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Agent-Based Architecture for Nursing Home Search and Appointment System

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Abstract
In the current context of an aging population and the development of assistance to the elderly, the needs of this category of people are increasing. The nursing homes are part of these needs. For an older adult, choosing a nursing home near his or her family, relatives, and friends can also be reassuring and allow regular visits from his or her entourage. The choice of a nursing home is a significant problem for aging adults. This particular category of people wastes too much time, money, and effort in moving to find an establishment that ensures care and meets their basic needs. This paper proposes an agent-based approach that performs nursing homes' search process by user-selected personalized criteria. The appointment step follows this process. This approach represents a significant help to dependent older adults.

Keywords: Nursing home; Older persons; Agent; Jade android; Health information

Introduction

The health sector is a growing field [1-3], and it is a significant concern for older adults. Given their advanced age, this category always looks for ways to improve and facilitate their lives. They always look to find the best places that adapt to their physical and intellectual capacities [4]. Nursing homes are a better solution for this category of people.

The elderly are generally presented as a category living in ephemeral socioeconomic conditions, experiencing housing and nutrition problems. They suffer from severe physical and mental deficiencies rendering them totally or partially dependent. Aging raises several problems both individually and socially [5]. The social, medical, and psychological care of the elderly is one of the signs of a country's general development. In Algeria, the issue of the elderly is not a major social concern in a country where the majority of the population is young. However, for some people, entering a nursing home represents a relief in that they no longer feel alone and are safe [6]. According to the updated data from the National Statistics Office [7], people aged 60 and over account for 9.8% of Algeria in 2020. The demographic perspectives reveal that the elderly population will represent 14.7% of the total population in 2030 and reach more than 22% in 2050.

According to Bouaziz [8], in Algeria, data analysis indicates that most older adults live with family members (98%). On the other hand, more than half of the elderly living alone declare that this situation is uncomfortable and does not suit them. In addition, with age, health problems become multiple and more chronic for both men and women. Women (42.2%) and men (33.0%) aged 60 and

over declare that their health is poor. The main diseases that were reported by the elderly are high blood pressure (43.5%), joint diseases (26.4%), gastric diseases (18.3%), diabetes (16.1%), back problems (14.9%), cardiovascular diseases (10.9%), cataract (10.6%) and migraines (11.2%). In addition, 43.9% of the elderly report having difficulty taking medication (42.8% of men and 44.8% of women).

These data show a continuing demand for care among the elderly. Thus, the investment in nursing homes is a necessity. These establishments are reserved for people with a loss of autonomy, whether psychological or physical, who need specialized medical supervision and care. Until now, in Algeria, few websites give complementary and sufficient information. Sometimes we find information in social networks, which forces the elderly to use traditional communications (e.g., phone or fax). Thus, the choice of an adequate establishment is difficult.

A nursing home's choice must meet the expectations and ensure a dependent older person's care [9]. This choice usually requires a complicated manual search operation with a lack of information about nursing homes. Besides, the majority of these establishments have only informative sites. Indeed, the main inconvenience is the loss of time, money, effort, and unreliability in the search results. The situation of dependent aging adults, the emergence of smartphones, and their ease of use led us to think of a solution for this people category. With their flexibility and functionality, agent technology and smartphones facilitate the creation of an information technology solution that responds to our needs.

The proposed system is an adequate solution for the nursing home search and appointment system in developing countries such as Algeria due to the traditional search process and appointment in nursing homes. Indeed, our system allows users to obtain the necessary information to know the modalities of care in a nursing home.

This work proposes an agent-based approach. Agent technology is getting much attention now, especially for distributed and open applications. These applications presuppose the interoperability of agents from different infrastructures [10]. Besides, the agent approach recommends communication mechanisms that provide elegant and satisfactory solutions. The MASs ((Multi-Agent Systems) are currently widely used, especially for complex applications requiring interaction among several computing entities. Indeed, the MASs have become a dominant paradigm in distributed systems development. Moreover, the multi-agent approach has the advantage of keeping the information of each agent completely private until there is a specific request.

Background and Related Work

Nursing Home

The nursing home is a health care establishment, and it provides full care for these residents. It offers the necessary care for each older adult according to his or her situation. A nursing home can be public or private, for-profit or associative. Generally, these persons are dependent or lose autonomy (chronic diseases). It is necessary to identify the needs and expectations of older adults, their families, and relatives to choose the appropriate establishment. This choice is based on different criteria, such as the establishment's geographical location, care, quality of life, cost, and comfort. The older person may obtain the advice of other persons that have already spent a stay at the chosen establishment. The admission process is mainly based on the availability of the place in the nursing home.

Furthermore, the quality of life differs from one nursing home to another [11], depending on the quality of care and services offered. Moreover, the establishments' variety of activities, entertainment, and services can significantly choose nursing homes. Likewise, the nursing home staff's team spirit plays a significant role [12].

Related Work

According to Boggatz [13], nursing homes' notion differs from one country to another. It is currently difficult to know how available web resources help older people decide on a nursing home choice. Shugarman and Brown [14] identified several barriers to the use of Internet-based information about nursing homes:

- Limited time to search and select an establishment
- Limited access to or familiarity with the Internet
- Limited use of resources
- No easy way to compare the quality of results
- Inconsistent access to information

Nursing homes' selection criteria depend on older adults' needs [15]. Wammes et al. [16] focus on nursing homes' quality of life; considering the coronavirus disease (COVID-19) pandemic, the authors insist on timely communication between residents and their relatives while maintaining a physical distance. Indeed, every year millions of older adults are looking for a place in a nursing home. In order to decide which nursing home to choose, these individuals and their families need to obtain relevant information about these establishments' quality. This task is difficult since there are several nursing homes [17].

Moreover, families and relatives require the rigorous follow-up of their older adults. In this context, Rodionov [14] describes a hybrid technique for locating the elderly in nursing homes. This solution combines different localization technologies to enhance localization accuracy.

The location of nursing homes is essential in the final choice of persons. The choice of the nearest nursing home encourages family members to visit regularly. A person may prefer to be near his or her home to facilitate its displacement. Xie and Pearson [17] show older people's difficulties using web-mapping applications to locate quality nursing homes. The authors used the "Nursing Home Screener" (NHS) website as a prototype for a Google Maps website study. The study revealed that the Google map page was confusing for most older people, who did not have the knowledge and skills to use it effectively. Besides, the Center for Medicare and Medicaid Services' website provides the aging adult with detailed information about a nursing home [19]. The website allows finding nursing homes based on a location and comparing the quality of care they provide and their staffing. Indeed, the person can verify the services offered and the reasonable distance from family and friends.

Material and Method

In this section, we detail the architecture of our system. We start by focusing on the principle of architecture, and then we define the different agents of our system and their roles.

Architecture Principles

The work involves realizing an agent-based system to allow older adults to search and schedule appointments in nursing homes. We have used reactive agents. Figure 1 illustrates an overview of the proposed architecture. This system offers the following set of functionalities:

- Facilitate the basic or advanced search for nursing homes according to different criteria chosen by the user
- Realize the operation of appointments in the nursing homes
- Evaluating of the establishment by users
- Inform the user by the appointment confirmation
- Notify the establishments of bad evaluations by users

The proposed architecture consists of three levels, as shown in figure 1. Each level has its specific agents and functionalities. A detailed description of each level is given below.

Users level. It is the level with an application provided to users to access the system through the interface agent. However, the smartphone is the primary tool for the user (that hosts the agent interface). The device must be connected to the Internet (wifi / 4G) to communicate with the broker agent.

Mediation services level. It contains the components responsible for the treatment and communication between the user and the nursing home. It comprises a broker, search and appointment agent, and central database containing all system information. This level offers services and acts as an intermediary between nursing homes and older adults (their families or relatives) that seek specific information and advice. Also, it allows the exchange of information among establishments. It ensures the continuity of the older adult's care if he or she moves from one establishment to another.

The Appointment agent, Search agent, and Rating agent populate the central database. It does not automatically gather data from local databases at the nursing home agent.

Authority under the supervision of the Ministry of National Solidarity and the Family will maintain the mediation service. The authority that manages the mediation service has all the information on the establishments. Since it is state-owned, the establishments are not obliged to register. On the other hand, the nursing home agents can provide additional information at the request of the other mediation service agents.

Nursing homes level. It is composed of nursing agents and local databases. Each database satisfies local needs and does not necessarily interact with other local databases. Indeed, nursing homes are attached to their data for their personnel use. However, it is essential to share this information with other health establishments.

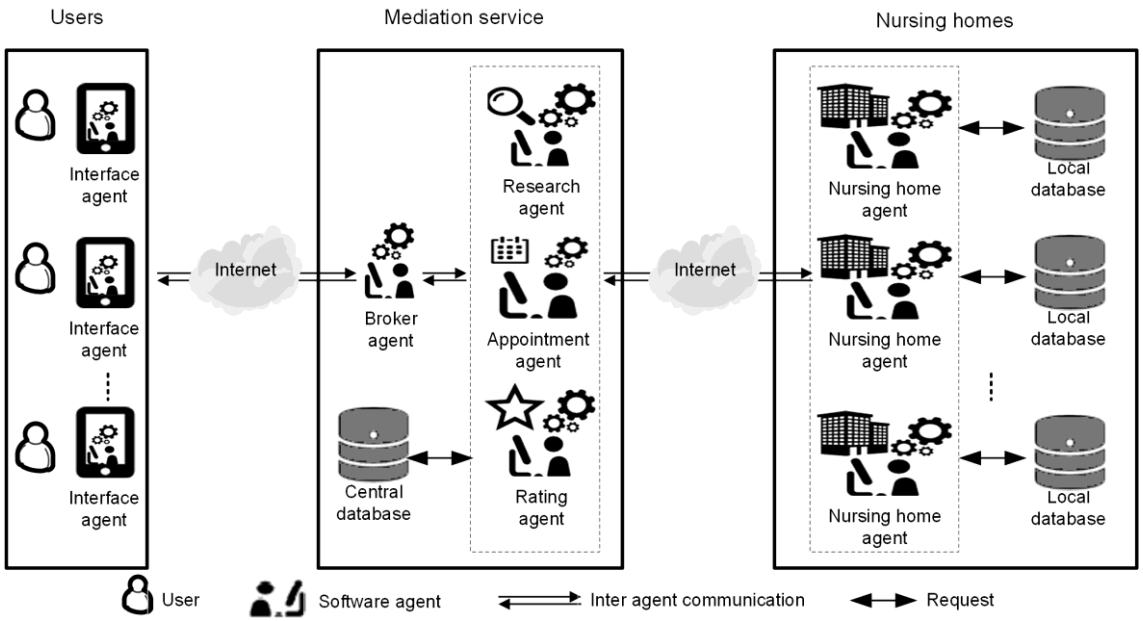

Figure 1. Overview of the proposed architecture

Roles of Adopted Agents

Interface agent. This agent connects the user interface to the broker agent. Its role is to transmit the information to the broker agent and display the results.

Broker agent. It is the principal agent in our system. It ensures a liaison between the interface agent and other system agents. It is responsible to:

- Receive the requests from users and send them to other agents in the system
- Present a list of establishments at the user's request
- Present all times and dates for the taking appointments
- Send the details of appointments to the appointment agent

Appointment agent. It is the agent responsible for all the functions of the scheduled appointments. Its roles are:

- Accept the details of an appointment sent by the broker agent
- Send the details of an appointment of a particular user requested by the broker agent
- Record the confirmation details of an appointment in the database
- Send the confirmation of an appointment to the establishment concerned
- Cancel an appointment and notify the establishment concerned
- Send the confirmation of an appointment to the broker agent

Nursing home agent. It represents an establishment. It is responsible for:

- Receive details of appointments from the appointment agent
- Receive a warning message when the establishment receives an unsatisfactory evaluation
- Manage details and information about the establishment (such services or activities)

Search agent. It is responsible for nursing homes search. Its roles are:

Receive the searches from users sent by the broker agent

Building a search request according to specific criteria

Search for the requested establishment that meets the user's search criteria

Send the search results to the broker agent

Rating agent. It is the agent responsible for users' evaluations of nursing homes. Its roles are:

- Calculate the users' evaluations on nursing homes (staff and quality of care)
- Calculate the number of persons that have passed by such an establishment
- Identify nursing homes that have several inadequate evaluations.
- Send results to the broker agent.

The following class diagram presented in figure 2 illustrates the relationship among agents.

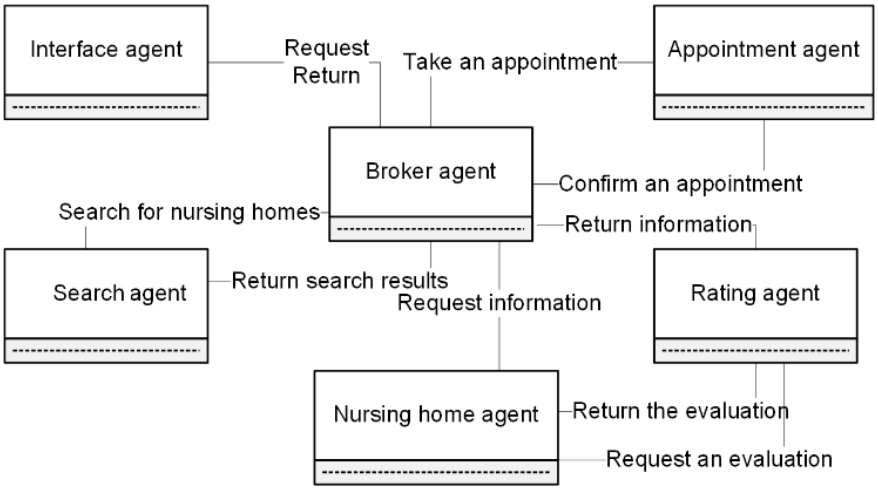

Figure 2. Agents class diagram

Functional Description and Results

After identifying the components of our system, this section describes its functioning. Our work focuses on searching and scheduling appointments in nursing homes. To ensure these activities, our system based on agent technology has the following main functionalities:

FrontOffice

The program will interact with the user. This part consists of several modules that allow the elderly and their companions to:

- Search for an establishment based on the following criteria: Location, care, quality of life, comfort and activity, costs, and rating.
- Take an appointment according to the availability of dates.

Back-office

The invisible part of our system. It is accessible in each establishment. It allows to :

- Update information about nursing homes (e.g., The costs)
- Check the availability of dates for the appointments
- Inform the concerned person by the confirmation of the appointment

Search Process

In this process, the agents involved are the interface agent, broker agent, and nursing home agent shown in figure 3. This process is as follows:

- The elderly or their companion choose the list of establishments
- The user enters the name of the establishment through a search form
- The user can select additional search parameters such as cost and quality of care.
- The interface agent intercepts any information entered
- The interface agent sends the search requests to the broker agent
- The broker agent sends the search requests to the search agent
- After processing the search query, the search agent returns the request's response to the broker agent, and then the broker agent returns it to the interface agent that displays it to the user.

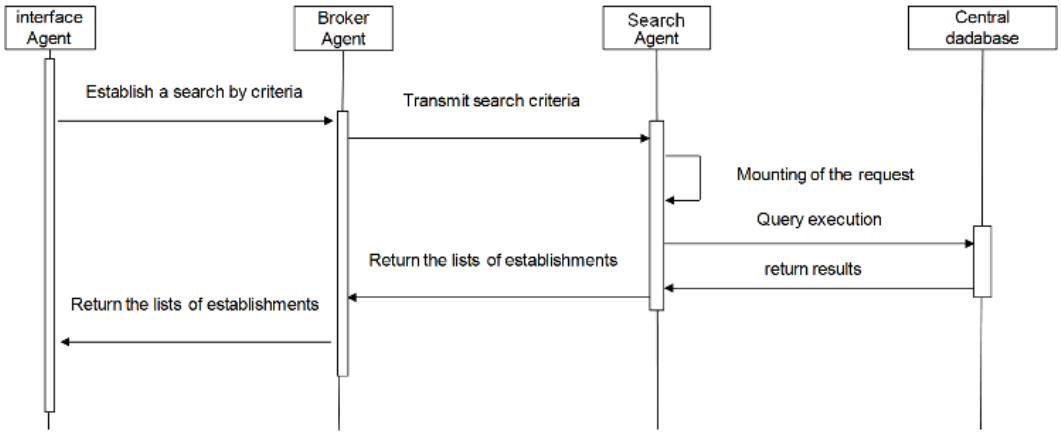

Figure 3. Sequence diagram of the search process

Appointment Process

In this process, the agents involved are the interface agent, the broker agent, the appointment agent, and the nursing home agent shown in figure 4. This process is as follows:

- After the user has chosen his or her establishment, he or she fills out a simple form containing the necessary information (such as personal details)

- The broker agent captures and sends the appointment to the appointment agent.
- The appointment agent checks the information sent and the availability of dates.
- The appointment agent saves the appointment in the database
- The agent sends a confirmation or error to the broker agent. This last one returns the message to the interface agent.

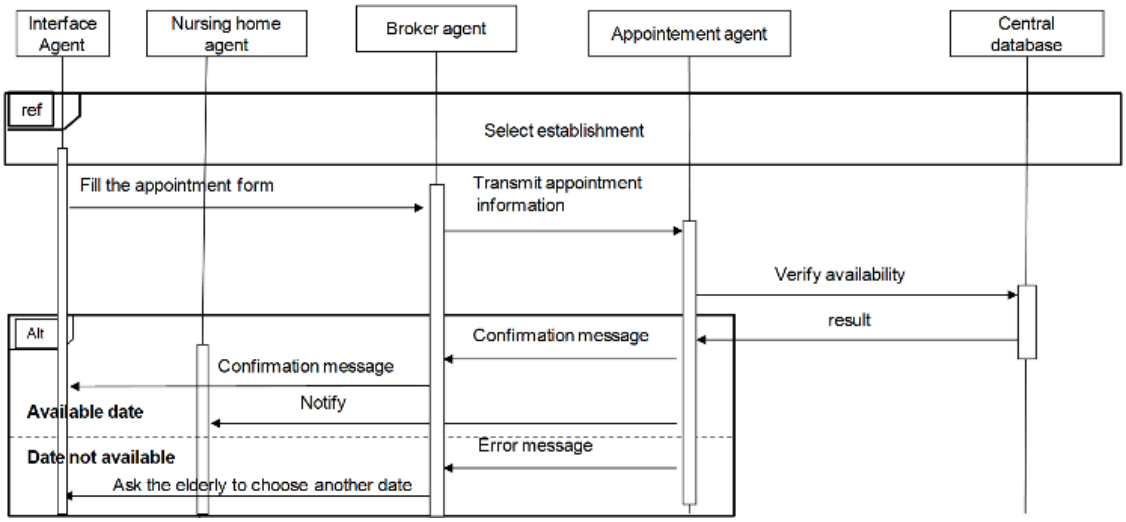

Figure 4. Sequence diagram of the appointment process

Some Implementation Aspects

Concerning the mobile application, the choice of Android environment was compared to the richness of the Android API available to developers of applications to manage mobile resources and an add-on JADE (Java Agent DEvelopment Framework) to develop a MAS under Android. JADE is a platform of agents' creation that considers FIPA (Foundation for Intelligent Physical Agents) specifications for the MAS interoperability [20]. FIPA-ACL (Agent Communication Language) is a standard language for communication among agents. Concerning databases, we have used MySQL. The set of essential tables created for the functioning of our system are:

- Nursing home: it contains all the necessary information about each nursing home.
- Service: It contains the different types of services in nursing homes.
- Equipment: It contains the different types of equipment present in nursing homes.
- Rating: It contains the ratings of the nursing homes done by the elderly.
- Appointment: It contains all the details related to the appointments.
- Older adult: It contains all the personal and health information of the elderly.

We propose a scenario to present the search and appointment process's execution for a dependent older adult to show our approach's feasibility. He or she lives in Constantine, Algeria, with a chronic illness (Diabetes). He or she is looking for an establishment that meets its medical care needs, accommodation costs, or location (i.e., the nearest nursing home).

The first contact between our system and the user is an introduction interface shown in figure 5. It presents the various services offered. When the user clicks on the button "Access the main menu", he or she will be redirected to the main interface illustrated in figure 6. It consists of four elements: (1) search for nursing homes, (2) list of nursing homes, (3) appointment (4) more information.

Figure 5. The introduction interface

Figure 6. The main interface

Scenarios of the Search Process

The older adult wants to search for an establishment that meets his/her needs. He or she chooses the "search" option from the main menu. A search interface is then exposed to the user, illustrated in figure 7, and he or she is asked to complete his choices. In a simple search, the scenario is the following: the broker agent uses the user's location and displays a list of establishments in its region. In a search by establishment name, the user enters the establishment's name, and then the interface agent sends the name to the broker agent. This agent transmits the data to the search agent. This latter builds a request and sends it to the database.

After processing the request, the search agent sends a response to the broker agent. This agent transmits it to the interface agent that displays it to the user shown in figure 8. However, if a search by advanced settings, the user selects the search criteria (price, location, services, or evaluation), and then the interface agent intercepts this information and sends it to the broker that will interact with the search and rating agent. Therefore, the broker transmits the data entered by the user to the search agent. This latter built a query according to the user's criteria. After processing the request, the search agent sends a response to the broker agent. This latter transmits it to the interface agent that displays it to the user. For the rating agent, it is the same procedure. The exception in this scenario is a lack of information about establishments (tariffs or quality of care). The broker agent must demand a search agent to have more information. Indeed, the search agent contacts the nursing home agent to provide the missing information or update it. This latter provides information, and the search agent validates it on our system's database.

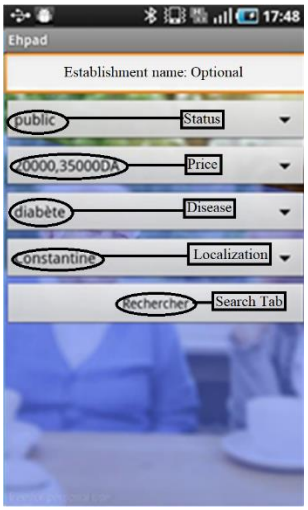

Figure 7. The search interface

Figure 8. The search result

Scenario of the Appointment Process

The interface agent displays a list of establishments for the user to choose one. We recall that this choice can be made directly after the search process. After choosing an establishment, the user can take an appointment by clicking on the tab appointments illustrated in figure 9. A form appears; it contains the date and time of the appointment. The user fills out the form shown in figure 10. The interface agent intercepts the information to the broker agent; this latter transmits it to the appointment agent. This agent checks the data. Finally, the system grants the appointment and confirms it or displays a message, 'Date occupied, please choose another date.'

Figure 9. The selection of a nursing home

Figure 10. The appointment interface

Discussion

Access to the appropriate nursing home establishment is a significant concern for most older adults and their relatives. Indeed, much information needs to be gathered about existing establishments, especially their locality. After collecting this information, the older persons or their

relatives have to compare the information, select, and then make an appointment with the chosen establishment. The time spent for this purpose would be a significant constraint for many persons when it concerns a website. According to most work, nursing homes' search and appointment scheduling are web-based [17, 19]. However, older people are not familiar with the web.

The proposed system uses an easy interface that allows users that do not have much experience using the Internet to use the application's different functionalities. The system is intended for older people and their relatives to avoid traveling to nursing homes to make appointments. It allows users to search for these establishments by several criteria, such as the establishment location and the quality of care offered. In our proposal, simplicity of use is a priority: it is much easier to read information by simply clicking on an icon than if a person has to launch a browser and then search for the site. The icon of the application responds perfectly to their requirements. Indeed, older adults like the concrete. In addition, there is no clinical risk for our app. Table 1 illustrates the differences.

There is little agent-based work for search and appointment in health care establishments in the literature [21]. In this work, the agent-based system was simulated, validated, and applied on a smartphone using JADE android and the JADE platform. This system is based mainly on the exciting concept of the multi-agent paradigm: communication.

The percentage of older adults living in rural areas in Algeria is 38.9% [8]. Some live in isolated areas, where the Internet is sometimes poor or non-existent. The lack of infrastructure accentuates the problem. Thus, this situation can disrupt the use and functioning of our system.

We have considered the guidelines for usability assessment of mHealth applications according to the Health Care Information and Management Systems Society (HIMSS) [22]. In addition, the accuracy and relevance of the information contained in the application. Users must be involved in evaluating the successful implementation and continued use of the application. Thus, they can contribute to the development and modification of the solution to meet better their specific needs.

Table 1. A comparison between what is used and our solution

	Traditional communications (phone or fax)	**Social media**	**website**	**Our solution**
Time of use	Very high	High	High	Low
Flexibility of use	High	Medium	Medium	High
Formal information	High	Low	Medium/High	Very high
Direct interaction	High	Medium	Low	High
Search Criteria	Very low	Low	High	Very high
Search Complexity	High	High	Medium	Low
Updating information	High	Medium	Medium	High

Nonetheless, this work has some limitations:

- The security aspect is not addressed.
- It is challenging to demonstrate elderly' satisfaction empirically due to the diversity of their diseases and technological backgrounds and their reluctance to change, which may condition the solution's success.

As future work, we hope to make a qualitative and quantitative study of the proposed system and its economic impact after its deployment in a real environment. The data collection will concern the coverage rate, the number of users connected to the system, and their consents. Moreover, it improves our system's functioning in the short term. We will deal with admission based on several criteria, such as the older person's health status and financial situation. It is to generalize our approach to any health establishment or institution and implement a reliable security system in the medium term.

Conclusion

In this work, we have proposed an agent-based approach for the nursing home communication center, to be used in the context of a developing countries, Algeria. Our platform simplifies multi-agent systems while providing complete services, and agents conform to FIPA specifications. We used the FIPA-ACL standard for representing information exchanged among the agents during their interactions.

Conflict of Interest

The authors declare that they have no conflict of interest.

Acknowledgments

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