

# Multi-Agent System for Supporting and Managing Real Estate Marketing

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## ABSTRACT

Recently there have been major changes in the real estate market, where everyone is investing in sell or buy properties, which meet their needs and suit their pockets. In this paper, a multi-agent system for real estate marketing where considered. The proposed system provides the clients with an easy and practical solution through advertising their property and searches for a buyer or seller on behalf of them. And The system makes use of agent's technology as its core function for locating a suitable property among hundreds or even thousands of the offers. The proposed system provides clients with an Android mobile app developed using Java which works as an agent for establishing a communication with the other agents located on a server. On the server, there are many agents that work together to fulfill the main goal like sell agent, buy agent, and others, using the Symfony PHP framework. The SUS results confirmed that the rate of overall satisfaction was high nearly 76.66%, which is above average and highly acceptable.

**Keywords:** Agent, Multi-Agent System, SUS, Android Platform, Real Estate Marketing.

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## 1. Introduction

Real estate (RE) means the industry committed in real estate operation, development and management, which plays a very important role in the economy. Real estate is closely related to people's standard of living; therefore, people are seeking for new ways for having or selling a house. Making use of new technologies is urgent in this field to assist people in their quest for trading RE which could be done using agents/services that automate most of the work on their behalf.

Autonomous agents were assumed by the artificial intelligence (AI) community as entities capable of autonomous actions in their environment, those actions could be considered as intelligent behavior. AI community was especially interested in groups of such agents sharing a common environment and capable of interacting with one another - multi-agent systems (MAS) [1].

In general, marketing using mobile devices is becoming the most important marketing way due to significant advancements in technology especially after a radical change in the last decade with the emergence of the

mobile phones, mobile programming languages and the availability of internet connection everywhere so that it could be accessed almost by everyone [2].

Marketing automation nowadays is one of the most encouraging fields in the software industry. According to the Grand View Research report (CMO Innovation Editors 2017), this technology is predicted to reach US\$7.63 billion by 2025. For example, most important software companies such as Google, Salesforce, IBM and Oracle have added it to their products as part of their solutions [3]

In this paper, A proposed multi-agent system for real estate marketing is used to provides the clients with an easy and practical solution through advertising their property and search for a buyer or seller on behalf of them. The proposed system makes use of agent's technology as its core function for locating a suitable property among hundreds or even thousands of the offers. The rest of this paper is structured as follows. Section 2, mentions the related work. Section 3, describes the agent with the multi-agent system in detail. Section 4, explains Android platform. Section 5, explains the

organization of the proposed system in detail. Section 6 illustrates the structure of the system. Section 7 shows the running server agents. Section 8 explains the users of the systems. In section 9, the Buy and Sell scenarios are presented. Section 10 presents the Snapshot from the MAS-REM system. Section 11 evaluation and results. Section 12 presents the conclusion.

## **2. Related work**

In 2015, Moradi, M., et al [4] proposed a knowledge management framework for making marketing decision via using agent technology. A MAS was developed to do a variety of operations on the related knowledge of marketing-mix decision making. MAS applied fuzzy logic to make decision.

In 2015, Ho, H.-P., et al [5] proposed a way to help people choose their preferred house using Internet. The proposed approach used fuzzy goal programming with an S-shaped utility function as a decision aid. By using a decision aid, people could provide some parameters regarding the house with different priority levels and thresholds, which were used as a matching mechanism for fuzzy search.

In 2016, Zhuge, C., et al [6] proposed an agent-based joint model of Residential Location Choice (RLC) and Real Estate Price (REP) (RLC-REP model) for SelfSim. The RLC-REP model is capable of simulating the negotiation between the buyers and sellers using agent-based modeling. Two theories had been utilized in this thesis, utility maximization theory and prospect theory to develop a utility function for simulating the location choice behavior of buyers. The utility function depended on only two factors: house price and accessibility.

In 2018, Le, D. T. [7] Investigated the broker-based trade and the challenging issues related to this trade in market-based multi agent environments so that buyers and sellers are allocated and determined to meet buyers' needs under the consideration of multi-attribute trading

and different objectives.

In 2018, Zhuge, C. and C. Shao [8] developed an agent-based RLC-REP joint model as a main component of an integrated land use-transport model called SelfSim. RLC-REP was able to simulating purchasing, renting and investing behavior, taking into account the interactions and competitions between different agent types in the estate market., including landlord, renter, purchaser, seller and investor agents, leading to new residential locations and real estate prices. both global and local sensitivity analyses (SAs), which employ the Elementary Effect Method (EEM) and Once-At-A-Time (OAT) Method, respectively, are carried out to fully test RLC-REP in a numerical example setup based on a Chinese medium-sized city, Baoding

In 2018 Conkinovska and Temjanovski [9] developed a website to promote real estate properties so that companies can put their services and offers on the site so that customers can be informed about not just to see on the site. In the current thesis, the system developed by researcher is not just informing customers about offers but also it provides a way for connecting sellers and buyers via chat or VoIP services with the ability to configure the notification system.

In 2019, Zhuge, C. and C. Shao [10] developed an agent-based office market model as a key component of an agent-based Land Use and Transport (L-T) model, SelfSim, connecting to several associated sub-models of Self-Sim, including the demographic evolution model, joint model of Residential Location Choice and Real Estate Price (RLC-REP), and activity-based travel demand model (MATSim).

## **3. Agent an Multi-Agent System**

In general, an agent in an intelligent system has been widely studied and used in different areas for many years. Other definition is "An agent is an encapsulated computational system that is situated in some

environment and that is capable of flexible, autonomous action in that environment in order to meet its design objectives". [3]

Generally, an agent is a computer system that acts on human behalf to do delegated tasks in semi-intelligent way and is situated in the environment "Fig.1"

The structure of an agent can be divided into states and rules. According to a state is a set of variables or parameters that defines an agent at a given period. States can be divided into:

- Internal state: just belonging to one agent
- Local state: contains the internal state and the public parameters and variables of the agents that interact with the current one.
- Global states: this includes all the related states in the environment that could be monitored.

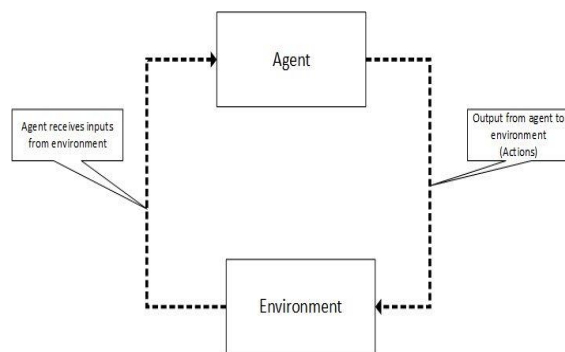


Fig.1. Agent

A multi-agent system is a system that consists of several interacting agents. In order to interact in human-like ways, agents must have capability to negotiate, cooperate, and coordinate. Hence main types of multi-agent systems are cooperative and competitive. For example, cooperative MAS concerns distributed problem solving and planning. Competitive or self-interested MAS are focused on voting, actions, contract nets and deal with fairness and stability. Multi-agent systems are also inspired by many other fields: Artificial Intelligence, Social Sciences, Distributed Computing, Philosophy, Ecology, Game Theory [2].

#### 4. Android Platform

Android is a mobile operating system, designed to run on devices with limited resources. Android is developed by Google at first and then via Open Handset Alliance (OHA) is promoted [11]. The Android platform is located on highest of the Linux kernel which is consists of the APIs, libraries, and middleware by writing in c programming language, and above the application framework the application software is running which contains other libraries which they are Java-compatible, [12]. Most Android applications are distributed applications [13]. Internet access is required by 68.5% of market apps, as a study of the Android permission system indicates. Common application types such as mobile commerce (Gaming apps, Business apps, Educational apps, Lifestyle apps [14], Entertainment apps [15], Utility apps, Travel apps) and educational [16] or social networking apps make extensive use of communication features. Those are the application types assumed in the following considerations.

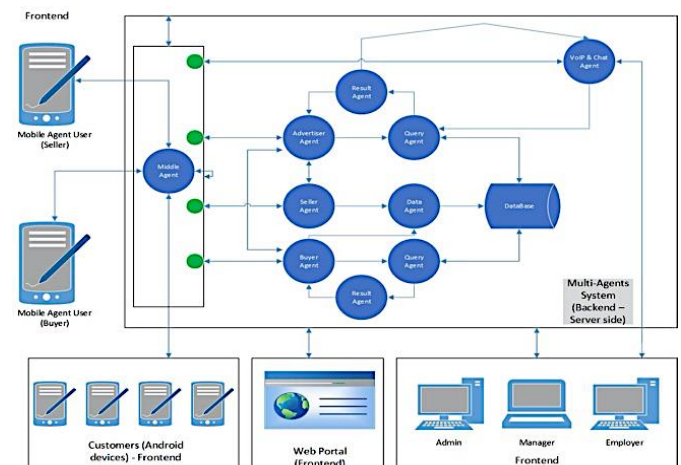


Fig.2. General Organization of the Proposed System

Middleware agent platforms like JADE or Jadex provide useful abstractions for communication [17]. E.g., Jadex, as an agent platform for distributed software development, treats distribution as first-class citizen [18] [19]. Remote service invocations, service discovery and an asynchronous programming model are available as platform services or in the platform API, respectively.

Using Jadex for Android application development supplements, the missing distribution features, but comes with two main drawbacks. First, Jadex and Android both provide their own decomposition principles (developers divide their Android apps into Activities and Services. Jadex applications are composed of active components. Second, to cope with the hardware limitations and performance requirements of a mobile device, a stripped-down platform variant is needed [20].

### 5. Organization of the Proposed System

The proposed system is organized with two sides (server and clients/ frontend and backend). Frontend-side consists of mobile application hosted with N-Android devices and Admin portal while the Backend-side consists of one host which is the hosting server where the backend part resides to handle requests and routings. The general view of the design of Multi-Agent Real Estate Marketing System (MAS-REM) with its components is shown in “Fig.2” below. As you can see, it is clear that the system is divided into two parts; front-end and back-end.

The proposed system is divided into two parts using server-client concept. First part which this stage refers to how to setup the server side and what tools are needed to achieve that. The researcher will implement Symfony framework which uses PHP libraries to facilitate server-client communication and build server-side web application for Real Estate marketing. The proposed system also uses a front-controller action provided by Symfony framework, which is responsible for handling each incoming request from client side and then figuring out what to do. See “Fig.3” below for the proposed system workflow regarding requests and responses:

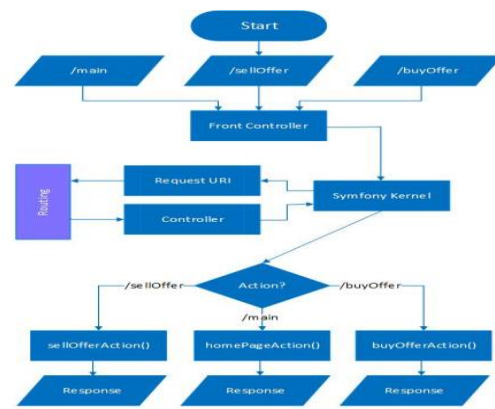


Fig.3. The Request-Response Flow

#### A. Front-End

Front-end has the following modules as shown in “Fig.4” User registration, User login/logout, Sell/Buy offer submission/ deletion/ edit, User profile, Chat, VoIP for voice communication over Internet Protocol, Notifications Admin portal to view/delete.

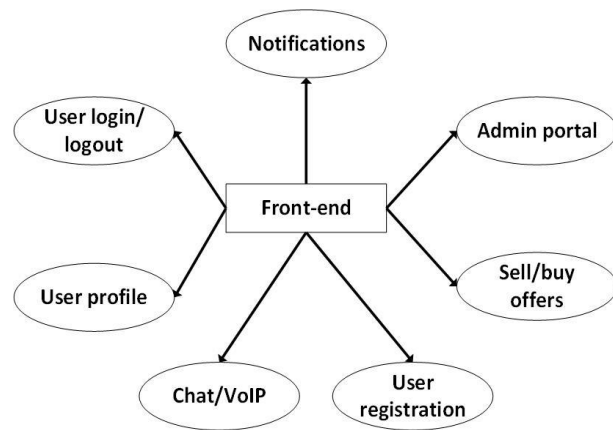


Fig.4. Front-end model graph

#### B. Back-End

Back-end has the following modules as shown in “Fig.5” Users management, offers management, Agents.

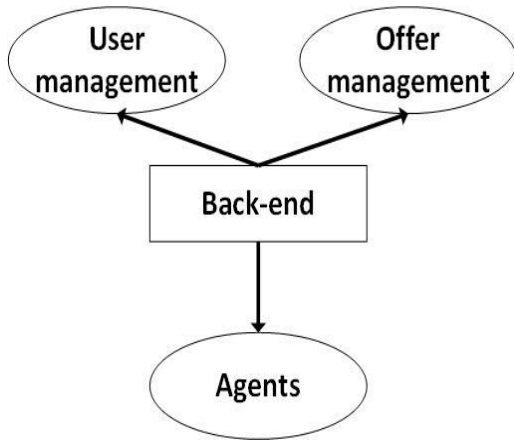


Fig.5. Back-end model graph

### 6. Structure of the Proposed System

The proposed system consists of nine stages: Initializing Backend Server, Running Server Agents, Detecting Connected Mobile Application Interface Agents (MAIA), Initializing Connected Clients, Detecting Offers,

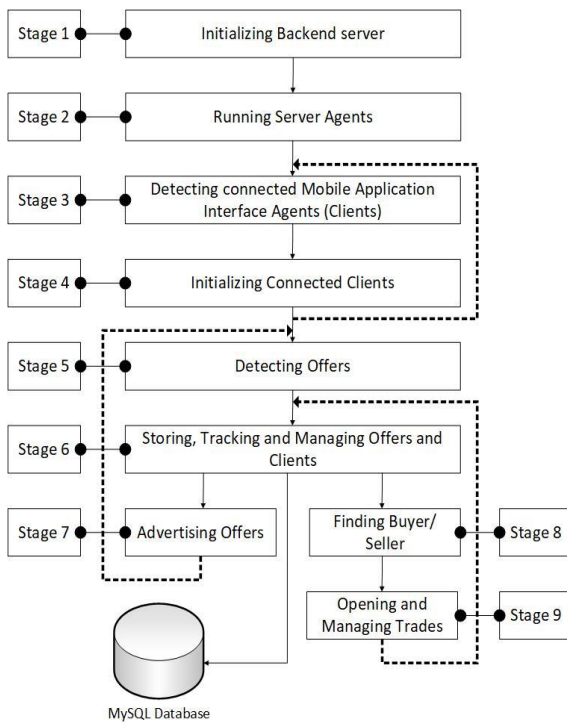


Fig.6. General Structure for the Proposed System

Categorizing Offers, Advertising Offers, Offer Tracking and Managing, Sorting, Tracking and Managing Offers and Clients, Advertising Offers, Finding Buyer/Seller, Opening and Closing Trades and MySQL Database. "Fig.6" shows the main stages of the general structure for the proposed system.

### 7. Running Server Agents

After initializing the backend server stage and when everything is going as wanted then the second stage will be started for the sake of running a number of agents inside the proposed system. Once the agents start running on the server, they will serve only one goal despite of that each agent has its own task in the proposed system.

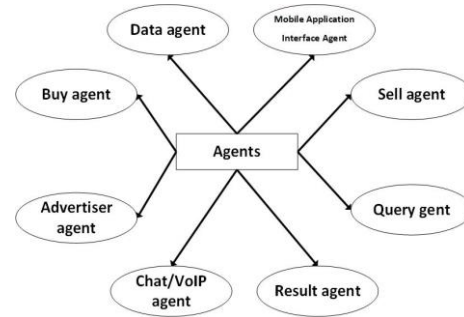


Fig.7. Agents Model Graph

The agents will start listening to the requests sent by clients and also by the internal system messages. "Fig.7" refers to the agents used in MAS-REM system. The proposed system is all about these agents which automate the operations on the offers sent by the clients. The objective of each agent is provided below:

- a. **Sell agent:** It receives property offers with their details including description and images from **Mobile application interface agent** (seller user). Then the **Sell agent** delivers the received requests to the **Data agent** which saves them into the database. After that it communicates with the **Advertiser agent** for sharing the involved property with other customers using notifications.
- b. **Buy agent:** It receives a request from **Mobile application interface agent** (buyer user) asking for a property according to some descriptions. Then the **buyer agent** sends the received request to **Query agent** which is in turn seeks the database for the wanted property.

- c. **Data Agent:** It is responsible for saving data received from clients into the MySQL database and making them available upon request by other agents in the proposed system.
- d. **Advertiser Agent:** It is responsible for announcing properties offered by seller users and the requests for properties issued by buyer users.
- e. **Query Agent:** Any request for information by other agents in the system is passed through this agent. It returns the information to **Result agent** for further processing.
- f. **Result agent:** It receives the information provided by **Query agent** and applies the necessary preparations and arrangements on it then deliver it to the relevant agent.
- g. **Chat/VoIP Agent:** It is responsible for establishing chat or VoIP between sellers and buyers who agreed on a trade between each other.
- h. **Mobile Application Interface Agent (MAIA):** This agent resides is the application that resides in mobile device, which allows clients to access services on the server side and therefore connecting them together in a controlled way.

## 8. Users of the Proposed System

This project's goal was to develop a tool for helping individuals to easily invest in this increasing and valuable market without the need for real human brokers. the number of users found are three types listed below with the functionality of each.

- a. **Admin user:** This user has full privileges over the proposed system. This user has Administrator account which allows it to have full access to the system.
- b. **Seller user:** This is the user who sends sell offers to the system for finding buyers. Notifications will be received by this user from buyers interested in the offers sent.

- c. **Buyer user:** This is the user who sends buy offers to the system for finding sellers. Notifications will be received by this user from sellers interested in the offers sent.

## 9. Scenarios

There are two scenarios of the obtained results from the implementation of the proposed system, which are described as follows:

- **Sell Scenario:** sell offer is sent by a client to the server, the agents start to find buyers.
- **Buy Scenario:** buy offer is sent by a client to the server, the agents start to find a seller.

### 9.1 Sell Scenario

A client starts preparing a sell offer by filling out the required and/or the optional fields as well using the sell menu. When the Submit button is pressed the MAIA agent, which resides in client mobile device, will take care of the sell offer and send it to the server. On the server side, the mentioned offer will be received by Sell agent which will be in contact with the MAIA agent. The Sell agent will deliver the sell offer to Data agent which in turn saves it in MySQL database. At the same time, the Sell agent will contact the Advertiser agent, the Advertiser agent will broadcast the offer to all the clients interested on that type of offer. The interested clients are identified by their notification settings and the type of offers they are more interested in.

### 9.2 Buy Scenario

A client starts seeking to buy a property through filling out the required and/or the optional fields as well using the buy offer menu. The MAIA agent which resides in client mobile device will take care of the buy offer and send a request to the server. Then Buy agent will be responsible of it until the trade is closed. The Query agent will receive the buy offer and start to search the database for a matched property. If a property is found in the database, the property will be sent to Result agent

to format the property's data and then delivering it to Buy agent. In case there is no matched properties found in the MySQL database, the Advertiser agent will be notified to start sending the request for the property to all the interested clients via short notifications. Also, the Data agent will save the request for buy property into the database for future use. As soon as a client receives a request for a buy property, he/she has the right to accept or refuse it. When a client accepts then more details on the request will be sent to. Then the client can either decide to open a trade with the owner of the buy request or cancel it. Once a trade is opened between them, they both can exchange even more details about the opening trade through Chat/VoIP agent.

### 10. Snapshot from MAS-REM system

MAS-REM system consists of two of interfaces; mobile application interfaces and admin ports interface. Figures ("Fig.8", "Fig.9", "Fig.10") show some of mobile application interfaces.

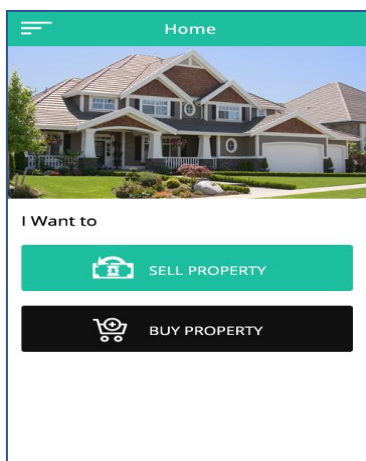


Fig.8. Home Page

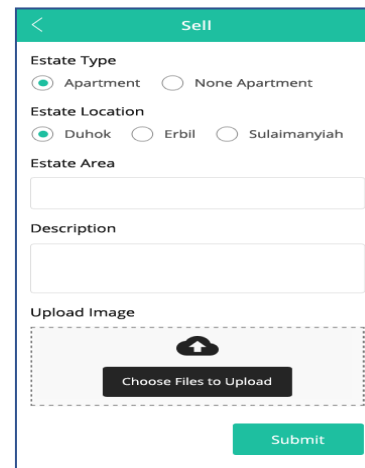


Fig.9. Sell Page

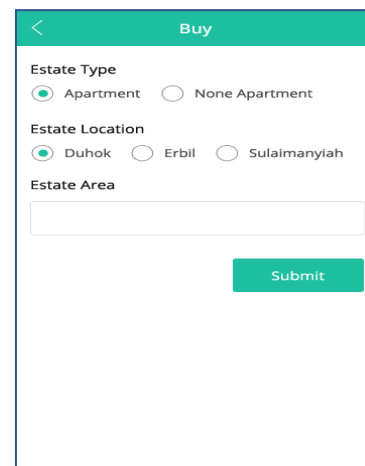


Fig.10. Buy Page

## 11. Evaluation and Results

### 11.1 Comparison with Related work

In the previous works, many real estate and marketing systems were developed using many different platforms and techniques and some tested their system on a real case and others evaluated their system use simulation. The proposed system developed a multi-agent system for real estate marketing that provides the clients with an easy and practical solution through advertising their property and search for a buyer or seller on behalf of them. The proposed system makes use of agent's technology as its core function for locating a suitable property among hundreds or even thousands of offers and involves the analysis of the external and internal environment of the real estate system of three companies

in Erbil and Duhok provinces.

**Table 1**  
**COMPARISON WITH OTHER IMPLEMENTATIONS**

#	Author	Year	Problem domain	Approach	Tested Region
1.	Moradi	2013	marketing decision	multi-agent system+ fuzzy logic	Car Factory
2.	Ho	2015	housing decision aid	fuzzy logic	Real Case
3.	Zhuge	2016	Real Estate Price	agent-based RLC-REP joint model	Simulation
4.	Le	2018	market-based services environments	matching algorithm	Simulation
5.	Zhuge	2018	real estate prices	agent-based RLC-REP joint model with EEM) and Once-At-A-Time (OAT) Methods	Simulation
6.	Conkino vska	2018	promote real estate properties	management information systems	Republic of Macedonia
7.	Zhuge	2019	firms and office buildings market	agent-based Land Use and Transport (L-T) model	Simulation
8.	Proposed System	2019	advertising their properties and searching	multi-agent system	Erbil And Duhok Provinces

### 11.2 System Usability Scale (SUS)

In this paper the usability of the proposed system was evaluated using the System Usability Scale (SUS) through the contribution of (50) participants, the results were analyzed as in table (1). SUS is a simple, ten-item scale giving a global view of subjective assessments of usability.

**Table 2**  
**SUS Scores by the Participants (#P=50)**

#P	SUS Score	#P	SUS Score	#P	SUS Score	#P	SUS Score	#P	SUS Score
P1	77.5	P11	55	P21	95	P31	75	P41	100
P2	50	P12	45	P22	95	P32	57.5	P42	100
P3	87.5	P13	55	P23	97.5	P33	32.5	P43	85
P4	75	P14	60	P24	80	P34	40	P44	82.5
P5	92.5	P15	95	P25	70	P35	50	P45	82.5
P6	100	P16	100	P26	57.5	P36	47.5	P46	55

P7	85	P17	97.5	P27	72.5	P37	97.5	P47	30
P8	62.5	P18	100	P28	80	P38	100	P48	97.5
P9	80	P19	92.5	P29	77.5	P39	85	P49	72.5
P10	52.5	P20	92.5	P30	82.5	P40	100	P50	80

**Average Score** 76.66%

Results in table 1 show that the total score of SUS is 76.66% indicating that (MAS-REM) is generally acceptable in accordance with the rules of the SUS tool as a 70% acceptable ratio.

### 12. Conclusion

In this paper, Multi-Agent System was proposed for supporting and managing real estate marketing using a client/server environment. The following conclusions can be marked:

- The proposed system has proven its ability and efficiency of connecting sellers with the buyers through mobile application in a simple and an easy way, and increased the rate of real estate processing with the increasing number of subscribers (Clients).
- Eliminating the traditional way of selling and buying properties which needs to broker as third person for
- supporting the process of finding sellers and buyers and Speeding up the process of locating buyers and sellers.
- Agents have been used to work on behalf of the real brokers for the purpose of speeding up the process of finding sellers and buyers freely without obstacles.
- By using System Usability Scale (SUS) tool, the conducted users showed that the overall satisfaction score of the proposed system was good, (76.66%).
- It is recommended to add more properties to sell and buy offers like the direction of the estate interface, number of rooms, and so on. Also, some agents and functions involved in this proposed system can be



coded in C++ language using frameworks like Qt to speed up some processes.

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