Application of Intelligent Agents in Hospital Appointment Scheduling System

Arthur Hylton III and Suresh Sankaranarayanan

***Abstract*—Normally when we want to make an appointment with the hospital staff, it becomes really tedious and time consuming. Over the past considerable amount of work have been done by using software Agents in areas like m-commerce, e-commerce, telemedicine etc. Agent based systems have also been developed for the hospital service, for searching and fixing appointment over mobile phones which gives a direct reply when the appointment is made or the next available date(s) or cancelled. However, no facility like priority appointment of patients has been developed. Also the appointment does not take into consideration emergency situations like Accidents and so on and the scheduling reported is only for general patient appointment only. Taking these important aspects into consideration, we here have developed an intelligent agent based system towards negotiating and collaborating with the agents of doctors and the hospital for the appropriate appointment time for the patient which would take the above factors into consideration. In addition the meetings of the junior staff like the duty doctor and nurse with the chief doctor regarding patients would also carried out again while taking into consideration the medical condition of the patient admitted and so on. These agents developed would function based on fuzzy preference rules, to make a proper decision regarding making an appointment for patient and other hospital staff , which is very unique and first of its kind. The system validated uses ANDROID 2.2 and JADE-LEAP, for providing a robust, user friendly solution for the patient and doctor.**

***Index Terms*—Agents, JADE-LEAP, android 2.2**

I. Introduction

The health care industry now is one of the largest and most important industries in most countries. It provides individuals access to medical and non-medical services that are aimed at improving that individual's quality of life. In many health care facilities, however, there exists a severe need for improvement in quality of service and patient waiting times. These needs must be met with an efficient and a practical solution. This solution must make use of the hospitals' valuable resources, such as medical experts' time, in the most efficient manner. Hospitals are continuously fighting a scheduling problem that causes either a waste in medical experts' time or a decrease in patient satisfaction and staff morale. Many scheduling systems have been developed and implemented in order to improve such operations in individual hospitals or even groups of health care facilities called health care networks [1], [2].

The internet initially revolutionized communication and access to information; however, in more recent times it has been the rapid improvements in mobile technology that has further expanded the communicative abilities of individuals and businesses alike. These mobile technologies, combined with the use of the internet have pushed mankind to a new frontier of information distribution and gathering. Recently there has been system developed for health care service towards searching and appointment using J2Me mobile handset [3], [4]. The drawback of this system in respect of appointment fixing is that it only gives confirmation for the available date requested or next available date [3], [4]. Literature shows no research has yet been reported in fixing the priority level of patients towards scheduling appointment with the doctor. With this as background, we have now developed an intelligent agent based system for the negotiation and scheduling of hospital appointments using Android 2.2. The system will provide patients and junior staff with the ability to choose a required appointment date and time along with the procedure being scheduled. The procedure for scheduling is based on priority level of patient and junior medical staff. With the information made available, the system will autonomously negotiate with the schedule of medical personnel and also negotiate for the best possible time for that visit, based on fuzzy preferences. This research attempt is unique and first of its kind.

The paper is organized in sections as follows. Section 2 provides details on ICT in health care. Section 3 details on Intelligent Agent Technology in Health Care. Section 4 details on Intelligent Agent based Scheduling system. Section 5 gives the implementation and validation details on JADE-LEAP [5], [6] and Android 2.2. Section 6 provides the conclusion and future work.

II. ICT in Health Care

Information and Communication Technologies (ICTs) are being employed in many industries today, mainly for the significant benefits to be gained through the use of ICT [7]. Benefits include improvements in process efficiency and information dissemination. The use of Information and Communication Technology (ICT) in the Health Care Industry (HCI) has also been on the rise. The Health Care Industry (HCI) has been slow in accepting the use of ICT and for many years relied on paper based systems, for task such as patient data management and appointment scheduling.

As the health care industry moves toward the promotion of a personalized health experience, it has become important that, methods to improve the access, efficiency, effectiveness

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and quality of the processes related to both the clinical and business aspects of health care be employed [7]. Health Care Facilities (HCFs) are able to use ICTs such as Internet based applications to provide current and potential clients with the information they need when they need it. Some facilities even allow clients to setup appointments to see a doctor using these internet based applications. The use of ICTs in health care led to a new term called Health Telematics (this term is used in Europe), and other now popular terms of e-Health and Telemedicine.

Electronic Health or E-Health is the use of Information and communication technology for storing and accessing the data stored electronically, sending the data digitally for clinical, educational and administrative purpose both locally and externally [7]. Through the use of ICTs such as the Internet, caregivers and family member have easy access to health care information, which allows them better deal with persons within their care. Clinicians are also able to continue enhancing their knowledge by participating in online courses and research in new areas, and improvements in other treatment areas .

III. Intelligent Agent Technology in Health Care

A. Intelligent Agents

In order to better understand the Intelligent Agent Technology, it is necessary to first understand what Agent Technology is. Agent Technology has been around for more than two decades, this area of research is still generating as much interest as it did when it was first introduced. Franklin and Graesser [8] in 1996 gave the following definition "an autonomous agent is a system situated within and a part of an environment that senses that environment and acts on it, over time, in pursuit of its own agenda and so as to effect what it senses in the future." So an agent is software that has the ability to sense an environment that it is located in, then carries out some action, based on the information / data that it gathers from that environment. The agent is defined [8] as the feature of being autonomous, meaning independent or self-directed. So an agent being self-directed should have control over its own actions and not have to rely on the intervention of other agents or even its human creator.

Agents also have other features such as being mobile, able to move from one system to another within a networked environment. Another feature is that of intelligence, an intelligent agent is a computer system that is capable of flexible autonomous action in order to meet its design objectives [9] .There are a number of toolkits available on the market ranging from general agent development platforms, like AgentBuilder developed by Reticular Systems, to highly specialized tools, like Excalibur developed by the Technical University of Berlin [10]. The four major categories of agent toolkits are mobile agent toolkits, multi-agent toolkits, general purpose toolkits, and internet agent toolkits [10]. But now for the purpose of this research a multi-agent toolkit would be ideal. Examples of multi-agent toolkits are Concordia, Gossip, FarGo, IBM Aglets and JADE (with the LEAP add-on).The most suitable of the five toolkits above would be the JADE powered by the LEAP add-on (JADE-LEAP). According to the literature JADE-LEAP is the only multi-agent toolkit capable of creating agents that can execute on a mobile device with limited resources [3], [4.]

B. Agents in Health Care

Agent based technology has been used and proposed for use in many health care system applications [10], [11]. The AgentCities Working Group on Health Care have proposed and created prototypes of agent applications for various areas in health care. These areas include patient data management, organ transplant and patient monitoring [10], [11] but to date there existed none which addresses the issue of hospital search and appointment scheduling via intelligent agents on mobile devices such as the cell phone. So an intelligent agent based hospital search and appointment system [3], [4] was developed for mobile phone which would allow users towards searching the best hospital and also fixing appointment. Even in the system developed there existed a drawback in scheduling the appointment with the doctors. It was found that appointment agent so developed only request for an appointment date which would reply with the requested appointment date or next available date if available. In this system the agent does not possess any intelligence towards negotiation and scheduling hospital appointment taking the priority level of patients. So from the literature it is clear that there is significant research being conducted in which single and multi agent systems are being proposed for solving problems within the health care domain. However there seems to be very limited work carried out in applying agent based technology in towards appointment scheduling. Taking these into consideration we here have developed an Agent based system for scheduling hospital appointment for patients and junior medical staff taking the priority level into consideration. The details of such system will be discussed in forthcoming sections.

IV. Intelligent Agent Based Scheduling System

Presently, for patients to have the time of medical personnel, especially experts, for either diagnostic or more urgent operational reasons they face problems. The patients may choose to walk in and wait for the personnel to become available but they usually end up waiting for very long periods of time. The patient can, however decide to schedule an appointment, but this option does not usually work well for all parties involved. Parties involved includes: the patient, the medical personnel and the hospital. The patient wishes for readily available and convenient appointment totimes. When they do not find a close enough appointment time they experience long periods of indirect waiting time (time between scheduling the appointment and that appointment becoming available). The patient also wishes to be seen either immediately or within minutes of their arrival (whether they scheduled an appointment or not).

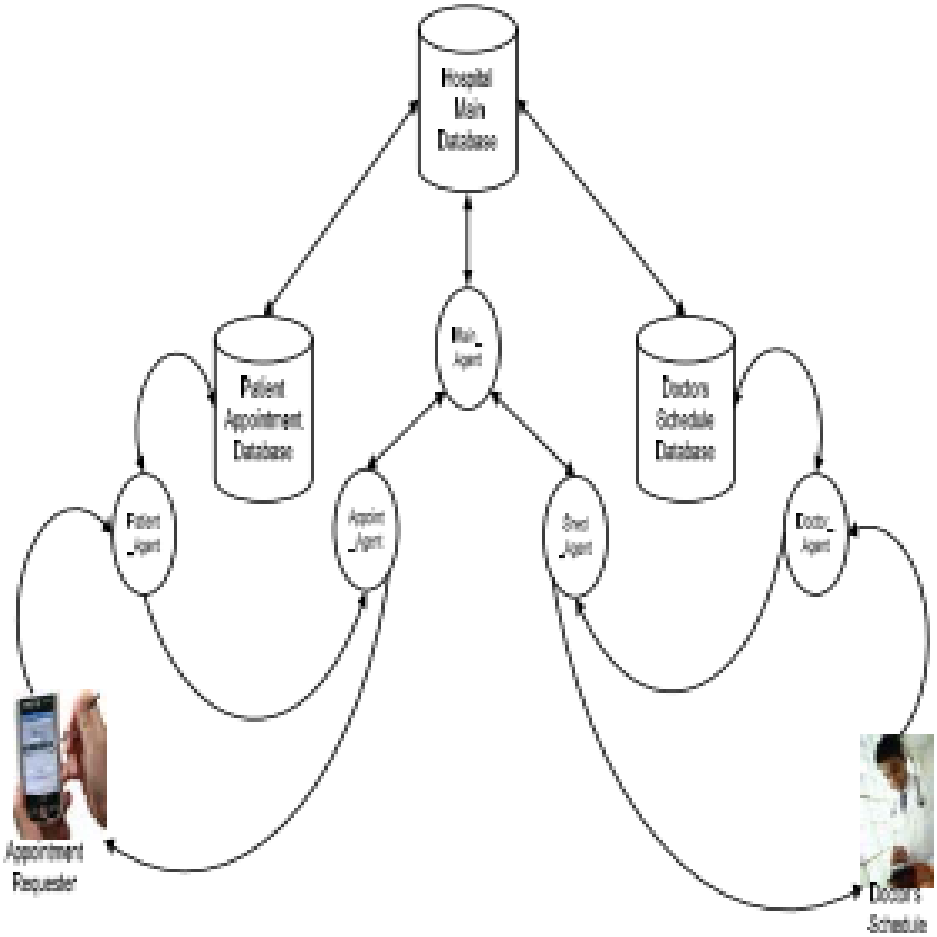

Fig. 1. Architecture of agent based scheduling system.

The time that the patient waits from the scheduled start time of their appointment to the time that they actually receive service is called direct waiting time. The medical personnel wishes to have some control over the uncertainty in the number of patient appointments in a day, and the mix of appointments on any given day. These factors can affect their earnings as well as their job satisfaction levels. The hospital wishes to use its resources (personnel and equipment) in the most efficient manner. Therefore the hospital doesn't wish for the medical personnel to have long periods of "wasted time". So the challenge is to provide a solution that allows patients to minimize both direct and indirect waiting time, also to provide some control over medical personnel appointments and finally to provide the most efficient use of the hospital's valuable resources. The proposed system will seek to provide such a solution using some fuzzy preference rules that will take patient priority into consideration. The system will also seek to implement some heuristics developed by medical personnel in their search for a solution themselves. The agents within the system will interact with each other and with a database of existing appointments and appointment slots. This system will allow the patient to enter some appointment criteria and have the appointment negotiated and either confirmed or declined. If an appointment is declined then a list of the most appropriate available appointment slots will be provided to the patient for selection. Taking these into consideration we here have developed an architecture for our system developed as shown in Fig. 1.

The proposed design includes five agents interacting with at three databases. The main function of the patient agent is to receive appointment request remotely, interfacing with the patient appointment database and the appointment agent. The appointment agent interfaces with the patient agent and main agent, with its main function being to provide confirmed appointment information to the appointment requesters. The main agent is considered most critical agent that interfaces with the appointment agent and doctors schedule agent along with the hospital main database. The core function of the main agent is interrogate appoint request against the doctor schedule in an effort to provide available appointment slots. The doctor agent core function is to receive doctor's schedule remotely or otherwise and interface with the doctor's appointment database and the schedule agent. The schedule agent interfaces with the main agent and provides confirmation of doctor's schedule and confirmed appointments. The implementation of agent based scheduling carried out using JADE-LEAP [5], [6] on Android 2.2 handset will be discussed in next section.

V. Implementation Using JADE-LEAP

The Intelligent Job Search System was implemented and validated using JADE-LEAP [5], [6] as the Agent container, MySql 5.0 database, and Android 2.2. In our implementation and validation, we have imposed certain constraints towards patient/staff appointment. Registered patient will be required to make appointment at least 24 hours before their scheduled appointment date and time. Non-registered patients will be required to make appointment at least 48-24 hours before

scheduled appointment date and time, thereafter they will become a registered patient. Senior Citizen/physically challenged/ Infants/pregnant woman/children be given highest priority irrespective they are registered or unregistered. And for them appointment can be made and confirmed latest 2-4 hours before the appointment time. A registered patient making an appointment for a second visit after medication will be given the next priority and provided with a confirmed ticket of their appointment time, providing that the requested slot is available. Secondly, a registered patient making an appointment for medication will be the next level of priority, providing the requested time slot is available. Regular check up and all other appointments by registered patient, such as request for consultation will be given a lower priority. A non-registered patient making an appointment for medication will be given priority, providing their request was done during the stipulated 48-24 hours lead time. All other appointments by registered patient, such as request for consultation will be given a lower priority. In addition, all registered or unregistered patient will be provided with the option of the next available time slot, if the original requested time slot is unavailable. Staff and doctors appointment request will be flexible through agents using the fuzzy rules to schedule such an appointment. The fuzzy preferences would be in Scheduler agent- main database for making appointment.

Let us consider a scenario in which unregsitesterd patient goes for appointment as shown in Figs. 2-4. Fig. 5 shows the selection of data and time by the patient for appointment. Now the registered patient who is a senior citizen, submits the request for appointment for same date and time as shown in Figs. 6-9. Unregistered and registered patient appointment requests are sent to main database agent which resides in the main database of the hospital. The main database agent possesses the intelligence by applying the fuzzy preference to schedule the appointment by looking into doctor's schedule and interfacing with the scheduler agent. The main agent schedule appointment for senior citizen, who is registered patient as ticket 1 and unregistered patient as ticket 2 in 10 - 11:00 AM slot as shown in Fig. 9. The appointment confirmation is communicated to appointment agent of patient and doctor agent by the scheduler agent. Main agent knows how many patients can be fitted in a particular slot which is dynamic and changed according to doctor's request.

Let us consider another scenario where unregistered and registered requests for appointment for same date and time i.e Jan 5th 2011, 11:00 AM. Here, the patients are neither senior citizens or physically challenged, etc. They are normal people. The appointment is submitted by the patient appointment agent to Main Agent which possesses the intelligence to schedule the appointment for registered patient by overriding appointment of unregistered patient by interfacing with the scheduler agent and doctor's schedule database. This is shown in Fig. 10.

Let us consider another situation wherein a registered patient who is senior citizen request for 10:00 AM appointment for medication as a senior citizen as shown in Figs. 6-8. Now a junior medical staff requests for the same appointment time of 10:00 AM with the same senior doctor for medical consultation and the performance is as shown in Fig. 11. The main agent possesses intelligence to apply fuzzy preference by looking into doctor schedule and interfacing with scheduler in confirming the appointment with the doctor agent. Another staff requesting for the same time slot, but for some different reason say, Leave and such other matters. But the main agent finds that the maximum number of tickets for the slot is full and so main agent now applies fuzzy preference for scheduling the appointment for another time slot i.e. 11:00 AM as shown in Fig. 12. Fig. 13 shows the appointment confirmation to the doctor agent.

VI. Conclusion and Future Work

For fixing appointments in respect of health applications, we normally employ a human agent to get the work done at the appropriate health care facility. But we have now shown that such a job can be done in the mobile environment by employing mobile agents which would replicate the job of the human being. With this in mind we have now developed and validated an Intelligent Agent Based hospital appointment system that makes appointment with the hospital based on fuzzy preference. In our system, the Agent gathers the information from the user and schedules appointment with the hospital based on fuzzy preferences. The Agents here possess adequate intelligence to schedule the appointment. The validated results of our research have been shown as screenshots. In future we also propose to develop the system towards directing the appointment to another clinic/hospital wherein the same doctor also works. Also providing automatic system calls as reminder before the appointment time begins and the least scheduling for emergency appointments need be taken care too.

Fig. 2. Unregsitered pateint.

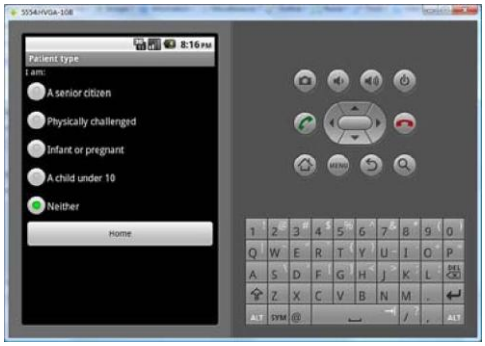

Fig. 3. Patient type.

Fig. 4. Appointment reason- unregistered.

Fig. 5. Date and time.

Fig. 6. Registered patient – logging.

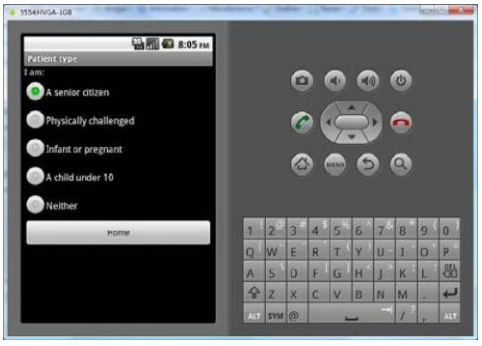

Fig. 7. Patient type- senior citizen.

Fig. 8. Reason for appointment- registered.

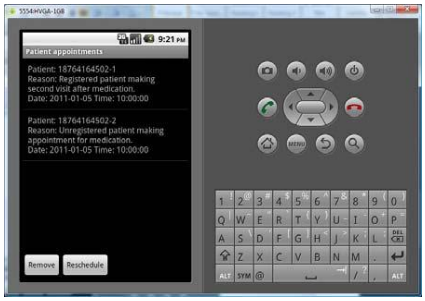

Fig. 9. Patient appointment- appointment agent.

Fig. 10. Patient appointment- appointment agent.

Fig. 11. Reason for appointment- staff.

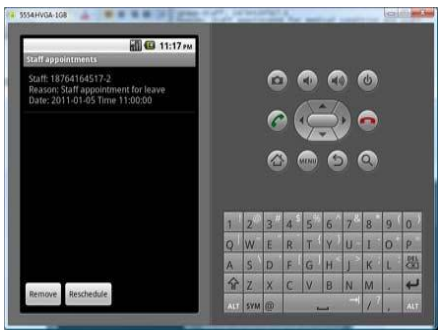

Fig. 12. Staff appointment- confirmation.

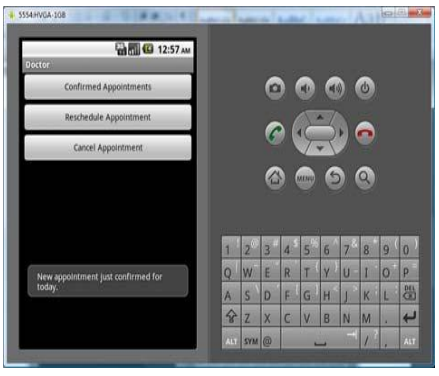

Fig. 13. Appointment confirmation- doctor.

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Arthur Hylton III started his professional studies at the University of Technology, Jamaica in 2006 where he obtained a Bachelor of Science Degree in Computing and Information Technology. After completing his studies during 2006 to 2008, he started working in City Optical as Freelance programmer towards the design and development of point-of-sale software for client registration, monitoring client accounts, sales transaction completion and transaction reports. During 2008-2009, he started working as Web Developer in Dcode Communications, Jamaica. Also during 2009 he started pursuing Master's degree in computer Science in University of West Indies, Jamaica. During 2009-2010, he was lead programmer of TEBS Technologies towards design and development of websites, standalone application and also leading way into mobile software development for the company. Since 2010 he is been working in Ministry of Education, Jamaica as Programmer/Analayst. Also in his Master's dissertation which was on application of intelligent agents in hospital appointment scheduling which was accepted and published in IEEE conference proceedings. He is very familiar and proficient in programming languages like AJAX, ASP.NET, C, C++, CGI, CSS, HTML, Java, JavaScript, Joomla, JSP, PHP, SQL, Visual Basic, Visual C #, WPF. Also very familiar and proficient in database development and administration experience like MS-SQl and MySQL server. Last but not the least well proficient and experienced in Agent programming languages like JADE-LEAP and Mobile programming using Android. His research interests are mainly on mobile computing, Intelligent Agents, Web.

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