Fuzzy Multi Agent System for Automatic Classification and Negotiation of QOS in Cloud Computing

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Zineb Bakraouy, Wissam Abbass, Amine Baina, Mostafa Bellafkih

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Abstract: *The use of Multi Agents Systems (MAS), Cloud Computing (CC) and Fuzzy Inference System (FIS) in e-commerce has increased in recent years. The purpose of these systems is to enable users of electronic markets to make transactions in the best conditions and to help them in their decisions. The design and implementation is often characterized by the constant manipulation of information, many of which are imperfect. The use of the multi-agent paradigm for the realization of these systems implies the need to integrate mechanisms that take into account the processing of fuzzy information. This makes it necessary to design multi-agent systems (MAS) with fuzzy characteristics. For the modeling and realization of this system, we chose to use the FMAS model. This paper deals with the presentation of the use of the Fuzzy MAS model for the development of a management and decision support application in a virtual market with high availability. After the presentation of the system to be realized in the first section, we describe in the second section the application of the model FMAS for the design and the realization of this system. We then specify the JADE implementation platform and how the fuzzy agents of our model (Expert, Choice and Query) can be implemented using this platform*

Keywords: *MAS, SLA, Negotiation, QOS, Availability, Web Services, Service Broker, Classification, Fuzzy Logic, Inference System, Fuzzy Inference System*

1. Introduction

Modern systems such as industry, economics, marketing, and ecology are increasingly based on computer systems, which are responsible for helping users to deal with problems and make decisions [1]. The complexity of the computer systems that need to be put in place leads many researchers to use modeling based on the multi-agent paradigm for the realization of these systems. This approach makes it possible to take into account the complexity of these systems by extracting the entities of actions that must be presented in the modeling of the system. The implementation of modern systems [2] (with the accompanying human-machine communication problems) is often characterized by the constant manipulation of information, many of which are imprecise, vague, uncertain and incomplete. However, the use of the multi-agent paradigm implies the need to integrate mechanisms that allow it to take into account uncertainty, inaccuracy and incompleteness of information. It is known that fuzzy logic [3] is the only framework in which inaccuracies and uncertainties can be dealt with, which also allow the treatment of certain incompleteness. It is also the only framework in which digital knowledge and knowledge symbolically expressed by natural language skills can be processed. This makes it necessary to design multi-agent systems (MAS) with fuzzy characteristics. Many applications of fuzzy logic that have been performed around the world have been proven effective in solving various types of problems in which the available knowledge is imperfect. Multi-agent technology with its features is the best way to model and build complex distributed systems [4, 5]. The combination of these two technologies should therefore open up a new avenue of research for the design and realization of modern systems that are often complex systems, composed with several entities interacting in distributed mode, and furthermore they are characterized by imprecision and uncertainty.

As part of our work, our goal is to take into account the fuzziness in agent-based systems in order to be able to manage applications in which some of the knowledge leading to the decision is imperfect, which is often the case in many applications. Indeed, the purpose of our work is to enrich the MAS enough for their behavior to acquire fuzzy characteristics. This means that the behavior of the system must be able, in particular, to deal with problems with imperfect knowledge, to make decisions (or help decision-makers in their decisions) under uncertainty and with unclear criteria and objectives, and respond to user queries expressed through vague and imprecise language skills.

In this paper, we provide an overview of the MAS and Fuzzy Inference System (FIS) approaches adopted in the QoS Classification and Negotiation platform to expose negotiation functionalities to Web services. Service Level Management (SLA)-based negotiation is a crucial support to handle the widely-ranging requirements that characterize Web services. The paper is organized as follows: Section II is dedicated to related work, the Cloud Computing, FIS and MAS concept, in Section III, we present the Fuzzy System Multi Agents for Automatic Classification and Negotiation Framework used in our contribution and we discussed it, eventually in Section VI we draw our conclusions.

2. Materials and Methods

2.1. Motivation

In the field of artificial intelligence, attempts are often made to equip artificial agents with techniques of representation and use of knowledge that allow them to solve problems and wait for their objectives. This problem of representation and use of knowledge is at the center of a relatively new and in any case controversial scientific discipline, called artificial intelligence.

This discipline has had a limited impact, until recently and exclusively, on the symbolic processing of knowledge, as opposed to the numerical modeling traditionally used in the engineering sciences. More recently, there has been a return to digital in these artificial intelligence problems, with neural networks, genetic algorithms and fuzzy logic. While neural networks offer an implicit "black box" approach and genetic algorithms are iterative optimization algorithms, fuzzy logic is more in keeping with symbolic artificial intelligence, which puts forward the notion of reasoning, and where the knowledge is explicitly coded.

The main objective of this section is to highlight the originality of our work and to motivate our choice to use fuzzy logic with MAS in Cloud Computing network.

2.2. Related Work

Cloud Computing. There are many definitions of the term Cloud Computing (CC) and there is little consensus on a single and universal definition. This multitude of definitions reflects the diversity and technological richness of Cloud Computing. In what follows, we cite some of the most relevant. According to [6], based on a close-up view of the Grid computing grids [7], Cloud Computing [8] is mainly based on the paradigm of distributed computing [9] on a large scale to ensure an on-demand service accessible through the Internet. A second definition, proposed in [10], [11] and which is more abstract, defines cloud computing by using the computing resources (hardware and software) that are offered as a service through a network (typically the Internet). A third definition, developed by a working group of the European Commission [12], considers Cloud Computing as an elastic performance environment for resources involving multiple actors to offer a service with a certain level of quality of service. This definition has been extended in [13] taking into account the perspectives of the different players in the Cloud Computing ecosystem (supplier, developer, user). However, the definition proposed by the National Institute of Standards and Technology (NIST) in [14], defines Cloud Computing as a model that allows access via a network in a simple and on-demand way to a set of shared and configurable computing resources. These IT resources can be allocated and released quickly with minimal management effort or interaction with service providers. In addition, NIST states that Cloud Computing is composed of five essential features, three service models (Infrastructure As A Service, Platform As A Service and Service As A Service).

Multi Agents System. Several definitions of an agent have been given throughout the years when each definition addresses one or more aspects of this paradigm:

- According to [15], an agent is a system capable of autonomous action and reflected in a real environment.
- According to [16], an agent is a persistent software that has a specific purpose, the agent can be distinguished from a conventional software by its size because smaller and by those objectives and agendas on which it is based to accomplish its tasks.
- According to [17], an agent is a computer system that is in a complex and dynamic environment, and that sees and reacts autonomously, in order to achieve the purposes for which it was created.
- According to IBM [18], an intelligent agent is a software that performs a set of predetermined tasks, with a certain degree of independence and autonomy, based on a set of knowledge and a representation of predetermined objectives.

Agent Features [19]:

- Autonomous: the agent is able to act without the influence or intervention of a human or agent and controls his own actions as well as his internal state;
- Proactive: the agent must exhibit opportunistic behavior;
- Social: the agent must be able to interact with other agents, especially when the situation requires it;
- Cooperation: able to coordinate with other agents to achieve the common objective;
- Mobility: the agent can be mobile, able to move to another environment;
- Rationality: the agent is able to act according to his internal objectives and his knowledge ;
- Learning: the agent is able to evolve and learn; As a function of this learning, he is able to change his behavior.

A multi-agent system (MAS) [15], [20] is a system composed of a set of autonomous agents, located in a certain environment and interacting according to certain relationships (ACL: Agent Communication Language) to arrive at a global objective. According to Ferber [15], as illustrate Figure1, a multi-agent system is a system composed of the following elements:

- An environment E, that is to say a space generally having a metric.

- A set of objects O. These objects are located, that is to say that for any object it is possible, at a given moment, to associate a position in E. These objects are passive; That is, they can be perceived, created, destroyed and modified by agents.
- A set A of agents, which are particular objects, which represent the active entities of the system.
- A set of relations R that unite objects (and therefore agents) between them.
- A set of operations Op allowing the agents of A to perceive, produce, consume, transform and manipulate O objects.

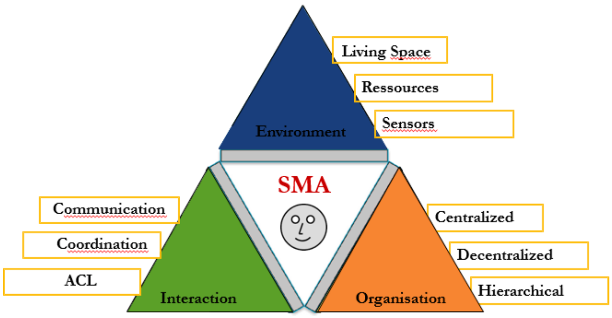

Fig. 1. Multi Agents System

Fuzzy Inference System. Fuzzy logic is a concept first developed by Lotfi zadeh [21], at the University of California in 1964. A concept that is essentially based on the notion of degrees of belonging to a set according to functions and fuzzy operations. The objective of fuzzy logic is to solve the problems encountered in the use of conventional logic. Problems that are often encountered because of absolute values (true or false) for evaluation of a logical expression. For this, it integrates a new concept of partial truth by assigning different degrees of absolute truth according to a membership function dedicated to the domain studied.

Fuzzy logic is used in various fields and research for the control and inference of conclusions based on vague and ambiguous inputs, which require special treatment. To this end, fuzzy logic establishes the link between numerical and symbolic modeling using linguistic variables. This makes it possible to manage numerical uncertainties, based on symbolic values resulting from fuzzy sets. It is on the notion of these that fuzzy logic is essentially based. They support degradation in the membership of elements to a class, such that an element can belong to at least one or more classes.

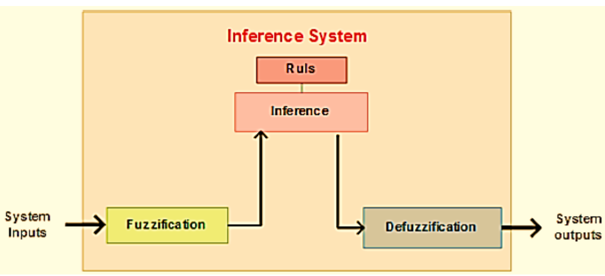

Fig. 2. Fuzzy Inference System

Figure 2 schematizes the steps of the nominal execution of a fuzzy inference system. These steps make it possible to identify the output value needed to derive the state or decision sought. The system entry is generally vague and ambiguous data, so the first phase is to define the membership of the entries, to link with the symbolic variables allowing processing in several steps:

- *Fuzzification*: The first step of the inference system is the conversion of the collections entries by the system to fuzzy sets. These are represented by linguistic variables, whose values are words or phrases of a natural language. The conversion uses the membership functions explained in the previous section. The shape and the end of the functions are found experimentally, since no technique exists for the automatic identification.
- *Inference*: The processing phase that links the input and the output of the system, via rules defined in advance. These are simple conditions that take the form of IF (Condition) THEN. The conditions are a combination of the input variables and the usual operations. The membership of the outputs is identified on the combination of the results of the set of conditions.
- *Defuzzification*: This phase aims to recover the numerical value of the output, via the symbolic value resulting from the treatment phase. An operation that is based on the membership function of the output fuzzy set. There are several techniques for defuzzification, the most used of which is the center of gravity

Modern complex systems such as in industry, economics, finance, marketing and ecology are composed with multiple agents interacting in distributed mode and, almost always, they are characterized by inaccuracy, uncertainty and Incompleteness of information. It is clear that fuzzy logic-based multi-agent systems are the most appropriate approach for the analysis, design, and realization of systems with such properties [22]. In the rest of this section, we will present a quick overview on the use of fuzzy logic with MAS in the literature with examples of the work done in this area.

Among the first works on fuzzy MAS are those of [23, 24], who introduced the concept of a distributed intelligent multi-agent system (Fuzzy Distributed Multi-Agent). Intelligent System (FDIS)). In particular, they considered the problem of coordination between autonomous agents, namely, fuzzy scheduling, fuzzy scheduling, dispatching, and online dynamic systems. Their model is used for the implementation of a control system in an industrial system. Another approach for designing fuzzy multi-agent systems is that presented in [25]. This model is a fuzzy and multi-criteria decision support system, its main idea is to break down the task between a number of parallel and competitive agents; each intelligent agent composed with a fuzzy knowledge-based system; each agent proposes a solution to the total problem (not only for a partial problem); the total solution of the problem is determined as a proposal of one of the agents after a competition procedure (not with coordination and integration of partial solutions of agents as in the classical distributed system). In [26], the author addresses the problem of group decision making in MAS, a decision in which a collection of n agents must collaborate on the choice of an alternative between a set, X = x1, x2, ... xn, possible alternatives. Based on fuzzy set theory, the author described some methods for helping with this type of decision. In [27, 28], fuzzy linguistic models for multi-agent system design are proposed. These models are offered for cooperative and linguistic filtering of information on the Web. [29] Proposes a method of aggregation of preferences in collective decision problems in the presence of uncertainty. The interest of this article lies in the fact that the decision problem is considered in the form of a possible multi-agent decision (four optimists, and four pessimists) for which a representation theorem is demonstrated. [30] Presents a fuzzy-logic based multi-agent e-commerce system capable of negotiating computer/laptop between the seller and buyer.

3. FMASACNQOS Framework (Fuzzy Multi Agent System for Automatic Classification and Negotiation of Quality of Services)

Disciplines have been produced, in order to make the operation of any natural and intelligent machine like the human being. Artificial Intelligence (AI) is one of those disciplines that aims to understand the nature of intelligence by building programs that mimic human intelligence. The classical approach of artificial intelligence, which is related to knowledge-based system design, was not suitable for progressive applications that require a large amount of knowledge and diversity of knowledge. In the same way, individuals usually work in groups. This led to the emergence of a new artificial intelligence approach called Distributed Artificial Intelligence (DAI). This distributed artificial intelligence is based on the principle of the distribution of intelligence between a set of entities that cooperate to achieve a global goal where each of them cannot achieve individually. An extension of the DAI systems is proposed [28], in which the components that have a certain autonomy must be endowed with the capacities of perception and action on their environment. We then talk about agent and therefore multi agent systems

Moreover, the implementation of modern systems often poses problems of representation and manipulation of imperfect reversals, this imperfection is due mainly to the nature of the real environment of the world, which cannot always be represented, in a precise quantitative format. Observation instruments that produce errors, and man-machine communication problems that characterize these systems.

However, the use of MAS implies the need to equip intelligent agents with reasoning and decision-making skills close to those of the human being, such as the ability to solve problems and make decisions under uncertainty and with inaccurate and incomplete knowledge. This leads researchers to associate fuzzy logic with intelligent agents to establish new kinds of autonomous systems.

Fuzzy logic is the most effective way to take into account the vagueness and uncertainty of information, and to formalize processes of reasoning and human decision-making. It is currently generating a general interest among all those who feel the need to formalize empirical methods, to generalize natural reasoning, to automate decision-making in their field, and to create intelligent agents performing the tasks. Usually taken care of by humans. It is for the possibilities it offers to manage uncertainty and inaccuracy, and for its ability to model mechanisms of reasoning and human decision-making, that we are interested in fuzzy logic.

The subject of FMASACNQOS case study is the realization of an online decision support system in a virtual market. This system must allow users of the electronic market to carry out their online transactions in a flexible manner and must assist them in their decision. Our system must allow market customers to use linguistic vague terms and imprecise in the criteria for qualifying the data sought and expressing preferences between these criteria, which is often a legitimate demand of the users. For example, the system must allow a user who seeks, via the Internet, a Telecom service, to use fuzzy requests. Thus, the data returned by the system must be ordered and presented to the user according to the QOS of the service provided by the service providers: The provider, the cost and the URL link

The objective of FMASACNQOS is to design a system of decision support (Classification and Negotiation of the Service Level Management (SLA)) allowing customers to obtain offers on the services requested, their price and URL. In order to realize this system, we chose to use our fuzzy MAS design model. This paper presents the application of the FMAS model for the desired decision support system modeling.

As descripted on the Figure 3 the Fuzzy Multi Agent System for Automatic classification and negotiation of QOS is based on the inference system to make the decision:

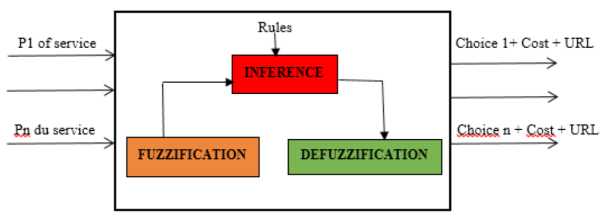

Fig. 3. FMASACNQOS

Generally, QoS [31], [32] is defined as degree of satisfaction of clients to use the service. The achievement of this satisfaction will be achieved when the QoS metrics for various network applications based on technology or user factor are respected.

Both of these elements play an important role to satisfy the desired requirement of QoS. The Service Level Agreements (SLA) is a compromise between user and provider of services by a document that defines the QoS, the prescribed service. In other words, these are clauses based on a contract defining the precise objectives expected and the level of service a client wishes to obtain from the provider and sets out the responsibilities. The mechanism of negotiation, monitoring and classification of SLAs provokes many issues like, congestion in providers side, increasing delay, low availability The way SLA between cloud service providers and cloud service consumers are established and managed is currently far from being ideal from the customer's point of view because of the huge number of requests which cause saturation of the buffers in consequence congestion of networks and Unavailability of services. This topic naturally gains crucial importance for customers being companies whose success depends, even partially, on the advertised QoS.

The overall aim is the development of an intermediary that generates SLA management tasks. The introduction of a Broker of Agreement facilitates the mechanisms of service discovery and automates negotiation and monitoring of SLAs, moreover it allows comparing the services according to their QoS requirements as mentioned on Table 1. Furthermore, clients can negotiate SLAs based on the QoS requirements outlined in the table below.

Tab. 1. Requirements of general QoS [29]

Service	**Data Rate**	**Delay**	**Loss Rate**
VoIP	64 Kbps	< 150 ms	< 0,1%
FTP	11,8 Kbps	~ 10 sec	0
Video	4-60 Mbps	< 150 ms	< 0,0001%
Email	< 10 Kbps	< 4 sec	0

The best way to build a multi-agent system (MAS) is to use a multi-agent platform. A multi-agent platform is a set of tools needed to build and commission agents in a specific environment. These tools can also be used for analysis and testing of the MAS created. These tools can be in the form of a programming environment (API) and applications to help the developer. There are currently several platforms for the development of multi-agent systems, such as Madkit [33], Zeus [34], Swarme [35] and JADE [36], etc. However, these platforms do not offer a solution to facilitate the use of interaction protocols, with the exception of the JADE platform.

The realization of our application, on the case study, which concerns the realization of a management application and decision support in a market, requires us to choose implementation tools. The development stage requires technological tools adapted to the field of research and the architecture of the application concerned. Our choice was on the Java programming language and the MAS: JADE development platform for the following reasons:

- It is easy to make a mapping of fuzzy agents from our model in a JADE code,
- It is simple to create agents with JADE,
- JADE manages communication between agents and offers agent management interfaces,
- The JADE platform respond to several features and offer a wide range of libraries,
- The agents developed in JADE are written totally in JAVA, which is an easy language and based on the notion of object.

The Framework used in FMASACNQOS to implement fuzzy inference system is JFuzzyLogic It present many advantages by facilitate and speed up the development of fuzzy systems. The main advantages are:

- Using standard programming language (FCL),
- Providing a fully functional and complete implementation of FIS,
- Creating API that can be extend by developers,
- Implementing an Eclipse plugin to easily write and test FCL code,
- Independency of the software platform.

As is shown below in Figure 4 every provider must make registration by sending its offers. Every offers must contain:

- Id of provider,
- Name of Service,
- Data Rate,
- Loss Rate,
- Link,
- Cost.

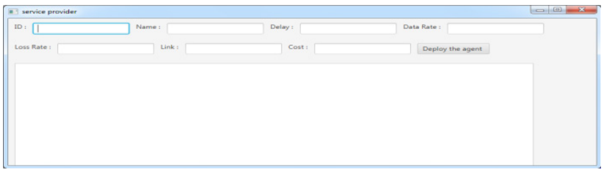

Fig. 4. Service Provider Container

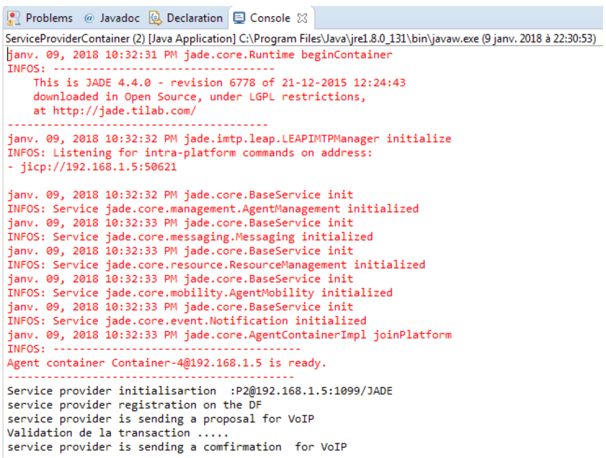

Fig. 5. Execution of deployment of Service Provider

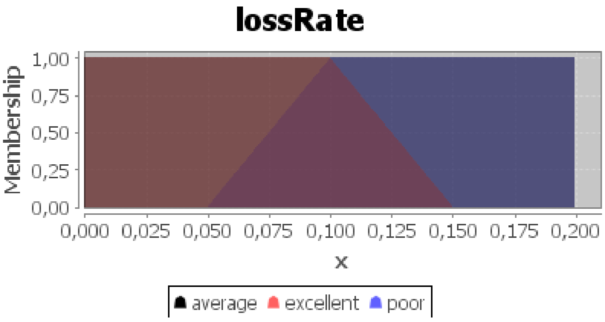

Fig. 6. Membership functions for LossRate

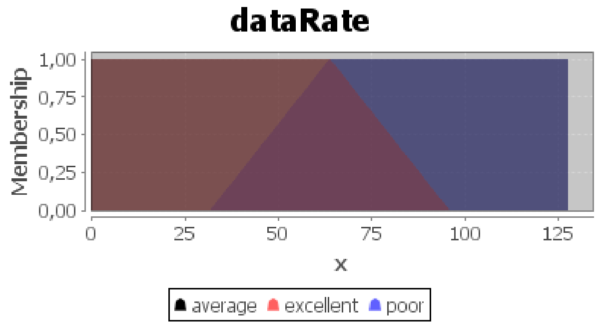

Fig. 7. Membership functions for dataRate

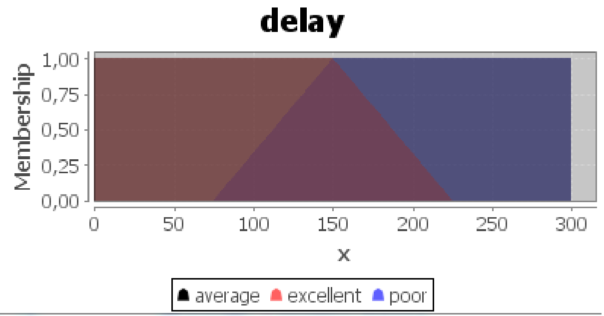

Fig. 8. Membership functions for Delay

Fig. 5 presents the execution of deployment of a service provider by its container. The membership functions of Qos parameters (Loss rate, Data Rate and Delay) are illustrated in the following figures. Fig. 6 defines the membership of Loss Rate. The value, called membership value or degree of membership, quantifies the grade of membership of the element to the fuzzy set. Fig. 7 defines the membership of Data Rate. The membership function characterizes the degree of certainty and truth in FIS. Fig. 8 defines the membership of Delay.

Fig. 9 describes the negotiation between the broker and the providers of service using the sniffer of JADE framework.

As it mentioned above, we have use the library FuzzyLogic to implement the fuzzy inference system (FIS) in our framework. Table II shows example of fuzzy control language code executed in our framework.

Tab. 2. Example OF Fuzzy Control Language (FCL) Code

RULE 1 : IF dataRate IS excellent AND delay IS average AND lossRate IS average THEN qos IS poor;
RULE 2 : IF dataRate IS average AND delay IS excellent AND lossRate IS average THEN qos IS excellent;
RULE 3 : IF dataRate IS average AND delay IS average AND lossRate IS excellent THEN qos IS excellent;
RULE 4 : IF dataRate IS average AND delay IS average AND lossRate IS average THEN qos IS average;

The use of decision support systems in e-commerce has increased in recent years. The purpose of these systems is to enable users of electronic markets to make transactions in the best conditions and

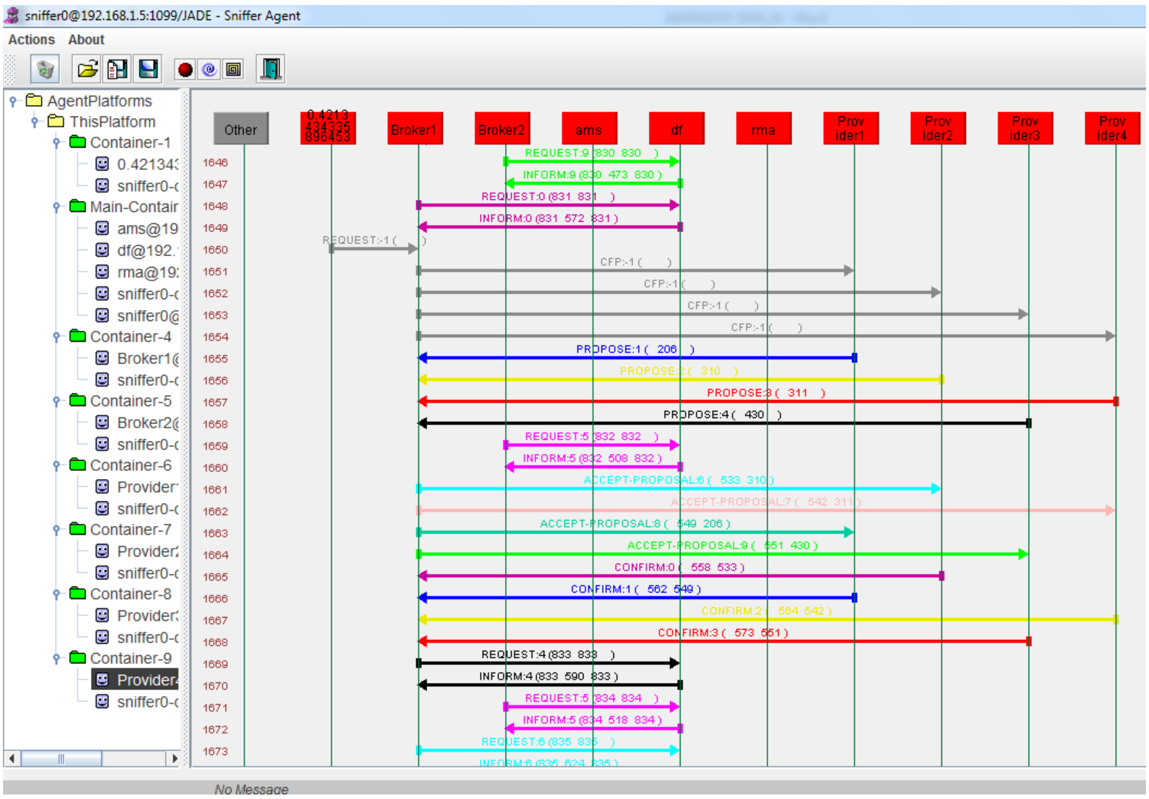

Fig. 9. Exchanged messages in the network

to help them in their decisions. The design and implementation of decision support systems, with the accompanying man-machine communications problems, is often characterized by the constant manipulation of information, many of which are imperfect.

The subject of our case study is the realization of an online decision support system in a virtual market (Cloud Computing). This system must allow users of the electronic market to carry out their online transactions in a flexible manner and must assist them in their decision. Our system must allow market customers to use vague and imprecise language terms in the criteria for qualifying the data sought and to express preferences between these criteria, which is often a legitimate request from users. Thus, the data returned by the system must be ordered and presented to the user according to preferences. On the other hand, our system must help service providers estimate their property at the right price.

The use of the multi-agent paradigm for the realization of these systems implies the need to integrate mechanisms that take into account the processing of fuzzy information. This makes it necessary to design multi-agent systems (MAS) with fuzzy characteristics. For the modelling and realization of this system we chose to use the FMAS model

4. Conclusion

In our work, we are interested in the problem of designing multi-agent systems with fuzzy characteristics to meet the needs of complex modern systems that must deal with imperfect information. To solve this problem, we have proposed in this paper a new approach for the design of fuzzy multi-agent systems, the model FMASACNQOS (Fuzzy Multi Agents System for Automatic Classification and Negotiation of QOS).

In our contribution, the proposed model is initially generic since we found, in the literature, the absence of a generic model for the design of fuzzy MAS. And unlike the work currently being done on fuzzy multi-agent systems, which offer architectures for specific applications or use logic to deal with problems in MAS our design model is based on the idea of integrating logic fuzzy in a multi-agent level, by the use of fuzzy agents independent of other system agents, it is therefore independent of the application in which we will use it. Indeed, our model will help build complex applications that can benefit from the advantages of the multi-agent approach and the capabilities of fuzzy logic, such as its ability to represent and manipulate imperfect knowledge.

In this paper, we presented the application of our Framework, the FMAS model, in a case study, which consists of modeling and implementing a system of classification and negotiation of services in a virtual market that is the Cloud. Computing. After the system modeling using our framework with the soft focus, we presented the execution scenarios with an example on the use. And for the system implementation, we used the JADE platform. In this case, we proposed rules that allow to easily implement the fuzzy agents from the FMASACNQOS framework, as well as the different modules. Portions of codes are presented to clarify certain operations

AUTHORS

Zineb Bakraouy* – STRS Lab., National Institute of Posts and Telecommunications, Rabat, Morocco, email: bakraouy@inpt.ac.ma.

Wissam Abbas – STRS Lab., National Institute of Posts and Telecommunications, Rabat, Morocco, email: abbass@inpt.ac.ma.

Amine Baina – STRS Lab., National Institute of Posts and Telecommunications, Rabat, Morocco, email: baina@inpt.ac.ma.

Mustafa Bellafkih – STRS Lab., National Institute of Posts and Telecommunications, Rabat, Morocco, email: bellafkih@inpt.ac.ma.

*Corresponding author

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