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Using RPG and MABS to develop Group Decision Support Systems

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Abstract

In-between games and theater, Role-Playing Games (RPGs) are group settings that determine the roles or behavioral patterns of players, as well as an imaginary context. A RPG is the performance of a roughly defined situation that involves people with given roles. Multi-Agent Systems (MAS) study the behavior of an independent agent set with different characteristics, evolving in a common environment. Additionally, the use of the simulation as auxiliary tool in human decision-making is very efficient, because it is possible to verify specific details with a better precision. From the union of multi-agent systems and simulation technologies, a research domain called Multi-Agent-Based Simulation (MABS) was created. In this work, we use these two techniques (RPG and MABS) in an integrated way to develop a Group Decision Support System (GDSS), using the GMABS methodology. We have developed two case studies, called JogoMan and ViP-JogoMan, in the natural resources management domain. This domain is interesting one since the negotiation process is extremely important and complex. These case studies showed that GMABS methodology can be applied to GDSS and can empower the negotiation process.

KEY WORDS: Group Decision Support Systems, Role-Playing Games, Multi-Agent Based Simulation, Natural Resources Management, Virtual Players.

1 Introduction

Role-Playing Games (RPG) are well known entertainment games where players play (or act, or perform) characters and, by doing this, live different lives, full of fantasy and entertainment (Costikyan, 1994).

Multi-Agent Systems (MAS) study the behavior of sets of independent agents, that interact with each other, and try to execute their tasks in a cooperative way by sharing information, preventing conflicts and coordinating the execution of their own activities (Alvares and Sichman, 1997). Additionally, the use of the simulation as auxiliary tool in human decision-making is very efficient, since its use allows the verification of specific details with a better precision. The combination of both, multi-agent systems and simulation, deals with problems that involve multiple domains, generates a new research area called Multi-Agent-Based Simulation (MABS) (Gilbert and Troitzsch, 1999).

Multi-Agent-Based Simulation (MABS) and Role-Playing Games (RPG) are methods that have already been used to represent natural resources management (Briot *et al.*, 2007; Guyot *et al.*, 2006; D'Aquino *et al.*, 2003). Computer tools are implemented using MABS and RPG techniques to integrate the conceptual modeling phase, allowing to represent and to explore the functioning and dynamics of the natural resources management through testing different scenarios. Combining MABS and RPG is a way to join the dynamism from MABS and the capacity to generate discussion from RPG techniques (Barreteau *et al.*, 2001).

Decision Support Systems (DSS) are information systems that supply information on the problem in study domain and support the decision making process (Dornelas, 2000). A subgroup of DSS is the Group Decision Support Systems (GDSS), where the focus is to work on the decision-making process in groups, because in cooperative work there are some problems related to activities coordination and timing.

We have organized this paper in 4 sections. In Section 2, we briefly present a short review about RPG, MABS and GMABS methodology. In section 3 the two development prototypes, using GMABS methodology, are presented. Finally, the conclusions and future work are shown in Section 4.

2 Used techniques

2.1 Role-Playing Games (RPG)

Role-Playing Games (RPG) are games where players perform characters. A character is created inside of a particular scene (an environment). It follows a system of rules that serves to organize its actions, determining the limits of what can or cannot be done (Bandini *et al.*, 2002). Thus, RPGs are games where each player plays a role and takes decisions to reach its objectives. In fact, players use RPG like a "social laboratory", because they can try many possibilities, without real consequences (Barreteau *et al.*, 2003).

RPG is a technique largely used in training, because players can be inserted in real decision-making situations. Moreover, big companies have used RPG during technical courses and the training and/or learning can occur in a facilitated way due to the game amusing factor (Barreteau *et al.*, 2001).

RPG has focused on the interaction among the individuals, i.e., people that participate in the game. It is an old technique that has been used in computer science from the eighties on, mostly in games (Costikyan, 1994).

2.2 Multi-Agent-Based Simulation (MABS)

Multi-Agent-Based Simulation (MABS) is the union of Multi-Agent Systems and Simulation and it is especially valuable to conciliate different interdisciplinary perspectives. Typically, it involves researchers from various scientific areas, such as social psychology, computer science, social biology, sociology and economics. MABS interdisciplinary characteristic is an important challenge faced by all researchers, while demanding a difficult interlacing of different theories, methodologies, terminologies and points of view (Gilbert and Troitzsch, 1999). MABS field is increasingly characterized by the study, design and implementation of computational platforms to simulate societies of artificial agents.

According to Drogoul and Feber (1992), MABS goals are:

1 Testing hypotheses about the emergence of social structures from the behaviors and interactions of each individual. This is done by testing the minimal conditions given at the micro-level that are necessary to observe these structures at the macro-level;
2 Building theories that contribute to the development of a general understanding of ethological, sociological and psycho-sociological systems, by relating behaviors to structural and organizational properties; and
3 Integrating different partial theories coming from various disciplines, as sociology, ethnology or cognitive psychology, into a general framework, by providing tools that allow the integration of different studies.

2.3 GMABS methodology

In our work, we call the integration of RPG and MABS within a same methodology as GMABS (*Games and Multi-Agent-Based Simulation*) (Adamatti *et al.*, 2005). The methodology steps, shown in Figure 1, are the following:

1. Players receive all the information about the game: the roles they can play, the actions and rules available to these roles, the common environment, the topological constraints. When the game starts, each player defines the role he is going to play. At that time, each player knows what actions he can execute, and the benefits

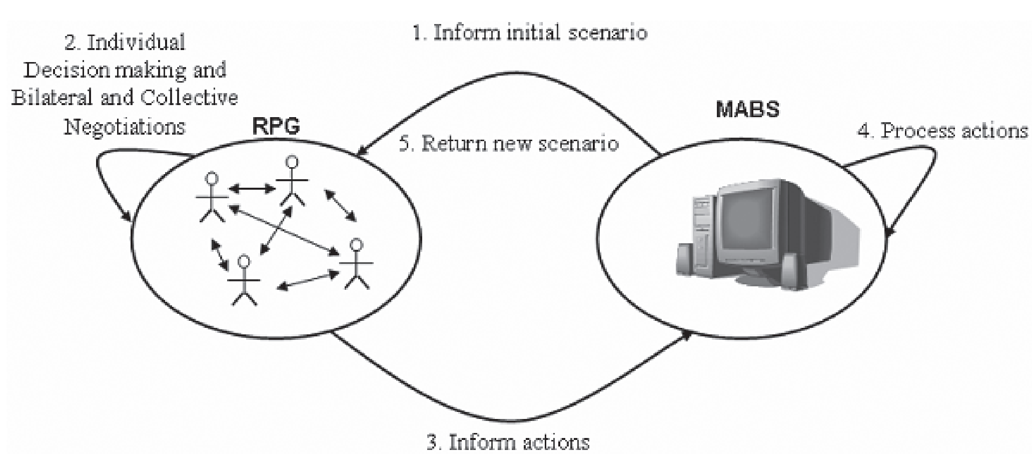


Figure 1. GMABS methodology.

and/or damages its actions can cause to the common environment. The initial scenario also defines where players are physically located within the common environment and what are their initial possessions (money, land, etc.);

2. There are three different activities in this step:
   a. Players may reason and decide about individual actions that just depend on themselves. As an example, in the natural resources domain, land owners change their land use;
   b. Players have all the information necessary to initiate bilateral negotiations with other players. In order to negotiate, they may exchange information and make their decisions, according to the rules their roles must follow. As an example, in the natural resources domain, land owners can sell their lands. Normally, the duration of these two previous activities, which occur simultaneously, is defined in the beginning of the game;
   c. After deciding about their individual actions and concluding the bilateral negotiations, players can negotiate about collective strategies for the next rounds. These collective strategies should benefit all players or just a subgroup of them. As an example, in the natural resources domain, players can demand improvements on infrastructures, more jobs, tax values, etc. This negotiation process of collective strategies is just a "predisposition" to define future actions: players are not really committed to keep their word and really use these strategies in further rounds. This process is very important for each player to better understand the other players' objectives and strategies;
3. Players inform to the MABS tool which individual actions were chosen and which bilateral negotiations were concluded;
4. Data is computed by the MABS tool: the latter actions modify the initial scenario. Therefore, the environment properties are modified, which implies the modification of each player data;
5. The MABS tool returns the new scenario. If the deadline of the game is not reached or the maximum number of rounds has not been achieved, return to step 2.
6. If the game is reached its end, a debriefing session is carried on, in order to enable all players to better understand the game dynamics.

More information about GMABS methodology can be found in (Adamatti *et al.*, 2005).

3 JogoMan and ViP-JogoMan prototypes

We have chosen the natural resources management domain, more specifically concerning the water resources. This domain deals with big land areas, such as cities, states, etc., where all ecosystem must be analyzed. Besides, a great diversity of actors with different objectives and strategies evolve in these scenarios. For example, the study of water problems in the São Paulo Metropolitan area (Brazil) is very complicated, because it is a region that includes nearly 8.000 Km^2 of physical area and 18 million inhabitants. One of the most important aspects in the natural resources management is the negotiation process between the actors, because their objectives and strategies are different which generates many conflicts. For example, a farmer and a manufacturer have different objectives and they normally do not have a consensus. Therefore, the use of a Group Decision Support Systems (GDSS) may help to mitigate these conflicts. We have developed two instances of GDSS, called JogoMan and ViP-JogoMan, explained in sequence.

3.1 JogoMan prototype

We have first developed a prototype called **JogoMan** (the Portuguese acronym for "**Jogo** dos **Man**anciais" that means: Water Sources Game). It was built according to the GMABS methodology, which simulates the management of a particular peri-urban catchment, located at Bacia do Alto Tietê, in São Paulo, Brazil. This prototype was implemented using Cormas (Cormas, 2007), a MABS simulator tailored to the natural resources domain.

JogoMan represents a simplification of the real phenomena of interaction between the several actors, in the context of the peri-urban catchment previously described.

The specific objective of this game is to determine water quality and quantity in a peri-urban catchment. It involves the management of land and water related problems in different cities. The game environment consists of a grid divided into portions. Figure 2 presents two interfaces of JogoMan scenario: cities and land occupation. Each portion represents a real state (or a piece of land) that is associated with an owner (the player) and a land use (such as agriculture or forest). The game allows players: to change the land use; to put some infrastructures on them and to sell/buy their/other portions.

There are four types of players, each one having different goals:

1. **Land Owner**: a land owner has some portions of space, each one with a land use. Each different land use type has different values for

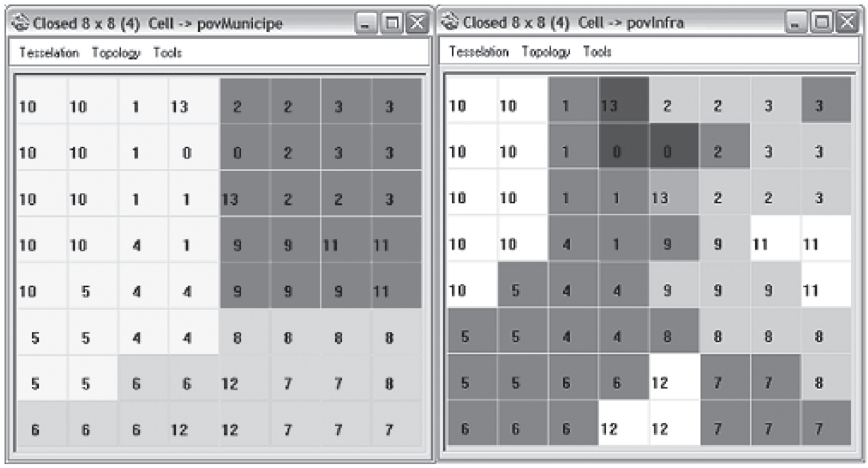


Figure 2. Interface of JogoMan scenario. Left figure presents the division cities (3 cities, represente by different colors). Right figure presents land occupation: numbers represent owners of each portion and colors represent land occupation type (industry, agriculture, etc.).

maintenance and financial return. Owners can sell or buy their private areas or they can exchange land use of these areas. Land owners can ask for infrastructure improvements to the respective mayors.

2. **Mayors**: The game has different cities, each one having its mayor. The mayor goals are closely related to the city main activity (urban, agricultural, etc.). For example, if the city "C" is a preservation area then the player that plays the "Mayor C" should try to preserve this city. The mayors can invest on public infrastructure, such as portable water net or to build schools, hospitals or police headquarters.
3. **AguaPura Company Administrator**: This player can invest on public infrastructure to improve water quality, like portable water and sanitation net.
4. **Migrant Representative**: This player has a special role in the game, since he/she must allocate a number of new homeless families. These families arrive in the cities (urbanization pressure), and they can be allocated in settlements or in slums. The quality and/or quantity of water of the region is modified depending on where these families are placed on.

Each player chooses his/her actions individually, but he/she should know that these actions have consequences to the others, because the quality and quantity of water depends on the overall land use and infrastructure. For example: if a mayor decides to decrease the land taxes for land owners that preserve the forests, various land owners can decide to maintain their forest areas or even decide to plant forest (reforestation). This action influences the others, because the water quality probably will improve. Considering another example, if a land owner decides to build an industry to increase his profit, the consequence will be raising the water pollution.

JogoMan is a mixed system since it provides just the MABS engine. Moreover, the action selection is made by filling paper forms that will be catalogued by a system operator who feeds the MABS with their data. Figure 3 presents the paper form for the Mayors role. These forms, filled by all players, are given to the operator after each round's end. Another task of the operator is to inform the new scenario (next round) to the players. Figure 4 presents the practical operation of JogoMan.

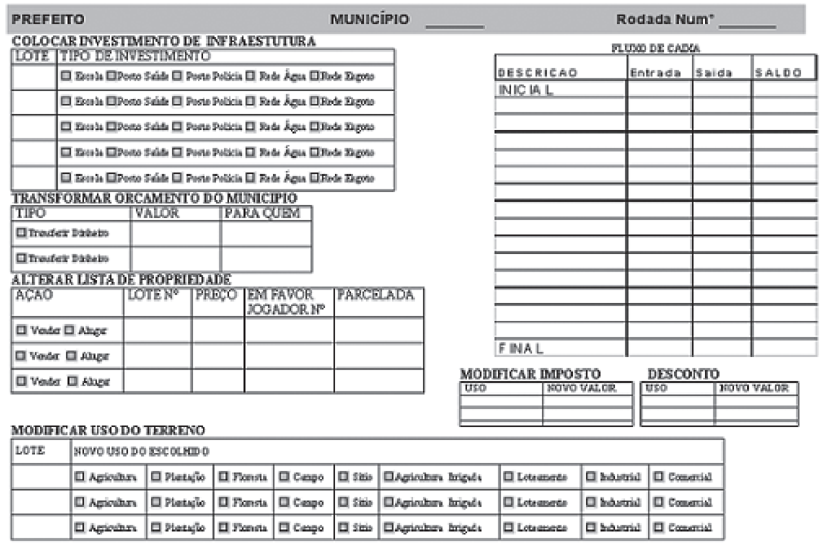
Before starting a new round of the game, a "Meeting of Peri-Catchment Committee" took phase. During this meeting the players discuss about collective strategies to be executed in the next rounds. This corresponds to step 2c at GMABS Methodology, as described in section 2.3.

3.3.1 Session tests

We performed four different tests using JogoMan prototype. These players were graduate and undergraduate students of Biology, Ecology and Social Sciences courses from São Paulo universities. The chosen scenario, for all tests, had 14 players: 9 land owners, 3 mayors, 1 migrant representative and 1 AguaPura Company Administrator.

The sequence of steps for these tests was the following:

1. General explanation for all participants of the game, presenting objectives and roles (possible players).



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TIPO	VALOR	PARA QUEM
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AÇAO	LOTE N°	PREÇO	EM FAVOR JOGADOR N°	PARCELADA
☐ Vender ☐ Alugar				
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FLUXO DE CAIXA

DESCRICAO	Entrada	Saida	SALDO
INICIAL			
FINAL			

MODIFICAR IMPOSTO

USO	NOVO VALOR

DESCONTO

USO	NOVO VALOR

MODIFICAR USO DO TERRENO

LOTE	NOVO USO DO ESCOLHIDO								
	☐ Agricultura	☐ Plantação	☐ Floresta	☐ Campo	☐ Sítio	☐ Agricultura Irrigada	☐ Loteamento	☐ Industrial	☐ Comercial
	☐ Agricultura	☐ Plantação	☐ Floresta	☐ Campo	☐ Sítio	☐ Agricultura Irrigada	☐ Loteamento	☐ Industrial	☐ Comercial
	☐ Agricultura	☐ Plantação	☐ Floresta	☐ Campo	☐ Sítio	☐ Agricultura Irrigada	☐ Loteamento	☐ Industrial	☐ Comercial

Figure 3. Paper form to Mayors (in Portuguese).

2. Each person chooses a role (a player) and fills in the pre-questionnaire game. The pre-questionnaire and the pos-questionnaire have half-structuralized and open write questions.
3. For each different player, specific information is given. For example: mayors know how much money they have and what are the actions they can execute.
4. The first round is started. Usually, it is longer than the other rounds, because the players do not have knowledge about all the actions they can execute and the benefits/damages these actions can cause. A time of 30-40 minutes was defined for the first round.
5. Players inform to the MABS operator which were the chosen actions.
6. Actions are computed by the MABS. These actions modify the initial scenario of the game.
7. All players discuss in the Meeting of Peri-Catchment Committee about collective strategies for the next rounds. The first round is completed.
8. System operator informs about the new scenario and a new round starts.
9. When the rounds finish (normally 3 or 4 rounds), a debriefing session is made, which enables checking the doubts and the suggestions that were made by players while filling in the pos-questionnaire. The debriefing is extremely important, because it is possible to do a qualitative evaluation of the prototype.

According to Egenfeldt-Nielsen (2004), one of the main problems of presenting test results is whether we can use or not traditional methods for measuring learning outcome. In our tests results are qualitative which means that we do not use any mathematical method to determine if the game result is or not good. Instead, we observe the game and ask questions about it through questionnaires in order to obtain more information.

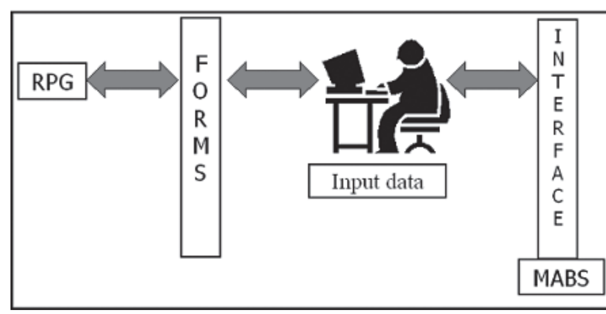

Figure 4. Practical operation of the GMABS methodology in JogoMan.

3.1.2 Tests analyses

We have used just one form to evaluate JogoMan's studies using the analyses of pre and post-questionnaires. By this information, the main aspects pointed out by players were:

1 Most of them thought the game was very interesting and realistic, helping the understanding the reality in peri-urban catchments.

2 They also affirmed they have learnt a lot about the domain, because RPG is a didactic and pleasant way of learning a new topic.

3 They thought that the Meeting of Peri-Catchment Committee was a great idea, because it is important to discuss collective strategies that could enable a better city quality for everyone.

We concluded that the JogoMan prototype, an instance of GDSS using the GMABS methodology, has helped players to understand the proposed domain. Also, we believe that the negotiation process was very important, because players could interact a lot with each other and discover (discussed) new perspectives for the same problem. Also players approved such a funny way of learning. More details about JogoMan can be found in (Adamatti *et al.*, 2005).

3.2 ViP-JogoMan prototype

Whenever any RPG is played, it needs a certain number of real players (people) to be executed. However, many times the game cannot be played because the minimum number of players is not available. Moreover, sometimes the players may be in different places (if the game is played through the Web, for example) and/or be available at different time schedules (if the game is played in asynchronous way). After testing JogoMan prototype, we have verified the need of some tool to substitute the real players. Thus, the existence of **Virtual Players** would be useful, since they could substitute real players without damaging the game. We understand by damaging the game the situation where real players easily identify virtual players decisions, whenever the virtual players decision-making are not realistic (actions very different from the ones real players expected to perform).

We have developed a second prototype, called **ViP-JogoMan** (**Vi**rtual **P**layers in **JogoMan**), where virtual players are inserted. The ViP-JogoMan prototype extends JogoMan by maintaining the existent roles and rules and including virtual players. In addition, it is designed as a web-based application, meaning that players could be in different places at a same time. Each player will have access to MABS, through a graphical interface (computer-based process). Figure 5 presents a snapshot of a graphical interface in ViP-JogoMan, representing the window used of players who play the Mayor role.

We have decided to analyze two aspects during the tests performed with ViP-JogoMan:

1. The effect of the insertion of virtual players in GMABS methodology: will these players have realistic decision-making?
2. The impact on the negotiation process between all players by the graphical interface: will players complete their interactions when negotiating using the graphic interface?

3.2.1 Virtual players

In ViP-JogoMan prototype, the development of virtual players is one of the most important aspects. We have chosen the BDI (Belief, Desire and Intention) architecture (Rao, 1996) to implement them.

In order to define the virtual player behaviors, we have mapped the human players actions from JogoMan session tests in order to discover their objectives and strategies. Having this information at hand, we have analyzed and extracted a sequence of actions that each player had executed. For each player playing a specifically role, different objectives were discovered, and guided us

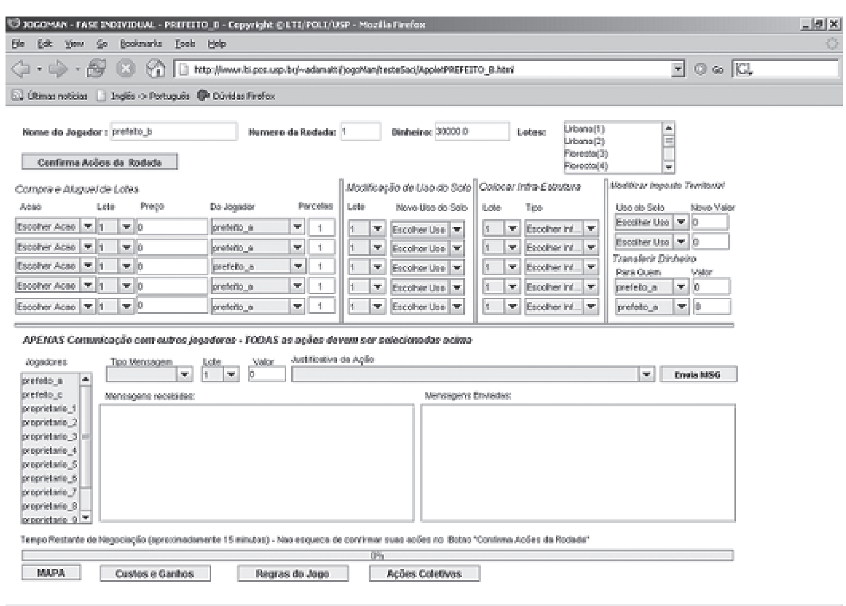

Figure 5. Graphic interface to Mayors (in Portuguese).

to define different behavioral profiles for the virtual players, as Table 1 presents.

For example, the *Economic* behavioral profile of Land Owners has as objective “save and earn money”. The strategies we have found observing the real players with this role, during JogoMan tests, were:

1 If the player has plots near to urban areas, he changes their use to Settlement aiming to sell to Migrant Representative, since this latter always wants plots that are near to the urban areas;
2 If the player has plots where the land use is not Forest, he changes to Agriculture or Irrigated Agriculture, because these land uses need a low investment and yield fast profit, comparing to other land uses, such as Industry;
3 If the player has plots where the land use is Forest, he changes the use to Plantation, in order to receive the suppression profit for cutting the trees.

The profiles were analyzed and evaluated by specialists of the natural resources domain in order to verify if the possible strategies and actions are similar to the real player activities. In order to measure the proposed objective of each profile, some specific variables in the prototype were analyzed. For example, for the Economic behavioral profile of Land Owners, we analyze the amount of money in *cash box* variable.

Each defined profile was implemented in *AgentSpeak(L)* language (Rao, 1996). The interpreter used to execute the knowledge base was Jason (Bordini and Hubner, 2004). Figure 6 shows how the first strategy of Land Owners with *Economic* behavioral profile was implemented in *AgentSpeak(L)* using Jason.

Table 1. Behavioral Profiles Defined.

Role	Behavioral Profile	Objective
Land Owner	Economic	must save and earn money
	Ecologic	must improve the ecological situation of region and be concerned about reservoir pollution
AguaPura Administrator	Rational	must improve water and sanitation networks with a rational use of money
	Ecologic	must improve water and sanitation networks
Migrant Representative	Economic	must allocate families without worrying about
		the social conditions of these families
	Social	must allocate families in good places (with infrastructure and near to urban area)
Mayors	Social	must improve the life quality of the citizens
	Economic	must improve the life quality of the citizens if the city has money to do it
	Ecologic	must improve the ecological situation in its city

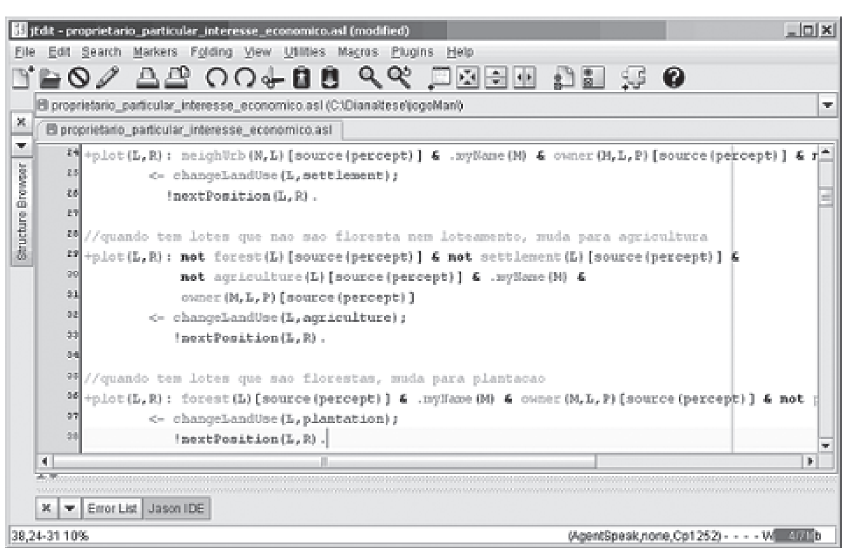

Figure 6. Example of knowledge data base implementation in *AgentSpeak(L)* to Jason.

3.2.2 Session tests

We have performed three tests with ViP-JogoMan prototype, involving real and virtual players. The chosen scenario, for all tests, had 14 players: 9 land owners, 3 mayors, 1 migrant representative and 1 AguaPura Company Administrator.

The sequence of steps for these tests was:

1. Some days before the game, real players received by email an instructions manual containing the game rules, objectives, roles, etc.
2. Each player chose a role, excluding the roles already defined for virtual players;
3. Each player received specific information about his/her role by email. With this information, the pre-questionnaire of the game was sent;
4. A link of the game's interfaces was made available for the players. It was the opportunity for each player to understand his/her role possible actions and how the interaction interface;
5. In a specific day and time, all players played via web browsers using their role's graphical. Through the interface, they chose actions, sent messages, etc. In each round, players informed their actions to MABS;
6. All players discussed in the "Meeting of Peri-Catchment Committee" about collective strategies for the next rounds. After this activity, the first round was completed;
7. The MABS automatically informed the new scenario to the players via graphical interfaces;
8. After four rounds, all players receive four graphics showing the global situation of the region: reservoir pollution, families connected into potable water network, families connected to sanitation network and the number of families living in slums. These graphics help players to understand the evolution of the system as a whole, giving then information to answer the post-questionnaire;
9. All players received a post-questionnaire by email.

In the Vip-JogoMan, all negotiations can be stored during the rounds of the game, including incomplete or rejected negotiations, different from JogoMan, where we just have completed negotiations, since players did not write in paper forms uncompleted or rejected negotiations. According to McKersie and Fonstad (1997), in Internet negotiations can be stored every data and it is possible to analyze them with more attention in order to better understand the negotiation process.

3.2.3 Tests analyses

In order to analyze the tests results, we have defined three ways for evaluating the ViP-JogoMan prototype: (i) pre and post questionnaires filled by real players; (ii) analysis of the behavioral profiles variables for the virtual players; and (iii) analysis of the message exchanging between all players (virtual and/or real) during the negotiation process, both bilateral and collective negotiations.

We have concluded, by the answers in the pre and post questionnaires that the ViP-JogoMan prototype brought to players interaction, entertainment and learning facilities. Interestingly, real players did not easily discover who the virtual players were in the game. In some cases, real players just discovered virtual players due to the speed of their answers and real players needed more time to think and to choose their actions, during negotiation.

By the analysis of the behavioral profiles variables, we have concluded that the defined strategies for each type of profile had reached the proposed objectives. For example, all virtual players with *Economic* behavioral profiles finished the game with high cash box values, comparing to other players.

Finally, by the analysis of the message exchanging between players during the negotiation process, we have concluded all players interacted a lot with each other, because the number of message exchanging was very high. According to Peppet (2002), people feel more comfortable to express their opinions via Internet, because they do not have problems with shyness or prejudice. Another important aspect in ViP-JogoMan prototype is the storage of the negotiation history (completed or not). Table 2 presents quantitative analyses of completed negotiation to buy plots, comparing JogoMan with ViP-JogoMan. This table shows that the number of completed negotiations in ViP-JogoMan prototype is bigger than in JogoMan prototype.

Table 2. Completed bilateral negotiations to buy plots in the two prototypes.

	JogoMan	ViP-JogoMan
Test 1	2	17
Test 2	2	14
Test 3	6	12

In section 3.2, we have cited two aspects to analyze in ViP-JogoMan. According to our results, we can conclude that:

1 Concerning the effect of the virtual player decision-making: the use of behavioral profiles and BDI architecture to model and implement these players is suited having realistic decision-making, since most of the real players did not discover the virtual players during the tests.

2 Concerning the negotiation process through a graphical interface: we believe that supplies to

players with adequate conditions to negotiate with one another, as the number of negotiations during the tests have augmented comparing to JogoMan prototype.

4 Conclusions and further work

GMABS methodology can be used as the basis for Group Decision Support System (GDSS), helping both the negotiation process and conflicts resolution in natural resources management. This could be shown by the tests results using our two prototypes, JogoMan and ViP-JogoMan.

Additionally, through the ViP-JogoMan prototype tests results show that the use of GMABS methodology through the *Web* is efficient and practical, since it makes the prototype available in remote places and for a great number of people. We have also concluded that the computer and the *Web* helped us to map the negotiation.

Nevertheless, we cannot affirm that the number of negotiation (completed or not) is directly related to the learning of negotiation process. Many players in JogoMan tests affirmed in the questionnaires that they knew the domain problem. However, during these tests, the number of negotiations was lesser than ViP-JogoMan tests (see Table 2). We can just conclude that both prototypes reached the proposed objective of their development: to help in the understanding of the negotiation process. We hope that human players that took part of the tests can better interact in real situations than before their participation in the tests, as stated in the post-questionnaire answers.

A good improvement of the ViP-JogoMan prototype could be the implementation of a dynamic knowledge base of virtual players. Until now, we have implemented the virtual players in a static way, but we want to insert new beliefs and plans into the profiles according to the actions chosen by players in the previous rounds. This will improve the set of actions of each profile and turn the game more realistic.

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