# A PARTIAL-VIEW COOPERATION FRAMEWORK BASED ON THE SOCIOLOGY OF ORGANIZED ACTION

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Abstract: In this work, we address the extension of the modeling of a fragment of the Sociology of Organized Action, making it possible to deal with a hierarchy of resources in an organization, allowing each of its members to have his own view of the organization.

## 1 INTRODUCTION

In this paper we are interested in social games, inspired by a sociology theory called the *Sociology of Organized Action* (SOA). This theory, initiated in (Crozier, 1964), parts from the notion of bounded rationality due to March and Simon (Simon, 1996) and extracts practical consequences from it (Crozier and Friedberg, 1995).

SOA addresses social organizations or, more generally, *Systems of Concrete Actions* (SCA), that interact with an environment, pursue some goals, and include some means, resources and tools, that are managed and used by the members of the organization according to some rules. Any such organization features regulation phenomena that ensure its relative stability and the balance of social relationships. This regulation is enacted by the organization members, and SOA intends to explain how and why social actors behave as they do.

SOA assumes that each actor behaves strategically although he has only bounded rationality capabilities. According to SOA, the behaviour of a member of an organization is fully explained neither by the formal rules and norms of the organization, nor by each member individual particularities resulting from his nature and life history. Social actors have a strategic behaviour, i.e., they perform actions with the intention to achieve some goals, and each actor aims, as a meta-objective, at having enough power to preserve or increase the autonomy and capacity of action he needs in order to achieve his own goals.

The power of an actor results from, and is exerted through, the mastering of uncertainty zones (UZ), which are the resources that are needed by other actors for their actions. The actor (or group of actors) in control of an uncertainty zone sets its exchange rules, that establish how well other actors can access and use this particular resource. UZs are thus the means through which the power relationships are established among social actors, and a balance results from the fact that each actor both controls some UZs and depends on some others.

SOA was formalized in (Sibertin-Blanc et al., 2006), and is employed in the interactive environment SocLab (available at sourceforge.net), which allows the user to edit the structure of a SCA, to analyze the properties of this structure and to simulate the behaviour of the social actors (Mailliard et al., 2003). This formalization was transposed to the fuzzy setting in (Sandri and Sibertin-Blanc, 2007a).

In this paper, we extend the original formalization of SOA given in (Sibertin-Blanc et al., 2006) by making it possible to assemble the resources of an organization in a hierarchy, so that we may consider resources that are the synthesis of lower levels ones. In



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this way, each member of the organization may have his own representation of the resources that are the basis of his relationships with others. This makes it possible to describe how a resource impacts the autonomy of an actor in a more general way.

# 2 FORMALIZATION OF A FRAGMENT OF SOA

In the following, we briefly describe the basic social game formalization, as given in (Sibertin-Blanc et al., 2006).

Within an organization, the *actors* are the active entities that process the inputs and produce the output and, by doing so, adapt their behaviours to the behaviour of the other actors. On the other hand, the *resources* (the UZs in SOA) are the means necessary for the actors to properly behave and to reach not only their own goals but also those of the organization. In this formalization, every resource is mastered by a *single* actor and every actor is assumed to master at least one resource.

The *state* property of a resource characterizes how this resource is managed by its controller, usually rather to his own advantage or to that of a few chosen actors. The characterization of how important a resource is to an actor is done by allowing each actor to distribute a limited amount of *stakes* among the resources in the game. The amount of stakes an actor puts on a resource is determined by how intensely he needs this resource to reach his goals, in other words, he puts more stakes on the resources he depends most.

When an actor depends on a resource, the *effect* function determines the impact of the actual state of the resource on his action capability. As a result, each actor both controls some others, by means of the resources he controls, and depends on others, by the resources he needs. The overall state of an organization is characterized by the composition of the states of the resources it contains, and this characterizes the behaviour of each actor with regard to others.

Let $R$ be a set of resources, let $stake(a,r)$ denote the amount of stakes an actor $a$ puts on resource $r$ and let $effect_r(a,s_r)$ denote the impact an actor $a$ suffers when resource $r$ is in state $s_r$. The global capacity of action of actor $a$ when the organization is in state $s$ is defined in this formalization as

$$payoff(a,s) = \sum_{r \in R} stake(a,r) * effect_r(a,s_r).$$

Within this setting, the actors of an organization coordinate their respective behaviours while playing the so called social game. An action of actor $a$ on a resource $r$ that he controls is a move $act_a[r]$ to be applied to the current state $s_r$ of $r$. A step of the game occurs when each actor $a$ has chosen a move $act_a[r_i]$ for each resource $r_i$ that he controls, and the game then goes from state $(s_{r_1}, s_{r_2}, ..., s_{r_M})$ to state $(s'_{r_1}, s'_{r_2}, ..., s'_{r_M})$, where $s'_{r_i} = s_{r_i} + act_a[r_i]$.

The game is repeated until it becomes stabilized, or stationary: each actor has a satisfying payoff and plays the null action, i.e., he no longer changes the state of the resources he controls. Such a state of the game is considered a *social equilibrium*, a regulated situation that is satisfying and accepted by all the actors in the game. This state depends on the strategy of each actor, i.e. how he adapts his behaviour (by changing the state of the resources he controls) according to the payoff he receives from others. In most human organizations, social games are positive sum games: each actor obtains some gain from being cooperative, because others will also be cooperative in return. Thus, typical social equilibria are *Pareto maxima*: any increase in an actor's satisfaction would entail a decrease of the satisfaction of another actor, and thus produce a situation that would not be accepted by all the actors.

# 3 THE EXTENDED FRAMEWORK

The formalization of the coordination among the actors of an organization as shown above has some limitations that do not allow it to handle some complex organizations.

There exist cases in which the actors that are members of an organization have different views on the set of resources handled in that organization. Some actors may view a set of several resources as a single one because they are unable to identify or to distinguish the elements of such a compound resource, whereas others may view each of those resources individually.

Also, a resource may be a substitute for another one (having a good access to a resource makes it needless to have a good access to the other one), two resources may be complementary (good access to one resource is useful only if it goes together with a good access to the other one), or they may have interactions of some kind (if there is a good access to $r_1$ then $r_2$ is more important than $r_3$, and the converse holds in case of a bad access to $r_1$). Moreover, these interactions among resources may be different for different actors.

The additive way used to compute the payoff of actors as given in Section 2 is very restrictive; there, the impact that the state of a resource has on an actor is independent on the state of any other resource. Also, the stakes that the actors distribute on the resources, that models the importance a resource has to an actor, have to be precisely quantified.

Here we extend that formalization so that these limitations can be overcome and a larger set of situations can be dealt with:

1. The control of a resource may be shared by several actors; in such a case, each of these actors contributes to the definition of the state of this resource according to his amount of control.
2. A resource may be composed of a set of resources.
3. The resources are no longer considered as being independent: the actual effect of a resource on one actor may depend on the state of another resource.
4. The payoffs may be calculated differently for each actor.
5. Each actor is allowed to be imprecise in the way he distributes the stakes on the resources that are important to him.

## 3.1 Formalization of the Extended Framework

We propose to formalize a social game in the following way:

- $A = \{a_1, ..., a_N\}$ is a set of social actors.
- $R = \{r_1, ..., r_M\}$ is a set of resources, each of which needed and controlled by some actors in $A$ (not necessarily the same ones). The state of a resource $r_i$ at a given moment is given by variable $s_i$, that takes values in the interval $[-1,1]$; $S$ denotes the set of state variables, and thus $|S| = |R|$. The overall state of the game is defined by the state of all the resources, described by a vector $s = (s_1, s_2, ..., s_M) \in [-1,1]^M$.
- $R^\circ \subseteq \mathbb{P}(R)$ is the complete set of resources needed to model a game, and an element $r \in R^\circ$ is either an elementary resource (a singleton) or a compound resource.
- Function $controls : A \times R^\circ \to [0,1]$ defines the amount of control the actors exert on the resources and is such that $\forall r \in R^\circ, \sum_{a \in A} controls(a,r) = 1$ and $\forall a \in A, \exists r \in R^\circ, controls(a,r) > 0$.
- Function $impacts : R^\circ \times A \to \{T,F\}$ states whether the state of resource $r \in R^\circ$ has a direct impact on an actor $a \in A$; when actor $a$ depends directly on resource $r$ we have $impacts(r,a) = T$.
- The perception of an actor $a$ on the state of a resource $r \in R^\circ$ at a given moment is denoted by $s^*_{a,r}$. Each actor only perceives the resources he depends on, i.e. $s^*_{a,r}$ is defined only when $impacts(r,a) = T$. The value of $s^*_{a,r}$ is obtained by means of a function of the state of $r \in R$ when $r$ is a singleton, and as a function of the states of the elementary resources composing $r \in R^\circ$, otherwise.
- Function $stake : A \times R^\circ \to I_{[0,10]}$, where $I_{[0,10]}$ is the set of intervals $[a,b] \subseteq \mathbb{R}$ such that $0 \leq a \leq b \leq 10$, expresses how important it is for an actor to access a resource, be it elementary or compound[1]. Each actor has the same amount of stake points to distribute among the resources he depends on directly and restrictions should be imposed to guarantee this constraint (see 4.3 for an example). For a resource $r \in R^\circ$, $stake(a,r) = [0,0] = 0$ means that $a$ has no need for $r$, whereas $stake(a,r) = [10,10] = 10$ means that $r$ is the unique resource needed by $a$. We have $impacts(r,a) = T$ iff $stake(a,r) > 0$.
- The payoff of each actor depends on his perception of states of the resources that have impact on him, and can be calculated as in (Sibertin-Blanc et al., 2006) or in a fuzzy framework as in (Sandri and Sibertin-Blanc, 2007a).

## 3.2 Playing the Social Game in the Extended Framework

The action of an actor $a$ contributes to the modification of the state of each resource $r \in R^\circ$ according to the amount of his control on $r$, given by $controls(a,r)$. The action of actor $a$ is a vector $act_a$ with as many positions as the number of resources he has some control on, i.e. the size of $act_a$ is given by $|\{r \in R^\circ \mid controls(a,r) > 0\}|$. When a resource $r$ is in state $s_r$ and the actors with some control on $r$, collected in $A(r) = \{a \in A \mid controls(a,r) > 0\}$, perform their actions, the resulting state $s'$ is computed by the application of a function, that takes into account $s_r$, $\{act_a[r] \mid a \in A(r)\}$, and $\{controls(a,r) \mid a \in A(r)\}$.

The $payoff$ of an actor $a$ is computed taking into account the states of the resources actor $a$ depends on, i.e. the resources in $\{r \mid impacts(r,a) = T\}$.

Thanks to the consideration of compound resources, an actor can view a set of elementary resources as a single compound resource $r$, and the the specification of a function to calculate $s^*_{a,r}$ allows us to deal with any interaction among these resources.

[1] The total amount of stakes to be distributed is fixed on 10 in accordance to previous works, but any other positive value could be used.

Thus there is no longer a drawback to compute the $payoff$ of an actor in a way that assumes that the involved resources are independent: all interactions are encapsulated into compound resources. Notice that these interactions can be specific for each actor, since it is possible to define two compound resources $r,q \in R^{\circ}$ such that $r \cap q \neq \emptyset$.

## 4 TREATMENT OF EXAMPLES

In the following we consider three examples of organizations to illustrate our framework. The third example, Trouville, is a classical example from strategic analysis taken from (Smets, 2004).

### 4.1 Two Clerks and One Boss

In an office, two clerks ($C_1$ and $C_2$) work under a boss ($B$). The boss controls 3 resources; the work hours of the clerks ($h$) on any given day and the premium each clerk receives at the end of the month on top of the salary ($p_1$ and $p_2$). Each clerk controls the amount of work he does during the day ($w_1$ and $w_2$). The boss depends on resource $w$, the composition of resources $w_1$ and $w_2$, clerk $C_1$ depends on $p_1$ and $h$ and clerk $C_2$ depends on $p_2$ and $h$.

Everyday, the clerks take documents from the *in* pile[2] that have to be processed during that day. After a clerk finishes with a document, he signs it, lays it on the *out* pile and takes a new one from the *in* pile. The boss does not verify every day which clerk did what during that particular day, although the signature on each document is verified before the end of the month. When the boss sees that the *in* pile is empty, it is up to him to give the clerks the rest of the day off.

Figure 1 illustrates the case. The set of actors is given by $A = \{B, C_1, C_2\}$, and the set of elementary and compound resources are respectively given by $R = \{p_1, p_2, h, w_1, w_2\}$ and $R^c = \{\{w_1, w_2\}\} = \{w\}$. In the figure, the edges from an actor $a$ to a resource $r \in R \cup R^c$ stands for $controls(a,r) > 0$, whereas the edges from a resource to an actor represents $impacts(r,a) = T$. We assume that each resource $r$ controlled somewhat by an actor $a$ has an impact on $a$ but we chose not to represent that impact explicitly in the figure.

The set of state variables, resulting from actions taken by the controllers of each resource, is given by $S = \{s_{p_1}, s_{p_2}, s_h, s_{w_1}, s_{w_2}\}$. The set of states perceived by the actors is given by $S^* = \{s^*_{C_1,h}, s^*_{C_2,h}, s^*_{C_1,p_1}, s^*_{C_2,p_2}, s^*_{B,w}\}$, which we simplify to $S^* = \{s^*_{1h}, s^*_{2h}, s^*_{1p}, s^*_{2p}, s^*_{Bw}\}$.

[2]We consider here that the amount of work on the *in* pile on any given day is set by an actor that is not relevant for the relations between the boss and the clerks under him.

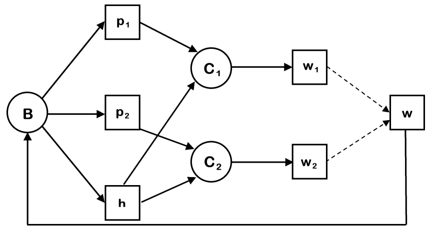

Figure 1: Structure of an organization with two clerks and one boss.

The actors may perceive the state of the resources in various ways. For example, we could have $s^*_{1h} = s^*_{2h} = s_h$, $s^*_{1p} = s_{p_1}$ and $s^*_{2p} = s_{p_2}$. In this case, the state of elementary resources perceived by the actors are the same as the states of the resources themselves. In what regards compound resources, the perception of an actor is always a function of the state of the elementary resources composing it. The perception of the boss in relation to the work done by the clerks at the end of a day could be given for instance by $s^*_{Bw} = (s_{w_1} + s_{w_2})/2$. The payoffs of the actors are calculated using the perceived state of the resources they depend upon. An example of payoff is for instance $payoff(C_1) = 10 \times \min(s^*_{1h}, s^*_{1p})$ and $payoff(C_2) = 10 \times \max(s^*_{2h}, s^*_{2p})$. Note that due to the way they aggregate their perception of reality, $C_1$ is more pessimistic and is less satisfied than $C_2$ even when the they receive the same premium and leave at the same time.

### 4.2 Two Bosses and One Clerk

In an office, a clerk ($C$) works under two bosses ($B_1$ and $B_2$). The clerk controls the amount of work he does during the day ($w$). Each boss controls one resource individually: the workload each one of them assigns to the clerk ($l_1$ and $l_2$). The total workload of the clerk is represented by compound resource $l$, a composition of $l_1$ and $l_2$. The bosses control together the job stability of the clerk ($j$). The bosses set the state of resources $l_1$ and $l_2$ independently (with the proviso that each one has a maximum workload to assign), whereas the state of resource $j$ is set by them by common accord. In Figure 2 we illustrate the example; note that in the figure we do not represent explicitly the edge from an actor to any of the resources he somewhat controls.

Given that $j$ is controlled conjointly, to facilitate visualization, we created a dummy node in the graph to represent their agreement. The edges between nodes $B_1$ and $B_2$ and the dummy node are la-

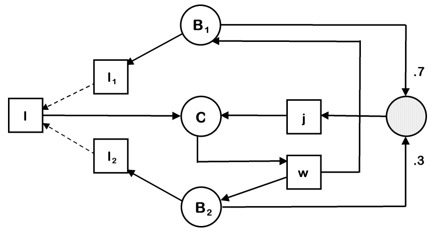


Figure 2: Structure of an organization with two bosses and one clerk.

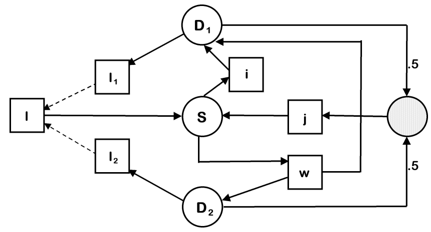


Figure 3: The structure of the Travel-Tours example.

beled with the amount of control of the secretary's job stability as set by each boss. Here we have weight .7 for $B_1$ and .3 for $B_2$, and thus boss $B_1$ has a stronger influence on the state of $j$ than $B_2$. Let us suppose that the value of the state of $j$ is calculated with the weighted arithmetic means. In this case, we would obtain $s'_j = s_j + controls(B_1, j) \times act_{B_1}[j] + controls(B_2, j) \times act_{B_2}[j] = s_j + .7 \times act_{B_1}[j] + .3 \times act_{B_2}[j]$.

Contrary to the case of compound resources, here we do not create a formal "compound actor". Actually, we could represent this situation using two extra resources, $j_1$ and $j_2$, each of which controlled by one the bosses. However, here we want to make a difference between an independent control of compound resources, as shown in Figure 1 where $w_1$ and $w_2$ compose $w$, and a control by agreement as shown in Figure 2.

## 4.3 Trouville

Travel-tours is a tour operator that has two agencies, TRO1 and TRO2, in Trouville. The directors of TRO1 and TRO2 have a secretary, Agnés, who works for both of them. She works half a day in each agency, what obliges her to move between the two jobs everyday, and her contract has to be extended every month as her position is not a stable one.

Lately, the results of TRO1 have increased, whereas the ones of TRO2 have stagnated, or even decreased. The regional director decides to reward TRO1 for its merits and proposes to regularize the situation of Agnés and to affect her exclusively to TRO1.

However, both Agnés and Paul (the director of TRO1), vigorously refuse the proposal, which seems counterintuitive: Agnés would hold a permanent position and would not have to split her work and time in two parts, whereas Paul would have a full-time secretary at his disposal in TRO1. A strategic analysis, by identifying the uncertainty zones, shows that both Paul and Agnés 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 TRO2 is more inventive than TRO1 in designing travel packages, while TRO1 includes a very efficient commercial staff; being aware of the TRO2 agency's activity, the secretary provides information to the director so that TRO1 takes full advantage of finalizing TRO2's ideas. On the other hand, for personal reasons, to get a steady job is not one of Agnés' short-time objectives. Moreover, she greatly appreciates that none of the 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 (something she does not want), and the director would lose the information given by the secretary on TRO2 (something he does not want).

In previous works, we modeled this example considering only two actors, Paul and Agnés (Sandri and Sibertin-Blanc, 2007a) (Sandri and Sibertin-Blanc, 2007b). Here we modify slightly this setting to include a new actor, the director of TRO2. He is not aware that Agnés is taking information from his agency to give to TRO1, and is basically interested that she continues to work to TRO2 and that she accomplishes the tasks he assigns her.

Here we implement the example using three actors $A = \{D_1, D_2, S\}$, where $D_1$ and $D_2$ stand for the directors of TRO1 and TRO2, respectively, and $S$ for the secretary. We have five simple resources $R = \{i, l_1, l_2, j_1, j_2\}$, where $i$ stands for the information provided by the secretary, $l_1$ and $l_2$ represent the workload set by each director to the secretary, and $j_1$ and $j_2$ stand for the job stability set by each director to the secretary. We also have two compound resources, $l = \{l_1, l_2\}$ and $j = \{j_1, j_2\}$, that stand for the total workload and job stability of the secretary. In Figure 3 we illustrate the example (the edges between an actor to the resources he controls are omitted).

The stakes that each actor places on the resources are illustrated in Figure 4. There exists a labeled edge between each actor and a resource that has any impact on him (including those he somewhat controls); the thin dotted ones represent those he has absolutely no control on. The larger dotted edges connect a com-

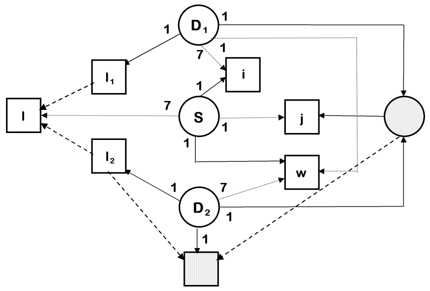


Figure 4: Stakes assignment in Travel-Tours example.

pound resource to its components.

The values were assigned considering the actors' attitudes. The more the secretary gives information from TRO2 to TRO1, the best it is for its director, who uses it to improve the activity of TRO1 agency, but the worse it can be for herself if someone from TRO2 discovers that she provides information to TRO1.

The director of TRO1 puts a high stake on the information resource (as far as the social game is restricted to his relations with the secretary) because bringing this information is the most important contribution of the secretary to the agency, whereas giving or not the information does not have a high effect on her. Similar considerations explain the values he assigns to the stability of the job and control of work resources. The director of TRO2 cares a little for both the secretary's job stability and content, but cannot be bothered to completely distinguish the individual value of these resources to him up to a point. Here we modeled $D_2$'s attitudes as $stake(D_2, j) = [a_j, b_j] = [1,2] = [a_l, b_l] = stake(D_2, l)$, and created a dummy compound resource to represent that the constraint that, according to $D_2$, the total amount of stakes for the secretary's job taken as a whole adds up to 3, i.e. $a_j + b_l = a_l + b_j$. Thus, the secretary's job situation is not so important to the director as the amount of work she does (which gets 7 stakes).

The stakes can be used to calculate payoffs but also to model concepts such as the *autonomy* and *subordination* of an actor (Sibertin-Blanc et al., 2006). The first (respec. the second) concept is modeled as the sum of the stakes an actor puts on resources he controls (respec. does not control); together, the autonomy and the subordination of an actor add up to 10. Here these concepts have to be extended to handle stake intervals and shared control. Let the minimal subordination (respec. minimal autonomy) be the sum of stakes an actor places on resources he has absolutely no control upon (respec. he certainly has absolute control upon). Then the pair (autonomy, subordination) are respectively given as $([1,2],[8,9])$ for $D_1$, by $([1,3],[7,9])$ for $D_2$ and by $([2,2],[8,8]) = (2,8)$ for $S$.

# 5 CONCLUSIONS

We presented a cooperation framework based on the Sociology of Organized Action, that makes it possible to model the different views actors may have on the resources of an organization, and that allows a resource to be controlled by more than one actor.

We intend to use it to model problems in crisis management, in which an actor has a partial representation of a crisis, focusing on the aspects that are important to solve his part of the problem; less important aspects are not perceived accurately, but through a general framework. As future work we intend to incorporate the notion of time in our framework, to make it closer to reality, since the actors usually receive information at different times during a crisis and their vision may not be synchronized.

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