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Jolanta Mizera-Pietraszko
Pit Pichappan · Lahby Mohamed
Editors

Lecture Notes in Real-Time Intelligent Systems

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Preface

Nowadays, powerful intelligent systems adopt variety of sophisticated novel approaches aimed to respond to the challenges of the real-world problems. Across almost all the domains, dynamical progress in development of innovative conceptual models, paradigms, and techniques of big data processing reflects in science and profoundly transforms the industrial infrastructure. Simply saying, artificial intelligence supports human intelligence in most areas.

This volume explores the current methodologies based on the state of the art in real-time intelligent computation. It presents the studies that address the real-world challenges and provides a complete synthesis of the research reflections in computer-aided intelligence.

The 46 research works published in this volume have been selected for oral presentations out of a total of 149 submissions received from many countries. They were presented at the Second International Conference on Real-Time Intelligent Systems held at Casablanca in Morocco during October 18–20, 2017. RTIS 2017 conference was organized by Digital Information Research Foundation in India and the UK and sponsored by University of Hassan II in Morocco.

This collection of chapters offers the latest trends in development of real-time intelligent computation and provides the comprehensive solutions to numerous challenging issues.

For that reason, the proceedings of the RTIS 2017 conference are mainly recommended not only to the scientific community but also to IT consultants, software developers, and all those interested in intelligent computing.

The Editors would like to express special thanks to this book series Editor Professor Janusz Kacprzyk and the Springer Editors for their work on publication of this volume. We are very thankful to the RTIS 2017 Chairs, Program Committee Members, and the authors who contributed to the growth of the domain.

Jolanta Mizera-Pietraszko
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Contents

Modelling Intelligent Systems

Modeling, Design and Development of a Multi-agent Decision Support System for the Real-Time Control of the Operating Theaters

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Abstract. The effective management of the hospital system user depends on multiple factors including the anticipation and responsiveness. A system of this exceptional situation is characterized by sudden onset of several elements that disrupt the execution of operatory program underway. Dealing with this kind of situations, the hospital must have a tool to help making decisions on time. In this context, we modeled the process of emergency care in the operating room with an IDSS (Interactive Support System Decision) embedded in a system multi agent (MAS). Specifically, the agents are assisted by a decision support system for planning elective surgery and the allocation of the necessary human and medical resources. Agents express their preferences using the method ELECTRE III to resolve the differences. The negotiation mechanism is based on the CNP (Contract Net Protocol). The protocol developed on JADE (Java Agent Development Framework) provides message exchanges between agents and their proposes predefined behaviors. The approach is tested through simple scenarios

Keywords: Coordination · Decision · Modeling · Multi-agents
Operating theaters · Real time

1 Introduction

The operating theaters are a very costly bottleneck in most hospital systems. All patient flows from the various surgical departments converge towards the operating theaters. In order to manage these flows, an operational programming is established. It is a question of specifying, in an operative program, the list of patients to be operated as well as their order of passage in each operating theaters and possibly in the post-operation care theaters (SSPI). However, this operating program is not often respected because of disruptions (arrival of emergencies) which constitute a reality of the operating theaters, which necessitates taking decisions and carrying out rapid actions.

The work presented in this paper describes a robust approach to guarantee the performance of the operative and flexible program allowing the real-time control of the operating theaters and to help the decision-makers of this block manage the hazards by

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defining. This approach is based on Integration the multi agents (MAS) in Interactive Decision Support System (IDSS). We define a supervisor agent, and the service agents.

The (IDSS) [1, 2] is an interactive computer-based system intended to help decision makers use communications technologies, data, documents, knowledge and/or models to identify and solve problems, complete decision process tasks, and make decisions.

The remainder of this paper is organized as follows: Some of the health care applications based on agent and, a general description of the problem is illustrated in the Sect. 2, in Sect. 3 we propose a multi-agent architecture based (IDSS) as a solution to the problem of decision support for the real-time control of the operating theaters, where we detail the behavior of each agent. In addition, we propose a scheduling method based on interactions between services agents and supervisor agents using (CNP), a well-known protocol for coordination, to efficiently allocate resources, and (JADE) in Sect. 4. The implementation of the model is described in Sect. 5. Finally, in Sect. 6 we presented the Conclusion and future works.

2 Related Works

Today, the (MAS) represent a new technology for the design and control of complex systems. They have been applied successfully in the field of health in general and problems related to operating theaters structures in particular, where agents must be able to interact and communicate with one another to resolve differences of opinion and conflict Of interest [3].

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 [4] Huang et al., they designed a (MAS) for distributed medical care, facing challenges regarding the distribution of data and control, information uncertainty, and environment dynamism. The coordination mechanism is based on commitments and conventions between different types of agents. The task allocation and coordination is done by managing agents that manage the execution of tasks and by contractor agents that execute the task.

Kim [5] presents a multi-agent system based proactive u-healthcare system which incorporates different functions designed to resolve problems for the sake of rapid and efficient mobile u-healthcare agents. The proposed system allows the system itself to recognize and identify u-healthcare domain problems arising.

Mutingi and Mbohwa [6] propose homecare multiagent system architecture in order to make decision with multiple objectives. The system integrates MAS based on Genetic Algorithm and Web Services that provide decisions in a dynamic multiple-objective environment. The proposed architecture consists of a number of agents that coordinated through efficient communication in homecare dynamic environments.

Decker and Li [7] modeled MAS for hospital patient scheduling with complex medical procedures. They took a function-centered view and modeled nursing wards as autonomous agents. They developed a generalized partial global planning (GPGP) approach as a constraint-based coordination mechanism. It is constructed to avoid

resource conflicts and patients are treated as exclusive resources that are handled by a special mechanism.

Nealon and Moreno [8] have discussed various applications of SMA in health care e.g., coordination of organ transplants among Spanish hospitals, patient scheduling, senior citizen care etc.

Riano [9] developed information technology and multi-agent systems to improve the care given to palliative patients.

The works mentioned above are domain specific, e.g. catering to special types of patients. These systems are therefore, not capable of handling problems related to taking care of emergency patients at operation theaters as presented in Sect. 1. More precisely, the efficacy of agents in this application area has still not been explored. So, in the subsequent sections we are introducing and highlighting the concept of using agent technology and the theorem the decision support systems in this regard.

3 Decision Support for the Real-Time Control of the Operating Theaters

3.1 Definition

Operating theaters department and the planning and scheduling of the operating theaters can be regarded as the engine of the healthcare surgery system. The entrance to the surgery system occurs either through the emergency system or the elective surgery [10].

The electives patients who do not need emergency medical treatment and can be served on a pre-agreed time and the emergency patients are served just after arrival. Important decisions of how to allocate the operating theaters capacity between the different surgery specialties. Also considerations have to be taken regarding prioritization, in which emergency cases have the highest priority [11, 12].

3.2 The Agents-Based Approach for Modeling the Operating Theaters

The functioning of the block is determined by a preliminary operating program which specifies the patients to be operated during the day, the various critical resources assigned to each operation and the order in which operations are carried out. However, it is possible that this operating program is not respected because of the different types of hazards that can occur. These uncertainties include uncertainty in the prediction of surgical time, unforeseen complications, the arrival of urgent cases to be performed during the day, before a given time. For this reason, a real-time control tool seemed to be appropriate for the operating theaters. In addition, real-time management complements the proposed decision-making approach, since it allows the decision-making process to be aided when a hazard occurs. Particular attention has been paid to the study of the consideration of urgency in the surgical program. We proposed a real-time approach based on multi agents [13] and a decision support system, the principle of supervision and mathematical modeling to help the piloting of the operating theaters in front of the occurrence of this type of hazards.

The agents used in our approach are cognitive agents; they are diverse by their specific functions. It is a real multidisciplinary co-operative team, participating in the design and implementation of decisions by combining their efforts and constantly adapting to the evolutions of the operating theaters system. Service agents and supervisors are distinguished.

The model of the proposed agents is adapted to the context and the specificities of the operating theaters. In particular, it enables research, selection, negotiation, coordination and cooperation to be carried out in order to realize a real-time control of the operating theaters (Fig. 1).

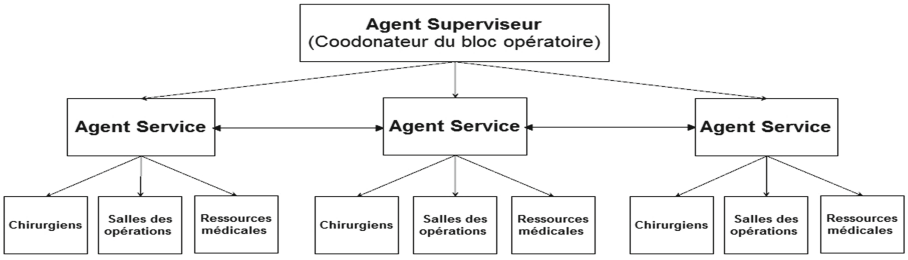

Fig. 1. The proposed approach for the piloting of the operating theaters (Multi-agent structure)

3.3 Structure of Agents

3.3.1 The Supervisor Agent

The supervising agent (cognitive agent) models the supervision and negotiation system in the operating theaters. Its role is then:

- Manage resources within the operating theaters;
- Receive requests for assignment of urgent operations;
- Receiving and negotiating medical resources available with the surgeon;
- Assist surgeons in decision-making to improve the scheduling of surgical operations;
- The supervisor also has the role and needs of patients.

A supervisor is composed of several subsystems:

The Analysis and Reaction Module: This module performs a continuous analysis of messages that the supervisor receives from all agents, through its communication interface, and activates the behaviors that correspond to them. It also updates the states of operations in the global agenda following messages sent by surgeons.

Behaviors: The supervising entity has a set of behaviors to accomplish its task:

– The CPC Behavior: is used to find the service agent satisfying the objectives to be achieved for the assignment of urgent surgical operations.
– CPM behavior: aims to find the best medical resources for a surgical operation (in case of unavailability of medical resources).

The Global Agenda: This schedule allows the supervisor to represent and monitor the progress of all operations in the system. This calendar also makes it possible to reconstruct the information of any local diary specific to an agent service.

The Communication Interface: Handles messages in transit between the supervisor agent and all other agents in the system.

The Real-Time Clock: Generates time by the supervisor.

3.3.2 The Service Agents

Each service agent (cognitive agent) has a sufficient level of knowledge to allow decision-making, its role is then:

- Real-time localization of scheduling processes, queues, etc.
- Manage the availability of resources necessary for surgical operations.
- Manage priorities between surgical operations.

The Analysis and Reaction Module: Performs a continuous analysis of the messages received by the supervisor, through its communication interface, and activates the behaviors corresponding to the events received. Thus, the state of surgical operations is updated.

The Behavior of the Service Agent: The behaviors are as follows:

– The Service agent-type1 behavior: is to manage the service agent queue and select the next surgical operation to be performed.
– The agent-service2: agent behavior: searches for resources to replace resources that are not available.

Local Agenda: The agenda being a form of representation of the commitments of every surgeon, obeys the following rules:

– 1st. At each beginning of a surgical operation, the service agent enters his or her agenda as the start of this surgical operation and reports it to the supervisor.
– 2nd. At each end of surgical operation, the service agent enters his or her diary the end of this surgical operation and reports it to the supervisor.

The Expert Interface: Allows the surgeon to view and modify the agent's configuration, to know the current state of the resources, and to monitor the evolution of the operating theaters activity.

The Communication Interface: Allows the management of messages in transit between the service agent and the other entities of the system.

Real Time Clock: Generates the real time factor in the agent service agent.

Each service agent is equipped with two additional modules in the decision subsystem:

The Proposal Generator: Constructs a proposal for a given surgical operation according to initial parameters and surgeon preferences.

The Decision Support Module: Is applied when each agent evaluates the solutions using a multicriteria decision support technique. In our system, Electre III [14] (ELIMINATION AND CHOICE REALITY TRANSLATION) is used to fulfill this function.

Among the ELECTRE methods, ELECTRE III is chosen because it allows us to propose a ranking of resources from the best to the worst, taking into account the effect of each of the criteria (non-compensation between the various criteria) To showcase incomparable resources.

Because of its properties, it is therefore quite appropriate to solve the problem of choosing a resource in an operating theaters management context.

3.3.3 The Coordinating Agent

The coordinating agent ensures that the coordination between the surgeons and the supervisor functions properly, executes the coordination process, processes the messages received and has a mechanism for processing message contents.

A negotiation coordinating agent comprises several types of functional modules such as:

The Module for the Management of Activities in the Operating Theaters: Is the core of this architecture, its role is to break down a complex problem into sub-problems; by its participation it provides valuable assistance to the supervising agent.

The Coordination Module: Allows to manage the stages of the negotiation and synchronizes the different results obtained. This module takes into consideration the overall coordination process.

The Database: Contains information about surgeons, who can perform operations, and all the necessary information and knowledge about the agent himself: his abilities and skills.

The Interface Module: Manages the exchange of information between the coordinating agent and the other agents (Fig. 2).

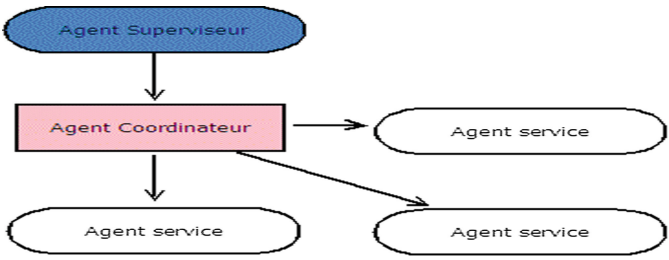

Fig. 2. Negotiation model

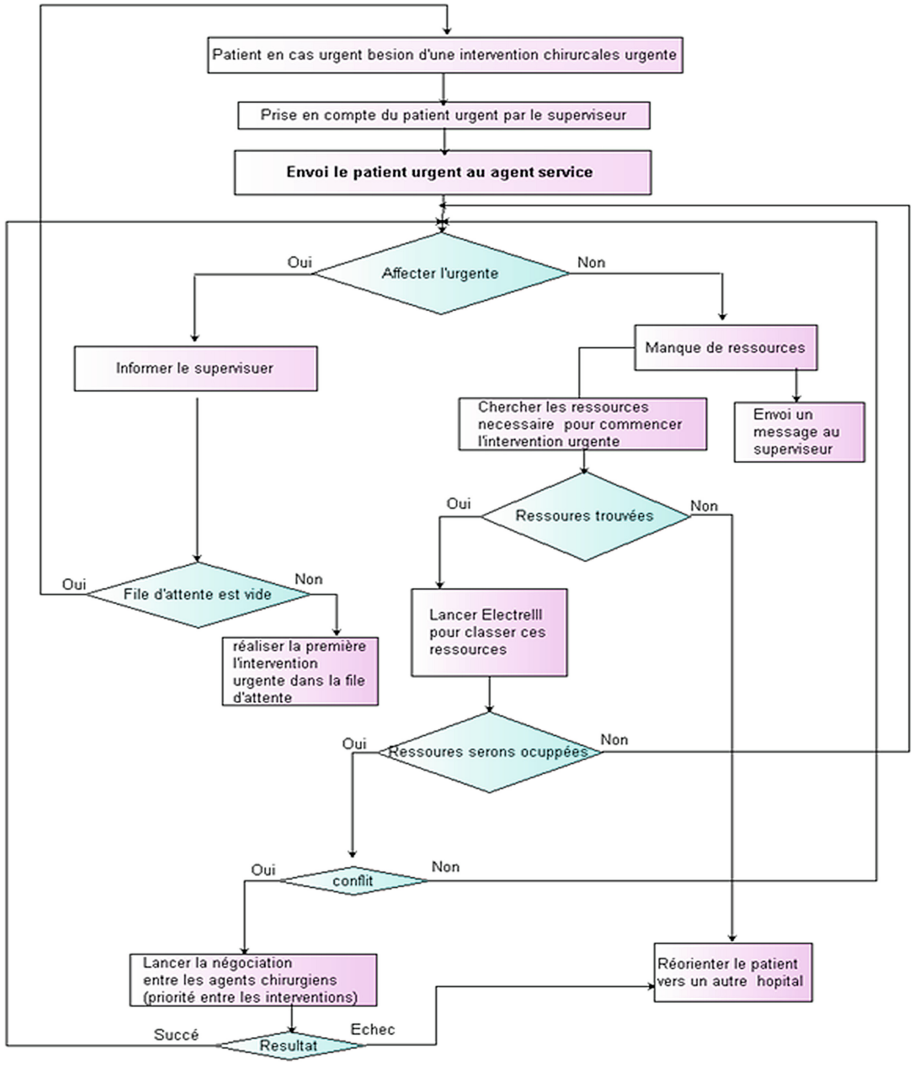

Fig. 3. Flowchart describing the points of integration of the negotiation and the ELECTRE method in the process of solving the problem posed

3.4 Decision-Making Levels

For each operation surgeon who arrives the supervisor must launch a request of execution to the surgeon able to realized it. Following this, it receives an acceptance or refusal response

1. In the first phase, the service agent recognizes the arrival of urgent matters, and triggers local decision- making processes. In case of success (all resources are available) it begins the urgent operation.

2. In the second phase, the service agent fails in the insertion of the urgent caused by a lack of resources or a situation of conflicts over the use of certain common resources. The service agent then opens the negotiation. The protocol is based on the traditional approach of the Contract Net Protocol (CNP) [15]; each service agent expresses their preferences, their priorities.

Decision-making processes use the ELETREIII multicriteria aid method. The surgical agents are in several cases, the most important correspond to:

– A service agent who encounters the problem when inserting the urgent, must make a decision in collaboration with the other service agents, it is called initiating service agent.
– A service agent who suffers the consequences of delay or disruption in performing surgical operations due to a conflict over the common resource or other unforeseen event.

Figure 3 describes the different steps of solving the problem, the unavailability of resources (the resource breaks down or it does not exist or is busy) following the arrival of an urgent order.

4 Agent Negotiation Protocol

4.1 Problem Solving by UML Diagram

At the arrival of the urgent the supervisor starts by assigning the urgent to the services decision-makers, in case of certain resources is not available or broken down, the decision-making service agent launches the Electre III method to prepare its strategy of resolution (Figs. 4 and 5).

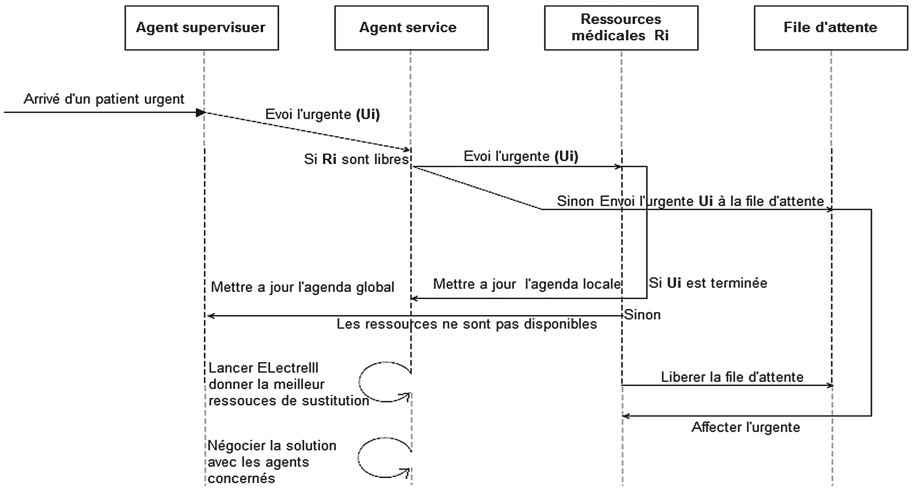

Fig. 4. Sequence diagram

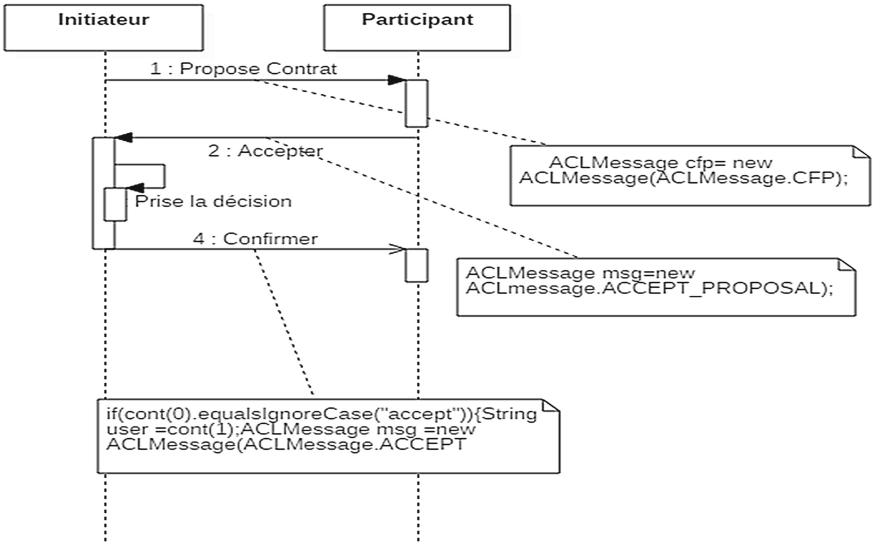

Fig. 5. Sequence diagram of the negotiation based for (CNP)

We describe in this section some scenarios of the negotiation as between the agents

4.2 Resource Allocation Algorithm

The coordinating agent applies the resource allocation algorithm after it receives resource allocation requests from the service agent.

```
Répéter
Réception des demandes d'allocation de ressource Ri par les agents services
RequestList[]=liste des ressources demandés ;
AgentRest[]=liste des agents demandeurs ;
Identificateur de l'état de la ressource Ri ;
      If (Ri.Etat = n'existe pas)
       Envoi le rejet d'initialisation à l'AgentRest[]
      Else
      If(Ri.Etat= occpées)
           Identification de la durée de libération de la ressource
                D=durée de la libération de la ressource
                Demande de rappel de demande de ressource après temps =D
      Else
      If Ri.Etat==libre
      //selon la priorité d'AgentRest
      Identification des priorités des opérations d'AgentRest
      AgentRest[]=PrioritéMax(AgentRest)
      If (AgentRest[]= contient un seul demande)
      Allocation faite pour AgentRest[]
```

Algorithm 1. The resource allocation algorithm

4.3 Resource Unavailability Algorithm

During the arrival of emergencies the resources are in constant danger of breakdown or are not available, whereas the realization of surgical operations is imperative. The service agent uses Algorithm 2 to find resources that are similar to resources that do not exist or are not available.

```
L'agent service reçoit la demande de l'urgente
Mise à jour de la base de données de l'agent service
Ressources « R» pour réalisation de l'urgente ne sont pas disponibles
(n'existe pas)
Recherche des ressources identiques à R
Demande de l'aide l'agent coordinateur ;

Traitement de l'aide l'agent coordinateur ;
      If (proposition de ressource)
       Envoi la confirmation de l'affectation de l'urgente  à l'agent
     superviseur
      Else
       Affectation impossible
       Ajout des informations du manque de ressources à la BD de l'agent
     coordinateur
Fin
```

Algorithm 2. Resource unavailability algorithm

4.4 Information Retrieval Algorithm (Request for Help)

The agent uses Algorithm 3 to search for information about resources

```
Réception de demande d'aide de la part de l'agent service
Liste_ressource[]=recherche liste de ressources identiques Libres
If (Liste_ressource[].size==1)
   Envoi proposition Liste_ressource[]d'allocation
   Réception la confirmation
Else
   If (liste_ressource[] !=0)
     R=choisir entre Liste_Ressource[]
     Envoie de R à agent service
   Else
   //Recherche des ressources identiques sous le contrôle des autres agents
   Liste_ressourcesIdentique []
     If (liste_ressourcesIdentiques[] !=0)
       Envoie de ressourcesIdentique [] à chirurgien
     Else
         Envoie pas d'aide ;
Fin
```

Algorithm 3. Information retrieval algorithm (request for help)

5 Experimentation of the Proposed Approach

In this simulation example, we chose, as the scenario, the negotiation between a supervisor and four Agents served who interact with each other in order to reach a compromise on the insertion of urgent surgical operations. These interactions are summarized in the following actions:

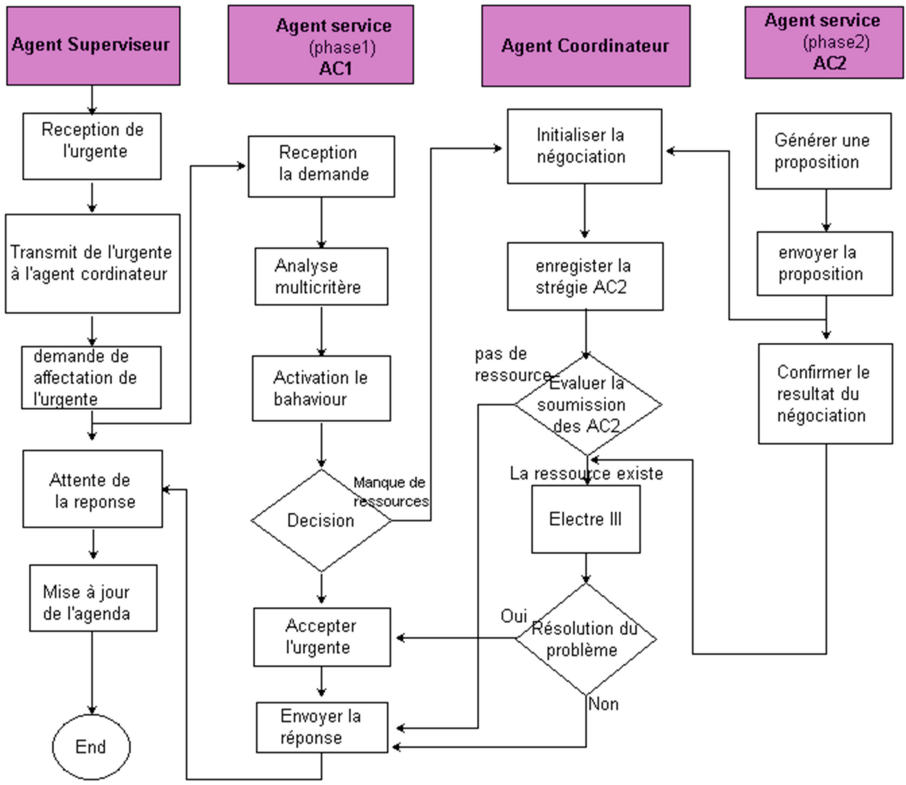

Fig. 6. Organization chart describing the states of the agents during the two decision-making phases

1- The supervising agent asks the service agent 2 (AC2) to insert the urgent operation,
2- If the resources (e.g. the operating theaters or the surgeon…) controlled by the service agent1 are not available or are inoperative, the analysis and reaction module detects this event and determines the associated behavior.
3- If the process fails, Service Agent 2 (AC2) redirects the resource request to the supervisor, triggering the supervisor's type1 behavior.
4- The supervisor sends the request to the other service agents, and processes the answers received in order to solve the problem posed.
5- The result will be communicated to the selected service agent and to the requesting service agent1 (AC2).

6- The service agent4 responds favorably to the supervisor's request (end of the first phase of the decision- making process).
7- Service and service agents find themselves in a situation of conflict.
8- The negotiation is then opened: the service agent 2 (AC2) becomes initiator and the agent serivce4 becomes the participant.
9- The initiating agent provided with its module of generator of propositions, formulates a proposition that it sends to the participating service agent.
10- The agent formulates his contract after consulting his evaluation matrix; Preferences and priorities between operations. Proposal evaluation or counterproposition is facilitated by the results given by ELECTE III in application of the over-ranking algorithm (Fig. 6).

To implement our proposed application, we have chosen JADE (Java Agent Development Framework) as a software framework for developing MAS. JADE presents several advantages [16] such as Interoperability, Portability, Simplicity, Distributed, Programmable interface and FIPA [17] (Foundation for Intelligent Physical Agents) protocols Library Standard. Also there are different reasons for using Jade in our application (Figs. 7, 8, 9, 10 and 11).

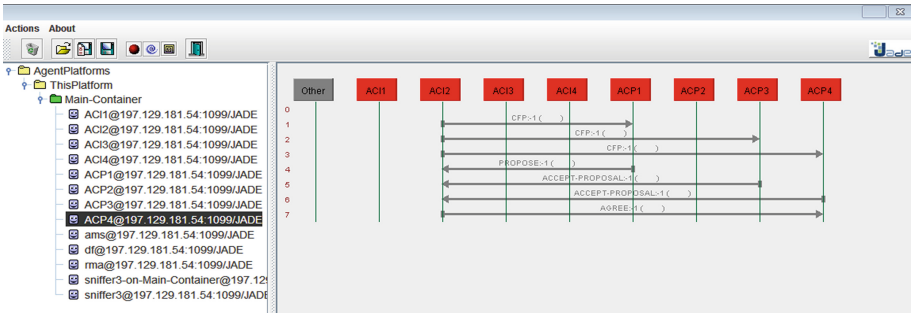

Fig. 7. Scenario negotiation results on the Sniffer

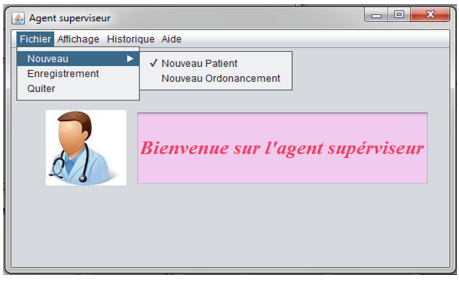

Fig. 8. Supervisor agent

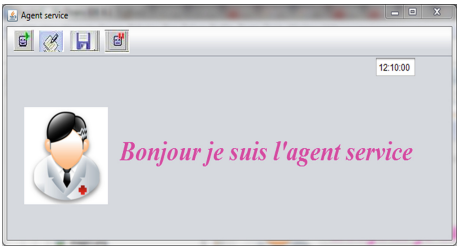

Fig. 9. Service agent

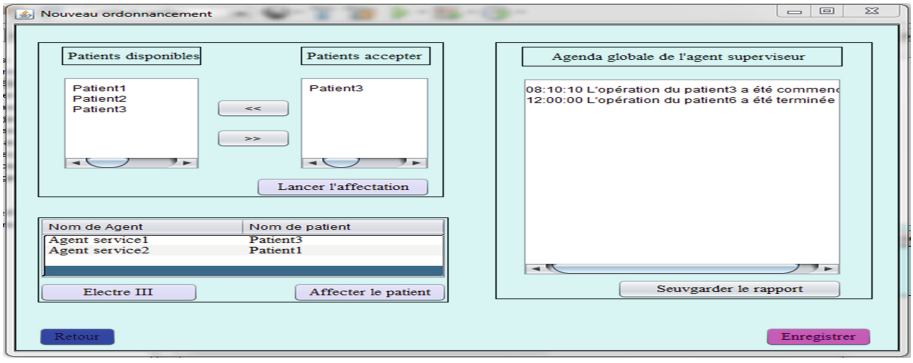

Fig. 10. Description of new ordering request

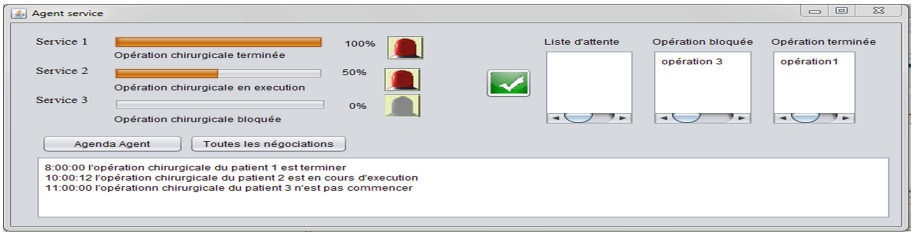

Fig. 11. Negotiation scenario

6 Conclusion

The goals to be attained are an "optimal" and rational use of resources respecting the various constraints of the operating theaters. To do this, we have developed a means of representing a scheduling through a global plan followed by the decision-makers (Service Agents). In practice, the computing time requirement remains an essential element in the construction of scheduling [18–20].

The problems that have been dealt with in this thesis relate to the optimal management of resources by setting up mechanisms to deal with and correct the problems of causing by the occurrence of urgent cases, and lack of resources [21]. This situation can easily lead to management of assignment of urgent surgical operations.

The application developed using the JADE platform enabled us to exploit all the communication management possibilities between the service agents.

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Applying Data Analytics and Cumulative Accuracy Profile (CAP) Approach in Real-Time Maintenance of Instructional Design Models

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Abstract. In a constantly changing climate, professors find themselves in a pressing demand to tailor their ways in schooling, according to the needs of the market and students. In conjunction with providing quality learning experiences, whereas the ambition is to attract the millennial generation that constructs a large portion of the student population. However, in an interconnected world with a massive data generated every second, there are opportunities to use it as a tool to gain insights on the seemingly chaotic environment. The aim of this paper is to provide a way to support decision making made by the instructional design engineers, by providing them with an objective method based on the cumulative accuracy profile curve that allows to assess, retrain and rebuild instructional design models used in constructing courses. Moreover, we propose a set of tools for applying this approach in decision making and managing educational resources more efficiently.

Keywords: Learning analytics · Big data · Modeling · Reporting systems
Instructional design

1 Introduction

Implementing an adaptive educational system, that is based on the real-time flow of data is not a simple task to achieve, as it focuses on different parts of the educational system and goes from the ground up to incorporate the best practices from different fields.

The focal point of this paper is to demonstrate the use of a data science approach, that will support first of all teachers in gaining insights about their instructional design method and adapt their teaching style accordingly.

Teaching is a highly complex activity [1]. That requires a high level of skills and knowledge. Before digging inside, there are some assumptions that this work is based on, it will guide you to understand and use the results of this article especially if you are

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