TA-Fuzzy Semantic Networks for Interaction Representation in Social Simulation

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Abstract. The need to model interactions between people of different cultures, religions and ethnic groups is evident. In Social Simulation, the combination of Artificial Intelligence and Multi-agent Systems has proven to be a good tool for modeling social groups, however much remains to achieve a model which represents a society with differences between individuals. Our proposal is to combine fuzzy logic, semantic networks and transactional analysis for representation of social interactions, taking into account the perception and a psychosocial profile of each individual. This model will facilitate the implementation of socially intelligent agents.

1 Introduction

Simulations as a research tool have gained more attention by researchers as a possibility for study and understand phenomena. Several disciplines have adopted it as a regular tool with success to generate data close to the real phenomena. In [1] and [5] presented two different types of formalizations, one using UML another using Logic Agent-Based to present tools for Social Simulation.

Traditionally, social sciences use statistical methods to develop and the study of models that describe the social phenomena, but with an emergent systemic approach, the possibility of developing software is more and more appealing. The social researchers coming from different fields, such as, sociology, psychology, anthropology, among others, have developed qualitative tools to take them to the practice in social simulations, but this is not sufficient to develop simulations that are resembled the reality more accurately. In order to carry out these simulations it is precise to define the scope in which they will be developed, from the point of view of the multi-agents systems (MAS) is an ideal frame to carry out the simulation.

A MAS is a distributed system in which the nodes or elements are artificial intelligence systems, that are called agents, or, it is a distributed system where the conduct of these agents produces an intelligent result altogether. It is necessary to notice that

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the agents are not necessarily intelligent; two approaches exist to construct them; the classic one, where the agent is equipped with greater possible intelligence; and the constructivist, which persecutes the idea to offer intelligence to the assembly of all the agents. This type of approach is habitually called emergent behaviour.

An interaction assumes the presence of agents able to act and/or to communicate to achieve a goal by means of individual and/or cooperative work; in this sense, the necessity to take into account the intentions of the agents in the interactions is fundamental, this can be obtained considering the psychological part of the same agents by means of the transactional analysis theory (TA).

TA theory [2] has been used anywhere in the world as a successful tool to understand the bases of the behaviour and feelings of the people as well as for the conflict detection in the interactions. Dr Berne introduced it for the first time at the beginning of the 60's and it is considered a tool that can be used to explain the human interaction [8].

With the purpose of describing the social interactions, one sets out to construct a representation mechanism that will take into account the attitude, implicit social interrelations, and the communication, assigning roles based on cultural scripts. As well as the inclusion of the fuzzy logic to represent the knowledge base of the agents by a fuzzy inference system.

2 Objective of the Model

This innovative proposal for the representation of the model is in which the theory of TA is modified to define the interactions among agents within a MAS. In this sense, the role of each agent is determined according to a set of elements that are comprised by the TA.

The transactional analysis provides to the people a rational method to analyze and to understand the human behaviour. [3] propose in their model the structure of the personality in a systemic and consistent sense. The TA sees the "personality" as the result of the interactions of forces within an individual. TA not only tries to formalize the human interaction, in addition detect conflicts too. The transactions happen between the people when they send messages. A transaction consists of a stimulus and an answer. The transaction can be obvious and verbal. Some times are not verbal nor are so obvious, for example a smile or a pitching.

Structural analysis is within TA theory; it is based on the concept of the ego state (ES). An ES is defined as a pattern of feelings, thoughts, and experiences and they are related to a behaviour profile. This personality is conformed of three ego states: Parent (P), Adult (A), and Child (C). Each ES perceives the environment of totally different form. The Parent ego state, tries to use the learned patterns (imitation), these patterns are called "culture". The Adult ego state, changes the environments stimulate into information, this is processed and archived in the previous experience. Finally the Child ego state reacts of a steep way based in a pre-logical mechanism and distorted perceptions.

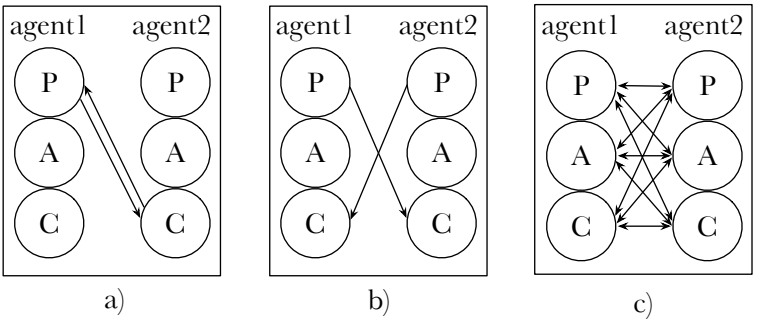

Fig. 1. Types of transactions. a) complementary, b) crossed, and c) ulterior.

In order than a transaction exists, a stimulate must be generated by a particular ES of one person and an answer that comes given from ES of another person. Stroke is named in the TA language when a person recognizes another one with a smile or a pitching, for example. Two or more strokes become a transaction. All the transactions can be classified in complementary, crossed, and ulteriors.

A complementary transaction is when the message initiates in a transmitters ES and is received by the appropriate receivers ES. In this case, cooperation and understanding of both parties is possible, that is to say, it exists a dialog. A crossed transaction happens when there is an unexpected answer to the stimulus, an unsuitable ES is activated and the lines of the transaction are crossed, when this happens appears a conflict and the communication is interrupted. The ulterior transactions are the most complex ones. These transactions involves more than one ES and the message is sent from more than one ES at the same time. These transactions can be seen in a graphic way in Fig. 1.

Another concept of the TA that taken into account is the analysis of the game. The games in which we participated, each person takes its own role. The Triangle of Drama of Karpman [12] defines three roles, persecutor, victim, and rescuer, which always are presents in all the games in which we participated. The drama generates the sensations that happen when people hide its intentions and secrets and later manipulates them to obtain personal advantage.

Once a role is defined, this one participates within a script. A script is a particular sequence of actions played by a role. The scripts have the particularitity that are repeated several times. The scripts have names and the way in which they will be developed can be calculated, then it is possible to think about them as small theater play where each participant repeats its lines over and over again.

In order to complete the proposal, it is taken into account the four positions from life developed by [6] that we shall call psychological posture. Ever since we are born we are taking some of these positions, when a child is defenseless and dependant takes the I'm not ok –You're ok $(-+)$ position and it happens in the first year of life. The second position (I'm not ok –You're not ok, $--$) it is the one that is adopted when a child is in the second year of its life, where there is not more

comfort and it receives scolds. When a child is mistreated in his childhood and survives it can assume the third called position I'm ok –You're not ok $(+-)$ and always it is recriminating to the society assuring that it is always right and that everybody in the world is against its. Finally, the fourth position is I'm ok –You're ok $(++)$, unlike the first three which they are in unconscious form, this position is not a feeling, is based in thoughts, faith and actions.

Including to this proposal the TA theory provides an approach to the reality because the agents must have major similarity to the human behaviour [4], but this is not enough since these concepts do not take into account the fuzzy concepts. Soft computing is an approach to computing which parallels the remarkable ability of the human mind to reason and learn in an environment of uncertainty and imprecision [14]; this is a characteristic of human being.

3 Fuzzy MAS Formal Description

In this section, the formal description of representation model of interactions among agents in a MAS is made. In order to describe a situation in adapted way, simple and easy to understand, representations can be used. A semantic network is a type of representation and consists of four parts, a lexical part, a structural part, one of procedure and a semantic part [11]. The lexical part, determines the symbols that are allowed in the vocabulary of the representation. The structural part describes the restrictions on the form in which the symbols can be become ordered. The operative part specifies the access procedures that allow to create descriptions, to modify them and to respond to questions. The semantic part establishes a form to associate the meaning with the descriptions.

Many schools of thought exist about the meaning of the semantics. But after all, the meaning always seems to have roots in the human perception and the intuition. A unknown object is identified with a idealized object if their characteristics are similar and not necessarily identical.

3.1 Formal Definition of Multi-agent System

A finite automaton is used to formally define the multi-agent system model. As it's defined in [10] a finite automaton is formed by several parts; this finite automaton has a set of states and rules and it goes from one state to another following the input symbol. It has an input alphabet that indicates the symbols that can store. It has an initial state and a set of acceptance states. The formal definition states that a finite automaton is a list of these five objects: set of states, input alphabet, rules for moving, start state, and accept states. In mathematical language a list of five elements is often called a 5-tuple. A finite automaton is defined as a tuple of five parts. Transition function is called to the rules for moving and it is denoted by δ. If a finite automaton has an arrow from the state x to the state y labeled with the input symbol 1 means that, if the automata is in the state x and reads a symbol 1 this automaton moves to the state y. This can be indicated of the form $\delta(x,1) = y$.

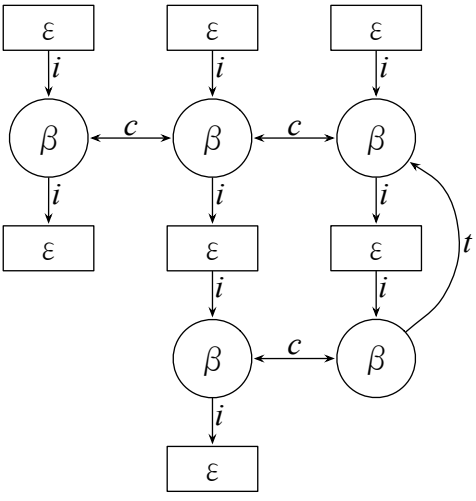

Fig. 2. Graphic representation of a MAS

Definition 1. A MAS is defined as a finite automaton with six elements

$$MAS = (\beta, \varepsilon, \alpha, \delta, q_0, \phi)$$

where:

1. β is a set of finite nodes that describes an agent, denoted by BP,
2. ε is a set of finite nodes that describes the events that happen in the MAS, denoted by E,
3. α is the finite set named alphabet, where $\alpha = \{i,t,c\}$ represents a link label between a node and another one. A labeled i link can initiate a type-BP node or type-E node; a labeled t link can terminate a type-BP node, finally a labeled c link corefers two type-BP nodes,
4. $\delta : \eta \times \alpha \rightarrow P(\eta)$ is the transition function, where $\eta = \beta \cup \varepsilon$ and it is defined by
$$\delta(\eta,\alpha) = \begin{cases} P(\beta) & \eta \in \beta \text{ and } \alpha \in \{c,t\} \\ P(\varepsilon) & \eta \in \beta \text{ and } \alpha = i \\ P(\eta) & \eta \in \varepsilon \text{ and } \alpha = i \end{cases},$$
5. $q_0 \in \varepsilon$ is the start state, and
6. $\phi \subseteq \beta$ is the set of accept states.

Fig. 2 shows a graphic representation of the semantic network of a MAS.

Definition 2. An agent is defineted as a 5-tuple

$$\beta = (\lambda, ESi, ESu, \pi i, \pi u)$$

where:

1. λ represents the perception of an event for an agent. It is defined in section 3.2 as a linguistic variable.
2. $ESi = \{P,A,C\}$ represents the ego state of an agent. Where **P** = Parent, **A** = Adult, and **C** = Child.
3. $ESu = \{P,A,C\}$ represents the perception of the ego state of another agent. Where **P** = Parent, **A** = Adult, and **C** = Child.
4. πi represents the psychological posture of an agent. It is defined in section 3.2 as a fuzzy inference system.
5. πu represents the perception of the psychological posture of the other agent. It is defined in section 3.2 as a fuzzy inference system.

Fig. 3 shows a graphic representation of an agent.

A link labels are *i*, an acronym for initiates, meaning that a type-BP node or a type-E node at the tail of an *i* link leads to the one at the head of the link; *t*, for terminates, meaning that a type-BP node at the tail turns off that happened in a previous time at the head; and *c* for corefers, meaning that two type-BP nodes are related in the same time of two or more agents. Links labeled with *c* have two heads to indicate that these nodes are related in both directions.

With two kind of nodes and three kind of links, $2 \times 3 \times 2$ combinations can be created of the type node-link-node; some combination from these 12 possibilities are shown in Fig. 4.

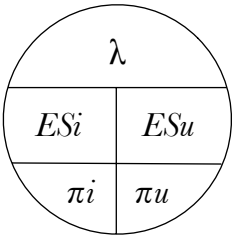

Fig. 3. Graphic representation of an agent.

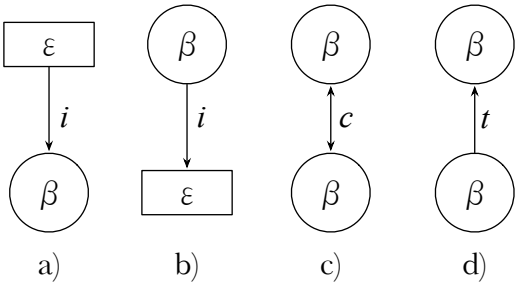

Fig. 4. Some cases of combinations in a semantic network. a) Enablement, b) Reaction, c) Perseverence, and d) Change of mind.

3.2 Definition of the Fuzzy Inference System

With the purpose to represent the perception of the event (λ) for an agent, a membership functions (MF) is defined. The MF maps each element of a collection of objects to a membership grade (or membership value) between 0 and 1 [7]. With this techniques of fuzzy logic [13] can be applied to turn the perceptions to linguistic values.

Let Λ = "event perception." The fuzzy sets are defined "not_important," "important," and "very_important" that are characterized by MFs $\mu_{not\_important}(\lambda)$, $\mu_{important}(\lambda)$, and $\mu_{very\_important}(\lambda)$ respectively. If "event perception" assumes the value of "not_important," then exists the expression "event perception is not important," and so forth for the others values, these linguistic values are displayed in Fig. 5, where the universe of discourse Λ is totally covered by the MFs and the transition from one MF to another is smooth and gradual.

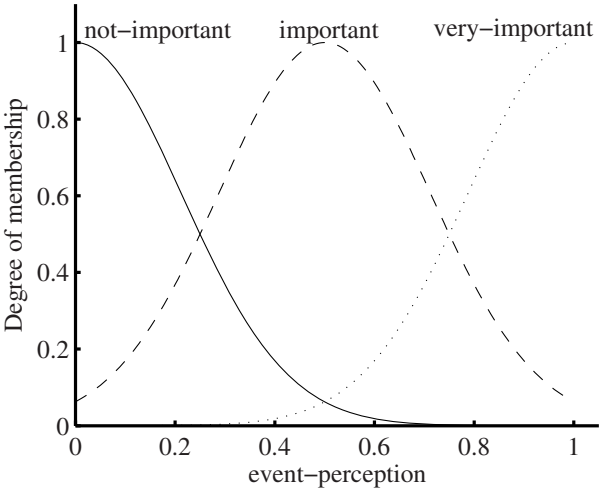

Fig. 5. Membership functions for event perception

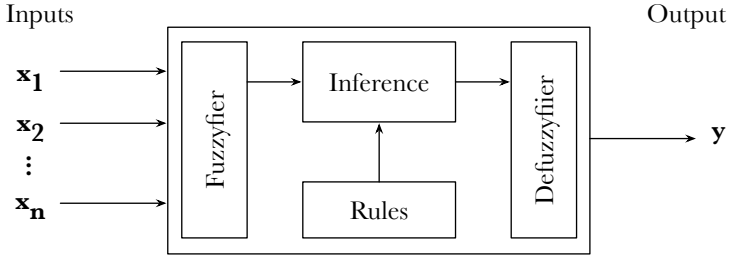

Fig. 6. Structure of fuzzy inference system

Table 1. Linguistic variables πi and πu and their linguistic values

Linguistic variables	linguistic values	
πi	NOK	OK
πu	NOK	OK

Table 2. Linguistic variables ρi and ρu and their linguistic values

Linguistic variables	linguistic values			
ρi	No-role	Persecutor	Rescuer	Victim
ρu	No-role	Persecutor	Rescuer	Victim

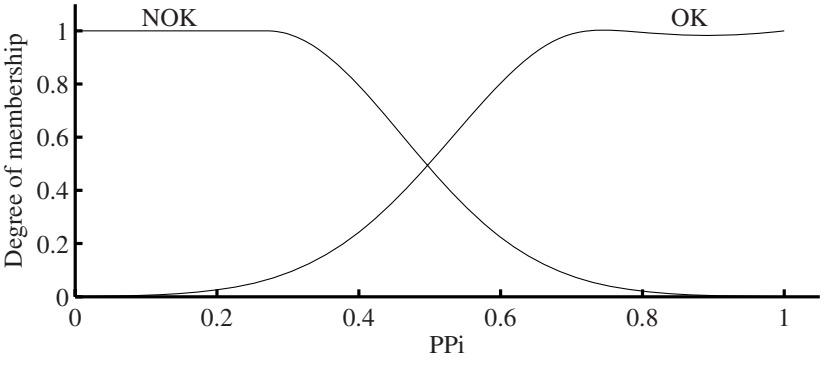

Fig. 7. Antecedent MF of Mamdani fuzzy model

In order to represent the roles that participate in a script uses a Mamdani fuzzy inference system (FIS). A FIS is based on fuzzy set theory, fuzzy if-then rules, and fuzzy reasoning [7]. Fig. 6 shown the blocks of the FIS. The rule base contains a selection of fuzzy rules; the database (or dictionary) defines the membership fuctions used in the fuzzy rules; and the reasoning mechanism, which performs the inference procedure upon the rules and given facts to derive a reasonable output or conclusion.

Table 1 shows the linguistic values for the input variables to the FIS, they are defined by πi (psychological posture of the agent) and πu (perception of psychological posture of another agent) as linguistic variables. Table 2 shows the linguistic values for the output variables, which are ρi (role of the agent) and ρu (perception of the role of another agent).

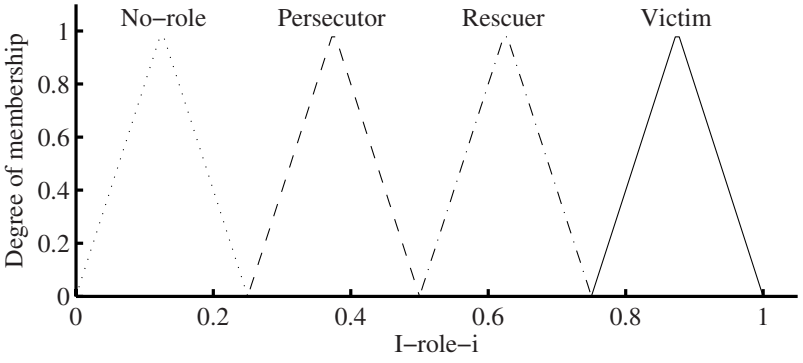

Fig. 8. Consequent MF of Mamdani fuzzy model

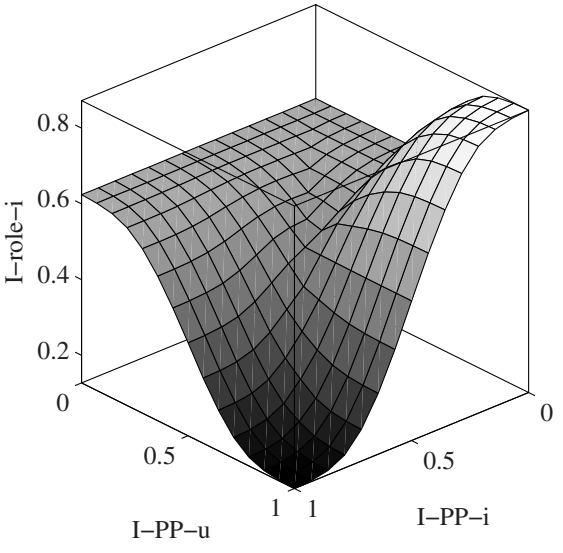

Fig. 9. Overall input-output surface

These variables and their linguistic values can be represented by membership functions as it is shown in the Fig. 7 and Fig. 8.

In Fig. 9 can be observed that while the psychological posture of each agents is more closed to linguistic value OK, they do not take any role. If an agent approaches linguistic value OK and the other agent approaches more linguistic value NOK, the role that takes the agent is Rescuer and the perception of role of the other agent is Victim. This is shows the overall input-output surface with the max-min composition and the defuzzyfication type centroid.

4 Case of Study

In order to use the model presented in the previous section, an example taken from [9] is used, that describes a psychological profile called "Don Juan" syndrome and presents a characterization of psychological script that a man who still is in this situation. The sequence of steps that follows in this psychological game is presented next:

1. Don Juan uses flattery and promises to present himself as the Rescuer of a woman who is prey to her own need to be free and to feel appreciated (the Victim).
2. The work of seduction continues until she capitulates (the response).
3. The moment "Don Juan" reneges on any further demands for emotional closeness, the woman remains bewildered and shocked.
4. As soon as she realizes how gullible she has been, she turns into a Persecutor seeking revenge, and Don Juan, in turn, becomes the Victim of female voracity–ready to start fresh anew as another woman's Rescuer (this move is the switch).
5. The game's playoff is for Don Juan to prove once again how voracious women are and to feel "all set and raring to go" in a new attempt to win over the ideal woman; the woman's payoff is to confirm man are untrustworthy.

In this game different types of messages can be identifed and a collection of them could be made, in the Table 3 some classifications of these messages with an example are shown.

Table 3. Classification of messages in a psychological game

Type of message	Example of message
Social	"Hello!"
Flattery	"You are beautiful"
Promise	"I'll do it next week!"
Reneges	"You ask too much"
Demand	"I want to see you right now!"
Revenge	"You're just like all the rest."

4.1 Scenario A. One Agent Don Juan

In this subsection we describes a scenario where there are 3 agents, one of them has the profile of "Don Juan," the two kind of agents using the proposed model are defined.

Definition 3. "Don Juan" is defineted as a 5-tuple $\beta_{agent1} = (\lambda, ESi, ESu, \pi i, \pi u)$ where:

1. $\lambda = very - important$,
2. $ESi = \{P\}$,
3. $ESu = \{C\}$,

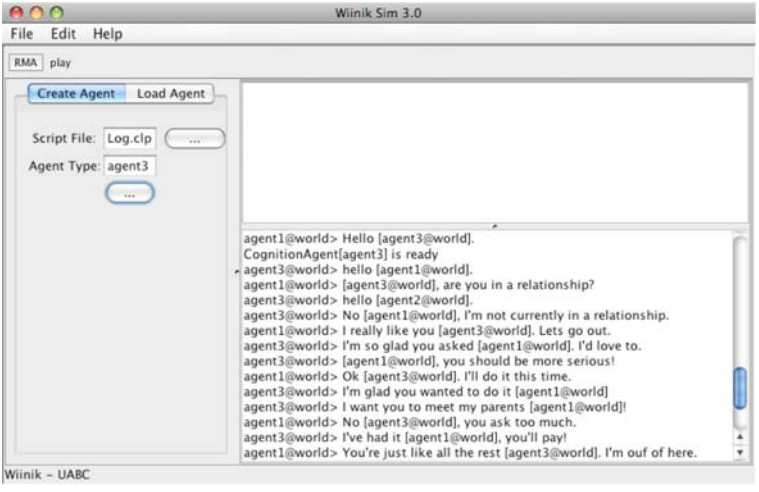

Fig. 10. Screenshot shows to the script of "Don Juan."

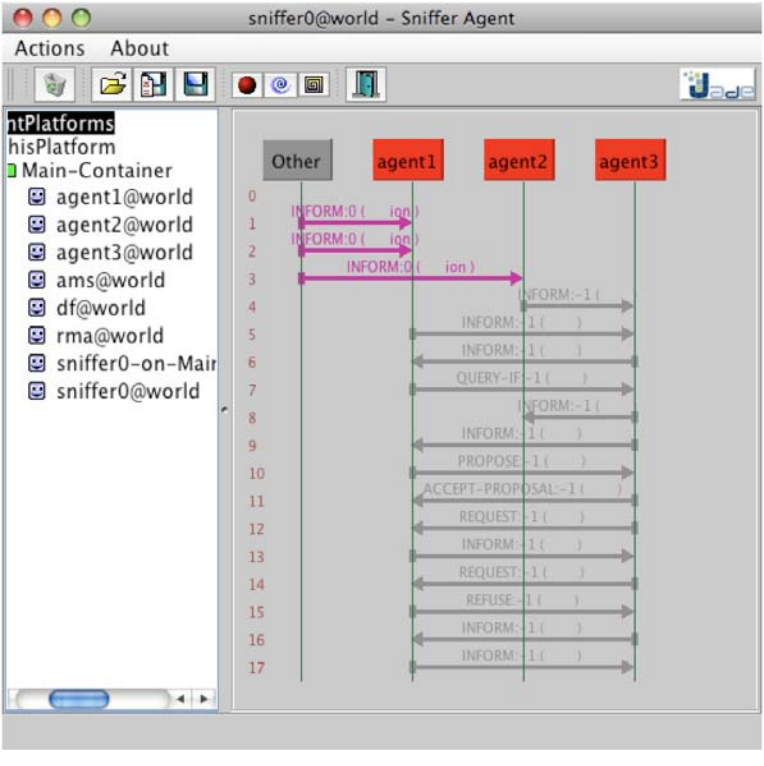

Fig. 11. Screenshot shows interactions among agents who exist in the world.

4. $\pi i = OK$,
5. $\pi u = NOK$.

Definition 4. agent2 is defineted as a 5-tuple $\beta_{agent2} = (\lambda, ESi, ESu, \pi i, \pi u)$ where:

1. $\lambda = very - important$,
2. $ESi = \{C\}$,
3. $ESu = \{P\}$,
4. $\pi i = NOK$,
5. $\pi u = OK$.

With this information establishing the role of Rescuer for agent1 and agents agent2 and agent3 are positioned in the role of Victim. Following the script of Don Juan must exist these two roles for agents to begin the steps shown in the previous section. In Fig. 10 shows a screenshoot of the way in which "hook" these agents and follow the dash to the end. In Fig. 11 shows a screenshot of the interactions among these agents, which can display the kind of message that is sent and received by the agents.

5 Conclusions

This research focuses on a proposal of a TA-Fuzzy Semantic Networks to represent the interactions among agents in social simulation. In the representation of Winston [11] does not show enough information to detect and resolve conflicts or to identify the manner in which a decision is taken by an agent. The proposal for TA-Fuzzy Semantic Network extends this representation combining fuzzy logic, semantic networks and transactional analysis for representation of social interactions, taking into account the perception and a psychosocial profile of each individual.

A tool to model a MAS based on the model proposed was presented. The case of study of "Don Juan" was used to demonstrate the proposed model. This approach could be a tool for sociologists, psychologists and other groups of researchers who are interested in the simulation of social situations.

We are working on a social platform developed by IMOX research group to perform simulations. This platform are programmed in Java language is also using a programming language based on fuzzy rules to define agents and their environment.

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