



— التجربة عقارية أفضل —

IT 496: Graduation Project Report Product Release-2

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3rd Semester 1444
2022/2023



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NOZOL

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Abstract (English):

As businesses are transitioning from a traditional to a more digitalized means of conducting business operations, property owners/real estate agents are beginning to advertise their properties on mobile applications more frequently. Additionally, people who are looking for properties to buy/rent usually try to look for them online as it is the easiest and fastest way. However, real estate mobile applications that are currently available locally are very limited in terms of functionality and provide a bad user experience. To address these issues, this project aims to develop a real estate Android mobile application that aims to facilitate real estate deals with an enhanced user experience. The Agile methodology was adopted for this project as it enables flexibility and encourages continuous development and testing throughout the software development lifecycle, by breaking the project into several sprints and delivering a tangible part of the product at the end of each sprint. Proper evaluation of the implemented features (functional and non-functional) was performed, showing a good acceptance level in terms of functionality and usability. It can be concluded that the project was a success as it managed to fulfill all of its main objectives. Future enhancements can be made to enhance its competitive advantage even more.

Abstract (Arabic):

في خضم التحول الرقمي الذي يشهده العالم ومع انتشار مفهوم الأتمتة للخدمات ما يزال سوق العقار في حاجة ماسة لتطوير خدماته رقمياً وذلك لارتفاع أعداد مستخدمي تطبيقات الجوال من تجار العقارات والباحثين عنها للشراء أو غيره، وهذه الحاجة تتبع من افتقار السوق السعودي خاصة لتطبيقات تدعم سوق العقار بكفاءة عالية وقدم للعملاء تجربة مستخدم مميزة. ومن هذا المنطلق يأتي تطبيق نُزل حاملاً معه العديد من الحلول الرقمية والتي أنشئت بدقة لتلائم احتياجات المستخدمين وتمدهم بجميع التسهيلات الممكنة التي تجعل من تجربتهم العقارية تجربة فريدة وممتعة.

تم اعتماد منهجية (أجيال) لتطوير تطبيق نُزل، والتي تعتمد بدورها على تقسيم دورة حياة بناء التطبيق إلى مراحل تكرارية، ويتم في نهاية كل مرحلة تسليم جزء ملموس من التطبيق ليتم تقييمه ومراجعته من قبل العملاء. وأخيراً عندما تم بناء التطبيق بالكامل تم اختباره عدة اختبارات مختلفة وكانت النتائج تشير إلى مستوى عالٍ من الرضا من ناحية المزايا المقدمة وسهولة الاستخدام، ومن هنا يمكن استنتاج أن المشروع كان ناجحاً حيث تمكّن من تحقيق جميع أهدافه الرئيسية وجميع مؤشرات الجودة العالمية مع توفر احتمالية وجود إجراءات وتحسينات مستقبلية لتعزيز ميزته التنافسية بشكل أكبر.

Keywords:

Property; Property tour; Content-based recommendation system; Good user experience



Introduction



1 Introduction

Nowadays, finding your ideal home in Saudi Arabia is becoming more difficult as its cities continues to grow and provide a limitless number of options. Additionally, property owners face difficulties when attempting to advertise their properties to make it visible to buyers due to limitations and issues with existing applications' functionality and user experience which needs addressing. Therefore, we aim to develop a solution that will give the owners the ability to effectively advertise their properties and will help buyers in finding the ideal property they're looking for way faster, while maximizing easy user experience and improving communications by providing many features that will be explained in detail in the following sections of the report.

This document provides an overview of the development process and the features of the application. In this chapter, we'll go through the problem this project intends to solve and its solution. Continually, we will show the product objectives, scope, and the product vision. Lastly, we will describe our approach in developing this project.

1.1 The Problem

For a long time, finding the perfect home has been the dream of many. But nowadays, finding and comparing houses that match your needs in Saudi Arabia, especially in one of its largest cities such as Riyadh, can be very difficult according to 2022 real estate statistics which show that Saudi Arabia has the highest demand for new housing within the GCC region, with its capital city of Riyadh having a leading stock of available office and retail real estate [1]. Similarly, making a property visible to many potential tenants or buyers can be a challenge too. Although there are existing applications that serve these problems, such as Aqar, they have issues with their functionalities as well as the user experience. More specifically, Aqar amongst the other apps has learnability and robustness issues. There is no main consistent menu that takes the user to the home page and the other pages immediately, and in some occasions, it's not apparent to the user what each button in the screen does, which makes navigating the app very frustrating [2]. Aqar also has a naïve ineffective recommendation system, that seems to recommend properties similar to a search operation that is based on one or two attributes such as the location, disregarding other important attributes such as the area and price. Moreover,



Aqar doesn't offer property tour appointment bookings which can be time and effort wasting to the user. Finally, the existing local apps lack several useful features for the target users.

1.2 Objectives

The main objective that this project aims to achieve is to help improve the whole real estate experience for both property owners and buyers by easing communications and improving the problems in existing real estate applications as described in the section before. By the end of the project and once it has been completed, Nozol should be able to:

- Provide a system that helps users to advertise and manage their properties.
- Help users to find a property that aligns with their preferences, whether they're looking for apartments, villas, or any other property type.
- Facilitates the communication between Nozol users.
- Provide users with a property tour appointments system, which helps them to book/request a property tour appointment.
- Provide the users with properties recommendations based on the property they're viewing.
- Help users to know how much rent they can afford by providing a smart “rental affordability calculator”.
- Allow users to view properties on the map with its details.
- Allow users to filter the map by changing its markers colors according to different criteria.
- Allow admins to manage accounts and handle complaints.



1.3 Scope

Nozol is a local android mobile application in Saudi Arabia that supports the Arabic language. It aims to fill the existing gap in the Saudi real estate applications market with many features that facilitate real estate deals. Our users are the admins, registered users (property owners/buyers/tenants) and any other guest users of any gender and any adult age with basic technical skills who are interested in real estate.

1.4 Product Vision

For property owners, buyers and tenants **who need to** buy, sell, or rent a property. **Nozol** is a mobile application that facilitates real estate deals by offering several services that help users in choosing a suitable property, **Unlike Aqar(عقارات)** and other real estate apps that lack some important features or provide bad user experience. **Our product** provides a better user experience by maximizing learnability and robustness, with enhanced property recommendations, in addition to a property tour booking system and other new and interesting features.

1.5 Approach

The software development methodology that was selected to be used throughout the project is the Agile methodology, which seeks an iterative & continuous delivery of small pieces of working software quickly to improve customer satisfaction. Firstly, we conducted interviews and a questionnaire to understand our users' needs and collect user requirements. Then we formed the product backlog, divided it into sprints and releases. Then we developed the product incrementally, delivering a working part of the product at the end of each sprint, and getting it evaluated by our supervisor (product owner) and scrum master. At the end, before the final release, the product was tested with UAT and NFR. The results helped us know which features can be improved, and what to consider for future work.



1.6 The Solution

In line with the kingdom's progress towards digital transformation; Nozol is a solution that involves developing a real estate Android mobile application that mainly helps the user to advertise their properties and/or find a property that aligns with their preferences, while maximizing good user experience [3]. Using Nozol, users can filter properties, search properties, add them to their favorites list, and have access to all the details necessary about a property. The user is also provided with a Direct Messaging feature to enhance ease of communication. Furthermore, our application will tackle the problems existing in Saudi real estate applications described in the previous section. Firstly, it will provide an improved and accurate content-based recommendation system, which recommends similar properties to the one the user is currently viewing according to several criteria such as city, type, price ...etc. The application will also provide the user with a very user-friendly interface and will improve the user navigation through the various regions of the application by making the main navigation menu visible and consistent across pages. Our application also offers many interesting new features that are not present in current local real estate applications, which are:

- Property tour appointments booking system: whenever a buyer is interested in a particular property and would like to view it, they can make a reservation with the property owner through the application. Each appointment will be recorded with the details of both parties along with the date and time, and the user can choose whether the tour is in person or via video chat. This feature benefits both sides as they would be able to view and manage their scheduled appointments in a timely manner, and property owners are able to keep track of all their potential customers in a more centralized manner through the application.
- Filtering using colored map markers: where properties on the map are filtered by coloring the markers on the map based on a chosen criteria such as property type, price...etc. This enhances the user experience in which a user can get multiple pieces of information just by one look at the map.
- Rental affordability calculator: that determines how much the user can afford to rent based on some user input and a certain formula (see 4.6.3.2 implementation section). Not only that, but it also recommends for the user properties that fall under their affordable range, and that are in the city and the property type the user has entered.

Furthermore, the user can filter the recommended properties to a particular neighborhood of their interest.

All of this is to ensure that every buyer's buying adventure comes to be easier and convenient, which in return leads to improved customer relationships and further beneficial deals, which directs to property owners' profitability.

1.7 Summary

In the following sections, we will introduce our background, and conduct a literature review. Continually, we will show our system design and development. Then we will go through the system evaluation. Lastly, we will provide our conclusion, future work, and acknowledgments.



Background

2 Background

2.1 Real estate – property

Real estate is referred to as the land as well as any permanent, whether natural or man-made, structures or improvements related to the property, such as a house. One type of real property is real estate. It contrasts with personal property, such as cars, yachts, jewels, furniture, and farm equipment, which is not permanently affixed to the land.

Real estate may be divided into five primary categories: residential, commercial, industrial, raw land, and special use (see figure 1).

Residential real estate: any property utilized for habitation. Single-family homes, condominiums, cooperatives, duplexes, townhouses, and multifamily buildings are a few examples.

Commercial real estate: any property that is utilized only for commercial reasons, including office buildings, hotels, restaurants, petrol stations, grocery shops, theaters, hospitals, and shopping malls.

Industrial real estate: any land used for production, distribution, storage, or any other type of industry.

Land: consists of undeveloped land, open space, and agricultural areas including farms, orchards, ranches, and forests.

Special purpose: public property, including cemeteries, government structures, libraries, parks, houses of worship, and schools [4].



Figure 1 clears four of the five real estate categories [5]

2.2 Digital transformation and its impact on the real estate industry

Digital transformation is affecting industries around the world, as smart devices have transformed the way buyers and sellers do business. Digital transformation is necessary for real estate because the way people search is changing. They prefer mobile searches rather than hiring real estate agents. And customers increasingly initiate contact online. Technology is paving the path for enhanced consumer relations and further beneficial deals, which leads to boosted profitability. The impact of internet marketing is so great in that the convenience of the consumer and the likelihood that a buyer will purchase a property online as opposed to in person are two and a half times higher [6]. In a survey [7], more than half of the participants expect that the adoption of digital technologies will result in a "slight increase" in sales during the following three years, while about one-third predicted a "significant increase". And that better access to customers is the main channel through which digitalization boosts sales growth. Lastly, the adoption of digital technology, according to about half of the respondents, has boosted their ability to alter prices over time, therefore respondents also perceive digitalization as boosting their flexibility when it comes to price setting (see figure 2).

Impact of digitalisation on prices

Channels through which digitalisation affects prices

(average scores across all replies: -1 = decrease; 1 = increase; 0 = no change)

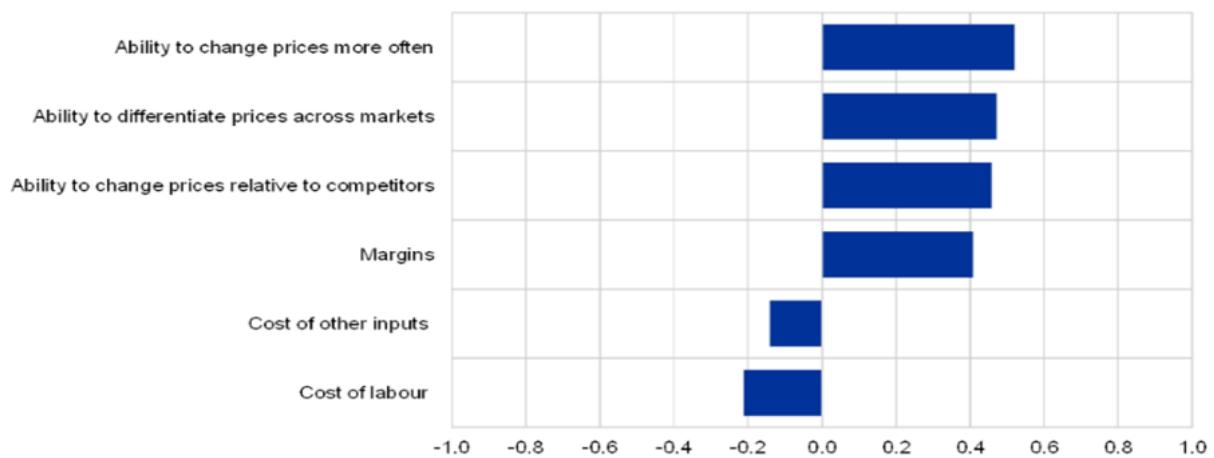


Figure 2 impact of digitalisation on price



2.3 Real estate applications

After technology became one of the reasons to increase income, many sectors tended to use technology in their fields. One of these sectors is the real estate sector. There are many real estate applications at the global and local levels. Real Estate applications are applications that automate real estate transactions such as real estate selling, buying, and renting. Real estate applications provide several services for all their users. They bring properties from different places and display them effectively. Also, they allow owners to offer their properties for sale easily and quickly without any complications. Moreover, they facilitate communication between different parties. One example of these applications is the “Zillow” application. It is a global application and one of the most famous real estate applications in the United States. At the local level, Aqar is a Saudi real estate application. Both of them provide many features that facilitate the selling and buying process. Such as displaying properties on maps, neighborhood ratings, real estate consultations, and so on.

2.4 Technical background

2.4.1 Application Programming Interface (API)

The API stands for Application Programming Interface, which means a set of programming codes that work as the intermediary between two software to transmit data from one software to the other. So basically, the API allows the developer to get data and services, without needing to develop them from scratch, by obtaining them from another service provider. For example, when you want to develop an application for a specific company, and you want to display tweets from the company’s Twitter account on the app’s home page instead of implementing this feature from scratch you can use Twitter API.

In our application we will use some APIs such as:

2.4.1.1 Google maps API:

As we note, most of the main functions in our application depend on a map. but it is too difficult to implement our own. Instead of that, we decided to utilize the Google Maps API, which allows us to access their maps within our application and use it for our goals. Google Maps supports the most famous platforms these days which are web-based, iOS, and android applications. It provides multiple libraries and services for each of them [8] such as:

2.4.1.2 Customize markers via bubble icons

Because the marker itself can contain text and other material, this utility gives you a mean to make your marker icons resemble info windows (see figure 3). The benefit is that you may have several markers active at once as opposed to simply having one info window open. Additionally, you may style the markers, alter the content's orientation, and alter the backdrop picture for the markers [9].



Figure 3 Customize markers via bubble icons utility.

2.4.1.3 Manage marker clusters

This tool allows you to control several markers at various zoom settings (see figure 4). This implies that a map may have a lot of marks on it without making it difficult to read. The individual marks appear on the map when a user zooms in heavily. The map is simpler to observe when the viewer zooms out to a lower zoom level because the markers group together into clusters [10].

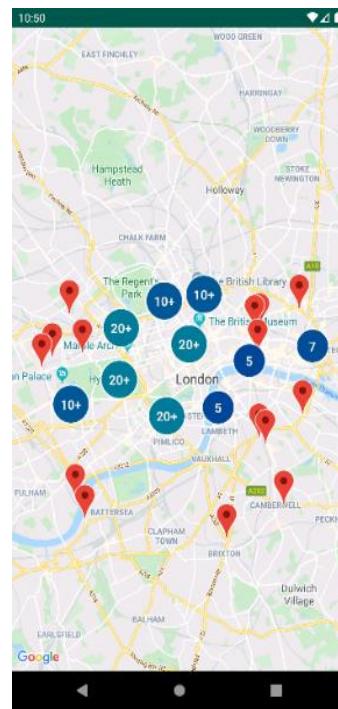


Figure 4 Marker Clustering Utility

2.4.1.4 Heatmaps utility

Viewers can easily comprehend the distribution and relative intensity of data points on a map according to heatmaps. Heatmaps employ color and shape to illustrate the distribution of the data rather than placing a marker at each point (see figure 5) [9].



Figure 5 heatmap utility

2.4.2 Recommender systems

Recommender systems are algorithms that try to present users with appropriate things (items being movies to watch, text to read, products to buy or anything else depending on industries). They are extremely important in several businesses because, when effective, they may provide a large amount of cash or serve as a means of differentiating oneself from rivals. [11]. The mechanism of the recommender system deals with the enormous amount of information quickly by selecting the most essential information based on the user's data and other variables that take into account the user's preferences and interests. It determines if a user and an object are compatible and extrapolates similarities between users and products to make recommendations. [12]. In our application, we will use a content-based recommender system to help buyers find compatible properties with their needs simply and quickly.

The recommender system is divided into mainly 3 major categories: Collaborative filtering, content-based filtering and hybrid from both.

- 1- Collaborative filtering is a technique that can filter out items that a user may be interested in based on the reactions of other users. It operates by scanning a huge group of individuals for users who have similar likes to a specific user. It considers the items they like and combines them to get a ranked list of recommendations [13]. The significant advantage of collaborative techniques is that they do not require any knowledge about people or products, allowing them to be employed in a wide range of circumstances. Furthermore, the more people engage with items, the more accurate fresh suggestions become given a fixed set of users and items, new interactions collected over time contribute new information and improve the system's effectiveness. However, because collaborative filtering only considers prior interactions to produce recommendations, it suffers from the "cold start problem": it is difficult to propose anything to new users or a new item to any users, and many users or items have too few interactions to be properly handled [14].
- 2- For the second category, which is content-based filtering, unlike collaborative methods that only rely on user-item interactions, content-based uses additional information about users and/or items. The idea of content-based methods is to try to build a model, based on the available "features", that explain the observed user-item interactions.

An example of both categories, in the collaborative approach when two buyers like property1 and then buyer A likes property2 it will be recommended for buyer B. but in the content-based approach, when buyer A likes property1, property2 will be recommended for buyer A if it has similar specifications to property1 (see figure 6).

3- To offer a greater choice of items to users, hybrid recommendation systems use both content-based and collaborative filtering at the same time. This is a new recommendation system that is touted to deliver more accurate recommendations than existing recommender systems [15].

From this comparison we can say that the suitable recommender system in our application is a Content-based recommender using the properties' specification to collect the similar properties and provide them for buyers.

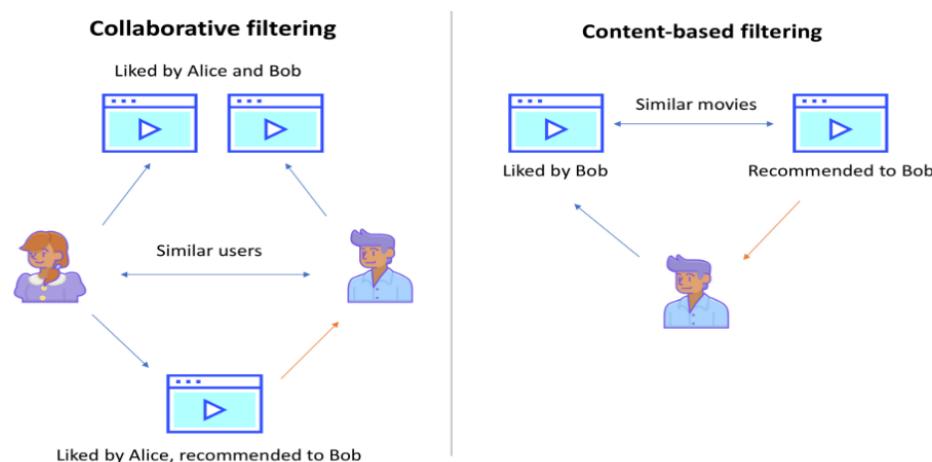


Figure 6 an example of two categories of recommender system in movies recommendation system [16]



Literature Review

3 Literature Review

Currently, there are several real estate applications similar to our application that are available on the market. In this chapter, we conducted comprehensive research about our competitors, which we categorized into two sections, as follows:

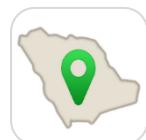
1- Local applications, that provide real estate features that serves Saudi Arabia and who are considered our direct competitors since we all strive to meet the same goal.

2- Global applications, that do not serve Saudi Arabia, who we will get inspired by them the interactive and engaging features they provide.

We chose eight real estate applications with valuable characteristics that are similar in some functions to be analyzed in detail. For each application, the main features are highlighted, and an evaluation of the overall application is made, highlighting the features and drawbacks of each application. This process was conducted to facilitate the requirements definition process, extracting essential features that the application should contain. In addition, gaps, and potential enhancements to existing real estate applications were also analyzed to provide an easy-to-use and more reliable application, while ensuring the best user experience for our target users.

3.1 Competitive Product Analysis

3.1.1 Local Application



Aqar (عقارات) [17] is a mobile application to view and search for real estate for sale or rent in Saudi Arabia.

Main features:

- Providing suggestions for properties similar to the one the user is currently viewing.
- Allowing users to review neighborhood services and find out residents' feedback about them by displaying their comments and ratings.
- Providing a direct messaging feature to give different users the ability to communicate with each other.

Drawbacks:

- Search options are limited, which only includes the type of property. It lacks the ability to search by text or by specific location coordinates.
- Poor user experience:

One big shortcoming of Aqar application is that the main navigation bar (menu) is not visible on all pages. For example, if I keep looking for different properties suggested from the similar ads section, there is no way to go back to the homepage immediately, you need to keep clicking the “→” button until you get to the home page. Also, the application contains lots of features and icons that may seem unfamiliar to the user, and there is no interactive walkthrough for first-time users, which makes learning the app difficult and takes time.

- There is no option for the users to book a property tour which makes the inspection process difficult, frustrating, and unorganized.
- Even though Aqar application has the direct messages feature, it is limited to sending conversations only between the two parties and lacks the ability to send photos, videos, or documents.
- Even though the Aqar application uses a recommender system to provide similar properties to the one the user is currently viewing, its behavior is unpredictable and inconsistent, which may lead to inaccurate results.

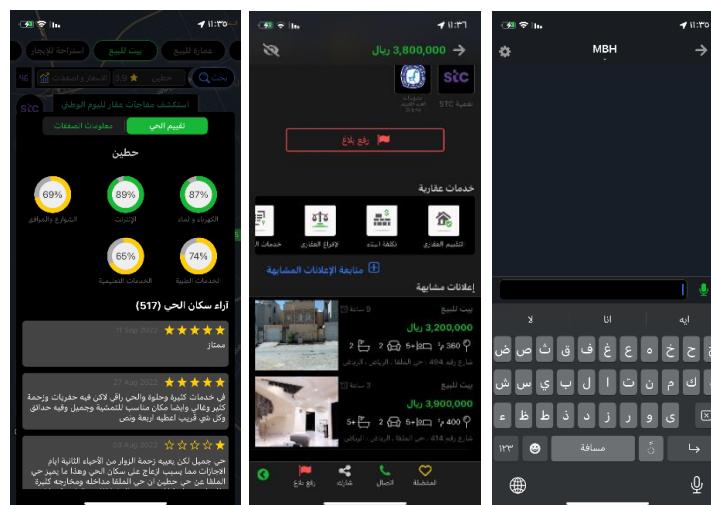


Figure 7 Aqar application



Suhail (سُهيل) [18] is an interactive real estate application that is aimed for lands' deals and provides real estate information and stats such as price indicators and other data on the Saudi real estate market.

Main Features:

- Providing an interactive map that gives the ability to view the prices of real estate deals on it.
- Allowing users to control the map by changing its colors based on area size, price, or the number of deals.
- Providing an interactive walkthrough for first-time users which facilitates learning the application.
- Allowing users to view all the detailed information about the land and share this information in a few seconds instead of typing the land information manually.

Drawbacks:

- Although there is a feature to save the land in the favorites, it may be considered impractical for some, since it requires making notes by the user. Otherwise, it will not be added to the favorites.



Figure 8 Suhail application



Sakani (سكنى) [19] is a governmental mobile application that aims to support and enable Saudi citizens to own their first home. It provides various housing solutions and options.

Main Features:

- Similar to what other real estate mobile applications have thus far, Sakani application displays search results either in a classic list format or display them on the Map.

Drawbacks:

- In contrast to other applications, Sakani application does not provide a favorite list for its users, which is an important feature for users, especially when they need time to decide and consider other available options about a property they are looking for. Hence, without a favorite list that saves their choices, they will have to search from the beginning for the property they liked next time.
- Sakani application does not provide similar properties using a recommender system.

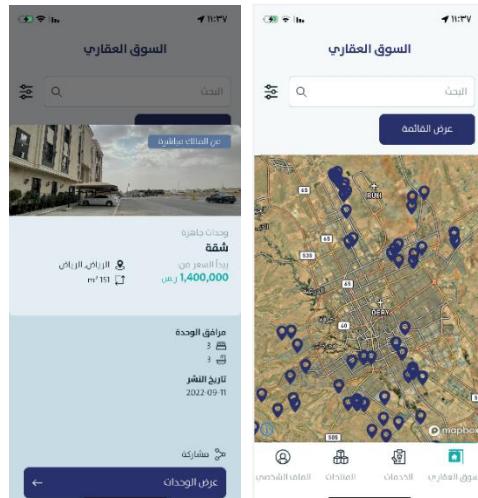


Figure 9 Sakani application



Property Finder [20] is a mobile application that searches properties throughout the UAE, Bahrain, Qatar, Egypt, and Saudi Arabia and supports both English and Arabic languages.

Main Features:

- Displaying search results either in a classic list format or on the map.
- Ability to save any listing that catches users' eye with a simple click on the "heart" icon and share it with others using the 'Share' icon.
- Providing a feature that takes previously completed search results and saves them to send the user a notification when a new property is added that matches his / her search.

Drawbacks:

- Property Finder does not use a recommender system to provide suggestions to users about the properties they are looking for, which may make finding other similar properties more difficult and time-consuming.



Figure 10 Property Finder application



Bayut KSA [21] is a real estate application to view and search for properties to sale or rent in Saudi Arabia.

Main features:

- Bayut KSA application provide the user the ability to search for properties based on several criteria, and saving the resulting list of this search.
- Bayut KSA application provides a mortgage calculator.

Drawbacks:

- Bayut KSA application don't provide direct message between different users.
- Even though Bayut KSA application uses a recommender system to provide similar properties to the one the user is currently viewing, its ineffective at all and gives the user inaccurate results.

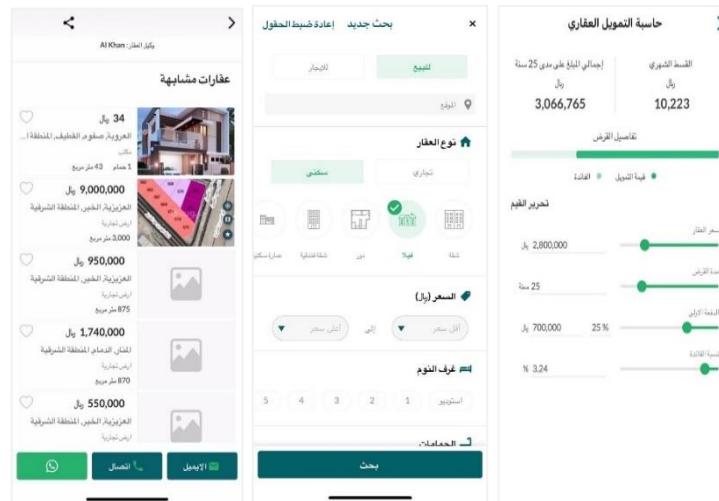


Figure 11 Bayut KSA

3.1.2 Global Application



Zillow [22] is a mobile application for anyone looking to buy, rent, or sell a home.

Main Features:

- Ability to save any property with a simple click on the "heart" icon and hide a property that doesn't meet users' needs by clicking the "Ø" icon, keeping it from popping up in future searches.
- Allowing users to reach out to schedule an in-person or virtual tour.
- Providing an affordability calculator that estimates whether users can afford to purchase a property or not based on some information.
- Providing 360-degree virtual tours for selected properties instead of the traditional approach of only providing potential buyers with static photos of the property.

Drawbacks:

- Property value estimates can be inaccurate:

Every property on Zillow application comes with a Zestimate "Zillow's home value estimation tool", which is often inaccurate. This misleads buyers and sellers and often makes an agent's job harder.

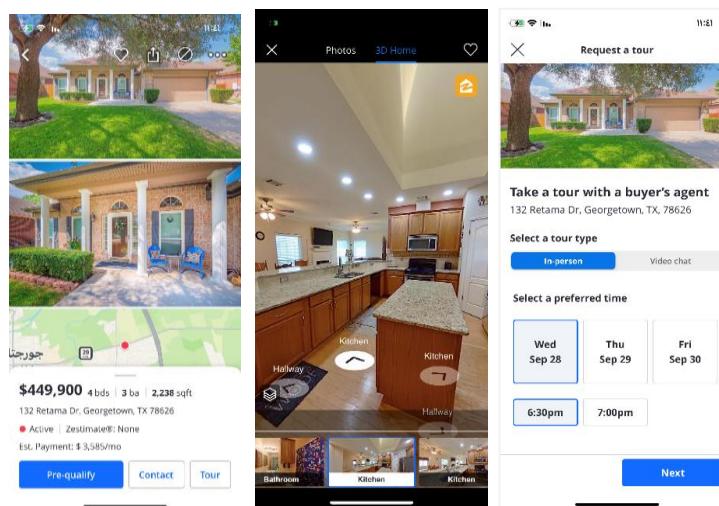


Figure 12 Zillow application



Ohmyhome [23] is a mobile application that allows buyers and sellers, landlords, and tenants to transact directly without agents. It aims to make housing transactions simple, fast, and affordable.

Main Features:

- Allowing users to manage their home buying and selling budgets with different financial planning calculators such as affordability calculator and seller stamp duty ...etc.
- Allowing users to search by location on the map by pinpointing a specific coordinate in which they would like to search for a particular property.

Drawbacks:

- No way to hide specific listings:

Users can't exclude individual properties from their results. For example, if users find a property that doesn't meet their needs, they still have to deal with it showing up in their search results as long as it meets their search filter criteria.

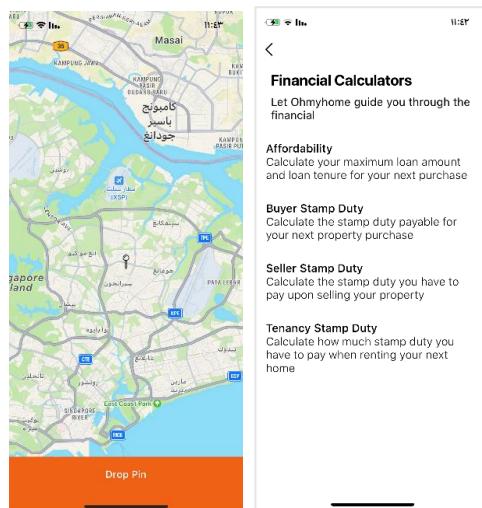


Figure 13 Ohmyhome



Trovit Homes [24] is a mobile application to find houses and apartments for rent and for sale on thousands of different websites and shows them to you in one place.

Main Features:

- Allowing users to narrow down and filter their search result's location by "circling" the area on the map.
- Allowing users to include points of interest such as schools, supermarkets, and hospitals to be displayed as icons along with the property's location on the map.

Drawbacks:

- Trovit application does not enable its users to communicate with owners or agents via direct messages. This may affect increased sales, and some users may not prefer communicating using other apps.

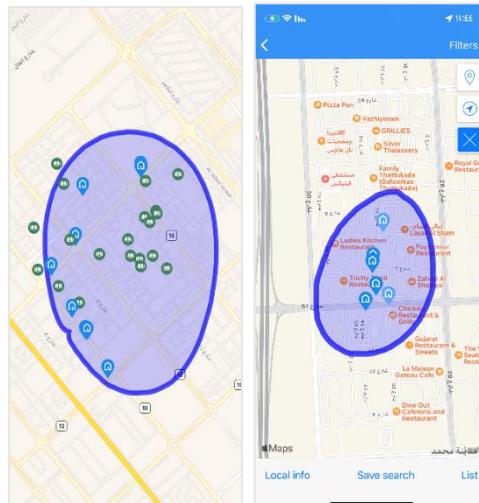


Figure 14 Trovit Homes application

3.1.3 Comparison Between Similar Applications

Table 1 comparison between similar applications

Features	Applications								
	عقارات	سهيل	سكنى	Property Finder	بيوت	Zillow	Ohmyhome	Trovit Homes	Nozol
Listing properties on a map	✓	✓	✓	✓	✓	✓	✓	✓	✓
Display properties as a list	✓		✓	✓	✓	✓	✓	✓	✓
Draw in the map a specific area						✓		✓	
Filter the map by changing markers colors based on different criteria									✓
Search for properties	✓	✓	✓	✓	✓	✓	✓	✓	✓
Search for properties by selecting a coordinate location on the map							✓		
Filtering properties based on several criteria	✓		✓	✓	✓	✓	✓	✓	✓
Direct messaging	✓					✓	✓		✓
View neighborhood ratings and reviews	✓								
Adding properties to favorite list	✓	✓		✓	✓	✓	✓	✓	✓
Affordability calculator						✓	✓		✓
Booking a property tour						✓			✓
Property tour via video chat						✓			✓
Virtual tour						✓			
Provide suggestions using a content-based recommender system	✓				✓	✓	✓	✓	✓
Provide notifications	✓	✓	✓	✓	✓	✓	✓	✓	✓

3.1.4 Summary

After completing the analysis of the real estate applications currently available in the market today, the structure of the overall application to be developed can be understood even more clearly. From the comparison table above (Table 1), we noticed that there are certain features that are common in all the applications, while there are some of them that are relatively unique.

We considered the features that have been provided by at least 4 applications and the features that make sense to be provided as main features for real estate applications, which must be added to our application. Features provided by less than 4 applications were considered unique, or "optional" features. Taking the "Search for a property" feature as an example, a real estate application without a feature that allows users to search for a particular property's location is an incomplete application as it restricts users from performing even the simplest of actions required. In contrast, the less important features, such as the "View neighborhood rating and reviews" are optional as the presence of this functionality would not affect the main purpose of the overall application.

Furthermore, we noticed that some local real estate applications like Property Finder and Sakani lack some of the main and important features, such as direct messaging and providing similar properties using a recommender system, while others did not provide these main features as required. As mentioned in the previous parts, even though Aqar application uses a recommender system, its behavior is inconsistent and unpredictable. Also, Aqar has some issues with providing good user experience. This shows that Saudi Arabia lacks good real estate applications. And because of that, we will be working on these problems in our application by providing an enhanced and accurate content-based recommender system and ensuring a better user experience by improving navigation through the various regions of the application.

Another thing that caught our attention is that none of the local real estate applications provide any of the unique features we have, which include the affordability calculator and booking a property tour, which we took inspiration from the global applications; since they are very useful in saving users' time and effort, and we believe that it will make us stand out and be in demand on the market. Also, no application paid attention to the option of changing map markers' colors based on different criteria.

Finally, it can be concluded that our application that is to be developed should contain the following features and functionalities:



- 1- Display properties on the map.
- 2- Display properties as a list.
- 3- Search for property.
- 4- Provides filters to narrow down the search results according to the user's preference.
- 5- Allow users to favorite their preferred properties.
- 6- Direct messaging feature.
- 7- Provides an option that allows booking properties' tours either in-person or via video chat.
- 8- Provides an option to filter the map by changing its markers' colors based on different criteria.
- 9- Smart rental affordability calculator that determines the maximum rental price the user can afford.
- 10- Provides similar properties to the one the user is currently viewing using a content-based recommender system.
- 11- Provide notifications.



System Design and Development

4 System Design and Development

4.1 Methodology

Agile software development methodology was selected as the best approach to be used in this project considering that the requirements were continuously changing. It is a methodology that emphasizes flexibility, communication, and rapid iteration. Agile development involves a continuous feedback loop that allows for frequent adjustments and improvements.

One of the most popular frameworks for implementing agile development is Scrum, which is an iterative approach that places a strong emphasis on communication, teamwork, and collaboration. Within the Scrum framework, there are three main roles:

Product Owner: which in our project is our supervisor, is responsible for defining the product backlog and prioritizing it based on business value.

Scrum Master: is responsible for facilitating the Scrum process and ensuring that everyone understands and follows the framework. They are also responsible for removing any obstacles that may prevent the team from delivering the product. In our project we had Dr. Hind Alrasheed and Dr. Maha Alyahya as scrum masters.

Development Team: which is us, is responsible for delivering the product increment.

Moreover, there are five events in the Scrum framework:

1. Sprint: which is a timeboxed period, usually between two and four weeks, during which the development team works to deliver a product increment. Our project consisted of a total of five sprints.
2. Sprint Planning: At the beginning of each sprint, the team meets to plan the work that will be completed during the sprint. The team reviews the product backlog and selects the items they will work on during the sprint. It was always done with the supervisor in a one-hour meeting at the start of every sprint.
3. Daily Scrum: is a 15-minute meeting where the team comes together to discuss progress and plan for the day.
4. Sprint Review: At the end of each sprint, the team presents the product increment to stakeholders and gets feedback.

5. Sprint Retrospective: At the end of each sprint, the team holds a sprint retrospective meeting so that all members can give input on what is working well and what is not.

And there are three artifacts in the Scrum framework:

1. Product Backlog: which is a list of all the features, enhancements, and bug fixes that need to be addressed in the product.
2. Sprint Backlog: which is a list of all the items the team plans to work on during the sprint.
3. Increment: which is the sum of all the product backlog items that have been completed during the sprint.

By practicing agile we were able to accommodate changing requirements throughout the development process, with frequent delivery of working software. All while maximizing simplicity by developing just enough to get the job done for right now. With a self-organizing and motivated team that communicates regularly, and shares ideas that deliver quality products which encourage great architectures, requirements, and designs. Lastly, employing the agile methodology and scrum framework was done with the help of two tools, Jira¹ and GitHub². Jira helped in sprint planning, recording meetings notes, managing the product backlog, among other things. And GitHub helped to keep track of the various changes made every iteration between the team members.

4.2 System Requirements

4.2.1 System Users

Nozol (نُزل) is aimed for anyone who's interested in real estate, with basic technical skills and who can read in Arabic regardless of their educational level. Our application will be so simple and easy to use that users do not need to have any experience or any specific knowledge in technology, so that the basic ability to use an application on an android mobile phone would be sufficient.

There are 3 types of users that interact with our application: admin, registered user and guest user.

¹ [GP2022G17 board - Agile board - Jira \(atlassian.net\)](#)

² [GitHub - khloudaldughaim/2022-GP1-17: Nozol Application](#)

An Admin of our application is a person who has adequate knowledge and experience about real estate and high technical skills. The admin should have the ability to read in Arabic and English to manage the system and its users.

A Registered User can be a property owner/buyer/tenant who's looking for a property or wants to advertise one.

A Guest is an unregistered user who just wants to take a look at the properties.

4.2.2 Requirements Elicitation and Analysis

For requirements elicitation we've decided for stakeholders and similar systems such as Aqar and global real estate applications to be our main sources of information.

Table 2 Requirements elicitation information

Method	No. Of questions	No. Of responses	Female / Male	Age
Questionnaire	13	122	85.2% females. 14.8% males.	55.7% between 18-23. 31.1% 40+ years old. The rest are between 24-40 years old.
Interviews	8	3	2 women. 1 man.	23-57

As illustrated in table 2 above, we used two requirements discovery methods: a questionnaire and interviews. Since questionnaires are inexpensive and can help us reach a large number and a variety of audiences in a short time. And there are fewer chances of misinterpretation using interviews since the confusions can be clarified instantly by asking questions further on. This helped us collect more information about our user's knowledge and needs. More details of the interviews and questionnaire will be in the appendices.

From the questionnaire and interviews, we've gathered that most people find it hard to look for properties using non-technical ways, and they usually gather information about the properties they like by using real estate applications. The reasons for this are summarized in the following:

- The lack of credibility of real estate offices due to materialistic goals.

- Transportation problems and difficulties in looking for real estate offices.
- Difficulties in communicating with the owner or the real estate agent as they don't reply whether for negotiations or for meeting for a property tour.
- The real estate offices aren't available all the time like real estate applications.

Although most of the people who replied to the questionnaire haven't used a real estate application, they are most likely to begin using one. We've found that the main real estate application that most people use is Aqar, yet most of them find local real estate applications not perfect and had unsatisfying experience with them. When asked about the difficulties they've faced using local real estate applications most of them answered:

- Inaccuracy in property location
- Inaccurate search filtering
- Deceiving property pictures that don't match reality
- Distracting interface with so many unclear stuff
- Prices that differ from reality and from the market price
- And lastly property information isn't updated regularly.

Whilst most responders aren't aware of global real estate applications, few of them think they are more efficient. To make local real estate applications better compared to global ones, they suggested improving user experience, keeping property information updated and stating the market price and the owner's price so the buyer can make the decision that suits them.

A large number of people think that real estate applications are easier and more time saving. And 96.7% of those who answered the questionnaire would like to have an affordability calculator to help them find properties within their budget. Our interviewees also found that useful, especially for busy working people or for people who are renting for the first time. Also, the majority would prefer a feature that facilitates booking an appointment for a property tour and having the option of it being via video chat.

Lastly, we received many suggestions that we may consider adding later in the project, such as: a feature that compares for me multiple properties based on different attributes, a 3d picture of the property and a notification whenever a property ad with price I want is posted.

4.2.3 User Interactions

The use case diagram below (Figure 15) shows the main actors of Nozol Application and the core use cases and functionalities provided by the application.³

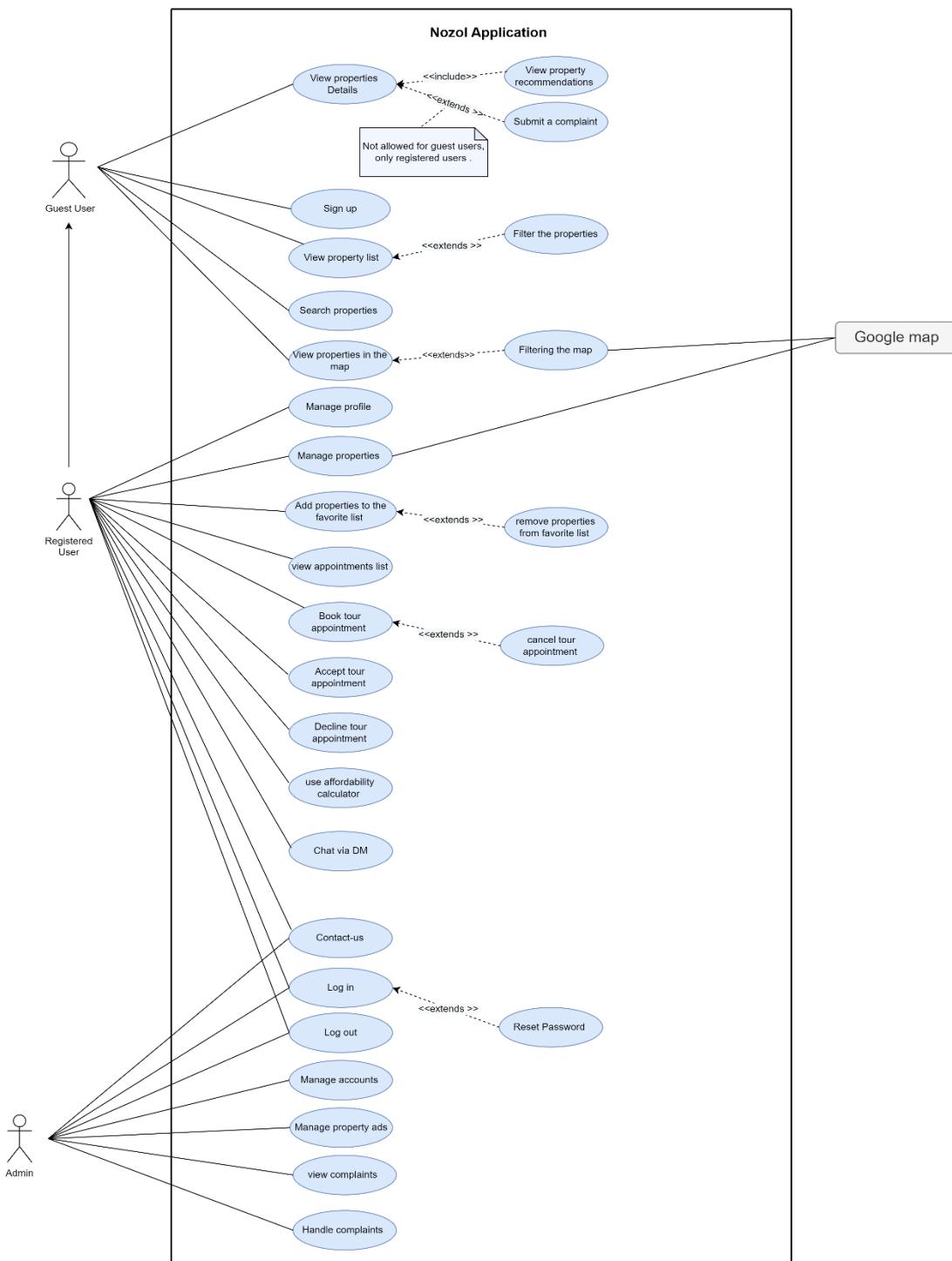


Figure 15 use case diagram

³ The concept for excluding particular users from a function was adopted from:
<https://stackoverflow.com/questions/47203336/can-the-included-extended-use-case-be-initiated-by-another-actor>

4.2.4 Roadmap and Product Backlog

4.2.4.1 Product Roadmap

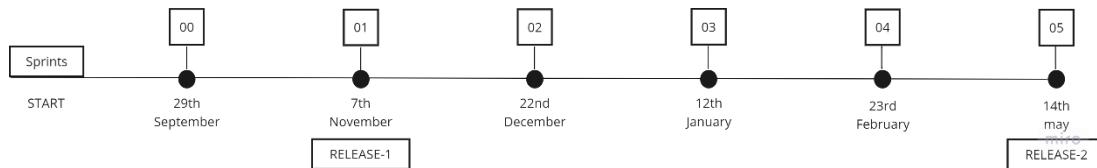


Figure 16 Roadmap

Table 3 Roadmap

Release-1		Release-2			
Sprint 0 (29 th Sep)	Sprint 1 (7 th Nov)	Sprint 2 (22 nd Dec)	Sprint 3 (12 th Jan)	Sprint 4 (23 rd Feb)	Sprint 5 (14 th may)
<ul style="list-style-type: none"> - Domain and requirements analysis. - Learn new languages such as Flutter & dart and get familiar with Android studio. - Tools set up. 	<ul style="list-style-type: none"> - Database creation. - Design system interface/theme. - User registration and log in & log out functionalities. - Listing and managing properties for rental or buying by user. - Searching for a specific property. - Updating user profile information. 	<ul style="list-style-type: none"> - Displaying properties on the map. - Filtering properties list according to several attributes. - Property tour appointments booking system. 	<ul style="list-style-type: none"> - Recommending similar properties to the one the user is currently viewing using content-based recommender system. - DM chat between users. - Notification system for messages and property tour appointments. 	<ul style="list-style-type: none"> - Filtering the map's markers by changing its colors based on different criteria. - Rental affordability calculator. - Adding / removing properties to / from the favorite list. - File a complaint by user. 	<ul style="list-style-type: none"> - Contact us feature (i.e. contact the admin). - Handling Complaints by admin. - Managing properties and accounts by admin. - Testing.



4.2.4.2 Product Backlog

Table 4 Product Backlog

ID	PBI (user story)	Size	Type	Status	Acceptance Criteria
1	As a guest user, I want to be able to sign up, so that I can have an account in the application that gives me access to all the features.	2	Feature	Done	<ul style="list-style-type: none">- As a guest user, if I go to sign up page and enter my name, email, password, phone number and click on sign up, then I should have an account in the app that gives me access to all features.- As a guest user, if I go to sign up page and leave a blank empty or enter invalid information, then sign up fails with an appropriate error message that indicates what's the error.(- Password should be 8 letters with at least one capital and one small- Email should contain @ sign-Email should be in email format “Example@example.com”).
2	As a registered user, I want to be able to log in to the application, so that I can access my own account.	2	Feature	Done	<ul style="list-style-type: none">- As a registered user, if I go to the log in page and enter my email and password and click on log in, then I should be able to access my account with all registered user features on the app.- As a registered user, if I go to the log in page and enter an incorrect email or password, then log in fails with an

ID	PBI (user story)	Size	Type	Status	Acceptance Criteria
					error message that says that the Email or password was wrong.
3	As a registered user I want to be able to reset my password, so that I can retrieve my account when I forget my password.	3	Feature	Done	- As a registered user, if I forgot my password and I click on “forget password” link that is in log in page and enter my new password, then this password should be my new password and allows me to access my account.
4	As a registered user, I want to be able to log out, so that I can exit my account and prevent any unauthorized access to it.	2	Feature	Done	- As a registered user, if I click on log out, then I should have no access to all registered user features on the app.
5	As a registered user, I want to be able to update my profile information, so that I can keep my information updated.	5	Feature	Done	<ul style="list-style-type: none"> - As a registered user, if I go to my profile page and click ‘update my information’ and enter updated information and confirm, then my updated information should be displayed. - As a registered user, if I entered invalid inputs, then an appropriate error massage should appear (- the name should be two digits or more). - The number should be correct mobile number (05xxxxxxxx), and update operation should not be completed.



ID	PBI (user story)	Size	Type	Status	Acceptance Criteria
6	As a registered user, I want to be able to add a new property, so that I can advertise it.	5	Feature	Done	<ul style="list-style-type: none">- As a registered user, if I go to the add page and fill all required property information and confirm add, then the property should be added to the property list.- As a registered user, if I go to homepage and click on 'add' then fill in the property information and left any required blank empty or entered invalid inputs (such as letters instead of numbers in price, space and in_floor fields) then an appropriate error message should appear and add won't be completed.- As a registered user if I chose a property type then only the fields that is related to this type should appear.
7	As a registered user, I want to be able to delete any of my properties, so that I can remove any properties that I do not want to advertise anymore.	5	Feature	Done	<ul style="list-style-type: none">- As a registered user, if I click on a property and press the 'Delete' icon button, then a confirmation message should appear, and deletion completes only if I confirm.- As a registered user, if I click on a property and press the 'Delete' icon button and confirm deletion, then this property ad shouldn't exist anymore in my property ads list.

ID	PBI (user story)	Size	Type	Status	Acceptance Criteria
8	As a registered user, I want to be able to update my property's information, so that I can have updated properties.	5	Feature	Done	<ul style="list-style-type: none"> - As a registered user, if I click on a property and press the 'Update' icon button and enter updated information, then a confirmation message should appear, and updates should be displayed after confirmation. - As a registered user, if I updated my account with invalid inputs then an appropriate error message should appear, and the update operation should not complete.
9	As a registered user or a guest, I want to be able to view properties in a list, so that I can see all properties with their details.	5	Feature	Done	<ul style="list-style-type: none"> - As a registered user or a guest, if I go to home page then I should be able to see properties list.
10	As a registered user or a guest, I want to be able to see details for specific property so that I can gain information about it.	5	Feature	Done	<ul style="list-style-type: none"> - As a registered user or a guest, if I click on any property in the properties list then I should be able to see its details.
11	As a registered user or a guest, I want to be able to search for a property, so that I can find the property that I want faster.	8	Feature	Done	<ul style="list-style-type: none"> - As a registered user or a guest, if I write a (city or neighborhood or type) then the property ad that matches the information I entered should appear with its information. - As a registered user or a guest, if I write a non-existing value of (city,

ID	PBI (user story)	Size	Type	Status	Acceptance Criteria
					neighborhood, type) in the search, then 'not found' message will appear.
12	As a registered user or a guest, I want to be able to classify properties based on whether they are for rent or for sale, so that I can find the property that I want faster.	8	Feature	Done	- As a registered user or a guest, if I go to homepage and tap on the 'for rent' or 'for sale' tap bars, then the property ad that matches the classification I tapped should appear with its information.
13	As a registered user or a guest, I want to be able to filter properties based on several attributes, so that I can find many properties with the same specifications.	8	Feature	Done	- As a registered user or a guest, if I click on the filtering option then fill any attributes of filtering and press 'apply', then only the properties with the chosen filtered attributes should appear on the list. - As a user or a guest, if I filter the properties list then clicked on the map button, then only the properties on this filtered list should appear on the map.
14	As a registered user or a guest, I want properties to be viewed on the map, so that I can generally determine the properties' location.	8	Feature	Done	- As a registered user or a guest, if I click on the map button in the homepage, then properties should be viewed to me on the map.
15	As a registered user, I want to be able to book an appointment for a property tour in-person or via	13	Feature	Done	- As a registered user, if I click on a property then click 'schedule a tour' button, pick a date and time, fill the required info (name, email, and phone

ID	PBI (user story)	Size	Type	Status	Acceptance Criteria
	video call, so that I can inspect the property.				<p>number), choose in person or via video call and confirm, then an appointment should be scheduled in” My Bookings” page and “Tour Requests” page in owner’s account.</p> <ul style="list-style-type: none"> - As a registered user, if I chose a date that was chosen by another user then an appropriate message should appear to let me choose another date. - As a registered user, if I book a property tour appointment, then a notification should be sent to the owner.
16	As a registered user, I want to be able to view the tour appointments that I booked, so that I can remember them until their time.	8	Feature	Done	<ul style="list-style-type: none"> - As a registered user, if I click on ‘My bookings’, then the bookings that I booked should be listed to me. - As a registered user, if I want to view my bookings, then I should be able to see them in sorted way depending on their classifications (pending- coming - past).
17	As a registered user, I want to be able to view the tour appointments that are booked for my property, so that I can remember them until their time.	8	Feature	Done	<ul style="list-style-type: none"> - As a registered user, if I click on ‘Tour Requests’, then the bookings that are booked with me should be listed. - As a registered user, if I want to view my tours requests, then I should be able to see them in sorted way

ID	PBI (user story)	Size	Type	Status	Acceptance Criteria
					depending on their classifications (new - coming - past).
18	As a registered user, I want to be able to cancel any tour that I booked, so that I can reschedule or inform the owner I'm not interested anymore.	8	Feature	Done	<ul style="list-style-type: none"> - As a registered user, if I press 'cancel' button on any of my bookings, then the tour booking should be tagged by 'canceled' tag in my page and owner page. - As a registered user, if I cancel a tour booking, then a notification should be sent to the owner.
19	As a registered user, I want to be able to decline the appointment for my property, so that I can manage my property's tour requests.	8	Feature	Done	<ul style="list-style-type: none"> - As a registered user, if I press 'decline' button in one of my property's tour requests and type the reason of my declination, then the tour request should be tagged by 'declined' tag in my page and buyers (requester) page with the reason. - As a registered user, if I decline a tour booking request, then a notification should be sent to the buyer.
20	As a registered user, I want to be able to approve the appointment for specific property, so that I confirm the appointment.	8	Feature	Done	<ul style="list-style-type: none"> - As a registered user, if I press 'approve' button in any of my property's tour requests, then the tour request should be tagged by 'approved' tag in my page and the buyers (requester) page.

ID	PBI (user story)	Size	Type	Status	Acceptance Criteria
					- As a registered user, if I approve a tour booking request, then a notification should be sent to the buyer.
21	As a registered user, I want to be notified when a buyer books/cancels a tour appointment for my property, so that I can know about it as soon as possible.	8	Feature	Done	- As a registered user, if a buyer books/cancels an appointment to view my property, then a notification dialog box should appear immediately at the top of my screen with a message indicating that.
22	As a registered user, I want to be notified when an owner approves/declines my tour appointment to inspect their property, so that I can know whether it is confirmed or not as soon as possible.	8	Feature	Done	- As a registered user, if an owner approves/declines my tour appointment to inspect their property, then a notification dialog box should appear immediately at the top of my screen with a message indicating that.
23	As a registered user, I want my tour bookings and my property's tour requests to be classified in different sections according to their status, so that I can find a certain booking easily.	8	Feature	Done	- As a registered user, if go to 'my bookings' page or 'my property's tour requests' page, then I should have tap bars each of them contains bookings of a certain status (pending, deleted, declined, approved, canceled).
24	As a registered user or a guest, I want to have property recommendations similar to the one that I'm viewing, so that I	13	Feature	Done	- As a registered user or a guest, if I'm viewing a property, then I should get property recommendations that are at least 80% similar to it based on (city, type, price, space).

ID	PBI (user story)	Size	Type	Status	Acceptance Criteria
	can view more properties with same specifications.				
25	As a registered user, I want to be able to communicate with other users via DM chat, so that I can exchange information about properties.	13	Feature	Done	- As a registered user, if I click on the 'chat' button in a property ad, then it will redirect me to DM chat, and I should be able to communicate with the ad's owner.
26	As a registered user, I want to be able to delete a specific chat so that I can remove any unwanted one.	13	Feature	Done	- As a registered user, if I long press on a specific chat and confirm the deletion, then the chat should be deleted in my side only.
27	As a registered user, I want to be notified when someone sends me a message, so that I can know about it as soon as possible.	8	Feature	Done	- As a registered user, if another user sends me a direct message, then a notification dialog box should appear immediately at the top of my screen with a message indicating that someone sent me a message.
28	As a registered user, I want to be able to contact the admin, so that I can get answers about any ambiguities I face using the application.	3	Feature	Done	- As a registered user, if I click on the 'contact us' button in my profile page it will redirect me to the admin's email, then I should be able to contact the admin.
29	As a registered user or a guest, I want to be able to filter the map by changing the markers colors based on different criteria, so that I can get multiple pieces of	8	Feature	Done	- As a registered user or a guest, if I clicked on the 'specifications' button on the map and chose a criterion of filtering (type, price, space), then the markers colors on the map should change based on the chosen criteria.

ID	PBI (user story)	Size	Type	Status	Acceptance Criteria
	information by just one look at the map.				
30	As a registered user, I want to be able to add the properties that I like to a favorite list, so that I can reach them faster.	5	Feature	Done	<ul style="list-style-type: none"> - As a registered user, if I click on a property then click on favorite 'heart' button, then the property should be saved in my favorite list. - As a user, if I go to the favorites page, then all the properties I have liked should appear.
31	As a registered user, I want to be able to remove a property from my favorite list, so that I can have only the properties that I want.	5	Feature	Done	<ul style="list-style-type: none"> - As a registered user, if I press on the 'filled heart' button to remove a property from my favorites, then the property should be removed from my favorite list.
32	As a registered user, I want to be able to file a complaint once I face a problem in the app, so that I can continue using the app with a high degree of satisfaction.	13	Feature	Done	<ul style="list-style-type: none"> - As a registered user, if I click on the 'flag' button on any property to file a complaint and write my complaint and click 'send', then my complaint should be sent to the admin.
33	As a registered user, I want to view the complaints I submitted, so that I can know their status and refer back to them.	8	Feature	Done	<ul style="list-style-type: none"> - As a registered user, if I clicked on 'My complaints', then the complaints that I submitted should be listed and sorted to me with their status.
34	As a registered user, I want to be able to determine the maximum monthly rental price I can afford,	8	Feature	Done	<ul style="list-style-type: none"> - As a registered user, if I go to the affordability calculator and enter the required information (city, type, monthly income, spendings, loans),

ID	PBI (user story)	Size	Type	Status	Acceptance Criteria
	so that I can rent a property that is within my budget.				then the calculator should estimate the maximum monthly rental price I can afford.
35	As a registered user, I want to be able to get recommendations of properties I can afford to rent, so that I can find a property that is within my budget.	8	Feature	Done	- As a registered user, if I go to the affordability calculator and calculate the maximum rental price I can afford, then the calculator should recommend me properties that is in the range of my affordable rental price and city and property type.
36	As a registered user, I want to be able to filter recommendations of properties I can afford to rent based on neighborhood, so that I can find a property that is in neighborhoods I'm interested in.	8	Feature	Done	- As a registered user, if I get recommendations in my affordable range of rental price and then chose a neighborhood, then the list of the recommended properties should be filtered to only the ones that are in the specified neighborhood.
37	As an admin, I want to be able to log in to the application, so that I can access my own account.	2	Feature	Done	<ul style="list-style-type: none"> - As an admin, if I go to the log in page and enter my Email and password and click on log in, then I should be able to access all administration functionalities on the website. - As an admin, if I go to the log in page and enter an incorrect email or password, then log in fails with an error message that says that the email or password was wrong and specifies the exact error

ID	PBI (user story)	Size	Type	Status	Acceptance Criteria
					(- Password should be 8 letters with at least one capital and one small - Email should contain @ sign -Email should be in email format “Example@example.com”).
38	As an admin, I want to be able to log out, so that I can exit my account and prevent any unauthorized access to it.	2	Feature	Done	- As an admin, if I click on log out, then I should have no access to all administration functionalities on the website.
39	As an admin, I want to be able to delete a user account via dashboard, so that I can prevent any violations.	5	Feature	Done	- As an admin, if I go to dashboard and click an account's 'delete' button, then a confirmation message appears, and deletion completes only if I confirm. - As an admin, if I click an account's 'delete' button and confirm deletion, then the account should be deleted from the database.
40	As an admin, I want to be able to suspend a user account via dashboard, so that I can hide any account that is suspected of any violations.	5	Feature	Done	- As an admin, if I click an account's 'suspend' button, then the account should be moved to the 'hidden users' table in the database and the account should not be accessible.
41	As an admin, I want to be able to Unsuspend a user account via dashboard, so that I can unhide it in the application.	5	Feature	Done	- As an admin, if I click an account's 'Unsuspend' button, then the account should be moved back to the 'standard users' table in the database

ID	PBI (user story)	Size	Type	Status	Acceptance Criteria
					and the account should be accessible again.
42	As an admin, I want to be able to see users accounts, so that I can see their information and properties.	5	Feature	Done	<ul style="list-style-type: none"> - As an admin, if I click ‘view account’ button, then I should be redirected to the user account page.
43	As an admin, I want to be able to delete a specific property via dashboard, so that I can prevent any illegal properties.	5	Feature	Done	<ul style="list-style-type: none"> - As an admin, if I go to a specific user account and choose a property ad from properties table and press the ‘Delete’ button, then a confirmation message appears, and deletion completes only if I confirm. - As an admin, if I click on a property ad and press the ‘Delete’ button and confirm deletion, then the user’s illegal property ad should be deleted.
44	As an admin, I want to be able to suspend a user property via dashboard, so that I can prevent any illegal properties.	5	Feature	Done	<ul style="list-style-type: none"> - As an admin, if I click a property’s ‘suspend’ button, then property should be moved to the ‘suspended properties’ table and the property should be suspended from the application.
	As an admin, I want to be able to Unsuspend a user property via	5	Feature	Done	<ul style="list-style-type: none"> - As an admin, if I click a property ‘Unsuspend’ button, then the property

ID	PBI (user story)	Size	Type	Status	Acceptance Criteria
45	dashboard, so that I can return the properties to the application.				should be moved to the ‘legal properties’ table and the property should appear in the application again.
46	As an admin, I want to be able to see property details, so that I can see its information.	5	Feature	Done	- As an admin, if I click ‘view property’ button, then I should be redirected to the user’s property details page.
47	As an admin, I want to be able to receive users’ complaints, so that I can handle them and keep the users satisfied.	13	Feature	Done	- As an admin, if a user files a complaint, then I should receive it in ‘complaints page’. - As an admin, if I go to the complaints page, then all filed complaints should be listed to me.
48	As an admin, I want to be able to change the complaints status, so that I can inform the users about their complaints.	5	Feature	Done	- As an admin, if I click ‘In progress’ button, then the complaint’s status should be updated to ‘in progress’ in the user’s complaints page. - As an admin, if I click ‘complete the process’ button, then the complaint’s status should be updated to ‘completed’ in the user’s complaints page. - As an admin if I click ‘complete the process’ and I write the actions taken, then what I typed should appear in the complaint’s details in the user’s page.

ID	PBI (user story)	Size	Type	Status	Acceptance Criteria
					- As an admin if I click 'complete the process' and I don't write any actions taken, then the unified message 'تم الوقف على البلاغ واتخاذ الإجراء المناسب' should appear in the complaint's details in the user's page.
49	As an admin, I want to be able to be redirected to the user's email, so that I can communicate with them.	13	Feature	Done	- As an admin, if I click on the user's email, then I should be redirected to their email immediately to be able to communicate with them via email.
Non-functional user story					
50	As a user, I want the homepage of the application to be opened within at most 2 seconds, so that I can use the application as quickly as possible.	-	Feature	Done	-
51	As a user, I want to use a secure application so that my information will be protected.	-	Feature	Done	-
52	As a user, I want the application to be available 99% of the times I try to access it, so that I can access the application at any time I need it	-	Feature	Done	-
53	As a user, I want to be familiar with the application's interface and icons so that dealing with them will be easy for me.	-	Feature	Done	-

ID	PBI (user story)	Size	Type	Status	Acceptance Criteria
54	As a user, I want the system to reconnect to the server within 15 seconds when the internet connection is dropped, so that I can complete browsing the application.	-	Feature	Done	-

4.3 System Design

4.3.1 Architectural Diagram

The system utilizes client-Server architecture as the functionalities can be organized into services and each service is obtained from a server. This model is effective when clients and the server have distinct tasks to perform. For example, when a client sends a request to a server, the server accepts the request and returns the response to the client [25].

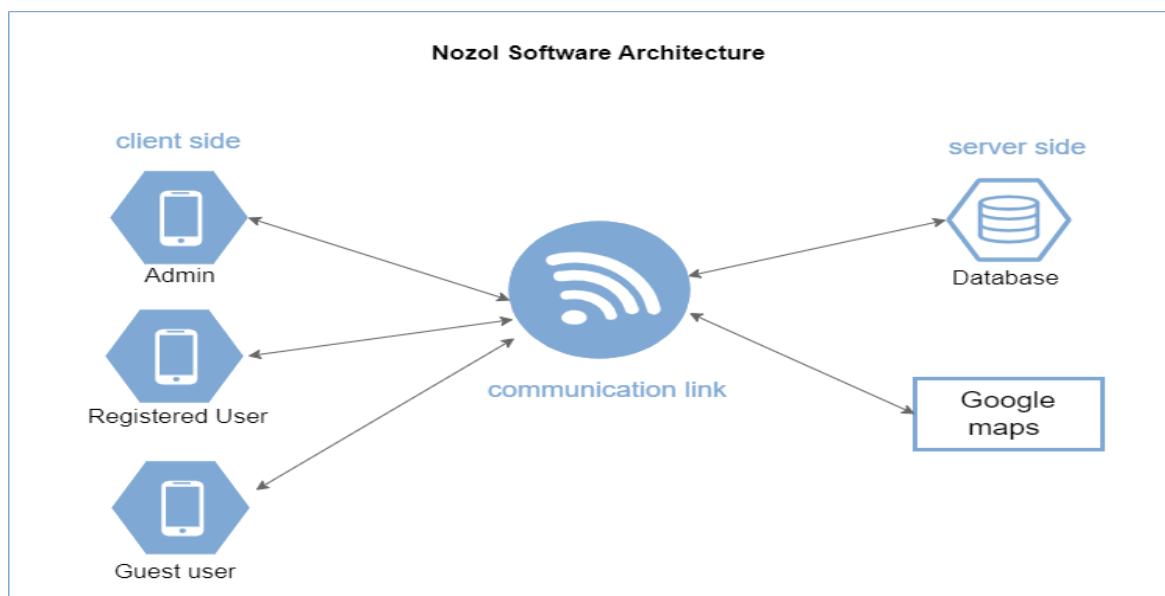


Figure 17 System architecture

By using this architecture (figure 17), we will divide the application into two main sides:

Client side: we have three types of clients on the client side who can access the servers to use its services. The first is the Admin, who can manage accounts and properties and handle complaints. The second is the Registered user, who can advertise and manage their properties, find a property that matches their preferences, make tour appointments, and use a smart "affordability calculator." The third is a Guest user, who can view and filter properties on the map and view property recommendations.

Server side: contains Nozol database and Google maps to provide the necessary services follows:

- Nozol Database Server: will be used to store the data of the users and properties. The server will control accessing this data.
- Google Maps Server: provides current location and any destination location.

4.3.2 Class Diagram /DFD

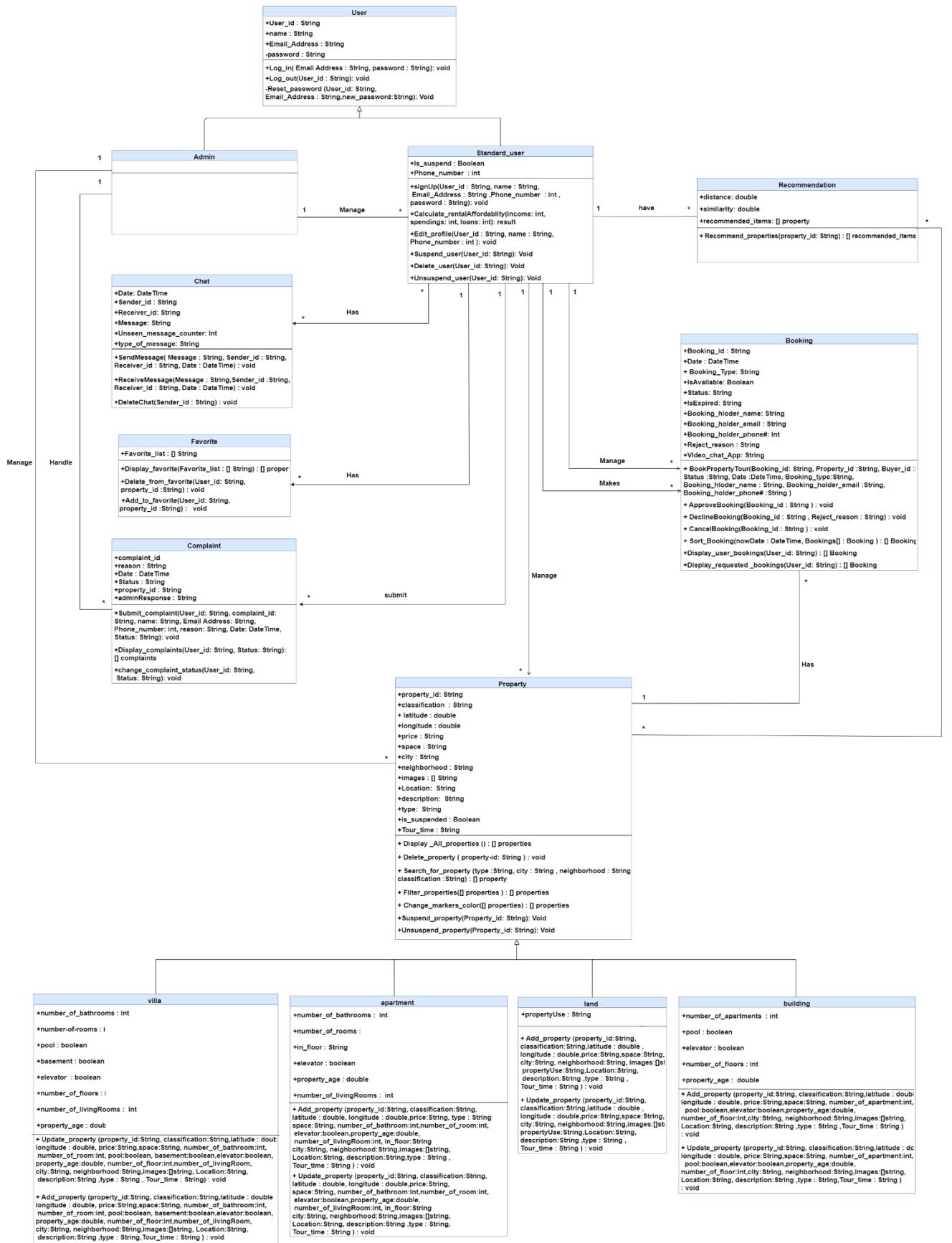


Figure 18 Class diagram of the application



4.3.3 Component Level Design

4.3.3.1 Rental affordability calculator

BEGIN

READ user inputs (city, type, income, spendings, loans)

SET result = (income - spendings - loans) * 0.25;

RETRIVE all_properties from database

DECLARE inRangeProperties []

FOREACH property IN all_properties

IF property.classification == 'للايجار' AND property.city == city

AND property.type == type AND property.price <= result

ADD property to inRangeProperties

ENDIF

ENDFOREACH

DISPLAY inRangeProperties

IF user enters address

FOREACH property IN all_properties

IF property.address == address AND

property.classification == 'للايجار' AND property.city == city

AND property.type == type AND property.price <= result

ADD property to inRangeProperties

ENDIF

ENDFOREACH

DISPLAY inRangeProperties

ENDIF

END

4.3.3.2 Property tour appointment booking

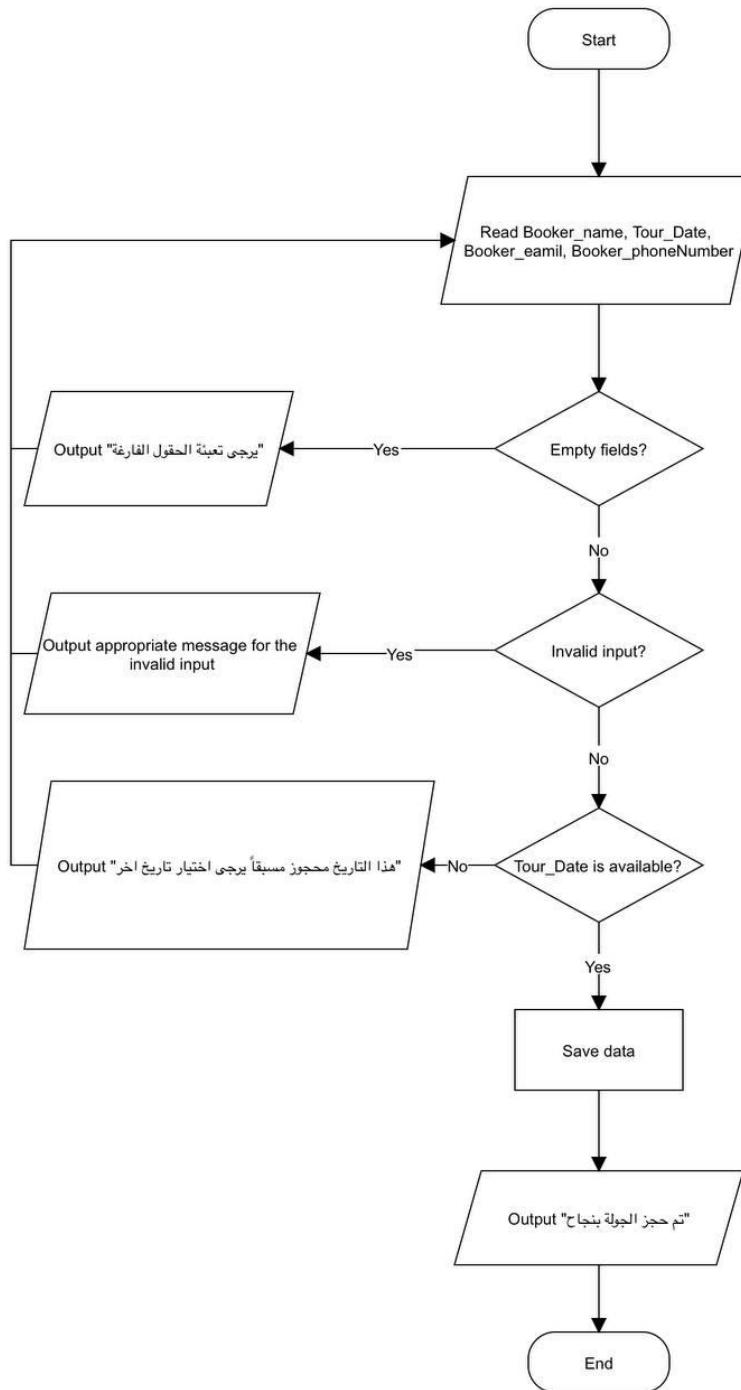


Figure 19 booking flowchart

4.3.3.3 Search feature

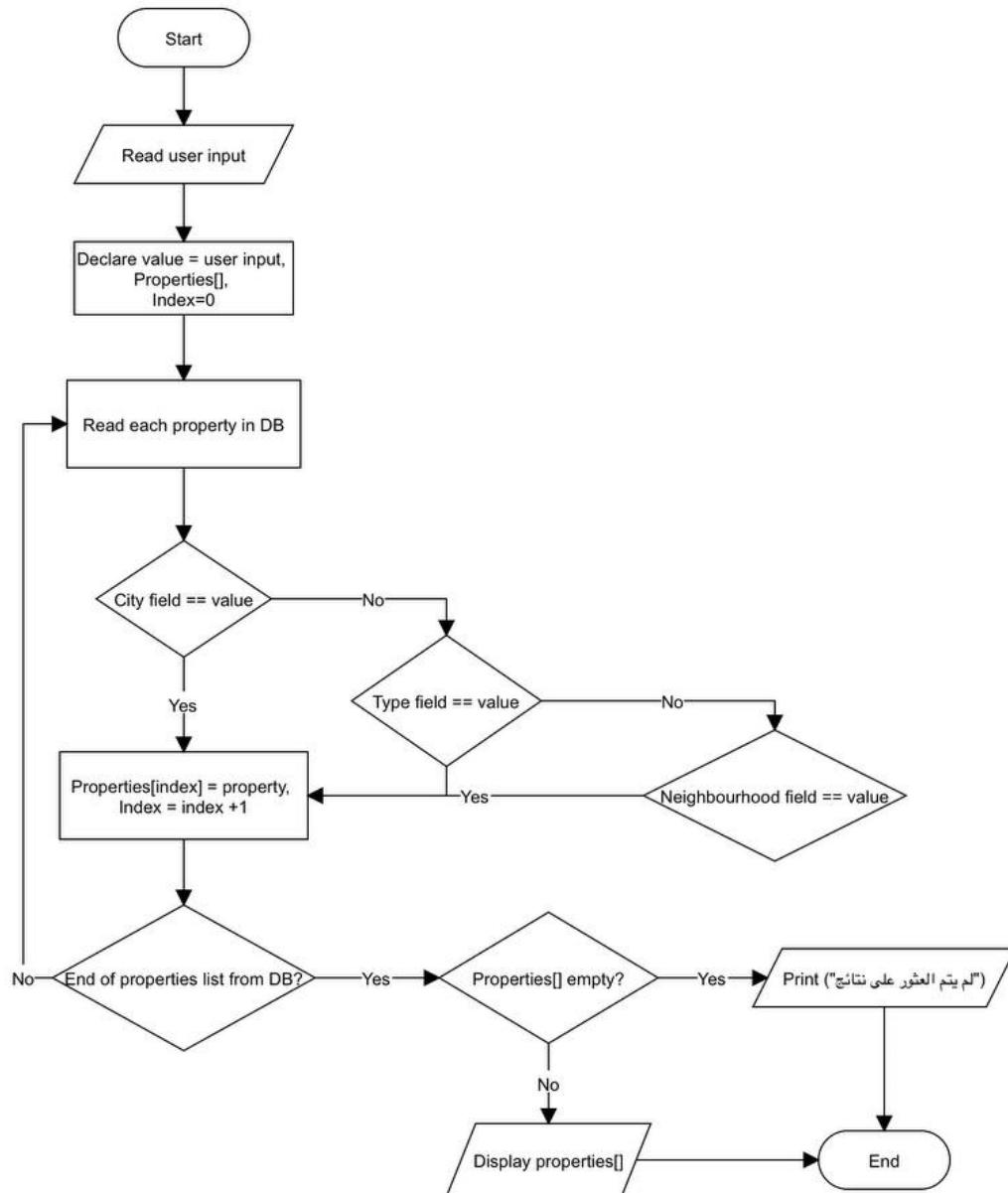


Figure 20 search flowchart

4.3.3.4 Recommendation system

The following flowchart and pseudocode are for our content-based recommender system. We built it using the KNN algorithm to recommend similar properties to the property the user is currently viewing (see section 4.6.3.1: Content-based recommendation system).

1- Flowchart:

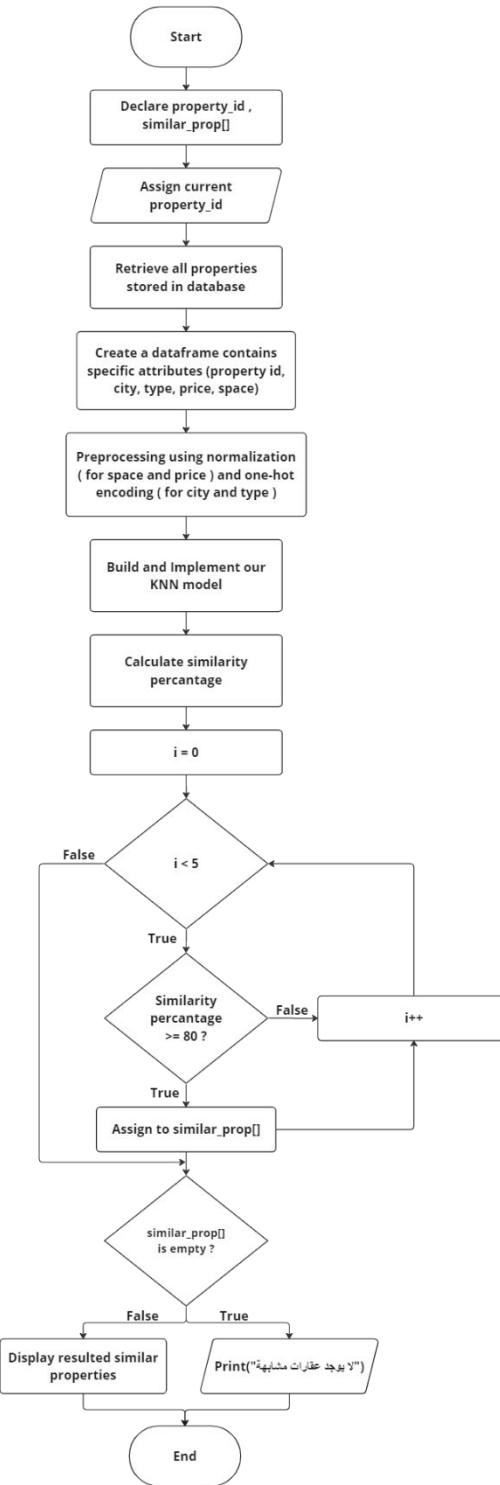


Figure 21 Recommender system flowchart



2- Pseudocode:

BEGIN

```
DECLARE property_id, similar_prop[]  
property_id ← current property id received from the app  
RETRIVE all_properties from database  
// Create a dataframe with attributes (property id, city, type, price, space)  
df ← DataFrame(all_properties)  
df ← df.drop(number_of_apartments, images, number_of_rooms,...) // all unnecessary  
attributes  
//Preprocessing using normalization & one-hot encoding  
df ← df.Normalization(space, price)  
df ← df.OneHotEncoding(city,type)  
//Build & implement KNN model  
nbrs ← NearestNeighbors(n_neighbors=5).fit(df)  
similar_properties[] ← nbrs.kneighbors(property_id)  
distance[] ← nbrs.distance (property_id)  
// Calculate similarity percentage  
DECLARE similarity[]  
FOR i to 5 DO  
    similarity[i] ← (1- distance[i]) * 100  
ENDFOR  
FOR i to 5 DO  
    IF similarity[i] >= 80  
        recommended_prop[i] = similar_properties [i]  
    ENDFOR  
    IF recommended_prop is empty  
        PRINT("لا يوجد عقارات مشابهة")  
    ELSE  
        DISPLAY recommended_prop  
    END
```

4.4 Data Design

4.4.1 Data Models

4.4.1.1 the ER diagram

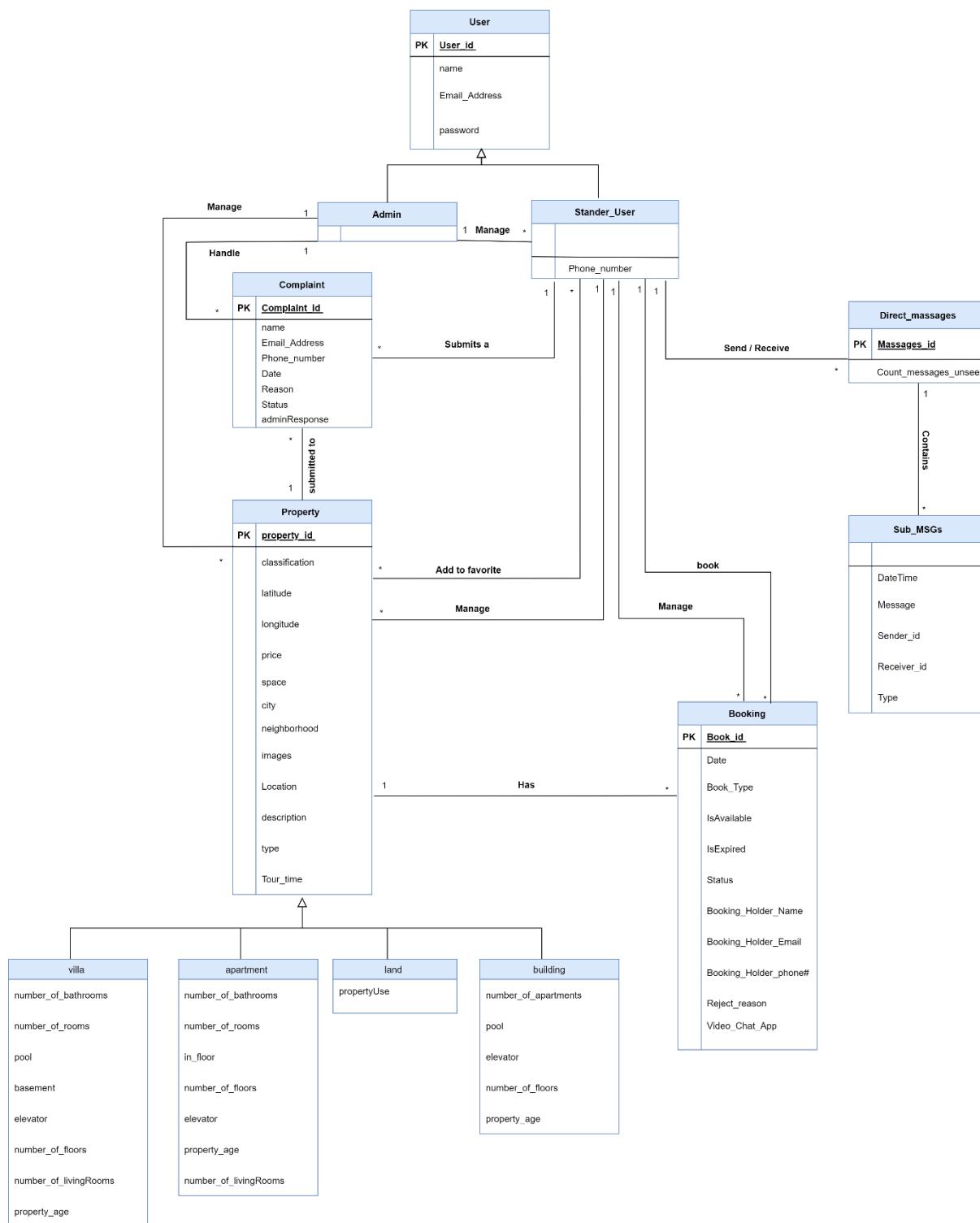


Figure 22 ER diagram

4.4.1.2 the non-relational data model

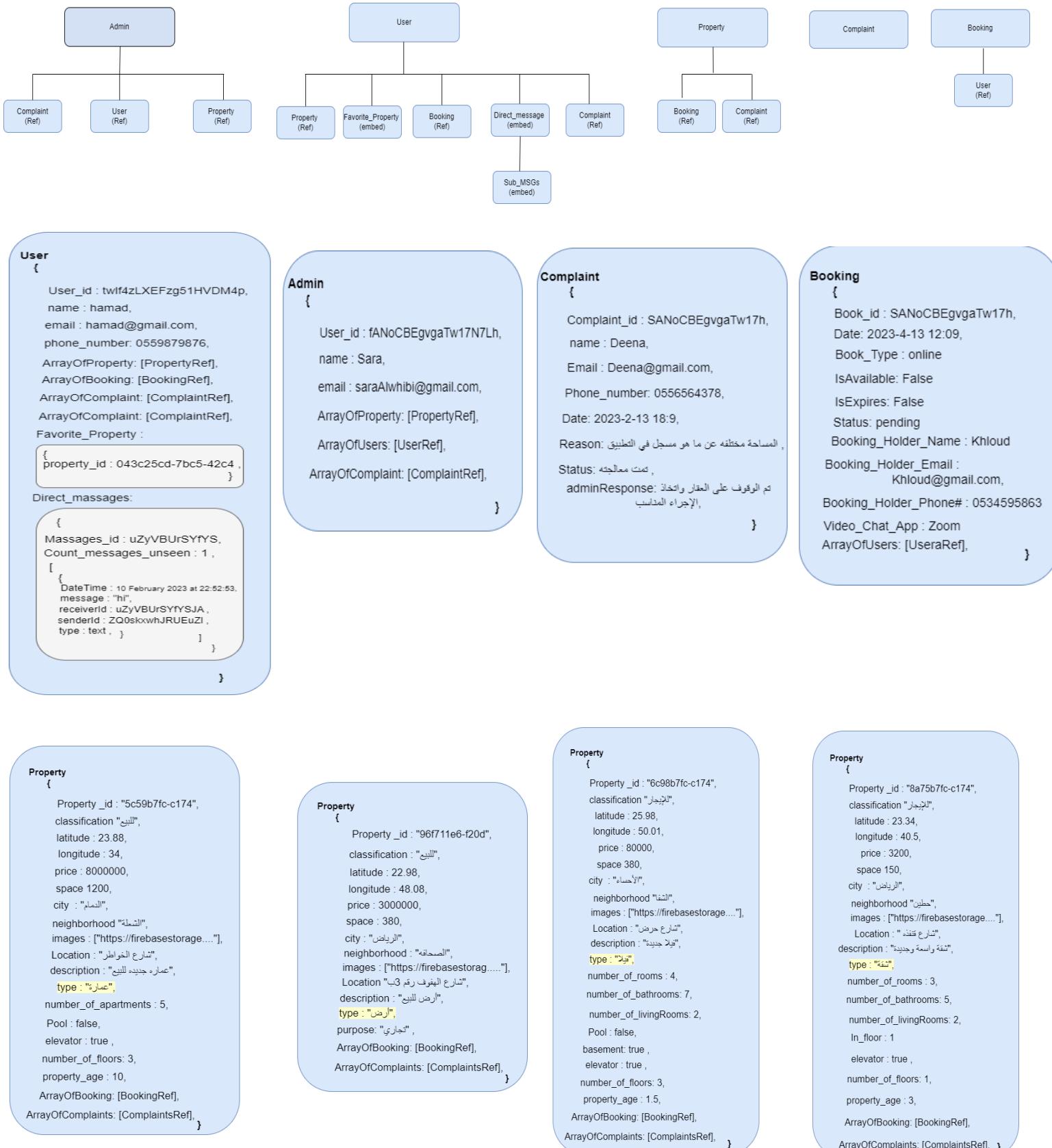


Figure 24 non-relational data model

We wanted to note that we used an array of references of properties, Booking, complaint in our user collection since there is a (one-to-many) relationship between the user and the property, Booking, complaint. It gives us better performance than using embedded, especially when searching and filtering.

A document in a property collection can be a different type of property since the class Property has many subclasses. That means we have fixed fields for all documents, and some fields are changed depending on the type of property.

4.5 Interface Design.

4.5.1 Admin navigation hierarchy

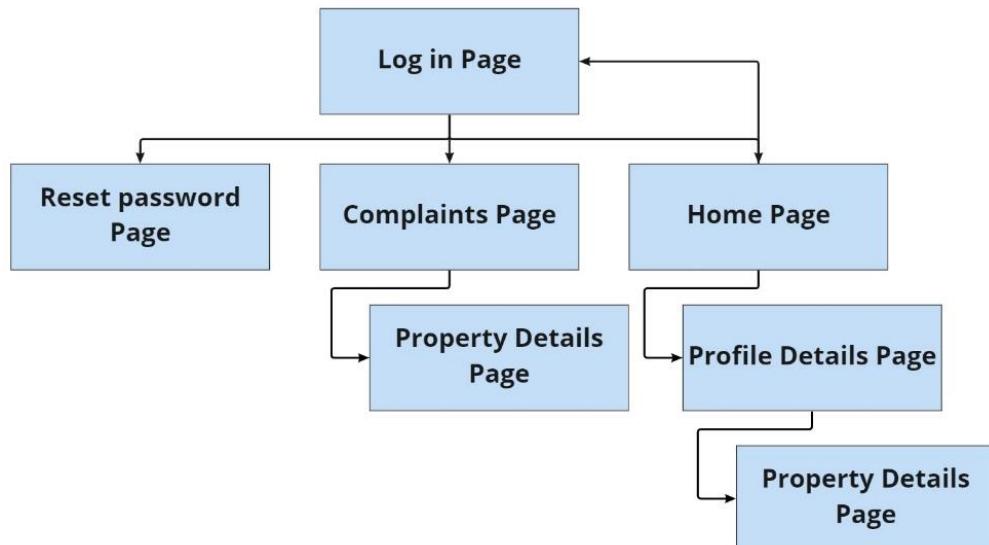


Figure 25 Admin navigation hierarchy

4.5.2 Guest navigation hierarchy

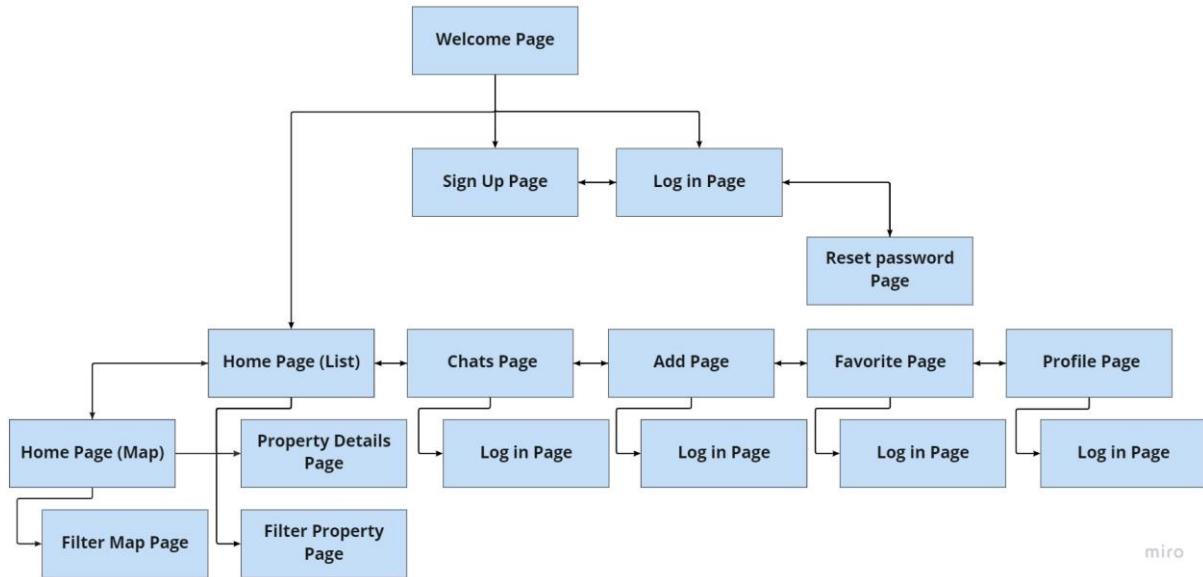


Figure 26 Guest navigation hierarchy

4.5.3 Registered User navigation hierarchy

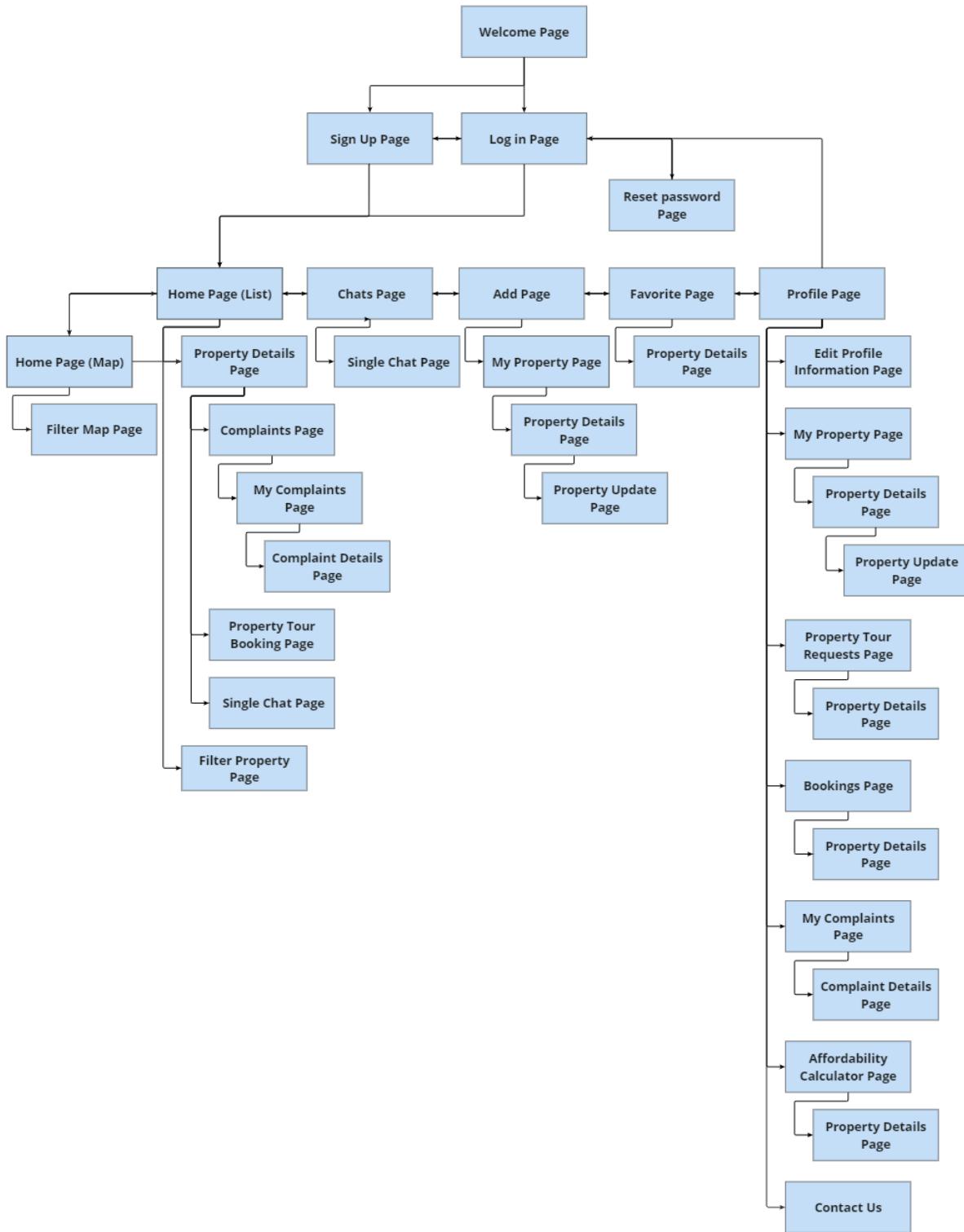


Figure 27 Registered User navigation hierarchy



4.5.4 UX guidelines

In our project, the following UX guidelines were adopted to help us deliver a more usable and appealing product:

- **Navigation Bar**

In a study done by Steven Hoober, he found that 49% of smartphone users prefer a single-handed grip while using an application! That means their reach across the mobile screen will be limited [26]. Therefore, we provided in our application a simple bottom navigation bar that provides an obvious and quick way of moving between different screens and finding the desired items.

- **Providing feedback:**

As one of Norman's design principles, the user must receive feedback after every performed action to let them know whether their action was successful [27]. Therefore, we applied this by informing our users when they successfully signed up, added a property, booked a property tour, and much more.

- **Preventing errors:**

Error prevention is one of the ten usability heuristics proposed by Jakob Nielsen [28]. To obtain that, we gave real-time messages that appear while the user is typing in the form fields on several pages. For example, on the sign-up page, we showed whether or not the user met each password requirement while typing it. Also, we checked for error-prone conditions to notify users and asked them to confirm before they committed to the action using confirmation messages. For example, when the user clicks the delete button, a confirmation message will be displayed to ensure whether he wants to delete it or just pressed it by mistake.

- **Consistency:**

Consistency in UX is concerned with making elements uniform, which means having them look and behave the same way [29]. We used the same color scheme on all pages and familiar phrases to the users. Also, users expect applications to share some similarities with other applications they regularly use. Therefore, we ensured that every component of our application behaves how most users would expect it to behave [30].

- Familiarity:**

It is the degree to which a user recognizes user interface components and views their interaction as natural [31]. As we applied it by using familiar icons as metaphors like the search icon, home icon, back arrows icon, and other well-known icons to the user.

4.6 Implementation

4.6.1 Software Tools

Table 5 Software tools

Software Type	Version	Description
Flutter	3.50.0	Google's UI toolkit, used to develop applications for Android, iOS, Linux, Mac, Windows, Google Fuchsia, and the web from a single codebase. Flutter code is compiled using Dart's native compilers [32].
Dart	3.50.0	Dart is a client-optimized programming language for apps on multiple platforms. It is developed by Google and is used to build mobile, desktop, server, and web applications [33].
Visual Studio Code	1.72.2	Visual Studio Code is a code editor redefined and optimized for building and debugging modern web and cloud applications [34].
Firebase	-	Cloud database service used to store data [35].
GitHub	3.1.2	A code hosting platform used to manage and integrate source code [36].
Python	3.9.10	Python is a high-level general-purpose programming language often used to build websites and software, automate tasks, and conduct data analysis. It can be used to create

		a variety of different programs and isn't specialized for any specific problems [37].
Flask	2.2.2	Flask is a micro web framework that provides you with tools, libraries, and technologies that allow you to build a web application in python [38].
Heroku	-	Heroku is a container-based cloud Platform as a Service (PaaS). It is used to develop and deploy applications in a variety of languages [39].
Html	5	HTML (HyperText Markup Language) is the most basic building block of the Web. It defines the meaning and structure of web content.[40]
CSS	-	Cascading Style Sheets (CSS) is a stylesheet language used to describe the presentation of a document written in HTML or XML (including XML dialects such as SVG, MathML or XHTML). CSS describes how elements should be rendered on screen, on paper, in speech, or on other media.[41]
JavaScript	-	JavaScript is a scripting or programming language that allows you to implement complex features on web pages[42]



4.6.2 Software Implementation

"Nozol" application was developed using "Visual Studio Code" environment with Flutter UI framework using the programming language Dart. We chose the programming language Dart since most of Flutter applications use it, in addition to being somewhat similar to the Java programming language, which makes it easier for us to learn. Another reason is that Dart includes many resources that help to implement the required functions. In order to run the application and ensure that the functions work as required and correctly, we used an Android virtual device (emulator) by Android Studio along with the use of an actual Samsung mobile device. In "Nozol" application we used Firebase for the features and facilitation it provides that is best suited for agile development. Also, as "Nozol" application has multiple users and each user will have their own property data, we used firebase cloud to store all their information and to help in identification and authentication when a user signs up and logs in. We also used Firestore service to store admin, and properties information. Integrating Firebase with "Nozol" was done by creating a project in Firebase, downloading, and placing the necessary files within "Nozol" project files.

For Nozol administration website, we built it with the most common web languages. HTML, CSS, and JavaScript. Particularly, we used JavaScript for the backend implementation to be able to connect our website to Firebase so we can reach Nozol database.



4.6.3 Major Parts of The System & Implementation Challenges

The major parts of our code include developing a content-based recommendation system and a rental affordability calculator, connecting to Google maps API and the map's markers. In this section, we will explain each major part and the challenges we faced during its implementation.

4.6.3.1 Content-based recommendation system

The main challenge here was deciding which algorithm works best for the purpose of our recommender. After days of searching deeply and studying recommendation systems, we came across some examples of recommendation systems using k-nearest neighbors algorithm [43][44], that are similar to how our recommender should work and we decided to use it in our recommender. The KNN algorithm takes an object and assigns this object to a group with the other nearest (i.e., most similar) objects in the database, usually done by making a matrix and calculating the Euclidean distance between each object and the others in the database. In python, there is a KNN built-in function, that does all the steps of KNN and returns the groups of similar objects, so instead of us creating the matrix and calculating the distance between each object, this built-in function does the work for us. To use this function, you need to specify the value of 'k', which is the number of similar objects in one group, so for example if we want to recommend 3 properties, we would specify k=4, because the first object will always be the object itself and the rest will be the nearest objects to it.

After importing our database from firebase, we got the id of the property the user is currently viewing and retrieved its information, with all the other properties in the database. Then, we applied data preprocessing as follows:

- 1- Drop irrelevant attributes.

```
df=df.drop(columns=['description','images','elevator', 'pool',
'User_id', 'number_of_apartment' , 'longitude','TourTime',
'property_age', 'number_of_room',
'in_floor','number_of_livingRooms','number_of_bathroom',
'propertyUse', 'basement', 'number_of_floors','ArrayOfbooking'])
df=df.drop(columns=['neighborhood','number_of_floor','latitude',
'Location', 'classification'])
```

2- Apply normalization to numerical attributes.

```
column = 'price'
c2 = 'space'
df_copy[column] =
MinMaxScaler().fit_transform(np.array(df_copy[column])).reshape(-
1,1))
df_copy[c2] =
MinMaxScaler().fit_transform(np.array(df_copy[c2])).reshape(-1,1))
```

3- Apply one hot encoding to categorical attributes.

```
encoded_data = pd.get_dummies(df_copy, columns = ['city', 'type'])
```

After that, we applied the KNN algorithm with k=6 because we wanted to recommend 5 similar properties to the user. Then to calculate the percentage of the similarity between the objects that are in one group, we took the distance between the object and every other object in the same similar group and calculated the similarity for each as follows:

```
nbrs =
NearestNeighbors(n_neighbors=5).fit(encoded_data.drop(columns=[ 'property_id']))
distances , indices =
nbrs.kneighbors(property1.drop(columns=[ 'property_id']))
distance = distances[0]
simelrty = []
for x in range(5):
    defrence = (1-distance[x])*100
    simelrty.append(defrence)
```

Then we returned only the objects that have more than 80% similarity percentage as follows:

```
recommend_item = []
index =0
for i in indices :
    print(type(encoded_data.iloc[i]['property_id']))
    jsonObj =
json.loads(encoded_data.iloc[i]['property_id'].to_json())
    print(type(jsonObj))
```



```
for key, value in jsonObj.items():
    if (simelrty[index]>=80):
        print(simelrty[index])
        recommend_item.append(value)
    index+=1

return json.dumps(recommend_item)
```

Choosing an 80% similarity threshold was done after experimenting with different similarity thresholds [45], a 90% or more similarity threshold gave us very limited results, and similarity thresholds that are under 80% resulted in recommending properties that are not so similar which might affect our recommender's reliability and makes it look untrustworthy. Lastly, to send/get data from/to flask and flutter we used HTTP requests. Then we deployed our recommendation system using Heroku for the recommender to work at any time instead of running it on the local machine.

4.6.3.2 Rental affordability calculator

The first step in deciding how much rent a person should pay is to decide how much rent they can afford. In order to implement this feature, we had to search thoroughly on how to decide what rental price a person can afford and based on what. To see what a person can afford, he/she should make a list of all their current monthly spendings. This includes mobile and vehicle fees and subscriptions. As well as less anticipated expenses like transportation, groceries, dining, and entertainment. And any school loans or other debts. Then they should deduct the total from their monthly income to determine how much money they have left for rent. In financial circles, there is a 30% rule, which is widely regarded, and many landlords use it when judging whether applicants can pay rent. The rule states that monthly rent should not exceed 30% of total monthly income. The 50/30/20 budget rule is another popular financial guide (see figure 31). It provides a spending pattern that distributes 50% of an income to essential necessities, such as rent, utilities, transportation, healthcare, and debt payments. 30% to non-essential wants. And 20% to savings, which is often overlooked but vital and should be used to create an emergency fund or save for retirement.

In conclusion, based on these rules, our calculator's formula is as follows:

Maximum affordable monthly rental price = monthly(income – spending – loans)
*** 25%**



Figure 28 implementation- 50/30/20 budgeting rule [46]



4.6.3.3 Connecting to Google maps API

Google maps API was one of the major services that our application depends on. We have chosen it since it's very familiar to users and it has easy instructions to install in any system.

For connect google maps API to our system we did as follow:

- 1- Adding google maps in our dependencies.

```
google_maps_flutter: ^2.2.1
```

- 2- Then we import it to any page that needs google maps services.

```
import 'package:google_maps_flutter/google_maps_flutter.dart';
```

- 3- Now using it's services as widgets.

```
GoogleMap(  
    initialCameraPosition: CameraPosition(  
        target: LatLng(23.885942, 45.079162),  
        zoom: 5,  
    ),  
    onMapCreated: (mapController) {  
        controller = mapController;  
    },  
    markers: markers.map((e) => e).toSet(),  
,
```



4.6.3.4 Map's markers

Putting the users' properties as markers on the map was one of the biggest challenges that we faced. Since it has many features, such as coloring them according to specific criteria, navigating to property details page when clicking on them, and filtering them.

Our implementation to display markers is as follows:

- 1- We retrieve the information for each property from the database and save it in a list for properties information.
- 2- Inside a loop, and by using google maps API, we create a marker for each property and give the marker the property's coordinates (longitude and latitude).

```
Future<void> intilize(MapArray) async {
    try {
        MapArray.forEach((element) {
            setState(() {
                if (element is Villa) {
                    final villa = element;
                    String titel = villa.properties.price;
```

- 3- For the markers' title we use properties price, and we use title feature in google maps markers.

```
        markers.addLabelMarker(LabelMarker(
            label: titel,
            markerId: MarkerId(villa.properties.property_id),
            position: LatLng(villa.properties.latitude,
                villa.properties.longitude),
            textStyle: TextStyle(
                fontSize: 35.0,
                color: Colors.white,
                letterSpacing: 1.0,
                fontFamily: 'Roboto Bold'),
            backgroundColor: filter_val == "type"
                ? Color.fromRGBO(255, 149, 203, 240)
                : filter_val == "price"
                    ? price_colored(villa.properties.price)
                    : filter_val == "space"
                        ? space_colored(villa.properties.space)
                        : Color.fromRGBO(255, 127, 166, 233),
```



The markers' colors can be changed based on specific criteria selected by the user. The criteria were stored as variables, and functions were used to change the markers' colors based on the variables. For example, if the user had chosen space, then the space function would be called.

In the function of each criterion, we chose the color according to what is shown to the user. For example, the color of each marker in the space function was chosen according to the range shown to the user. In order to make the colors meaningful, we used light colors for small numbers and dark colors for large numbers.

Since Nozol deals with different kinds of properties, programmatically that means it deals with different kinds of objects. The problem that we faced with this concept is how to let every marker reflect its property correctly therefore when user click on it the marker will navigate to the property details page. We solved this problem by building a page for each object. So, we have 4 different pages (villa – apartment – building – land), each with different attributes and layout that corresponds to the property type. Then we used if statement for each property we retrieved from the database to know its type to display its marker properly.

- GitHub link: <https://github.com/khloudaldughaim/2022-GP1-17.git>



System Evaluation



5 System Evaluation

5.1 User Acceptance Testing

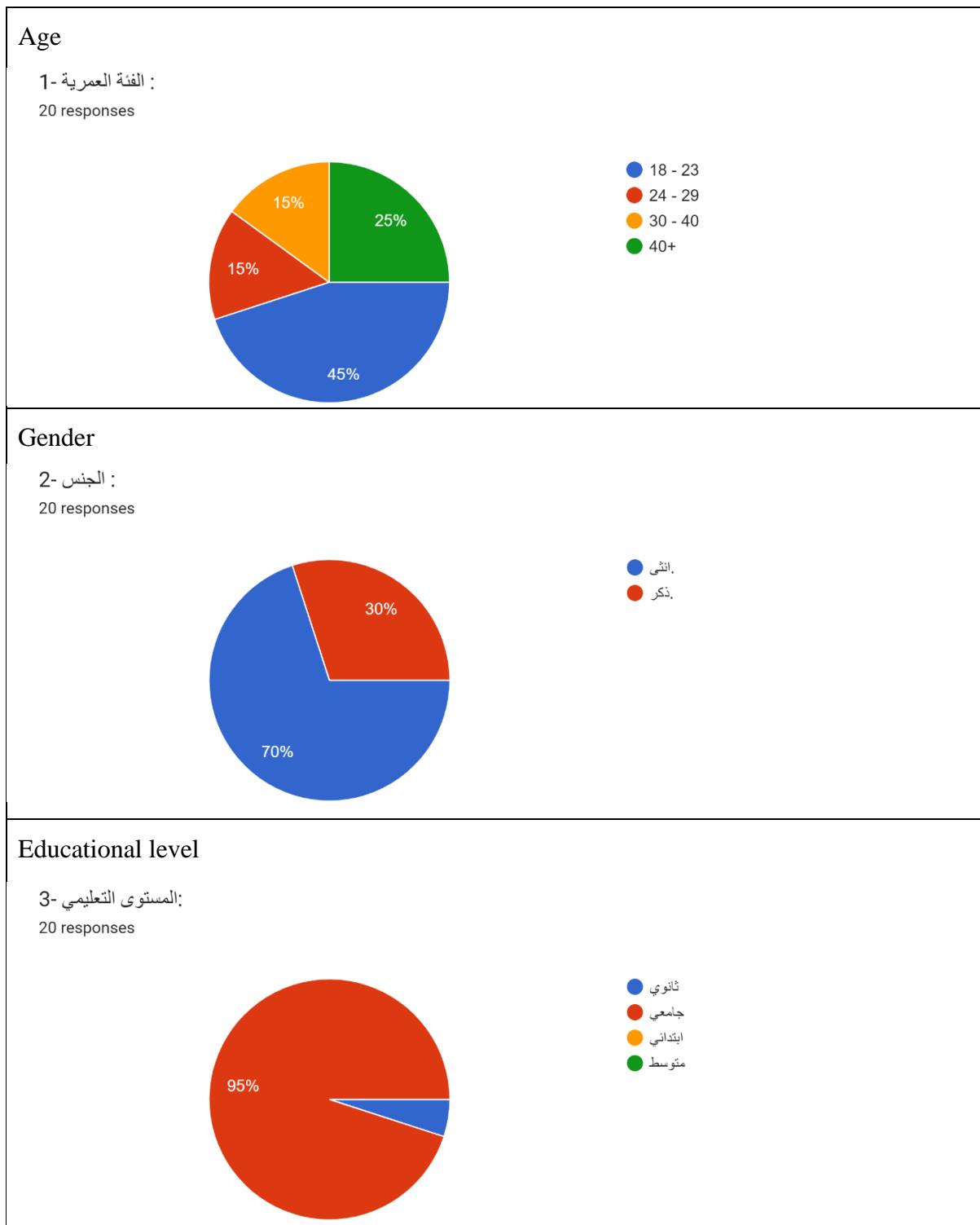
In this section, we will explain the testing of our system. Firstly, we conducted user acceptance testing for the application and the admin's website, to check if the system fulfills business requirements and can be used by end users. We recruited 20 participants who are interested in real estate from property owners to buyers to both, who meet certain criteria (see section 4.2.1: System users), to test our application. We also recruited five participants to test the admin website. The participants age ranged from 18-50 of both genders, with the ability to read in Arabic regardless of their educational level, and with basic technical skills and basic ability to use an application or the website.

After the testing team had used the application and the admin website, we checked acceptance concerning user interface, technical aspects, major strengths, and major weaknesses by collecting information about it using a questionnaire regarding the participants and their experiences with our system. The questionnaire consisted of 25 questions for the application test team and 15 questions for the admin website test team. In each question, the respondent has to choose from four options Strongly agree (1), Agree (2), Disagree (3), Strongly disagree (4).

Lastly, for a furthermore information on the participants and the findings of the questionnaire, we will present the demographics of participants, questionnaire results and a discussion that interprets the results.

5.1.1 Demographics of Participants

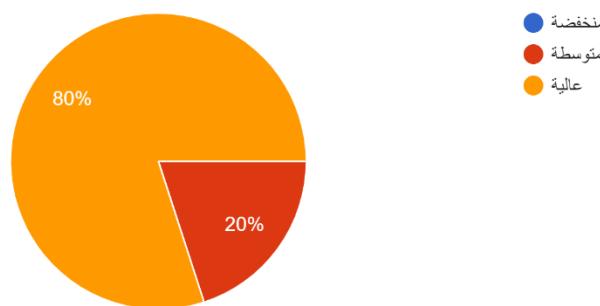
The participants in the application testing were asked about their age, gender, education level, and experience with mobile applications, as well as if they used the application as buyers, owners, or both. The following figure (Fig. 29) displays their answers.



Experience in using mobile applications

الخبرة في استخدام تطبيقات الجوال-4:

20 responses



Use of the application

استخدامك للتطبيق كـ-5:

20 responses

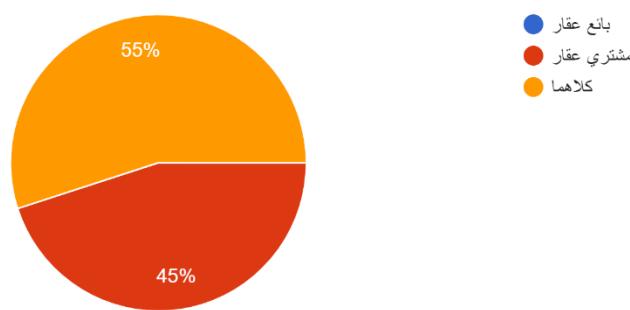
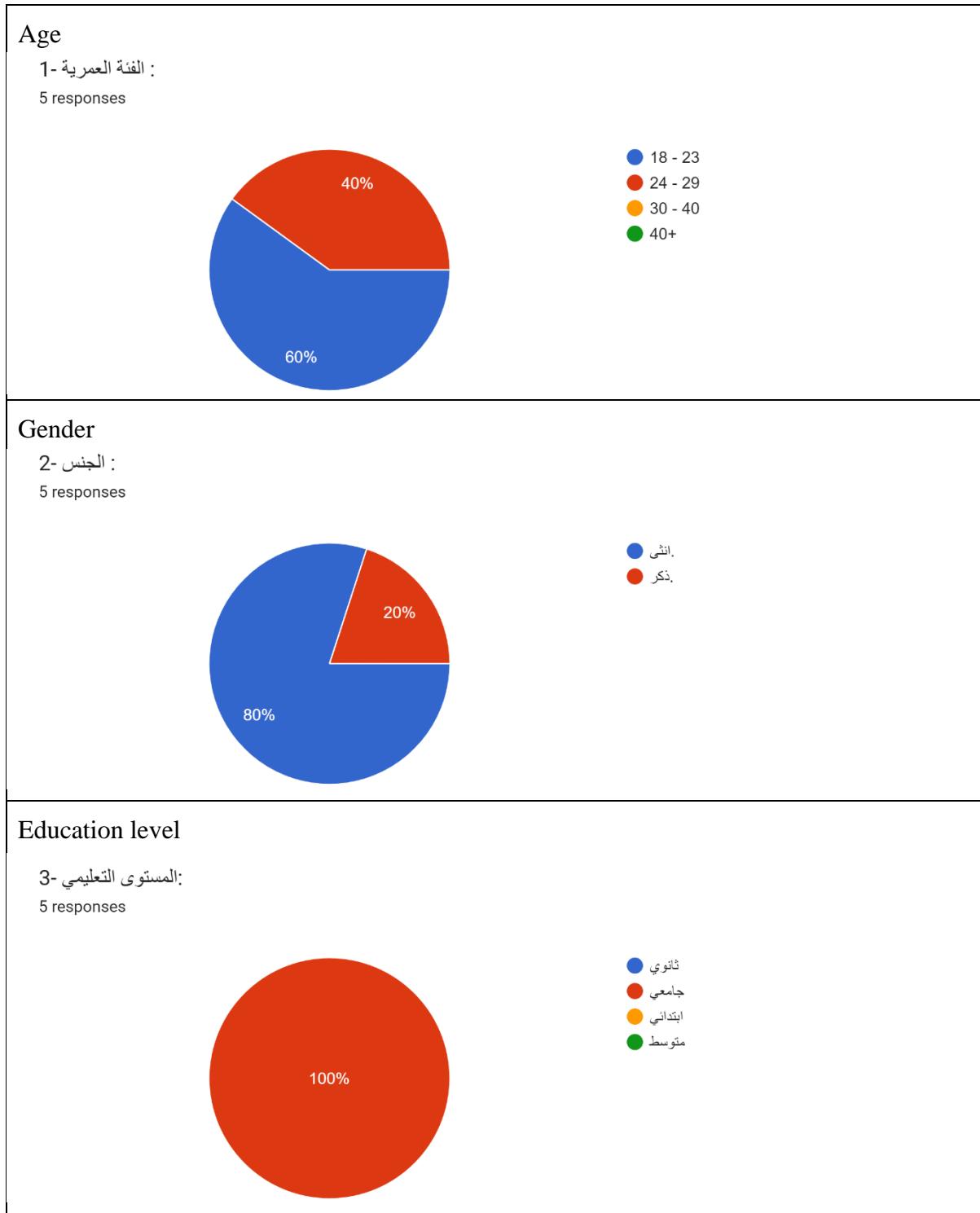


Figure 29 Demographic of users participants

Participants in the admin website testing were also asked about their age, gender, education level, and website experience. The following figure (Fig. 30) displays their answers.



Experience in using websites

الخبرة في استخدام الموقع الالكتروني 4-

5 responses

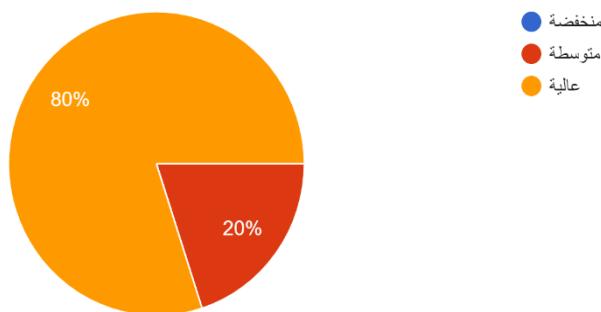


Figure 30 Demographic of Admins participants

5.1.2 Questionnaire Results

The 20 participants in the application testing were asked about their experience with our application. The results of the questionnaire are summarized in Table 6.

Table 6 Responses of participants to the application questionnaire

Question	Number of respondents (Percentage of responses)			
	Strongly agree	Agree	Disagree	Strongly disagree
I needed previous experience to use the app.			1(5%)	19 (95%)
I found the app easy to use.	17 (85%)	3 (15%)		
I found the app to be properly threaded and navigating between pages was easy.	17 (85%)	3 (15%)		
I found the colors comfortable.	17 (85%)	3 (15%)		
I found the application interface design clear and easy to use.	19 (95%)	1 (5%)		
I found that some of the icons did not have a clear meaning.		1(5%)	3 (15%)	16 (80%)
I found the app to have a fast response.	18 (90%)	2 (10%)		
I think I will use the app frequently.	16 (80%)	4(20%)		
I was able to add a property and modify its information correctly, easily, and clearly.	15 (83.3%)	3 (16.7%)		
I was able to search for a property correctly, easily, and clearly.	18 (94.7%)	1 (5.3%)		
I was able to filter properties correctly, easily, and clearly.	19 (95%)	1 (5%)		
I was able to book a property tour and manage tour dates correctly, easily, and clearly.	17 (85%)	3 (15%)		
I was able to manage property tour requests correctly, easily, and clearly.	16 (94.1%)	1 (5.9%)		

When I viewed a particular property, the recommended properties below the property were useful to me.	17 (89.5%)	2 (10.5%)		
I was able to chat with other users through private messages correctly, easily, and clearly.	19 (95%)	1 (5%)		
The feature of customizing the colors of the markers on the map was useful, and the colors are clear.	17 (85%)	3 (15%)		
I was able to calculate the monthly rent that I could afford correctly, easily, and clearly.	19 (95%)	1 (5%)		
I was able to send complaints correctly, easily, and clearly.	19 (95%)	1 (5%)		
The pop-up messages I get from the app were helpful and clear.	18 (90%)	2 (10%)		
I will recommend this app to my friends and family.	18 (90%)	2 (10%)		
We will be pleased with your suggestions and comments:				
The application is wonderful and was built professionally, with a smooth and clear user experience. There are no notes, and I found your distinction in customizing the map colors when filtering, in addition to booking a property tour and the affordability calculator.				
It is preferable to add a button that takes you to WhatsApp directly.				
The interfaces were beautiful, the colors were clear, the icons were in the appropriate places, I liked it.				
The marker should be highlighted/shadowed in the map after clicking on it.				

As for the admin website testing, the participants were asked about their experience with the website, The results of the questionnaire are summarized in Table (7) below.

Table 7 Responses of participants to the admin website questionnaire

Question	Number of respondents (Percentage of responses)			
	Strongly agree	Agree	Disagree	Strongly disagree
I needed previous experience to use the website.			1(20%)	4 (80%)
I found the website easy to use.	5 (100%)			
I found the website to be properly threaded and navigating between pages was easy.	5 (100%)			
I found the colors comfortable.	4 (80%)	1 (20%)		
I found the website interface design clear and easy to use.	5 (100%)			
I found that some of the icons did not have a clear meaning.				5 (100%)
I found the website to have a fast response.	4 (80%)	1 (20%)		
I was able to manage complaints from users correctly, easily, and clearly.	5(100%)			
I was able to suspend an account or property correctly, easily, and clearly.	5 (100%)			
I was able to delete an account or property correctly, easily, and clearly.	5 (100%)			
Access to the email of the complainant or the owner of the property was easy and clear.	5(100%)			

5.2 Quality Attributes (NFR testing)

Table 8 NFR testing

User story	Quality Attribute	Measure	Results
As a user, I want the homepage of the application to be opened within at most 2 seconds, so that I can use the application as quickly as possible.	performance: how the speed, and responsiveness of an application holds up under a given workload [47]	Compute the response time for opening the homepage. The application should be open the homepage in less than 2 seconds.	We tested 20 users individually, and a timer was used to compute the time of the application response. The average of the response time to open the homepage was 0.79 seconds which is less than 2 seconds.
As a user, I want to use a secure application so that my information will be protected.	security: How authorized access to protected data is granted and unauthorized access is restricted in the application. [48]	Only authenticated users are allowed to access the software.	Nozol depends on firebase authentication for authentication, and we found that Firebase Authentication uses an internally modified version of script to hash account passwords [49]. Also, the application prevents registering with a week password. the password must have both upper and lower cases also it should have numbers and at least 8 characters.
As a user, I want to be familiar with the application's interface and icons	Usability: how the application is easy to learn and user-friendly.[50]	The System Usability Scale (SUS) was used which is a reliable	We tested our application with five users, and the average score was 88, which is higher than the

so that dealing with them will be easy for me.		and quick tool that measures the usability of a system [51]. SUS consists of 10 questions (see 9.3 appendix C for the questions) and the overall usability is calculated by finding the mean score for the responses of the participants.	average system usability scale (SUS) score of 68, indicating that our application is highly usable.
As a user, I want the application to be available 99% of the times I try to access it, so that I can access the application at any time I need it	Availability: how likely it is that a user will be able to access the system. [52]	Compute the percentage of application availability.	Nozol depends on Firebase for authentication and storage data, and this is what effects on availability. According to the Firebase website [53], we found that Firebase's availability is at least 99.95% of the time, which means our application's availability is greater than 99%.
As a user, I want the system to reconnect to the server within 15 seconds when the internet connection is dropped, so that I can complete	Reliability: How well the software can perform in a particular environment for a specified period of	Compute the time it takes the application to reconnect to the server when the internet connection is dropped.	We tested 20 users individually with different devices. We used a timer to calculate how long it takes for the application to reconnect. We found that the average reconnect time

browsing the application.	time without failure. [54]	The application should be reconnected to the server in less than 15 seconds.	was 7.6 seconds, which is less than 15 seconds, and there was no failure (more than 15 seconds to reconnect) in any of the tests carried out.
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5.3 Discussion

After completing the user's acceptance testing with 20 application users and 5 website admins, we can say that the system evaluation was great according to the questionnaire results. For the UX/UI design, all participants found the colors of the interfaces comfortable. Most of them agreed that the icons have a clear meaning, and they didn't face any problem understanding them, but it was suggested to make them bigger. Almost all the users strongly agreed that the system was easy to understand and navigate and there was no need for previous knowledge to deal with it, and that the pop-up messages were useful and clear. In addition, all participants were able to use all the functions correctly and easily. And almost all of them strongly agreed that they would use the application frequently and that they would recommend it to other people.

As for NFR testing, based on the results we can conclude that the performance of the application is great, as the response time for home page was less than 1 second. And it has a high level of security, since it puts restrictions when choosing a password, and uses firebase authentications to hash the passwords. Nozol also has high availability, since it depends on firebase for authentication and data storage, and firebase is available 99.95% of the time [53]. As for the usability, Nozol scored 88 in the SUS, which exceeds the average score of 68, thus it can be concluded that it is highly usable. Also, Nozol is highly reliable, since it was able to reconnect within less than 8 seconds without any failure during the testing with 20 different users.

Overall, the feedback was great and Nozol showed a very good acceptance level and now we can see the good aspects of the application. Most participants praised the UX/UI of the application and website as well as their ability to use its functions correctly and easily. Also, according to the results we can see all our major features, such as the property tour booking system and recommendation system, were met with a high degree of satisfaction. However, there were some improvements that were suggested by the participants that we considered, such as shading the property's marker on the map when the user clicks on it and making the icons bigger. And other suggestions that seem very good and might be included in future releases, such as adding a button that takes the user directly to WhatsApp and expanding our scope to include home construction contracting and consultation offices.



Conclusions and Future Work

6 Conclusions and Future Work

This document represents our journey with Nozol, starting from the idea like a bare land, and constructing this land brick by brick. From the introduction, followed by the background chapter, to the literature review; where we reviewed mobile applications in the same field of Nozol to specify Nozol's feature and deliver an application that fills the gap in the market. After having a clear vision of Nozol's features, we move on to the system's analysis and design chapter, which transforms Nozol's features into a form that facilitates the implementation of Nozol and supports understanding of its components and how they work together. Then after analyzing our system, we started developing Nozol application using Flutter framework, then we tested it to make sure there are no bugs in the application. And just like that, our land has completed construction and became a safe home and a friendly destination for anyone looking to sell, buy or rent a property.

6.1 Global and local impact

The real estate industry in Saudi Arabia is a crucial part of the economy. With the advancement of technology and the use of it to improve the buying and selling process, as mentioned earlier in the background chapter (see section 2.2), the industry has undergone a significant transformation, and a real estate application such as Nozol would have a significant local and global impact.

On a local level, our application can help to stimulate the real estate market, by making it easier for people to buy and sell properties. It exposes the properties to a wider range of people, thereby further growing the real estate market, and increasing the profit of property owners. With our application, buyers and sellers can access more information about properties, which leads to a more informed decision-making process, as buyers can assess the value of a property before making a purchase. Furthermore, our application can make it easier for foreigners to find rental properties in Saudi Arabia, and as more people move to Saudi Arabia, the demand for housing increases, which stimulates the real estate market.

On a global level, Nozol comes in line with the development of the Saudi Vision 2030 and the kingdom's progress towards digital transformation which aims to diversify the economy and reduce the dependence on oil revenues and to raise the kingdom's index globally. The real estate sector is a key area of focus for the Saudi government, and our application will provide a platform to showcase the investment opportunities available in the country. Our application

has the potential to transform the way we look at real estate investments. People outside Saudi can invest in properties from the comfort of their own homes. This can help create new opportunities for people to invest in real estate in Saudi, and the economy would benefit from a rise in foreign investment in the sector.

6.2 Problems and challenges encountered during the software development

The most challenging part of this project was learning a new programming language and tools in a short time. With no prior experience in Dart/Flutter nor Firebase, it was a very stressful yet rewarding experience for us. We were mostly learning on-the-go as we were implementing our app. This challenge improved our learning abilities in a short time.

6.3 Limitations of the system

While the project has managed to achieve the target of its initial specification successfully, there are still certain limitations that could not be implemented due to time constraints. Nozol is currently only supporting Android and the Arabic language, and it focuses on (villas, apartments, lands, and buildings) so it does not support all types of real estate, and it is currently only focusing on Saudi Arabia.

6.4 The main contribution of the project

To improve the quality of our lives, it is our duty as students and members of society to contribute to the development of knowledge. Nozol is a project that helps the user sell, buy, or rent a property with great user experience along with many other useful features. It allows users to browse properties from their mobile devices, which makes it easier for them to find the right property. Users can also filter the map by coloring its markers, use a rental affordability calculator, schedule property tours, and communicate with real estate owners. This streamlines the entire process, making it more convenient for people to buy or sell properties. By using our application, those interested in real estate can easily promote their properties to a larger number of people, as they will be able to view a wide range of properties and use other services within the application. Furthermore, our application has the potential to attract foreign investment, support the local economy, and contribute to the achievement of the Saudi Vision 2030 and will help increase the growth in the real estate field.

Like any experiment a person goes through, this one has an impact on our abilities. We learned a lot during our challenging journey with Nozol, it has allowed us to apply the knowledge we learned during our university study and helped us develop information searching skills. As for hard skills, we have learned new programming concepts. We have programmed using the Dart programming language and the Flutter framework, used the Firebase database and integrated it with our system, and solved difficulties and issues encountered during system development. We have gained lots of experience while implementing this project, which is documented in this report including all of the process that we walked through. Therefore, it can be a reference to anyone who wants to build a similar system.

6.5 Future work

Like most applications out there in today's market, there are never a perfect software as new features and updates are constantly being pushed out to its users. Thus, the same can be said about Nozol. A good starting point would be resolving the limitations that were mentioned earlier in the limitations section, by supporting other languages such as the English language, supporting other operating systems like iOS, expanding to other countries, and supporting more property types. Furthermore, there's many interesting features we could not include in this release due to time constraints that we could include in later releases, such as:

- Pricing feature that prices a property based on a pricing model that predicts a suitable price based on multiple information.
- 3d home tour.
- A button that takes the user to WhatsApp immediately.
- Expanding our scope to include home construction contracting and consultation offices.
- A feature that compares multiple properties based on different attributes.
- A notification whenever a property ad with a specified price is posted.



Acknowledgements



7 Acknowledgements

First, we would like to thank everyone who contributed to the successful completion of this project. We would like to express our gratitude to our supervisor, Dr. Nouf Alromaih, for her invaluable advice and guidance throughout the development of the project. In addition, we would also like to express our gratitude to our loving parents and friends who helped and given us encouragement throughout the entire process of completing this project. Lastly, we would also like to thank the testers who have agreed to participate in the project's user acceptance testing. The feedback provided is valuable and informative, which helped contribute to the improvements of the project.



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Appendix

9 Appendix

9.1 Appendix A: Requirements Elicitation: Interviews

Interview questions:

- 1- What's your name, age and are you a buyer or an owner or both?
- 2- What would you do if you want to buy, rent, or sell a property?
- 3- What difficulties have you faced when trying to buy, rent, or sell a property using existing real estate applications? What do you suggest to deal with these difficulties?
- 4- What features do you like the most about the real estate apps you are using?
- 5- What are the things or features you would like to have, or you want to be improved in the existing real estate applications?
- 6- How do you do a property tour, and what problems you may encounter? Do you think a video tour would be useful?
- 7- Is it easy for you to know whether renting a property in a particular area fits your budget?
(Do you think having an affordability calculator would be useful in this case?)
- 8- Do you have anything else to add?

Interviews transcriptions:

Table 9 interview-1

Interview 1	
Date: 22/9/2022	
Location: interviewee's office	
Duration: 15 minutes	
Interviewee: Haila Abdulaziz	Interviewer: Sara Alwhibi
Reminders: - the interviewee is interested in real estate. And she's both a buyer and an owner. - the interviewee's age is 57.	
Questions	Answers
1- What's your name, age and are you a buyer or an owner or both?	Haila, 57, both.

2- What would you do if you want to buy, rent, or sell a property?	<p>When I want to buy a property, I usually look for it in real estate applications. Or sometimes I look for properties by contacting a real estate agent that someone has recommended for me.</p> <p>While for selling or renting as an owner, I usually ask a real estate agent to sell it or advertise it for me in real estate applications. It's mostly because I rather not bother myself with it, I use Aqar and I find it difficult to figure out how to advertise a property, especially at my age I'm not very good with mobile applications.</p>
3- What difficulties have you faced when trying to buy, rent, or sell a property using existing real estate applications? What do you suggest to deal with these difficulties?	<p>As I said previously, as an owner I find it difficult to advertise my property by myself using Aqar, It would be better if there was an explanation or a simulation on how to do it exactly in very easy steps that is understandable for someone who doesn't know much about technology.</p> <p>There's a difficulty I would like to add too as a buyer although I don't know how it can be solved but sometimes I find it hard contacting an owner of a property, they never answer their texts or calls so it's hard to reach them and I lost so many good properties due to this problem,</p>
4- What features do you like the most about the real estate apps you are using?	<p>Well, first of all in general they made it way easier for us to look for properties. Instead of going around real estate offices to look for properties I can just look for them while lying in my house.</p> <p>As for the features inside a real estate application, I like that it shows me other similar properties to the one I'm searching for. I also like that I can directly go to someone's WhatsApp profile to text them by clicking on it without the hassle of registering their numbers first.</p>
5- What are the things or features you would like to have, or you want to be improved in the existing real estate applications?	<p>I can't think of anything to add, especially that there are no special local competitors, maybe if I tried global applications I would feel the huge difference and think of something to add.</p> <p>As for something I want to improve, I want photos or videos of the property to be mandatory as there are a lot of ads with no pictures.</p>

6- How do you do a property tour, and what problems you may encounter? Do you think a video tour would be useful?	<p>I contact the owner and we set up a suitable time to meet for a property tour. Sometimes we waste time looking for a suitable time for both of us so this may be a problem to solve using a booking system or something similar.</p> <p>As for the video tour I find it very useful, most of the time the pictures are not clear and a video call can be time and effort saving as a first step rather than going to see the property in person and wasting time.</p>
7- Is it easy for you to know whether renting a property in a particular area fits your budget? (Do you think having an affordability calculator would be useful in this case?)	<p>Well for me it's easy because I already know my budget. But I know a lot of people, especially people who have jobs and loans that will find an affordability calculator very useful.</p>
8- Do you have anything else to add?	No, thank you.

Table 10 Interview-2

Interview 2	
Date: 22/9/2022	
Location: interviewee's office	
Duration: 30 minutes	
Interviewee: Abdulaziz Altamimi	Interviewer: Sarah Alkhayef
Reminders: - the interviewee works in a real estate company. And he's both a buyer and an owner. - the interviewee's age is 49.	
Questions	Answers
1- What's your name, age and are you a buyer or an owner or both?	Abdulaziz Altamimi , 49 , both.
2- What would you do if you want to buy, rent, or sell a property?	I will first establish the location of (purchasing, selling, or renting), then determine the budget allotted for that, and finally I will do a search using a variety of ways, including the quickest and most thorough option, which is real estate application (Aqar - Haraj - Sohail), choosing the best option, negotiating it, standing next to it to assess its suitability, then complete the deal .
3- What difficulties have you faced when trying to buy, rent, or sell a property using existing real estate applications? What do you suggest to deal with these difficulties?	The difficulties I faced first was the lack of updating of some offers in some real estate applications. Secondly, the prices are a bit exaggerated. Third, the same offer is repeated more than once and the value of the offer varies! Fourth, not being serious about selling. Fifth, the reality of the product differs from the images shown because they are old or modified images. Sixth, it is focused on some products over others.
4- What features do you like the most about the real estate apps you are using?	The benefits are numerous, including its modernism and the abundance of offers in real estate applications. And that it's linked it to authorized websites, for example the

	building system. Additionally, to minimize manipulation, only those with a permit exhibit real estate.
5- What are the things or features you would like to have, or you want to be improved in the existing real estate applications?	The most important advantage that I want to improve is the ability to compare a number of offers from several different aspects, such as price and specifications. Also, linking with the valuer approved by ministry of Justice and the approved engineering offices through the Baladi website, as well as the classified and approved contractor, as stated in the new Saudi building code system.
6- How do you do a property tour, and what problems you may encounter? Do you think a video tour would be useful?	Firstly, I contact the owner of the property and find out if the property is available for viewing and what time it can be viewed so that I do not waste my time and effort going to the property only to find it is not available. Also, it may be done using a video of the property that the property owner filmed for me without modifying that video in any way. A live video call can also be very helpful and can save time and effort.
7- Is it easy for you to know whether renting a property in a particular area fits your budget? (Do you think having an affordability calculator would be useful in this case?)	For me, it is easy to set the budget and plan for a project based on what I have seen from my previous experiences, and it is often close to reality when I plan for a project and set the budget to suit the need. There is a possibility that the affordability calculator will be able to solve many of the problems that may be encountered when investing in or purchasing private housing.
8- Do you have anything else to add?	The above is all I have to say, along with my best wishes for your future success.

Table 11 Interview-3

Interview 3	
Questions	Answers
1- What's your name, age and are you a buyer or an owner or both?	Ghaida Altaweel, 23, buyer.
2- What would you do if you want to buy, rent, or sell a property?	Searching for available options in real estate offices' accounts on social media, accessing the Aqar application, previewing what is on the ground and traditional search.
3- What difficulties have you faced when trying to buy, rent, or sell a property using existing real estate applications? What do you suggest to deal with these difficulties?	There are inaccuracies in the data displayed as well as the lack of credibility in the offers and pictures. The pictures may be repeated for the same apartment in multiple neighborhoods, indicating that these are lies. Additionally, some real estate applications have a bad user experience since they are hard to use and inflexible. I suggest enhancing applications with simple interfaces that are suitable for all users.
4- What features do you like the most about the real estate apps you are using?	the ability to easily access the right property by knowing the information and comparing the exhibits, as well as communication with the seller, as well as easy access to the property by knowing the exact location on the map of the property.
5- What are the things or features you would like to have, or you want to be improved in the existing real estate applications?	Information accuracy, filtering offers that correspond to what I am looking for in terms of budget, space, location, etc., as the filtering in the current applications is not of high quality and does not meet my expectations.

<p>6- How do you do a property tour, and what problems you may encounter? Do you think a video tour would be useful?</p>	<p>When wanting to visit a property, it may be difficult to determine the time when the property guard will be available and ready to present it to the customer at the requested location, we may go to the property and not be able to enter because the guard is busy or not reachable. I think a video call might be of some help. It saves a lot of time and effort, as it gives an initial impression of the property and whether it is suitable for my needs or not in a clearer way than the pictures only.</p>
<p>7- Is it easy for you to know whether renting a property in a particular area fits your budget? (Do you think having an affordability calculator would be useful in this case?)</p>	<p>One of the problems that people face (especially in their first experience of buying or renting) is not studying the topic well, and then discovers that he has incurred something beyond his ability and cannot manage his expenses and rent or loan that he borrowed to buy. I think it could be really useful.</p>
<p>8- Do you have anything else to add?</p>	<p>I hope your application focuses on ease of use, and clarity.</p>

9.2 Appendix B: Requirements Elicitation:

- Questionnaire:

السلام عليكم ورحمة الله وبركاته

عن مهارات تقنية المعلومات من جامدة الملك سعود ، تنسج بين أيمكم سبلية لإنكليز مهارات مشروع تخرجنا لازل ، وهو تطبيق
عقاري يساعد المستخدم في شراء ، تأجير أو بيع قطعة عقارية بطريقة سهلة وفعالة.

سعد لمساعدكم في تجديء جزء من مطبيات هذا المشروع ، وشكرون لكم تعاونكم في تعزيز هذا الاستبيان

* 6- وفقاً للقياس أدناه ، ما هي احتمالية أن تبدأ / تستمر في استخدام تطبيقات العقار ؟ *

5	4	3	2	1
<input type="radio"/>				
غالية جداً				منخفضة جداً

* 7- كيف ترى تطبيقات العقار الموجهة حالياً في السوق السعودي من حيث ثلثية الحدود ؟ *

<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
مثلثة	ليست مثلثة	لا استخدم اي تطبيق خارج

* 8- هل تعتقد ان تطبيقات العقار البسطوية أقل كفاءة من الاجنبية ؟ *

<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
نعم	لا	لم تتطلعا على التطبيقات الاجنبية

* 9- ما هي الفوائد التي تعتقد ان تطبيقات العقار ستقدّمها ؟ (يمكن اختيار أكثر من خيار) *

<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
توفير الوقت	تقدير الكلفة	ترزودي بمعلومات مفصلة ومتقدمة
سهولة الاستخدام	السماح بالمقارنة بين قطع عقارية مختلفة	يمكن الوصول اليها في أي وقت ومكان
المغزو		

* 10- هل تفضل وجود ميزة في التطبيقات العقارية تساعدك على قرار مدى ملائمة سعر العقار مع ميزانيتك ؟ *

<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
نعم	لا	

* 11- هل تفضل وجود ميزة تسهيل حجز مواعيد زيارة العقار (واقعها او اقتراضاها) من خلال التطبيق ؟ *

<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
نعم	لا	

* 12- هل تفضل أن يكون بإمكانك إجراء جولة في العقار من خلال مكالمة فيديو ؟ *

<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
نعم	لا	

* 13- ما هي الفوائد التي تعتقد ان تطبيقات العقار ستقدّمها عادة لجمع معلومات عن قطعة عقارية تهتم بها ؟ (يمكن اختيار أكثر من خيار) *

<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
موقع الانترنت العقارية	مخصصات التراخيص العقارية، مثل تويتر وسبلاشات	اعلانات الشوارع
اقرار من قبل وسيط عقاري	عن طريق أفراد العائلة او الأصدقاء	آخر :

* 14- هل البحث عن عقار من خلال الطريق التقليدية - مثل مكتب العقار او سوق خيرا و غيرها - يغير امراً سهلآ ؟ *

<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
نعم	لا	

* 15- إذا كانت إجابتك على السؤال السابق لا ، انكر بعض المسموعات التي وجهتها خلال بحثك عن عقار مناسب.

<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
إجابتك		

* 16- هل سبق لك استخدام تطبيق عقاري من قبل ؟ *

<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
نعم	لا	

* 17- إذا كانت إجابتك على السؤال السابق نعم ، ذكر اسماء تطبيقات العقار التي استخدماها.

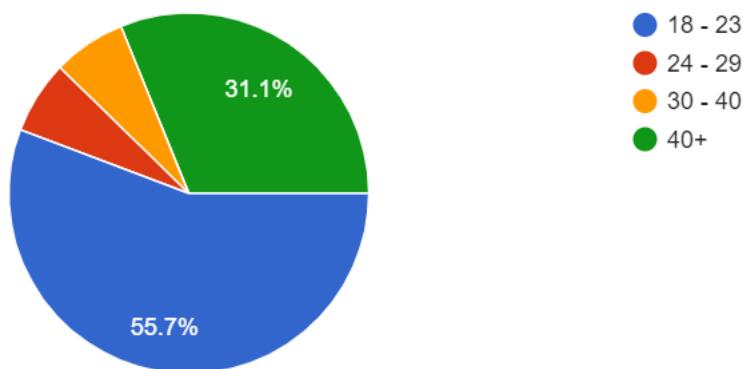
<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
إجابتك		

Figure 31 Requirements Questionnaire

- Questionnaire results :

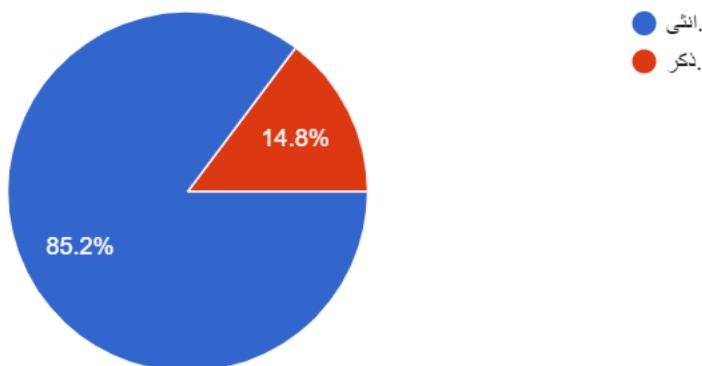
1- الفئة العمرية :

رجال 122



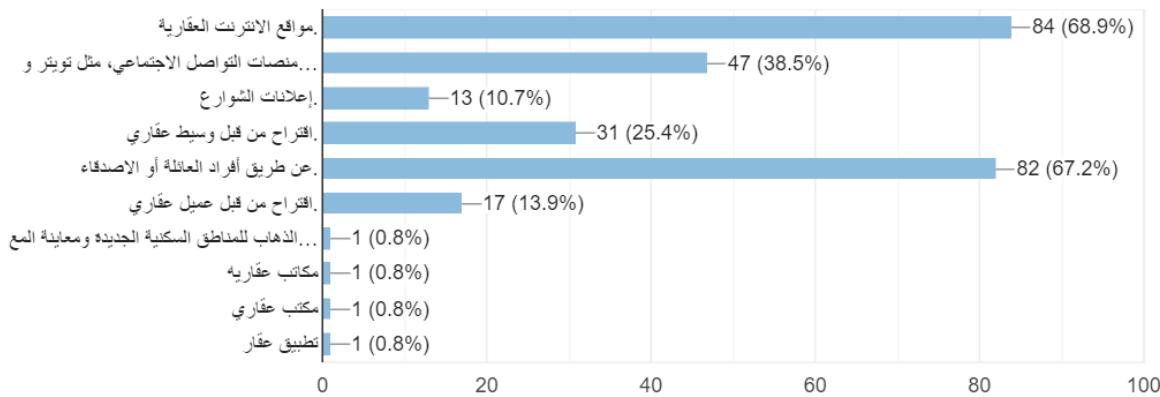
2- الجنس :

رجال 122



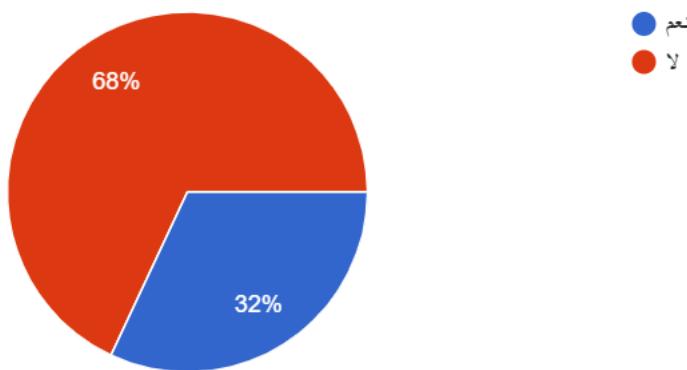
3- ما هي الطرق التي تستعملها عادة لجمع معلومات عن قطعة عقارية تعجبك ؟ (يمكنك اختيار أكثر من خيار).

122 ردًا



4- برأيك ، هل البحث عن عقار من خلال الطرق التقليدية - مثل مكاتب العقار أو سؤال خبراء وغيرها - يعتبر أمرا سهلا ؟

122 ردًا



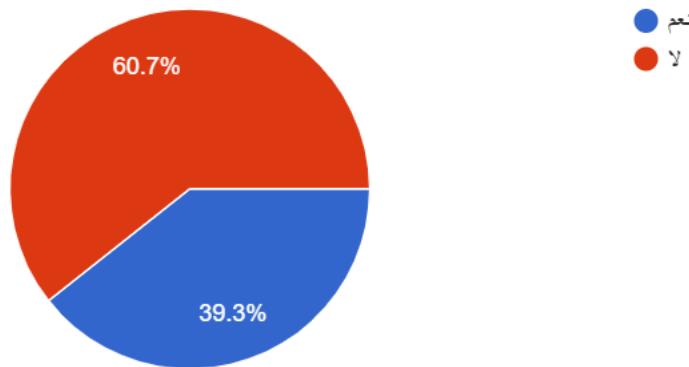
إذا كانت إجابتك على السؤال السابق لا ، اذكر بعض الصعوبات التي واجهتها خلال بحثك عن عقار مناسب.

61 ردًا

عدم المصداقية
مكتب أمين، موظفين فاهمين():
المصداقية
استخدام التطبيقات العقارية اسهل واسرع
الجهد البدني وعدم وجود الوقت
عدم المصداقية - الارتفاع في الاسعار
التشتت بالتواصل مع عدة شركات و مكاتب عقار مختلفة، ضياع الوقت والجهد بانتظار رد كل مكتب وعدم العلم حين البحث بتوفير العقار او تم بيعه او ايجاره

5- هل سبق لك استخدام تطبيق عقاري من قبل ؟

رداً 122



إذا كانت إجابتك على السؤال السابق نعم ، ذكر أسماء تطبيقات العقار التي استخدمتها.

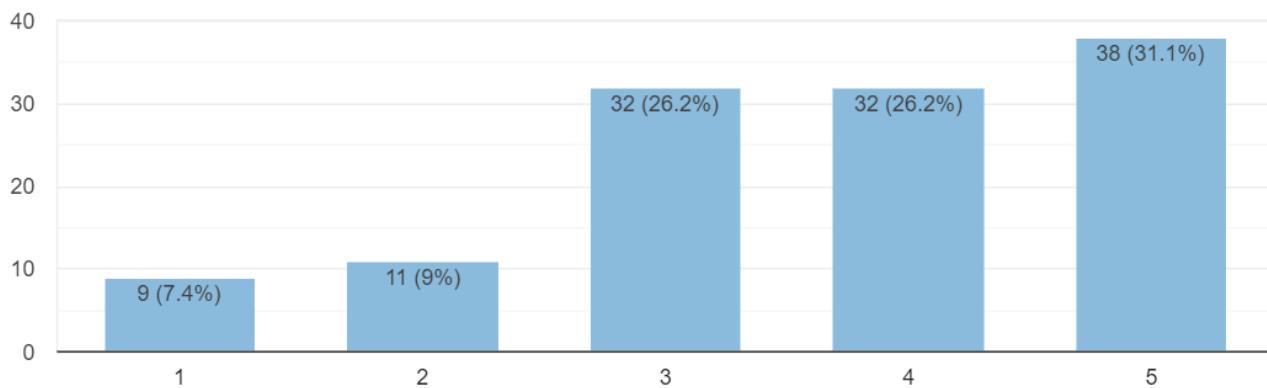
رداً 45

	عقارات
	تطبيق عقار
	عقارات
	تطبيق عقار
	عقارات - جاذزان
	عقارات - سهيل - حراج



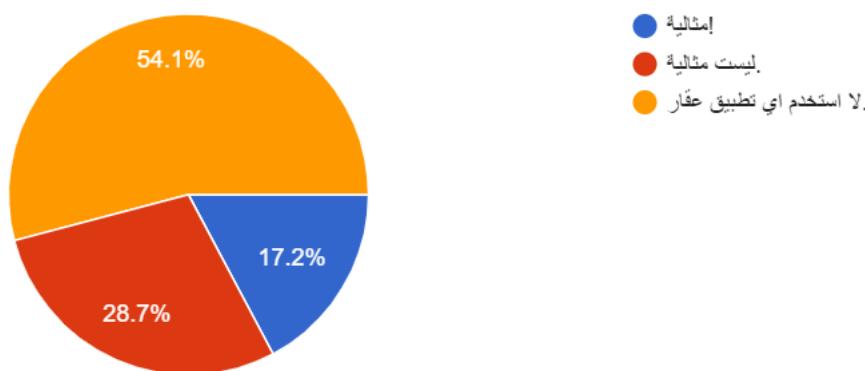
6- وفقاً للمقياس أدناه ، ما هي احتمالية أن تبدأ / تستمر في استخدامك لتطبيقات العقار ؟

رداً 122



7- كيف ترى تطبيقات العقار الموجودة حالياً في السوق السعودي من حيث تلبية الخدمات ؟

رداً 122



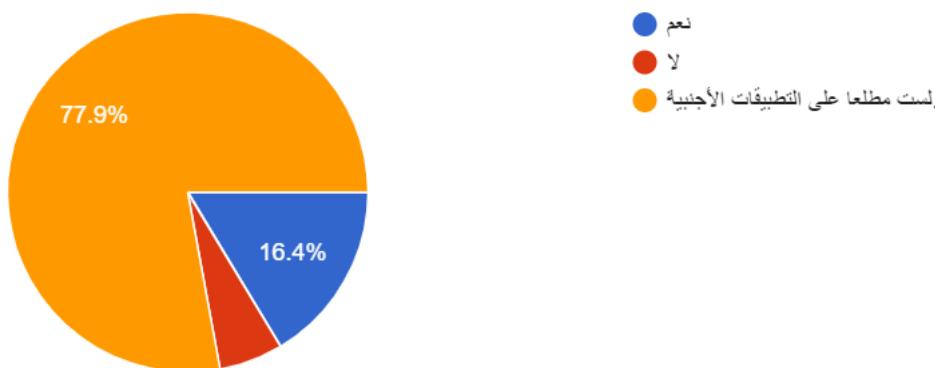
إذا كانت إجابتك على السؤال السابق ليست مثالية ، أذكر بعض الصعوبات والعيوب التي واجهتها.

30 ردًا



8- هل تعتقد أن تطبيقات العقار المحلية أقل كفاءة من الأجنبية؟

122 ردًا



إذا كانت إجابتك على السؤال السابق نعم ، برأيك كيف يمكن تحسينها ؟

14 ردًا

زيادة الوضوح

طريقة العرض ممكن تتحسن

لست مطلع

ان يكون عرض العقار عن طريق مكاتب موثوقة او صاحب العقار او من يوكله بموجب وكالة شرعية ويجب ان يكون موقع العقار المعروض هو العقار فعلاً و عدم السماح بذكر كلمة الموقع غير دقيق

عن طريق مراقبة العقار

كسب ثقة العميل

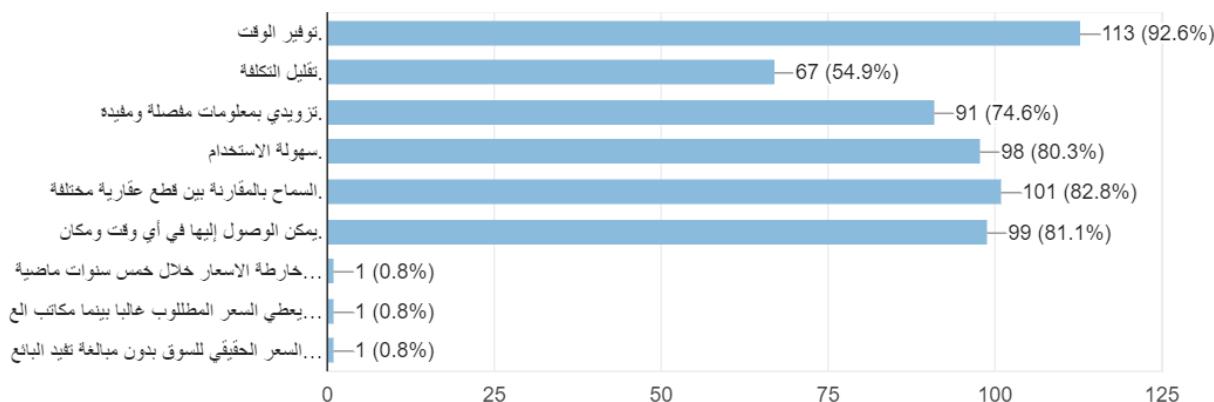
توفير طرق التواصل مع صاحب العقار
توضيح كافة تفاصيل العقار والموقع مرافق بالصور

وضعها سهلة في متناول يد الجميع و نشر اسمائها

نسخ

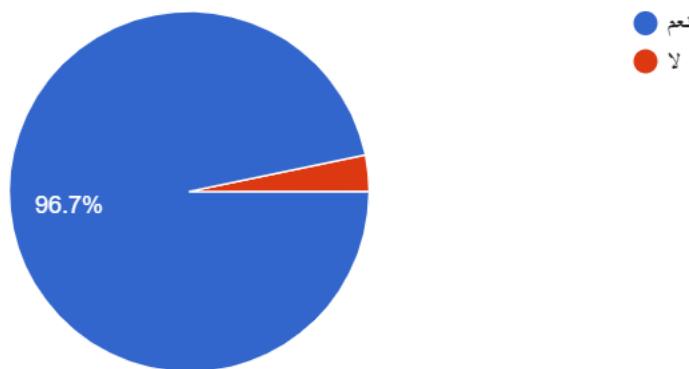
9- ما هي الفوائد التي تعتقد أن تطبيقات العقار ستقدمها ؟ (يمكنك اختيار أكثر من خيار).

122 ردًا



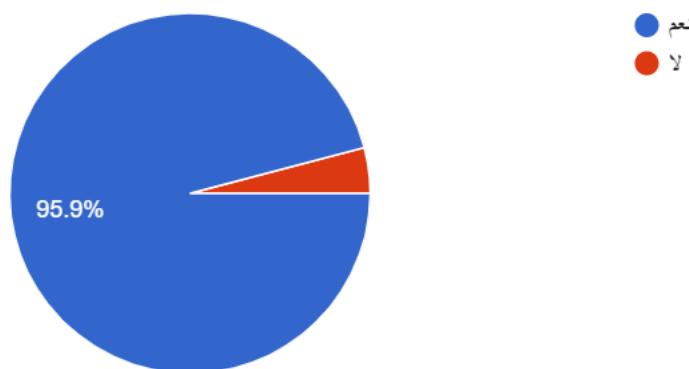
10- هل تفضل وجود ميزة في التطبيقات العقارية تساعدك على قياس مدى مناسبة سعر العقار مع ميزانيتك ؟

رداً 122



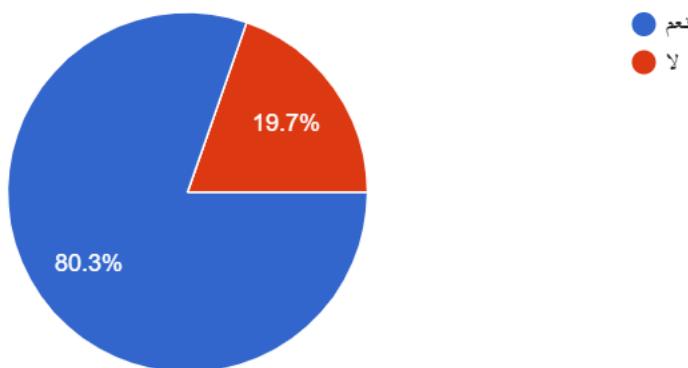
11- هل تفضل وجود ميزة تسهل حجز مواعيد لزيارة العقار (واقعياً أو افتراضياً) من خلال التطبيق ؟

رداً 122



12- هل تفضل أن يكون بامكانك اجراء جولة في العقار من خلال مكالمة فيديو ؟

رداً 122



نسعد باقتراحاتك ولاحظاتك :

رداً 19

بال توفيق فعلا هناك فجوة في السوق

ادراج في تطبيق العقار الصورات والشهادات

نقترح الاشتراك مع مقيمين عقاريين باسعار رمزية لتقدير العقار واعطاء تقدير له ويكون هذا التقديم خياري عند العرض

مشروع ذو فكرة جميلة جداً و يقدم مميزات جميلة ❤️

بال توفيق والسداد يارب العالمين ❤️

وفقك الله

فكرة جولة مكالمة فيديو فكرة جيدة، ولكن أعتقد وجود صورة ثلاثة الأبعاد يمكن التنقل من خلالها في الأرض أفضل وأقل كلفة

الله يوفقكم فكرة مشروع تخرج ليست بسهلة لكن أتمنى قدتها إن شاء الله

تسوون كذا جزء يعني أني أقارب الشيء بشيء من حيث الاسعار والمكان والمساحة وكذا

9.3 Appendix C : NFR Usability Test :

- SUS questions:

<p>I think that I would like to use this system frequently.*</p> <p style="text-align: center;">1 2 3 4 5</p> <p>disagree vehemently <input type="radio"/> <input type="radio"/> <input type="radio"/> <input type="radio"/> <input type="radio"/> agree completely</p>				
<p>I found the system unnecessarily complex.*</p> <p style="text-align: center;">1 2 3 4 5</p> <p>disagree vehemently <input type="radio"/> <input type="radio"/> <input type="radio"/> <input type="radio"/> <input type="radio"/> agree completely</p>				
<p>I thought the system was easy to use.*</p> <p style="text-align: center;">1 2 3 4 5</p> <p>disagree vehemently <input type="radio"/> <input type="radio"/> <input type="radio"/> <input type="radio"/> <input type="radio"/> agree completely</p>				
<p>I think that I would need the support of a technical person to be able to use this system.*</p> <p style="text-align: center;">1 2 3 4 5</p> <p>disagree vehemently <input type="radio"/> <input type="radio"/> <input type="radio"/> <input type="radio"/> <input type="radio"/> agree completely</p>				
<p>I found the various functions in this system were well integrated.*</p> <p style="text-align: center;">1 2 3 4 5</p> <p>disagree vehemently <input type="radio"/> <input type="radio"/> <input type="radio"/> <input type="radio"/> <input type="radio"/> agree completely</p>				

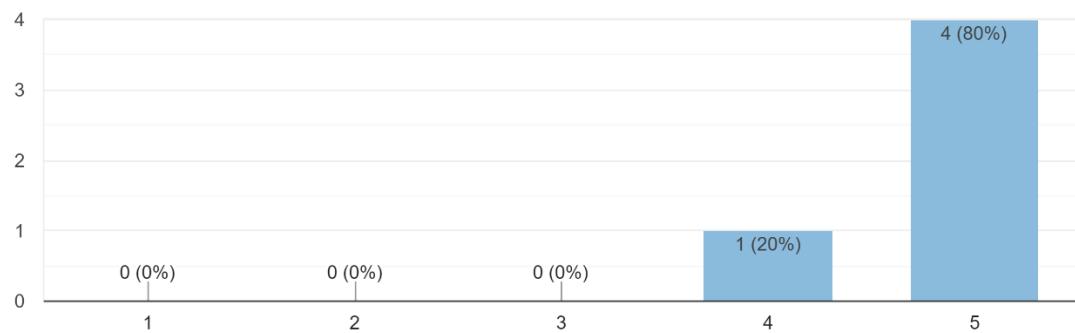
I thought there was too much inconsistency in this system.*						
1	2	3	4	5		
disagree vehemently	<input type="radio"/>	agree completely				
I would imagine that most people would learn to use this system very quickly.*						
1	2	3	4	5		
disagree vehemently	<input type="radio"/>	agree completely				
I found the system very cumbersome to use.*						
1	2	3	4	5		
disagree vehemently	<input type="radio"/>	agree completely				
I felt very confident using the system.*						
1	2	3	4	5		
disagree vehemently	<input type="radio"/>	agree completely				
I needed to learn a lot of things before I could get going with this system.*						
1	2	3	4	5		
disagree vehemently	<input type="radio"/>	agree completely				

Figure 32 SUS questions

- SUS results :

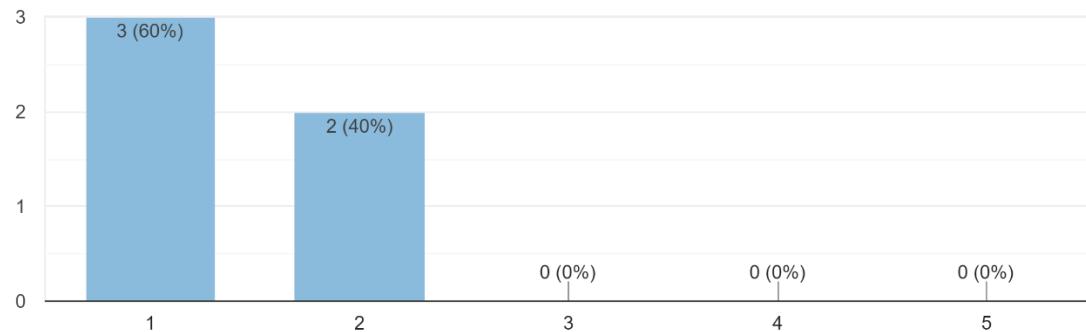
I think that I would like to use this system frequently.

5 responses



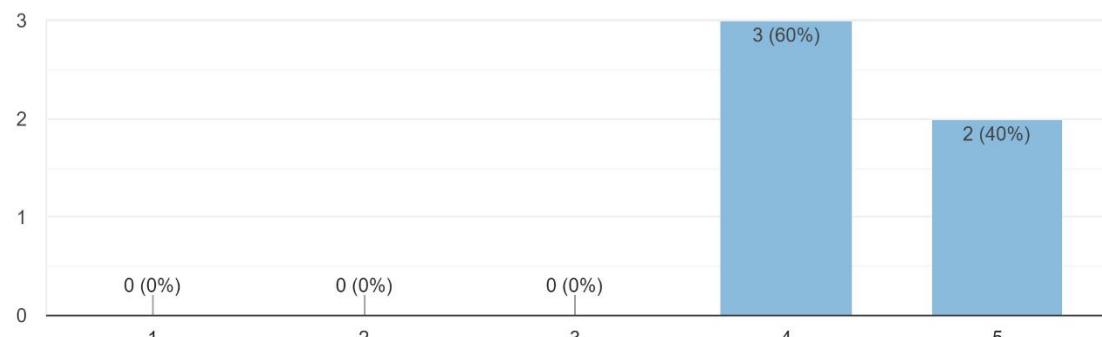
I found the system unnecessarily complex.

5 responses



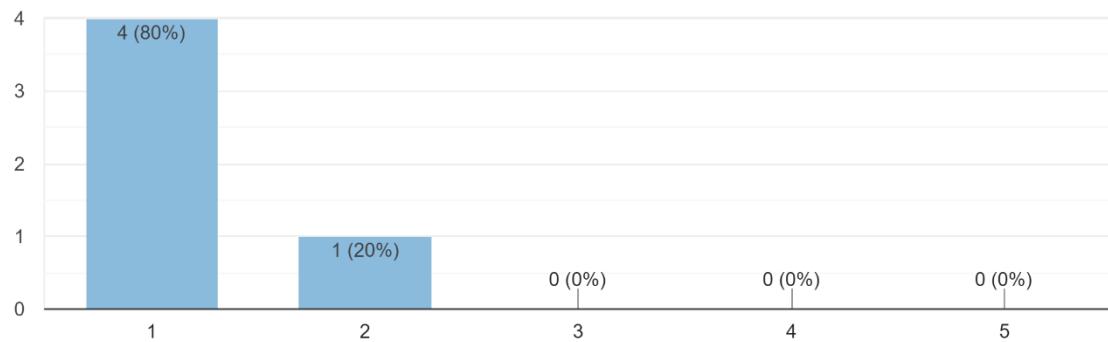
I thought the system was easy to use.

5 responses



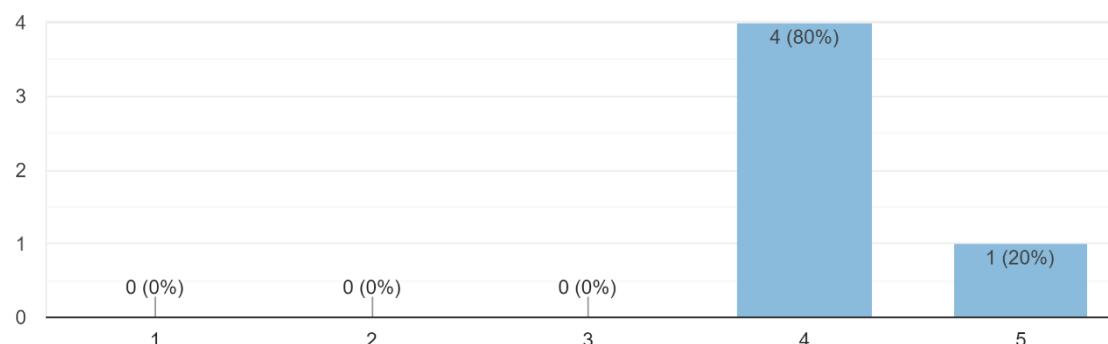
I think that I would need the support of a technical person to be able to use this system.

5 responses



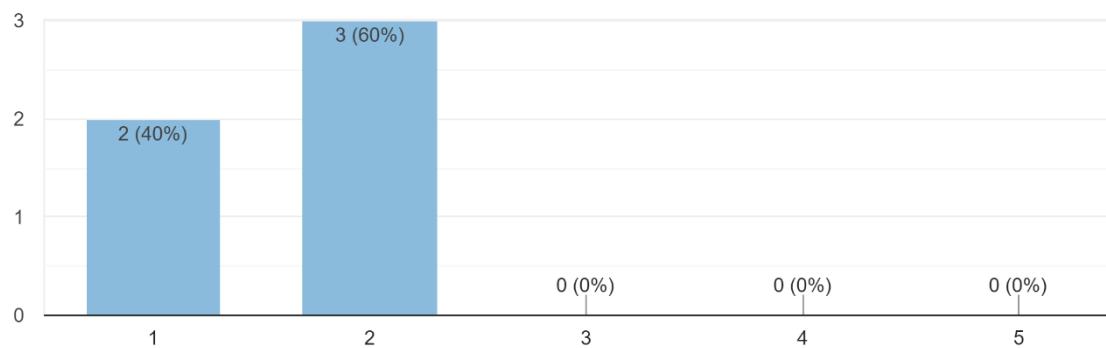
I found the various functions in this system were well integrated.

5 responses



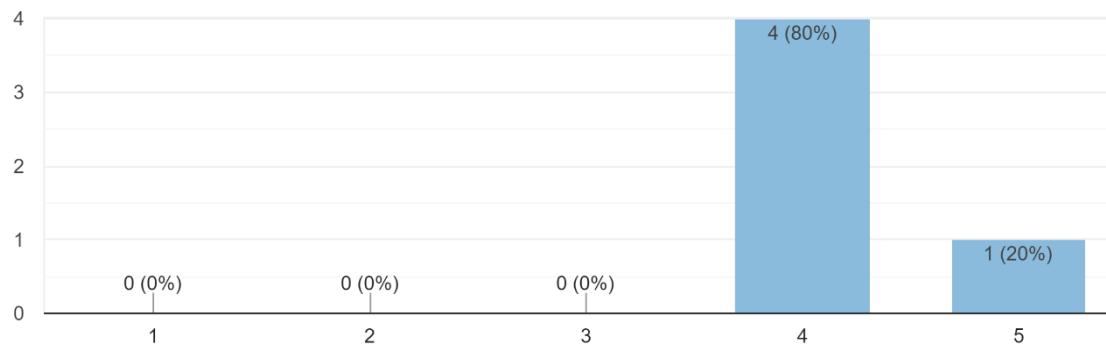
I thought there was too much inconsistency in this system.

5 responses



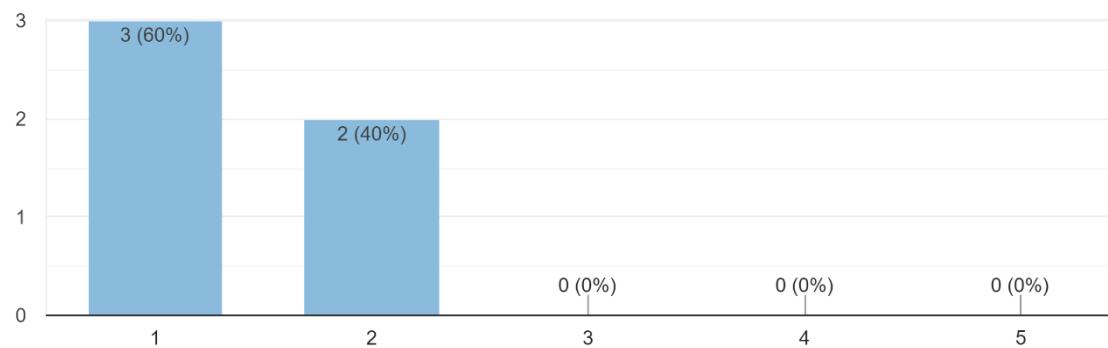
I would imagine that most people would learn to use this system very quickly.

5 responses



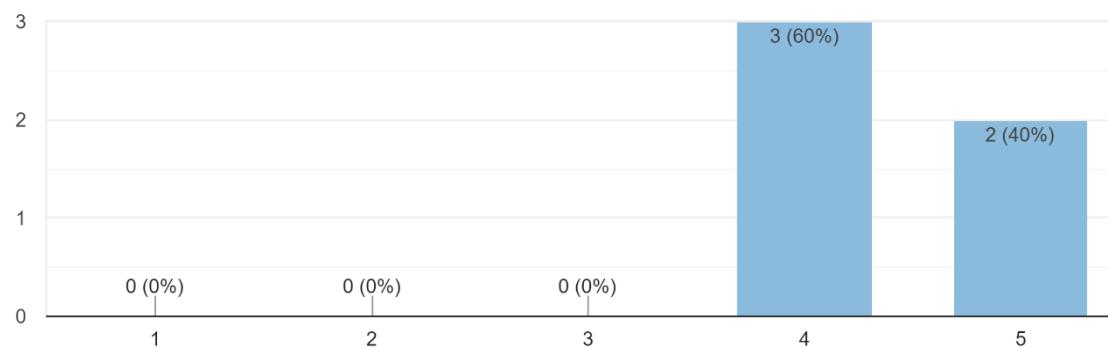
I found the system very cumbersome to use.

5 responses



I felt very confident using the system.

5 responses



I needed to learn a lot of things before I could get going with this system.

5 responses

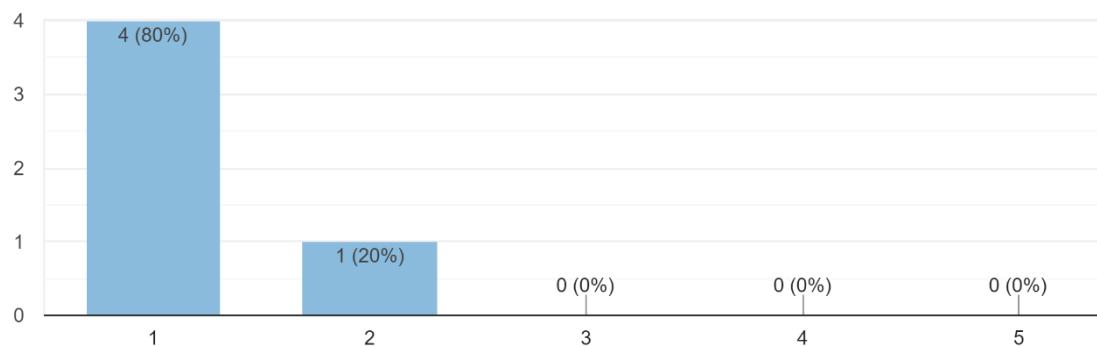


Figure 33 SUS results