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MEDI -CONNECT: AI HEALTHCARE SCHEDULER

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Abstract- Healthcare organizations are currently facing the challenge of delivering top-notch services through the effective management of processes at various levels. One crucial aspect that requires attention is patient scheduling, which has led to the development of a cutting-edge information service for mobile users. These agents embody the qualities of being situated, autonomous, and flexible, making Multi-Agent Systems (MAS) the perfect solution for the medical field. This paper proposes the integration of access to distributed healthcare services within a multi-agent environment in order to enhance the quality of service. The framework, which has been developed on the Java platform, aims to streamline the process of appointment scheduling between patients and doctors in an efficient manner, catering to both routine and emergency services.

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

1.Introduction

Most of the Healthcare professionals extensively utilize computer systems to access patient medical records or information about hospital resources and to schedule appointments for multiple patients, often with conflicting schedules. The concept of Meeting Scheduler in the healthcare domain is expected to experience rapid growth, offering an economical and popular methodology with autonomous agents capable of scheduling meetings and managing calendars on behalf of their users, thereby saving time for patients and physicians.

Additionally, such systems are typically designed to facilitate remote patients in scheduling appointments with doctors through online platforms and guide them to appropriate hospitals in

unfamiliar cities. This paper provides a brief introduction to the concepts and methodologies employed in the research.

Currently, many hospitals rely on simple GUI-based applications to manage patient, doctor, and scheduling information. However, effective and timely communication among patients, physicians, and other healthcare professionals is crucial for providing quality healthcare. Unfortunately, existing communication mechanisms largely rely on paper records and prescriptions, which are outdated, inefficient, and unreliable. Despite the era of electronic record-keeping and communication, the healthcare industry still relies heavily on paper documents that are prone to errors, illegibility, and forgery.

Healthcare professionals working in dynamic hospital environments often contend with challenging schedules that are difficult to manage. Emergent tasks and shifting priorities frequently render existing schedules obsolete, while managing patient appointments consumes significant administrative overhead and cost. Clinic and office administrators find themselves juggling multiple phone calls, physician requests, and patient demands, leading to frustration among patients due to delays and inefficiencies in communication with clinic or office administrators. Consequently, this results in no-shows, lost revenue, and operational inefficiencies.

The growing specialization and technological advancements in healthcare necessitate efficient resource management and timely treatment for the patients. The agents are employed to address the scheduling challenges in hospitals due to their effectiveness in distributed, decentralized, and dynamic environments. An agent, in this context, refers to a software program that acts on behalf of a user, typically utilized for retrieving and processing information. Each patient and resource in hospitals is represented by an agent, with interaction protocols employed to narrow down the range of potential responses to messages from the agent.

In the realm of healthcare, the implementation of a Multi-Agent System (MAS) presents an opportunity to tackle various challenges. MAS comprises agents that empower users to explore medical facilities meeting specific criteria, access their medical records, or schedule appointments with particular types of doctors.

Within this MAS framework:

- Certain agents are dedicated to furnishing information about available medical canters within a given city.
- Each medical centre is represented by an agent, enabling inquiries regarding the doctors employed there or facilitating appointment bookings with specific physicians.

Furthermore, the MAS architecture facilitates a systematic breakdown of the problem, aligning agents with entities that could realistically engage in such interactions within the healthcare domain. This approach emphasizes controlling access to pertinent information, ensuring that each agent operates within its designated scope.

1.1 Why Agents?

The rationale behind utilizing agents stems from their distinctive characteristics and capabilities. While there isn't a universally accepted definition, a widely recognized one, as per [Wool95], describes an agent as a software entity exhibiting autonomy (operating independently), proactivity (driven by goals), reactivity (prompt response to events), and social ability (communication with other agents for collaborative goal achievement). Additionally, mobility (moving between hosts) and learning (improving performance over time through experience) are frequently cited attributes [1].

Software embodying these traits presents opportunities for enhancing business operations by:

- Streamlining routine tasks through automation.
- Assisting users/customers in finishing intricate or difficult tasks that would otherwise consume time, money, or be impractical.

- Automatically adjusting to unexpected events or changes in the enviroment.

While it's possible to achieve cost savings and performance enhancements without agents, agent technology offers a more intuitive model that closely mirrors real-world dynamics. In this model, entities pursue their own objectives, communicate, and often collaborate for mutual benefit. This is quite different from existing software paradigms, such as object-orientation.

Additionally, agent technology consolidates and builds upon various computing technologies, including object-orientation, distributed computing, parallel processing, mobile code, and symbolic processing. It also draws from research findings across diverse disciplines such as artificial intelligence, biology, and mathematics. As a result, agent technology provides a unified and simplified approach to harnessing the wide array of available software technologies today.

1.2 Problem Statement

The utilization of multi-agent systems is widespread in tackling large-scale distributed combinatorial real-world problems. Among these challenges lies meeting scheduling (MS) in the healthcare domain, distinguished by its inherently distributed and dynamic nature. This complexity is underscored by patient preferences, transforming the task into a quest for optimal rather than merely feasible solutions. Within this context, several key questions emerge:

- Determining the optimal timing for meetings.
- Navigating to an appropriate hospital.
- Identifying available services within the hospital.
- Assessing the availability of doctors.
- Identifying free slots for doctor appointments.
- Estimating the number and identity of patients scheduled to meet with a doctor on a given day.

Presently, heuristics are predominantly employed to address these challenges due to the absence of a universal optimal algorithm. Artificial intelligence techniques are also utilized, with intelligent agents equipped to understand and prioritize individual interests and preferences. Agents manage routine scheduling activities for physicians by filtering and organizing information and responding to inquiries. By envisioning each patient having their own agent-administered calendar, the reliability of scheduling can be greatly enhanced, while ensuring the security of private data.

The overarching objective is to devise a framework for distributed healthcare services using multi-agent systems and to devise and implement an algorithm for intelligent scheduling within the healthcare domain, leveraging MERN technology.

1.3 Scope of the study

The paper aims to establish a framework and showcase the practicality of distributed healthcare services through collaborative multi-agent systems. As such, the focus is on implementing a sophisticated application for scheduling meetings involving numerous patients. Nevertheless, the paper does not address the development of task graphs or parallel algorithms for computational purposes.

2. Agent Technologies

Agents are regarded as a crucial paradigm with the potential to enhance existing approaches to conceptualizing, designing, and implementing software systems. Additionally, they offer a promising solution to the challenge of integrating legacy software.

2.1 Software Agents

Software agents streamline complex systems by handling the "how" of tasks, shielding users from intricate details and operations. They operate autonomously, learning from user preferences to make decisions and execute tasks without constant human intervention. Dynamic and adaptable, agents respond to changing environments efficiently, expediting system usage.

While the exact definition of a software agent maybe vague, certain key concepts remain crucial. Typically, goal-directed, agents autonomously perform delegated tasks while being aware of and responsive to their surroundings. They have the ability to collaborate with other agents, whether software or human, to achieve tasks or acquire new ones. Desired characteristics include intelligence and mobility, laying the groundwork for the advancements of large heterogeneous applications.

At a high level, the agent model comprises various skills specialized in different domains. Task-level skills define the agent's capabilities in resolving user-given tasks and managing environmental observations and information, such as database queries. Knowledge encompasses the rules guiding the agent's task execution, derived from environmental awareness acquired through programming, user input, or environmental and peer learning. Communication skills enable agents to interact with other agents and users, potentially through natural means like speech and facial expressions.

2.2 Intelligent Agent

Intelligent agents are typically expected to operate autonomously, catering to user needs without constant oversight. Their intelligence is derived from advancements in artificial intelligence (AI) research, which has introduced various techniques like neural networks and genetic algorithms for problem-solving and learning.

3. Proposed Scheme

This section delineates the proposed model, concerning the network environment, hospital environment, patient environment, and the agencies responsible for establishing and managing the medical data centre. It further elaborates on the interactions between agents in developing an automated meeting scheduler within the healthcare domain for accessing distributed healthcare services. Furthermore, it examines the advantages and limitations of this proposed system.

3.1 Network Environment

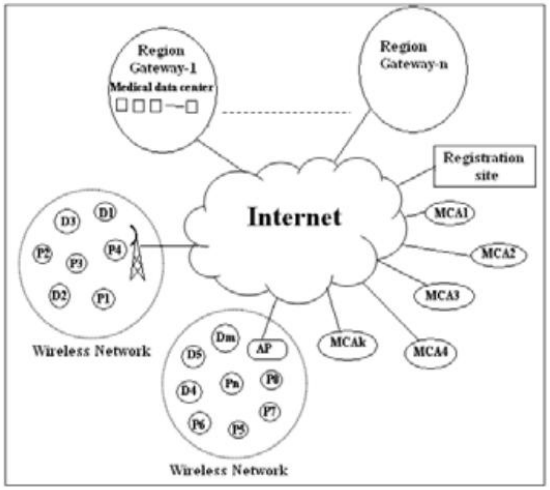


Fig. 1 Network Environment

The network environment for the proposed system is illustrated in Figure 1. It consists of clusters of medical center agents (MCA1…MCAk) within a fixed network, regional gateways, a registration site, as well as mobile patients (P1…Pn) and doctors (D1…Dm) in a wireless setting. These clusters are organized based on their physical geographic locations, with each cluster housing multiple medical centers. The gateways are connected to the network according to regional divisions.

Mobile users or patients are situated within the vicinity of a wireless local area or cellular network. Patients within a specific region request their respective regional gateway to arrange appointments with doctors. The gateway integrates medical center data, case base information, and patient preferences to identify relevant medical centers and doctors, facilitating the scheduling process. An agent platform is deployed across all components of the network environment to support agent-based activities, given the distributed nature of the information involved.

The servers hosting medical centers are reliable and equipped with ample bandwidth and robust connectivity to accommodate requests from a large number of mobile patients.

3.2 Hospital Environment

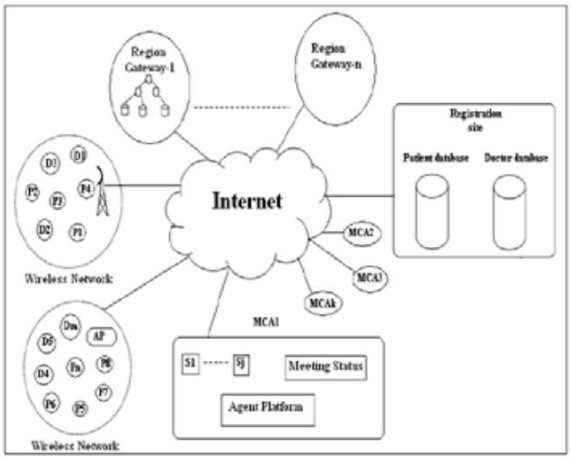


Fig. 2 Hospital Environment

Figure 2 illustrates the Hospital Environment, which comprises several Medical Center Agents operating concurrently on various servers connected to the World Wide Web (WWW). Each medical center agent manages its own data, while each doctor maintains personal information, including an updated daily schedule, on their personal computer equipped with an agent platform hosting an agency responsible for conducting meetings and communicating with patients.

The meeting status encompasses scheduling details for each patient, including appointment confirmations, postponements, or rescheduling. The registration site maintains databases of patients and doctors, as well as medical records of potential patients within the system. Additionally, the medical data centre located on the regional gateway offers information about all medical centres and doctors operating within the respective medical centre.

The agent platform provides support for persistence, security, communication, and computing services within the hospital environment.

3.4 Advantages

The proposed system offers several advantages:

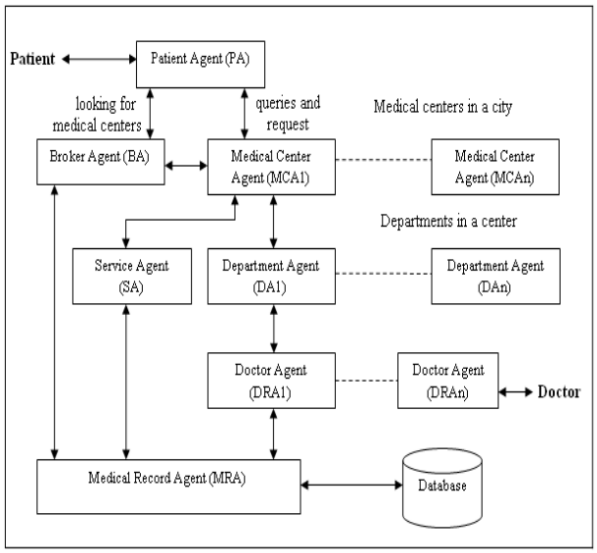
- It allows for autonomous scheduling of appointments with doctors according to patient preferences.
- Users can securely access their medical records anytime, ensuring privacy and convenience.
- The system provides support for inquiries about medical centres and the availability of doctors within them.
- Online scheduling for appointments with specialists doctors is facilitated, with their offices receiving relevant medical records automatically for references and updates.
- It guarantees high accuracy and reliability in its operation.
- The system provides enhanced time efficiency and flexibility by offering rapid and efficient access to information.

4. Requirement Analysis

The forthcoming generation of computer desktop applications is expected to be notably more proactive in assisting users in accomplishing their objectives compared to current applications. Instead of users having to meticulously outline each step of a task, the future desktop is envisioned to feature a collection of intelligent agents to which higher-level tasks can be delegated. These agents will autonomously determine how to execute the task and carry out the required actions, including managing potential interactions with other intelligent agents. This chapter presents the requirement analysis and specification of a specific agent-based application designed to coordinate meetings between patients and doctors.

5. Architecture

The primary objective of the MAS is to facilitate access to basic healthcare services within a given city for patients and to coordinate meetings between patients and doctors. The diagram depicts the interactions among agents, as well as between humans/resources and agents.



Patients interact with the system through a Patient Agent (PA), which provides a graphical user interface (GUI) for patients to make queries and receive responses. The PA stores both static and dynamic patient data, including national healthcare numbers, personal details, login credentials, and agendas. Static data is utilized for patient identification and authentication, while dynamic data aids in negotiating meetings with other agents, ensuring optimal scheduling based on patient availability.

All PAs communicate with a Broker Agent (BA), which serves as an interface between internal system agents and patient agents. The BA acts as a bridge between patients and medical centers, assisting in discovering information about the system and finding medical centers that meet specific criteria.

Patients can access the system through the Medical Center Agent (MCA), which centralizes and monitors external access. Each medical center is represented by an MCA, containing relevant information such as address, contact details, opening hours, and available services. MCAs also oversee department agents (DAs) and service agents (SAs), along with doctor agents (DRAs) specializing in various fields and maintaining their schedules.

Medical records are stored in a database accessible through the Medical Record Agent (MRA), ensuring secure access through authentication measures. When patients or doctors wish to schedule appointments, meetings are arranged considering various constraints such as service and doctor availability, as well as patient agendas. Emergency cases are prioritized, with appointments rescheduled accordingly.

The aim is to create an automated meeting scheduling agent within the healthcare domain, enabling patients to submit meeting requests, negotiate with other patient agents, identify optimal time slots, respond to incoming requests, display scheduled meetings, and accommodate patient preferences.

6. Results

This section delves into the simulated results acquired from the proposed work.

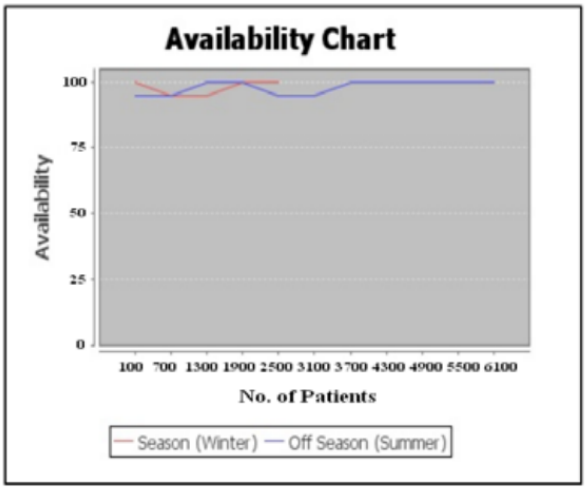


Figure 4 illustrates the Success Rate of Appointment Booking. On the X-axis, the number of patients is represented, while the Y-axis indicates the availability of doctors as a percentage, categorized into the seasons and off-seasons. During the off-season, such as summer, when the incidence of diseases is lower, doctors tend to have higher availability. Conversely, during the season,

Fig. 4 Success Rate of Getting an Appointmenttypically in winter when there's a higher influx of patients due to climate transitions, the number of diseases increases, leading to more appointment requests but lower availability of doctors. Therefore, the success rate of booking appointments fluctuates based on the seasonal variation in patient numbers and doctor availability.

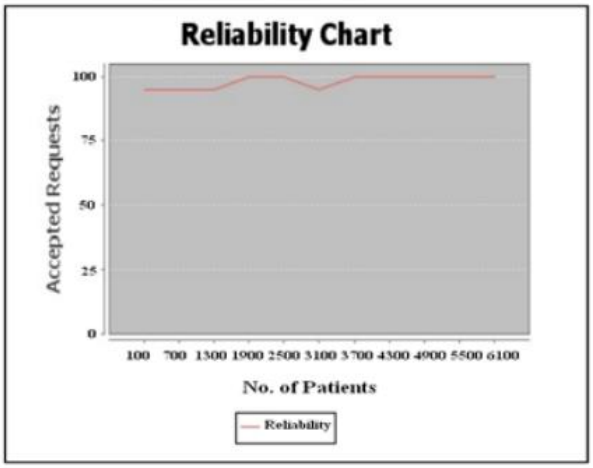


Fig. 5 Reliability of the System

Figure 5 illustrates the Reliability of the System, where the x-axis denotes the number of patients, and the y-axis indicates the percentage of accepted requests. As the number of patients increases, resulting in higher request volumes, the system's reliability also increases. The figure also depicts the Response Time of the System, with the x-axis representing the number of patients and the y-axis representing the time in milliseconds. Response time refers to the duration required to process a request, indicating how quickly a request gets confirmed after being sent.

7. Conclusion

This paper presents a framework for Intelligent Scheduling within the Health Care Domain, which has experienced notable growth in the utilization of agents. These agents facilitate interoperability among existing systems, thereby enhancing overall performance. The architecture includes agents facilitated by personal agents residing in computers or mobile devices. Key agent characteristics such as autonomy, situatedness, and flexibility are leveraged to address various challenges within the health care domain.

An example problem tackled in this paper is the efficient scheduling of patient and doctor meetings, incorporating both routine and emergency services by accessing distributed medical information across a city. A Multi-Agent System (MAS) is developed to model real conditions, courses, and human decision-making behaviours. The MAS architecture and the behaviour of each agent are emphasized, particularly focusing on the scheduling model for care activities and the interaction protocol ensuring cooperation among coordinating agents. The system is designed with reusable services to easily incorporate new agents or features, further enhancing time efficiency.

While the current implementation simulates patient personal assistants through a web interface with all agents running on the same computer, a WAP-accessible version of the MAS is necessary for real mobile environments. The paper suggests leveraging the latest version of JADE, specifically JADE-LEAP v2.4, for improved performance and reliability compared to existing mechanisms.

interacting both with each other and with humans,

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