A Coordination Framework Based on the Sociology of Organized Action

C. Sibertin-Blanc, F. Amblard, and M. Mailliard

IRIT – Université de Toulouse 1
21, allées de Brienne, 31042 Toulouse Cedex – France
{sibertin, famblard, mmaillia}@univ-tlse1.fr

Abstract. This paper proposes a basis to design coordination models in multi-agent systems. This proposal is based on the exploitation of an in-depth exploration of a well-experienced sociological theory, the Sociology of Organized Action, also called Strategic Analysis. This theory intends to discover the functioning of any organization beyond its formal rules, especially how social actors build the organization that in return rules their behaviors, and which are the mechanisms they use to regulate their interactions. We first present the concepts developed by this theory to reveal the strategic aspects of the actors' behaviors in an organized actions framework. Then we introduce a meta-model that allows us to describe the structure of Concrete Action Systems and how social actors handle its elements. A classical case study is used to illustrate the approach.

1 Introduction

Agents' coordination mechanisms in models of organizations pose new demands compared to traditional Multi-Agent Systems models, such as the integration of organizational and individual objectives with possible problems of compatibility, the dynamic adaptation of agents' behaviors to organizational changes, or conversely the way agents' behavior lead to organizational changes. As systems grow to include increasing number and heterogeneity of agents, the coordination has to be improved in order to consider both the agent-centric, as well as the organization-centric views. However, formal theories, tools and methodologies are still very much in short supply. Even if an externally designed organizational structure is necessary as a coordination device to achieve global social order, there is a possibly inefficient and ineffective tension between such imposed constraints and the agents' autonomous behavior.

In order to enrich this field, we think that a controlled metaphor based upon well founded sociological theories could enable to devise and design high-quality models for coordination in agents' organizations. Some works similar to the Agent-Group-Role paradigm [1] showed the limits of approaches, which, inspired from metaphors with the fields of psychology or cognitive sciences, are exclusively centered on the structure and the abilities of the agents (e.g. architectures like Belief-Desire-Intention [2]). The focus on the organizational level is actually at play in many works in Multi-Agent or Component-based Systems. Our work follows the line of works like the ones

G. Lindemann et al. (Eds.): ANIREM and OOOP 2005, LNCS 3913, pp. 1 – 15, 2006.

of Malone and Crowston [3], of Castelfranchi [4] or Hermann [5], who research in the sociology a pertinent and well-grounded metaphor for a coordination model allowing to root the definition of the organizational level in MAS. The *Sociology of the Organized Action* [6], also known as the *Strategic Analysis*, has defined emergent coordination mechanisms. Based upon very abstract concepts, they are susceptible to serve as a suggestive source of inspiration and to be used in several application domains. Despite its notoriety, its wide use by enterprise sociologists and organization consultants, and its generalized teaching, the Strategic Analysis had never been taken as a subject for modeling.

We then first present the sociological theory that is the basis for our proposal, namely the Sociology of the Organized Action (SOA), insisting on the major concepts we retained to build up a meta-model of this theory. We therefore present in the third section our framework based on the concepts of Actors and Resources-Relations, the things in the Actors' organizational environment they use to establish control and dependency links between them – in fact power relationships. This is the static aspects of the meta-model, e.g. the objects present in the model as well as the objects manipulated by the actors, allowing to describe *the structure of a social system*. The fourth section presents the dynamics aspect of the model. We focus explicitly on the distinction between *functional dimension* and *structural dimension* of the actors' actions, and how we do manage this distinction in the current version of the SocLab simulation environment. Finally in a last part, we exemplify the approach on a concrete system that is a classical example taken from the literature in the Sociology of the Organized Action. It enables us to illustrate our model of coordination as well as pointing certain limits of our approach that are currently under investigation.

2 Sociology of the Organized Action

The Sociology of the Organized Action (SOA) aims at discovering the real functioning of an organization beyond its formal rules. The Concrete Action Systems (CAS) that it allow to study, for instance a firm, a university or a local political system, are composed of « numerous differentiated actors interacting in a non-trivial way among each others » [6]. Moreover, these actors are engaged durably in the achievement of some organization's objectives. A CAS is an interaction context precisely delimitated which supplies the means and motivates the cooperation among a group of social actors. This structure is admittedly constraining but it always leaves some freedom in the way of acting. The SOA deals with structured relational contexts and it does not aim to address spontaneous effects like crowd behaviors or riots [7]. If the sociology of the organized action inherits the sociology of organizations [8, 18], its application scope spreads to all kind of « organized » action systems, whatever their level of codification or formalization. The SOA focuses on regulation phenomena which ensure both the evolution of such systems and their relative stability.

The SOA is built upon the idea that an organization is a social construct actualized by and within the relationships among its member actors. Moreover, this theory assumes that each actor behaves strategically although it has only *bounded rationality* capabilities [9].

Each actor's behavior is then neither totally conditioned by the organizational rules that constrain him, nor it is by pure individual or emotional factors. This behavior is *strategic*, that is in includes actions that aim at realizing some objectives, would it be conscious or not. Beyond the achievement of both his own objectives and those given by the organization's formal rules, each actor aims, as a meta-objective, at having enough *power* to be able to preserve or increase his autonomy and acting capacity within the organization.

This power results from the mastering of one or several *uncertainty zones* (UZ) that enable him to behave in a way that is unpredictable for other actors and consequently to set, to some extent, the *exchange rules* in the course of his relations with others. Each uncertainty zone is a resource for the action, and thus both a constraint and an opportunity. Each social actor both controls some UZs and depends on some others, so that UZs are the media of the power relationships between actors. The interactions among actors regulate those power relationships and as a consequence transform the related uncertainty zones, their control as well as their relevance, and then the rules of the social game. The four main uncertainty zones that support power relationships within a CAS are based upon: competence or expertise; the control of interactions with the environment of the organization; the control of the internal communication; and the knowledge and proper use of the organization's norms and rules.

To summarize, the Sociology of Organized Action is a theory of the action that explains the effective running of organizational processes while taking into account the double dependency between the actor and the system, by using the concepts of bounded rationality, power relationships, uncertainty zones and concrete action system. This theory and the related concepts serve as a theoretical basis as well as an analysis grid to study many cases: the introduction of the automation in a traditional firm or the decision-making process during the crisis of the Cuba's missiles [10, 6]. Interested readers can refer to [8] for a detailed analysis of ten case studies.

3 The Proposed Meta-model

A formalization of the SOA leads to consider that constitutive elements of a concrete action system are of the three different types shown in Fig. 1: Actor, Relation and Resource. We indeed adopt the term *Resource* rather than *Uncertainty Zone* from the SOA terminology because every uncertainty zone is a resource required for the system's activity, and its constitutive property is less the uncertainty on the behavior of its controller actor than the existence of other actors who need this resource for whatever reason while they don't control the conditions of its use.

To describe briefly the figure 1, a *Resource* is the support of one or more *Relations* associated to *Actors* who either *control* the Relation or *depend* on it. Each actor puts *stakes* for each one of the Relations he is implied in and receives in return a *pay-off*. The actor who *masters* a Resource (by the mean of a Relation he controls) decides of the distribution of the pay-offs to the actors who depend on this Relation.

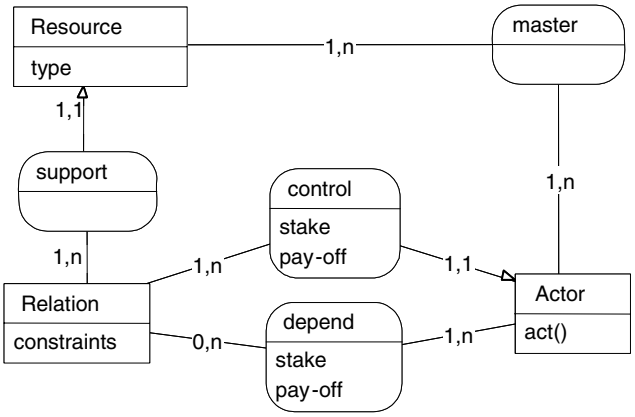

Fig. 1. Model of the structure of a CAS (using the Entity/Association formalism)

3.1 Actor, Resource and Relation

The *Resources* of a CAS are the things necessary for the organized action, their availability being required in order to make some action.

Every Resource is *mastered* by one or more Actors who decide about its availability and therefore influence the action capability of the Actors who need it. Each Resource leads to the introduction of one or several *Relations*. A Relation corresponds to a certain type of transaction, or bargaining concerning the use of this Resource. A Relation is unbalanced as a unique Actor (among the ones who master the Resource) *controls* this Relation while other Actors *depend* on this Relation because they need this Resource to achieve their goals. The controller of the Relation determines the conditions of the access to the Resource and so controls the possibility for the depending Actors to achieve their objectives.

Every *Actor* masters one or more Resources and then possesses some freedom to act that he exerts by means of the Resources he controls. As a result, the SOA denies the status of social actor to a person who would not master any Resource. The concepts of Resource and Actor are then defined one from the other: a Resource is such only if some Actors depend on it while it is controlled by another Actor; conversely, a social Actor is somebody who controls at least one Resource.

3.2 Stakes and Pay-Offs

Each Actor distributes his *stakes* on the Relations he participates to, either by controlling them or depending on them. He makes this repartition depending on the importance of the Resource in regard to his objectives. The more necessary this use of the Resource to achieve an important objective, the higher the stake he places on this Relation. Figure 2 shows how to introduce explicitly the concept of *Objective* in the model of a CAS: for a given Actor and a given Relation, the value of the *stake* property in the associations *control* and *depend* is determined by the value of the properties *importance* and *necessity*. This repartition of an Actor's stakes is in proportion with the impact of these objectives on his behavior. For the understanding

of the functioning of a CAS, the very identification of the objectives of an Actor does not matter, much more important is what they lead the Actor to do. The stakes enable to link causally the Actor's behavior with his objectives. The stakes take their value on a qualitative scale such as *null*, *negligible, ..., important, ..., vital* that can be therefore translated on a numerical scale; we take for the example below from 0 to 10.

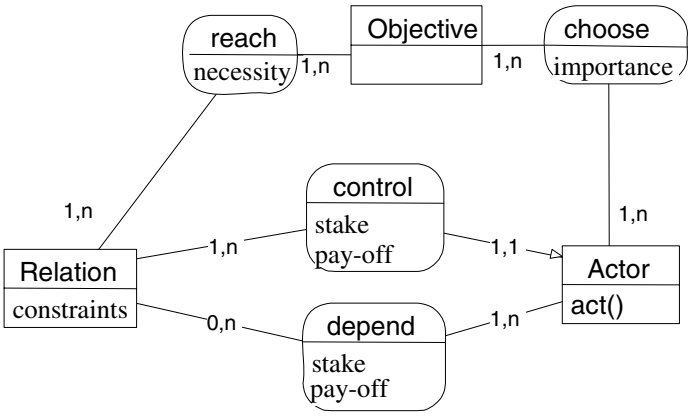

Fig. 2. Place of the *Objective* concept in the formalization of a CAS

The Actor controlling a Relation is the one who determines the *exchange rules*, that is the conditions governing transactions concerning the access to the Resource. We also use the term *pay-off,* which evocates the result of the transaction, while "exchange rules" refers to the modalities of its processing. The pay-off corresponds to the quality of the Resource availability; more or better the usability of the Resource by an Actor, higher his pay-off for this Relation. The distribution criterion of the pay-offs between the different participants of a Relation is specific to each Relation. We are expecting Relations where the pay-offs are a « zero sum game »: if the usability of the Resource is good for some actors, it will be as bad for the others. Other Relations for which the pay-offs of the controller and depending Actors vary in the same direction could be qualified of *win-win,* or *loose-loose* whether the pay-offs tend to be favorable or not. Pay-offs take their value on a scale like: *awful, ..., bad, ..., neutral, ..., good, ..., optimal* and therefore can be translated on a numerical scale, e.g. from –10 to +10.

3.3 The Constraints on a Relation

We now have to give the meaning of the *constraints* property of Relations. The Actor who controls a Relation has not the possibility to give any value to the pay-off property of the participating Actors. He has to respect organizational constraints, the « rules of the social game », that regulate the interactions among the actors within the organization and determine the range of value he may give to the pay-offs. These constraints originate either from formal rules of the organization or rules imposed by the environment, either from technical or feasibility restrictions that result from the

very nature of the Resource, or from social norms that determine the socially acceptable behaviors. (The sociology of organized action does not include such a classification of constraints, but a deeper analysis of the various types of Resources and associated constraints could ease the modeling of the structure of CASs). In addition, we have to deal with the fact mentioned in the previous section that the values of pay-offs attributed to the different Actors are in relation. So we propose to formalize the constraints associated to a Relation as the following items:

- two boundary values *b_min* and *b_max,* such that $-1 \leq b\_min < b\_max \leq 1$;
- for each actor *A* participant in the relation, a function $Effect_A : [-1, 1] \longrightarrow [-10, 10]$.

The interval [-1, 1] corresponds to the whole *space of choice* of the controller Actor when he has a full control upon the Relation: choosing a value within this interval is to set the exchange rules, it corresponds to choosing a way to manage the relation and so what kind of access is given to other Actors concerned by the relation. The choice (by the controller Actor) of a value $\alpha \in$ [-1, 1] produces the $Effect_A(\alpha)$ value for the pay-off to Actor *A*. It is clear that any number could be used instead of –1 and +1 as the boundaries of the space of choice, and only the relationships between the different functions $Effect_X$, *X* being the Actors participant in the Relation, is of matter. (In order to chose an interval [a, b] as the space of choice instead of [-1, 1], you just have to compose the $Effect_X$ function with the function $x :\longrightarrow 2/(b-a)*x - (a+b)/(b-a)$; The convenience of the [-1, 1] interval as spaces of choice relies upon its similarity with the range of pay-off values, that is [-10, 10]).

As for the *b_min* and *b_max* boundaries, they are intended to account the fact that the Actor controlling the relation is possibly in a situation where he cannot select whatever value in the space of choice. For any reason, his *effective space of choice* is more limited and then he can only chose a value within the [*b_min*, *b_max*] interval. So the range of this interval (that is the number *b_max* – *b_min*) measures the extent of the control on the Relation by the controller Actor.

Such a formalization describes the specificities of each Relation as a tool to exercise some power on actors dependent on it. It enables to give a quantitative value to social features of a CAS and thus to compare the respective position of Actors and Relations. We just propose some illustrative examples that would require a deep discussion to get a well-founded semantics [17]. Let us consider the *influence* that the Actor controlling a Relation R is able to exert on another Actor *A* participating in the Relation. If you consider:

$$influence_R(A) = max \{Effect_A(\alpha) - Effect_A(\beta) ; \alpha, \beta \in [b\_min, b\_max]\},$$

you have the maximum difference between the pay-offs that he can attribute to Actor *A*, that is the greatest amplitude of the effect of his choice in the management of the Relation.

The global influence of the Actor controlling the Relation *R* can then be defined as the greatest influence subjected by one of the Actors:

$$influence_R = max \{influence_R(A) ; A \text{ Actor concerned by the relation } R\}.$$

Indeed, the Actor subject to the greatest influence will behave accordingly and thus pass the effect of this influence to other Actors. So, one can consider that this highest level of influence is the one that will spread over the whole organization.

The following quantity

$max\{Effect_A(\alpha) - Effect_A(\beta)$; *A Actor concerned by the relation R,* α *and* $\beta \in [-1, 1]\}$

may be considered as the *strength* of the Relation R as a tool for exercising the power. Then the $influence_R$ of the controller of Relation *R* is a weighting of this strength by his level of mastering of *R* (that is `b_max - b_min`, the range of his effective space of choice), and thus corresponds to the actual usability of this relation as a support for his power.

4 Actors' Behaviors and Organization's Dynamics

The modeling formalism we exposed enables to distinguish, within a CAS, what corresponds to its structure – its constitutive elements and their relations –, and what corresponds to its state which changes to pursue the achievement of the system goals. The *CAS's structure* can be described in terms of Actors, constrained Relations based on Resources, and stakes placed by Actors on Relations; as for the *CAS's state*, it can be described in terms of the pay-offs put by Actors on the Relations they participate to, that is their available means for action.

4.1 Structural and Functional Dimensions of the Actors' Behavior

This allows to distinguish two dimensions in the actions of an Actor who searches to comfort his power: a structural dimension which acts on the system structure, and a functional dimension which acts on the system state (Cf. Figure 3). The action's *structural dimension* contributes to the building of the CAS organization, to the establishment of the social game rules and then consists in, following our formalization, acting on the elements which constitute its structure: the Resources, the Relations, the constraints and the stakes. Concerning the action's *functional dimension* of an Actor, it is the one which insures the regular operating of the system and makes its state to evolve in a synchronic way. It participates in the achievement of the Actors' immediate objectives. This functional dimension of Actors' activity complies with the current rules of the game, without regard for possible changes concerning the mission and objectives (i.e. the stakes) or the means for action (i.e. the Relations and the associated constraints). In the behavior of a human being social actor, each concrete action comprises a structural and a functional component in a proportion specific to the circumstances of the action achievement. When modeling a CAS, we are not trying to account for the practical modalities of the actions, instead we only focus on their effects. These effects on the structure and on the state of a CAS being disjoint, we have the possibility, concerning simulation issues, to model the actors' behavior by mean of mechanisms specific for each one of these two dimensions.

Within the structural dimension of actors' behavior, actions deal with the Resources, the Relations, the constraints and the stakes. Concerning Resources, an

Actor may introduce a new Resource supporting a Relation that he will master by using his proper capacities, or rather introduce a new Relation based on a Resource that he is yet mastering. An Actor may also neutralize the possibility of another Actor to control a relation, for instance by giving a free open access to the Resource or conversely to make it definitely inaccessible whatever the circumstances. Another possible structural action is to transform a Resource in such a way that some $Effect_X()$ functions become modified. Concerning the constraints which apply on the pay-offs of Relations, an Actor may decrease their severity for a Relation he controls by enlarging the effective space of choice (decreasing *b_min* or increasing *b_max*), or conversely reinforce the severity of constraints applied to a Relation controlled by another Actor. Finally, concerning the stakes, Actors may move their own stakes to reinforce their autonomy, but also and above all they may influence other Actors in the distribution of their stakes.

Within the functional dimension of the actor's behavior, every action consists in exerting control on a mastered Relation, e.g. manipulating the pay-offs value attributed to the participating Actors, while staying inside the limits imposed by the constraints on this Relation. This manipulation can be absolute, then it modifies the pay-offs value without care to their current value, or relative if it increases or decreases regularly this value. This latter case corresponds to a management of the control, without sudden shift, which seems to be the norm in most social structures.

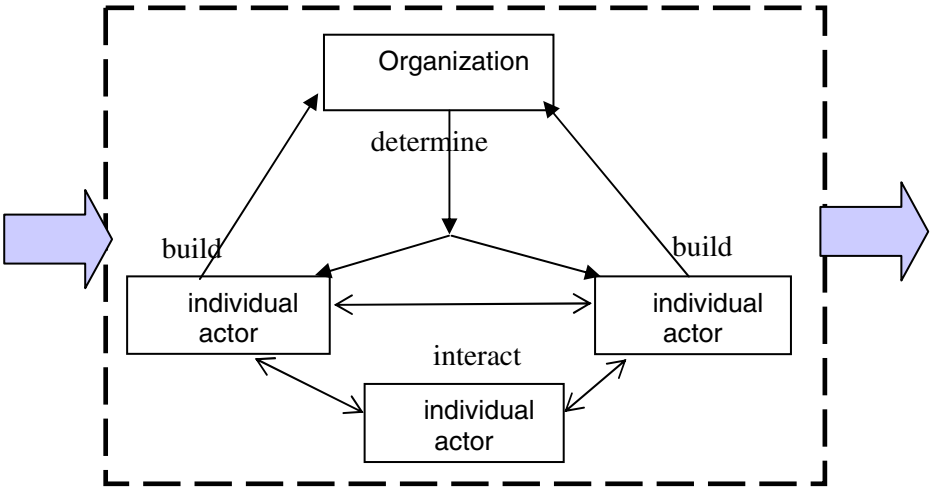

Fig. 3. The structural behavior of Actors builds the organization that in return constraints their functional behavior

4.2 Actor's Satisfaction and Strategic Behavior

The distribution of pay-offs and stakes on numerical scales enables, applying simple operations, to aggregate those values in synthetic and significant values. One can graduate the stakes on a scale *null = 0, negligible = 1, important = 5, vital = 10*, and the pay-offs with the correspondence *awful = -10, bad = -5, neutral = 0, good = 5,*

optimal = 10. As evidence, these numerical values do not correspond to something; they just enable to perform comparison among them. To do so, we have to normalize the sum of the Actors' stakes and then to attribute to each one the same amount of stake points to be distributed on the relations he participates to. This normalization comes down to grant the same investment to each actor, the same possibility of personal implication in the social interactions game.

It becomes therefore possible to quantify several concepts of the SOA by numerical values belonging to the same scale of values, and thus to compare them. For instance, the *relevance of a Resource* could be estimated as the sum of the stakes placed by the whole population of Actors on the Relation supported by this Resource, as those stakes reflect the importance of these Relations for the Actors. The *power of an Actor* can be also estimated as the sum, over all the relations he controls, of a combination between the relevance of this Relation and the influence of this Relation. The *autonomy of an Actor* can be evaluated as the sum of the stakes he places on the Relations he controls. It corresponds to the possibility to achieve his objectives independently from other Actors, the *actor's dependency* being evaluated conversely as the sum of the stakes he places on the Relations he depends on. Other notions like the power of an Actor on another one or the dependency network among Actors could be defined also.

A particularly significant value for an actor is the sum, on the whole set of Relation he is involved in, of a combination between his stake and the pay-off he receives. We name this value the actor's *satisfaction* (rather than utility because it is more linked to a bounded rationality context). It expresses the possibility for an actor to access the resources he needs in order to achieve his objectives, and then the means available for him to achieve these objectives. A linear version consists in considering the sum, on every relation he is involved in, of the stake by the pay-off:

$$Satis(a) = \sum_{r/\ a\ participates\ to\ r} stake(a, r) * pay\text{-}off(a, r) \quad (1)$$

As far as the satisfaction of an Actor is a measure of his possibility to achieve his concrete objectives, to obtain or preserve a high level for this satisfaction is a *meta-objective* for every actor**.** Abstracting the objectives of each particular Actor at the level of the stakes he puts on the common Resources allow to consider that each Actor has his own version of the same meta-objective.

The strategic characteristic of an actor's behavior leads him, by definition, to aim to achieve his objectives and then to obtain an acceptable level (if not the optimum) for his satisfaction. The rationality hypothesis implies to ground this behavior on the standard three steps cycle:

1. perception of his own state and of the environment;
2. selection of an action to perform, according to its expected effect on the gap between the current state and the goal state;
3. execution of this action.

We have implemented a simulation environment, SocLab [11], that allows to describe the structure of a CAS according to the meta-model introduced in section 3 and to simulate the functional dimension of Actors' behaviors, that is the mutual adjustment of the payoffs they give the ones to the others. This "social behavior engine" uses the classifiers mechanism [12] for the selection of the action; a classifier

system is based upon the learning of behavioral rules by test-errors and reinforcement of the rules depending on the results they produce. This approach presents two advantages compared to a cognitive approach [13]: we only need a global model of the CAS, while the cognitive approach requires to make explicit the own representation of the CAS by each one of the Actors; it brings little hypothesis on the required abilities to act as a social actor within a CAS, and it not need to explicit the rules governing the social behavior of the actors.

5 The Trouville Case

To illustrate how the SOA analyses a concrete action system and how we formalize this analysis, we consider a classical example from the strategic analysis (the other name for the SOA) [14]. The Travel-tours firm is a tour operator having two agencies, TRO1 and TRO2, situated in the Trouville city. These last months, the results of the TRO1 agency increase, as the ones of TRO2 agency stay stable, or even decrease. The regional director decides to reward the TRO1 agency for its merits. He proposes then to regularize the position of Agnès, the secretary of the agency and to allocate her exclusively to TRO1. As she is temporary employed for several months, and even if she is attached to TRO1, she works half time in each one of the TRO1 and TRO2 agencies and this obliges her to move between two jobs.

Both Agnès and the TRO1 agency's director, Paul, should be glad with this proposal. Agnès will have a permanent job contract and will be relieved to split her work in two parts, while Paul will have a full-time secretary at his disposal in the agency. But each one of them refuses vigorously the proposal. How to understand this matter of fact? The strategic analysis by identifying the uncertainty zones shows that both of them are rationally right to be opposed to this organizational change, because it would decrease their respective power. Indeed, a more attentive analysis of the case reveals that:

- The TRO2 agency is more inventive than TRO1 in designing travel packages, while the TRO1 agency includes a very efficient commercial staff; being aware of the TRO2 agency's activity, the secretary provides information to the director so that the TRO1 agency takes full advantage of finalizing the TRO2's ideas.
- For personal reasons, to get a steady job is not a short-time objective of the secretary. On the other hand, she is very cool in her working relations with the other employees of TRO1, and she greatly appreciates that none of the TRO1 and TRO2 directors has the possibility to exert a precise control on her work.

Thus the situation shift would increase the control of the director on the secretary's activities (that is what she does not want), and the director would loose the information given by the secretary on TRO2 (that is what he does not want).

5.1 Model of the Concrete Action System

The purpose of the analysis is to understand the behavior of the director and the secretary, so both of them are Actors to be considered, and it appears that other employees of the TRO1 or TRO2 agencies do not play a significant role is this affair.

Concerning the uncertainty zones or Resources, *Information about TRO2* is the one mastered by the secretary while the director masters *the secretary's job*. This latter Resource gives raise to two different Relations between the director and the secretary: the stability of the job and the content of the work she has to achieve. Table 1 shows the values given to the different parameters of the model. The value of stakes results straight from the observations below about the wishes of the director and the secretary. Both of them have ten points to distribute over the three Relations, and the relevance of each Relation is just the sum of the stakes.

The value of the *b_min* and *b_max* bounds and the definition of the Effect functions require more explanations. Concerning the stability of the job, the director has only a partial mastering of this Relation; on one side he may renew the contract of the secretary each week without discussion, although he may not set a firm contract to on his own, only the regional director can do this, so $b\_max \approx 0.4$; on the other side, he has to respect the job legislation, to justify his decision to the regional director, and to account for the reaction of other employees in case of unfairness, so $b\_min \approx -0.4$. Having a steady job produces a full effect for the secretary and thus $Effect_{secretary}(1) = 10$, $Effect_{secretary}(-1) = -10$, -10 and 10 being the extreme values of a pay-off. As for the director, his worry about this job is in proportion with its stability, but this worry is quite low, that is $Effect_{director}(x) = 3 * x$.

Concerning the content of the job, the agency director has a larger room of manoeuvre. We consider positive values in the space of choice as a strict control on the quantity and the quality of the secretary's work and on the organization of this work, and negative values as the lack of such a control. The $b\_min \approx -0.3$ value results from a high concern of the director for having friendly relationships with the employees; nevertheless, he has to ensure the production of the agency and thus to have a look at the work achieved by each employee, so the $b\_max \approx 0.7$ value. The effect on the secretary is in proportion with the level of control, because the convenience of any employee is to suffer a low level of control on his/her work. As for the director, the proposed effect function is based upon the ideas that any excess or lack of control could rapidly bring difficulties and that his interest is to exercise a moderate control.

Table 1. Parameters of a formal model for the Travel-tours case study

		Stability of the job	**Content of the job**	**Information about TRO2**
Controller Actor		Director	Director	Secretary
Stake	Director	1	2	7
	Secretary	2	7	1
Relevance		3	9	8
Effect	Director	$3 * x$	$-3 * x^2$	$10 * x$
	Secretary	$10 * x$	$7 * x$	$-2 * \lvert x \rvert$
b_min , b_max		- 0.4 , 0.4	- 0.3 , 0.7	-0.3 , 0.8
Influence		0.8 * 10 = 8	1 * 7 = 7	1.1 * 10 = 11

For the information about the TRO2 agency Relation, positive values in the space of choice correspond to give information about the projects of TRO2, negative values to give false information, and the zero to give no information. The *b_min* and *b_max* proposed values correspond to the amount of information on TRO2 that the secretary can obtain and make to be credible by the TRO1's director. The effect function for the director models his full use of this information; as for the secretary, her own tranquility would be to give no information, neither real nor false.

Table 2. Satisfaction of Actors in notable cases, and their respective power

		Secretary's satisfaction		**Director's satisfaction**		**global satisfaction**		**Autonomy**	**Power**
		min	**max**	**min**	**max**	**min**	**max**		
Value in the space of choice	**Stability of the job**	-0.4	0.4	-0.4	0.4	-0.4	0.4		
	Content of the job	-0.3	0.7	-0.3	0	-0.3	0.7		
	Info on TRO2	0.8	0	-0.3	0.8	-0.3	0.8		
Satisfaction	**Director**	54.3	-1.7	**-22.7**	**57.2**	**-**22.7	54.3	3	87
	Secretary	**-24.3**	**42.3**	-23.3	6.4	-23.3	40.7	1	88
	Global	30	40.5	-46	63.5	**-46**	**95**		

5.2 Behavior of Actors

The columns of table 2 correspond to typical states of the system resulting from an analysis providing the values given in table 1. The three last rows show the satisfaction of the director, the secretary and the whole system, while the three first ones show the values in the spaces of choice of the relations that lead to these satisfactions. The cases where the secretary or the director get their extremum satisfaction are not socially feasible; considering the Secretary's maximum satisfaction as an example, the director has no reason to be especially indulgent with her if she does not bring any specific advantage to the agency. More generally, no Actor will accept to relinquish the power given by the control of a Resource if this renouncement leads to a situation that is too far from an acceptable satisfaction. We observe that the maximal global satisfaction, that is the Pareto optimum, is reached with each Actor having the most cooperative behavior; but this fact is specific to the Travel-tour case study and can not considered as a general property of CAS. Figures 4 shows one simulation of this case study with the *SocLab* environment. In almost simulations of this case, the satisfactions of both Actors stabilize at a level that is near the Pareto optimum. The gap between the satisfactions of the secretary and the director is about 20%; it allows to conclude some thing like "the director has at least as much means to act as the secretary has", that is: the informal (and effective) power relationships among the secretary and the director are not inconsistent with the formal

rules of the organization (organizations where the *authority* granted by formal rules is in opposition with the *power* resulting from informal behaviors are not safe). Considering the two last columns, it appears that the secretary and the director are highly dependent since they have a low level of autonomy, and this can be related to the fact that their worst (minimum) satisfaction is very low. They have the same power one on the other, and since they can get a acceptable satisfaction, they have rational reasons for refusing the proposition of the regional director of Travel-Tour.

All these numerical results must be considered very carefully when they are used to provide a social interpretation that is meaningful. First, the scales of values are arbitrary, so that each value considered in isolation has no meaning; only the relative values of parameters make sense, and the results are given for comparison only. Second, the gap between two values must be important – e.g. 20 or 30 per cent – to be considered as significant. Indeed, the values of the stakes and other parameters provided by the empirical sociological analysis are rough in nature. Moreover, the formulas proposed to evaluate the power or satisfaction of Actors are not the result of a formal argument; they are grounded in a firm sociological theory but intend only to be an approximation of these concepts. Finally, we agree with the bounded rationality paradigm that considers errors as a constitutive properties of affairs.

Concerning the Travel-tour case, a sensitivity analysis shows that the model summed up in table 1 is quite robust. But a better use of the numeric values introduced by our meta-model would be to process and interpret them within a fuzzy calculus [15].

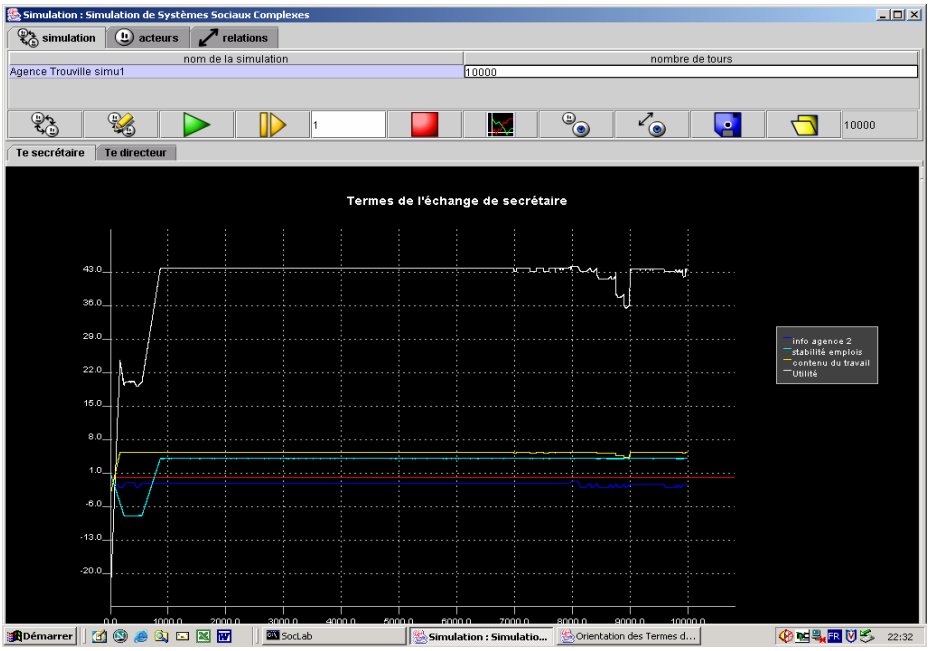

Fig. 4. Evolution of the satisfaction (sum of the pay-offs weighted by the stakes) of the secretary during one 10000 steps simulation

6 Conclusion

From the viewpoint of the Sociology, this project could appreciably transform both the practice and the teaching of the SOA thanks to possibilities offered by a tool which objectifies the hypothesizes and results of a sociological analysis. Such an attempt to formalize an inherently discursive theory goes with questions about this theory; and this project has already proved to impact the theoretical corpus of the SOA [17], by the mean of investigations that can be done in using a virtual experimental framework, a radically new approach in sociology [16]. In this respect, the work presented in this paper differs of the very interesting socionik German project (see [19, 20] as representative papers) that mainly proposes straight translations of sociologic theories into computer science formalisms. Concepts and models in social and human sciences are often not well defined, not formalized and thus can support inconsistent and ambiguous discourses. AI and MAS are sciences that produces new concepts, new models, new experimental evidences by simulation, and also new theories of mental and social phenomena that can benefit to sociology. In accordance with an (anonymous) referee of this paper, "Artificial modeling and computer simulation will change the social sciences at least as much as cybernetics, information theory, logic, IA, … has changed the behavioral sciences, giving origin to 'cognitive sciences'".

From the viewpoint of computer science, it could be the case that the SOA provides a *coordination model* for MASs, and more generally for computer applications including a lot of heterogeneous components that collaborate to some ends. The specific properties of such a coordination model and its domain of application have to be studied in deep and compared with the other main coordination models such as planning, agent communication languages, protocols and games [21]. As it is, the model introduced in this paper is very abstract and it seems to be compliant with most organizational models such as the ones presented in this bock or [1, 4, 5] among many others. This is due to the fact that the Sociology of Organized Action does not account for the formal dimension of organizations: the hierarchical positions of actors, their roles, missions and duties, etc. These aspects need to be re-introduced in the theory in order to lead to an organizational model allowing to define the global structure of a system, independent of the micro-level architecture and properties of its populating computational components (agents).

The model presented in this paper raises many questions that must be answered for it becomes operational, either for sociologist, or as a powerful coordination model for MASs and distributed systems, or for providing virtual creatures with a plausible human-like social behavior. Among these questions we can cite the followings. Coalition-actors, who have their own stakes related to the objective of the coalition, but whose satisfaction relies upon the satisfaction of the coalition member actors; a typology of resources and relations to ease their identification and the definition of the Effect function in analyzing the structure of CASs; the resources dynamics: how to characterize resources and relations which can be removed or conversely introduced in a CAS in the course of its regular operating; the circumstances that lead an Actor to try to make the structure of a CAS to evolve, the kind of changes he will prefer, and the means he could use to achieve this change. This last question, which is nothing else than the auto-evolution and adaptation of social systems, is probably one of the most difficult, but also one of the most interesting if we focus on the expressive power of this coordination model.

References

1. Ferber, J., Gutknecht, O.: A Meta-Model for the Analysis and Design of Organizations in Multi-Agent Systems. Proceedings of the *3rd International Conference on Multi-Agents Systems* (ICMAS), IEEE CS Press , 1998.
2. Cohen, P.R., Levesque, H.J. : Intention is Choice with Commitment. *Artificial Intelligence*, vol. 42, 213-261, 1990.
3. Malone, T.W., Crowston, K. : The interdisciplinary study of coordination. *ACM Computing Survey* 26, 1, 1994.
4. Castelfranchi, C.: Modeling social action for AI Agents. *Artificial Intelligence*, 103, 157–182, 1998.
5. Hermann, T., Jahnke, I., Loser K-U.: The Role Concept as a Basis for Designing Community Systems . In *Cooperative Systems Design*, M. Zacklad & al Eds, IOS Press, 2004.
6. Crozier, M., Friedberg, E. : *L'acteur et le système : les contraintes de l'action collective*. Edition du Seuil, Paris, 1977.
6. Crozier, M., Friedberg, E. : Organizations and Collective Action: our Contribution to Organizational Analysis. In S.B. Bacharrach, P. Gagliardi and B. Mundel (Eds), *Studies of Organiszations in the European Tradition*. Series « Research in the Sociology of Organizations » Greenwich Corn. jay-Press, vol 13, p. 71-93, 1995.
7. Granovetter, M.: Threshold models of collective behavior. *American Journal of Sociology*, vol. 83, 1360–1380 (1978).
8. Bernoux, P.: *La sociologie des organisations,* Edition du Seuil, Paris, (1985).
9. Simon, H.: *The sciences of the artificial*, MIT Press, 3rd edition (1996).
10. Crozier, M. *The Bureaucratic Phenomenon.* University of Chicago Press, *Le phénomène bureaucratique*, Edition du Seuil, Paris, 1964.
11. Mailliard, M., Audras, S., Casula, M. : Multi Agents Systems based on Classifiers for the Simulation of Concrete Action Systems. In Proceedings of the *1st EUropean Workshop on Multi-Agent Systems* (EUMAS), Oxford University, (2003).
12. Holland, J., Booker, L.B., Colombetti, M., Dorigo, M., Godberg, D.E., Forrest, S., Riolo, R., Smith, R.E., Lanzi, P.L., Soltzmann, W., Wilson, S.W.: What Is a Learning Classifier System?. *LCS'99*, LNAI 1813, 3-32, 2000.
13. Sichman, J., Conte, R., Demazeau Y., Castelfranchi, C.: Reasonning about others using dependence networks. Proc. of the *3rd italian Workshop on Distributed Artificial Intelligence*, Rome, 1993.
14. Smets P.: The Travel-Tours Agency. http://homepages.ulb.ac.be/~psmets1/travel.pdf.
15. Slowinski, R., Teghem, J.: *Optimization models using fuzzy sets and possibility theory*. Theory and decision library; Kluwer Academic Publishers, 1990.
16. Gilbert, N., Troitzsch, K.: *Simulation for the social scientist*. Open University Press, Londres, 1999.
17. Sibertin-Blanc C.: Pour une formalisation de la Sociologie de l'Action Organisée. Communication au *XVIème congrès de l'Association International des Sociologues de Langue Française*, 5-9 juillet, Tours (F), 2004.
18. Clegg S.R., Hardy C., Nord W. R.: *Handbook of organization studies*. Sage, 1996.
19. Michael Köhler M., Langer R., Moldt D., Rölke H.: Combining the Sociological Theory Bourdieu's with Multi Agent Systems. *Sozionikaktuell* vol. 1, http://www.sozionik-aktuell.de, University Hamburg, 2001.
20. Köhler M., Martens M., Rölke H.: Modelling Social Behaviour with Petri net based Multi-Agent Systems. *Sozionikaktuell* 4, http://www.sozionik-aktuell.de, Univ. Hamburg, 2003.
21. Wooldridge M. : *An Introduction to MutiAgent Systems*. Wiley, 2002.