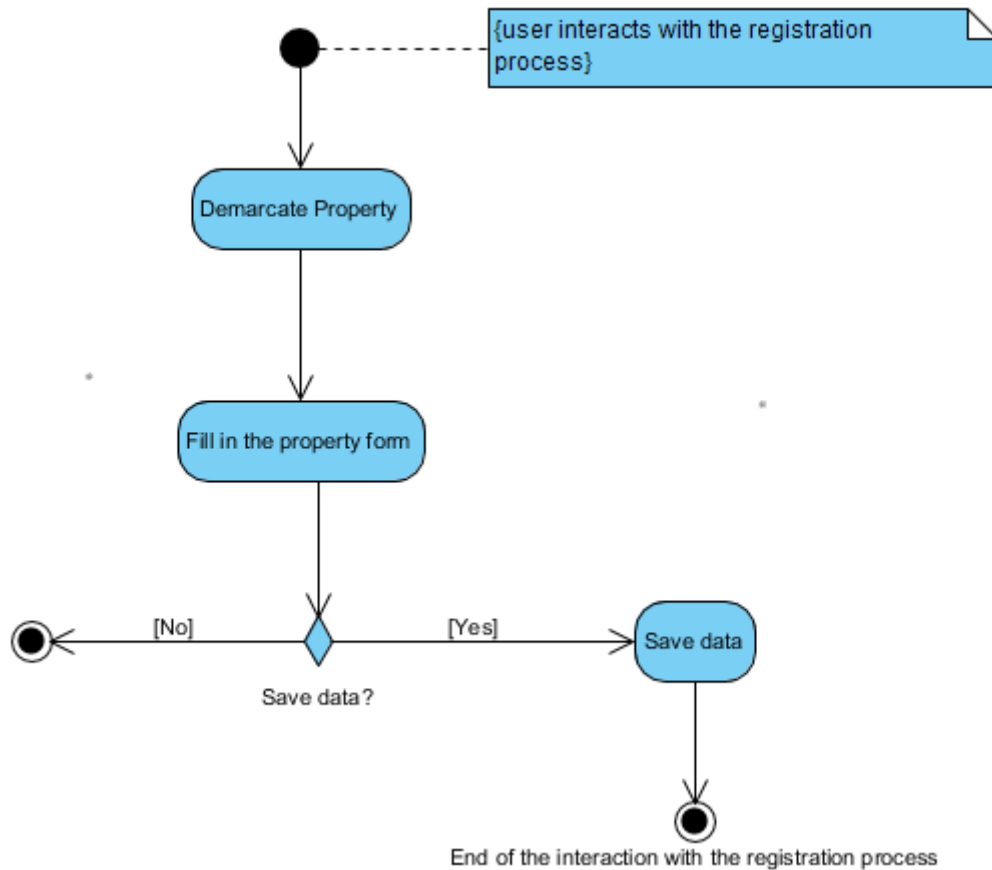


Figure 9: Activity diagram of registration process

The activity diagram of the registration process is smaller compared with the identification process, however, each step of this process has more complexity and more interaction with the user, as explained below.

In the start of the interaction with the property registration process, the user is presented with the option to start demarcating a property, along with a map geographically represented on the device screen.

It is important to note that, unlike the previous processes, this process requires the user's device to be with GPS enabled during all the time of the demarcation, with this the current physical position of the user is centered on the map.

This stage of the registration was built so that it is not necessary to be connect to the Internet. Notice that, many of the properties are on rural areas, where data communication is not guaranteed, at least with the necessary quality. It is why, the registration, specially the demarcation procedure, was idealized in such way that user can do it without has access to data communication.

When starting the demarcation stage, user walks through the perimeter of the property under registration. The mobile application automatically begins to collect geographic coordinates referring to the current position of the device, as can be seen in Figure 10, which represents only the demarcation process.

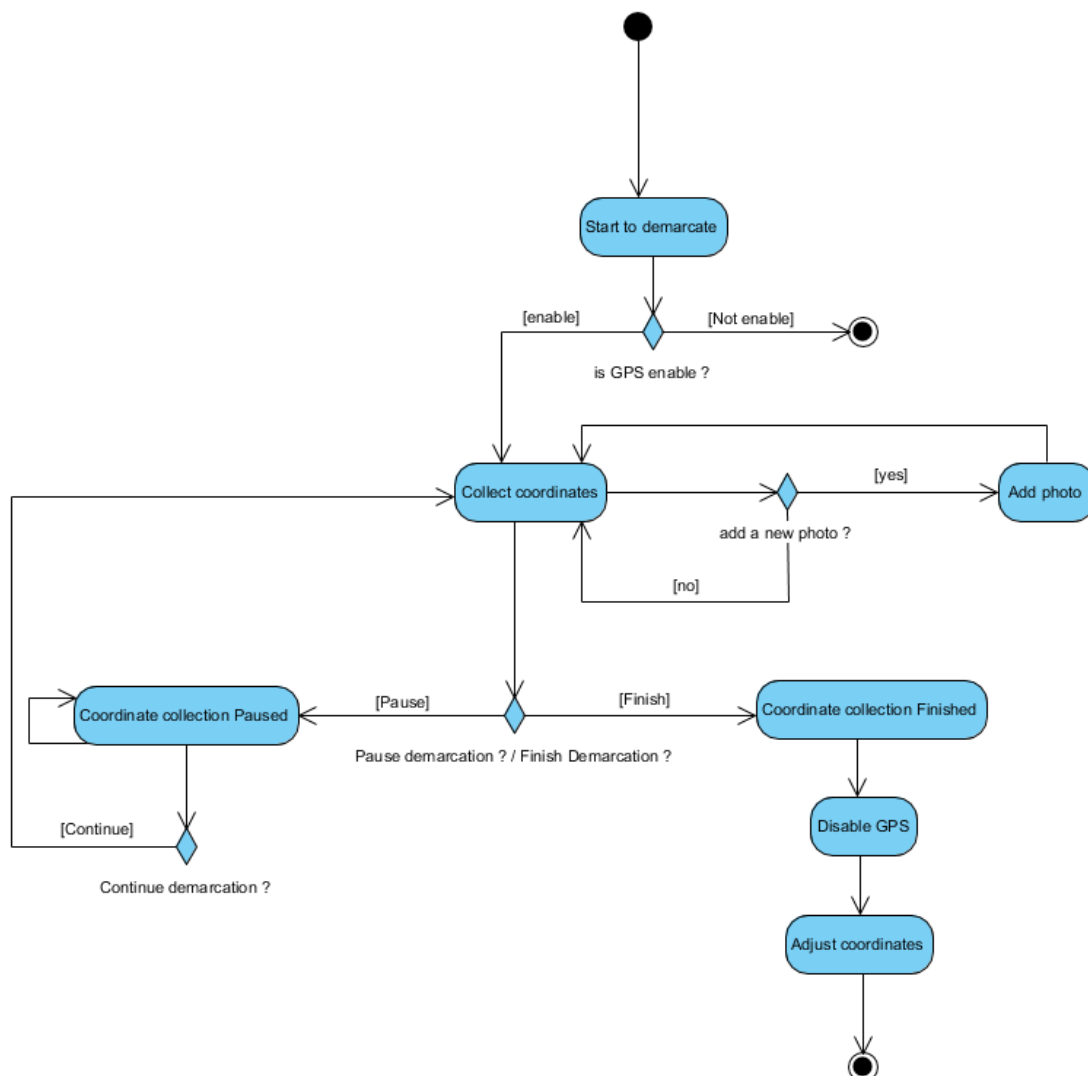


Figure 10: Activity diagram of demarcation stage

Graphically, the user can follow the process on the screen of the device since with each new position covered, a new landmark is made available in the corresponding coordinate in the map presented on the screen.

During the demarcation stage, it is also possible for the user to make use of the camera of the device to register relevant landmarks or important particularities of the properties in question. The photos taken are contextualized geographically and temporally during this process to support the concept veracity of the registration.

The collection automatically proceeds by collecting new coordinates each time it is identified that the user is in a new position and is only terminated when the user requests this option in the device. It is important to note that during this stage, the user also has the option to pause the demarcation process – this option allows user to surpass physical obstacles or adverse situations, allowing circumventing physical obstacles such as natural or artificial fences, without collect wrong data (coordinates that do not belong to the perimeter of the property).

The next stage for the user is to finish the demarcation, with this, the data collection is immediately discontinued and the GPS stops to be used. At that moment the user can already visualize on the map, displayed in the screen of the device, the polygon that represents the newly demarcated area. It is understood that at this time the user can edit the polygon to adjust possible error margins during coordinate collection.

Finished the demarcation, the next expected action to be taken by the user is fulfil a form with the property data, as shown in Figure 9. This form contains some data that will be made available to other users during the identification process. It is up to the user to fill in information such as descriptions of the property, a status that signals directly the reason for the demarcation, be it commercial or private. It is also in this form where the user identifies himself by putting personal information, such as name and documents as well as forms of contact such as email and telephone.

During the process of fill in the form, the user can add new images and yet get data already calculated by the solution, such as the area in m^2 of the demarcated property.

Finally, it is up to the user to agree or disagree with the terms of use of the data, which require that the user allows the use of data collected by the application, agree to the disclosure of the data as well as agree with the use of the user personal data. Furthermore,

the user identifies himself as being an owner or a representative of a real estate company with representative rights over the property.

During the stage of completing the form, additional services can be suggested or required, aiming to support the business sustainability of the solution.

There is the possibility that at the time of filling the form, if the user is a representative of a real estate or affine, he can advertise the property or even make the connection between the demarcated property and advertisements through links submitted during this stage.

It also possible to the user request the mediation service available to the commercial properties. With this the user can remain informed if there is a demonstration of interest of other users with his property during the identification process.

After completing the form, together with the agreement or not of the terms of use of the data, the user submits the information collected to the system, as can be seen in Figure 11.

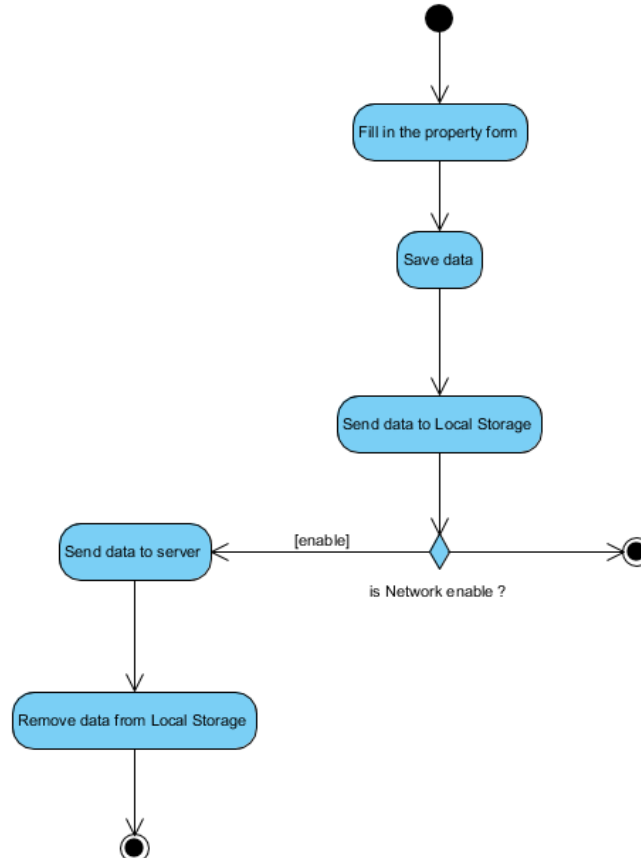


Figure 11: Activity diagram of the data saving process

At that moment, upon the property form fulfilment, the first action to be taken by the application is to save the data locally in Local Storage. If there is an internet connection, the data is sent to the server and saved by the administration of the application. It is understood that there is no need to keep the data saved locally after sending to the server, so the local storage is cleaned.

If there is no connection, a common scenario in rural areas where this process was idealized, the data will stay saved locally in the device itself until the moment that connection is identified. With this, the interaction with the property registration process is finalized.

If the user decides to not save the data, the process returns to the beginning, where he can start a new demarcation.

As described above, although this process has a number of stages similar to the process described previously, it presents a greater complexity tied to each individual activity, making this analysis even more important, since with the observation of the particularities of the actions and of the possibilities identified, it is possible to find the viability of the solution as a whole.

6.4. Conclusion

The analysis process is very important for the correct understanding of the proposed solution because it is in it that can be observe the necessary functionalities for the correct operation of the solution, as well as the correct methods for the implementation of them.

As can be seen with figures above, the activity diagrams present a sequence of logical actions that further facilitate the understanding of what is proposed.

Considering the explanations given above, it is understood that the proposed solution, composed of the two processes: identification and registration, has viability and a set of steps to be taken to be functional. Also, the commercial feasibility to be explored in both processes is observed, an essential factor to support the previously proposed business plan.

Chapter 7 Implementation

In this chapter, the implementation of the proposed solution is explained and the stages of development of the application, server and database are presented. The chapter also shows the key features created and the biggest difficulties found during the process. Finally, a conclusion is made highlighting the complexity of the solution and stating the correct operability of the application.

7.1. Introduction

As can be observed in the architecture chapter, the solution proposed in this thesis consists of a complete system containing an application, a server and a database.

This chapter is concerned with explaining the development of each of these elements mentioned above, highlighting the choices made during the construction of them, as the main features developed and the difficulties encountered in this process. The chapter also explained the methods of communication between the elements.

For a better understanding, each section of the chapter focuses on one of the elements of the solution, so it becomes possible to understand with more simplicity the explanations about the different technologies used in the different levels of the system.

7.2. Application development

The application developed in this master's thesis made use of the Ionic framework together with the Angular in order to provide better user experience, besides allowing

access to native functions and APIs with Apache Cordova. The access to technologies like Geolocation, Local Storage and Camera are essential for the execution of the solution.

At the start of the Ionic project, the entire organization of the project is established automatically, taking the structure observed in Figure 12.

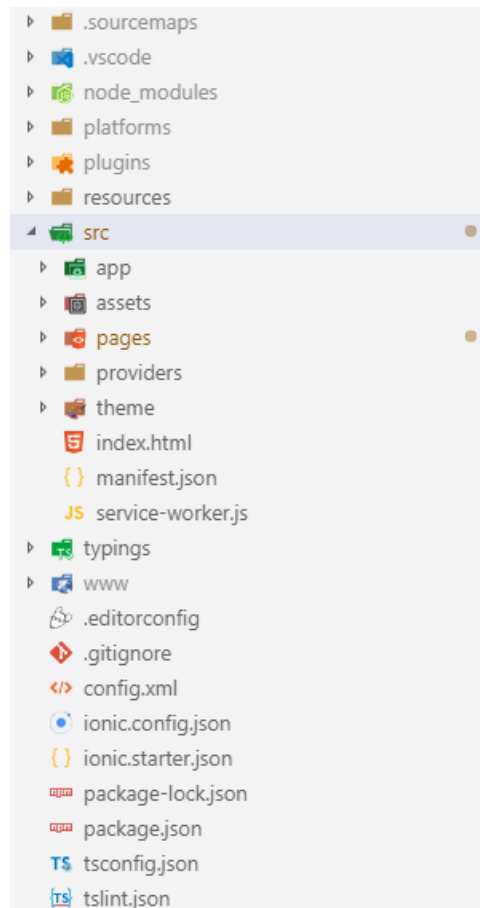


Figure 12: Ionic project structure

The project presents many directories and files, but only in a few of them the effective development is made, being the others responsible for specific configurations, modules or files of the system. It is in the “pages” and “providers” directories within “src” that the layout and logic concerns are managed.

The first concern observed at the beginning of development was the choice of a layout that would allow simplified navigability. Therefore, it was decided to choose the tabs layout, which is responsible for separating in a visual way the two processes already discussed in the course of this work, registration and identification, Figure 13 shows application main layout.

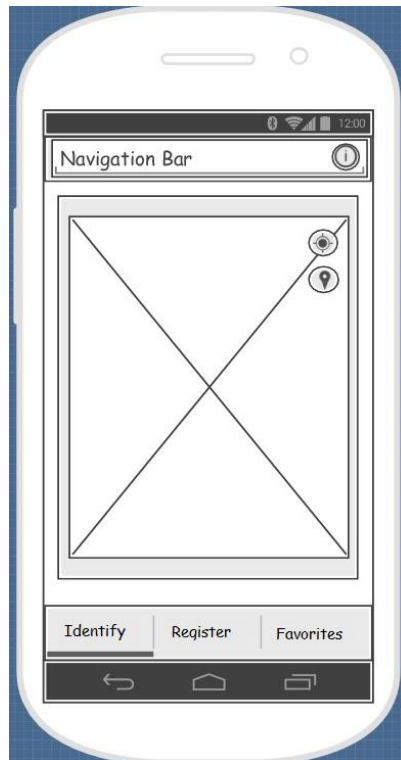


Figure 13: Application tabs layout

As can be seen in the image above, the tab layout provides simplicity in the app navigation, with a touch on the desired option presented at the bottom of the screen, the target page is available.

In the image above, Figure 13, it is possible to observe that three main navigation tab options have been created, being respectively: identify, register and favorites. The first two options represent the two main processes discussed in this work. The favorites did not have a focus on this work because these are additional features that did not compete with the resolution of the proposed objectives.

7.2.1. Identification process development

It is in the Identify tab that the process of property identification occurs. This is possible because the central rectangle presented in the mockup of Figure 13, symbolizes the display of the map. The use of Google Maps API is what makes possible the map availability.

The use of external APIs, as is the case of Google Maps, occurs in a simple way, since the dependencies are all automatically downloaded through pre-defined commands of the framework and saved in the directories responsible for the modules.

At the moment, the user enters in this tab, a native Ionic function is used automatically, since it is triggered when a page is requested, it is the first function to be performed and was chosen to call the operations involved with the creation of the map.

During the creation of the map, a location is requested to be made available visually, this location is supplied by means of coordinates. The native Geolocation API is used to obtain the current position of the device and then uses it to visually make the same position available to the user on the map.

The framework itself requests the activation of the GPS. If the inactivity persists, the creation of the map is done without a set of specific coordinates, resulting in the disposition of a generic position previously defined by the API.

Once the map has been created, a request is made to the server to obtain the areas to be made available graphically, taking the form of polygons.

7.2.1.1. Asynchronous operations

It is important to note that during the development process, complications were observed regarding the time taken for map availability and the server response. For several times the process of requesting to the server was completed before the loading of the map, which entailed in errors since after the response of the server the areas should be displayed on the map but the same was not yet available. With this, it was observed the need to use the concept of Promises during programming, supported by the typescript, to work with the synchronization of the functions.

The use of promises, as exemplified in Listing 1, allows operations to be chained, that is, it becomes possible to codify in such a way that the request and download of the areas from the server are only performed after the complete map construction.

Listing 1: Code fragment representing the function chaining

```

1  this.mapProvider.loadMapAsync("visualizationMap").then(() => {
2    this.areaStorage.getAllAreasServerHTTP().then((data) => {

```

Promises were used at several key points during coding and proved to be an important tool for proper communication with the server.

7.2.1.2. Communication between application and server

The process of requesting the server is done via HTTP protocol, as explained in the code below, Listing 2, where a response timeout is pre-defined. If it is exceeded, it is understood that there is no active connection with the server, and then a message informs the user of the problem. All this process repeats every time the user enters the tab or refreshes the page.

Listing 2: Code fragment representing the HTTP request

```

1  getAllAreasServerHTTP(): Promise<any> {
2    return new Promise((resolve, reject) => {
3      this.http.get('http://192.168.1.103:8080/smartland/allAreas/')
4        .timeout(10000)
5        .subscribe((result: any) => {
6          resolve(result.json().data);
7        }, (error) => {
8          reject(false);
9        })
10   })
11  }

```

The exchange of messages between application and server occurred through JSON, since it was observed that this method made the process of dealing with data simpler. Also in the listing above, the function represented consists of the first function to be performed after the complete load of the map and it requests the coordinates of the areas already registered in the System.

7.2.1.3. Google Maps API functions

At this first moment, the biggest concern is linked to the visual display, it would be a computational waste to bring the complete data of all areas, so it was decided to bring only the coordinates since they are enough for the presentation of the polygons on the map.

After the correct display of the areas on the map, in the form of polygons, the concern is the interaction of the users with the polygons. To deal with the interactions, the Google Maps API is used to control touch events related to polygons. Therefore, when a polygon is touched, the event responsible for handling the action uses the native function of the API to retrieve the set of coordinates that form the polygon, as the code fragment in Listing 3 shows.

Listing 3: Code fragment representing the retrieve of coordinates from a polygon

```

1    polygon.on(GoogleMapsEvent.POLYGON_CLICK).subscribe(() => {
2        let pontos: BaseArrayClass<ILatLng> = polygon.getPoints();

```

The coordinates obtained in the touch event are used for the server request. When it finds the area that corresponds to the list of required coordinates, the information about them is returned through a JSON and then made available to the user in a new screen, taking the structure of a form. It is also important to point out that crucial operations, such as the property area calculations presented in the registration process, are supported by this API.

The features discussed above symbolize the most relevant technical aspects that needed more attention during the development of the identification process.

7.2.2. Registration process development

As in the identification process, several difficulties were encountered in the development of the property registration process. Most of the difficulties encountered in this process are related to the concern about the physical movements made by the user during the demarcation, since the user may be responsible for creating self-intersections on the area, causing an invalid area.

The first aspect that is worth to mention is the demarcation act, that consists of the user cross through the boundaries of the property registered.

7.2.2.1. Geolocation functions

As previously mentioned, during the demarcation process, the GPS must be enabled. When the user selects to start a demarcation and touches the corresponding option, a

native Apache Cordova Geolocation API function is triggered. This function is responsible for capturing the current coordinates of the device and watch for changes, as shown the following code fragment, Listing 4.

Listing 4: Code fragment representing the collect of coordinates

```

1   let optionGPS: GeolocationOptions = { enableHighAccuracy: true };
2   const location = this.geolocation.watchPosition(optionGPS)
3     .filter((currentCoords) => currentCoords.coords !== undefined)
4     .subscribe((currentCoords) => {
5       newLat = currentCoords.coords.latitude;
6       newLng = currentCoords.coords.longitude;

```

As can be seen in the code fragment above, it was used the native function with the high accuracy option enabled. The use of this option tells the framework to use more accurate methods, it is understood that during this moment it was important to achieve the highest possible precision. The code is also concerned to filter possible errors resulting from the read of new coordinates.

7.2.2.2. Polygon intersection identification algorithm

Another detail during this process that required greater attention in the development was the treatment of polygons.

It should be mentioned here that Google Maps API for Ionic is relatively recent and some features are not yet implemented, as is the case of identifying polygons that are self-intersecting.

Self-intersecting polygons present a not predictable behaviour when submitted to predefined functions of the API. With this problem, it was necessary to develop a function to identify whether the polygon present self-intersections or not. This function is based on the algorithm of [20] as can be seen in Listing 5.

Listing 5: Code fragment representing the polygon verification function

```

1 verifyIntersection(p0_Lat,p0_Lng,p1_Lat,p1_Lng,p2_Lat,p2_Lng,p3_Lat,p3_Lng){
2   let s1_x, s1_y, s2_x, s2_y, s, t;
3   s1_x = p1_Lat - p0_Lat;
4   s1_y = p1_Lng - p0_Lng;
5   s2_x = p3_Lat - p2_Lat;

```

```

6   s2_y = p3_Lng - p2_Lng;
7
8   s = (-s1_y*(p0_Lat-p2_Lat)+s1_x *(p0_Lng-p2_Lng))/((-s2_x*s1_y)+(s1_x*s2_y));
9   t = (s2_x*(p0_Lng-p2_Lng)-s2_y *(p0_Lat-p2_Lat))/((-s2_x*s1_y)+(s1_x*s2_y));
10
11  if ((s >= 0) && (s <= 1) && (t >= 0) && (t <= 1)) {
12    console.log("intersection detected");
13    return 1;
14  } else {
15    console.log("intersection not detected");
16    return 0;
17  }
18 }

```

First, the polygon is transformed into a list of straight lines, and the straight lines are passed in pairs as a parameter of the above function for checking intersections, that is, the function verifies all the lines that form the polygon. When the intersections are identified, the user is informed so that he can make the corrections manually by touching the screen.

7.2.2.3. Camera settings

Still, in the registration process, the component that has great importance is the camera. The use of the camera is similar to GPS since both are native resources from the device. It is worth mentioning the set of options used for the photos taken in the process, as shown in the Listing 6.

Listing 6: Code fragment representing the camera options

```

1  takePicture() {
2    const options: CameraOptions = {
3      quality: 100,
4      destinationType: this.camera.DestinationType.FILE_URI,
5      encodingType: this.camera.EncodingType.JPEG,
6      mediaType: this.camera.MediaType.PICTURE,
7      allowEdit: false,
8      correctOrientation: true,
9      saveToPhotoAlbum: true,
10   }
11   this.camera.getPicture(options).then((imageData) => {

```

As can be seen in the code above, due to the context of the solution it was decided to use the highest possible quality in the images taken during the process, besides not allowing

them to be edited. However, all images taken are saved in the gallery of the device so that they can be accessed later.

7.2.2.4. Storage strategy

Finally, another important development point addressed in this process was the method of saving.

As previously said, the registration process does not require internet connection, so after completing the process all data is first saved locally, using Local Storage. The Local Storage system saves the data indexing with a specific key, in this case, the key consists of the string of coordinates that determine the polygon.

After that, it is understood that if there is a connection to the internet, the data can be sent to the server, so if it succeeds the Local Storage will be clear as shown in Listing 7.

Listing 7: Code fragment representing the save strategy

```

1  this.areaStorage.sendDataToServer().then((data) => {
2    this.areaStorage.storage.clear().then(() => {
3      console.log('All the local saved itens were send to the server')
4      console.log('synchronized with the data base');

```

Again, the promises are used to chain the operations so that Local Storage is only clear if the data is successfully sent to the server. This process repeats every time the application home page is requested or updated.

The features discussed in this section represent the difficulties and challenges during the development of this process, so they can also be considered as essential for the correct functioning of the solution.

7.3. Server and Data Base development

Along with the development of the application, it was necessary to worry about the development of a web server able to handle the HTTP requests of the application and to control the interactions with the database. In order to fulfil this, it was made use of

technologies such as Express, REST API and Sequelize, version 4.43.0, which will be explained below.

7.3.1. Express

First, it was necessary to worry about the system scalability. Taking this into consideration, it was made use of the Express, version 4.16.0, that is a Node.js web application framework. The Express allows the creation of APIs and modulates the project in order to guarantee easy maintenance, as Figure 14 shows.

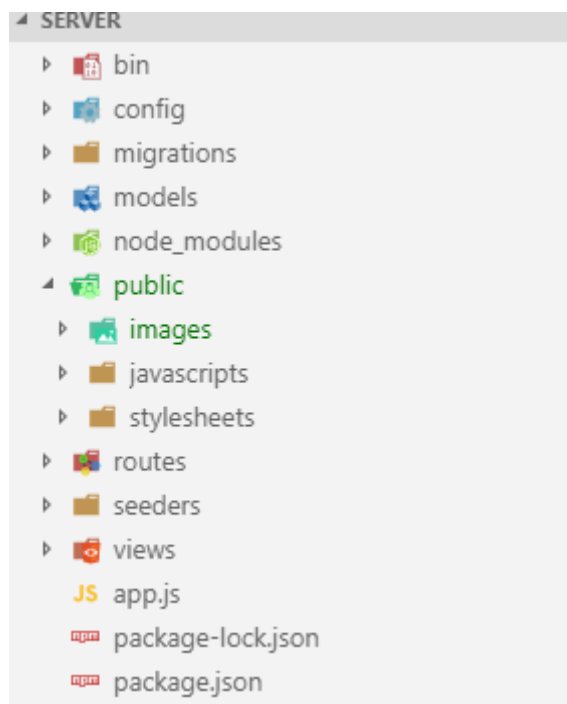


Figure 14: Server NodeJS Express project structure

As can be seen in the image above, the Express organizes the project in a way that defines the correct place where each element of the web server must be established.

It is worth mentioning at that moment that the "images" directory is where it was established the storage of the images referents to cadastral areas since it is understood that it is not an intelligent practice store the files in the database. In addition, the "routes" directory maintains the HTTP communication rules and it is where the REST API was built.

7.3.2. REST API

As previously mentioned, the REST API was built in the "routes" directory. The API consists of a JS class, which makes use of the entity mapping on objects by Sequelize and uses the GET, POST, PUT and DELETE methods to exchange information between the application and database through data in JSON format, as exemplified in the code fragment below, Listing 8.

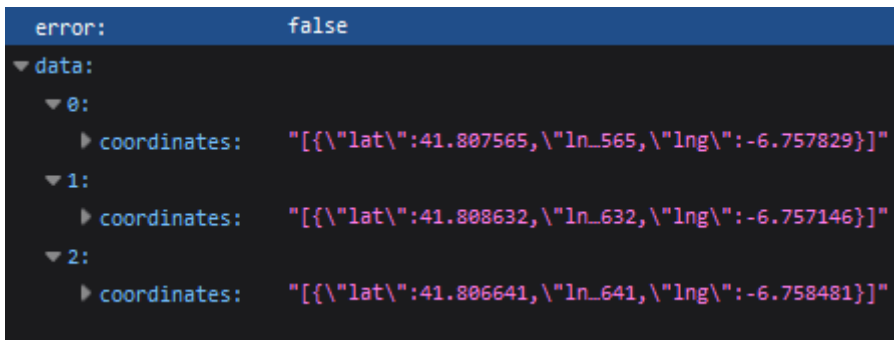
Listing 8: Code fragment representing one method of the REST API

```

1/* GET all area listing. */
2  router.get('/allAreas', function (req, res, next) {
3    model.area.findAll({ attributes: ['coordinates'] })
4      .then(area => res.json({
5        error: false,
6        data: area
7      }))
8      .catch(error => res.json({
9        error: true,
10       data: [],
11       error: error
12     }));
13 });

```

The code fragment above corresponds to one of the methods of the REST API, responsible for requesting the coordinates of all the areas, or properties, stored in the database. Finally, the result is returned to the application in JSON format, as the Figure 15 shows.



```

error: false
data:
  0:
    coordinates: "[{"lat":41.807565,"ln_565","lng":-6.757829}]"
  1:
    coordinates: "[{"lat":41.808632,"ln_632","lng":-6.757146}]"
  2:
    coordinates: "[{"lat":41.806641,"ln_641","lng":-6.758481}]"

```

Figure 15: Result of the REST API request

7.3.3. Sequelize

Also, along with the Express, it was used the Sequelize, that is responsible for Object-relational mapping (ORM) functions, with the MySQL Database. That is, the tables present in the database as user, property and files, were converted into objects to be used in simpler ways with the NodeJS. The image below, Figure 16, represents the "files" table of the database that is responsible for storing the files information related to the areas, as pictures.

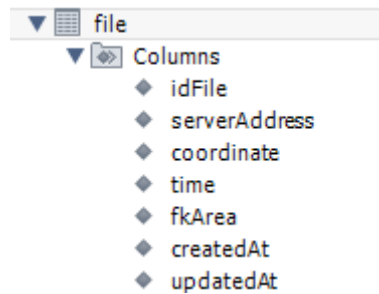


Figure 16: Database table file

Using Sequelize, the table "file" was mapped to an object. Its model can be found in the "models" directory and its structure is shown in the code fragment below, Listing 9.

Listing 9: Code fragment representing the "file" model

```

1  module.exports = function (sequelize, DataTypes) {
2    return sequelize.define('file', {
3      idFile: {
4        type: DataTypes.INTEGER(11),
5        allowNull: false,
6        primaryKey: true,
7        autoIncrement: true,
8      },
9      serverAddress: {
10       type: DataTypes.STRING(200),
11       allowNull: false
12     },
13     coordinate: {
14       type: DataTypes.STRING(200),
15       allowNull: false
16     },
17     time: {
18       type: DataTypes.STRING(200),
19       allowNull: false
20     },
21     createdAt: {

```

```

22         allowNull: false,
23         type: DataTypes.DATE
24     },
25     updatedAt: {
26         allowNull: false,
27         type: DataTypes.DATE
28     },
29     fkArea: {
30         type: DataTypes.INTEGER(11),
31         allowNull: false,
32         references: {
33             model: 'area',
34             key: 'idArea'
35         }
36     }
37 }, {
38     tableName: 'file'
39 });
40 };

```

The mapping process shown above simplifies the administration of the data since they are treated as objects.

The features discussed above, present the resources used for the operation of the web server and its communication with the database. Although the construction of the mobile application received more attention during the development of this work, the elements discussed in this section present vital importance for the correct operation of the solution as a whole, since they are responsible for running and making possible the correct exchange of data between the mobile application and the database through the web server.

7.4. Conclusion

As can be seen in the progression of this chapter, different technologies have been explored in the development process, this fact increased the complexity of the solution. Also, it should be emphasized that during the construction of the solution, the development of the mobile application consumed more time when compared with other elements such as the development of the web server and the database, so it is understood that there may be space for future analysis on these elements.

The functionalities highlighted in this chapter are sufficient for the correct functioning of what was proposed, although it is understood that there is space for additional

implementations, as said in the development of this work, that help even more on the solution's profitability concerns, such as the implementation of the administrative panel for the application control.

Finally, it is understood that the correct operability was guaranteed by the use of the methods and technologies described in the course of this chapter.

Chapter 8 Conclusion

In this chapter, the conclusion of the work is made presenting the results from this master's dissertation and a critical analysis addressing the viability of the solution. Finally, future work is discussed.

8.1. Discussion of results

In the course of this work, it was possible to observe the current problems in the context of registration and identification of properties, especially in the context of Portugal. It was noted that the methods used today still refer to old periods and thus offer space for mistakes. The problem is even worse because the official data associated with rustic properties, when exist, is quite inaccurate. And in many cases, there are not any data at all.

Consequently, these facts led to the need to prove the operational and commercial feasibility of a low-cost solution with the purpose of solving the properties registry, as well as the property identification process.

As it was observed in the chapters of architecture, analysis and implementation, it was found that the proposed solution would lead to the construction of a complete system, appealing to an extensive set of approaches and technologies to be used together to run a system containing not only a mobile application but also a server, a database and the communication between those elements.

However, despite the complexity involved and the size of the challenge that it is sought to achieve, the proposed solution proves to be feasible on both aspects, technological and commercial.

At the technological aspect, this work presents as results a functional mobile application developed with low cost since it makes use of technologies already present in smartphones such as camera, GPS, and local storage.

The technologies developed, already addressed mainly in the architecture chapter, have resulted in an application with user-friendly design, easy to operate, allowing the two main processes, registration and identification.

Also, to support the operation, a server was implemented, with due attention to future scalability and the correct communication with a database structured in order to answer the fundamental proposals of the applications. With this, the technological viability of the solution was demonstrated.

In the commercial aspect, the different possibilities that can be explored with the use of the tool, along with the range of different users and possible integrations between this system with real estate and public sectors, have been used to build a business model that allows the commercial viability.

It is still valid to state that despite the points cited in this paper and the presentation of viability in technological and commercial aspects, it is understood that the existing bureaucracy may interfere with the use of the solution, since the validation of the data obtained through the proposed solution, despite presenting evidence, has not legal value. However, it is valid to say that the proposed solution successfully completes the tasks that would normally make use of specific equipment such as GPS devices that would present a cost incomparable with what is proposed.

Therefore, it was concluded in this dissertation that the objectives set at the beginning of the work were fulfilled, and it was possible to build a solution to ensure the low cost in order to solve the problems addressed in the first chapters of the work, besides showing that the solution itself possessed technological and commercial viability.

8.2. Application test

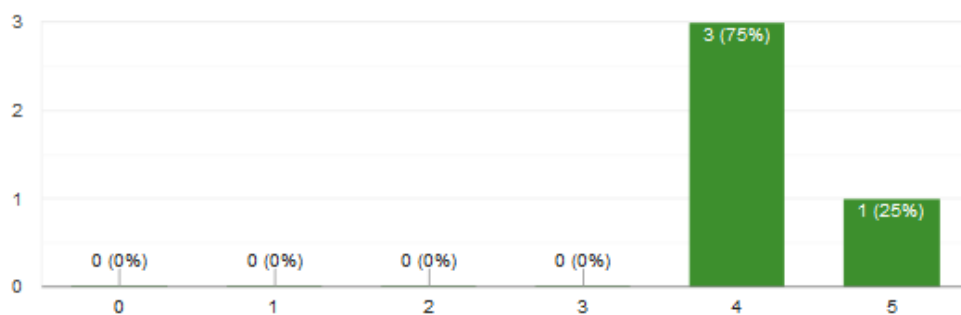
At the end of the application development, it was decided to make it available to a small group of users, without technical knowledge on property demarcation, in order to obtain

feedback on pertinent questions involving the solution proposed as: coordinates collection, user friendly interface and personal opinions about the potential of the solution in the context of property identification and registration.

In order to do this, after the test, the users answered these questions in an online form, as shown in the Figure 17.

Com base nos dados coletados, qual o nível de precisão a demarcação apresentou em sua opinião ?

4 responses



Com base na sua experiência, qual o nível de facilidade na utilização da aplicação ?

4 responses

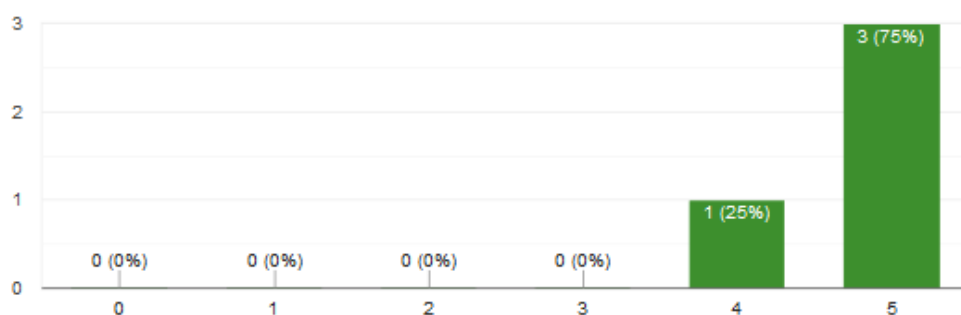


Figure 17: Charts representing the form answers about the solution

After analyzing the answers, it is understood that most users reported that the application was effective in collecting the coordinates with an acceptable precision, despite some warnings of mistakes that may be caused by the climatic conditions or the limitation of

the devices. Most of the answers also confirmed that the solution presents a user-friendly interface. In the Figure 18, the opinion of the users regarding the potential of the solution can be observed.

No contexto de identificação de propriedades, você acredita que a ferramenta apresenta potencial ?

4 responses

| |
|---|
| sim, entretanto a validação de uma intersecção entre demarcação não ficou clara na aplicação. |
| Sim, a ferramenta trás grande facilidade no reconhecimento de espaços. |
| Sim |
| Sim. Existe potencial considerando o cenário atual. |

No contexto de registro de propriedades, você acredita que a ferramenta apresenta potencial ?

4 responses

| |
|--|
| com certeza. |
| Uma vez que padronizado, é de grande valia. |
| Sim |
| Sim. Porém não ficou claro como tornar os dados da demarcação oficial. |

Figure 18: Answers from users regarding the potential of the solution

In the answers of the form is concluded that there is potential for the tool to suppress the difficulties encountered in the current context, but there were reservations about the administrative control of the application, since according to some answers it was not clear how to differentiate and validate the demarcation of different users that may intersect the registration between their properties. Moreover, the officiality of the data was also questioned.

8.3. Future work

During the development of the work, possibilities to be explored in the future were observed since the period of development of the master's thesis limits the scope of what could be done.

It is understood that there is space, aiming the support the solution built, to the development of an administrative panel in order to assist the use of the tool by those who have commercial purposes. The administrative panel could organize interactions between owners, advertisements, among other possibilities.

Another point that could be explored is related to the storage of data. Although the solution does not require great care with the geographic data, it is understood that today there are more appropriate solutions for the management of geographic information.

It is necessary to point that during the development of this project, it was made use of the free plan of Google Maps to access the online API. In the future, with the development of new functionalities and with the higher traffic related to the API online calls, it will be necessary to worry about the costs with this service.

Finally, there is a need for a deeper analysis of the legal issues regarding rustic properties in Portugal. In the course of this research, it was not possible to full clarify the concerns related with collect and share the data about the properties and its owners.

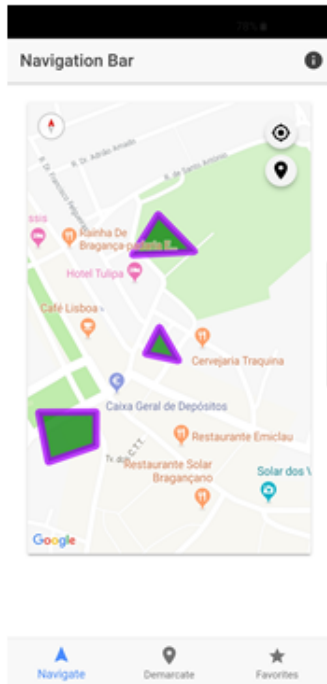
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Annexes

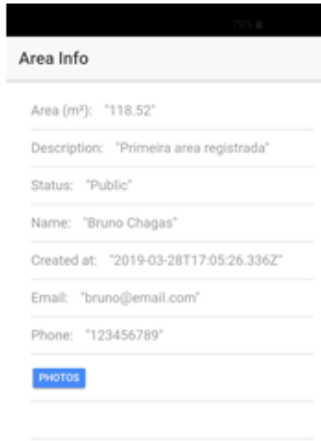
Application Guide



Screenshot 1: Identification page

- 1) The Screenshot 1 consists of the main screen of the property identification process. As can be seen in the image, the polygons present on the map represent properties registered in the system. When the user clicks on a polygon, information about it is made available. The user can also see the tabs layout at the bottom of the screen with the other navigation options.

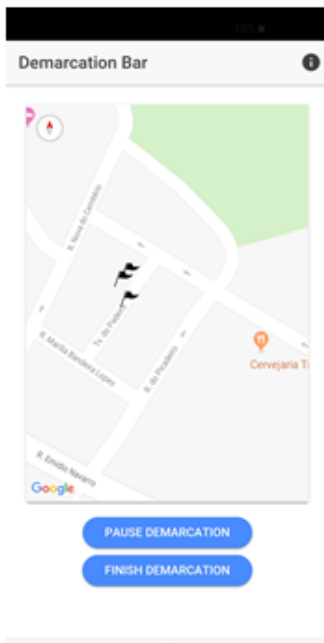
Figure 19: Application guide part 1



- 2) The Screenshot 2 represents the property information page. This screen appears after a polygon is touched on the previous screen.

Screenshot 2: Area information page

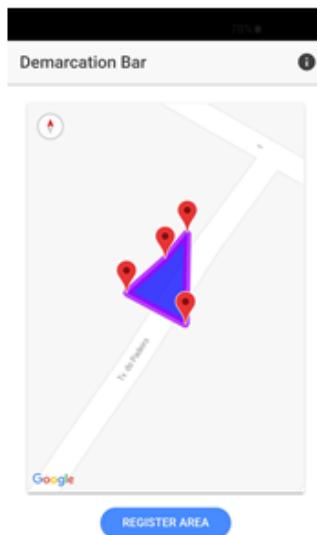
Figure 20: Application guide part 2



- 3) The Screenshot 3 consists of the main screen of the property registration process. At the beginning of the demarcation, the user follows the collection of coordinates, represented by the flags at the map. At this point, the user can pause and finish the demarcation. At the end of the demarcation, it is up to the user to make the necessary adjustments to fill out the form about the area.

Screenshot 3: Demarcation page

Figure 21: Application guide part 3



- 4) The screenshot 4 represents the area adjustment screen. At this point, the user can make the manual changes in the coordinates collected by dragging them. After the necessary corrections, the user can fill out the form about the property.

Screenshot 4: Area adjustment screen

Figure 22: Application guide part 4

- 5) The Screenshot 5 represents the last action in the registration process. The form is presented to the user after demarcation. By filling in and saving the information the data will be available to another user in the demarcation process already exemplified earlier.

Figure 23: Application guide part 5