A Computer-based Support for Participatory Management of Protected Areas: The SimParc Project

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Abstract. *In this paper, we introduce our current research project aimed at computer-based support for participatory management of protected areas, in order to promote biodiversity conservation and social inclusion. Its applicative objective is to help various stakeholders (e.g., environmentalist NGOs, communities, tourism operators, public agencies, and so on) to collectively understand conflict dynamics for natural resources management and to exercise negotiation management strategies for protected areas, one of the key issues linked to biodiversity conservation in national parks. Our approach combines techniques such as: distributed role-playing games, support for negotiation between players, and insertion of various types of artificial agents (decision making agents, virtual players, assistant agents). After a general introduction to the project we will present project's current prototype architecture and results from game sessions, as well as some prospects for the future.*

1. Introduction

One of the principles of the Convention on Biological Diversity [Irving 2006] refers to a participatory process of social actors in the management of the biodiversity. One of the main challenges is the construction of social technologies to support participation process in decision making. This subject became more strategic in Brazil when Law 9985/2000, that defined the Brazilian National System of Conservation Units (SNUC), was established [Brazil 2000], in order to regulate and organize protected areas management strategies, considering social participation as a key issue [Irving et al. 2007]. Brazil has also

recently approved the Strategic National Plan of Protecting Areas (PNAP), that reinforces ethical principles for democratic governance building in public politics for nature conservation [Irving 2006]. A significant example of these challenges is the management of protected areas (e.g., national parks) which usually undergo various pressures on their resources, creating conflicts (e.g., irregular occupation, water pollution...). This makes the question of the conflict resolution one of the key issues for participatory management of protected areas.

In late 2006, we started a research project, named SimParc (which stands in french for "Simulation Participative de Parcs") [Briot et al. 2007], in order to investigate the use of advanced computer techniques and methodologies for participatory management of protected areas, and more specifically national parks. The idea is to help park managers, stakeholders and all researchers involved in park management, to explore conflict identification, negotiation and decision strategies for management of parks. The current SimParc prototype is based on a role-playing game and advanced computer techniques such as: distributed role-playing interfaces, negotiation support, artificial decision makers. In this paper, we will at first introduce the objective and structure of the SimParc role-playing game. Then, we will discuss the current support architecture and then the design of an artificial decision making agent modeling the park manager and summarize our first preliminary experimental evaluation. Last, we will discuss ongoing and future work before concluding the paper.

2. The SimParc Project

2.1. Project Motivation

A significant challenge involved in biodiversity management is the management of protected areas (e.g., national parks), which usually undergo various pressures on resources, use and access, which results in many conflicts. This makes the issue of conflict resolution a key issue for the participatory management of protected areas. Methodologies intending to facilitate this process are being addressed via bottom-up approaches that emphasize the role of local actors. Examples of social actors involved in these conflicts are: park managers, local communities at the border area, tourism operators, public agencies and NGOs. Examples of inherent conflicts connected with biodiversity protection in the area are: irregular occupation, inadequate tourism exploration, water pollution, environmental degradation and illegal use of natural resources.

Our SimParc project focuses on participatory parks management [Briot et al. 2007]. It is based on the observation of several case studies in Brazil. However, we chose not to reproduce exactly a real case, in order to leave the door open for broader game possibilities [Irving 2006]. Our project aim is to help various stakeholders at collectively understand conflicts and negotiate strategies for handling them.

2.2. Approach

Our initial inspiration is the ComMod approach about participatory methods to support negotiation and decision-making for participatory management of renewable resources [Barreteau 2003]. They pioneer method, called MAS/RPG, consists in coupling multi-agent simulation (MAS) of the environment resources and role-playing games (RPG) by

the stakeholders [Barreteau 2003]. The RPG acts like a "social laboratory", because players of the game can try many possibilities, without real consequences.

Recent works proposed further integration of role-playing into simulation, and the insertion of artificial agents, as players or as assistants. Participatory simulation and its incarnation, the Simulación framework [Guyot and Honiden 2006], focused on a distributed support for role-playing and negotiation between human players. All interactions are recorded for further analysis (thus opening the way to automated acquisition of behavioral models) and assistant agents are provided to assist and suggest strategies to the players. The Games and Multi-Agent-based Simulation (GMABS) methodology focused on the integration of the game cycle with the simulation cycle [Adamatti et al. 2007]. It also innovated in the possible replacement of human players by artificial players. One of our objectives is to try to combine their respective merits and to further explore possibilities of computer support.

3. The SimParc Role-Playing Game

3.1. Game Objectives

Current SimParc game has an epistemic objective: to help each participant discover and understand the various factors, conflicts and the importance of dialogue for a more effective management of parks. Note that this game is not (or at least not yet) aimed at decision support (i.e., we do not expect the resulting decisions to be directly applied to a specific park).

The game is based on a negotiation process that takes place within the park council. This council, of a consultative nature, includes representatives of various stakeholders (e.g., community, tourism operator, environmentalist, non governmental association, water public agency). The actual game focuses on a discussion within the council about the "zoning" of the park, i.e. the decision about a desired level of conservation (and therefore, use) for every sub-area (also named "landscape unit") of the park. We consider nine pre-defined potential levels (that we will consider as types) of conservation/use, from more restricted to more flexible use of natural resources, as defined by the (Brazilian) law. Examples are: Intangible, the most conservative use, Primitive and Recuperation.

The game considers a certain number of players' roles, each one representing a certain stakeholder. Depending on its profile and the elements of concerns in each of the landscape units (e.g., tourism spot, people, endangered species. . .), each player will try to influence the decision about the type of conservation for each landscape unit. It is clear that conflicts of interest will quickly emerge, leading to various strategies of negotiation (e.g., coalition formation, trading mutual support for respective objectives, etc).

A special role in the game is the park manager. He is a participant of the game, but as an arbiter and decision maker, and not as a direct player during negotiation and interaction phase. He observes the negotiation taking place between players and takes the final decision about the types of conservation for each landscape unit. His decision is based on the legal framework, on the negotiation process between the players, and on his personal profile (e.g., more conservationist or more open to social concerns) [Irving 2006]. He may also have to explain his decision, if the players so demand. The park manager may be played by a human or by an artificial agent (see Section 6).

3.2. Game Cycle

The game is structured along six steps, as illustrated in Figure 1. At the beginning (step 1), each participant is associated to a role. Then, an initial scenario is presented to each player, including the setting of the landscape units, the possible types of use and the general objective associated to his role. Then (step 2), each player decides a first proposal of types of use for each landscape unit, based on his/her understanding of the objective of his/her role and on the initial setting. Once all players have done so, each player's proposal is made public.

In step 3, players start to interact and to negotiate on their proposals. This step is, in our opinion, the most important one, where players collectively build their knowledge by means of an argumentation process. In step 4, they revise their proposals and commit themselves to a final proposal for each landscape unit. In step 5, the park manager makes the final decision, considering the negotiation process, the final proposals and also his personal profile (e.g., more conservationist or more sensitive to social issues). Each player can then consult various indicators of his/her performance (e.g., closeness to his initial objective, degree of consensus, etc.). He can also ask for an explanation about the park manager decision rationales.

The last step (step 6) "closes" the epistemic cycle by considering the possible effects of the decision. In the current game, the players provide a simple feedback on the decision by indicating their level of acceptance of the decision.[1]
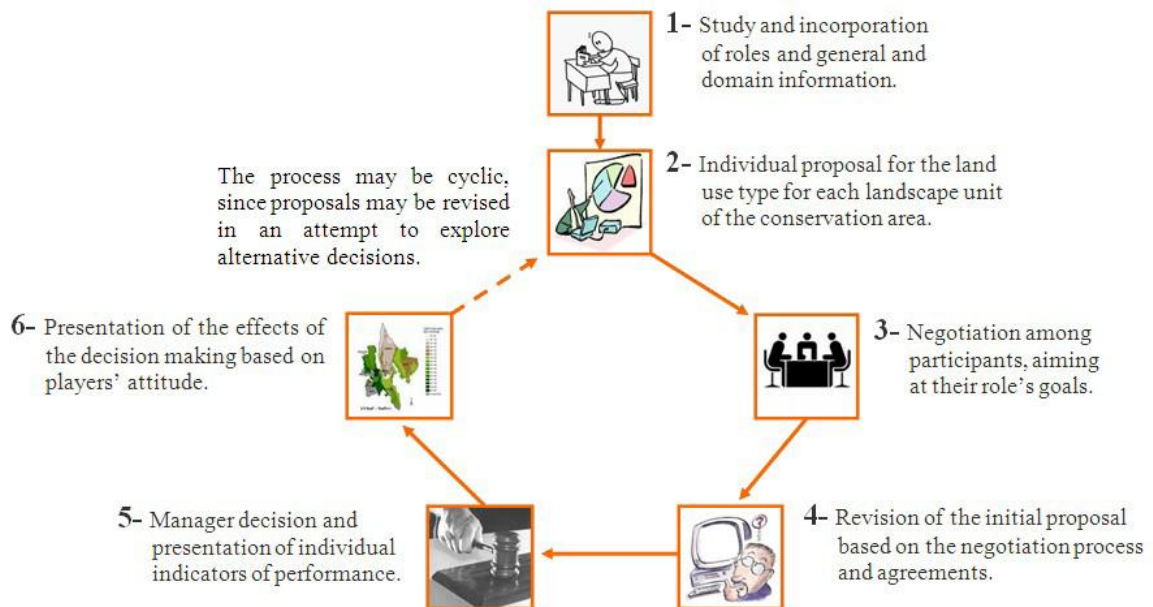

Figure 1. The six steps of the SimParc game.

A new negotiation cycle may then start, thus creating a kind of learning cycle. The main objectives are indeed for participants: to understand the various factors and perspectives involved and how they are interrelated; to negotiate; to try to reach a group consensus; and to understand cause-effect relations based on the decisions.

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[1] A future plan is to introduce some evaluation of the quality of the decision. See Section 7.

4. The SimParc Game Support Architecture

Our current prototype benefited from our previous experiences (game sessions and a first prototype) and has been based on a detailed design process. Based on the system requirements, we adopted Web-based technologies (more precisely J2E and JSF) that support the distributed and interactive character of the game as well as an easy deployment.
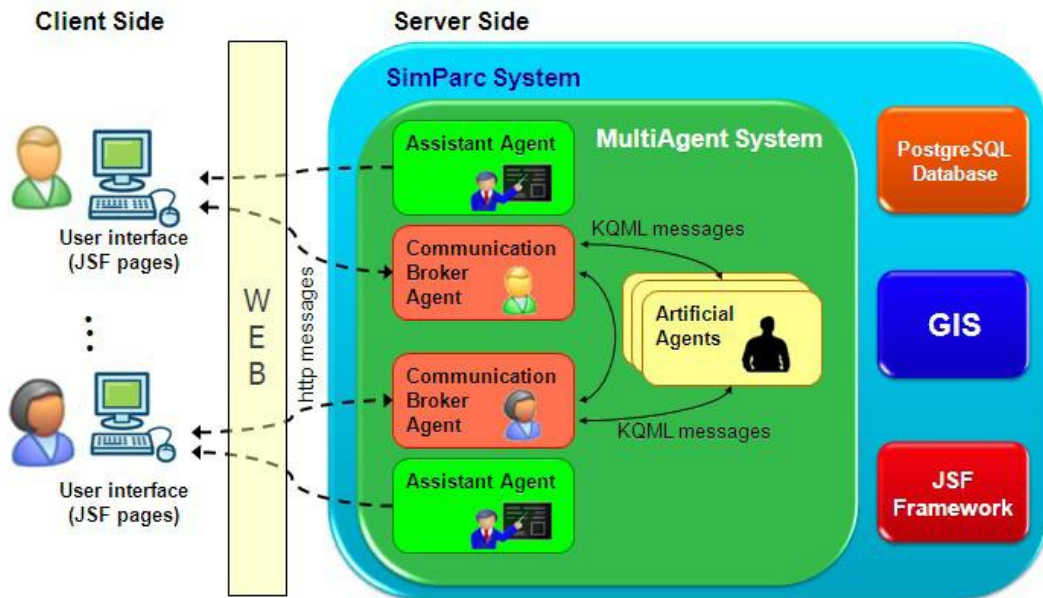

Figure 2. SimParc version 2 general architecture.

Figure 2 shows the general architecture and communication structure of SimParc prototype version 2. In this second prototype, distributed users (the players and the park manager) interact with the system mediated internally by communication broker agents (CBA). The function of a CBA is to abstract the fact that each role may be played by a human or by an artificial agent. For each human player, there is also an assistant agent offering assistance during the game session.

During the negotiation phase, players (human or artificial) negotiate among themselves to try to reach an agreement about the type of use for each landscape unit (subarea) of the park. We include below two screendumps to provide a quick idea about current interface support and their look and feel. The interface for negotiation is shown at Figure 3. It includes advanced support for negotiation (rhetorical markers and dialogue filtering/structuration mechanisms), detailed in [Vasconcelos et al. 2008]. The interface for players decision about the types of use is shown at Figure 4.

A Geographical Information System (GIS) offers to users different layers of information (such as flora, fauna and land characteristics) about the park geographical area. All the information exchanged during negotiation phase, namely users' logs, game configurations, game results and general management information are recorded and read from a PostgreSql database.

5. Preliminary Evaluation

The current computer prototype has been tested through two game sessions by domain expert players (including a professional park manager) in January 2009 (see Figure 5).
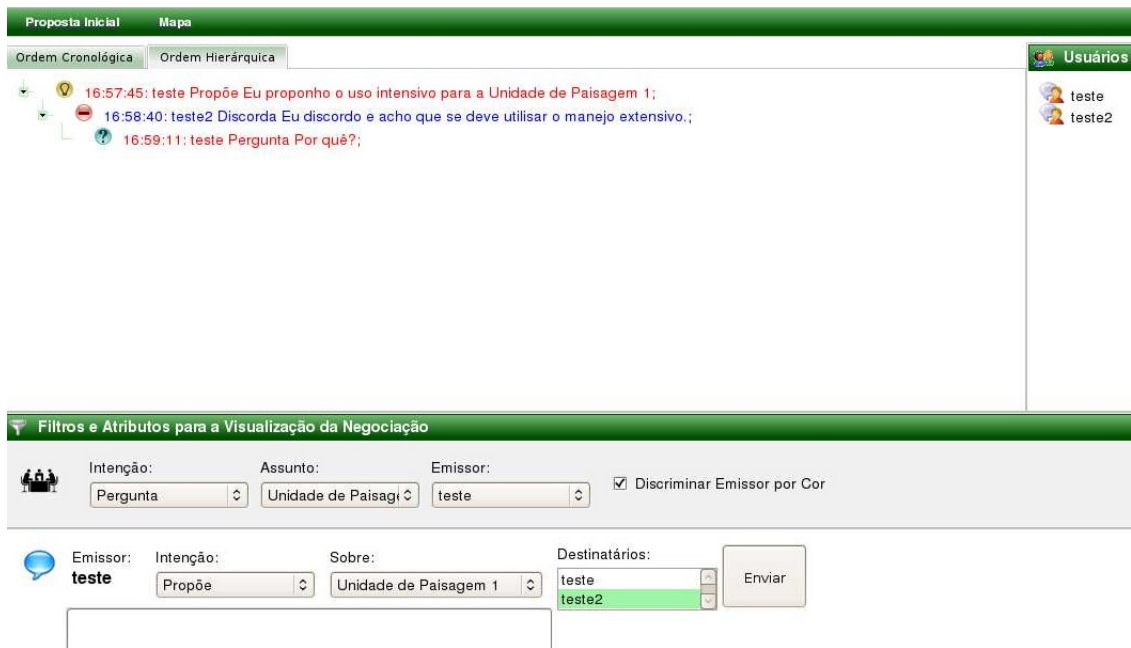
Figure 3. Current prototype's negotiation graphical user interface.

Figure 4. Current prototype's decision graphical user interface.

The 9 roles of the game were played by humans and the park manager was also played by an human.[2] Among these 10 human players, 8 were experts in park management (researchers and professionals, one being a professional park manager in Brazil). The two remaining players were not knowledgeable in park management. One was experienced in games (serious games and video games) and the other one a complete beginner in all aspects.

Figure 5. SimParc current prototype game session (January 2009).

More generally speaking, the game was well evaluated by the human players. We accumulated data on the game sessions (written questionnaires, recorded debriefing, etc.) and an internal report in portuguese has already been completed. As one of the player also took part in a previous game session in September 2007, with no computer support yet, we could also have some preliminary clues at the benefits of a computer support as well as the relative loss in modality of interactions between players. Overall, that player acknowledged the progress in structuring and analysis of the negotiation, thanks to the computer support. An interesting finding after the sessions was also that all players learned and took benefit of the game. The experts explored and refined strategies for negotiation and management, whereas the beginner player took benefit of the game as a more general educational experience about environmental management. In other words, the game appeared to be tolerant to the actual level of expertise of players, an aspect which had not been planned ahead.

Although we believe these first experimental tests as quite encouraging, we clearly need to do more evaluation. As some parks in Brazil expressed their interest to test the game with a real park management council, we can expect further evaluation data to come.

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[2]At the time of that test, the artificial player was operational and already tested off-line, but it was not yet integrated into the prototype.

6. Park Manager Artificial Agent

As explained in Section 3.1, the park manager acts as an arbitrator in the game, making a final decision for types of conservation for each landscape unit and explains its decision to all players. He may be played by a human or by an artificial agent.

The artificial agent's architecture is structured in two phases. The first decision step concerns agent's individual decision-making process: the agent deliberates about the types of conservation for each landscape unit. Broadly speaking, the park manager agent builds its preference preorder over allowed levels of conservation. An argumentation-based framework (see, e.g. [Dung 1995]) has been implemented to support the decision making. The key idea is to use the argumentation system to select the desires the agent is going to pursue: natural park stakes and dynamics are considered in order to define objectives for which to aim. Hence, decision-making process applies to actions, i.e. levels of conservation, which best satisfy selected objectives. In order to deal with arguments and knowledge representation, we use first-order logic. Various inference rules were formulated with the objective of providing various types of reasoning capability.

The next step of our approach consists of taking account of players' preferences. Despite participatory ideals, a whole spectrum of park managers, from autocratic to fully democratic ones, can be measured, depending on how more participatory and democratic decision-making is operationalized. We propose a method, fitted into the social-choice framework, in which participatory attitude is a model parameter. The result of the execution is the modified park manager decision, called agent participatory decision, according to players' preferences.

Further details about architecture formal background and implementation are reported in [Sordoni 2008] and in [Briot et al. 2009]. The architecture has been implemented and tested offline and its outputs (decision and arguments) have been validated by our project domain experts. Next step is to organize a new series of game sessions, with an online test of the artificial park manager architecture. Some possible future work is also to use the traces of arguments produced for the decision as a basis for the explanation of the decision to players.

7. Ongoing Work and Future Prospects

We are currently planning on inserting other types of artificial agents into the prototype.

7.1. Artificial Players

Artificial players represent an ongoing research based on previous experience on virtual players in a computer-supported role-playing game, JogoMan-ViP [Adamatti et al. 2007]. The idea is to possibly replace some of the human players by artificial agents. The two main motivations are: (1) the possible absence of sufficient number of human players for a game session and (2) the need for testing in a systematic way specific configurations of players' profiles. The artificial players will be developed along artificial park manager existing architecture (see previous section), with the addition of negotiation and interaction modules. We plan to use the argumentation capabilities to generate and control the negotiation process. In a next stage, we envisage to use automated analysis of recorded traces of interaction between human players in order to infer models of artificial players. In some previous work [Guyot and Honiden 2006], genetic programming had been used

as a technique to infer interaction models, but we will also plan to explore alternative induction and machine learning techniques, e.g., inductive logic programming.

7.2. Assistant Agents

The assistant agents are being designed to assist players through the game. The basic initial function of these agents is to present and explain each step of the game. During the negotiation step, assistant agents also may propose to participants some helpful informations, in order to improve their analysis concerning the negotiation. For instance, they may provide each player with an ordered list of the players taking into account criteria such as the compatibility or incompatibility of proposals of other players with the proposals of the assisted player. Since we decided to favor a bottom-up approach, we decided to avoid intrusive assistant agents through the game. We believe that intrusive assistant agents could interfere in the players' cognitive processes. That is why our assistant agents can not suggest players a decision.

7.3. Expert Agents

Last, we are starting to work on expert agents which will provide the human players (including the park manager if played by a human) with some technical evaluation of the quality and viability of a given park management decision (e.g., considering the survival of an endangered species). Therefore, we plan to identify cases of usage conflicts (e.g., between tourism and conservation of an endemic species) and model the dynamics of the system (in an individual-based/multi-agent model or/and in an aggregated model). We would then like to explore the use of viability theory [Aubin 1992] to evaluate the viability of the decision. These technical evaluations would be encapsulated into expert agents, technical assistants for the players. Another considered type of expert agent will be based on decision theory analysis, for instance to evaluate the dominance relations or equity properties among players votes.

8. Conclusion

In this paper, we have presented the SimParc project, a computer supported role-playing serious game aimed at participatory management of protected areas. We have also summarized the architecture of an artificial decision maker park manager. The first game sessions conducted with domain experts have been successful. Although more evaluation is needed, we believe the initial game session tests are encouraging for the future and we are welcoming any feedback and input from similar or related projects.

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