USING A MULTIAGENT SYSTEM FOR SIMULATING FOREST STAKEHOLDERS' ACTIVITIES[1]

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Abstract

This paper is aimed to show the potential use of multiagent system or distributed artificial intelligence for simulating complex ecosystems, which comprise people and natural resources. A multiagent system combines the concepts of system dynamics, GIS modeling and behavior sciences. CORMAS is free software, and the Smalltalk codes are open for everyone. Export/Import and Communication of CORMAS to other software such as Arc Info, IDRISI or Excel can be made with few efforts. The paper's author involves in the network of CORMAS further development

INTRODUCTION

It is no disputes that sustainability involves satisfying present needs without compromising future options. A forest sustainability concept, in which maintaining or enhancing biodiversity is a key criterion, requires a good understanding on how forests influenced by involved people. The behaviors of people or stakeholders including forest managers, local communities, governments, NGOs etc. influence the sustainability of forests. Each stakeholder has their own goal, perception, activities and the way to communicate with the others. Simulation on how they interact and their impact to sustainability is an interesting research domain.

Simulation is a technique particularly deals with dynamic behavior of a system. There are many ways to predict systems behavior besides simulation such as statistical or physical methods. Grant et al. (1997) described them in Figure 1. Considering the complexity of sustainability problems and the amount of data can be taken, simulation is the appropriate way to deal with time constraints.

Most simulation techniques such as Dynamo, Stella, Powersim, AME (Agricultural Modeling Environment) etc. were created based on differential or difference equations and dedicated for system dynamics modeling. This modeling comprises auxiliary variables, states, rates and constants, which are aimed to biophysical components.

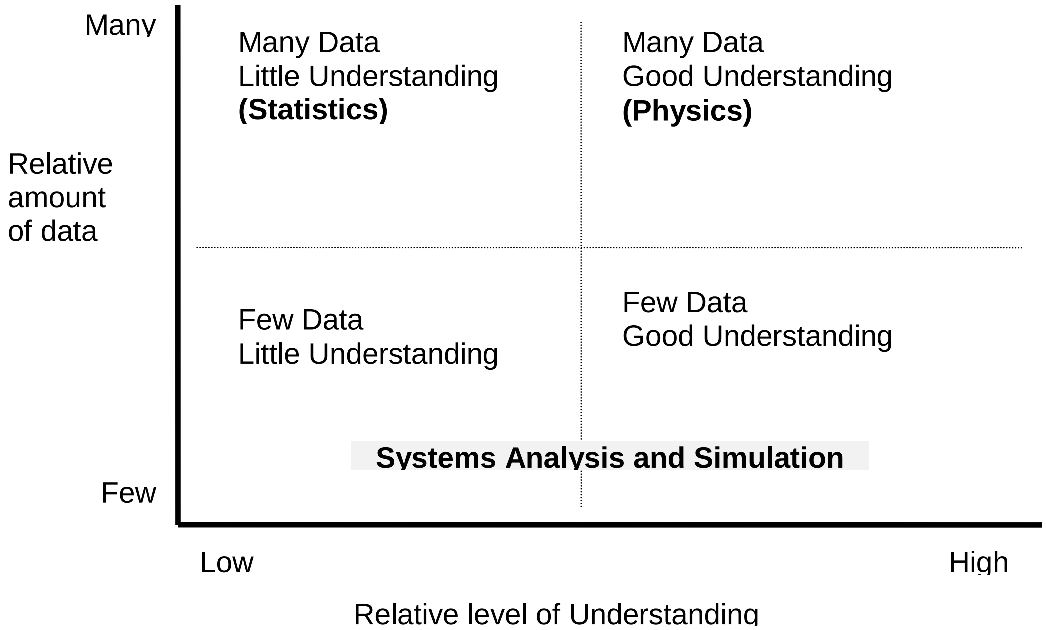

Figure 1. Comparisons of Methods of Problem Solving (Grant et al. 1997)

MULTIAGENT SYSTEMS

Simulation of the stakeholders' activities and interactions needs a tool that is able to represent individual knowledge, belief and behaviour of each stakeholder. First attempt of this kind of modelling is to assume that each stakeholder or agent who acts autonomously depending on one's perception on the environment as shown in Figure 2

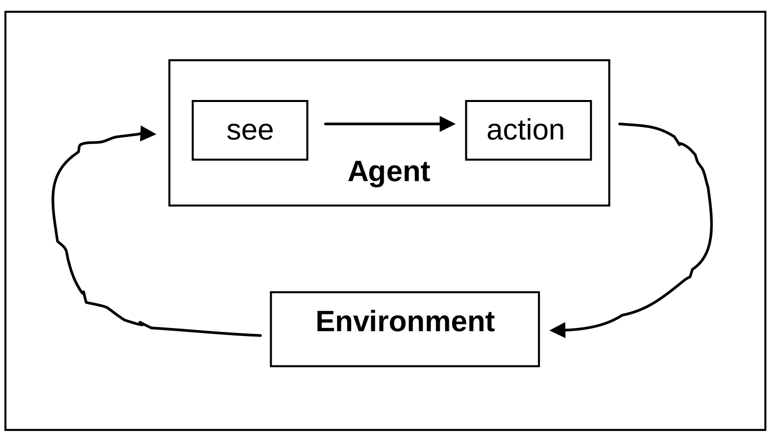

Figure 2. Perception and action subsystems (Weiss, 1999)

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If the agent want to take into account the previous perception state then the agent needs to integrate what he perceive and what is already in his mind as depicted in Figure 2. More comprehensive architectures, called *Belief-Desire-Intention* (BDI) is shown in Figure 3. These architectures have their roots in the philosophical tradition of understanding *practical reasoning* – the process of deciding, moment by moment, which action to perform in achieving the goal.

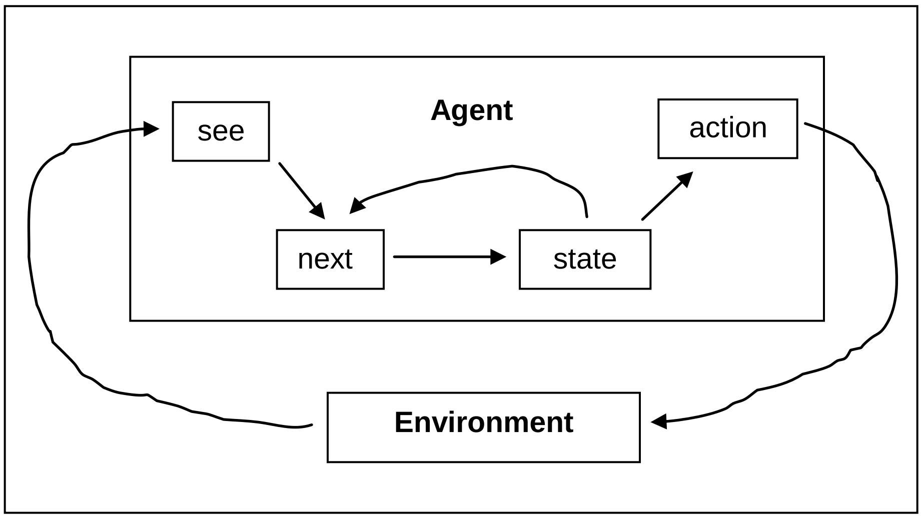


Figure 3. Agents that maintain state (Weiss, 1999)

The process of practical reasoning in a BDI agent can be illustrated as follows (Weiss, 1999)

- a set of current *beliefs*, representing information the agent has about its current environment;
- a *belief revision function (brf)* which takes a perceptual input and the agent's current belief, and on the basis of these, determines a new set of beliefs;
- an *option generating function, (options),* which determines the options available to the agent (its desires), on the basis of its current beliefs about its environment and its *current intentions;*
- a set of *current* options, representing possible courses of actions available to the agent;
- a *filter* function *(filter),* which represents the agent's deliberation process, and which determines the agent's intentions on the basis of its current beliefs, desires, and intentions.

- a set of current *intentions*, representing the agent's current focus – those states of affairs that it has committed to trying to bring about;
- an *action selection function (execute),* which determines an action to perform on the basis of current intentions.

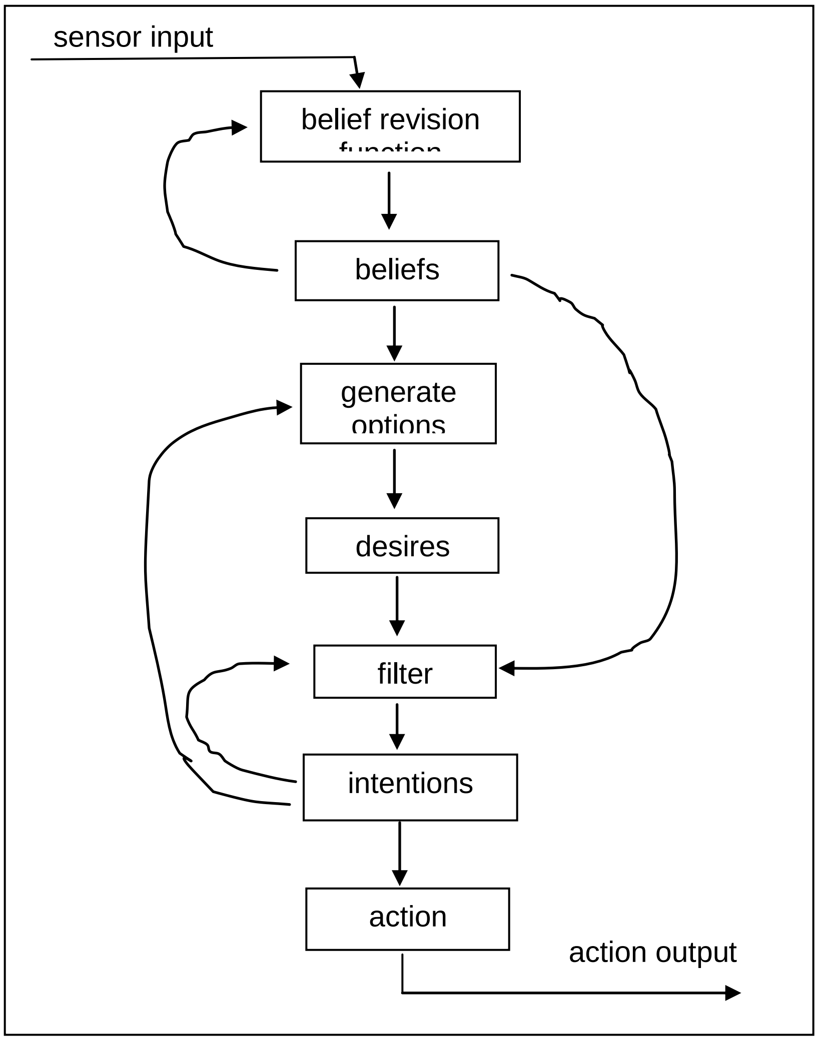


Figure 3. Schematic diagram of a generic belief-desire-intentions architecture (Weiss, 1999)

Agents operate and exist in some environment. The environment might be open or closed, and it might or might not contain other agents. If it contain other agents, it can be seen as society of agents or Multiagent Systems (MAS). Ossowski (1999) illustrated the coordination among agents as shown in Figure 4.

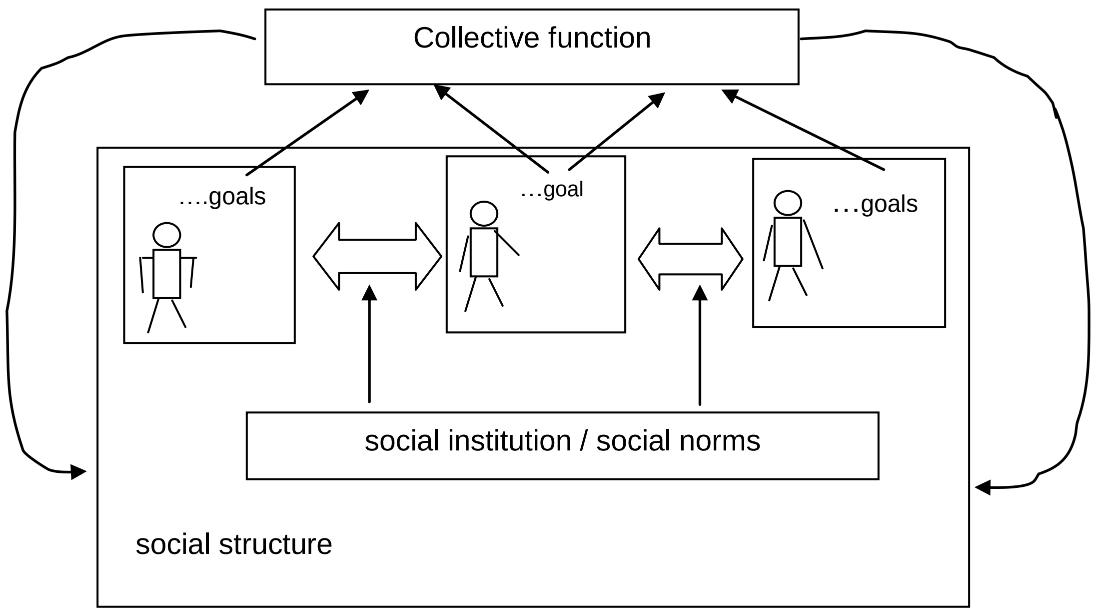


Figure 4. Coordination among agents (Ossowski, 1999)

The communication protocols enable agents to exchange and understand messages. A communication protocol might specify that the following messages can be exchanged between two agents (Weiss, 1999):

- Propose a course of action
- Accepts a course of action
- Reject a course of action
- Retract a course of action
- Disagree with a proposed course of action
- Counterpropose a course of action

An Artificial Society of Forest Stakeholders

A Multiagent System (MAS) is used to simulate the behavior of each agent and the interaction between agents. The agents located in a spatial system environment. In Figure 5, **for example**, there are three kinds of agents used in the simulation i.e. firm, villagers and local government. The firm and villagers are located in a forest in which the local government has an obligation to maintain its sustainability by giving rules to the firm and local people. As shown in Figure 6, the firm is located in certain area and they log wood with taking into account the distance of logging site and wood available. The villagers move to the best site for collecting NTFP (Non Timber Forest Product).

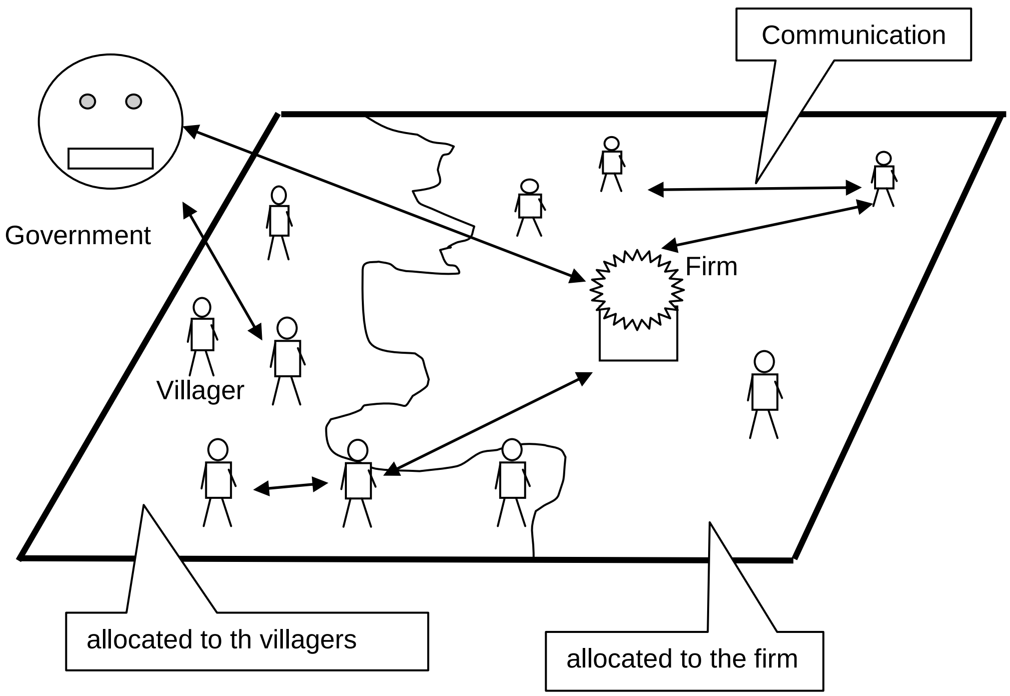


Figure 5. The example of model components and their interaction located in the spatial system

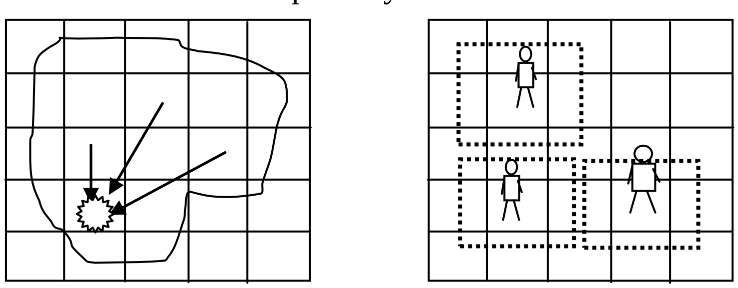


Figure 6. Spatial representation of the firm's activity and villager's moving activity

The communication among stakeholders arranged to meet the actual condition in the field with some simplifications. An example on the communication is shown in Figure 7. The firm send a message (#proposition) to the local government that they need wood, more that they can get from the current logging area. Then, the government reasons this message and then gives #agreement or #disagreement message. Since the sites are not allocated to the firm but the villagers, the firm send a message (#demanding) to the villagers asking whether they want to sell wood to the firm. The villagers reason this message, then perhaps some of them send #offering message to the firm. Then the firm finds the best offering and makes contract with them. The villagers who have the contract do not move to collect NTFP, and tell the other villagers as well as the government that we're busy. The firm memorise the performance of each villager for future utilisation.

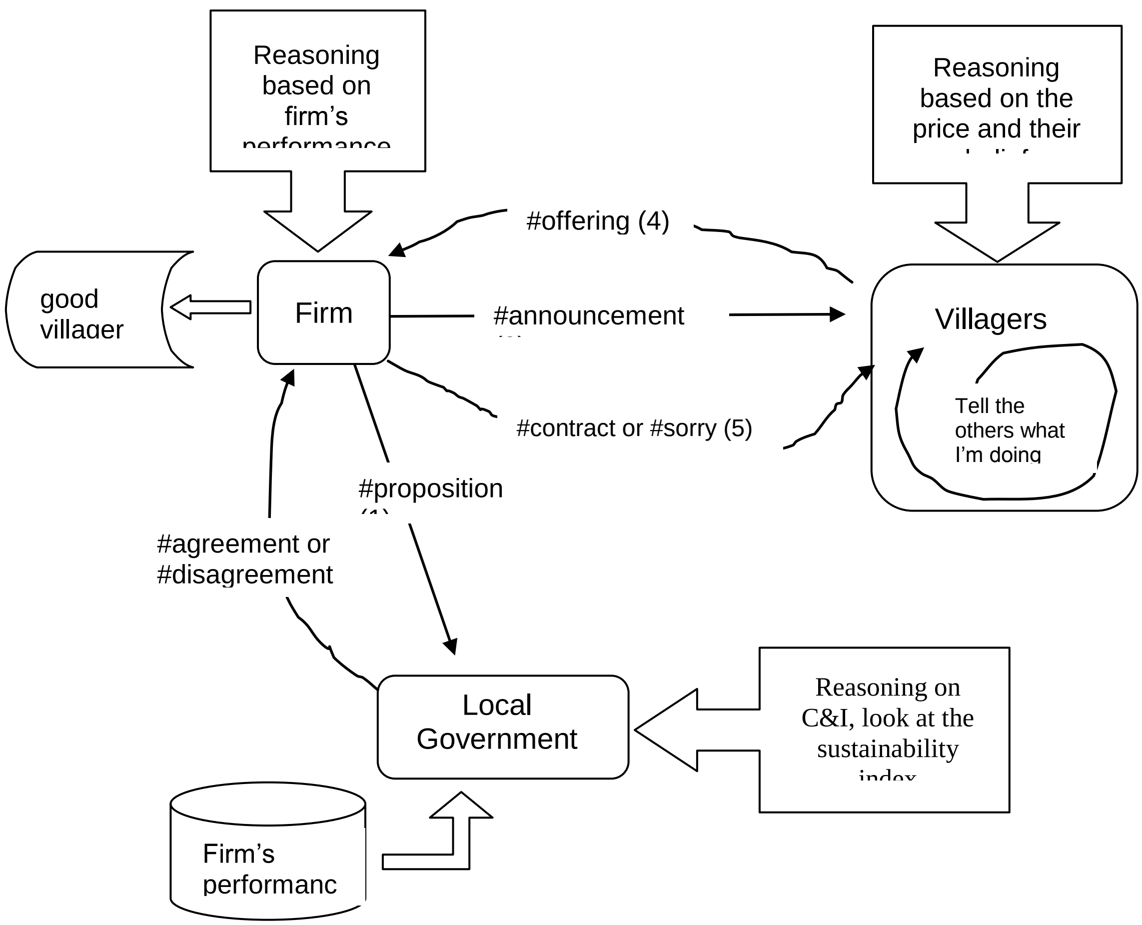


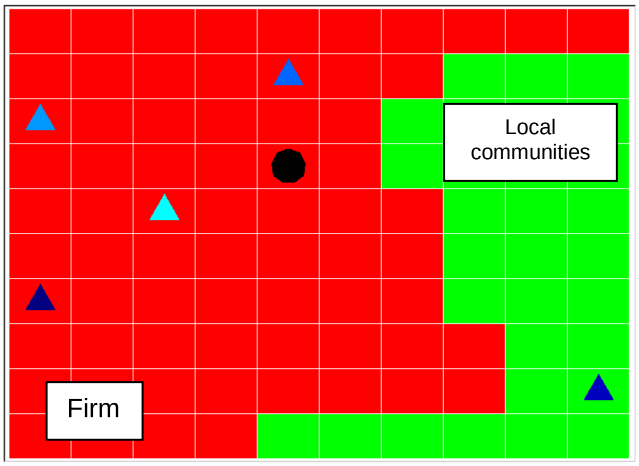
Figure 7. The example of communication of forest stakeholders

Based on the activities of the forest stakeholders, the following can be observed during the simulation time:

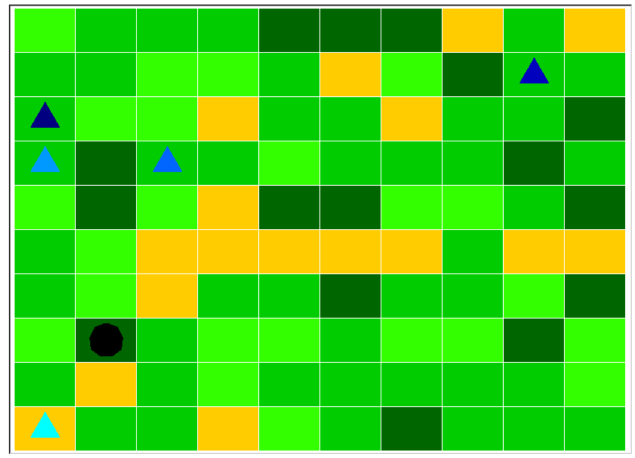
- Biodiversity at the landscape level
- Forest-dependent people well-being
- Firm's revenue
- Taxes collected by the government

The artificial society was developed with Smalltalk Computer Language in CORMAS (Common Pool Resources and Multiagent Systems developed by CIRAD Fôret, France.) environment. The system can be run in Windows, UNIX / LINUX and Macintosh system. The following is the simulation process using hypothetical "bad" data.

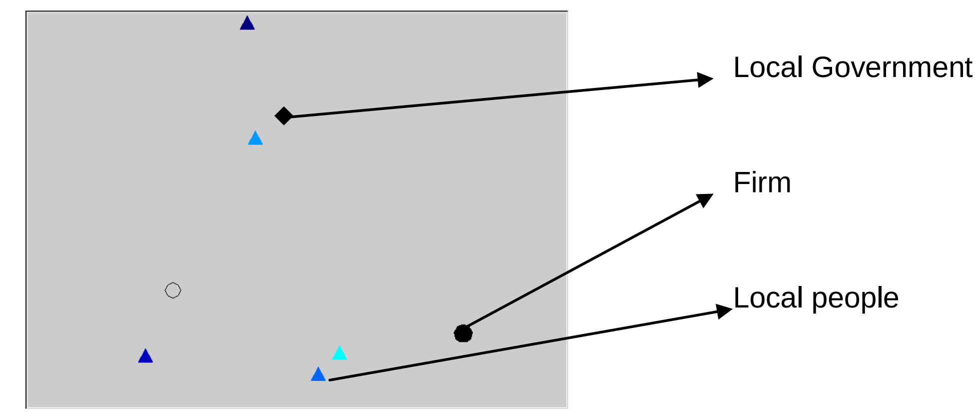
Initial Condition



Land ownership

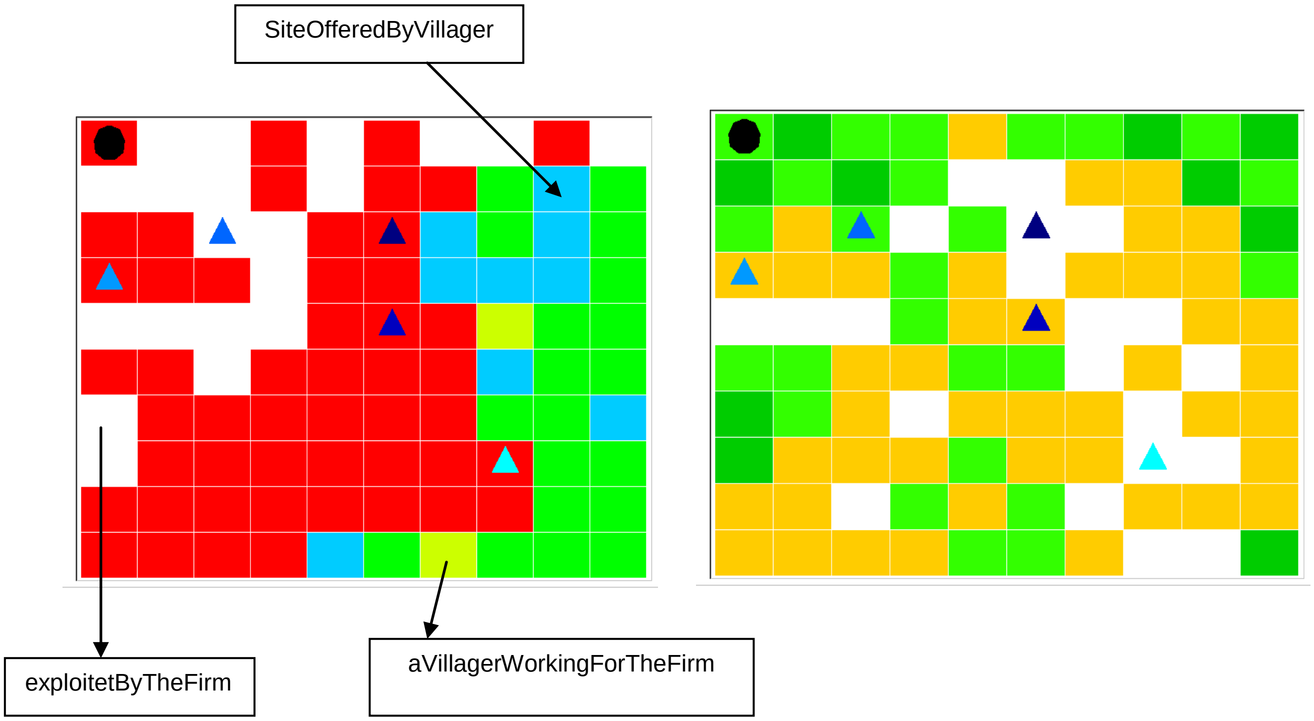


Randomly distribution of forest condition (status, dark green better than light green or yellow)

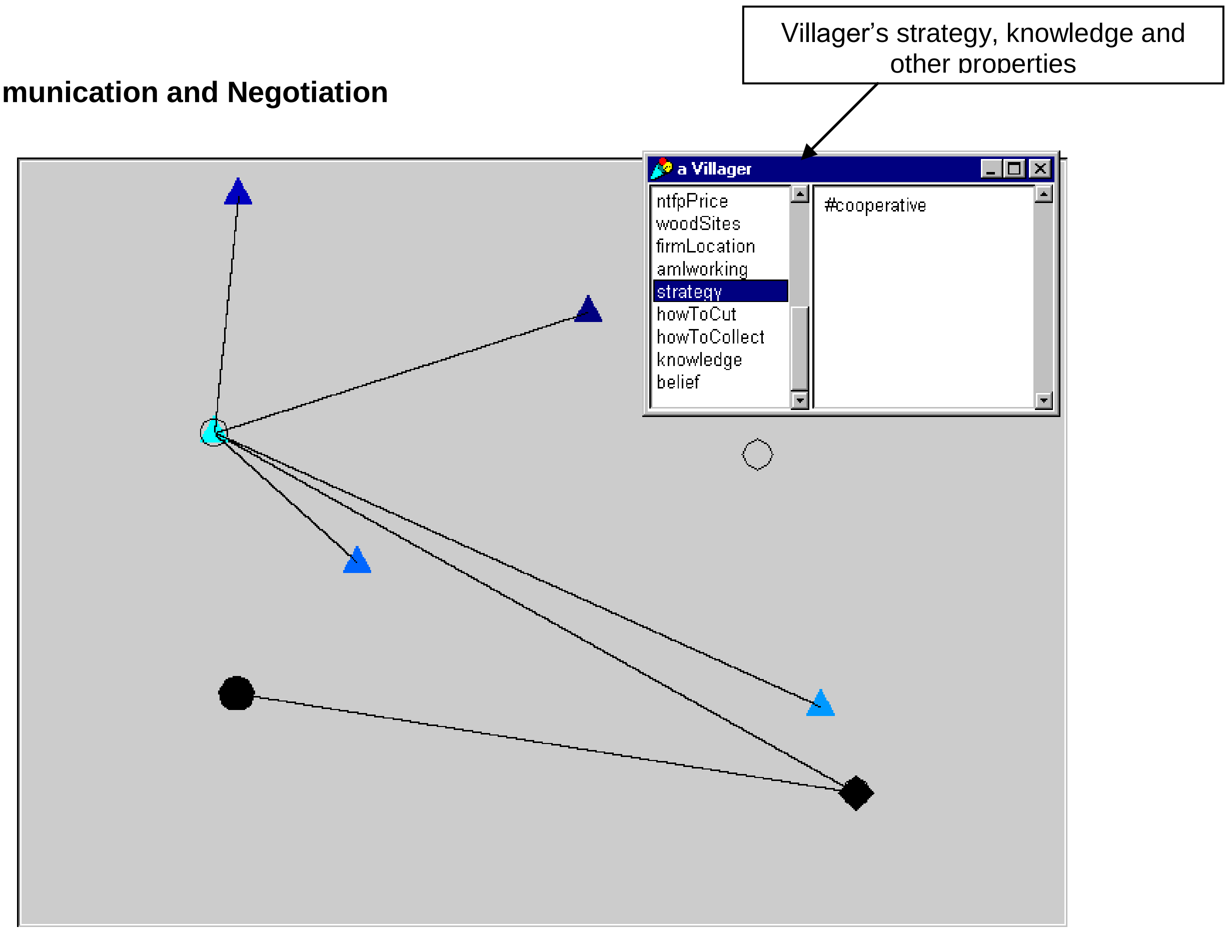


Communication and negotiation

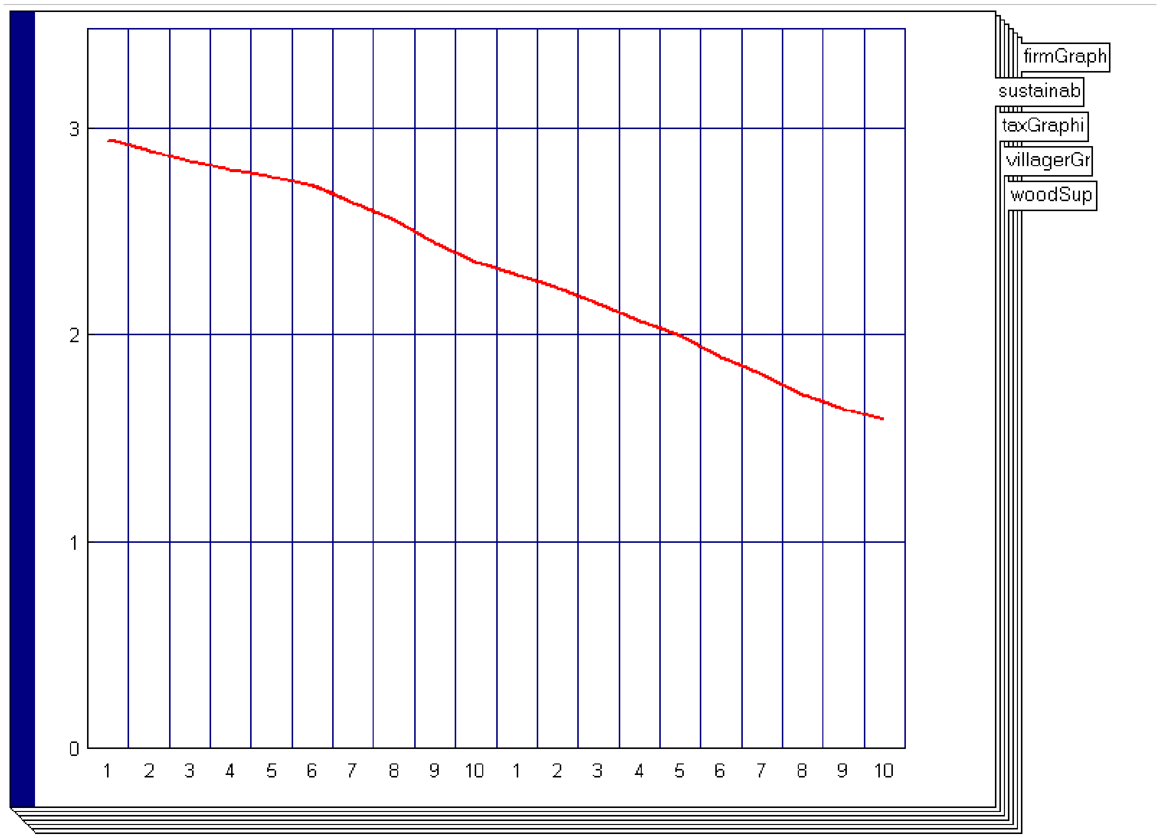
Simulation Process and Outputs



Communication and Negotiation



“Sustainability” level



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