

A Multi-Agent System For Arranging Doctor Appointments

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Abstract. In the 21st century, some countries have a deficient healthcare system, caused by population growth and the cost of care, among others. Following previous research articles concerning Multi-Agent Systems (MAS), which demonstrated how beneficial these MAS are for these scenarios, taking advantage of Agent properties, we created a simple MAS which is capable of booking appointments with specialized doctors.

Index terms: healthcare, agent, multi-agent system, communication.

I. Introduction

Nowadays, there are some poverty-stricken countries with critical issues, such as Tunisia. One of these is the healthcare sector, which is entirely unsustainable. The number of clinics is significantly low in order to satisfy the population's needs. Additionally, the lack of medical equipment and human resources is also unsatisfactory.

Nonetheless, the most consequential drawback is the lack of a communication infrastructure between services. That is the dilemma we focused on.

To ensure good communication, we thought multi-Agent systems are one of the finest alternatives, owing to the fact that these systems were specifically crafted to communicate and negotiate between them.

II. State of art

Our work is based on previous articles concerning multi-Agent systems and the healthcare domain.

Fields	Systems
Decision support systems	Singh et al. 2005 Hecase2 2008 Health agents 2008
Remote care	Aingeru 2007 Koutkias et al. 2007
Planning and resources allocation	MIA 2005 CARREL 2008 Agent Hospital 2008
Medical data management	NeLH 2005 VEPR 2006 CHIS 2008
Composite systems	SHAREIT 2008 Ger Ami 2008 K4Care 2009 Mutingi and Mbohwa 2013 Haeng-Kon Kim 2013

These articles are divided into five fields:

- Medical Data Management. It presents all systems focused on the management, retrieval, and processing of data.

For instance, The National electronic Library for Health (NeLH) is a governmental project from the National Health Service (NHS) from the UK. NeLH introduces a portal to recover medical information via the Internet [1]. The NeLH system contains network agents in order to update information, management, and automation of the documents.

- Decision Support Systems. This presents all systems and approaches aimed to help and assist caregivers in the performance of medical tasks.

For instance, Singh et al. [2] present an intelligent assistant agent in healthcare. This assistant was considered to recover and use knowledge in order to solve medical episodes. They use case reasoning in to capture the experiential knowledge of healthcare [3].

- Planning and Resource Allocation. It presents all systems focused on the scheduling and planning of physical and human resources.

For instance, CARREL is an Agent-Mediated Electronic Institution for the distribution of organs and tissues for transplantation purposes [4]. CARREL assists caregivers in the decision-making during the sharing and allocation of pieces for transplants.

- Remote Care. It presents approaches focused on the remote monitoring of patients.

For instance, The Aingeru system supports intelligent, permanent, and persistent monitoring of elderly people through the PDA data [5].

- Composite Systems. It presents all systems which offer complete healthcare solutions.

For instance, SHAREIT (Supported Human Autonomy for Recovery and Enhancement of Cognitive and motor disabilities using Agent Technologies) is a MAS that integrates technologies to build tools for users with sensors[6].

As you can see, there is a high number of research projects done in this field of expertise quite recently. However, these articles propose very complex systems, which leads to a lack of efficiency when the difficulty and size of the environment increase. We wanted to take a different approach, so we proposed a significantly simpler system.

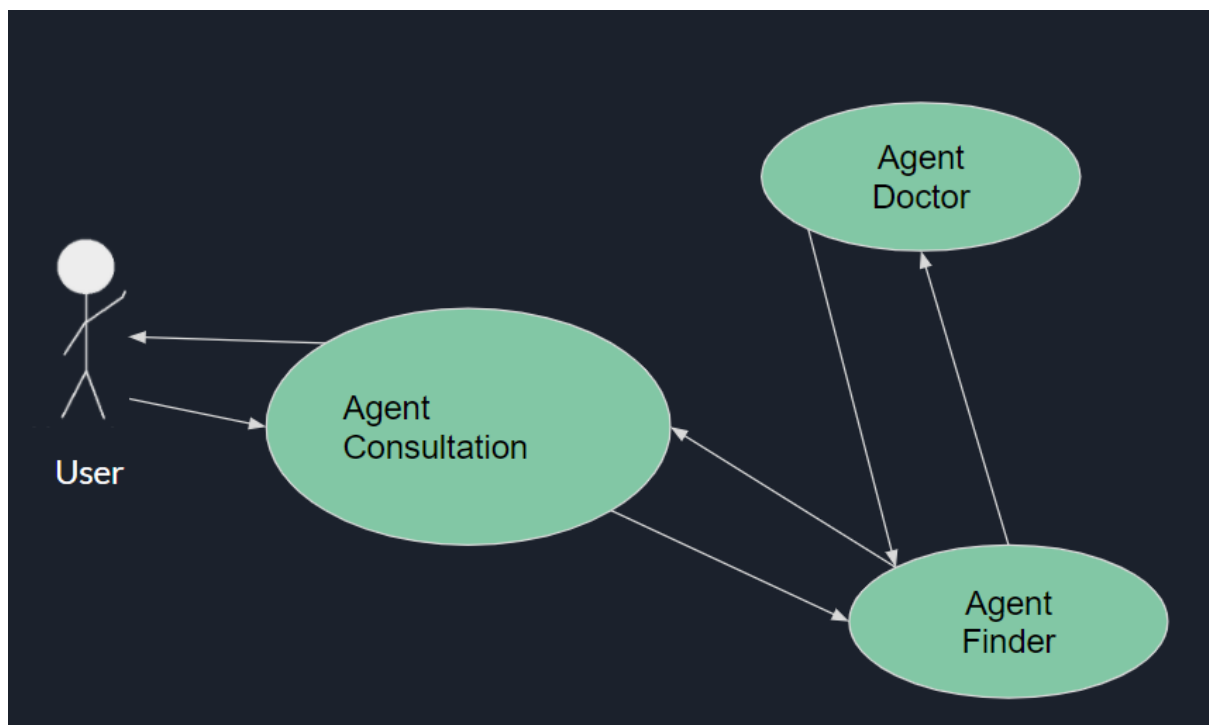
III. Proposed architecture

Our system is composed of three types of agents: Agent Doctor, Agent Consultation and Agent Finder.

Agent Consultation: this agent oversees communicating with the users. The agent will get the user data, which will be the required doctor type, and will also send the information to Agent Finder. It will return a suitable expert to the user. In case there is not an appropriate specialist, it will display a message to the user that asked for it. Each Agent Consultation will take care of a user.

Agent Finder: this agent will communicate with Agent Doctor, and its purpose is to find a convenient doctor given the information sent by Agent Consultation. Once it has it, it will return it to Agent Consultation.

Agent Doctor: this agent will get an appointment with a fitting given the information sent by Agent Finder and will return the data to Agent Finder.



IV. Results and conclusion

In order to solve the problems, we used JADE (Java Agent Development Framework) and Java.

Both Agent Finder and Agent Doctor implement a Cyclic Behaviour, whereas Agent Consultation implements a OneShot Behaviour.

Our model is based on a class called Doctor, which contains all the information related to one doctor, such as the name, the field of expertise, and available appointment dates. That's why our model has a list of objects of the class Doctor.

```
public class Doctor {  
  
    private String nombre;  
    private String apellido;  
    private String especialidad;  
    List<String> fechas;  
    List<Integer> consultas_disponibles;  
}
```

To make a more pragmatic approach, we've decided to create these Doctor objects based on the real data of a hospital in Salamanca.*7

Additionally, we used the Date class from java.util*8, and we used it to calculate every date between a range defined by two dates. *9

The way these agents communicate is by using the ACL Message type. Agent Consultation will send the field of expertise the user inputs.

Agent Finder will send a message to Agent Doctor with the field of expertise and once it has the information back, it will send the doctor to the Agent Consultation that asked for that medic.

Agent Doctor will get the satisfactory doctor and will get the nearest appointment. Then, it will send a message back to Agent Finder with the results.

These Agents will not be working in the background unless they have messages to work with, since they are using the Blocking Receive method.

Here's an example of the program execution with two Agent Consultation:

```
INFO: -----
Agent container Main-Container@192.168.56.1 is ready.
=====
Bienvenido al servicio de consultas del hospital de Salamanca
=====

Los servicios disponibles son: Cardiologia, Neurologia, Urgencias, Traumatologia, Neumologia, Aparato digestivo, Urologia y Atencion primaria

Introduce el tipo de medico con el cual desea concertar una cita:
dic 08, 2021 8:45:06 P. M. jade.core.PlatformManagerImpl localAddNode
INFO: Adding node <Container-1> to the platform
dic 08, 2021 8:45:06 P. M. jade.core.PlatformManagerImpl$1 nodeAdded
INFO: --- Node <Container-1> ALIVE ---
dic 08, 2021 8:45:15 P. M. jade.core.PlatformManagerImpl localAddNode
INFO: Adding node <Container-2> to the platform
dic 08, 2021 8:45:15 P. M. jade.core.PlatformManagerImpl$1 nodeAdded
INFO: --- Node <Container-2> ALIVE ---
dic 08, 2021 8:45:18 P. M. jade.core.PlatformManagerImpl localAddNode
INFO: Adding node <Container-3> to the platform
dic 08, 2021 8:45:18 P. M. jade.core.PlatformManagerImpl$1 nodeAdded
INFO: --- Node <Container-3> ALIVE ---
Cardiologia

Cita concertada con el doctor Pedro Luis Sanchez en la fecha 2021-11-17
```

```
dic 08, 2021 8:45:06 P. M. jade.core.BaseService init
INFO: Service jade.core.management.AgentManagement initialized
dic 08, 2021 8:45:06 P. M. jade.core.BaseService init
INFO: Service jade.core.messaging.Messaging initialized
dic 08, 2021 8:45:06 P. M. jade.core.BaseService init
INFO: Service jade.core.resource.ResourceManagement initialized
dic 08, 2021 8:45:06 P. M. jade.core.BaseService init
INFO: Service jade.core.mobility.AgentMobility initialized
dic 08, 2021 8:45:06 P. M. jade.core.BaseService init
INFO: Service jade.core.event.Notification initialized
dic 08, 2021 8:45:06 P. M. jade.core.AgentContainerImpl joinPlatform
INFO: -----
Agent container Container-1@192.168.56.1 is ready.
=====
Bienvenido al servicio de consultas del hospital de Salamanca
=====

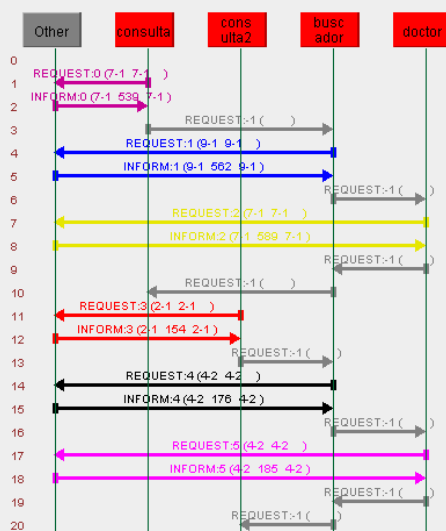
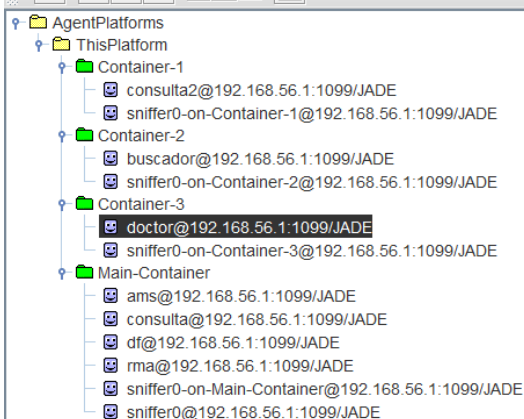
Los servicios disponibles son: Cardiologia, Neurologia, Urgencias, Traumatologia, Neumologia, Aparato digestivo, Urologia y Atencion primaria

Introduce el tipo de medico con el cual desea concertar una cita:
Neurologia

Cita concertada con el doctor Jose Carlos Moran en la fecha 2021-11-17
```

sniffer0@192.168.56.1:1099/JADE - Sniffer Agent

Actions About



As you can see, the sniffer shows the communication between the agents as we explained before.

Our proposed system has certain advantages:

- Fast user interaction. Users can now set an appointment without a phone call.
- Portability. This system uses a standard communication system such as ACL.
- Extensibility. This system can withstand a high number of users at the same time, and more features could be implemented in the future.

In conclusion, Multi-Agent System properties are highly promising in the healthcare domain, given their properties (pro-activity, reactivity, sociability, and autonomy) and how proficient they are with problems that require a significant amount of communication and coordination.

More improvements could be made to this system in the future, since its high extensibility property. For instance, we could be able to communicate between different hospitals or the ability to add and delete more doctors to it.

V. References

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