Gente: A generic board-game addressing cooperation and conflict in territorial management from the context of core behavior analysis.

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Keywords: cooperation, complex systems, table game, inference engine, open standards, open source, network games, software engineering

Abstract.

It is understood that participatory role-playing games can be useful tools to help stakeholders involved in solving natural resource management issues come to a better understanding of how their actions, coupled with the actions of others, allow or hinder socially and ecologically robust solutions. As a means of examining the core behaviors that motivate or discourage collective action in places such as La Sepultura Biosphere Reserve in Chiapas, we have developed a generic and simple board game. The game invokes core cooperative and selfish behaviors in a contextual environment: offering players the opportunity to consider how small decisions can influence behavior towards others in selfish or altruistic ways. The authors detail a generic system for implementing this game and others like it; using an open-source inference engine to handle modeling and game logic while leveraging open standards and open source to handle simultaneous access to shared data in a scalable fashion. Finally, we discuss the utility of such a system for the development and testing of ecological theories.

Introduction

As Castillo and Saysel (among others) have noted, conflict occurs when stakeholders attempt to resolve issues around common pool resources which they require for survival; an occurrence they refer commonly to as the “cooperation dilemma”:

> According to the “tragedy of the commons” hypothesis, as a rational being, a user of a common pool resource tries to maximize his/her own benefits by increasing individual resource extraction. If every actor follows the same rationale, the resource will eventually be overexploited or depleted and will not be able to generate any social benefit in the long term. This problem represents a cooperation dilemma among common pool resource’s (CPR) users where everyone has to extract less and “sacrifice” from their individual short-term benefits in order to improve the social benefits in the long term. Many renewable natural resources, the fisheries, pastures, forestry, groundwater, and others such as biodiversity, the atmospheric ozone and the global atmosphere are common pool resources. [Castillo and Saysel, 2005]

The cooperation dilemma over common pool resources that Castillo and Saysel speak to can also be considered as an iterated Prisoner’s Dilemma; where a resource (such as trust) may be shared or exploited and where an individual’s actions, over time, have a consequential impact on each stakeholder’s ability to share or exploit that resource. This insight into the fundamental drivers of the cooperative dilemma opens the possibility of concrete and abstract investigation.

For us, this insight allows for the consideration of more abstract, social games that attempt to come to terms with core behavioral decisions in a shared context.

We are developing a number of games that include this cooperation dilemma. GENTE is the first of these games, and acts as a prototype for our efforts as both an experimental game and a software implementation on a new and evolving platform.

Background

Our team works in the Rio Tablón watershed, located in the Sierra Madre de Chiapas in Chiapas, Mexico. We work closely with two ejidos that live in the buffer zone near the La Sepultura biosphere: Los Angeles and Tierra Libertad. Both ejidos predate the founding of the reserve; consequently management of the reserve and its buffer zones must take into account the needs, requirements and impacts of these individuals.

The buffer zone that surrounds the Sepultura where the ejidos are located suffers from a high rate of deforestation with signs of desertification. [Valdivieso, 2008] [AridNet Conference, ECOSUR-SCLC, 2008] Land use in the region has changed from a high Maize agricultural economy in the 1980s to a cattle based economy today. The effects of deforestation on the hillsides for the purposes of Maize cultivation created conditions for soil erosion and began this process decades ago. [Valdivieso, 2008] The repurposing of this land for its current use as pasture has exacerbated this process; exposing greater amounts of soil from the tread of cattle and domestic animals to the torrential rains typical of this area in the summer months.

Exposed soil and deepening eroded ravines are clearly visible in the buffer zone managed by the ejidos and are of concern to many organizations active in the region. [Valdivieso, 2008]

Figure 1. (Deforestation and erosion are clearly visible in this photograph. Ejido Los Angeles, La Sepultura buffer zone.) [Photograph, Andrew Waterman, 2008]

Several academic groups work in the reserve: ECOSUR, doing agroforestry outreach; the Universidad de Chapingo providing research and support to the Consejo de la Reserva (reserve council); and the Universidad Autonomo de Chiapa, providing Agroforestry outreach. [García-Barrios, et. All. Unpublished field notes, March 2009]

Along with academics, several governmental and non-governmental organizations are also active. The Comision Nacional Forestal (CONAFOR) provides payments to inhabitants for environmental services[1], the Comision Nacional de Areas Naturales Protegidas (CONANP) runs the reserve, the Secretaria del Campo subsidizes maize production thru PROCAMPO and cattle production thru PROGAN, and the local Municipality of Villaflores provides funding for infrastructure projects. PRONATURA, Conservation International and The Nature Conservancy work along with the local coffee producer organization and the local Sociedad Ganadera de Los Angeles (ranching association) to improve environmental quality. [García-Barrios, et. All. Unpublished field notes, March 2009]

All of these external groups have legitimate and sincere interests in different aspects of development in the reserve. Subtle conflicts between these interests may be understood when a perceptible dynamic between two active groups is considered: one promotes conservation and ecological land use in the reserve and the buffer zone while the other promotes agricultural and economic development. This is not to say that agricultural and economic development are at odds with sustainable ecological practices; but rather that the emphasis is placed differently by differently aligned organizations, which may create complex effects. [García-Barrios, Speelman and Pimm, 2007]

In our game, “Manantiales de la Sierra”, we built a system for playing with these differences and providing participants a perspective upon the influence of their own actions as intensified by the actions of others in the buffer zone. [García-Barrios, et. All, Workshop Document, 2009]

With GENTE, our focus was primarily upon something abstract; a game focused on small decisions made in a competitive context. By this we meant a game that would allow us to use the pressure and context of a competitive game to look at how human agents react in an open-ended cooperative dilemma. To do so, we needed to model a game that would provide two types of competition: between teams and between resources. In the case of GENTE, as in an iterated prisoner’s dilemma, teamplayers compete over trust; but within the evolving context of team competition (the overall game).

Game Design

We started with Gary Gabriel’s game, PENTE, invented in 1978. [Wikipedia, Pente] The simplicity of the board and pieces, as well as the game’s notable playability greatly influenced our decision. Of course, PENTE is a game played by two players, on a large Go board, each in direct competition with the other. The game is complex, with players taking years to master its subtleties. There is no concept of “free-loading”, “defection” or “cooperation” involved in the game; just a complex configuration of pieces on a competitive board whose topology can be modified through “captures” by the opposing player. The game itself is zero sum; there can only be one winner. As we considered what we wanted to take from PENTE, we realized that we could only inherit a few concepts from the game in order to build something suitable for research.

Implementation

GENTE (translated as “people”) is played on a 19 by 19 grid; modified from the traditional GO board by allowing pieces to be placed in the center of each square, as opposed to traditional play which requires placement on intersecting vertices. As in PENTE, the first player must occupy the center square, marked on our board by a small red star. At this point, the two games significantly diverge.

In PENTE, only two players are active on the board at a time. In GENTE, four players are active and divided into two teams, “HOT” and “COLD.” In PENTE, stones are black or white; in GENTE, stones are colored to fit our team metaphor. Hence, our stones are green, blue, red and yellow. Play is alternated among teams, with turn order as follows: yellow, then blue, then red and finally green. The goal of the game is to be the first player to achieve three “trias”, or to be the first team to form two mixed “tesseras.” We follow a similar

[1] Environmental services is a payment that CONAFOR provides to habitants of the buffer areas in La Sepultura to help maintain the natural resource.

meaning for these terms as in PENTE; a tria means three stones of the same color adjacent to one another (in a row, a column, or diagonal), a tessera means four stones of the same team colors adjacent to one another (in a row, a column, or diagonal). Similar to PENTE, opposing players can block tria or tessera formation by interrupting the grouping with one of their own colored stones.

We exclude most of the other rules from PENTE. As mentioned above, winners are determined in GENTE by a combination of adjacent stones in sets smaller than that required by PENTE and with the notable innovation of allowing two players to contribute to a single team tessera. In addition, we have intentionaly excluded the concept of capture, as we believed this would hamper our game analysis by significantly altering the topology of the final alignment. Our software implementation belays this objection, but our game design was intended for a game that can be easily played both on the table and upon the computer.

The artifact we are left with is a game abacus and log; recording each player's movement and strategy of play across the board. As with most tabletop games, although we can see the topology of moves; we are lacking an ordered record of those moves. Game analysis must be conducted by means of note-taking and general interviews of each player; what they thought of the game, what types of behavior they think they exhibited and those that his or her teammate and opponents did.

At first, it was this lack of a good mechanism for analysis that motivated us to move towards a more generic system that would do several things we saw as lacking in tabletop play: detailed logging, persistent tracking of games over time, and the ability for players present in other locations to interact.

Players

As in Manantiales, our targeted players initially were the stakeholders and participants in our project in La Sepultura. We wanted to engage these players in their own environment; playing versions of our game on the tabletop and getting detailed recordings of player interactions. We also desired to engage stakeholders that were not present in the reserve itself, but working kilometers away, sometimes at quite a distance. We hoped most of all to engage a mixture of players; stakeholders playing in La Sepultura along with those far away in Tuxtla Gutiérrrez, San Cristóbal de Las Casas, or Mexico City.

Of course, these goals could not be fulfilled with a simple table-top implementation; nor even that of a non-networked software implementation. We needed a way forward towards a networked, virtual table game; one that allowed for player interaction at a distance and where new games could be easily implemented and "tried out" with stakeholders.

Software

Due to these requirements, we were tasked with creating a networked, scalable system for playing in a virtual space. We needed to write software tailored specifically to GENTE, but also applicable to other games that we saw ourselves building in the future; such as Manantiales de La Sierra. [García-Barrios, et. All, 2009] We wanted something that would work as both a game with real participants (human players) and something that could also be played by agents; either on their own, or as a multi-agent system (MAS). We wanted something persistent, so we would have a clean data-set for external analysis. In particular, we wanted something similar to the games Luis and Erika had implemented with agent based modeling software [García-Barrios, Speelman and Pimm, 2007] but structured to natively handle large numbers of networked clients and using a set of shared, reusable components.

As the development team for this project was quite small, only two programmers working together for a short time (2 ½ months) we decided to spend our initial efforts where they would have the greatest affect; on the game presentation, persistence, and modeling system.

We required client networking and scalability as well, but as these are common requirements in the enterprise, we realized that we would get these for free by using an enterprise class application server. We chose to construct our system along familiar enterprise architecture patterns. We use a clusterable Application Server and database connection pool which allows us to connect to a local in-memory database (for development) or a database cluster instantiated on another set of machines. This leaves us with the consequent of pushing overall scalability of the system into the hardware layer upon which our application is deployed (scalability becomes a factor of the number of machines running the cluster, not a factor of our implementation or our connectivity layer). [Wikipedia, Cluster (computing)]

The design in figure 2 attempts to convey the generic network architecture of such a system. I have substituted a physical load-balancer for the cluster's software load-balancing algorithm for visual simplicity.

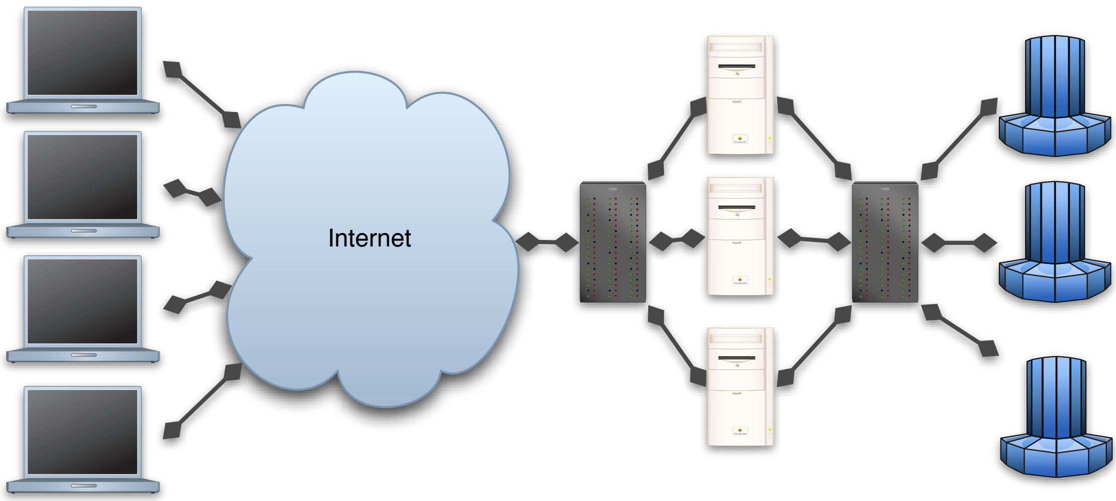

Figure 2. Enterprise Architecture, Cluster pattern. [Diagram, Andrew Waterman, 2009]

Our tasks were segregated into the development of a hosted application for the business tier [Sun Microsystems, Business Tier Design] and the construction of a rich internet application (RIA) for presentation of the game to networked players. [Wikipedia, Rich Internet Application] We followed an implementation plan very similar to that outlined in the Java Blueprints by Sun Microsystems, but using current Java 1.6 server technology (JEE). We elected to use Stateless Enterprise Java Beans (EJBs) and the Java Messaging Services (JMS) as the connecting layers between the user interface and the shared model on the server. For our initial prototype, we used proprietary JEE lookup techniques for connecting our RIA with its EJBs. As time has passed, we are in the process of modifying this implementation to use the more agile RESTful [Wikipedia, REST] techniques for communication between the interface and back-end layers.

User Interface Design

Players that use our RIA are met with a login screen, which, due to the limited exposure of our game, simply queries the user for his name, which is used by our system for registration.

Before we expose our work to the outside world we are planning on expanding this user registration process to make use of the the OpenID framework. [OpenID, 2009] This allows our data-set to be externally consumable; OpenID provides a security standard that uniquely identifies users across applications, allowing for surety in terms of the uniqueness of results tied to the play of our staged games.

After a user logs in to the application, our Flash based RIA presents what we call the "lobby" screen; where unfinished, pending and new games may be created or joined [figure 3].

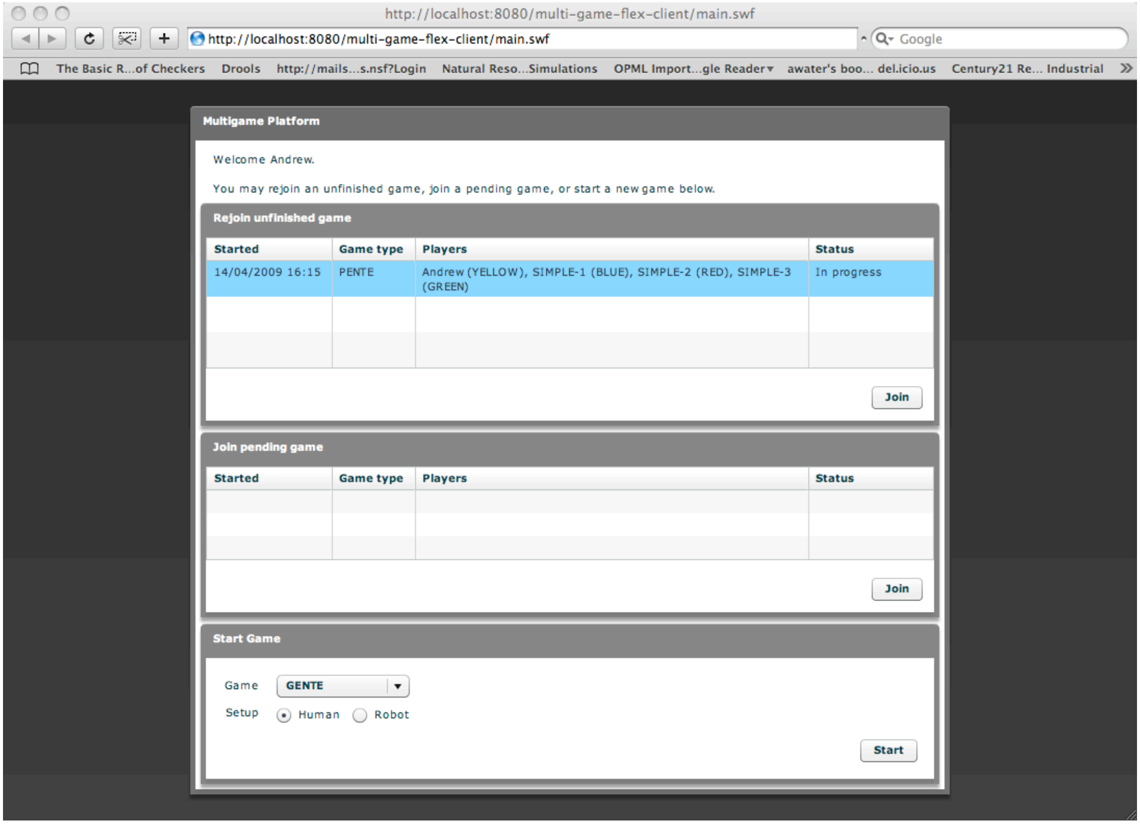

Figure 3. Game lobby. [Screenshot, Andrew Waterman, 2009]

The top portion in figure 3 lists all unfinished games to which a user is registered; the middle table lists all pending games that other users have created and require more players, while the bottom table allows players to create new games for play with either other users or agents (robots).

We intend to modify the lobby in the future to create an invitation based system; using presence information from our OpenID registrants with a SIP based invitation system [Rosenberg, et. All, 2002] to connect disparate users across multiple platforms. We intend to implement this approach in a manner similar to that presented by Wong and Cheung [2009] but using OpenID/OAuth for presence authentication [Balfenez, et. All, 2009] and an open source SIP/Presence server for registration. Of course, these plans may change; but we do see the need for greater player (and researcher) control over whom gets invited to which game, when, and on what platform they play (allowing us to expand beyond our current RIA with the same back-end implementation).

Figure 4 shows the actual GENTE game board as it currently exists. The screenshot is taken from a mixed game, with a single user playing against three agents. The screen is divided into four sections: 1) menu bar, providing access to system level commands; 2) a left-hand control bar, providing status information, access to game tokens (when the player has a turn) and move history; 3) a center panel providing a drag and drop aware shared game board; 4) a right-hand side information bar providing access to player scores and game local chat.

The menu bar provides game players access to system level commands; allowing users to return to the game lobby, quit and conclude the game or access game specific help. The left-hand-side notifications component alerts users to changes of state during play, announcing which user currently has the turn and welcoming players at the beginning of the game. Beneath the status component, active players (those with the turn) get access to their tokens for placing moves on the shared game board. As the board is drag and drop enabled, users simply need to select a colored token and drag it to an empty space.

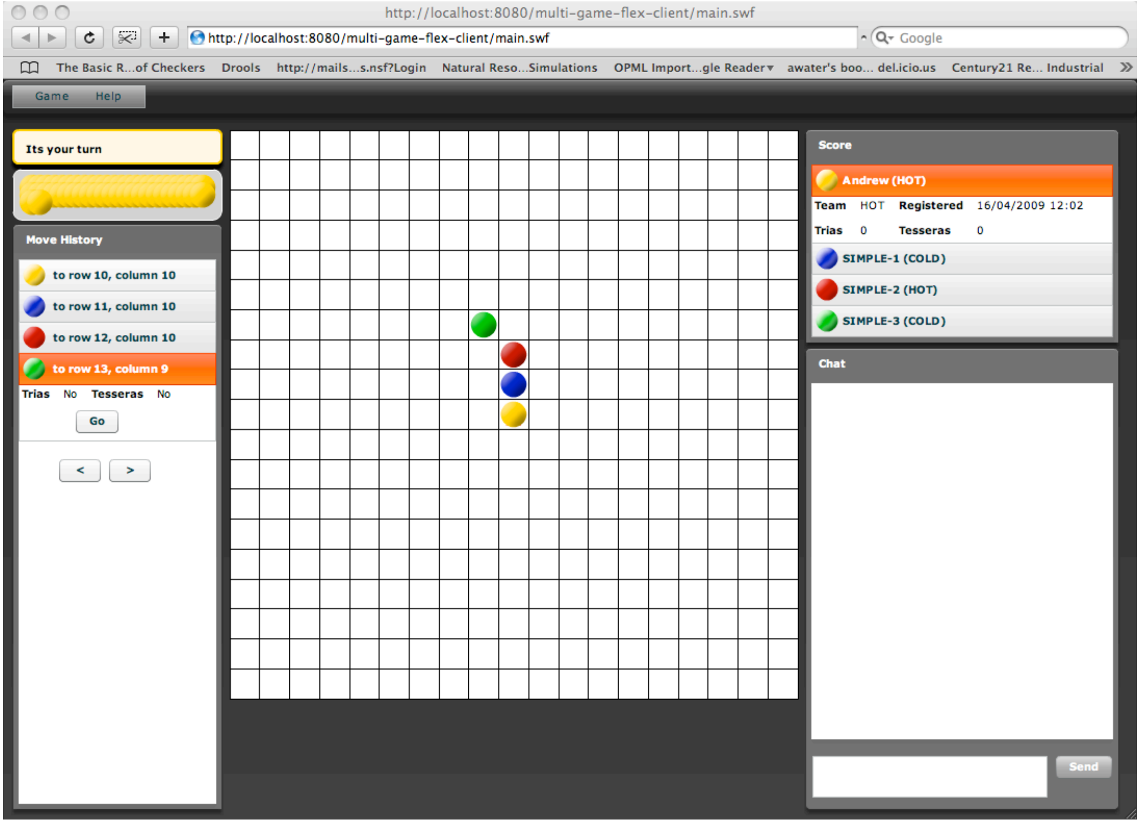

Figure 4. GENTE game board. Yellow player's turn. [Screenshot, Andrew Waterman, 2009]

The move history component allows players (or analysts in replay mode[2]) to visually walk through game state and player moves at any recorded point of the game. The center game board acts as a two dimensional representation of the recorded game state, interactive, as mentioned above, with the player and the token store to advance gameplay. Finally, we use the space on the right hand side to convey player information: such as which team is the active player on? How many trias does he or she have? And to allow trackable discussion through chat.

We solve the problem of analyzing each user's view of the actions of his or her partner by means of a dialogue, which starts once a teammate makes his or her move [figure 5].

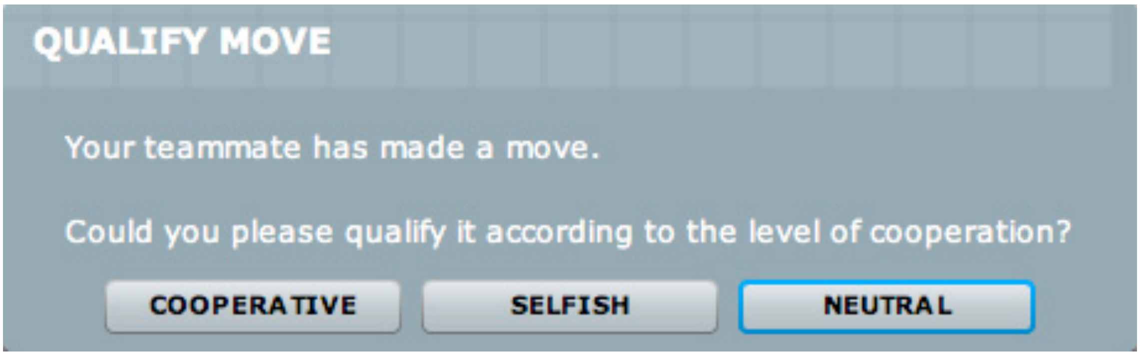

Figure 5. Move qualification question. [Screenshot, Andrew Waterman, 2009]

This allows our system to be able to correlate each move of a player during a game with the perceptions of that player's teammate.

[2] Our RIA is built with two modalities: play and replay. Replay allows analysts to load any previous game and review the game in detail.

Server Architecture

Our server software is a JEE 1.6 implementation of the classic J2EE 1.4 business tier pattern, using both client-side connections to EJBs in the middle tier and a client connection to the JMS service configured on the server. This results in the layered architecture visually represented in figure 6.

Figure 6. Business tier and Connectors. [Graph, Andrew Waterman, 2009]

Messaging is the glue that holds the stack together; it touches upon all layers of our server-side implementation; from persistent data storage (JPA) [Sun Microsystems, Java Persistence API FAQ] to the remoting interface for the RIA. We have constrained its activation (messages going out over the wire) to the rules that inform our inference engine, implemented in the Drools open source rules framework. [Red Hat, 2009]

Inference Engine

We use an inference engine to handle modeling in GENTE. As this was our first prototype, we created a clear separation between the data-model and the logic-model. Our current intention is to move towards a unified expression of these two subsets. Going forward, we are looking to use the templating facility in the latest release of Drools to push a description of the data-model into its logical expression. [Red Hat, Inc.]

Currently, our data-model is expressed in a generic set of reusable JPA components while the logic-model that governs the interaction of active data is written in drools rules language (DRL). DRL is quite expressive, allowing us to use a very clear and formal logic to express conditions and consequences from game state. For example, the following rule executes a pending move on the shared game board:

```
# Executes a simple move
rule "execute-move"
    agenda-group "move"
when
    game   : Game (state == GameState.PLAY)
    move   : Move (player.turn == true, status == Status.VERIFIED)
then
    GameGrid modifiedGrid = game.getGrid();
    modifiedGrid.updateCell (move.getDestination());
    modify (move) { setStatus (Status.MOVED) }
    modify (game) { setGrid (modifiedGrid) }
```

```
    MessageSender messageSender = new MessageSender();
    messageSender.sendMoveComplete(move);
end
```

This expression divides into two sides: a) the left-hand-side (LHS) which decides if a given rule should fire and b) the right-hand-side (RHS) that encodes the consequence or the logical implication of the RHS being true.

In the case outlined in the "execute-move" rule, very simple conditions need to be satisfied in the inference engine's memory in order for the consequences to fire. As can be understood from the RHS of the rule itself, these conditions cause changes to the state of our data-model (the logic of our model in action) which is consequently stored in the persistent database and made accessible to all clients of the session.

Search conditions may also be codified into rules for an inference engine, which allow much greater clarity with regards to a stream of actions. For example, in our implementation of Manantiales, we encode the following search constraint on active moves:

```
rule "row contiguous intensive"
    agenda-group "verify"
    no-loop true
    when
        $tok1 : Ficha ($row : row, $col : column,
                    type ==  TokenType.INTENSIVE_PASTURE)
        $move : ManantialesMove (status != Status.INVALID,
                    destination.row == $row,
                    type == TokenType.INTENSIVE_PASTURE)
        eval (Math.abs ($col - $move.getDestination().getColumn()) == 2)
    then
        modify ($move) { setStatus (Status.INVALID) }
end
```

This rule allows the inference engine to fire its consequent, when a valid move and a token (ficha) has been discovered that meets the specified conditions (two intensive tokens are placed contiguously upon the same row).

Rules can be loaded onto a shared server and made dynamically adaptable; an approach that fits quite well with participatory modeling and the COMMOD process. [Bousquet and Trébuil, 2005] Researchers can take a running system (such as the RIA defined for GENTE) and modify the rules upon suggestions by participants. Researchers may then game on the existing UI but with new rules and consequences. Rules are application agnostic. Agent based systems can be easily built from rule based expressions, participating in a running system such as ours through messaging, as we do with our existing implementation of JMS based rule agents.

<u>Results</u>

How should we interpret the results of these games? Players that elect to win by tria, thereby only using their own colored stones, are coded as "selfish." Users that win by cooperating with their teammate and creating tesseras are coded "cooperative." By using such a simple game to introduce players to the cooperation dilemma, we provide an easy entrance into discussions about general dilemmas of cooperation that concern stakeholders in all kinds of development scenarios.

Conclusion

We believe that the system presented here provides a strong separation between software components in a manner that should allow researchers (and implementors) the opportunity to focus on areas of their own expertise.

In particular, we have found that our use of an inference engine provides researchers with the opportunity to make use of simple propositional logic to express their domain knowledge with a rules-based model.

In addition, open source tools such as Drools can be used by technical workers to generate domain specific languages which map more clearly to propositions put forward in the modeling process. [RedHat, Inc.]

AsCarl Folke, et. All state:

> Processes that generate learning, meaning, knowledge, and experience of ecosystem dynamics expressed in management practice are part of the social capacity of responding to environmental change. [2005]

Games such as GENTE provide players and analysts alike with the opportunity to learn from and experience the drivers that cause negative environmental change (priviliging the interests of the individual above that of the group). By systemizing information in a very empircal, exportable and externally consumable way, we provide a suitable means for presenting information to stakeholders (or experts in social psychology and economics) so they can identify patterns and consequences of modeled actions.

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