MAIS-E^2 MODEL AND R^2-IBN FRAMEWORK: PORT APPLICATION CASE

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Abstract: This paper aims to study the problem of cooperation in the extended enterprise case. This study focuses on the presentation of agent-oriented extended enterprise as a solution allowing enterprises to overcome the cooperation problem, in general, and conflict resolution, in particular. In this regard, this objective is defined by three aspects: organizational, reasoning and application. The organizational and reasoning aspects are presented through an overview of designing the extended enterprise by an agent-oriented approach via the proposed MAIS-E^2 model (Multi-Agent Information System for an Extended Enterprise) and the proposed argument-based negotiation framework R^2-IBN (Relationship-Role and Interest Based Negotiation) defined for MAIS-E^2 model, respectively. Then, we focus mainly on the application aspect through the instantiation of MAIS-E^2 model to the port application. These aspects are consolidated by the experimental validation via the developed prototype using JADE platform and experimental results with different cases in the port area.

Keywords: Extended enterprise, cooperation, multi-agent systems, MAIS-E^2, argument based negotiation, R^2-IBN.

Introduction

Nowadays, a number of new concepts have been proposed, e.g., Virtual Organization, Supply Chain Management, Virtual and Extended Enterprise, etc [28,18]. An extended enterprise is a cooperation of legally independent enterprises, institutions, or individuals. The extended enterprise will be characterized by intensively concurrent engineering based on information technologies such as digitalization, computer network, and artificial intelligence [28]. In order to face new challenges, extended enterprises must be up to date to the new strategic, economic and organizational structures. The intelligent software agent technology provides a natural way to overcome such problems [18]. Agents help to capture individual interests, local decision making by using incomplete information, autonomy, responsiveness, robustness, modular and distributed. A Multi-Agent System (MAS), as a society of autonomous agents, is an inherently open and distributed system. It is made up of a group of agents combined with each other to solve a common problem cooperatively. In addition, negotiation is a key form of interaction in systems composed of multiple autonomous agents [2]. The automated negotiation plays a key role in sharing information and resources to look

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for a common agreement. Argumentation theory has become an important topic in the field of Multi-Agent Systems and especially in the negotiation problem. The research literature proves that Argument-Based Negotiation is an effective means of resolving conflicts in MAS [2]. Moreover, the bridge between theory and practice play crucial rules for validation, applicability, reliability and effectiveness of designed intelligent system. For that, application aspect has an effective means of experimental validation. In this paper, we present an overview of our research efforts in developing, first, a MAS architecture named Multi-Agent Information Systems for an Extended Enterprise (MAIS-E^2) for highlighting organizational aspect, second, the Relationship Role and Interest Based Negotiation (R^2-IBN) framework for highlighting reasoning aspect. R^2-IBN framework is an extension of an existing one namely IBN [4]. Then, for application aspect, we instantiate MAIS-E^2 model to a port application and simulate R^2-IBN framework via a designed and developed prototype.
The remainder of this paper is structured as follows: section 2 presents MAIS-E^2 model overview, section 3 presents R^2-IBN framework overview, section 4 presents an instantiation of MAIS-E^2 in the port case. Section 5 presents the developed prototype and enumerates experimental results. Finally, section 6 concludes the paper and outlines some research directions.

MAIS-E^2 : Multi-agent model for inter-enterprises cooperation

The extended enterprise is "a set of partner agents sharing resources and complementary skills, similar or dissimilar, and cooperating together to maximize shared goals" [3]. Two notions emerge from this definition: *cooperation* and *agents*. Cooperation among partner agents of the extended enterprise is a *Diagonal* (Cooperation is called Diagonal because both Horizontal and Vertical. Horizontal cooperation is a set of bilateral relationships between partners who have chosen to cooperate on joint projects. Vertical cooperation is characterized by the dependence of the lower level towards the upper level) cooperation [11,12,13]. This cooperation is carried out through the proposed *Mediators* agent agency. The term agent is not a coincidence. Indeed, we have borrowed it from Distributed Artificial Intelligence (DAI) with reference to Multi-Agent Systems (MAS) and specifically the agents' agency concept. We consider the extended enterprise as agent agency seeking to cooperate; hence, the proposed multi-agent model MAIS-E^2, where MAIS-E^2 stands for Multi-Agent Information System for an Extended Enterprise [13,9]. Moreover, in MAIS-E^2 the agents that we study are cognitive and social. We distinguish four types of agents: *Enterprise* agents, *Mediator* agents, *Specialist* agents, and *Personal* agents.
Enterprise agents: composed by different kinds of enterprises composed the extended enterprise that can be partners, subcontractors, contractors, competitors, suppliers, etc. The architecture of each *Enterprise* agent rests on reflexivity (An agent is composed by a set of agents)[20]; therefore, it is an agent agency composed by artificial agents (software or hardware) or non-artificial ones (e.g., individuals,

group of individuals, organizational entities). This agency is composed by *Mediator*, *Specialist* and *personal Assistant* agents.
Mediator agents: assume cooperation between different *Enterprise* agents and cooperation with agents composed the same *Enterprise* agent. These agents are artificial (e.g., software entities equipped with knowledge and behaviours).
Specialist agents: can be planning, information, or logistics agents. Note that these agents may be artificial (e.g., software or hardware) or not (e.g., individuals, group of individuals, organisational entities).
Personal assistants: represent users in the agent network and, therefore, are not artificial.

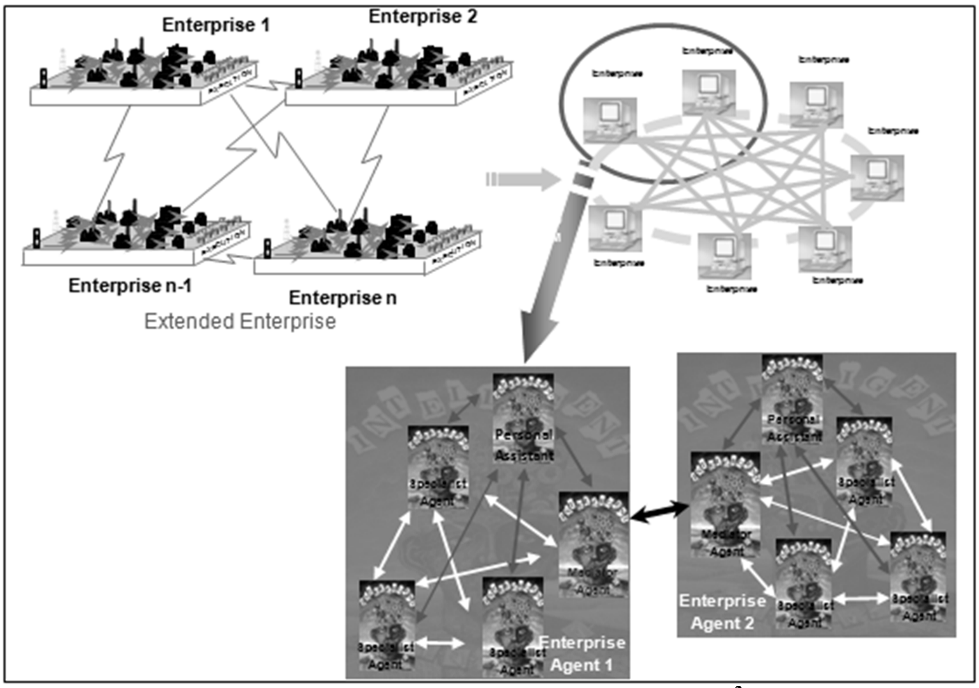

Figure 1. Organizational architecture of MAIS-E^2 model

Our proposed model MAIS-E^2 [9], shown in Figure 1, rely on the existence of the distributed *Mediator* agent agency that will assume binding between all partners in the extended enterprise. This agent agency has an essential role that consists of cooperation and conflicts resolution within MAIS-E^2 model. This agency constitutes the key element for MAIS-E^2 functioning. Furthermore, the extended enterprise environment is characterized by: openness, heterogeneity, dynamicity etc. These features make the conflict resolution process more and more difficult. As a solution we use automated negotiation. In fact, designing negotiation mechanisms aims at satisfying a number of features: simplicity, efficiency, distribution, symmetry, stability and flexibility [5]. Thus, in the extended enterprise case study the Flexibility (By this property, we mean that the mechanism should lead to agreement even if agents did not have complete and correct private information in relation to their own decisions and preferences. This property requires a mechanism for enabling agents to refine their decisions, in light of new information, during the negotiation process) feature play a crucial role by taking into consideration the heterogeneity of different actors. For this reason, we adopt the Argumentation Based Negotiation approach, and we propose, in the next section, the R^2-IBN (Relationship-Role and Interest Based Negotiation) framework.

R^2-IBN : Intelligent negotiation framework

In this section, we rely on different theories and frameworks of negotiation, in order to describe the proposed framework R^2-IBN (Relationship-Role and Interest Based Negotiation) [14]. The formal description for R^2-IBN is presented through a specific theory of argumentation, which is based on the work of Rahwan [15,21] and Amgoud and Cayrol [22]. R^2-IBN framework is an extension of an existing one which is IBN proposed by Rahwan [15]. IBN uses mental attitudes: beliefs, desires, goals and planning rules as the primitives upon which argumentation are based [15]. Being in the context of the extended enterprise, concepts like agent roles, relationships and confidence play a crucial role by taking into consideration the heterogeneity of different actors. For that, such concepts are essential to be integrated. Hence, we propose R^2-IBN framework as a solution to the conflict resolution problem for the *Mediator* agent agency of MAIS-E^2 model already advocated in the previous section. So to present the description of R^2-IBN framework, it is crucial to advocate that in order to be able to negotiate with other agents, based on argumentation approach, a *Mediator* agent must be provided with three set of rules: Argument Evaluation Rules; Argument Generation Rules and Argument Selection Rules.
In this paper, and due to lack of space, we will describe an overview of these rules. A detailed analysis was described in [14,1,10].

<u>Arguments Evaluation Rules</u>

In order to evaluate an argument and the fact that we choose to adopt a Belief-Desire-Intention (BDI) architecture [8], we present the evaluation through three sub-frameworks corresponding to the three levels of depth of a BDI agent: one for reasoning about beliefs, the second for reasoning about desires, and the third for reasoning about intentions. And those through an exploration and extension of the work presented by Rahwan [15,21]. The proposed extensions take into consideration the roles of agents via their capabilities and their relationships with other agents in the reasoning mechanism of a Mediator agent. Rahwan works [15,21] have as starting point works proposed by Amgoud and Kasi [24], on one hand, and Hulstijin and Torre [17], on the other.

<u>Arguments generation rules</u>

Within our Framework, R^2-IBN, the arguments generation process is to produce candidate arguments by a *Mediator* agent to be presented to one or several opponent agent(s) (other *Mediator* agents). In our approach, the arguments generation process takes form in deductive reasoning context [6]. Thus, we need inference rules to deduce conclusions from the knowledge base. For this, we adopt the basic rules of reasoning used in classical logic: the *Modus Ponens* for forward reasoning and the *Modus Tollens* for backwards reasoning [7].

Arguments selection rules

In strong correlation with the arguments generation process, we find the arguments selection process. The main issue in the arguments selection process is: « Given a number of arguments that a candidate agent can send to his opponent, what is the best argument to send from the point of view of proponent agent? » [15,21]. To answer this question, we proceed in the context of our proposed framework, R^2-IBN, to propose new approach to the arguments selection process. This approach allows a *Mediator* agent to generate several arguments for any specific situation and only one argument should be used for each step of the negotiation.

The key features that determine what argument to send are the following:

- utility of the proposal to the proponent (*Mediator* agent) (Value between 0 and1);
- the confidence degree (which describes the confidence degree that the proponent puts in the opponent,); The value of the confidence degree, as an inspiration of REGRET system [19,25] varies by two dimensions: Individual dimension (addressed from direct interactions of the agent with his opponent) and Social dimension (addressed through the average of the various reputation reports of an agent received from other agents of society). Therefore, the confidence degree is defined in general by the following function:

$$\begin{aligned} Conf_{A_j} &: Ag * Ag \longrightarrow [0,1] \\ Conf_{A_j} &= W_R * Reput_{Aj} \\ &+ W_C * \frac{\sum_{k=1}^{nb\_parameter_{Conf}} Conf^k_{A_j}}{nb\_parameter_{Conf}} \end{aligned} \quad (1)$$

Where:

A_j: Agent j. $Reput_{Aj} \in [0, 1]$: The reputation value (value assigned by indirect interactions) of an agent A_j given by other agents of society

$Conf^k_{Aj} \in [0,1]$: The trust value (value assigned by direct interactions) attributed to the agent A_j for k^{th} parameter ($k \in$ {helpfulness, dependence, lateness degree, hesitation degree, availability degree})

$nb\_parameter_{Conf}$: The number of trust setting used

$W_R \in [0, 1]$: The weight assigned to the reputation value (indirect interaction)

$W_C \in [0, 1]$: The weight assigned to the trust value (direct interaction)

- the capability degree of the opponent in the specific task (according to the proponent belief).

Since these characteristics are generally imperfect and uncertain, we propose fuzzy rules based system as an intelligent method in order to better estimate the desirability degree of the argument to send [26]. Thus, the fuzzy controller [26,30] we propose, is summarized in a Takagi-Sugeno-Kang or short TSK (The choice of using the TSK fuzzy system [29] lies in the advantage of providing output values without a specific phase of defuzzification). Figure 2 illustrates the architecture of the proposed fuzzy system. In the latter we distinguish three input parameters and an output parameter:

Input parameters: Confidence degree: {Low, Medium and High}, Capability degree: {Low; Medium and High} and Proposal utility: {Low and High}.

Output parameter: The argument desirability degree.

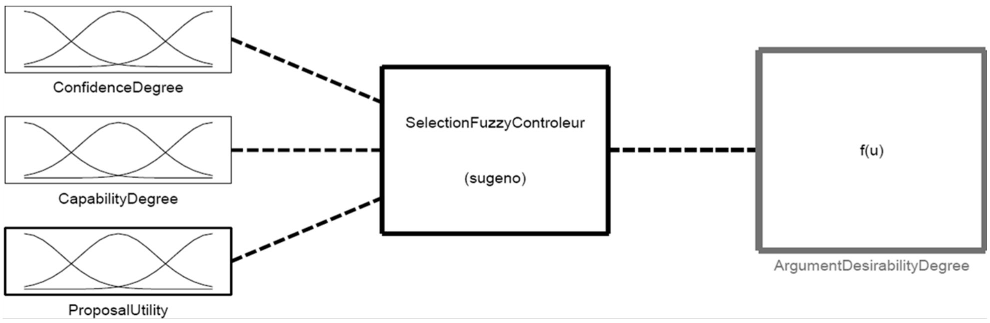

Figure 2. Architecture of the fuzzy system proposed: Argument Selection Module

MAIS-E^2 model : Port application case

In this section, we instantiate our proposed MAIS-E^2 model of extended enterprise (cf. Section 1) to a Port application, in general, and to Sfax port through a research and development study, in particular. This instantiation of MAIS-E^2 model is illustrated in figure 3. Reality consideration can attest the heterogeneity and complexity of situations. For this purpose, and to simulate the proposed model MAIS-E^2 via the proposed Argumentation Based Negotiation R^2-IBN (cf. Section 2), we focus on a subset of the port application. Henceforth, we anchor our interest on the conflict resolution that may arise between two links in this port application projecting an instantiation of the extended enterprise; namely, the *Maritime* agent and the *ShipOwner* agent as illustrated in Figure 3.

Simulation

With the aim of enhancing the effectiveness of the R^2-IBN framework, in this section, we present, firstly, the general architecture of the developed prototype, then the experimental evaluation and finally some experiment results by using different cases.

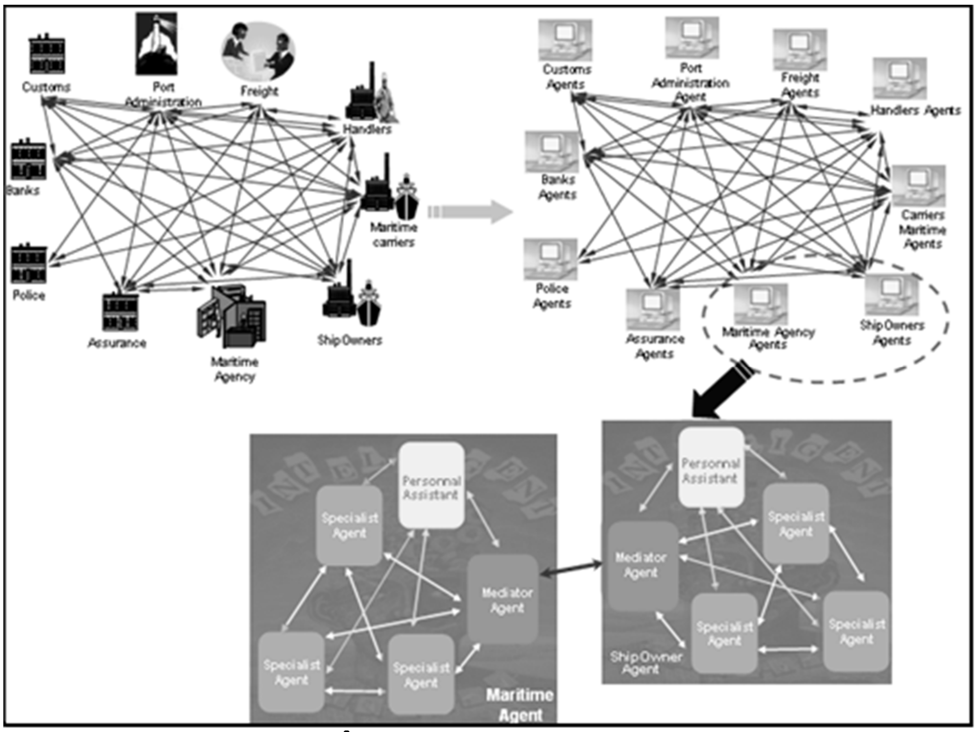

Figure 3. MAIS-E^2 model Architecture in Port application case

General architecture of the prototype

The prototype that we develop is composed of the modules illustrated in Figure 4 and detailed in the following:

Evaluation Module :

This module is concerned with evaluation of an input locution. To this effect, it extracts the contents of the proposal and the carried argument, if it is already grafted. In this regard, this module deals with the evaluation of a simple proposal and the evaluation of argument according to the rules fixed by the section 2.1.

Moreover, this module uses the JDOM API for manipulating the knowledge base represented in XML file format, on the one hand, and conducts an interconnection with MATLAB, to activate appropriate fuzzy controllers, on the other.

Generation Module :

This module allows the generation of proposals, in response, and candidate arguments through the application of arguments generation rules set out in section Moreover, manipulation of the knowledge base of the agent through manipulation of XML files.

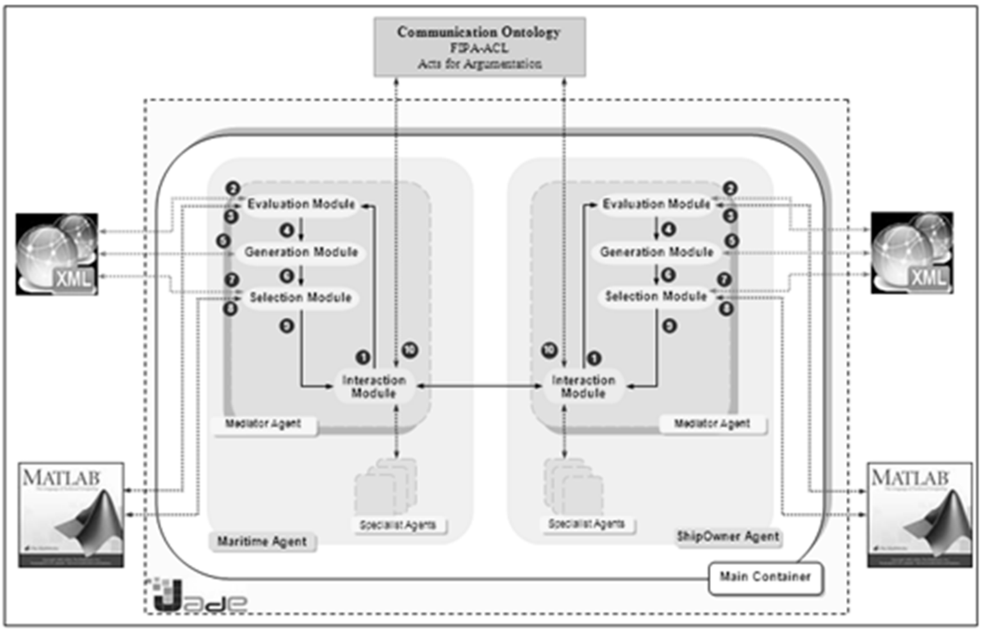

Figure 4. General architecture of the prototype

Selection Module :
This module allows selecting the argument considered the better one to be carried by the generated proposal. And this through the invocation of MATLAB in order to activate the fuzzy controller defined by the arguments selection rules set out in section 2.3.
Interaction Module:
This module allows managing the interaction. In this regard, this module allows the shaping of locution in output and the routing of locution as an input to the evaluation module.
It is conducive to indicate that these modules coexist within the reasoning structure of each *Mediator* agent.
Communication ontology :
To exchange knowledge within the R^2-IBN framework and MAIS-E^2 model, agents Communication Language is necessary. For that the communication ontology module is used to represent an ontological structure of communication. This structure includes Communication Language noted *CL*. Each message has a unique identifier $Act \in \mathcal{CL}$ which has the following structure: $Act(i, j, \Gamma)$.With *Act* represents message or locution type. *i* is the proponent agent, *j* is the opponent agent and Γ is the content of the locution, with Γ can be a simple proposal or a proposal with additional information which it grafted, this is the *argument*.
The agent communication language is equipped with an *argumentative semantics* and a *social semantics*. The *social semantics* of acts can be interpreted according to

the received act, thus Commitment Stores (*CS*) are (or not) updated. This semantic represents *update rules*.

While the *social semantics* of the communication language can interpret an act, the *argumentative semantics* of the communication language determines how an act can be spoken.

The speech act associated with a message ($Act(M(\bar{k}))$) consists of a locution and a propositional content. The propositional content, called hypothesis, consists of a well-formed expression ($\Psi \in \boldsymbol{L}$ [$\mathcal{L}$ the explored propositional language within R^2-IBN framework [1,10]) or a set of well formed expressions ($\Phi \in \boldsymbol{L}$). However, the list is slightly different locutions. A speech act within our R^2-IBN framework may be an assertion (ASSERT), a proposal (PROPOSE), acceptance (ACCEPT), validation (OK), refusal (REJECT), withdraw (WITHDRAW), pass his turn (PASS), a questionable (CHALLENGE), a question (QUESTION), a blindness (UNKNOW), a grant (CONCEDE), justification (ARGUE) and retraction (RETRACT).

The basic and specific speech acts used in our R^2-IBN framework, are listed in Table 1 and 2 respectively. The moves contain speech acts and a propositional content. In addition, commitment stores (CS) were principals to notify the forms on which participants engage in a dialogue. Thus convention depends not only in history but also the state of commitment stores (CS).

Table 1. Synthesis of basic speech acts used by the R^2-IBN framework

Locution $Act(A, B, \Gamma)$	Precondition	Post-condition			
		Argumentative Semantics: Response			Social semantics:
		Affirmation	Abdication	Attack	Update of CS
$PROPOSE(A, B, \Omega)$	$\emptyset$	Initiate I/SI $ACCEPT$	$WITHDRAW$	$REJECT$ $CHALLENGE$	$CS_A = CS_B = \emptyset$
$ACCEPT(A, B, \Omega)$	agent B stated $PROPOSE(B, A, \Omega)$	OK	$\emptyset$	$\emptyset$	Add to CS_A and CS_B the contract Ω
$OK(A, B, \Omega)$	agent B stated $ACCEPT(B, A, \Omega)$	$\emptyset$	$\emptyset$	$\emptyset$	Without effect
$REJECT(A, B, \Omega)$	agent B stated $PROPOSE(B, A, \Omega)$	$\emptyset$	$\emptyset$	$\emptyset$	Without effect
$WITHDRAW(A)$	$\emptyset$	$\emptyset$	$\emptyset$	$\emptyset$	Without effect
$PASS(A)$	$\emptyset$	$\emptyset$	$\emptyset$	$\emptyset$	Without effect

Table 2. Synthesis of specific speech acts used by the R^2-IBN framework

Locution[1] $Act\,(A,B,\Gamma)$	Precondition	Post-condition			
		Argumentative Semantics: Response			Social semantics:
		Affirmation	Abdication	Attack	Update of CS
$ASSERT$ (A,B,H)	agent B has stated: $ASSERT(B,A,X)$ $CHALLENGE(B,A,X)$ $QUESTION(B,A,X)$	$ASSERT$ $CONCEDE$	$RETRACT$	$CHALLENGE$ $ARGUE$	$CS_A{}^2(Act_{k+1}$=$CS_A(Act_k) \cup H$ $CS_B{}^3(Act_{k+1}$=$CS_B(Act_k) \cup H$
$QUESTION$ (A,B,H)	agent B has stated $PROPOSE(B,A,\Omega)$	$ASSERT$ $UNKNOW$ $ARGUE$ $CONCEDE$	$RETRACT$	$ASSERT$ $(B,A,\neg H)$	$CS_A(Act_{k+1}$=$CS_A(Act_k)$ $CS_B(Act_{k+1}$=$CS_B(Act_k)$
$CHALLENGE$ (A,B,ψ)	agent B has stated $ASSERT(B,A,H)/H \in CS_B(Act_k)$ $ARGUE(B,A,\psi)$	$\emptyset$	$RETRACT$ $UNKNOW$	$ARGUE(\Phi \rightarrow \psi)$ $ASSERT(B,A,\psi)$	Without effect
$RETRACT$ (A,B,H)	agent B has stated $ASSERT(B,A,H)$ $CHALLENGE(A,B,H)$ $QUESTION(B,A,H)/ H \in CS_B(Act_k)$	$\emptyset$	$\emptyset$	$\emptyset$	$CS_A(Act_{k+1}$=$CS_A(Act_k) - H$ $CS_B(Act_{k+1}$=$CS_B(Act_k) - H$
$ARGUE$ $(A,B,\Phi \rightarrow \psi)$	agent B has stated $ASSERT(B,A,\psi), ARGUE(B,A,\psi')$, $CHALLENGE(B,A,\psi)$, $QUESTION(B,A,\psi)$	$ASSERT$ $UNKNOW$ $PASS$	$CONCEDE$	$CHALLENGE$ $(\phi \in \Phi)$ $ARGUE$ $(\Phi' \rightarrow \Psi')$	$CS_A(Act_{k+1}$=$CS_A(Act_k) \cup \Phi \cup \{\psi\}$ $CS_B(Act_{k+1}$=$CS_B(Act_k) \cup \Phi \cup \{\psi\}$
$CONCEDE$ (A,B,Γ)	agent B has stated: $ASSERT(B,A,\Gamma)$, $ARGUE(B,A,\Gamma), QUESTION(B,A,\Gamma)$ $CHALLENGE(B,A,\Gamma)$	$\emptyset$	$\emptyset$	$\emptyset$	$CS_A(Act_{k+1}$=$CS_A(Act_k) \cup \Gamma$ $CS_B(Act_{k+1}$=$CS_B(Act_k) \cup \Gamma$
$UNKNOW$ (A,B,Γ)	agent B has stated: $QUESTION(B,A,\Gamma)$, $CHALLENGE(B,A,\Gamma)$	$ARGUE$	$ARGUE$	$ARGUE(B,A,\neg\Gamma)$	$CS_A(Act_{k+1}$=$CS_A(Act_k)$ $CS_B(Act_{k+1}$=$CS_B(Act_k)$

[1] A and B: Two Agents. [2] CS_A: Commitment Store of Agent A. [3] CS_B: Commitment Store of Agent B.

<u>*Experimental Evaluation*</u>

The experimental evaluation is intended to show the effectiveness of the proposed MAIS-E^2 model via our Argument Based Negotiation framework R^2-IBN. The experiments are to evaluate the various modules developed within the R^2-IBN framework, in particular, the reasoning structure of Mediator agent, a key element of MAIS-E^2 model functioning, composed by the following modules: evaluation of received argument, generating a set of acceptable arguments, and selection of an argument considered the better one to be sent. In order to anchor the effectiveness of our model, we examine, firstly, the negotiation cycle number, and secondly, the arguments exchanged number in order to reach agreement (success or failure). For that, at this stage of work, we restrict the negotiation to two *Mediator* Agents in port application, as stated in section 4, the set of arguments that can be uttered between 0 and 10 and the negotiation cycle per proposal between 1 and 10. These encounters are paired between Mediator agents using the same reasoning structure. After the review of these assessments in the context of our framework R^2-IBN, we proceed to conduct a comparison with different frameworks of literature. We elaborate these experiments through simulation using JADE platform.

Experiments

We present experiments through a set of cases:

Case 1: Comparison of frameworks: R^2-IBN and IBN.

With the aim of enhancing the effectiveness of the R^2-IBN framework, compared with the basic framework IBN from which it inherits (the basic characteristics of R^2-IBN and IBN frameworks are described in Table 3), we have proceeded to perform simulations of these two frameworks between two *Mediator* agents (a *Mediator* agent for a *ShipOwner* agent and a *Mediator* agent for a *Maritime* agent). The scenario of this simulation corresponds to a conflict of fixing the arrival date of a ship. The results of this simulation are identified in Table 4.

The effectiveness of the framework R^2-IBN versus IBN, in both cases of perfect and imperfect knowledge, lies in the extensions brought by R^2-IBN, namely the role of an agent through the capabilities and the Trust and Reputation degree which depends on the nature of social relations, and their applicability in the extended enterprise context. Furthermore, hybridization of intelligent fuzzy approach, through a fuzzy reasoning, with a logic-based approach, through a non-monotonic reasoning.

Table 3. R^2-IBN and IBN frameworks Features

	BDI architecture	**Evaluation**	**Generation**	**Selection**	**Trust & Reputation**
R^2-IBN	×	IBN Extension - Roles & Capabilities - Trust & Reputation - Fuzzy reasoning	Rules : - Modus Ponens - Modus Tollens	Fuzzy reasoning - Utility - Trust - Capabilities - Strength of an argument	Specific model - Social Dimension - Individual Dimension - Fuzzy Set - statistical model
IBN	×	Reasoning : Belief, Desire, Intention	based on had-hoc rules		∅

Table 4. Comparative Results: R^2-IBN and IBN

	Perfect knowledge			*Imperfect knowledge*	
	Negotiation cycle Nb.	**Arg. Nb.**		**Negotiation cycle Nb.**	**Arg. Nb.**
R^2-IBN	4	8		6	12
IBN	7	10		9	14

The described vision in the above case focuses on the effectiveness of R^2-IBN compared to IBN framework from which it inherits. Nevertheless, it is conducive to compare R^2-IBN to different frameworks of the literature.

Case 2: agents have perfect knowledge of the evaluation function (for the strength value of an argument and their effect on the opponent beliefs) of each other.

From the experimental results shown in Figure 5, we derive that the proposed framework R^2-IBN offers improved behaviour compared to other considered frameworks (cf. Table 5). This improvement affects not only the negotiation cycle numbers but also the number of arguments set.

Clearly, R^2-IBN has a number of negotiation rounds and exchanged arguments in order to reach agreement, much better compared to those used by the *Ramchurn* framework, on the one hand, and the *Ramping* framework, on the second hand (1000 vs. 1371 for *Ramchurn* and Vs 1542 for *Ramping* concerning the number of negotiation cycle).

Nevertheless, the *Random* model presents number of negotiation cycles slightly lower than *Ramping* (1398 vs. 1542 for Ramping) but using much lower number of arguments than *Ramping*. Nevertheless, the *Random* model presents a number of negotiation cycles and exchanged arguments high compared to the *Ramchurn* framework and essentially the R^2-IBN framework. However, the model *without argument* presents a number of negotiation rounds much higher in comparison to other frameworks.

To this end, we draw the following conclusions: i) the good choice of the Argument Based Negotiation approach ii) the advantage of revealing meta-information about a proposal during a negotiation, improves more flexible reasoning and maximizes the number of rounds and hence reduce the communication traffic.

Agents defined by *Ramchurn* framework features (cf. Table 5) present a number of negotiation rounds and arguments greater than used in R^2-IBN and this because *Ramchurn* classify the arguments into three classes: *Threat*, *reward* and *Appeal*. In our object of analysis, the last two classes are important and will have a positive impact, while the first class, *Threat* is not sought as extended enterprise part, in which the sociological relations are of major importance. Hence, the inapplicability of this class in our context. This explains the high number of negotiation rounds and arguments used to converge. Of even for the *Ramping* framework proposed by *Kraus* [27] is based on the three classes already presented by the *Ramchurn* framework [16]. Moreover, the argument selection process, it follows a rigid order, through argument classes, starting with *Appeals*, then by *Rewards* to finish with *Threats*. This explains the number of cycles and arguments used. Moreover, in the Ramping framework, there is no consideration of the strength value of an argument.

Furthermore, the *Random* framework provides a negotiation cycle numbers high because there is no application of a strategy for arguments generation and selection process which results in an argument selected in a random way and hence degrade the agents effectiveness of *Random* type. For the model *without argument*, the agents negotiate without doing recourse to the exchange of argument, therefore, the agents exchange simple proposals, because they do not have the right to change the subject of negotiation, this induces the non-flexibility of the model, which explains the high number of cycle compared to other frameworks.

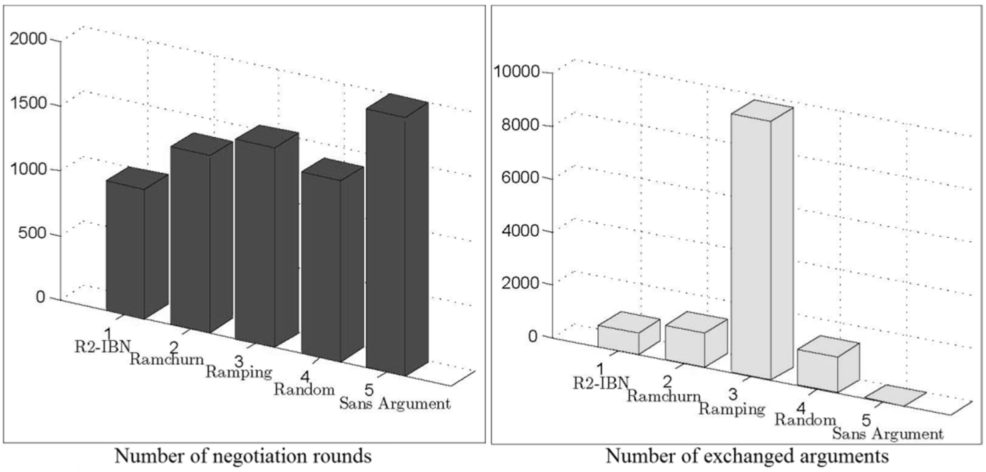

Figure 5. Number of negotiation rounds and exchanged arguments: Perfect Knowledge Case

Table 5. Characteristics of the experimental validation models

	BDI architecture	**Evaluation**	**Generation**	**Selection**	**Trust & Reputation**
R^2-IBN	×	IBN Extension - Roles & Capabilities - Trust & Reputation - Fuzzy reasoning	Rules : - Modus Ponens - Modus Tollens	Fuzzy reasoning : Utility, Trust, Capabilities, Strength of an arg.	Specific model : Social Dimension, Individual Dimension, Fuzzy Set, statistical model
Rumchurn	∅	Utility	Not Specified	Fuzzy reasoning : Utility, Trust	∅
Ramping	×	Conflict & persuasion	had-hoc rules	Arguments classes	∅
Random	×	IBN	had-hoc rules	Random	Specific model : Social

					Dimension, Individual Dimension, Fuzzy Set, statistical model
Whithout Arg.	×	∅	∅	∅	Specific model : Social Dimension, Individual Dimension, Fuzzy Set, statistical model

Case 3: agents have an imperfect knowledge of the evaluation function (for the strength value of an argument and their effect on the opponent beliefs) of each other.

From the experimental results shown in Figure 6, we derive that, under imperfect knowledge of the impact of the strength value of an argument on knowledge and beliefs of an opponent agent, the proposed framework R^2-IBN offers improved behaviour compared to other frameworks considered. This improvement affects not only the number of negotiation cycle but also the number of arguments set forth.
However, the exchanged argument number is raised enough. This is due to the lack of knowledge of the strength value impact of the arguments set forth by an agent on the knowledge and beliefs of an opponent agent, which induces to exchange an important number of arguments to converge.

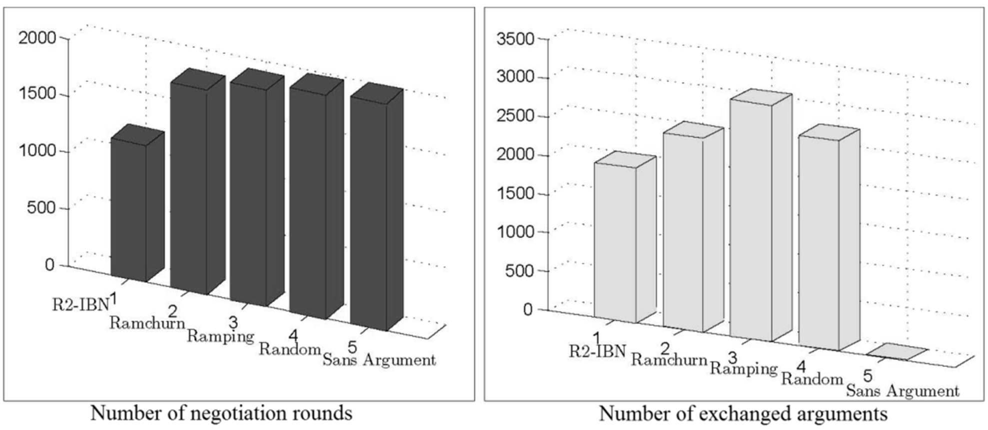

Figure 6. Number of negotiation rounds and exchanged arguments: Imperfect Knowledge Case

Summary

The choice of intelligent software agent provides a natural way to design extended enterprises (EE) because the intrinsic features of MAS correspond to those to be preserved in the hoped EE. MAIS-E^2, provides the cooperation of different actors in EE. In addition to that, the analysis of cooperation leads to the problem of conflict resolution. For that, Argument-Based Negotiation is an effective means of solving conflicts in MAS. In this way, we have already defined R^2-IBN framework. R^2-IBN is an extension of an existing one which is IBN. Extensions take into consideration the roles of agents via their capabilities and their relationships and confidence with other agents in the reasoning mechanism of *Mediator* agent. To improve bridge from theory to practice, MAIS-E^2 model and R^2-IBN framework have been instantiated to a port application. MAIS-E^2 and R^2-IBN prove their effectiveness in comparison to the IBN framework and different benchmarks that are taken into considered. However, it is still difficult to evaluate the number of arguments and cycles to reach agreement between more than two *Mediator* agents. In addition, each one can use its own reasoning structure.
The future research goals consist of making deep experimental evaluation by extending the negotiation between more than two *Mediator* agents. Moreover, these *Mediator* agents can use the same or different reasoning structure.

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MODEL MAIS-E2 ORAZ STRUKTURA R2-IBN: PRZYPADEK ZASTOSOWANIA W PORCIE

Streszczenie: Celem niniejszej pracy jest zbadanie problemu współpracy w przypadku rozszerzonego przedsiębiorstwa. Niniejsze opracowanie koncentruje się na prezentacji zorientowanego na przedstawicielstwo rozszerzonego przedsiębiorstwa jako rozwiązania pozwalającego przedsiębiorstwom na rozwiązania problemu ogólnej współpracy a w szczególności rozwiązywania konfliktów. W związku z tym, cel ten określony jest przez trzy aspekty: organizacyjne, rozumowania i wnioskowania. Aspekty organizacyjne i rozumowanie przedstawione są poprzez przegląd projektowania rozszerzonego przedsiębiorstwa przez podejście zorientowane na przedstawicielstwo przez środek proponowany model MAIS-E2 (Multi-Agent Systemu Informacji Rozszerzonego Przedsiębiorstwa) oraz proponowanego argumentu opartego na ramach negocjacji R2-IBN (Powiązania-Rola i odsetek w oparciu negocjacji), odpowiednio określone dla modelu MAIS-E2. Następnie skupiamy się głównie na aspekcie aplikacji poprzez tworzenie instancji modelu MAIS-E2 do portu. Aspekty te są konsolidowane przez zatwierdzenie eksperymentalnego powstałego prototypy w oparciu o platformę JADE i wyniki z różnych przypadkach w obszarze portu.

MAIS-E² 模型和R²-IBN 框架：端口应用案例

摘要 ：本文主旨在于以扩展企业为案例研究合作问题。本次研究重心在于面向代理的拓展企业解决方案介绍。从大体上，本解决方案在于克服企业合作问题，特别是冲突解决。在这方面，这个目标涉及三个方面：组织，推理及应用。分别通过MAIS-E2模型以及基于R²-IBN框架的MAIS-E2模型介绍组织和推理方面。其次，我们将重心主要放在基于MAIS-E² 模型的端口应用方面。通过运用JADE平台开发原型的实验验证以及端口方面不同案例的实验结果将以上三方面整合。