Agent Based Approach in Accessing Distributed Health Care Services

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Abstract. Healthcare organizations are facing the challenge of delivering high-quality services through effective process management at all levels- locally, regionally, nationally, and internationally. There have been frequent changes of clinical processes and increased interactions between different functional units. Software agents were adopted to provide the means to accomplish real-time application, due to their autonomous, reactive and/or proactive nature, and their effectiveness in dynamic environments by incorporating coordination strategies. Multi Agent Systems (MAS) will helps in minimizing the waiting time of patient and cost of the care also it can be used to represent the real conditions, courses, and the human decision behavior. This paper presents an overview of health care system, intelligent software agents and integration of both to achieve better Quality of service.

Keywords: Mobile users, Software agents, Multiagent systems, medical ontology, FIPA-ACL.

1 Introduction

In the last few years there has been a shift in healthcare practice towards healthcare promotion, shared patient provider decision-making and managed care, creating an increased demand for information and online services. The shared decisions and actions of all concerned need to be coordinated to make sure that the care is efficient and effective. To facilitate this, software systems are needed to reduce error in diagnosis and treatments, deliver healthcare to remote locations, improve medical training and education, and make healthcare information more accessible to patients. In this concern we intend to develop ontology for patient medical record in healthcare organizations and share information through the web to be used in different departments, healthcares, clinics or hospitals of a city, town or a remote area abroad and help to have a better treatment and efficient care system. An increase in specialization and technology, especially in the health care department requires efficient management of the resources and more timely treatment of the patients. Agents are used to solve the patient scheduling problem in the hospitals because they

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work well in a distributed, decentralized and dynamic environment. An agent is a software program that acts on behalf of a user, typically used to retrieve and process information. An agent is used to represent each patient and resource in the hospitals. Interaction protocols are used to reduce the search space of possible responses to an agent messages. A medical centre contains a lot of professionals such as nurses, doctors, administrators, etc., and resources such as x-ray, gym, rehabilitation unit, etc. All of them play a specific role within the medical centre, and they must coordinate their activities to provide the best possible care to patients. Agents are often described as intelligent. That indicates that the agent takes actions on its own, and pursues the goals in the best way possible. They are not perfect, but they can operate flexibly and rationally in a variety of environmental circumstances, given the information they have and their perceptual and effectual capabilities.

The challenges in Health care services includes, Communication between services-sharing ontologies and semantics which could be heterogeneous even within the health care domain. Second challenge is Security/Authorization- accessing/editing sensitive medical data, such as the medical records of the patients. Third challenge is that creating an environment where agents can discover one another and access one another's services. Fourth challenge is the Communication between users and agents-graphical user interfaces to communicate with personal assistants. The last challenge is the Coordination between distributed services. Thus it is necessary to develop a model or a framework which overcomes the above mentioned challenges that may emerge as one of the efficient way for accessing distributed health care services.

In this paper we describe the design of Multi Agent System (MAS) which contains agents that allow the user to search for medical centers satisfying a given set of requirements, to access his/her medical record or to make a booking to be visited by a particular kind of doctor. Some of the agents in the system can provide information about the medical centers that are available in a given city. The MAS also contains an agent for each medical center in town, these agent may be asked about the doctors working in that hospital, or may be requested to perform a booking in the schedule of a specific doctor and also can access a database.

2 Related Works

Here we present accessing of health-care related services by deploying intelligent agents. The software-agent paradigm [2] [3] [4] was adopted due to its autonomous, reactive and/or proactive nature, which comprises of important features in real-time application deployment for dynamic systems like the one under consideration. Furthermore, software agents can incorporate coordination strategies, thus enabling them to operate in distributed environments and perform complex tasks. Software-agent technology is considered an ideal platform for providing data sharing, personalized services, and pooled knowledge. The work in [7] presents the Foundation for Intelligent Physical Agents (FIPA) that defines standards for agent interoperation. The aim in the Agent Cities is the construction of a worldwide publicly accessible network of FIPA based agent platforms. Each platform will support agents that offer services similar to those that can be found in a real city. Once the initial services have been deployed, it will be possible to implement

intelligent complex compound services. In the research literature, there are several agent-based applications reported in the healthcare domain. In particular, one of the earliest examples of work examining the role of multi-agent systems in healthcare is offered by [6]. The focus of the work presented there, and of the broader context, in which it was conducted, is upon appropriate theorem proving in decision support systems that have to deal with complex, incomplete, inconsistent and potentially conflicting data. The agent component is designed to support of tasks amongst players in the system. Heine et al [17] simulate an agent oriented environment for German hospitals with the objective to improve or optimize the appointment scheduling system, resource allocation and cost benefit of clinical trials. Nealon and Moreno [12] have discussed the potential and application of agents to assist in a wide range of activities in health care environments. Mabry et al [18] employ the Multi agent system for providing diagnosis and advice to health care personnel dealing with traumatized patients. Nealon and Moreno [19] have discussed various applications of MAS in health care e.g., coordination of organ transplants among Spanish hospitals, patient scheduling, senior citizen care etc. A research project, called PalliaSys is offered by [20]. It incorporates information technology and multi-agent systems to improve the care given to palliative patients. An Intelligent Healthcare Knowledge Assistant [21] was developed which uses multi agent system for dynamic knowledge gathering, filtering, adaptation and acquisition from Health care Enterprise Memory unit.

The decision of using a Multi-Agent System in this medical setting and not other more traditional AI techniques such as an expert system or a decision support system is motivated by the following reasons:

- The information that must be dealt with is geographically distributed, because each hospital or medical centre will keep its own data, each doctor will have his/her personal information an up-to-date daily schedule in a personal computer, the medical records of the potential users of the system may be located in different databases, etc. Therefore, a distributed AI approaches such as the one offered by multi-agent systems seems suitable in this case.
- There must be a fluent communication between the user and the medical centers. For instance, the user's personal assistant should be able to ask for a booking with a certain doctor, and be able to react quickly if the doctor's schedule is full (so another doctor has to be chosen). Agents are not only reactive but also endowed with social abilities, so they are able to communicate with other agents in order to negotiate and co-ordinate their activities.
- Existing systems such as databases containing medical records may be easily included in a multi agent system. The standard way of agentifying a database is to put a wrapper around it. A wrapper is an agent that receives the queries to be made to the database in a standard agent communication language such as FIPA-ACL or KQML and is able to translate these requests into queries in SQL to the database; the wrapper may translate the answer to the common agent communication language and send it to the requesting agent.

- The most important reason for capturing services as agents in this way is to enable the individual medical services to interact with each other at a high enough level to ensure that they can all interoperate. Agent communication languages such as FIPA – ACL [8], content languages such as SL [9], and formal ontologies are very useful in describing communication between different services at the application level- i.e. in a way which relates to the domain of discourse rather than to any single implementation.

However, it is observed from literature survey that when the Agent Cities initiative was made public, the potential development of agents that could offer not the usual leisure-oriented services but health-care related services. The work here describes automation of a multi-agent system that caters to special types of patients or providing assistance to patients for appointments. So, the concept of intelligent agent and mobile technology is used to achieve automation, efficiency, reliability and scalability in devising Health care domain for distributed, decentralized and dynamic environment to treat the patients efficiently by cutting down the time and cost.

3 Proposed Work

This section describes the Multi-Agent System which has been developed. The primary design objectives of the work were the following:

- To provide a decomposition of the problem that matched agents to entities which could be realistic players in such a domain (e.g. medical centers, personal agents, etc).and to take care in who had access to which information.
- To provide ontology for the domain.
- To make the developed agent services as reusable as possible by using standard languages and providing detailed service models to describe the individual functioning and objective of each agent including descriptions of actions, protocols used.

The aim of the multi-agent system is to provide access to the basic health-care services in a given city to the users. This system supports routine activities of physicians at the hospitals by maintaining information such as appointments for a specific day or week, the patients that the physician has examined, and notes related to patients. Although this distributed healthcare system provides user-friendly interfaces for busy healthcare professionals and patients. The system authenticates users and logs session information for security and privacy, so that only privileged users can view or modify the data.

The basic architecture of the MAS is shown bellow. The architecture shows interactions among agents, and also the interactions between humans/resources and agents. Here the Patient interacts with the system through a Patient Agent, provided a GUI through which patients could make queries and receives answers. This agent stores static data related to the user such as the national healthcare number, name, address, phone number, and information for allowing secure access to the system.

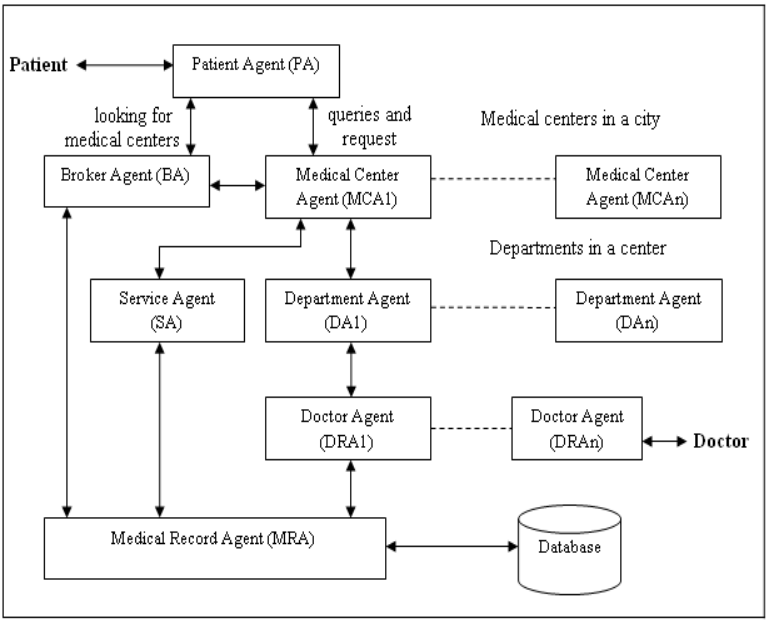

Fig. 1. MAS Architecture

It also stores dynamic data such as the agenda of the patient. The static data will be used to identify the patient in the system (authentication and ciphering). The agents of the system will exchange required data automatically in each step, *e.g.* a doctor needs to know personal details of a patient before the medical visit, in order to retrieve his/her medical record from a database. The dynamic data is very useful to guide negotiations between any Patient Agent (PA) and other agents, because PA can avoid coincidences in those negotiations, *e.g.* if the patient works from 9:00AM to 14:00PM, his agent would arrange meetings during the afternoon and night.

All PAs can talk with a Broker Agent (BA) provided an interface between all the agents internal to the system and the user agents. The BA is the bridge between patients and the medical centers, and it is used to discover information about the system. All PAs can ask this agent in order to find medical centers satisfying certain criteria. The BA covers all the medical centers located in a city or nearby area.

Any patient can access the system through the Medical Centre Agent (MCA) that centralizes and monitors the outsider's accesses. Each medical center is represented by Medical center Agent which contains all the information related to the medical center such as address, phone number, opening times, location, and so on. A MCA monitors all of its departments, represented by Department Agents (DAs), and a set of general services represented by Service Agents (SAs), such as a blood test service, etc. Each department is formed by several doctors represented by Doctor Agents (DRA) and more specific services known as Service Agents (SA).Database is used to store all users' medical records which can be accessed through Medical Record Agent (MRA). This agent provides a secure access to the data using authentication and ciphering through a Public Key Infrastructure (PKI).

When a patient wants to arrange an appointment with a doctor, or a doctor must arrange a visit of a patient with a service, it is required to schedule a meeting according to different constraints such as timetable of services or doctors, and agenda of the patient. Here the patient will search nearby hospitals by selecting city or area and category of hospitals also the available services in the hospitals, patient will then request for the appointment dates with the doctor online. The contacted doctors can see the request of appointments online and can accept, schedule or reschedule the meetings and can also confirm the same to the respective user.

4 Algorithm

The complete life cycle of the multiagent system to access the distributed health care services is given bellow in steps.

Step 1: Maintain central databases containing a list of hospitals in a city, with each hospital containing different departments with associated services and list of doctors with different specialization and free time and day of doctors.

Step 2: Here any number of patients can access the system by filling all the details such as nature of disease, preferable time and date provided in the meeting request form to fix the appointments with appropriate doctor by searching the nearby hospital in the city.

Step 3: The patient has to first open the login page. If he/she is a new patient then he/she has to click new patient and Register. The window will be the registration page of the patient. Once the patient registers he will be activated by the broker and can easily login.

Step 4: The patient may request information about all the medical centers available in a particular city. If the patient is aware of a specific medical centre in the area, he/she may request information about the medical services, departments and doctors in that centre also it is possible to book a visit to a doctor. In this kind of request the patient has to select the Broker Agent (BA) as the recipient of the message. As BA is aware of all Medical Center Agents (MCAs) in town, it will find out which of them satisfy the patient's constraints.

Step 5: Broker Agent (BA) must have a predefined Broker name and password through which he can do various operations and can insert, update any data from the database based on complaints received from patient. Broker can deactivate any member at any time. Broker can add new area, category of hospital, specialty of hospital and new hospital.

Step 6: The Patient Agents (PA) sends a request (REQ) to the MCA through BA. This REQ is forwarded to the department selected by the patient. The Department Agents (DA) will send the REQ to all the doctors of the department. Each Doctor Agent (DRA) replies to the request, in which it displays the earliest time in which the doctor has a free slot for making a visit. The patient can view all Meeting status such as postponed, completed, and in completed meetings.

Step 7: The Doctor can login at any time and can view the List of recent appointment request, List of forthcoming appointments and the calendar showing the available dates and time for meeting.

Step 8: Upon receiving the patient request, doctor will accordingly schedule, or postpone the appointment meetings by viewing the available date in the appointment calendar. If the patient arrival occurs at emergency case, the doctor will give first preference to emergency case and reschedule the appointment of already scheduled meetings and convey the same to the concerned patient. Finally, DRA confirms that the schedule of the doctor has been modified, and this confirmation is sent to the patient through DA and MCA.

Step 9: The medical records of the patients are stored in a database called Medical Record Agent (MRA), the access to which is controlled by Database Wrapper (DW). There are two services that this agent provides: accessing a medical record and updating it.

5 Performance Analysis

In this section, the simulated results obtained with the proposed work are discussed.

Doctor Availability

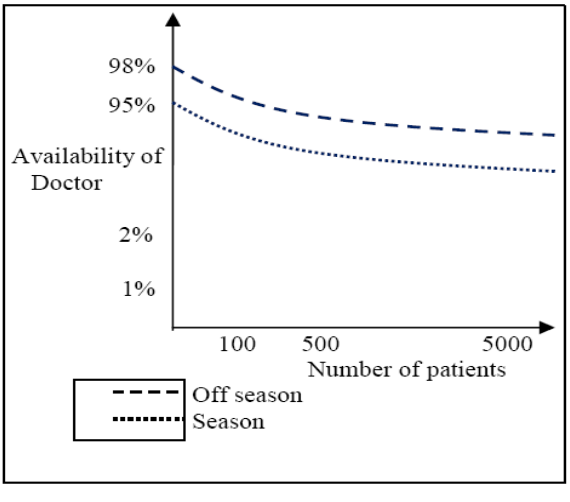

Fig. 2. Doctor Availability

The fig2 depicts the success rate of getting an appointment. The X axis represents the number of patients and Y axis represents the availability of doctor in terms of percentage during off season and season. During off season, the number of diseases will be less (summer) and the availability of doctor will be more (98%) when compared to season (winter). During season, the number of diseases will be more, hence the requests will be more and also the availability of doctor will be less (95%).

Response Time

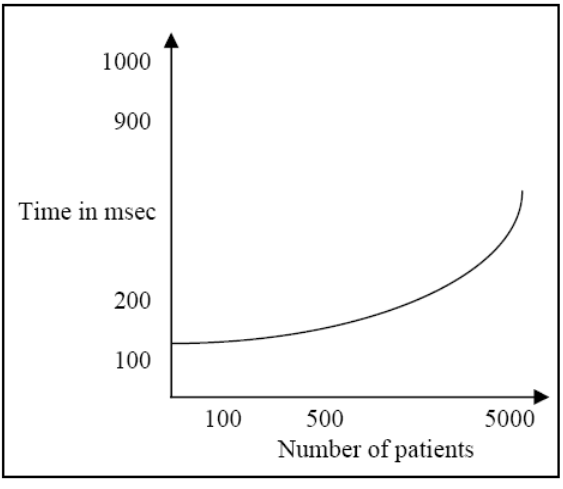

Fig. 3. Response Time

The fig3 depicts the response time. i.e. the time required to process the patient request. Here the X axis represents the number of patients and Y axis represents the time in terms of mili seconds. As the number of patients increases it takes more time to process the requests.

Availability of patients

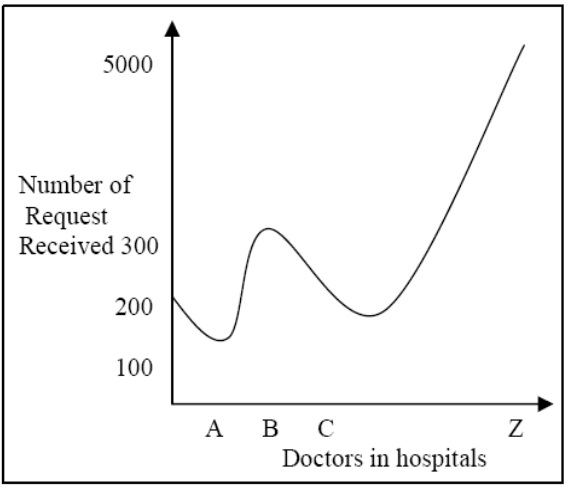

Fig. 4. Availability of patients

The fig4 depicts the Availability of patients. Here the X axis represents the doctors in the hospitals and Y axis represents the Number of request received from the patients. Doctor will get more patients as the number of requests is more.

Reliability

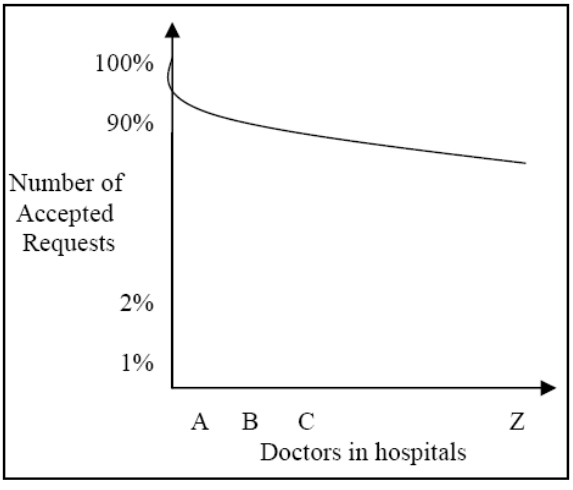

Fig. 5. Reliability

The fig 5 depicts the reliability of the system. The X axis represents the Doctors in the hospitals and Y axis represents the number of accepted requests (processed or confirmed request) in terms of percentage. As the number of requests increases, the numbers of requests accepted by the doctor will decreases.

6 Conclusion

The use of agents in health care has experimented an important growth. One of the main benefits of this paradigm is to allow the interoperability of preexisting systems for improving its general performance. We have designed an agent-based architecture respecting the health care national organization, but it could be adapted to other situations. The architecture defines the interaction between agents, also between humans and agents. The interaction human-agent is made through personal agents that could be located in computers or mobile devices.

Intelligent agents have a set of properties (sociability, proactivity, autonomy) that make them suitable to be used to solve many problems that appear in the health care domain. One such problem we discussed here is access to medical information of a city. The MAS described in this paper can be implemented using JADE (Java Agent Development Framework). JADE is a library of Java classes that eases the implementation of FIPA- compliant multi agent systems. The content of all messages must be in FIPA-SL and the medical record databases in MySql.

This paper explains the combination of agents with health care services in order to provide coordination among different types of agents. If a patient arrives at the emergency case, then agents negotiate the best alternative according to the preferences/constraints of the patient, the doctor and the services. The system implements services as reusable as possible by using standard languages for communicating and for the content and the representation of ontologies. It could easily allow the addition of new agents or features to further improve the time efficiency.

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