

Final Year Project Report

A Spatially Aware Android Application for Interactive Property Search

Erik Burka

A thesis submitted in part fulfilment of the degree of

BSc. (Hons.) in Computer Science

Supervisor: Gavin McArdle



UCD School of Computer Science
University College Dublin

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Project Specification

Subject: Android Development

Project Type: Design and Implementation

Software Requirements: No specific software requirements

Hardware Requirements: Android device/Emulator

Target audience: Main Computer Science Stream

Preassigned: No

General Information:

Given the rapid increase in the cost of accommodation (to rent and to buy) in urban areas, individuals and families are considering moving to new areas. While cost and the availability of jobs are often key determinants of where to reside, factors such as population demographics, property profiles, access to schools, hospitals and emergency services, types of communities, age of homes, broadband availability, percentage of Irish speakers, car ownership, cultural diversity, proximity to the coast, etc. may all be factors which influence location decisions.

Much of this spatial data is available from public sources such as the Central Statistics Office but is not in a format which is easily understandable nor fast to find. This project will develop spatial profiles for all areas in Ireland and provide an Android app to help individuals find areas and properties which match their requirements.

Core:

- The student will develop a spatial profile for meaningful statistical units (small areas or electoral divisions) within Ireland. A set of parameters to describe each area will be designed and agreed with the project supervisor. The following datasets may be used:
 - Quarterly Household Survey
 - Census of population
 - Open Street Map
 - The Irish Property Price Register
- The student will develop a native android application which allows users to describe their ideal living area (based on questions or by naming an area they like) and develop suitable techniques to recommend similar areas based on the results of requirement 1 above.

Advanced:

- The student will develop an interactive map within the app to allow individuals to query an area and view its complete profile.
- The student will extend the recommender tool to include a property recommender by integrating it with property sites such as Daft.ie and MyHome.ie to recommend individual properties.

Abstract

The increasing price of buying and renting properties is a major problem in Ireland. The scope for searching provided by property applications is limited specifically to the details of the property rather than the area that surrounds it. People are therefore forced to seek affordable accommodation in areas that they are unfamiliar with.

The project aims to solve this problem by providing people with a service which locates areas suitable to them. This is done through an Android application which recommends areas that match the needs of the users ideal living conditions.

Acknowledgements

I wish to express my sincere thank you to my supervisor, Gavin McArdle for the continuous support, knowledge, motivation and encouragement throughout this process.

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Table of Contents

1	Introduction	5
1.1	Aim	5
1.2	Motivation	5
1.3	Structure	6
2	Background Research	7
2.1	Residential choice	7
2.2	Data	9
2.3	The Irish Property Crisis	10
2.4	Other Applications	12
2.5	Technologies	13
3	Overview of Project and Analysis	15
3.1	Data Cleaning	15
3.2	User Input	17
3.3	Queries	18
3.4	Result and Integration	20
4	Detailed Design and Implementation	21
4.1	System Architecture Flow	21
4.2	User Interface	22
4.3	Client	23
4.4	Server and Database	24
5	Testing and Evaluation	26
6	Conclusions and Future Work	27
6.1	Future Work	27

Chapter 1: Introduction

1.1 Aim

The aim of the project is to develop an Android application which allows the users identify areas around Ireland which are fitting and satisfactory to their needs. The application asks the user a series of questions to gather a profile of their ideal living conditions. The information is processed and the user is given a recommendation with the option to search for individual properties within the recommended areas.

1.2 Motivation

The motivation behind the project stemmed from the problems with property applications and the price increase of renting and buying properties.

The property applications that are currently on the market lack in functionality, as they are limited to the ability of only searching by price, number of bedrooms, house type and location. The search only provides the information of the property, with no information on the area that the property is in or its surroundings. The user is unable to determine whether the area of the property is somewhere they wish to live and would have to conduct independent research outside the application.

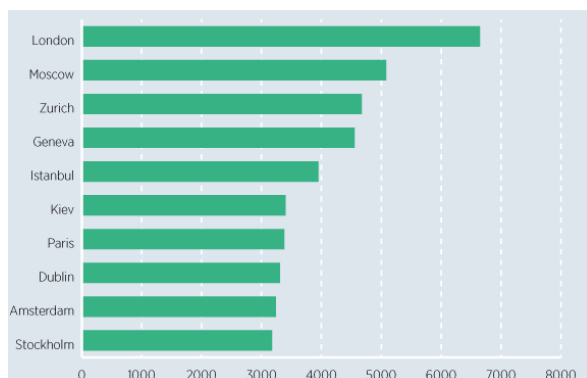


Figure 1.1: Europe's top 10 most expensive rental cities [11]

The problems with property applications are strongly coupled with the increasing price of buying and renting properties in Ireland. The price of rent in Ireland has been increasing steadily in the last 8 years, especially in Dublin, which now ranks as the 8th most expensive city in Europe for rental accommodation according to ECA International [11]. Similarly, the Irish property prices have also been rising, seeing a total increase of 56% since 2011 [12]. Dublin is affected by this the most is ranked 9th place for capital cities in Europe with the highest average price per square meter according to Check in Price [13] and 16th place in Europe with the highest price per square meter to buy apartments according to Numbeo

[14]. As statistics evidently show, the increase of rent prices is a problem which affects the people who are seeking for accommodation in Ireland. This leaves them with less choice and forces them to look for affordable accommodation elsewhere.

The project aims to overcome these problems with an Android application. When using the application the user is able to determine what areas suit them best and has the ability to search

for affordable properties in these areas. This is achieved through the applications recommending tool. The application asks the user a series of questions about their ideal living conditions. This information is stored and compared to a large and open source of data which contains the spatial profile of every area in Ireland. The following details will be explained in greater detail in the report.

1.3 Structure

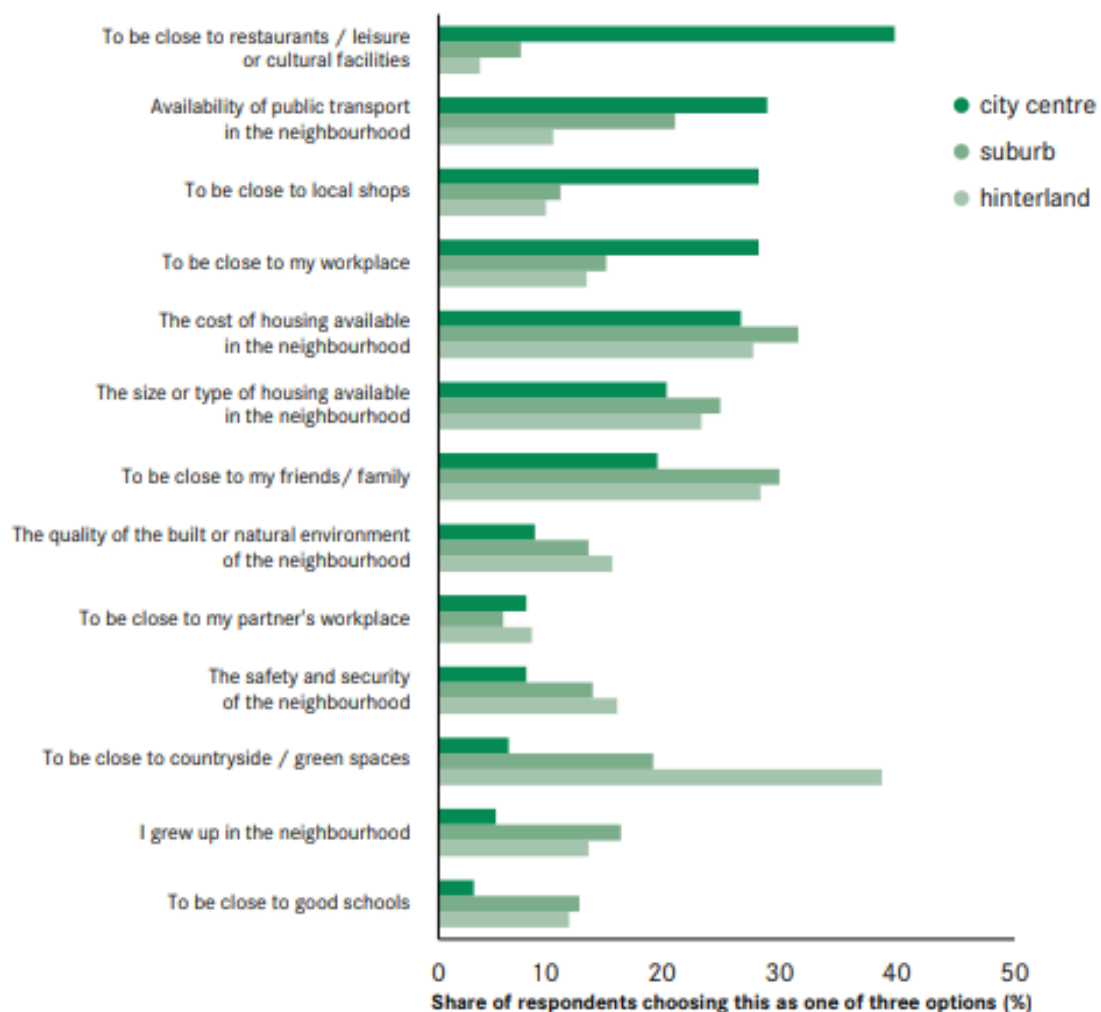
The report is structured with a remaining five chapters. The chapter on background research will give insight on why people live where they do, technologies and data. The chapter on overview of project and analysis will give a high level overview describing how and why the application works, how it looks and the results that it provides. The chapter on detailed design and implementation will describe in depth how the application works and the reasons behind the implementations or design chosen. Testing and evaluation will discuss whether the results of the application are correct and useful. Finally, the conclusion will conclude the project and state what was achieved as well as give good insight into the thought put into the project in terms of future work.

Chapter 2: Background Research

Conducting background research was a vital element to the project. This chapter consists of five sections which will indicate the root of the problem being studied, its scope, the extent to which other applications tackle this problem and the data and technologies used to overcome the problem.

2.1 Residential choice

Choosing where to live can be an extremely difficult and crucial decision of ones life. There are many factors which affect the reasoning behind peoples residential choice. The articles and studies which support these reasons will be discussed in this section.



Source: YouGov, 2015, 1725 residents from four city regions.

Figure 2.1: The main reasons why respondents chose to live in their neighbourhood [5]

Based on population demographics it is clear that majority of people choose to live in the more populated or capital cities. The population growth within the four Irish provinces between 2011 and 2016 is a prime example which supports the statement of people choosing to live in areas more populated [8]. Leinster sees the biggest increase in population of 130,000 during between 2011 and 2016 comparing to Munster, Ulster and Connacht who saw an increase of 36,000, 2,000 and 9,000 respectively. The statistics clearly delineate the fact that the population growth is larger in areas holding more residents. This is why the capital city of most countries is the most populated and more developed as services are required to accommodate everyone. Oxford's paper on why people live in cities discusses this statement in great detail. People choose to live in cities for the economic advantages as they offer better access to work, industry, trade and income as well as the social advantages as access to services like schools, hospitals, entertainment and sport is much more accessible [17]. Although there are disadvantages to living in big cities, they don't have as big of an impact on residential choice.

The report on the Urban Demographics of why people live where they do by Elli Thomas, Ilona Serwicka and Paul Swinney provides statistics and discussion on the factors which exert influence on residential choice [5]. Figure 2.1 is a representation of the most influential factors when choosing where to live. The factors shown to be most popular for people living in the city centre include being close to restaurants, leisure or cultural facilities, availability of public transport, being close to local shops, the cost and the type of housing available in the neighbourhood. The representation portrays the importance of being in close proximity to services when choosing where to live. According to the graph the decisions to live in the suburb or hinterland were mainly to be close to the countryside however the figures for the proximity to services still remain high. Although the most important residential factor for people living in or outside the city differs, the figures for being close to services remains consistent.

David Quilty discusses 14 factors he believes people take into consideration when choosing where to live [6]. Some of the factors that Quilty mentions are employment opportunities, crime rates, proximity to family and friends, climate, town size, food options, proximity to an airport, public transport, culture, education system and affordability. Diane Schmidt gives further insight of the factors one would consider when choosing a place to live [7]. Schmidt talks about the size of the city, culture, infrastructure and the cost of living, as well as climate, politics, safety and spirituality of an area. Similarly, 'The Wheres and Hows of Residential Choice' is a report written by six people who discuss the factors of residential choice [9]. The report states that the "most important ones include place of work and the households budgetary constraints". It also mentions other relevant factors which people take into consideration including the type and size of accommodation and its level of comfort, the quality of the residential environment and accessibility to places the household members wish to frequent.

The recurrence of similar factors which affect the choice of residential location is evident among the papers and articles. The factors mentioned the most, and deemed as most important include the cost, proximity to services and the quality of the area. This information is beneficial to the implementation of the application as some of the questions the user is asked are derived from the results of the background research. Alongside the factors deemed most important, influential matters such as culture, housing type employment rates along with many more will still play a big part in the implementation of the application. Having conducted research on the importance's of residential choice, data must be found that applies to the findings.

2.2 Data

Data is extremely important in all applications as it is used to generate the contents that the user can analyze or interpret. The application of the project must use a large amount of data as it builds spatial profiles of every small area in Ireland in order to give accurate recommendations to the user based on their input. The data consists of 2 major data sets being the Census Small Area Population Statistics and the Property Price Register along with other smaller data.

2.2.1 Census Small Area Population Statistics

The most important set of data used for the project comes from the 2016 Census Small Area Population Statistics. A census is "the procedure of systematically acquiring and recording information about the members of a given population" [18]. Every person living in Ireland must complete the census every 5 years by answering a series of questions about themselves and their housing arrangements. According to Deirdre Cullen, Senior Statistician with the CSO, the census has many purposes. The statistics help the country plan for the provision of areas such as health care, employment and education. It also identifies services which might be needed in certain areas and can also measure the level of migration [19].

The 2016 Census Small Area Population Statistics is open source and consists of 15 themes including: sex, age and marital status, migration, ethnicity, religion and foreign languages, Irish language, families, private households, communal establishments, principal status, social class and socio-economic group, education, commuting, disability, carers and general health, occupations, industries and motor car availability, PC ownership and internet access. The Census statistics is immense, consisting of over 800 columns and 18000 rows. Every row represents a small area and it's data based on the themes. A small area, according to Martin Charlton, is an area consisting of an average of 231 people and 87 households [20].

A lot of this data was redundant for the needs of my project so it was manually cleaned to only hold information relevant to the project. The method behind the selection of relevant information consisted of stages which are described in detail in the overview of project and analysis under section 3.1.

2.2.2 Property Price Register

The Property Price Register is another set of data used by the project. It is produced by the Property Services Regulatory Authority (PSRA) and consists of information relevant to the purchases of properties that have been declared to the Revenue Commissioners for stamp duty purposes since the 1st January 2010. The Property Price Register was set up for tax assessment purposes. The data is updated every day and consists of over 300,000 records.

Shane Lynn provides an edited version of the Property Price Register on his website where the properties are geocoded to small areas [10]. The information for every record of property purchase therefore contains a small area ID along with its price, address, date of sale and other details. The edited Property Price Register is of more use to the project as it creates a link between the two sets of data, as both contain a small area ID. The application will be able to identify every small area by its electoral division and the price of properties within that area.

2.2.3 Other Data

There was more data available for use such as the Census boundary file and OpenStreetMap that could have been used by the application.

The Census 2016 boundary file is an open source shape file that could have been incorporated with the application. A shape file is a simple, non topological format for storing the geometric location and attribute information of geographic features. Geographic features in a shape file can be represented by points, lines, or polygons. This would have been used to create boundaries between every small area in the map fragment of the application.

The OpenStreetMap data contains information on the points of interest on a map. This would have been used together with the shape file to determine the distance between a small area and different services such as hospitals, restaurants, universities etc. Both of the data sets are something that the application can improve on as future work.

2.3 The Irish Property Crisis

Ireland is third most expensive countries to live in within Europe [22]. The cost of buying property and rent has been increasing throughout the duration of the past 7 years and rent has now reached an all time high. According to Jason Hamilton from The Irish Times, the average rent price across the whole of Republic of Ireland has peaked at an extensive approximate amount of €1,300 a month, comparing to the approximate amount of €740 a month in 2011 [1]. Ronan Lyons, when talking about property prices in Ireland, mentions in his Daft.ie report that "Prices up 56% from their lowest point Nationally, the average asking price reached its lowest point in the third quarter of 2013 and has risen 56.3%" [12].

As Dublin is the capital of Ireland, and it holds almost a third of the Irish population, it would be important to talk about the role that Dublin has to play in the Irish property crisis. As mentioned in the introduction, Dublin is now 8th place for cities in Europe with the most expensive rental accommodation [11] and 9th in terms of highest average price per square meter [13]. Based on the highly increasing figures mentioned above and the poor economic state that Ireland is in, Ronan Lyons predicts that both rent and property price will continue to get higher in the upcoming years.

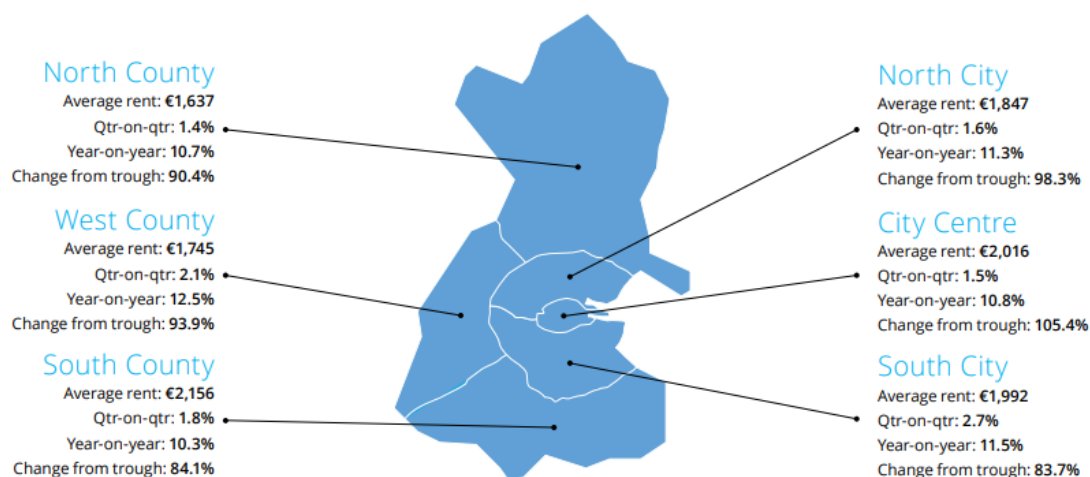


Figure 2.2: Rent price map of Dublin [2]

Figure 2.2 is a representation of the increasing price of rent in different areas of Dublin as per the 12th of November 2018. The average rent price in the South County Dublin exceeds €2,100, which is the highest average rent price Ireland has ever seen. Although certain areas of Dublin being around €400 less in according to average rental prices, the increase seems to be happening at a steady and similar rate for all areas. According to Ronan Lyons, "Rents have risen by more than 100% since 2012 in nine of Dublin postal districts - South County Dublin has seen the smallest increase in the city (84%)" [2]. Fiona Reddan, who wrote an article based on the Daft.ie rental report for 2017, mentions how 2017 seen a 10.4% increase in rental prices, comparing to an increase of 13.5% in 2016, 9% in 2015 and 10.7% in 2014 [3].

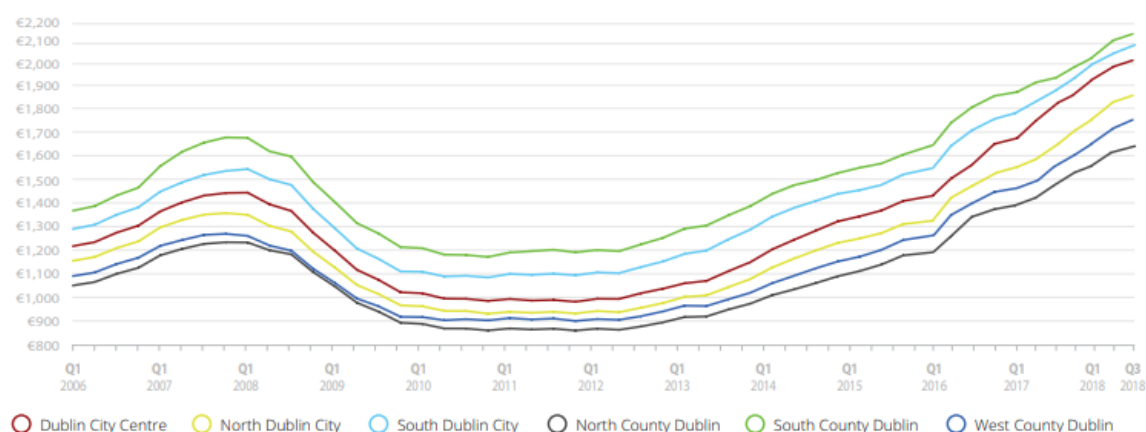


Figure 2.3: Graph of the Dublin Rental Price Trends [2]

Figure 2.3 is another representation identifying the rent prices and their increase according to quarters, years and change from trough. The Dublin city centre appears to have the highest increase from trough at a figure of 105.4%, making it the only part of Dublin to have exceeded the 100% mark. This means that most parts of Dublin have seen an increase in rent prices by 10% or more a year from trough. It seems like the trend will continue, which is evident from Figure 2.2, by which rent prices have increased in parts of Dublin between 1.4% and 2.7% from the last quarter. As well as rental prices on the rise, Ronan Lyons' report illustrates how Leinsters, Munsters, Connacht/Ulsters average property prices have risen by 70%, between 39% and 66%, and 44% respectively [2]. Figure 2.4 is a representation which illustrates the increase of property prices in Dublin between 2006 and 2018. Similar to figure 2.3, a steady increase is seen, although not as rapid.

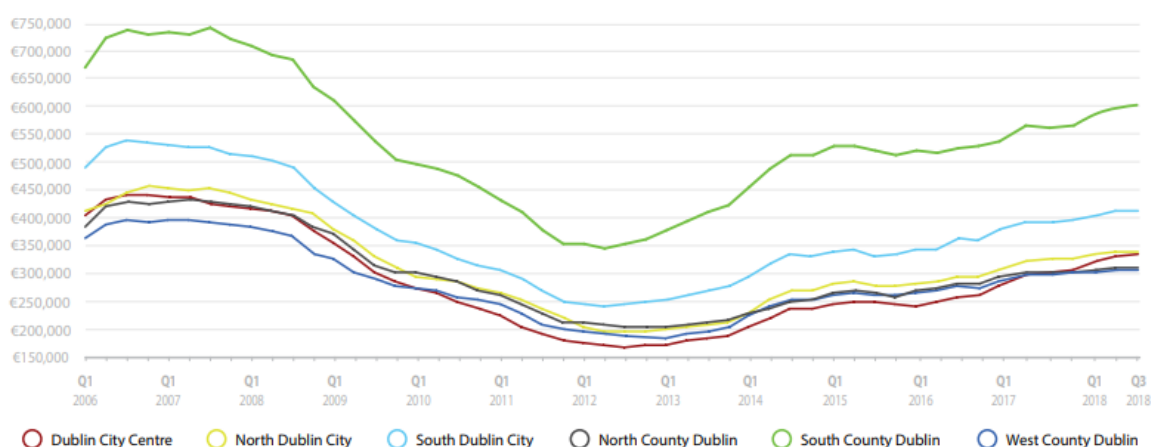


Figure 2.4: Property price map of Dublin [2]

Lets compare the recent rental trends of Dublin with those of the city of London, which has it's name placed as the number 1 most expensive city in Europe for rental accommodation as seen

through figure 1.1. Anna Isaac, an economics correspondent for The Telegraph, mentions how "For the first time in nearly eight years, London rents fell by 0.2% in the year to May" [4]. She also mentions how "the growth rate of London rental prices has been slowing since August 2014, when it hit a peak of 4.3%". We can observe from this that the rental prices in various parts of Dublin have in fact been increasing at double, if not triple the rate than those of London. We can also compare how whilst London's rent prices are starting to see a decline in 0.2%, Dublin's rent prices have increased by between 1.4% and 2.7% as seen in Figure 2.2, in the last quarter of a year. By observing the figures, it is evident that these changes are not positive for Dublin.

The increase in both property price and rent, as discussed in great detail above, is forcing people to move out to places that they are unfamiliar with to seek affordable accommodation. The application aims to help people overcome this problem.

2.4 Other Applications

There are many applications and websites dedicated to property search. A lot of these are, however, poorly built, difficult to navigate through and don't provide the specifics that a person searching for accommodation might be looking for. This section will discuss some of the property search applications in Ireland including Daft.ie, MyHome.ie, Rent.ie and Property.ie as well as property search applications in the United Kingdom and America which are rightmove.co.uk and zillow.com respectively.

2.4.1 Irish Applications

- **Rent.ie:** Rent.ie is one of Ireland's property search websites. It allows the users to search for holiday homes, sharing, short lets and student accommodation. As well as that, Rent.ie also provides the feature of renting out your parking space and is integrated with Adverts for purchase of hardware.
- **Property.ie:** Property.ie is another property search website in Ireland that is very alike with Rent.ie. It also allows the user to search for rent properties, to let, new homes, commercial properties and is similarly integrated with Adverts for the purchase of hardware. The website does not offer the option to search for holiday homes or student accommodation.
- **MyHome.ie:** MyHome is another property search application. MyHome provides a similar service such as the previous examples but seems to be a more comprehensive tool. It provides extra features such as a trending property page, open viewings, auctions, advice, property reports, property price register and an agent finder.
- **Daft.ie:** Finally, Daft is seen to be the most advanced property search application in Ireland through its functionality. It lets the user to search for properties for rent, sale and short term lets as well as commercial properties, holiday homes, parking spaces and new homes. It offers some great extra features such as the ability to navigate through Google Navigation, view street photography of properties using Google Streetview, acquire information on nearby schools and transport and save your most common searches to favourites.

2.4.2 International Applications

- **Zillow.com:** Zillow is an American property search website. The application allows you to buy, rent, sell properties and look for home loans and agents. Zillow also provides an interactive map on which the properties are displayed on.
- **Rightmove.co.uk:** Rightmove is a British property search website. Rightmove provides similar services such as buying, renting, selling properties as well as an inspire tab which contains property advice, property blogs, moving stories and house trends.

2.4.3 Comparison

As mentioned, property search applications do not give the user the ability to perform an advanced search on a property and its area. The user is limited to search only by the price, location, number of bedrooms and the property type which is evident in the discussion in section 2.3.1 and 2.3.2. Although some of these applications have extra features, the user cannot determine whether the area of the property suits them. None of the applications provide the facility to search by cultural diversity, employment rates, education, infrastructure or proximity which have been identified in the literature as important factors for residential choice. The aim of the project is to overcome this problem and provide people with a better service of searching for properties which suit them better.

2.5 Technologies

2.5.1 Android Studio

The project aims to develop an Android application and so the most important technology used in the development of the project is Android Studio. Android Studio is an official integrated development environment which is designed to let people develop Android applications. Android Studio seems to be the better IDE in comparison to Eclipse in terms of Android development. Mehtu Rajput gives us an insight into why this is so [15] where he says that Android Studio outdoes Eclipse due to Gradle integration, advanced code completion, user interface, organization of project, system stability and its drag and drop features. Android Studio also provides the user with an Android emulator which is a virtual device used for running and testing your application.

2.5.2 Languages

The languages in the development of the project include Java, XML and PHP.

Java is used as the fundamental language for the development of the application. According to Alex Nordeen Java gives the best option for development of mobile applications that are based on Android. Android consists of its own API's and Java libraries so therefore both are used for writing code [23]. The markup language used for drawing interfaces is XML. PHP is the language used for the server connection with the application.

2.5.3 PostgreSQL and MySQL

PostgreSQL is a database management system which would have been used to support the spatial data of the application. PostgreSQL has many advantages which are listed below:

- PostgreSQL is completely free and open source software.
- PostgreSQL is widely used in large systems where the speed of operations needs to be fast when dealing with a large amount of data
- PostgreSQL maintains an excellent community with constant effort to improve the current features as well as introduce new features to maintain itself as one of the most advanced databases.
- PostgreSQL is excellent when dealing with spatial data. PostgreSQL provides geospatial data support through an extension called PostGIS.
- PostgreSQL supports materialized views, extensibility and programming languages.

Although PostgreSQL is a more suitable database management system for the project, MySQL is used for the implementation of the application due to its ease of use, familiarity and integration with the WampServer. PostgreSQL was an unfamiliar technology, which halted the progress of the project due to being very difficult in comparison to personal capabilities. As discussed in chapter 6, there is however a scope to extend the project to incorporate spatial operations as future work.

2.5.4 Server

The Android application deals with a large amount of data, which can not be stored locally. The data must be stored on a server and queried indirectly for security purposes.

Firebase was the first server attempted to be incorporated with the application. Firebase however, is a non-SQL server that does not have a schema and therefore did not meet the demands of the project. The application also attempted to be incorporated with a UCD provided server. Similarly, this plan did not go ahead due to its problems with PostgreSQL. Finally a WampServer was used which was successfully implemented. The server is connected to the application through PHP and uses MySQL queries for get and post operations. The Property Price Register and the Census Small Area Population Statistics are deployed on the server.

Chapter 3: Overview of Project and Analysis

The result of the project is an Android application which provides a recommendation of areas which match the ideal living conditions provided by the user. The user is asked a series of questions describing the type of area they would like to live in. The application uses a recommending tool to display areas which match the users criteria. The application is integrated with Daft.ie which allows the user to search for individual properties within areas which have been recommended. The core aspects of the application which form its functionality are the user input, queries, data and integration, all of which will be discussed in this chapter.

3.1 Data Cleaning

The gathered data is used as the basis for the development of the application. As mentioned in section 2.2 the application makes use of the Census Small Area Population Statistics and the edited version of the Property Price Register. The census data contained over 800 rows, most of which were redundant to the needs of the application. The process of data cleaning was driven by the literature, data availability and a conducted survey.

The first step involved determining the availability of data which is useful to the project and understanding its format. The data then had to be cleaned based on the findings of background research. As mentioned in section 2.1, there are many important factors which influence the decision of why people live where they do. The data has to narrowed down to represent these important factors. This involved manually selecting data and comparing it to the literature to see if it is of importance or necessary for the application.

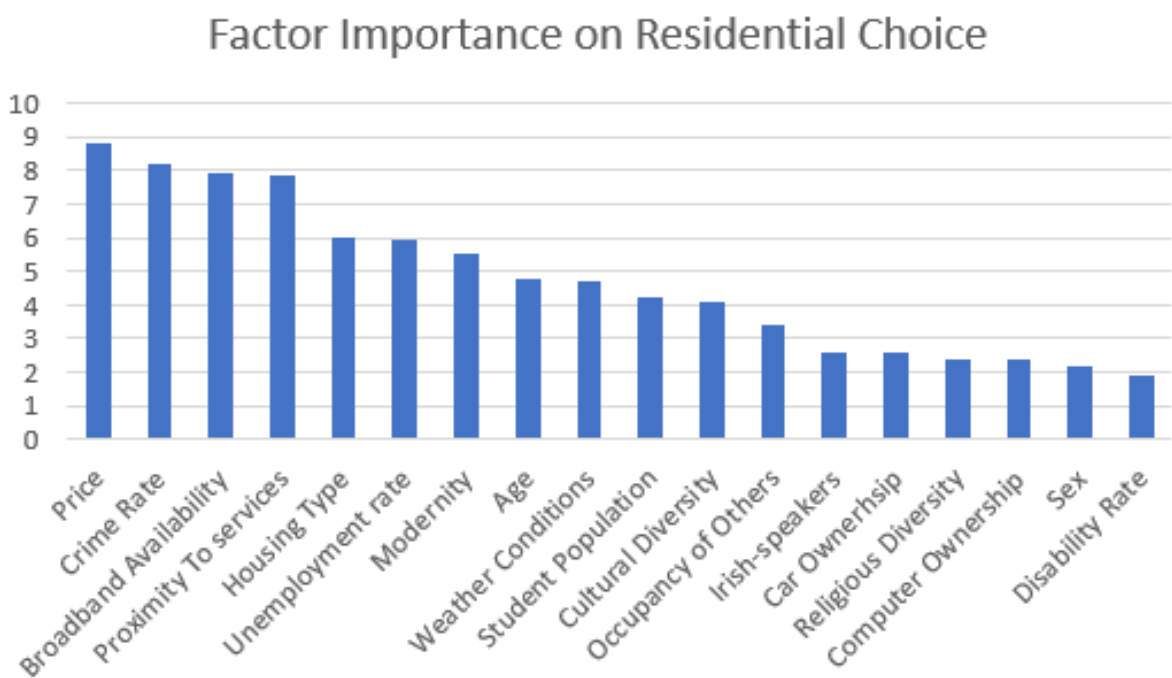


Figure 3.1: Results of conducted survey

An online survey was conducted to aid the decision of determining what questions are more important to ask the user about their ideal living conditions. The survey consisted of 18 questions where each question consisted of a different factor. Every question asked how important or unimportant that factor is in reaching a decision when looking for a new place to live. The person taking the survey had to choose between 0 and 10 where 0 represented the factor being very unimportant and 10 represented the factor to be very important. The survey had a total of 50 participants who's results were graphed into a well presented line graph.

Figure 3.1 represents the average result for every factor that could potentially help with the decision of choosing somewhere to live. The factors were chosen based on the data available by the Census Statistics and from the findings of conducted background research. The graph represents the factors starting from the most important on the left side to the least important on the right side. We are able to evaluate from this graph that the factors deemed most important are the price, crime rate, broadband availability and the proximity to services such as bus stops, shops and restaurants. The factors deemed very unimportant include the population of Irish-speakers, car ownership, religious diversity, computer ownership, the population of a certain sex and finally the disability rate. A bulk of the findings from the survey match with the findings found from background research, where the more important factors are still found to be important from other sources. The survey helped to shape and finalize the type of questions that the user would be asked. Factors that had an average of above 4, meaning they have somewhat of an importance to ones decision, were then the driving factor behind the questions the user is asked.

Factors like the crime rate and weather conditions, which were deemed as important were not included as questions in my application. As explained in section 2.2 of background research, data for these factors would be very different to the ones used by the application, therefore incorporating them would be extremely difficult and beyond the scope of the project. It is of course something that is considered as future work as it would be a great addition to the application. Similarly proximity to services is another factor that is considered to be included in the application as future work as explained in chapter 6. This however would have required the application to perform spatial operations, something that is considered as future work. Since these factors could not be included as the basis for the questions, The Irish-speaking and sex factor were both used as questions within the application. The motivation to pick these factors stemmed from personal opinion and recommendation from the supervisor.

Figure 3.2 is a representation of the main factors chosen from the census statistics that are used for the implementation of the application. The left side of the represents the code which is used for referencing, and the right side represents what that code means. For example 'T1_1AGETM' represents the total number of males in a given small area. 'T15_3.B' represents the total number of people with broadband in a given area. 'T6.2_11LP' represents the total number of people living in a house built in 2011 or later in a given area. All of these factors are accompanied by a small area ID and the figure.

Data cleaning was also conducted on the Property Price Register in order to remove redundant data, however it was not as tedious. This involved getting rid of the 'SAPS2017_' prefix for the

T1_1AGETM	Males
T1_1AGETF	Females
T1_1AGE25_29T	People aged 25-29
T1_1AGETT	People
T2_2WI	White Irish
T2_2WIT	White Irish traveller
T2_2OW	Other white
T2_2BBI	Black or Black Irish
T2_2AAI	Asian or Asian Irish
T2_2OTH	Other cultural backg
T6_1_HB_H	House/bungalow
T6_1_FA_H	Flat/apartment
T8_1_ST	Students
T8_1_ULGUPJT	Unemployed
T15_3_B	Broadband
T15_3_OTH	Other
T15_3_T	Total
T3_2DOEST	Daily Irish-speaking
T3_2WOEST	Weekly Irish-speaking
T3_2LOOEST	Little Irish-speaking
T6_2_11LP	House built 2011/later

Figure 3.2: References

small area ID. This was done to ensure that the IDs are in similar format in both of the data sets so they can be referenced against each other. Other columns such as the date of purchase, address, VAT along with some others were removed to reduce the size of the data as it contains over 200,000 rows.

3.2 User Input

In order for the application to give a recommendation, it requires user input. The user is given a series of questions to answer as seen in figure 3.1 where they must provide their residential choice preferences. The questions consist of a choice of province, county and different preferences for the chosen county. The user must choose one Irish county within one province. A message will pop up asking the user to choose an Irish county if the user tries to click on counties such as Derry or Down. The Census statistics did not provide statistics on the 6 counties in Northern Ireland, but the option of selecting them was included for demonstration purposes as it is something that can be achieved in future work. The user has the opportunity to specify their ideal living conditions based on the choices made in regards to the preferences. The third image in figure 3.3 shows the type of questions the user is asked, however not all of these are shown in the image as the user is able to scroll down to answer the remaining few. The questions include a preference of sex, age, cultural diversity, Irish-speaking, student population, house type, modernity, employment rate, broadband availability and property price.



Figure 3.3: User interface of application

As mentioned in section 2.4, the Census Small Area Population Statistics contains a variety of information on every small area in Ireland and thus containing the relevant information that relate to the preferences displayed. The questions which are displayed on the application are only a representation of some of the important things which may contribute to ones residential choice. As mentioned in chapter 2 of background research and something that can be seen through the

results of the survey is the effect climate, crime rate, proximity to service and as well as other factors have on one's decision. This is something that could be incorporated into the application as future work to give an even more personal and ideal recommendation to the user which is described in greater detail in chapter 5.

The user is required to choose one of the three options for every question asked. The options mainly consist of a majority, minority or no preference to the question being asked, this however does differ slightly for some questions. For example the three choices for price preference consist of €0 - €150,000, €150,000 - €300,000 and €300,000+. Similarly, the options for rate of unemployment differ slightly as the options include either low or normal unemployment as it makes more sense that giving the user the option to choose high unemployment rates. The user must choose one option from every question, otherwise a message will come up asking the user to answer every question.

3.3 Queries

Forming queries is an important aspect of the project. The queries formed are responsible for interacting with the databases to retrieve results. Once the user has selected their options for every preference question, the data is stored within the application. The data is formed into one query, as explained in greater detail in chapter 5, which interacts with the database to determine if an area with the same conditions exists. If one or more areas exist which match the criteria, the application will display the list of areas which match the user's ideal living conditions.

As described in chapter 4, a query is formed of strings which represents its conditions. These conditions are set depending on what answer the user chooses.

- **Age:** The user has the choice of majority young people, old people or no preference.

$$\frac{('T1_1AGE30_34T' + 'T1_1AGE35_39T' + 'T1_1AGE40_44T' + 'T1_1AGE45_49T' + 'T1_1AGE50_54T' + 'T1_1AGE55_59T' + 'T1_1AGE60_64T' + 'T1_1AGE65_69T' + 'T1_1AGE70_74T' + 'T1_1AGE75_79T' + 'T1_1AGE80_84T' + 'T1_1AGEGE_85T')}{('T1_1AGETT')} < 0.5$$

This condition checks for the population of people above the age of 30 in an area to be under 50%. If the user chose majority old, the same condition would look to be greater than 50%. No preference returns an empty condition.

- **Sex:** The user has a choice of majority men, majority women or no preference.

$$('T1_1AGETM') > ('T1_1AGETF')$$

This condition checks for the total population of men to be greater than those of women. The greater than sign becomes a less than sign if the user chooses majority women. No preference returns an empty condition.

- **Culture:** The user has a choice of diversity, low diversity or no preference.

$$('T2_2WI') / ('T1_1AGETT') < 0.8$$

This condition is a diverse area which checks for the areas consisting of less than 80% white Irish people. The less than sign becomes a greater than sign if the user chooses low diversity. No preference returns an empty condition.

- **Irish-speaking:** The user has a choice of a well spoken Irish area, a low speaking Irish area or no preference.

$((('T3_2DOEST'+ 'T3_2WOEST'+ 'T3_2LOOEST')/ 'T1_1AGETT') > 0.25)$

This condition is a well spoken Irish area which checks if the percentage of people who speak Irish daily, weekly and less often is greater than 25%. If the user chose the low Irish-speaking option this condition would be less than 25%. No preference returns an empty condition.

- **Student:** The user has a choice of an area with many students, few/none students or no preference.

$((('T8_1_T'/ 'T1_1AGETT') > 0.15)$

This condition is an area with many students that checks if the percentage of students is over 15%. If the user chose the few/none students option this condition would be less than 15%. No preference returns an empty condition.

- **Unemployment:** The user has a choice of normal unemployment, low unemployment or no preference.

$((('T8_1_ULGUPJT'/ 'T1_1AGETT') < 0.05)$

This condition is an area with low unemployment that checks if the percentage of people unemployed is less than 5%. If the user chooses normal unemployment this condition would be greater than 5%. No preference returns an empty condition.

- **House Type:** The user has a choice of majority houses, majority apartments or no preference.

$((('T6_1_HB_H' > 'T6_1_FA_H')$

This condition is an area where the number of people living in an apartment is greater than people living in houses. If the user chooses majority apartment, the condition would be greater less than. No preference returns an empty condition.

- **Modernity:** The user has a choice of very modern, not modern or no preference.

$((('T6_2_11LP'/ 'T1_1AGETT') > 0.05);$

This condition is an area where the number of people living in a house built in 2011 or after is more than 5%. If the user chooses not modern, the condition would be less than 5%. No preference returns an empty condition

- **Broadband Availability:** The user has a choice of high or normal availability or no preference.

$((('T15_3_B'+ 'T15_3_OTH')/ 'T15_3_T') > 0.8)$

This condition is an area where the number of people with broadband availability is greater than 80%. If the user chooses normal availability the condition would be less than 80%. No preference returns and empty condition.

- **Price:** The user has a choice between the property price in the range of €0 - €150,000, €150,000 - €300,000 or €300,00+.

$((('Price' > 150000) \text{ AND } ('Price' < 300000))$

The figures in the condition would change based on users answer.

The conditions are used to make two queries, which is explained in section 4.6. The answers to the first 9 questions are the conditions which form a query against the census statistics to retrieve small areas whose profiles match the user input. The small areas retrieved from the first query, along with the users choice of price form the second query against the Property Price Register data to retrieve the name of the electoral divisions which match the users ideal living conditions.

3.4 Result and Integration

Once the user input is stored and formed into queries, the user has the option to navigate between 3 pages of the application including the results, map and integration with Daft.

The core purpose of the project is to create an application which gives the user area recommendation based on their input. The user is directed to the results page, which displays a list of areas whose conditions match those that were selected by the user as seen by the first image in figure 3.4. A small area name is not provided in the databases, however a small area ID is. This ID can be referenced to retrieve an electoral district. An electoral district is slightly bigger, as it is made up of approximately 5 small areas. The results which are displayed to the user are the electoral district names, which contain the small areas that match the users ideal living conditions. The user has the option to search again, where they will be directed to the first page of the application asking to select a province to search in.

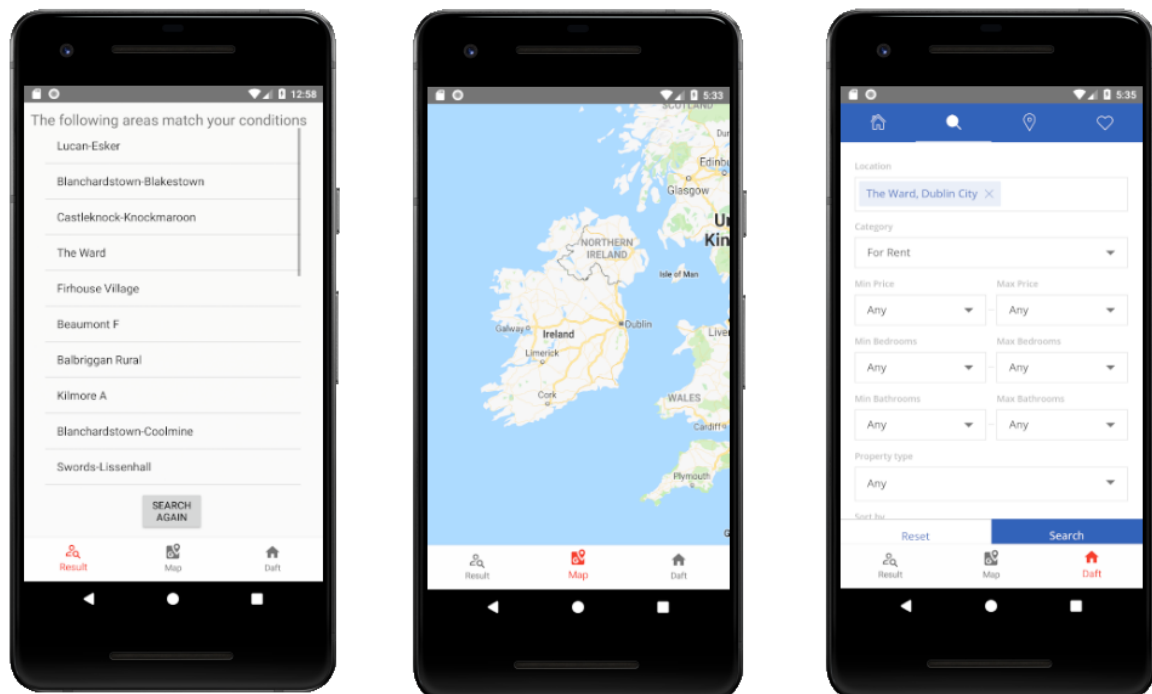


Figure 3.4: User interface of application

The second image of figure 3.4 shows the map page. The application only provides the user with the basic use of navigating through the map. The map should be implemented using the spatial data provided by the census statistics as described in section 2.2 to allow the user interact with the areas in Ireland. This is something that is planned for future work and is described both in section 4.2 and 6.1.

The third image of figure 3.4 shows the applications integration with Daft, a property search website. This gives the user the opportunity to search for individual properties to either buy or rent in the areas which have been recommended to them. The ability to search through Daft can be done inside of the application to reduce the time and effort the user would require to do this themselves through the browser.

Chapter 4: Detailed Design and Implementation

The design and implementation of the project was formed following the system architecture. This is made up of the user, client and the server. Several technologies, as described in section 2.5 of background research, attributed to the design and flow of the application as well as its implementations. This chapter will explain how the application is designed and implemented and the motivation behind it.

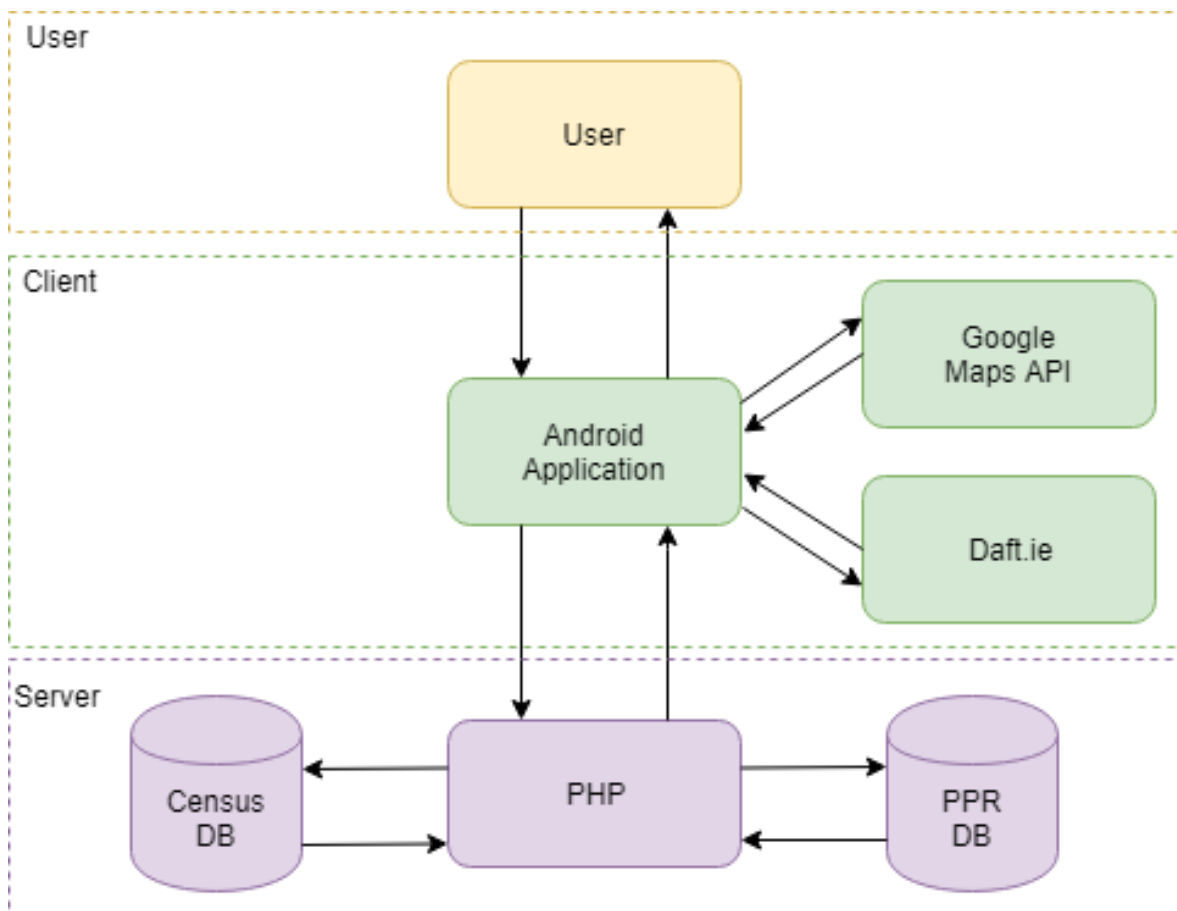


Figure 4.1: Project system architecture

4.1 System Architecture Flow

Figure 4.1 is a diagram of the applications system architecture. This is made up of three components, the user, client and server. The server side of the application consists of two large databases being the Census Small Area Population Statistics and the Property Price Register, both of which are discussed in detail in section 2.2. Two of these MySQL databases are hosted on a WampServer. For the purpose of the project, the server is run on local host. As part of future work the server could be changed to run online but this was not necessary under the project

specification. A PHP server connection is made between the client and the databases hosted on the server. When the user provides input into the application a request is sent to the server and the result is then displayed to the user. The user is also able to interact with Google Maps and Daft.ie which are integrated with the client of the application. The implementation of these components will be described in greater detail in section 4.3.

4.2 User Interface

The application has a simple and minimal user interface with the purpose of allowing the user to navigate through the application in an easy-flow manner. The applications user interface is designed through XML, a markup language and Java. The motivation behind the interface design stems from the well-known words of the famous Leonardo Da Vinci "Simplicity is the ultimate sophistication" as well as the words of Ludwig Mies Van Der Rohe "less is more". According to Seonghoon Kang and Won Kim the design of the user interface must be simple in order for the user to have no complications in terms of usability. They mention in the report that "to be simple, we believe that the UI must diligently and consistently adhere to three principles: minimum, intuitiveness, and consistency" [24]. The applications user interface design can be broken into two parts, the questions and the results interface.

4.2.1 Questions Interface

The first three pages the user interacts with are made up of different questions asked which build up the users profile of their ideal living conditions. As shown on figure 3.3, the user interface for these pages are made up of buttons which are placed in a scrollview. Every button represents an answer to the question asked. The use of buttons throughout the activities keeps the application consistent and avoids any confusion as it is clear to the user on how to use the application. When a user presses the button, the button changes to a light blue colour to indicate that it has been pressed. The user must choose 1 option for every preference question in order to be able to search for areas.

4.2.2 Results Interface

Figure 3.4 shows the results user interface of the application. The design of the user interface here is split into 3 fragments. The user is able to navigate between the 3 fragments through a navigation bar at the bottom of the screen or by sliding the screen to the left or to the right, depending which page they want to access. The navigation bar consists of 3 icons and their name to represent the 3 pages. The icon and name has an animation when clicked and changes to a red colour to let the user know what page of the application they are on.

The first fragment is the results page which displays the areas recommended to the user. The results are presented in a listview as the design is neat, easy to use and the number of areas returned is sometimes too large to fit on the screen. The second fragment is the applications integration with Google Maps. The map takes up the whole screen and the user is able to navigate through it. The third and final fragment is the applications integration with Daft, a property website. The Daft.ie website is loaded within the application in a webview which takes up the whole screen. The user can search for properties within the recommended areas with Daft.

4.3 Client

The client for the project is the Android application. The core implementation of the client is the handling of user input, the results of queries and displaying it to the user. The users input consists of a choice of province, county and set of preferences to different themes as described in section 2.2 of background research. The input is recorded by the user pressing buttons, where every button correlates to an answer that the user is being asked. Every button contains a value, and when pressed, that value is stored within the application as the users answer.

As seen on the third image of figure 3.3, every question in relation to preferences has a choice of 3 buttons which correspond to the answers. Each of these buttons hold a value which resemble a condition for the query to be made. For example, if the user selects the majority men button in relation to the sex preference question, the value stored for that question would be the following string 'T1_1AGETF <T1_1AGETM' where 'T1_1AGETF' and 'T1_1AGETM' refer to the total number of females and males living in an area respectively. The structure of the conditions for every question is described in section 3.3. The same methodology was used for every question and the logic behind how these conditions are made is described in depth in chapter 5. Once the user selects an option for all questions and presses search, all of the conditions represented by the values are combined together into one well-formed logical string which is the query. The string is posted to the server where it is passed in as a parameter of a MySQL query used to retrieve results from the database.

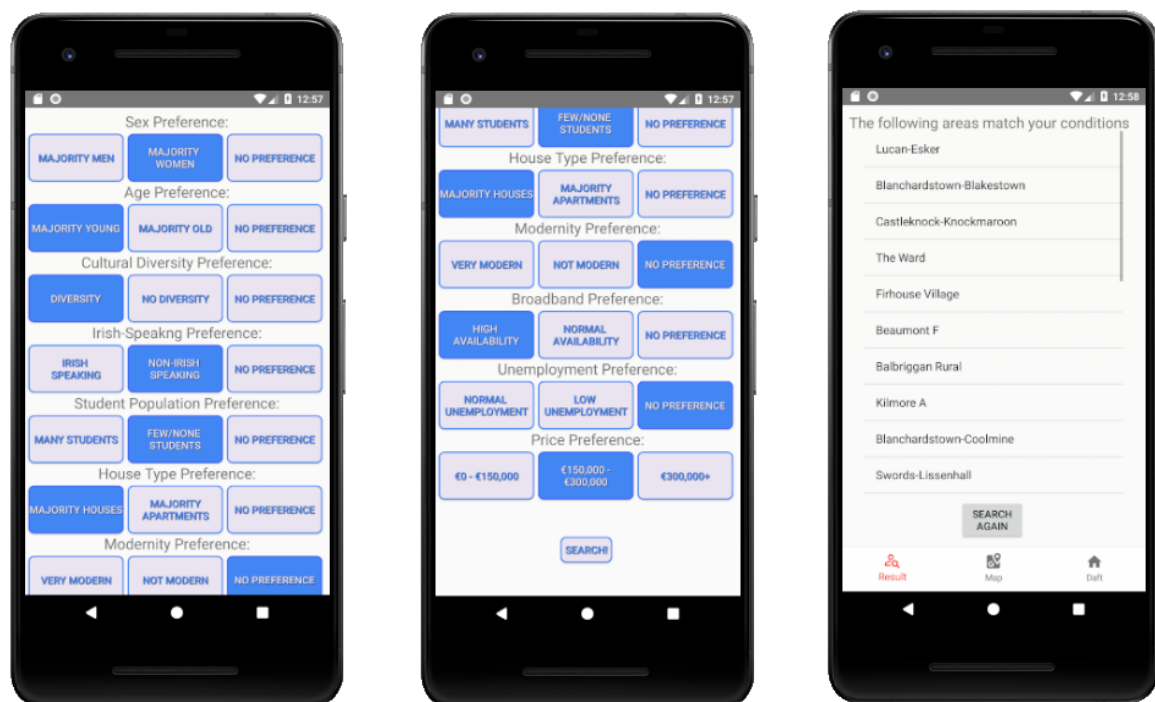


Figure 4.2: User interface of application

Figure 4.2 is an example of how the user may answer the questions and the results that come from such a search. The user described their ideal living conditions to be in an area of majority women and young people, with cultural diversity, a low amount of Irish-speaking people and students, populated with mostly houses with no preference of their modernity but a property price ranging between €150,000 to €300,000, high availability of broadband and no preference in terms of unemployment rate. The conditions are added together into one long string, along with the "SELECT ... FROM ... WHERE" statement. This string is sent to the server where it is read by

PHP and queried against the census database to retrieve the ID's of small areas which match.

```
SELECT `GEOID` FROM `censusdata` WHERE
(((('T1_1AGE30_34T'+'T1_1AGE35_39T'+'T1_1AGE40_44T'+'T1_1AGE45_49T'+'T1_1AGE50_54T'+'T1_1AGE55_59T'+'T1_1AGE60_64T'+'T1_1AGE65_69T'+'T1_1AGE70_74T'+'T1_1AGE75_79T'+'T1_1AGE80_84T'+'T1_1AGEGE_85T')/('T1_1AGETT')) < 0.5) AND (('T1_1AGETM'<'T1_1AGETF') AND (('T2_2WI'/'T1_1AGETT')<0.8) AND (((('T3_2DOEST'+'T3_2WOEST'+'T3_2LOOEST')/'T1_1AGETT')<0.25) AND (('T8_1_ST'/'T1_1AGETT')<0.15) AND (((('T15_3_B'+'T15_3_OTH')/'T15_3_T')>0.8) AND ('T6_1_HB_H'>'T6_1_FA_H'))|
```

Figure 4.3: Constructed query based on example

The retrieved ID's along with the price specified by the user are then formed into the second query interacting with the Property Price Register. The query is formed in the same way, where strings are added together along with the "SELECT ... FROM WHERE" statement. Figure 4.4 is how the second query would look for the example being described.

```
SELECT `Electoral_District` FROM `ppr` WHERE |(`Small_Area` = 17010008 OR `Small_Area` = 17010047 OR `Small_Area` = 17034005 OR `Small_Area` = 17051012 OR `Small_Area` = 17051013 OR `Small_Area` = 27024003 OR `Small_Area` = 27025005 OR `Small_Area` = 37027014 OR `Small_Area` = 37057034 ..... OR `Small_Area` = 37057042 AND (('Price` > 150000) AND (`Price` < 300000))
```

Figure 4.4: Second constructed query based on example

The query is selecting the names of the electoral divisions containing the small areas which possess the qualities of the user's ideal living conditions. The result is displayed as a listview of the electoral divisions as seen in the last image of figure 4.2.

The application is integrated with the Google Maps and Daft to allow the user to interact with a map and search for properties based on the recommendations. The application uses Google's API which provides libraries and functions for the creation of the map. The map does not provide any spatial information, but it is however a plan for future work. PostgreSQL provides PostGIS, which has functions taking in co-ordinates and drawing boundaries. This would be done by using the census shape file. Every area would have its profile pop up once a user presses on it where the profile is made up of information from the census small area data.

4.4 Server and Database

The core implementation of the server side is to host large amounts of data and create a connection between it and the android application. As explained previously in section 2.2 of background research, the data is too large to be located within the application therefore it must be hosted on a server. The data was cleaned and modelled manually, as mentioned in section 3.1, to include only the relevant information. The connection between the server and the client occurs through a simple MySQL connection in PHP which takes in four parameters: the server name, user name, password and database name. If the connection is successful the application will then query the database.

As explained in section 4.3 the structuring of the queries are formed in the application based on user input. This is then queried against the database as a MySQL query and if successful, the result retrieved by query is sent to the application in JSON format. If the query is unsuccessful

the user is prompted to try again as no matches have been found. The process of querying occurs twice for every search as there are two data sets to retrieve results from. The first MySQL query queries the Census Statistics data to retrieve all of the small area ID's which match the users ideal living conditions. These ID's are structured together into a query within the application as explained in section 3.3. The second MySQL query then queries the Property Price Register to retrieve the names of the electoral divisions referenced by the small area ID. The retrieved electoral divisions are decoded from JSON format into a presentable format displayed by the application to the user.

The connection was made through PHP rather than directly from the Android application for security purposes. If the connection was direct rather than through PHP, the server password would be exposed and the user could potentially have direct access to the database meaning they could view or exploit the data. PHP was also the most familiar technology in terms of server connection which was the motivation for its use in this project. Similarly, MySQL was also the most familiar database technology being the reason it was used. As mentioned in chapter 6, converting to using PostgreSQL for querying rather than MySQL is something to be considered as future work.

Chapter 5: Testing and Evaluation

The purpose of the project is to create an application which uses suitable techniques to recommend similar areas based on the users ideal living conditions. To ensure that these techniques provide accurate and correct recommendations, a substantial amount of testing was required. As mentioned throughout the report, the users answers to the preference questions correspond to the conditions which form a query. Testing was conducted on all answers to the questions to ensure that their conditions return a logical and reasonable result when used in a query. The testing methodology of trial and error was performed through phpMyAdmin where numerous MySQL queries queried the database.

Every condition was tested independently in order to decide its relative weight. The weighting is different for each condition and the goal was to weight the conditions accordingly to what is logically correct and whether that condition would retrieve results independently and as a combination with other conditions. The testing of conditions was through the method of trial and error. This involved changing the percentages of the queries independently and as a combination of conditions, to ensure that results are retrieved most of the time. The process involved testing one condition and examining the amount of results it retrieved, to examining the results of a combination of two results, to three results, all the way to all 10. For example, for cultural diversity, as explained in section 3.3, cultural diversity means that the percentage of white Irish people in an area is less than 80%. This figure was altered until and tested till the amount of results retrieved from this condition was satisfactory, as well as it sounding logically correct. Not all queries however, give results. Some searches may be too specific and not match the conditions specified by the user. In such a case, the user is informed to try again through a pop up.

As described in section 3.1, a survey was conducted to get peoples opinions on the importance of various factors for residential choice. Figure 3.1 shows the factors being most important starting from the left and being the least important at the right side of the graph. The results of the survey were evaluated to aid in the decision of choosing the questions. To no surprise, the results had a direct link to information retrieved from the literature.

Partial user testing was conducted to test whether the application is functional. This application was tested on several colleagues who would use all of the functions of the application. The feedback was positive, however there is no written documentation of the results. This is something that must be conducted as future work to gain feedback from potential users to gain insight on what areas of the applications are good and what areas need improvement. It is important to keep the application engaged with the users as they are essentially the ones who use it.

As mentioned in future work, there are lots of ways possible to expand on the functionality of the application such as creating more advanced queries, expanding the use of data and adding extra features. To ensure that the process of expanding the application is done efficiently, Junit tests are something that is planned to be implemented as future work. Junit tests would help with the design of the application, facilitate change and simplify integration, make it easier to find bugs and improve code quality.

Chapter 6: Conclusions and Future Work

With the rapid increase of property prices in Ireland people are forced to move out to unfamiliar areas to seek cheaper accommodation. Coupled with this is the lack of advanced property services available in Ireland, meaning people are unable to gain insight into whether these unfamiliar areas are suited towards their ideal living conditions. These problems are overcome through the Android application which helps the user familiarize themselves with areas through an accurate recommendation based on their ideal living conditions. The application provides accurate and pinpoint recommendations and the option to search within this area through an integration with an outside property search service. Although functionality of the application is complete, there is room to improve on through future work.

6.1 Future Work

6.1.1 Data

There is a scope to improve the functionality and appropriateness of recommendations available, by including other data sets such as the census boundary file and other relevant data in terms of crime, weather, proximity to services and more.

One limitation of the application is the fact it does not support any spatial data. Due to having no previous experience with servers or spatial data, there was severe difficulty of setting up the server side of application through PostgreSQL. Several methods were attempted to get PostgreSQL working on server including using the UCD provided server, the PostgreSQL JDBC Driver and a PostgreSQL connection through PHP however all failed and were beyond the scope of my ability. Instead the application makes use of more simple and familiar technologies such as MySQL, WampServer and PHP. With a slightly better understanding of servers and the technologies behind it, switching over to use PostgreSQL instead of MySQL is something that could be achievable as future work to ensure the application supports spatial data. This would involve using the census boundary file and the functions of PostGIS to draw the boundaries around small areas in Ireland to make the map more interactive and allow users to click on the areas to retrieve its information.

As mentioned previously in section 2.4 of background research and chapter 5, there is a lot more data possibly to be used for the application that could be incorporated with the project as future work. The application can be expanded to include data on climate, crime rates, employment opportunities, politics, infrastructure and the cost of living. This would allow the user be even more precise with their ideal living conditions and potentially find areas based on data that the application currently not provide.

The literature states that proximity to services is a major factor which influences the residential choice of a person. The OpenStreetMap data allows to calculate distances between certain points of interest. This data can be incorporated with the application as future work to implement more questions involving proximity's to services like hospitals, restaurants and universities.

6.1.2 Expansion of the application

There is plenty of room for major improvement of the application which can be done by expanding its services to a new level. The application can be expanded to apply to other countries, use more and bigger data and possibly expand to act as an intermediary service.

Other countries

As mentioned throughout the report, the application makes use of the Census Statistics which give it the ability to recommend areas within Ireland. The scope of recommendation can be expanded to other countries as the Census Statistics can be found for other countries such as the USA, Canada, or the UK. This means the application has the potential to expand its recommending tool to countries outside of Ireland as future work if a demand were to exist.

More appliances

The project is an Android application meaning only people with an Android device would be able to use the service. Something that can be considered as future work is expanding the application to be available on iOS and as a web application. According to the global stats counter the market share of Android and iOS devices in Ireland is 52.37% and 47.32% respectively [16]. This means that the application, being only Android, is missing out on a 47.32% market share of devices which relates to a lot of potential users.

Property search service

The application recommends areas and lets you search within these areas through an integration with Daft. There is however room for expanding the application to compete with the likes of Daft and MyHome by implementing functions such as buying, renting, selling properties within the application, rather than being integrated with other property search websites.

Intermediary service

Following up from section 6.1.3, the application can take a different approach for future work. Instead of being its own property application, it could act as an intermediary service. Intermediary applications have seen a huge success over the coming years with well known applications such as Uber, Just Eat and Airbnb. Intermediary services provide a platform on which the application acts as a link between independent services and customers. Although quite ambitious, it could definitely be seen as potential future work with the right team and resources.

Bibliography

- [1] Peter Hamilton. *Average rents reach all-time high of 1,304 per month*. The Irish Times. 17 August, 2018.
- [2] Ronan Lyons, Assistant Professor of Economics at Trinity College Dublin. *The Daft.ie Rental Price Report. An analysis of recent trends in the Irish rental market 2018 Q3*. Daft.ie. 12 November, 2018.
- [3] Fiona Reddan. *Dublin rents to rise to 2,500 before they start to slow*. The Irish Times. 13 February, 2018.
- [4] Anna Isaac, Economics Correspondent. *London rents fall for first time in eight years*. The Telegraph. 13 June, 2018.
- [5] Elli Thomas, Ilona Serwicka & Paul Swinney. *Urban demographics Why people live where they do*. 2 November, 2015.
- [6] David Quilty. *Where Should I Live? 14 Important Factors When Deciding the Best Place to Live*. Money Crashers. 2008.
- [7] Diane Schmidt. *How to Choose Where to Live*. The Spruce. 12 December, 2018.
- [8] *Irish population analysis*. Wikipedia, the free encyclopedia.
- [9] Anne Griffond-Boitier, Sophie Mariani-Rousset, Pierre Frankhauser, Jrme Valentin, Victor Alexandre, and Bernadette Nicot. *The Wheres and Hows of Residential Choice*. www.springer.com.
- [10] Shane Lynn, Data Science professional, tech-enthusiast and start-up founder. *The Irish Property Price Register Geocoded to Small Areas*. www.shanelynn.ie.
- [11] *London remains the most expensive location for rental accommodation in Europe*. ECA International. 17 January, 2018.
- [12] Ronan Lyons, Assistant Professor of Economics at Trinity College Dublin. *The Daft.ie House Price Report*. Daft.ie. 30 September, 2018.
- [13] *EU Capitals Square Meter Prices (2018)*. Check in Price. 6 August, 2018.
- [14] *Europe: Price Rankings by City of Price per Square Meter to Buy Apartment in City Centre (Buy Apartment Price)*. Numbeo.
- [15] Mehul Rajput, CEO of mindinventory. *Why Android Studio Is Better For Android Developers Instead Of Eclipse*. DZone. 20 May, 2015.
- [16] *Mobile Operating System Market Share in Ireland*. Statcounter.com. March, 2019.
- [17] *Why do people live in cities?*. Cities and urban life. Oxford University Press.
- [18] *Census*. Wikipedia, the free encyclopedia.
- [19] Orla Ryan. *Why do we have a census? Here's what the statistics are used for*. The journal. 6 April, 2017.
- [20] Martin Charlton. *Small Areas in the Republic of Ireland*. Strategic Research in Advanced Geotechnologies.

- [21] *Property price register brimming with errors*. The Independent. 4 July, 2014.
- [22] Ruairi Scott Byrne. *Ireland ranked third most expensive country in the EU to live in*. Buzz. 16 March, 2017.
- [23] Alex Nordeen. *WHY JAVA IS THE BEST PROGRAMMING LANGUAGE FOR MOBILE APPLICATIONS*. Irish Tech News. 19 November, 2018.
- [24] Seonghoon Kang and Won Kim. *Minimalist and Intuitive User Interface Design Guidelines for Consumer Electronics Devices*. Journal of Object Technology. April, 2007.