

# Agent-Based Evolving Societies

## (Extended Abstract)

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### ABSTRACT

This paper describes a method to build artificial societies that can dynamically expand themselves from bottom-up, in order to cope with environmental changes. This method is then applied to model the evolutions through the first stages of human societies, inspired by social science theories.

### Categories and Subject Descriptors

I.2.11 [Distributed Artificial Intelligence]: Multiagent systems; I.6.5 [Simulation and Modelling]: Model Developments; J.4 [Social and Behavioral Sciences]: Sociology

### Keywords

Artificial societies, Emergent behavior, Simulation techniques, tools and environments, Social simulation

## 1. INTRODUCTION

The evolution of human societies have been broadly studied through various fields (history, psychology, social sciences, management. . .). In particular, several theories consider this evolution as expansions (and resulting organizational shifts) of an initial primitive society ([1, 2, 4, 5]).

These theories argues that changes in environmental conditions (generally, an increase of the population caused by technological improvement) eventually reaches a point where the society cannot cope with them. This incapability triggers social challenges (e.g. people start fighting each other) which are solved by the emergence of new institutions (e.g. a militia) enforcing a given behavior (protect). Thus, environmental changes trigger *transitions* between *social stages* of human societies.

In this article, we propose a generic method to build such a model of extensible societies in Section 2. Then, in Section 3, we describe the application of this method to build a model of human societies.

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## 2. DESIGN METHOD

We want to define a methodology to build societies which are capable of dynamically expanding themselves with new institutions. These institutions cope with social issues caused by changes in the environment or within the society itself. Moreover, we want these institutions to be created from bottom-up, thus, to emerge from individual perceptions and actions. Consequently, the model cannot rely on switches using global environmental or social perceptions.

### 2.1 Building dynamically an issue-solving institution

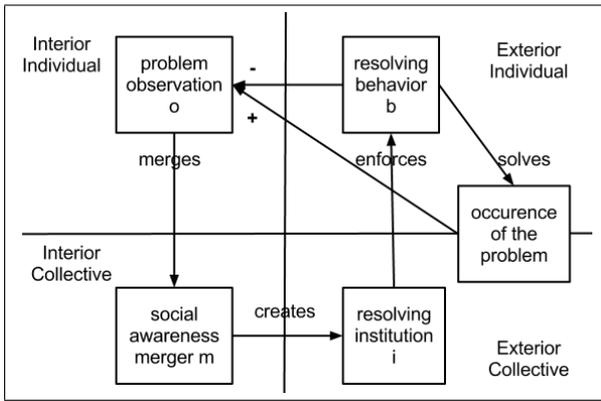
The method relies on a sequence of steps: environmental changes raise problems to some individuals, creating a local observation  $o$  of the problem (step 1). Then, this observation is reported to the rest of the society via a social merging mechanism  $m$  (step 2). If the society decides that this problem needs to be specifically tackled, a special institution  $i$  is created (step 3) enforcing institutional individual behavior  $b$  solving the problem. Thus, this process allows a society to create a problem-solving institution from bottom up observation. For this section only, we illustrate our methodology in building a society confronted to an increase of thefts and fights in a tribal society, triggering the creation of a law enforcement institution.

The individual problem observation function is hold by every agent defined by  $o \in [0, 1]$ .  $o$  increases when the problem is spotted by the agent. This observation being possibly partial (seeing only one fight) or indirect (seeing people with bruises). The value of  $o$  should collectively increase when the problem is “more important” (fights start more frequently).

The social merging mechanism is defined by  $m \in [0, 1]$ .  $m$  increases when  $o$  collectively increases. Various solutions can be used to represent  $m$ , e.g. people may vote, sign a petition or support a strike action. Simpler computer-oriented solutions can also be selected (e.g. averaging  $o$ ).

The new institution  $i$  should “resolve” the problem triggered by  $o$  (e.g. a police brigade solves the problem of fights). This social structure allows/enforces an institutional behavior  $b$  to be performed by some agents (e.g. protect people). Thus, the performance of  $b$  reduces the value of  $o$  and so the value of  $m$ . Moreover, if the institution can improve its performance (e.g. the number of policemen) at the cost of some resource, the value of  $m$  can be used to determining the need for improvement. So, if the performance of  $i$  is too low, the value of  $m$  increases.

Finally,  $i$  has to disappear if the problem is solved. Determining the removal of  $i$  is done by the removal mechanism



**Figure 1: Conceptual diagram of the institution creation process using the MASQ formalism. Interior Individual represents the information process done within the agent, Interior Collective represents the shared beliefs amongst the society, Exterior Individual is what can be observed in the environment and Exterior Collective is what is globally observable from the simulation (at the collective level).**

$r$  (e.g. a plague reduced the population to a single family which cannot afford any fight).  $r$  can be implemented in various ways, e.g. a global disregard for institution ( $m = 0$ ), a more efficient institution achieving the same purpose has been created or even self-terminated.

A diagram of the institution creation process is presented in Figure 1 using the MASQ formalism [6].

Creating an institution to solve an issue may not be sufficient. This new institution may trigger another issue (e.g. need to feed the policemen), or this institution may become unfit (preventing the fights allows the society to expand up to the point that the density prevents policemen to stop the fights). These issues can be solved in turn by new institutions (e.g. a tax collector, a school). Moreover, the model designer may want the institutions to emerge in a predefined order (e.g. no education as long as the physical protection is not well established).

Thus, being capable of combining transitions is an important feature of this model. There are two main ways to cope easily with this issue. The first way is relies on *implicit* constraints: the occurrence of the second institution is not possible as long as the first one has not been solved. The second way consists in *explicitly* preventing the second institution to be created as long as the former institution has not been set up, in spite of the observation of the problem.

### 3. IMPLEMENTATION

We applied this method to build a model of the first stages of the human evolution. We focused mainly on the Diamond’s theory [2] (but others [1, 4, 5] were also taken into consideration), which description fits accurately our purpose: each social stage is linked to the occurrence of a new institution. Moreover, this theory describes clearly the link between individual issues caused by the evolution of the society and how individual behavior triggers the change.

Diamond states that societies evolve through four stages (we kept only the three last ones which highlight the most our work): tribes, chiefdoms, nations. The tribe stage is a small group of individuals linked by family bonds. These

bonds prevent individuals to attack each other in case of food shortage. But, when the size of the population increases, these bonds are loser. Thus, when the food become sparse, starving individuals steal and fight with family outsider, which is most of the population, leading to physical insecurity. This situation is solved by the rise of a chief who hires a militia, leading the society to the chiefdom stage). This militia prevents unrelated individuals to fight each other, allowing the population from the same village to grow. But, when the the village becomes too big, the chief fails to control it and has to delegate. This situation generally leads to violent coups, unless person-independent rules are established by special entities we refer as cultural harmonizers (e.g. written laws, religions). Thus, the cultural harmonizer’s structure leads the society to the national level, allowing further expansion of the village.

This description is modelled with a society with 2 possible extensions. The first transition (tribe to chiefdom) emerges when the number of more attacks suffered by each individual  $o_1$  increases. Local vote  $m_1$  polls the number of individuals who feel unsafe and want the rise of a leader (ratio of  $o_1 > 0.5$ ). Thus, a militia  $i_1$  enforces the “protect” behavior  $b$ . The second transition (chiefdom to nation) is characterized by a low loyalty  $o_2$ , socially merged by with  $m_2$  (mean over  $o_2$ ). This social issue is solved by the creation of cultural harmonizers institution ( $i_2$ ) enforcing the “harmonize” behavior  $b_2$ . Useless institution are removed when  $m$  and the amount of resource allocated to  $i$  are 0.

We implemented this model in NetLogo with a SugarScape-like [3] approach. Agents collect food and reproduce. In case of starvation, they attack an family-unrelated agent unless a militiaman prevents it. Agent’s culture is represented by a Sugarscape-like binary vector. The loyalty is the distance between its vector and the chief’s vector. Thus, when the population increases, the average loyalty decreases. This reduction triggers the second transition.

Running this simulation leads to the expected results: the social stage matches the population size. Thus, the rightful institutions are created to allow the population to keep growing. We also observed that nations are not sustainable if the chiefdom fails to be created, which matches the social theories.

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