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An Analysis of the Insertion of Virtual Players in GMABS Methodology Using the Vip-JogoMan Prototype

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Abstract

The GMABS (Games and Multi-Agent-Based Simulation) methodology was created from the integration of RPG and

MABS techniques. This methodology links the dynamic capacity of MABS (Multi-Agent-Based Simulation) and the discussion and learning capacity of RPG (Role-Playing Games). Using GMABS, we have developed two prototypes in the natural resources management domain. The first prototype, called JogoMan (Adamatti et. al, 2005), is a paper-based game: all players need to be physically present in the same place and time, and there is a minimum needed number of participants to play the game. In order to avoid this constraint, we have built a second prototype, called ViP-JogoMan (Adamatti et. al, 2007), which is an extension of the first one. This second game enables the insertion of virtual players that can substitute some real players in the game. These virtual players can partially mime real behaviors and capture autonomy, social abilities, reaction and adaptation of the real players. We have chosen the BDI architecture to model these virtual players, since its paradigm is based on folk psychology; hence, its core concepts easily map the language that people use to describe their reasoning and actions in everyday life. ViP-JogoMan is a computer-based game, in which people play via Web, players can be in different places and it does not have a hard constraint regarding the minimum number of real players. Our aim in this paper is to present some test results obtained with both prototypes, as well as to present a preliminary discussion on how the insertion of virtual players has affected the game results.
Keywords:

Role-Playing Games, Multi-Agent Based Simulation, Natural Resources, Virtual Players

Introduction

1.1

Within the context of complex systems, negotiation in the natural resources management is a very important topic, since it deals with many different agents, groups of interest, and institutions that interact with the ecosystem (Bousquet et al 1999).

1.2

Multi-Agent-Based Simulation (MABS) and Role-Playing Game (RPG) have been used in several lines of research (d'Aquino et. al 2003; Guyot et. al 2006; Bousquet et. al 2002; Barreteau 2003) with interesting results, due to the dynamic capacity of MABS and the discussion and learning capacity of RPG techniques. The association between RPG and MABS is called GMABS methodology (Games and Multi-Agent-Based Simulation) (Adamatti et. al 2005).

1.3

In RPG, participants assume the roles of fictional characters. By playing these roles, they live different lives, full of fantasy and entertainment (Costikyan 1994). Each participant plays a role and takes decisions to reach its objectives. In fact, players use a RPG as a "social laboratory", because they can experience many possibilities, without real consequences (Barreteau et. al 2003; Barreteau and others 2003).

1.4

MABS combines multi-agent systems and simulation techniques, dealing with problems that involve multiple domains (Gilbert and Troitzsch 1999). A good example of a MABS application domain is natural resources management, as it explores several knowledge areas, such as sociology, hydrology and biology.

1.5

In order to implement a prototype based on GMABS methodology, we need to analyze how both components (MABS and RPG) interact with each other, considering mainly two aspects: players and system operator. The system operator is the one that feeds the MABS tool with input data gained from the RPG players and that forwards the next scenario information to them. This operator can be a real person (manual operator), or a specific program (automatic operator) that integrates several functions between the RPG and MABS components. On the other hand, game players can be real people (real players) or some specific program that tries to capture and "imitate" the real players behavior (virtual players). In Figure 1, we present these two levels of integration, where the simulator is represented by the MABS tool, and the real or virtual players are represented by the RPG element. In Figure 1(a), players are real and the operator is manual; in Figure 1(b), the operator is still manual while all the players are automatic; in Figure 1(c), the players are real and the operator is automatic; finally, in Figure 1(d), we have virtual players and an automatic operator. Obviously, at least regarding game players, we can think of several other mixed situations, where real and virtual players coexist; this would correspond to situations (a/b) and (c/d).

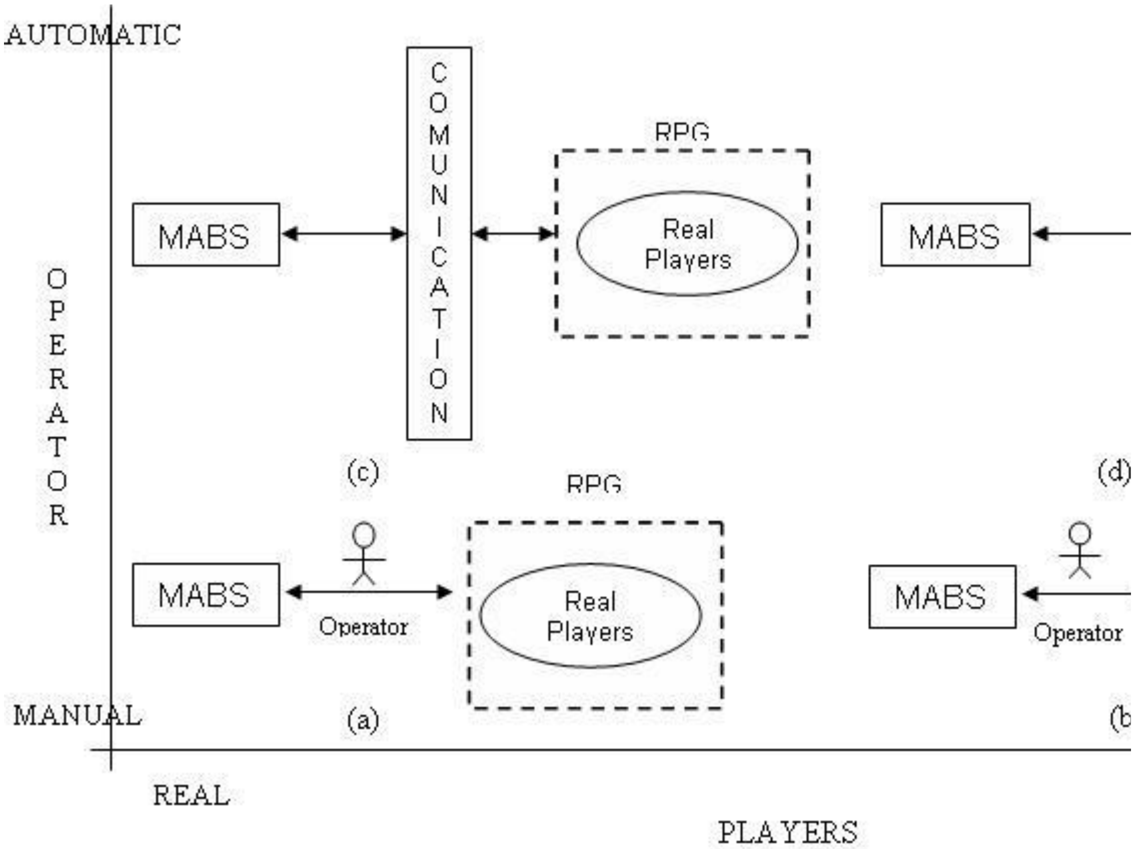


Figure 1. Integration levels of MABS methodology

1.6

Our first prototype, called **JogoMan**, is an instance of the case presented in Figure 1(a). On the other hand, the second prototype, called **ViP-JogoMan**, is able to insert virtual players in **JogoMan** prototype, and it has an automatic operator. It can be used either as an instance of both cases, shown in Figures 1(c) and Figure 1(d), or in an intermediate one where both real and virtual agents coexist (c/d). We have made experiments by adopting these three different situations (Adamatti 2007).

1.7

The main goal of this paper is to present a preliminary discussion of a game used as a negotiation support setting associated with MABS, and its introduction in a hybrid situation with the insertion of virtual players. We have organized the rest of this paper in 6 sections. In Section 2, we briefly introduce the GMABS methodology.

Section 3 describes the two prototypes developed, **JogoMan** and **ViP-JogoMan**. In Section 4, we show how we have designed the virtual players. In Section 5, we present the test results obtained in several games using both prototypes, and as well as an initial analysis based on these results. Finally, we show our conclusions and future work in Section 6.

GMABS Methodology

2.1

Barreteau et al. (2001) were the first researchers to propose the combined use of RPG and MABS in the natural resources domain, but they did not name the methodology. This methodology, called by us GMABS (Games and Multi-Agent-Based Methodology) (Adamatti et al. 2005) is composed of 6 steps, shown in Figure 2:

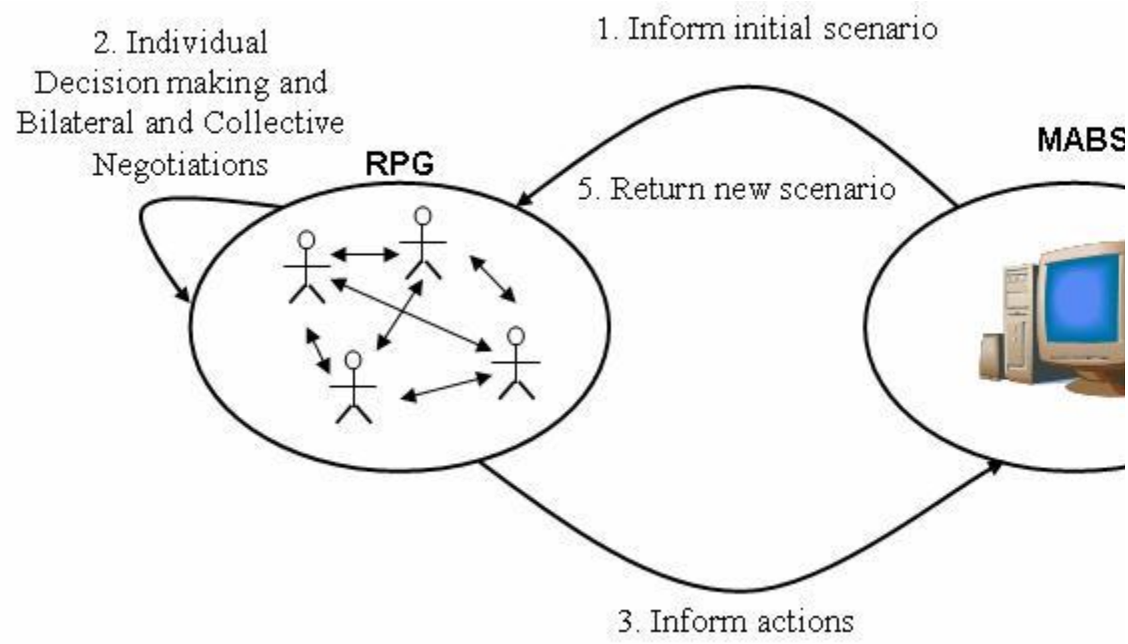


Figure 2. GMABS Methodology

1. Players receive all the information about the game: the roles they can assume, the actions and rules available to these roles, the common environment,

and the topological constraints. When the game starts, each player defines the role he/she is going to play. At that time, each participant knows what actions he/she can execute, and the benefits and/or damages their actions can cause to the common environment. The initial scenario also defines where the participants are physically located within the common environment and what their initial possessions are, like money, land, etc.;

2. In this step there are three different activities:
    a. Players may reason and decide about *individual actions* that just depend on themselves. As an example, in the natural resources domain, land owners may change their land use;
    b. Players have all the necessary information to initiate *bilateral negotiations* with each other. In order to negotiate, they may exchange information and make their decisions, according to the rules that must be followed by the roles they are playing. In the natural resources domain, for instance, land owners can sell their plots.

       Normally, these two previous activities (a and b) take place simultaneously, and their duration 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 everyone or just a subgroup of players. Once more considering the natural resources domain, players are able to demand improvements in infrastructures, more jobs, lower tax values, and so on. 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 others' objectives and strategies;

3. Players inform to the MABS tool, mediated by the operator presented in Section 1, which individual actions were chosen and which bilateral negotiations were concluded;
4. The MABS tool computes the data, and as a result the players' actions may modify the initial scenario. Therefore, the environment properties are modified, which implies the modification of each player's data;
5. The MABS tool gives the new scenario back to the players, once again mediated by the operator. If the game deadline is not reached or the maximum number of rounds has not been achieved, the game returns to step 2.
6. If the game has reached its end, a debriefing session is carried on (Dorn 1989).

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

GMABS Based Prototypes: JogoMan and ViP-JogoMan

3.1

We have chosen the natural resources management domain to build two prototypes following the GMABS methodology. More specifically, we have decided to investigate the problem of quality of the water resources. This domain deals with big land areas, such as cities, states, etc., where all ecosystems must be analyzed. Moreover, a great diversity of actors with different objectives and strategies evolve along these scenarios. For example, the study of water problems in 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, therefore possibly generating many conflicts. We have applied the GMABS methodology to help in the negotiation process (Ducrot et. al 2003), since we can analyze the players' interaction and decision-making during the game.

3.2 We have developed two instances of GMABS methodology: **JogoMan** and **ViP-JogoMan**. The first prototype, **JogoMan** (the Portuguese acronym for "Jogo dos Mananciais" that means Water Sources Game), simulates the management of a particular peri-urban catchments, located at Bacia do Alto Tietê, in São Paulo, Brazil. The second one, **ViP-JogoMan** (Virtual Players in **JogoMan**), inserts virtual players in the **JogoMan** prototype.

JogoMan prototype

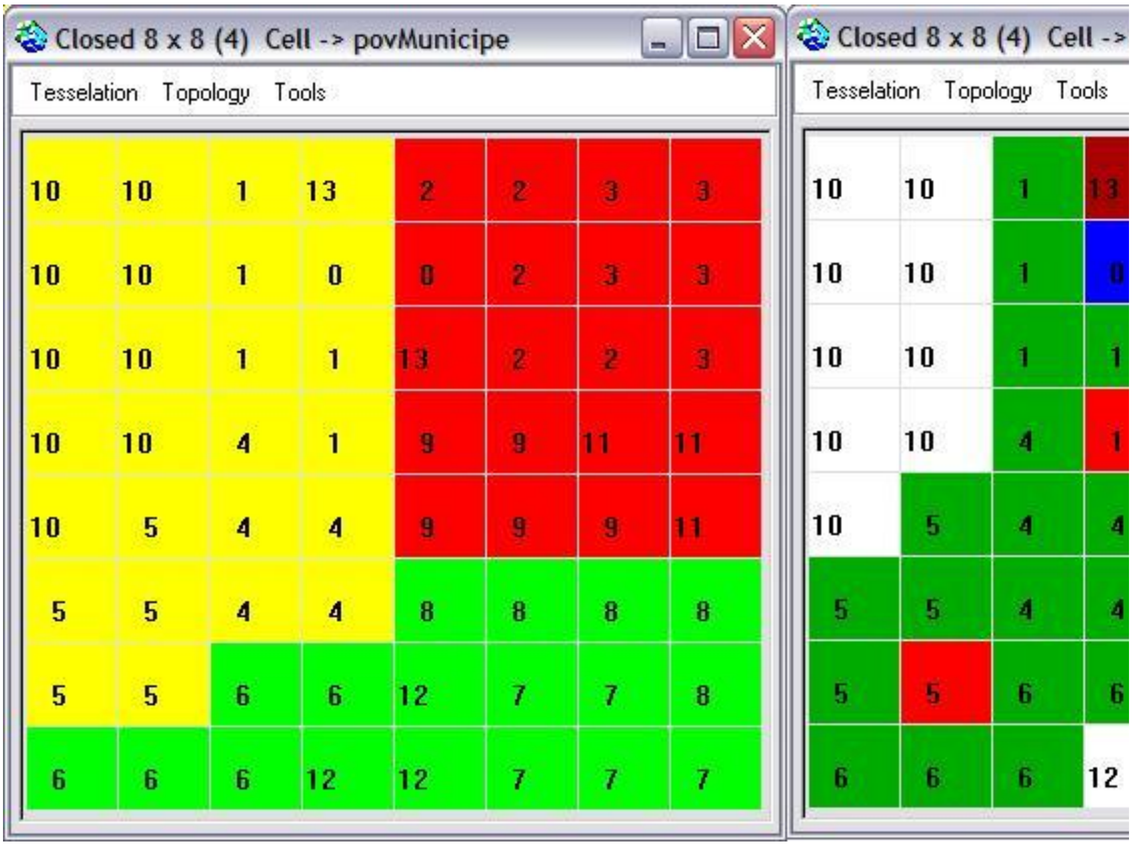
3.3 As mentioned in Section 1, **JogoMan** is an instance of Figure 1(a) case: there are real players and a human being performs the operator function. The MABS element is the only computational tool.

3.4

The JogoMan prototype was implemented using Cormas (Bousquet. et. al 1998), a MABS simulator tailored to the natural resources domain. It represents a simplification of the real phenomena of interaction between the several actors, in the context of the peri-urban catchments previously described.

3.5

In this game, the main idea is to determine water quality and quantity in peri-urban catchments. It involves the management of land and water related problems in different cities. The game environment consists of a grid divided into plots, and the whole grid represents 3 different cities, as shown in Figure 3(a). Each plot represents a physical state (or a piece of land) that is associated with an owner (the player) and a land use (such as agriculture or forest), according to Figure 3(b). The game enables players to change the land use, place some infrastructures on them and sell/buy their/other plots. The rules and roles of this prototype were defined by the experts of the Negowat Project[1] (Ducrot et. al 2007).



(a) (b)

Figure 3. Interface of first scenario of JogoMan. Figure 3(a) presents the cities division (3 cities, each one with a different color). Figure 3(b) presents land occupation, the numbers represent the owners of each plot and the colors represent the land use (industry, agriculture, etc.).

3.6

There are four roles defined in the game, each one having different goals:

1. **Land Owner**: a land owner has some plots, each one with a land use. Each different land use has different financial values associated with its maintenance and financial return. Owners can sell or buy their plots, or they can exchange their land use. Land owners can ask the respective mayors for infrastructure improvements.
2. **Mayors**: the game has different cities, each one having its mayor. The mayor's goals are closely related to the city's main activity (urban, agricultural, etc.). For example, if the city "C" is a preservation

area then the player that plays the role "Mayor C" should try to enhance its preservation. The mayors can invest in public infrastructure, such as portable water system or build schools, hospitals or even police headquarters.

3. **AguaPura Company Administrator**: this company is the responsible for the water and sanitation networks in the whole area and the participant who plays this role can invest in public infrastructure to improve water quality.
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 either in settlements or in slums. The quality and/or quantity of water of the region are modified depending on where these families are settled.

3.7

Although each player chooses his/her actions individually, he/she knows that these actions have consequences to the others, since the quality and quantity of water depends on the overall land use and the infrastructure.

3.8

More details about the **JogoMan** prototype may be found in Adamatti et al. (2005).

ViP-JogoMan Prototype

3.9

The second prototype, **ViP-JogoMan** (Virtual Players in **JogoMan**), inserts virtual players into GMABS methodology. One question should be asked: why is it interesting to insert virtual players in GMABS methodology? One possible answer is that whenever any RPG is played, it needs a certain number of available real participants. However, there are situations that require a high number of people and are not manageable within a human game setting. In this way, many times the game cannot be played because this minimum number of players is not available, and therefore the use of virtual players would be beneficial.

3.10

After several test sessions of the JogoMan prototype, we have verified the need for some tool to substitute some real players. One the other hand, virtual players should substitute real players without "spoiling" the game, i.e., arriving to situations where real players could easily identify the virtual player's decisions and/or whenever the virtual players' decision-making is not realistic, i.e., their actions are very different from the ones that real players are expected to perform.

3.11

In other works that proposed virtual players as extensions of real players, such as Guyot and Honiden (2006) and Barreteau and Abrami (2007), the virtual players are explicitly presented during the game, and their goal is to help real players in their decision making, acting like assistant players. In our approach, the virtual players substitute the real ones and they are implicit in the game.

Selected Tools

3.12

In order to implement the ViP-JogoMan prototype, we have selected some tools as presented in Figure 4:

- **MABS Tool**: Cormas was used as the MABS simulator (Bousquet et. al 1998). As Cormas was previously used to implement the **JogoMan** prototype, this was quite an obvious decision. Moreover, it has specific functions to extract system data in different formats, like ASCII, Excel and several database formats like Oracle, MSAccess, MySQL or PostgreSQL;
- **Virtual Players**: we have chosen the BDI architecture as a cognitive architecture to design the virtual players. The BDI paradigm was our choice because of its richness of behaviors and its realistic representation of human conduct in interaction simulation. As a matter of fact, BDI mimes the overall characteristics of humans, because it is based on psychological theories and it facilitates to focus on strategic agents and negotiation. The BDI architecture has already some pre-defined underlying logics, as AgentSpeak(L) language (Rao 1996) and some implemented interpreters, such as AnyLogic (AnyLogic 2008), Jack (Jack 2008) and Jason (Bordini and Hubner 2007). However, the first two are commercial systems, and since this is an academic project, we have chosen to use Jason. This interpreter allows that each step in BDI logic can be visualized and analyzed individually. It also enables communication between virtual players, as well as between virtual players and the environment.
- **Real Players**: each type of player (Mayor, Land Owner, AguaPura Administrator or Migrant Representative) has an associated Java applet. In these applets, players can choose their actions and exchange information with each other, both for real and/or virtual players;

- **Communication Layer**: we have chosen SACI (Simple Agent Communication Infrastructure) (Hubner and Sichman 2000) as the communication layer to be used between real and virtual players. This tool provides communication infrastructure for agents, using KQML (Knowledge Query and Manipulation Language) (Labrou and Finin 1997), which is an interchange format already used by Jason. On the other hand, the communication layer between MABS and RPG elements was based on the SOAP (Simple Object Access Protocol) protocol (W3C 2007), because the MABS tool (Cormas) and Jason were implemented in different programming languages (SmallTalk and Java, respectively). SOAP technology provides interoperability between both languages through the use of XML.

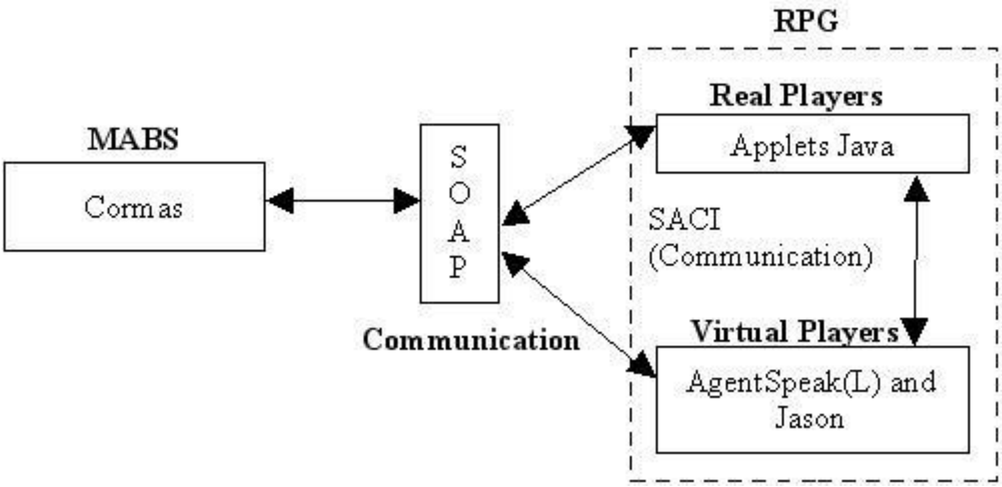


Figure 4. Selected Tools to implement **ViP-JogoMan**

3.13

ViP-JogoMan is designed as a web-based application, meaning that players could be in different places, but the game is synchronous: the participants must play the game at the same time. Each real player will have access to the MABS tool through a graphical interface (computer-based process). All real players can interact with real and/or virtual players by using these interfaces. Hence, the interactions between real and virtual players happen in a transparent way: real and virtual players can interact directly with each other. All graphical interfaces were defined in Portuguese. Figure 5 presents a snapshot of a graphical interface in **ViP-JogoMan**, representing the window used by participants who play the Mayor role. In part "A" of Figure 5, the mayor's bilateral actions are presented, like buying a plot from other player or putting an infrastructure in his/her city. In part "B" of Figure 5, a tool to communicate with other players is available, where he/she can see all received and sent messages, which are typed: users may select the kind of message (selling or buying), the corresponding data (such as the parcel number, the price) and the action justification. These justifications are used mostly to provide a broader interaction spectrum during negotiations held between human and virtual players. Hence, a virtual player would interact differently with human players that have selected the same action, but with different justifications.

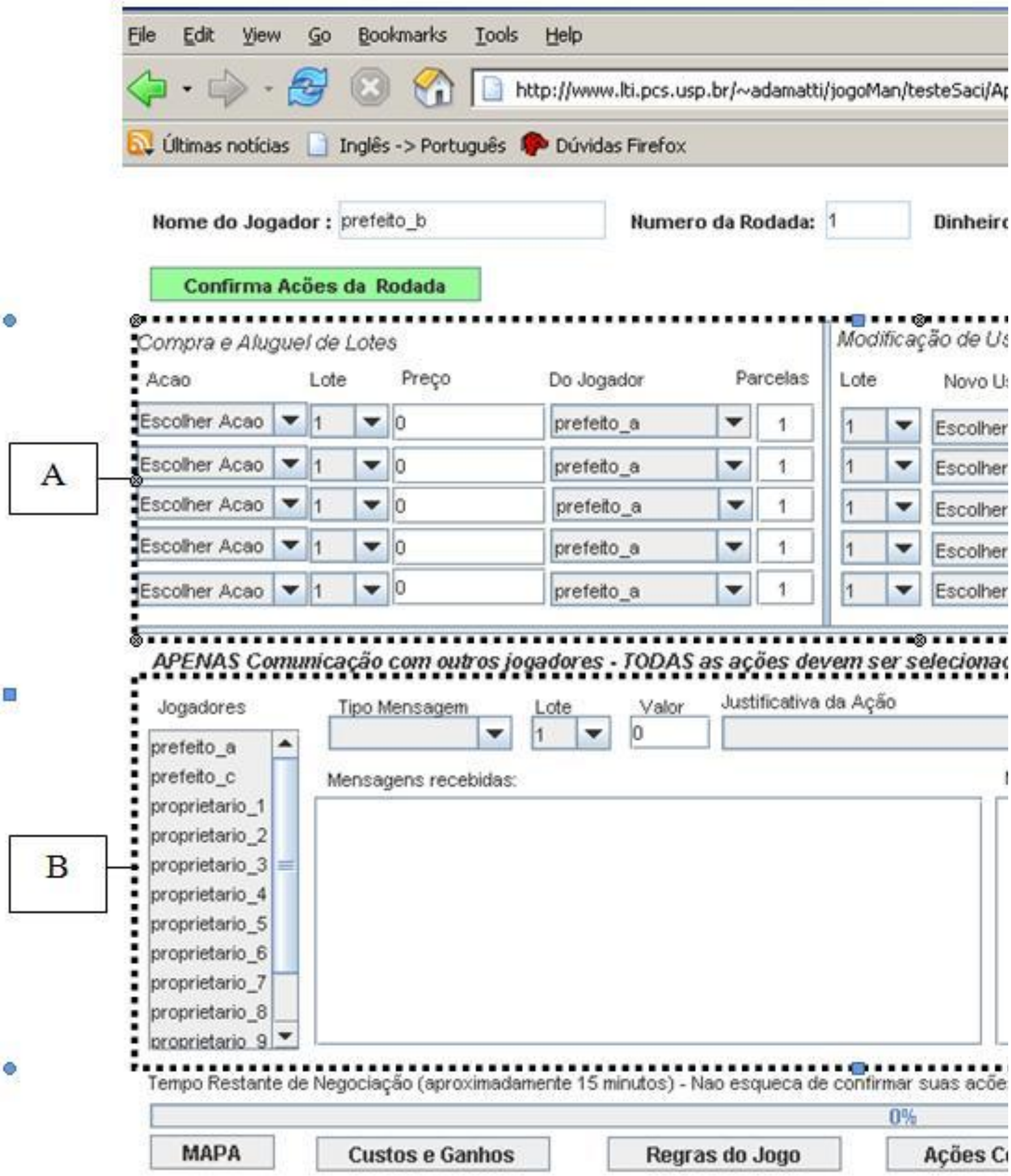


Figure 5. Mayor's graphic interface in ViP-JogoMan (in Portuguese)

3.14

As mentioned before, **ViP-JogoMan** prototype is an instance of the cases shown in Figures 1(c), 1(c/d) and 1(d) cases: we can have games exclusively with real players (c), exclusively with virtual players (d) or with mixed players (c/d). However, the operator is an automatic one. In our prototype, the operator was embedded in the communication layer between RPG players and the MABS tool. In Adamatti et al. (2007) and Adamatti (2007), the **ViP-JogoMan** prototype is described in more detail.

3.15

In order to build a "believable" game when virtual players are inserted, one has to define how to represent, in a BDI model, the typical actions that real players would take. This procedure, based on the data gathered by the **JogoMan** session tests, is described next.

Designing Virtual Players

4.1

In **ViP-JogoMan** prototype, the development of virtual players is one of the most important issues. We have chosen the BDI (Belief, Desire and Intention) architecture (Rao et. al 1991; Rao 1996) to implement them, because it is the predominant approach to the implementation of "intelligent" or "rational" agents (Wooldridge 2000). BDI paradigm is a relatively mature framework and has been successfully used in a number of medium to large scale software systems.

4.2

In order to define the virtual player behaviors, we have mapped all human players' actions from **JogoMan** session tests in order to find out their objectives and strategies. This procedure was repeated for each round of each test session, and it was composed of 5 steps:

1. We mapped all **JogoMan** actions for all players using Excel;
2. We analyzed each player role;
3. Considering the same or different games, we found out that in some cases human players chose very similar (or even the same) action sequences. This

happened even despite the role being played by the agent. We have called this sequence of actions a *strategy*[2]. An example of a strategy is the fact that mostly all players of AguaPura Company Administrator role preferred to install first the water network and then, in a further cycle, to install the sanitation network.

4. We proposed to define *behavioral profiles* for each player role. A behavioral profile consists of a set of strategies used by the players in a coherent way, in order to fulfill some possible high-order goal, such as to preserve the environment.
5. We asked experts from Biology and Social Sciences to validate these profiles. These experts have verified if the possible strategies and action sequences are similar to the real player activities[3].

4.3

In what regards the definition of the behavioral profiles (steps 2 and 3), we must stress that we have never given instructions to the players on how to combine different actions; the real players, while playing the game, chose patterns of action sequences autonomously. Moreover, we have noticed some regularity in these sequences in all four session tests of **JogoMan**, meaning that several different players, that did not know each other and did not play in the same test session, have chosen the same sequence of actions. As an interpretation of this result, we believe that we could associate different behavioral profiles to each role, each of them consisting of different objectives (step number 4).

4.4

We could have used automatic machine learning techniques, like neural networks, genetic algorithms or decision trees, to read the log files of **JogoMan** prototype in order to identify the behavioral profiles. However, in our first model, we preferred to map each player action manually (step number 1) and discuss with some experts of Negowat Project (step number 5). These experts helped us on defining 9 specific profiles, as shown in Table 1.

4.5

For example, the Economic behavioral profile of Land Owners has as a high level objective "to save and earn money". The strategies that we have found out observing the real players of this role during **JogoMan** tests were the following:

1. If the player has plots near to Urban areas, he changes their use to Settlement, aiming to sell the plots to the 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 or Urban areas, he changes its use to Agriculture or Irrigated Agriculture, because these land uses need a low investment and yield fast profit, in comparison with other land uses, such as Industry;
3. If the player has plots where the land use is Forest, he changes its use to Plantation, in order to receive the suppression profit for cutting the trees.

Table 1: Behavioral Profiles of Roles

Role	**Behavioral Profile**	**Objective**
Land Owner	Economic	Must save and earn money
	Ecologic	Must improve the ecological situation of the 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 their social conditions
	Social	Must allocate families in good places, with infrastructure and near to urban areas
Mayors	Social	Must improve the citizens' quality of life
	Economic	Must improve citizens' quality of life if the city has enough money
	Ecologic	Must improve the ecological situation of the city

4.6

We can notice that Land Owner with Economic profile was created with some of the strategies presented in Annex B. Other strategies were used in the Ecologic profile.

4.7

Each defined profile was implemented in **ViP-JogoMan**. Figure 6 shows how the three strategies presented above, that define Land Owners with Economic behavioral profile, were implemented in AgentSpeak(L) using Jason. For example, the code in AgentSpeak(L) of the second strategy (land use is not Forest, he changes its use to Agriculture or Irrigated Agriculture) is presented in Figure 6 (starts in line 28):

```
+plot(L,R): not forest(L)[source(percept)] &
     not settlement(L)[source(percept)] &
     not agriculture(L)[source(percept)] &
     .myName(M)  & owner(M,L,P)[source(percept)]
  <- changelanduse(l,agriculture);
     !nextposition(l,r).
```

where Land Owners with Economic behavioral profile for EACH plot (L, R) test: IF this plot is not a forest AND it is not a settlement AND it is not agriculture AND it belongs to the player, THEN change the plot's land use to agriculture AND go to the next plot.

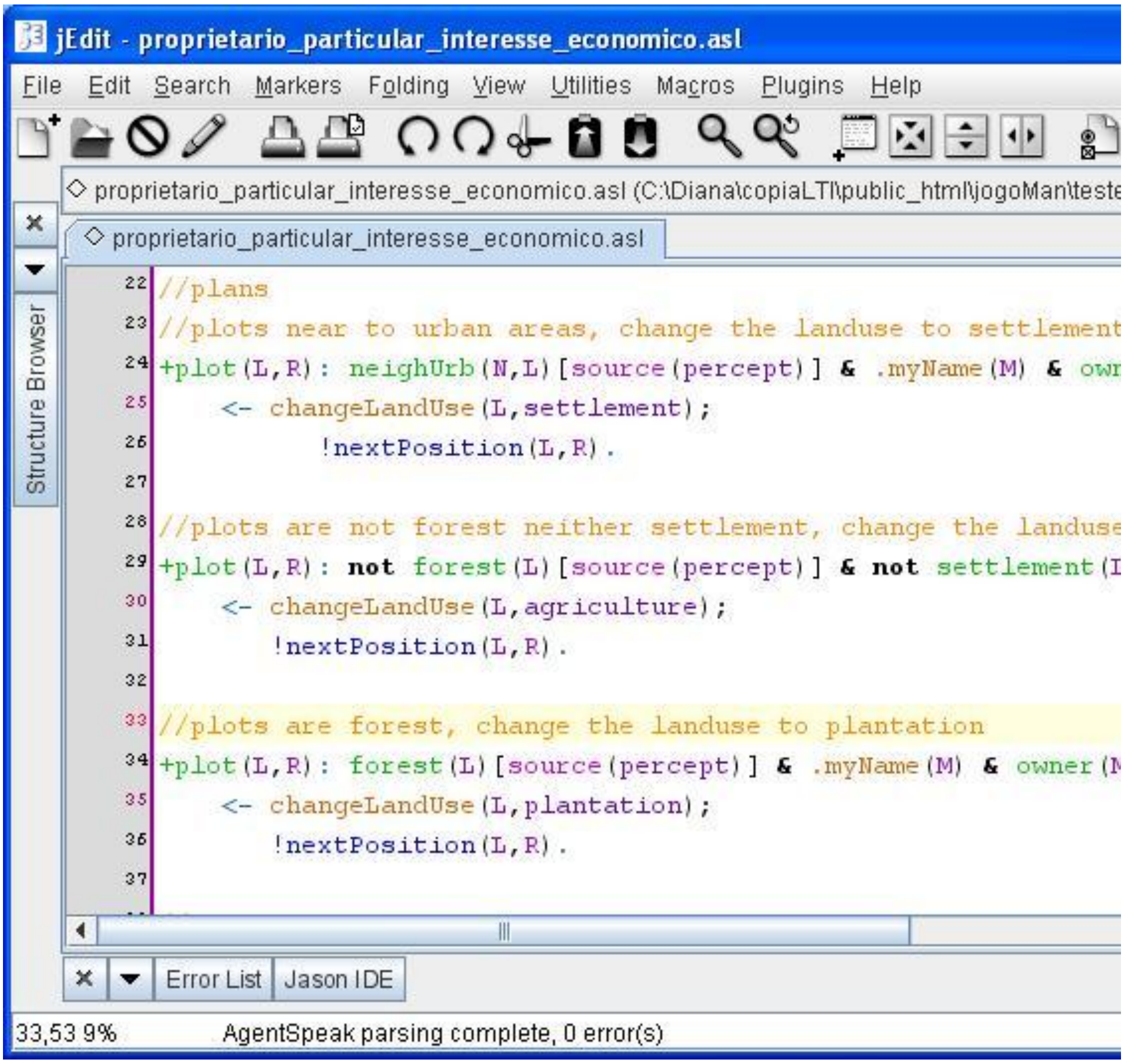


Figure 6. Example of Land Owners with Economic behavioral profile in AgentSpeak(L) using Jason

Experimental Results

5.1

We have run several session tests, with both **JogoMan** and **ViP-JogoMan** prototypes. In the next subsections, we describe those tests, and we present a preliminary discussion about the effect of inserting virtual players in the ViP-**JogoMan** prototype.

Evaluation Methodology

5.2

We did not find in the literature a universally accepted evaluation methodology for RPG and MABS. In order to better define our methodology, we have made a research in similar areas, as Intelligent User Interfaces (IUI) and Computer Supported Cooperative Work (CSCW). In IUI, users are helped by a dynamic and autonomous system, whose behavior may be similar to our virtual players, who are also dynamic and autonomous. On the other hand, in CSCW, questionnaires that are filled in by the users of the system are used to gather information about the usability of the system.

5.3

Hence, we have defined three complementary evaluation methods for our system:

1. *Analysis of virtual players behavioral profiles variables*: each type of player (Land Owner, Mayor, AguaPura Company Administrator and Migrant Representative) has some specific variables to measure its proposed objective. These variables are stored in each round of the game. For example, when considering a Land Owner with economic behavioral profile, the variable to be analyzed is the amount of money in the "cash box" of this player. Annex C presents the variables for all behavioral profiles.

   This kind of analysis, based on behavior profiles, is well known in HCI (Human-Computer Interaction) and presents us a quantitative measuring of the virtual players' behavior.

2. *Application of pre and post-questionnaires to real players*: the pre-questionnaire verifies the knowledge level of the players in the domain. In order to verify if the virtual players' decision-making seemed realistic to the real ones, we apply the post-questionnaire, which had an important question to be answered: "This game may have included some synthetic players (non human-beings). Can you discern if any player has a non-human behavior? Which one?" Annex A shows the pre and post-questionnaires applied to the players of **ViP-JogoMan** Prototype.

   According to Dennis and Valicich (2001), the use of questionnaires helps to identify the players and how they interact with the game. For this reason, the majority of computational games evaluation is based on questionnaires. In our evaluation, it presents a qualitative measure of virtual and real players' behavior.

3. *Analysis of exchanged messages between players*: all types of messages exchange (bilateral and collective negotiations) between all kinds of virtual and/or real players are automatically stored during the game. This evaluation will help to analyze quantitatively whether the interaction between players has changed in comparison with the paper-based game (**JogoMan**). Moreover, we can compare if the number of interactions change if virtual players are inserted in the game.

   According to Ross et al. (1995), this kind of evaluation helps to better understand how people interact with new technology—computers—and other people. In our evaluation, it presents a quantitative measure of virtual and real players' level of interaction.

JogoMan Tests

5.4

We have performed four different session tests using **JogoMan** prototype. These tests took place between October 2004 and May 2005. The game players were graduate and undergraduate students of Biology, Ecology and Social Sciences courses from several universities of São Paulo state.

5.5

We have followed a sequence of steps to execute these tests:

1. A general explanation was given for all participants of the game, presenting its objectives and roles (possible players);
2. The players received a pre-questionnaire of the game;
3. Each person chose a role (a player);
4. The game started, following all steps of the GMABS methodology described in Section 2. The first round took approximately 40 minutes, as the players did not know the effect of their actions. In most of the cases, we fixed a number of 3 or 4 rounds to finish the game (at least 3), depending on the number of players and the length of each round;
5. Players received a post-questionnaire after the debriefing session.

5.6

In **JogoMan** prototype, we just applied the second evaluation method (questionnaires), because we have not stored the players' actions. The players pointed out some suggestions in their post-questionnaires:

- Most participants found the game very interesting and realistic, and it helped them to understand the reality in peri-urban catchments;
- The participants also claimed that they learned a lot about the domain, because RPG is a didactic and funny way of learning a new topic;
- The participants highlighted that it is easy to identify the relationship between social and environmental issues, like urban pressure versus forest preservation;
- Most participants thought that the rules were rather complex. They suggested the creation of a handbook, to help them to decide and/or to negotiate in each round. We agree with this idea, and we think that the complexity of the game may demand a longer preparation process, previous to the game application.
- The participants thought that the time available (30-40 minutes) for their decision-making in the first round was too short.

5.7

These session tests were very important, because many suggestions and modifications were proposed in order to obtain a game more similar to the reality. However, we did not monitor all the actions that took place during the negotiation processes. For example, we do not know how a player decided to buy a plot from other player and how long this negotiation took before being completed[4].

Consequently, since we did not record the negotiation sessions, we could only register the negotiations that were successful, as players did not write in the paper forms incomplete or rejected negotiations. This was considered further a limitation in our analysis. The main consequence of this problem was that we were not able to compute the total number of negotiation in the session tests, as we did in **ViP-JogoMan** prototype. Hence, the values of total negotiation of **JogoMan** prototype are not presented in Table 2.

ViP-JogoMan Tests

5.8

We have performed three types of tests with the ViP-**JogoMan** prototype:

- *Virtual Players* (VP) *Games*: only virtual players composed this type of game, that has helped us to test the implementation of each virtual players behavioral profile;
- *Real Players* (RP) *Games*: only real players composed this type of game, what has helped us to test both the implementation of each graphical interface and the communication layer in **ViP**-GMABS architecture;
- *Mixed Players* (MP) *Games*: both virtual and real players composed this type of game, which has helped us to test the players' interactions during the negotiation process[5].

5.9

In the tests where real players (people) are involved—RP and MP tests, we have followed a sequence of steps to execute them:

1. A few days before the game, real players received a manual by email, containing instructions about the game rules, objectives, roles, etc.
2. Players replied the email, choosing a role. If two players wanted the same role, the player who replied first would get the role. If the test was a MP, real players couldn't choose roles already distributed for virtual players[6];
3. Each player received specific information about his/her role by email. Together with this information, a pre-questionnaire of the game was sent, whose questions are presented in Annex A;
4. A link to the game's interfaces was made available for the players, giving them the opportunity to understand his/her role possible actions and experience the interaction interface;
5. On a specific day and time, all participants played via web browsers using their role's graphical interface. Through the interface, they chose actions, sent messages, etc. The GMABS methodology was once again followed.
6. After four rounds, all players received 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. An example may be seen in Figure 7. In this particular game, the pollution level has practically doubled after 5 rounds, from 5000 to 10000 units.
7. All players received a post-questionnaire by email. The graphics presented in the previous step helped the players to answer the post-questionnaire. The

questions of this post-questionnaire may be found in Annex A.

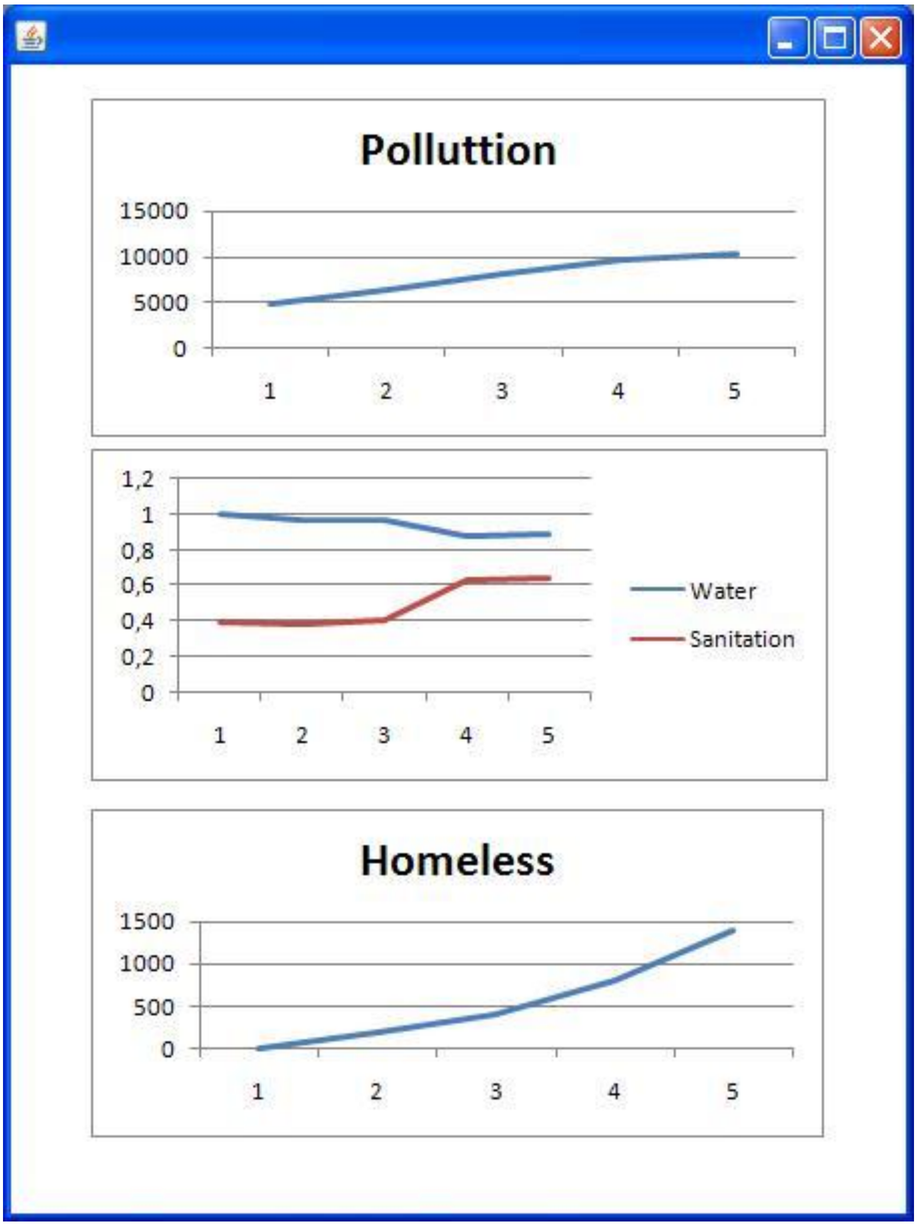


Figure 7. **ViP-JogoMan** graphical output with final results used in game debriefing

5.10

In **ViP-JogoMan**, all the negotiations, whether concluded or not, were automatically stored during the rounds of the game. According to McKersie and Fonstad (1997), in Internet negotiations every data can be stored and it is possible to perform a more detailed analysis in order to better understand the negotiation process.

Results Analysis

5.11

We have defined a scenario composed by 14 players for all types of tests: 9 land owners, 3 mayors, 1 migrant representative and 1 AguaPura Company Administrator.

5.12

Since there are different types of players (real and/or virtual), we have analyzed four different negotiation types between them:

- Real-real (RR) negotiation: a real player starts the negotiation and he/she interacts with another real player;
- Real-virtual (RV) negotiation: a real player starts the negotiation and he/she interacts with a virtual player;
- Virtual-real (VR) negotiation: a virtual player starts the negotiation and he/she interacts with a real player;
- Virtual-virtual (VV) negotiation: a virtual player starts the negotiation and he/she interacts with another virtual player.

5.13

The players cannot identify if their negotiations are made with other real and/or virtual players, since the interaction panel in the interface is the same for every type of negotiation.

Results Overview

5.14

In Table 2 (a, b and c) we present a summary of the number of all negotiations types in both **ViP-JogoMan** and **JogoMan** tests. Only in MP games we find all four types of negotiation presented above.

In **JogoMan** prototype and in RP games, we have just RR negotiations. In VP Games, there are just VV negotiations.

5.15

Table 2 (a, b and c) presents for each negotiation type two different values: the total number of negotiations (TOT) and the number of concluded negotiations (CON).

In **JogoMan** tests, the value of the total and concluded negotiation was supposed to be the same, because players did not write in paper forms the incomplete or rejected negotiations. In **ViP-JogoMan** tests, the total number of negotiations is bigger than the number of concluded ones. This negotiation "log" is important to better understand the goals of each player during the game (Peppet 2002).

5.16

Table 2 (a) presents all negotiations started by real players. The **ViP-JogoMan**—RP and **JogoMan** tests could be compared, because just real participants played both games. The number of concluded negotiations was very similar (33 *versus* 27). However, the standard deviation was very different (10,02 *versus* 2.94). In **ViP-JogoMan**—RP tests, the standard deviation was smaller.

Table 2a: Summary of Negotiations Started by Real Players

Negotiations:[7]	RR						RV					
Games/Type	CON[8]	AV[9]	DEV[10]	TOT[11]	AV[12]	DEV[13]	CON	AV	DEV	TOT	AV	DEV
JogoMan	**33**	8,25	10,02	*[14]	*	*	-	-	-	-	-	-
ViPJogoMan - VP	-	-	-	-	-	-	-	-	-	-	-	-
ViPJogoMan - RP	**27**	9	2,94	**85**	28,33	6,54	-	-	-	-	-	-
ViPJogoMan - MP	**10**	3,33	2,12	**20**	6,66	6,01	**22**	7,33	1,63	**39**	13	6,16

Table 2b: Summary of Negotiations Started by Virtual Players

Negotiations:

Games/Type	VR CON	AV	DEV	TOT	AV	DEV	VV CON	AV	DEV	TOT	AV	DEV
JogoMan	-	-	-	-	-	-	-	-	-	-	-	-
ViPJogoMan - VP	-	-	-	-	-	-	**30**	15	1,41	**54**	27	2,82
ViPJogoMan - RP	-	-	-	-	-	-	-	-	-	-	-	-
ViPJogoMan - MP	**4**	1,33	0,94	**17**	5,66	10,03	**7**	2,33	2,16	**22**	7,33	6,37

Table 2c: Summary of Negotiations

Negotiations:

Games/Type	TOTAL CON	AV	DEV	TOT	AV	DEV
JogoMan	**33**	8,25	10,02	*****	*	*
ViPJogoMan - VP	**30**	15	1,41	**54**	27	2,82
ViPJogoMan - RP	**27**	9	2,94	**85**	28,33	6,54
ViPJogoMan - MP	**43**	3,58	1,71	**98**	8,16	7,14

VP games analysis

5.17

As said before, VP games are useful to analyze the correct functioning of all virtual players behavioral profiles defined in Section 4.

5.18

We have verified that this was the case for all profiles. As an example, Land Owners could have either an Economic or an Ecologic behavioral profile. We have effectively verified that the amount of money in the cash box variable for players with an Economic profile has augmented during the game, as presented in Table 3. We can also notice that the amount of money of these players is higher than those with an Ecologic behavioral profile. Table 3 shows that Ecologic players have a negative cash box. This is not a problem, it just evidences that this kind of player does not have strong concerns about spending money.

Table 3: Cash box values of Land Owners in a **ViP-JogoMan** VP game with 4 rounds

Player	Round 1	Round 2	Round 4	Round 5
Land Owner 1 - Ecologic	2.000,00	-49.452,00	-53.104,00	-51.756,00
Land Owner 2 - Economic	2.000,00	5.300,00	8.600,00	11.900,00
Land Owner 3 - Ecologic	2.000,00	-70.300,00	-56.100,00	-53.900,00
Land Owner 4 - Economic	2.000,00	6.500,00	11.200,00	15.900,00
Land Owner 5 - Ecologic	2.000,00	-89.500,00	-68.600,00	-63.700,00
Land Owner 6 - Economic	2.000,00	7.000,00	12.000,00	17.000,00
Land Owner 7 - Ecology	2.000,00	-71.500,00	-15.700,00	-12.900,00
Land Owner 8 - Economic	2.000,00	5.387,00	8.774,00	12.161,00
Land Owner 9 - Ecologic	2.000,00	-82.139,00	-52.965,00	-50.791,00

RP games analysis

5.19

As mentioned before, the main objective of RP games was to test both the implementation of each graphical interface and the communication layer in **ViP**-GMABS architecture.

5.20

In order to analyze the RP tests results, we have used two evaluation methods:

1. pre and post questionnaires;
2. analysis of exchanged messages between players.

5.21

From the answers in the pre-questionnaires, we can conclude that the real players had a good understanding of natural resources problems despite being inexpert in RPG games. From the answers of the post-questionnaires, we can conclude that the RP games provided the player with interaction, entertainment and learning facility.

5.22

On the other hand, analyzing the message exchange between players during the negotiation process, we have concluded that all players interacted a lot with each other, because the number of exchanged message was very high.

5.23

Table 4 presents the bilateral negotiations to buy/rent plots between players in the first round for the first RP game (10 negotiations), whether they are concluded or not. These negotiations can happen during bilateral negotiation for all players (see step 2c in GMABS methodology in Figure 2) and the players can receive more than one proposal in the same round: they must decide which one is more profitable. An unconcluded example is negotiation 4, where the Administrator of AguaPura proposed to buy plot number 22 from Land Owner 2 by $1.000,00, and Land Owner 2 requested that AguaPura paid a higher value ($40.000,00). However, AguaPura did not finish the negotiation. On the other hand, a concluded example is negotiation 8, where Mayor C proposed to buy plot 59 from Land Owner 6 by $1.000,00 then Land Owner 6 requested a higher value ($1.200,00) and finally Mayor C accepted the proposal, concluding the negotiation. The concluded negotiations between players are represented in bold.

Table 4: Bilateral negotiations to buy/rent plots between players in the first round of the first **ViP-JogoMan** RP game

	Buyer	Seller	Type of Message	Plot	Value
1	AguaPura	Land Owner 1	Propose	1	1.000
2	AguaPura	Land Owner 1	Propose	20	1.000
3	AguaPura	Land Owner 2	Propose	2	1.000
4	AguaPura	Land Owner 2	Propose	22	1.000
	AguaPura	Land Owner 2	Request	22	40.000
	AguaPura	Land Owner 2	Propose	22	2.500
	AguaPura	Land Owner 2	Request	22	30.000
	AguaPura	Land Owner 2	Propose	22	2.500
5	LandOwner 6	Land Owner 4	Propose	43	1.000
6	LandOwner 6	Land Owner 5	Propose	42	1.000
7	LandOwner 6	Land Owner 5	Propose	49	1.000
8	Mayor C	Land Owner 6	Propose	59	1.000
	Mayor C	Land Owner 6	Request	59	1.200
	Mayor C	Land Owner 6	**Accept_proposal**	59	1.200
9	Mayor C	Land Owner 6	Propose	52	1.000
	Mayor C	Land Owner 6	Request	52	3.000
	Mayor C	Land Owner 6	Propose	52	1.500
10	LandOwner 2	Land Owner 8	Rent	46	500

5.24

In Table 5 we present the number of the total and concluded negotiations in the three tests of RP games, in all rounds. The total amount shown in the last line is the same shown in Tables 2 (a), (b) and (c). In Table 5, we can see that real players concluded a lower number of negotiations than the total number of proposals. A good example of the difference between these numbers could be the data in Table 4, where only one negotiation (number 8) was completed to buy/rent plot action in the first round of the first **ViP-JogoMan** RP game, in a total of 10 negotiations.

Table 5: Negotiations in **ViP-JogoMan**RP games

RP	**Concluded Negotiations**	**Total Negotiations**
Test 1	10	29
Test 2	5	20
Test 3	12	36
Average	**9,0**	**28,33**
TOTAL	**27**	**85**

MP games analysis

5.25

As mentioned before, MP games succeeded in testing the player's interactions during the negotiation process. In order to analyze the tests results, we have used the three evaluation methods:

1. pre and post questionnaires;
2. analysis of the behavioral profiles variables;
3. analysis of the exchanged messages between players.

5.26

In the answers obtained from the pre and post-questionnaires, once again real players answered that the game brought interaction, entertainment and learning facility. Interestingly, real players did not easily identify who the virtual players were. In some cases, real players even thought that other real players were the virtual ones!

5.27

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. This was already the case in VP (Virtual Players) games, and this new result showed us that the virtual players' behavior was robust even when playing against real players.

5.28

Finally, from the analysis of the message exchanges between participants during the negotiation process, we can conclude that the players interacted a lot with each other. According to Peppet (2002), people feel more comfortable to express their opinions via Internet, because they do not have to deal with shyness or prejudice.

5.29

In Tables 2 (a), (b) and (c), we have presented the results obtained in all tests/negotiation types, and we could observe that the MP (Mixed Players) games presented a higher number of negotiations, compared to the other tests. Some interesting questions arise: how much do the virtual players modify the negotiation process? Do they just interact between themselves or do they interact in an effective way with real players?

5.30

Hence, it is important to analyze in more detail both RV and VR negotiations, because these negotiations involve both virtual and real players: the first type started by real players and the second one started by virtual ones. A summary of the number of total and concluded negotiations in MP games, classified by each negotiation type, is presented in Table 6. The total amount shown in the last line is the same shown in Tables 2 (a), (b) and (c).

Table 6: Negotiations in **ViP-JogoMan** MP games

MP	**Concluded Negotiations**					**Total Negotiations**				
	RR	RV	VR	VV	TOT	RR	RV	VR	VV	TOT
Test 1	7	6	2	2	17	15	11	15	12	53
Test 2	0	8	2	4	14	1	10	2	7	20
Test 3	3	8	0	1	12	4	18	0	3	25
TOTAL	**10**	**22**	**4**	**7**	**43**	**20**	**39**	**17**	**22**	**98**

5.31

In the three MP games tests, we can observe that the higher number of both total and concluded negotiations occurred in the RV type, where real players started the negotiation and interacted with a virtual one. Instead, in VR negotiations, where virtual players started the negotiation with real ones, we have obtained the minimal number of both total and concluded negotiations, according to the last line in Table 6. Therefore, we can state that in our tests virtual players did not manipulate the negotiation process, and they have interacted in an effective way when it was necessary, i.e., a real player initiated the negotiation.

5.32

Another interesting result can be inferred from Table 2c, regarding the number of negotiations held by real players when playing a table game (**JogoMan**) or a computer mediated game (**ViP-JogoMan**). We can notice that in the second case we have a slight advantage as regards the first one (9 for RP games *versus* 8,25 for**JogoMan** games concluded negotiations in average). This fact confirms that a computer interface, even if it may limit the range of possible interactions between the players (since the negotiation messages are pre-defined), has the effect of stimulating the participants to engage in negotiations.

Conclusions and Further Work

6.1

We believe that GMABS methodology can be used as a basis to develop computer-based tools to help negotiation processes, as we have shown in this work concerning the natural resources management domain. By applying this methodology, no matter the chosen domain, we are able to: (i) identify role strategies; (ii) model these roles in a BDI architecture; (iii) test the system with a set of real and virtual players; and (iv) analyze the real players (people) behavior when virtual ones are inserted in the game.

6.2

In addition, two questions may be answered by the analysis of our experiments:

1. The effect of the insertion of virtual players in GMABS methodology: will these players have realistic decision-making?

   The use of behavioral profiles based on BDI architecture to model and implement these players seems to be well suited to make their decisions believable, since most real players did not identify the virtual players during the tests.

2. The impact on the negotiation process between all players by the graphical interface: will they complete their interactions when negotiating using the graphic interface?

   We believe that the graphical interfaces supply the players with adequate conditions to negotiate with each other, as the number of negotiations in the **ViP-JogoMan** session tests has increased, when compared to the **JogoMan** session tests.

6.3

Another aspect about the **ViP-JogoMan** prototype, shown in our tests results, is the use of GMABS methodology through the Web as an efficient and practical tool, since it makes the prototype available in remote places and for a greater number of people. We have also concluded that the computer-based and the Web approaches helped us to map the tentative negotiation.

6.4

Nevertheless, we cannot infer from our experiments that the number of negotiations - concluded or not - is directly related to the learning of negotiation process. Many players in **JogoMan** tests claimed in the questionnaires that they knew the domain problem. However, during these tests, the number of negotiations was lower than in **ViP-JogoMan** tests (see Table 2 (a), (b) and (c)). We can only come to the conclusion that both prototypes reached the proposed objective of their development: help the understanding of the negotiation process. We believe that human players that took part in the tests can now better interact in real situations, as stated in the post-questionnaire answers.

6.5

Some possible improvements to the **ViP-JogoMan** prototype that we intend to develop in the future are the following:

1. Implementing a dynamic knowledge base for the virtual players. So far, 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 the players in the previous rounds. We can use some machine learning techniques for this purpose, as genetic algorithms or neural networks;
2. Developing an extension of BDI model to support Fuzzy Logic (Zadeh 1965). The Fuzzy Logic could model "uncertainties" about the action of virtual players. This kind of extension would create more realistic virtual players, like the results presented in (Casali et al. 2006; Cruz 2008);
3. Inserting emotions in the plans of the virtual players, to show different feelings during the game, depending on the interaction with other players. A good candidate model would be the OCC model (Ortony et. al 1988). This model was developed by psychologists specifically to be implemented in a computational system: the major data structures constraints were described and its implementation can be done more easily;
4. Using NLP (Natural Language Processing) techniques, to enable an open chat between all real or virtual players. In this case, we could use ontologies in the communication layer to have a default communication language during the negotiation phase.

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Notes

[1] The scenario prototype was part of the Negowat Project: Facilitating Negotiations Over Land and Water Conflicts in Latin American Peri-Urban Upstream Catchments: Combining Multi-Agent Modeling with Role-Playing Games, financed by the European Community, grant ICA4-CT-2002-10061.

[2]See Annex B for a description of such strategies.

[3] Some Negowat Project members evaluated the behavioral profiles. Most of them are experts from Biology/Agronomy and Sociology/Anthropology.

[4] As a completed or concluded negotiation, we consider a negotiation that generates an action, like buying a plot.

[5] In Mixed Players Games, the proportion of real players (people) was 50%. As **ViP-JogoMan** needs 14 players, 7 of them were real players and the others were virtual ones.

[6] In our tests, we have arbitrarily decided to define the virtual players' roles.

[7] We played a different number of session tests for each game type: in JogoMan 4 session tests; in VP 2 session tests; RP and MP 3 session tests.

[8] Number of concluded negotiations.

[9] Average of concluded negotiations.

[10] Standard deviation of concluded negotiations.

[11] Total number of negotiations.

[12] Average of negotiations.

[13] Standard deviation of negotiations.

[14] In JogoMan Prototype we do not have the total number of negotiations.

Annex A

Questionnaires of ViP-JogoMan Prototype

Pre-questionnaire

1. What do you expect by participating of this game session?

2. How often do you surf on the net during a week?
( ) every day
( ) 2 or 3 times a week
( ) once a week
( ) less than once a week

3. Have you already played any game (RPG or not) by Web?
( ) Yes. Which one?

( ) No

4. In your opinion, which are the major problems of water management in peri-catchments? Could you explain?

5. In your opinion, which are the successful aspects in a natural resources negotiation?

Post questionnaire

1. What role did you play during the game? Were you satisfied with your performance?
What were your goals in the game? Did you achieve these goals? How?

2. What did you think about the game? What kind of expectation did you have? Explain

3. What did you learn about water management?

4. Did you have some problems during the negotiations with other players? Could you negotiate in a deeper way? Do you think that the chat is a proper way of negotiation?

5. In your opinion, who had the bigger negotiation power? (write the name of the players)

6. What is the kind of relationship between the players? (cooperation or competition)

7. What did you learn about negotiation?

8. During the game, did you understand what was happening (the progress)? Do you think that the collective negotiations were positive? Did all players execute what was accorded during these negotiations?

9. During the game, did you use maps, table of prices or any other kind of information?

10. For you, the major problems in the game were:
( ) Negotiation by Web
( ) Understanding the rules
( ) Time in each round
( ) Making decisions
( ) Other:

11. In this game, some synthetic players could have been inserted. Do you think that some players have shown a non-human behavior? Which of them? Why?

Annex B

JogoMan Players Strategies

A. *Land Owners*

1. Change the land use 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;
2. Change the land use from forest to plantation, in order to receive the suppression profit for cutting the trees.
3. Change the land use to settlement in plots near to urban areas, aiming to sell the plots to the Migrant Representative, since this latter always wants plots that are near to the urban areas;
4. Change plots near to urban areas with Majors or others Land Owners for plots with forest land use.

B. *AguaPura Company Administrator*

1. Install Sanitation nets in plots where there are already Water nets;
2. Install Water or Sanitation nets in plots where Migrant Representative families live;
3. Negotiate with Mayors to have Water and Sanitation nets installed and paid for;
4. Preserve plots near the reservoir in order to reduce its pollution.

C. *Mayors*

1. Build Schools, Hospitals or Police Headquarters only in urban areas;
2. Hire AguaPura Company Administrator to install Water and Sanitation nets, since they build these infrastructures for a lower price;
3. Buy plots near to urban areas from Land Owners, and sell them to Migrant Representative;

4. If there are a huge number of plots with Agriculture or Irrigated Agriculture land use, increase the taxes of these kinds of land use.

D. *Migrant Representative*

1. Try to buy plots close to urban areas. If he/she cannot buy, he/she should invade these plots;
2. Try to allocate a maximum number of families in a same plot – already built or invaded. For example, if the maximum capacity of a plot is 400 families, he/she will allocate this exact number.

Annex C

Analyzed Variables for Behavioral Profiles

Role	**Behavioral Profile**	**Variables**
Land Owner	Economic	Cash box
	Ecologic	Reservoir Pollution
AguaPura Administrator	Rational	Reservoir Pollution Cash box % Families with water % Families with sanitation
	Ecologic	Reservoir Pollution % Families with water % Families with sanitation
Migrant Representative	Economic	Cash box % People live in slums
	Social	% People live in slums % Families with water % Families with sanitation

Mayors	Social	Social Development % People live in slums % Families with water % Families with sanitation % Unemployment % Public Services
	Economic	Social Development Reservoir Pollution Cash box % Families with water % Families with sanitation
	Ecologic	Social Development Reservoir Pollution % Families with water % Families with sanitation

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