ON THE BASIC BINDING STRUCTURE OF A BASIC INTERACTION SCHEME

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ABSTRACT

This paper introduces and analyses the idea of the *binding structure* of a *social interaction scheme*. Binding structures are proposed as means to model the binding power that an interaction scheme imposes on agents interacting according to the scheme, in a social context. The paper considers the case of a *basic interaction scheme*, namely, the basic *Producer-Consumer* scheme, to explain the way the binding structure builds on the operational structure of that scheme, in particular how the binding structure is constructed in terms of *binding relations*. In addition, the non-reducibility of binding structures to their component binding relations is established. The importance of a detailed analysis of the *derivation scheme* of binding structures from operational structures of interaction schemes, including the role that *legal and moral norms* may play in such derivation, is briefly indicated. The relevance of the ideas introduced in the paper for the concrete representation of macro-level social structures as macro-level artifacts in social simulation is also indicated.

INTRODUCTION

In this paper, we introduce the idea of the *binding structure* of a *social interaction scheme*.

The binding structure of a social interaction scheme models the positive, observational components of the interaction scheme that contribute to socially bind the agents that interact according to the scheme, namely, the following set of *binding relations*: objective dependence relations, elementary social functions, exchange value-based dependence relations, and functional rights and duties.

The paper shows how binding structures derive from the *operational structures* that organize the temporal dependence of the behaviors involved in interaction schemes. This allows for a systematic organization of binding structures in terms of the binding relations that constitute them.

For simplicity, the paper restricts itself to the analysis of the so-called *basic binding structure* of the *basic Producer-Consumer interaction scheme*, a sequential and synchronic version of the well-known *Producer-Consumer* form of social interaction.

The paper is structured as follows. Initially, the paper introduces the concept of binding structures of interaction schemes, and their relation to the operational structures of such schemes. Then, the paper characterizes the basic Producer-Consumer interaction scheme in terms of its operational and basic binding structures.

Next, various sections respectively characterize, both in general and in the particular case of the basic *Producer-Consumer* interaction scheme, the four main binding relations that constitute a basic binding structure: objective dependence relations, elementary social functions, exchange value-based dependence relations, and functional rights and duties.

Then, the paper analyses the inter-relations between the four types of binding relations, showing that, in general, they are not reducible to each other, because each brings a specific contribution to the binding power of the basic binding structure of the basic *Producer-Consumer* interaction scheme.

Following, related work – additional to the ones discussed during the development of the paper – are briefly analyzed.

Finally, the Conclusion discusses the possible relevance of the ideas introduced in the paper for the work on simulation of agent societies, in general, and social interactions, in particular.

INTERACTION SCHEMES, AND THEIR OPERATIONAL AND BINDING STRUCTURES

By *interaction scheme* we understand a way through which two or more agents exchange matter, energy, or information among them[1].

Interaction schemes comprise both an *operational* and a *binding* structure:

- By *exchange behavior* we understand a behavior that an agent performs, through which it exchanges matter, energy, or information, with another agent.
- By *operational structure* of an interaction scheme we understand the specification of the temporal organization of the exchange behaviors that the agents perform,

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[1]So that interaction schemes do not concern only the exchange of messages among the agents, but also the exchange of products and behaviors.

while operating according to the interaction scheme[2].

• By *binding relationship* we understand any relationship that two or more agents take into account when interacting, and that motivates them to keep interacting with each other, without discontinuing the interaction or changing partners.

• By *binding structure* of an interaction scheme we understand the interconnected set of *binding relationships* that bind together the agents involved in the interaction scheme.

The scheme illustrated in Fig. 1, is here proposed for the *derivation* of the basic binding structure of an interaction scheme, from the operational structure of that scheme.
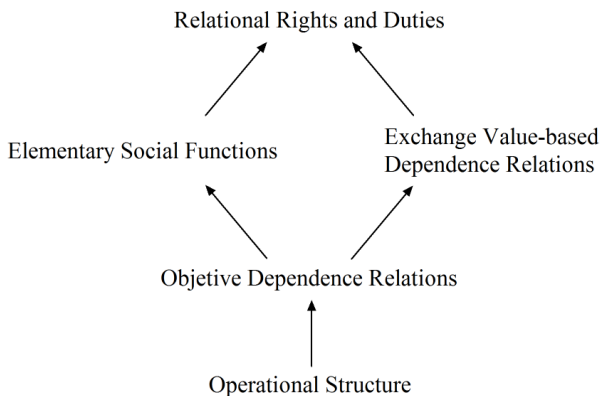

Fig. 1. Derivation of the basic biding structure from the operational structure of an interaction scheme.

BASIC PRODUCER-CONSUMER INTERACTION SCHEME

A. Operational Structure of the Basic Producer-Consumer Interaction Scheme

Figure 2 illustrates the operational structure of the basic `Producer-Consumer` interaction scheme.
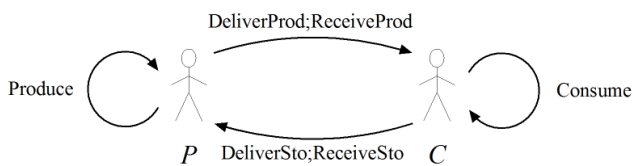

Fig. 2. The basic *Producer-Consumer* scheme.

The scheme defines a way for interaction between two agents, the *Producer* (*P*) and the *Consumer* (*C*): the *Producer* periodically produces some *product* (object or service) and the *Consumer* periodically consumes that *product*, as it is produced.

The following procedure clarifies the operational structure shown in Fig. 2:

1. The *Producer* delivers the *product* to the *Consumer* by storing the *product* in a *storage* (not explicitly represented in the scheme), after producing the it;

2. The *Consumer* consumes the *product* only after receiving it from the *storage*;

3. After consuming the *product*, the *Consumer* frees the *storage* to the *Producer* store the next *product* it will produce;

4. The *Producer* only produces a new *product* after receiving a free *storage* to store it;

5. This *production-consumption* cycle is repeated permanently[3].

B. Basic Binding Structure of the Basic Producer-Consumer Interaction Scheme

We define the *basic binding structure* of the basic Producer-Consumer interaction scheme as constituted by the following four *binding relations*:

• Objective Dependence Relations
• Elementary Social Functions
• Exchange Value-based Dependence Relations
• Functional Rights and Duties

The rest of this paper analyses these four binding relations, and the way they relate to each other, and to the operational structure of the basic Producer-Consumer interaction scheme, as suggested by the derivation scheme shown in Fig. 1.

OBJECTIVE DEPENDENCE RELATIONS

C. Social Dependence Relations in General

The theory of social dependence relations [3] states that social organization arises from social phenomena (power, influence, etc.) that emerge from *social dependence relations* that are objectively established between agents when agents operate in a shared environment.

As such, social dependence relations – and the social dependence networks that aggregate the set of social dependence relations that exist in a society – are seen as a foundation for social organization and for society itself.

An essential feature of the notion of social dependence relation is the part that cognition plays in its definition: dependence relations that are established between agents derive from both cognitive notions such as agent goals and plans, and non-cognitive notions such as environmental resources and the agents' capabilities of action performance.

Formally, we express social dependence relations as follows. Let ag_1 and ag_2 be two agents of an agent society S that respectively have tasks θ_1 and θ_2 to perform, the tasks being respectively determined by $\theta_1 = (g_1, \varepsilon_1)$ and $\theta_2 = (g_2, \varepsilon_2)$, that is, the task of agent ag_1 is to achieve goal g_1 by using some element (resource, action, behavior, etc.) ε_1 and the task of agent ag_2 is to achieve goal g_2 by using some element ε_2.

We say that the agent ag_1 *depends on* agent ag_2, with respect to goal g_1 and element ε_1 if, at the time t at

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[2]The kernel of an operational structure is, thus, a temporal relation, partially ordering in time the actions of the exchange behaviors involved in the interaction scheme.

[3]Note the features that make the interaction scheme shown in Fig. 2 a basic one: the actions performed by the agents are organized in a sequential way, so that their behaviors are constrained to occur in a synchronic way. The general *Producer-Consumer* interaction scheme is not subject to such constraints, so that the behaviors of the agents may proceed concurrently, in an asynchronous way.

which ag_1 tries to achieve g_1, agent ag_1 does not have access to element ε_1 and if, at that time, agent ag_2 can provide the access to element ε_1 to agent ag_1.

The dependence of ag_1 on ag_2, with respect to the goal g_1 may be denoted either by $Dep_S(ag_1, ag_2, \varepsilon_1, g_1)$ or else as:

- $(ag_1 \prec ag_2 : \varepsilon_1 \prec g_1)_S$

The social dependence relations so defined are considered to be *objective* [3], in the sense that their existence is not a consequence of the beliefs of the agents about their respective situations.

D. Objective Dependence Relations in the Basic Producer-Consumer Interaction Scheme

The following are the objective dependence relations of the basic Producer-Consumer interaction scheme:

- the *Producer* alternates between three main goals: *ReceiveSto*, *Produce*, and *DeliverProd*;
- the *Consumer* alternates between three main goals: *ReceiveProd*, *Consume*, and *DeliverSto*;
- the *Producer* depends on the *Consumer* performing the *DeliverSto* action, to be able to achieve the goal *ReceiveSto*; having achieved the goal *ReceiveSto* the *Producer* is free to perform by itself the action *Produce* and achieve the goal *Produce*;
- the *Consumer* depends on the *Producer* performing the *DeliverProd* action, to be able to achieve the goal *ReceiveProd*; having achieved the goal *ReceiveProd* the *Consumer* is free to perform by itself the action *Consume* and achieve the goal *Consume*.

Formally, we express the objective dependencies between the two agents as:

- $(Producer \prec Consumer : DeliverSto \prec ReceiveSto)$
- $(Consumer \prec Producer : DeliverProd \prec ReceiveProd)$

Note how an objective dependence relation refers basically to a dependence between an agent's goal and an action of another agent, which is able to immediately enable the achievement of that goal.

As such, objective dependence relations operate as motivators for the realization of social interactions, thus, also as binding relations in interaction schemes.

ELEMENTARY SOCIAL FUNCTIONS

E. Social Functions in General

Functionalism has a large tradition in Social Sciences, having received since its beginning both wide acceptance and strong criticisms [6]. Its central idea is that of *social function* – the satisfaction of a social need (either a need of a component of a social system or a need of the social systems as a whole) through the performance of an activity (either by a system component or by the social system as a whole).

By the term *elementary social function* we mean a social function where:

- the notion of *need* is interpreted as an *operational requirement*, namely, that the performance of an activity by an agent ag_2 requires, for its accomplishment, that ag_2 interacts in a certain way with some other agent ag_1, so that ag_1 provides ag_2 with some element e that

is indispensable for the correct execution of ag_2's activity;

- the notion of *satisfaction of a need* is interpreted as the providing of the element e by ag_1 to ag_2;
- as proposed in [9], the performance of a *function* by ag_1 for ag_2 occurs when a renewable need of ag_2 is repeatedly satisfied by a *persistent interaction* between ag_1 and ag_2 (not, as is often considered, cf. e.g. [4], when a single occurrence of a need of ag_2 is satisfied by a single occurrence of a behavior of ag_1).

We formalize the notion of elementary systemic function as follows. Let ag_1 and ag_2 be two agents of a social system S. Let ag_2 operate in S according to a *behavior requirement* BR_2, which also imposes an additional *interaction requirement* $IR_{1,2}$ between ag_1 and a ag_2, so that the realization of BR_2 by ag_2 is viable only if ag_1 interacts with ag_2 in a way that meets $IR_{1,2}$.

We denote the fact that ag_2 behaves according to the behavior requirement BR_2 by $(ag_2 : BR_2)$. Similarly, we denote the fact that ag_1 interacts with ag_2 in such a way that their interaction meets the interaction requirement $IR_{1,2}$ by $(ag_1 : IR_{1,2} : ag_2)$.

Additionally, we denote the fact that the behavior requirement BR_2 imposed upon ag_2 requires the presence in S of an agent ag_1 capable of an interaction with ag_2 that satisfies the interaction requirement $IR_{1,2}$ by $BR_2 \rightarrowtail IR_{1,2}$.

Thus, we say that ag_1 performs an elementary function for ag_2 in S if and only if:

- $(ag_2 : BR_2)$, that is, ag_2 operates in S according to a behavior requirement BR_2;
- $BR_2 \rightarrowtail IR_{1,2}$, that is, BR_2 requires the presence of another agent ag_1 in S, which interacts with ag_2 in a way that satisfies the interaction requirement $IR_{1,2}$;
- $(ag_1 : IR_{1,2} : ag_2)$, that is, ag_1 interacts with ag_2 in a way that meets the interactional requirement $IR_{1,2}$.

We denote the fact that ag_1 performs an elementary function for ag_2 in S by interacting with ag_2 in a way that meets the interaction requirement $IR_{1,2}$ imposed by the behavior requirement BR_2 of ag_2 by

- $(ag_1 : IR_{1,2} : ag_2) \triangleright_S (ag_2 : BR_2)$

We say that ag_1 is the *performer* of the function, and that ag_2 is its *beneficiary*.

F. Elementary Social Functions in the Basic Producer-Consumer Interaction Scheme

Figure 2 shows that two elementary social functions are being performed in the *Producer-Consumer* scheme, namely:

$PC =$
$\quad (P : DeliverProd; ReceiveProd : C) \triangleright (C : Consume)$

$CP =$
$\quad (C : DeliverSto; ReceiveSto : P) \triangleright (P : Produce)$

that is:

- a function PC such that the *Producer* delivers *product*s to the *Consumer*, so that the *Consumer* can realize its *Consume* behavior;

- and a function *CP* such that the *Consumer* delivers *storage*s to the *Producer*, so that the *Producer* can realize its *Produce* behavior.

Note how an elementary social function concerns basically the performance of an interaction process between two agents that enables the achievement of a goal that is of *central importance* for the beneficiary agent.

As such, social functions operate as motivators for the realization of social interactions, thus, also as binding relations in interaction schemes.

EXCHANGE VALUE-BASED DEPENDENCE RELATIONS

G. Exchange Value-based Dependence Relations, in General

Social exchange theory [15] conceives social relations as exchanges of elements (matter, energy, or information) among agents.

The agents, by attaching some set of subjective, qualitative values to the behaviors or the elements involved in the exchanges, can subjectively assess the exchanges with regard to their quality, utility, etc. [12], and on the basis of such assessments take several decisions: wether to continue or discontinue the interactions, which partners to select for interactions, etc.

In our work, we adopt Piaget's model of social exchanges [19] to support the conceptual model of agent interactions that we have been developing (cf. [8] and the references cited there).

Figure 3 illustrates the set of exchange values that the agents may attach to their exchanges, and the two types of interactions with which they may perform exchanges.

The two types of values that are involved in the assessment of social exchanges are:
- *actual values* – i.e., $r_I, s_I v_{II}, s_{II}$ – meaning values concerned with elements that actually occurred in the interaction, like investments and satisfactions;
- and *virtual* (or, better, *potential*) *values* – i.e., t_I, v_I, v_{II}, t_{II} – meaning values representing debts and credits arisen in the interaction, thus concerning values that are to be realized in future interactions.

The two types of interactions are:
- Type I, where ag_1 acts on behalf of ag_2, resulting in ag_2 acquiring a debt t_I regarding ag_1, and ag_1 acquiring a credit v_I regarding ag_2;
- Type II, where ag_1 charges ag_2 a return behavior with value proportional to the credit v_{II} that it has regarding ag_2, and ag_2 performs a return behavior proportional only to the debt t_{II} that it acknowledges to ag_1.
Whenever needed, agents may change the roles they play in the interaction, with either ag_2 acting on behalf of ag_1, or ag_2 charging ag_1 for a credit previously accumulated.

In addition, Piaget's model makes use of qualitative comparisons between exchange values, to define so-called *equilibrium conditions*, which may be used to support the continuation/discontinuation decisions of the agents about their interaction with each other:
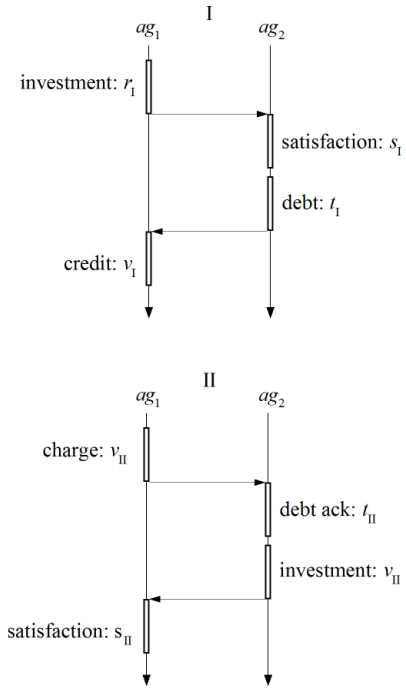- Equilibrium condition:

Fig. 3. Operational structure of a social exchange, and associated exchange values.

– $r_I \simeq s_I$ and $s_I \simeq t_I$ and $t_I \simeq v_I$, so that $r_I \simeq v_I$
– $r_{II} \simeq s_{II}$ and $s_{II} \simeq t_{II}$ and $t_{II} \simeq v_{II}$, so that $r_{II} \simeq v_{II}$
– $v_{II} \simeq v_I$
   so that $s_{II} \simeq r_I$
- Among the various types of disequilibrium condition, the following examples:
– $r_I > s_{II}$: ag_1 is not being properly compensated for his action on behalf of ag_2
– $s_I > t_I$: ag_1's action on behalf of ag_2 is being depreciated by ag_2

Piaget makes use of such mechanism of social exchange values, and the equilibrium/disequilibrium conditions which it gives rise to, to characterize the behavioral rules that impose themselves to the agents, when deciding about the continuation/discontinuation of their interactions, or when choosing partners for social exchanges [19]. Examples of such rules are:
- If the exchange is in equilibrium, agents tend to continue interacting with each other.
- If an agent is in advantage with respect to the other, it may initiate an interaction that will benefit the other, in order to restore the equilibrium condition.
- If the two agents consider, in common agreement, that one of them has a higher social status than the other, then it may become acceptable to both that their interaction continuously benefits the former much more than the latter.

From the point of view of a dependence relation between the agents, in the *equilibrium* condition, one may say that the two agents are *mutually dependent* on each other, for each depend on the proper behavior of the other for the maintenance of such beneficial situation.

In the disequilibrium condition, on the other hand, when one agent is being benefited more than the other, one may say that the former is *dependent* on the latter,

for it depends on the latter continuing to accept such disadvantageous situation, in order for the former to continue benefiting of the situation in such large extent.

Formally, we may express the two dependence situations by:

- $ag_1 \langle b_2 | b_1 \rangle ag_2$

meaning: ag_1 and ag_2 mutually depend on each other, for there is an equilibrium in values exchanged between them, with ag_1 performing behavior b_1 on behalf of ag_2, and ag_2 performing behavior b_2 on behalf of ag_1;

- $ag_1 [b_1 \rangle ag_2$

meaning: ag_2 is dependent on ag_1 performing behavior $b_!$, for there is a disequilibrium favoring ag_2 with respect to ag_1, when the latter perform that behavior on behalf of the former.

As such, exchange value-based dependence relations operate as motivators for the realization of social interactions, thus, also as binding relations in interaction schemes.

H. Exchange Value-based Dependence Relations in the Basic Producer-Consumer Interaction Scheme

In the basic *Producer-Consumer* interaction scheme, one may identify two different, coordinated flows of elements among the two agents, namely:

- a flow of *full storage places*, filled with products, flowing from the *Producer* to the *Consumer*, allowing the *Consumer* to consume products;
- a flow of *empty storage places*, flowing from the *Consumer* to the *Producer*, allowing the *Producer* to deliver products that it has produced.

Assuming that each of the two agents is interested in the continued realization of the flow that respectively allows it to achieve its behavioral goal (production, for the *Producer*; consumption, for the *Consumer*), we may determine the following possible *dependence conditions* in their interaction:

- $Producer \langle DeliverSto | DeliverProd \rangle Consumer$

meaning that the agents are in equilibrium and thus are mutually dependent on each other;

- $Producer [DeliverProd \rangle Consumer$

meaning that the *Consumer* is in advantage with respect to the *Producer*, benefiting from the interaction more than the latter (for example, because the cost of the delivery of the product is much higher than the cost of the delivery of the empty storage);

- $Consumer [DeliverSto \rangle Producer$

meaning that the *Producer* is in advantage with respect to the Consumer, benefiting from the interaction more than the latter (for example, because of the poor quality of the product, that keeps low the cost of its production).

FUNCTIONAL RIGHTS AND DUTIES

I. Functional Rights and Duties, in General

We have proposed [7] (cf. also [9]) the term *functional rights* and *functional duties* to denote the moral and juridical concepts that correlate to each other in social interactions, and that have been identified, analysed, and given importance in several social contexts [18], [17], [19]:

- a *right* is an authorization given to an agent, to exact a behavior from its partner;
- a *duty* is an obligation assigned to an agent, to behave in a certain way, directed toward its partner.

As such, functional rights and duties operate as *normative motivators* for social interactions, thus, also as binding relations in interaction schemes.

The strong correlation of rights and duties makes them occur together in any situation. Thus, we formally represent them by the following basic RD operator [7]:

- $RD(ag_2, ag_1)[b]$

meaning: ag_2 is allowed to exact ag_1 to perform behavior b and ag_1 has the functional duty to perform behavior b for ag_2.

More generally, however, the functional right and the functional duty involved in a social interaction do not concern one single behavior, that an agent has to perform for the other: often, the functional duty involved in the interaction is a behavior b_1 that ag_1 has to perform in order to *enable* a behavior b_2 that ag_2 has the functional right to perform.

So, we get formally [7]:

- $RD(ag_2, ag_1)[b_1 \rightsquigarrow b_2]$

meaning: ag_2 is allowed to exact ag_1 to perform behavior b_1 and ag_1 has the functional duty to perform behavior b_1 for ag_2, so that ag_2 is enabled to perform behavior b_2, which it has the functional right to perform.

J. Functional Rights and Duties in the Basic Producer-Consumer Interaction Scheme

In the basic *Producer-Consumer* interaction scheme, we may identify the following functional rights and duties:

- $RD(Consumer, Producer)$
$$[DeliverProd \rightsquigarrow ReceiveProd]$$

meaning: the *Producer* has the functional duty to perform $DeliverProd$ to enable the *Consumer* to perform its functional right to $ReceiveProd$; and:

- $RD(Producer, Consumer)$
$$[DeliverSto \rightsquigarrow ReceiveSto]$$

meaning: the *Consumer* has the functional duty to perform $DeliverSto$ to enable the *Producer* to perform its functional right to $ReceiveSto$.

INTER-RELATION OF THE BASIC BINDING RELATIONS OF THE BASIC PRODUCER-CONSUMER INTERACTION SCHEME

We collect in Table I the set of *basic binding relations* that we have identified in the basic *Producer-Consumer* interaction scheme.

Such set of basic binding relations constitute the *basic binding structure* of that interaction scheme.

Clearly, there is no equivalence among the various binding relations, meaning that each type of binding

TABLE I: The binding structure of the basic *Producer-Consumer* interaction scheme

1) Binding relations based on **objective dependence relations**:

$(Producer \prec Consumer : DeliverSto \prec ReceiveSto)$
$(Consumer \prec Producer : DeliverProd \prec ReceiveProd)$

2) Binding relations based on **elementary social functions**:

$(Producer : DeliverProd; ReceiveProd : Consumer) \triangleright (Consumer : Consume)$
$(Consumer : DeliverSto; ReceiveSto : Producer) \triangleright (Producer : Produce)$

3) Binding relations based on **exchange value-based dependence relations**:

$Producer \langle DeliverSto | DeliverProd \rangle Consumer$ - if the exchange is equilibrated
$Producer [DeliverProd \rangle Consumer$ - if the exchange favors the *Consumer*
$Consumer [DeliverSto \rangle Producer$ - if the exchange favors the *Producer*

4) Binding relations based on **functional rights and duties**:

$RD(Consumer, Producer)[DeliverProd \rightsquigarrow ReceiveProd]$
$RD(Producer, Consumer)[DeliverSto \rightsquigarrow ReceiveSto]$

relation has a contribution of its own to the binding structure:

- the *objective dependence relations* extract, from the operational structure of the interaction scheme, the operational dependencies between the behaviors involved in the interaction;
- the *elementary social functions* add information about the functions performed by the agents, for each other, in the interaction scheme;
- the *exchange value-based dependence relations* add information about the state of equilibrium or disequilibrium of the interaction;
- the *functional rights and duties relations* express in a normative way the binding conditions in the scheme.

In other words, there is no possibility of reducing the basic binding structure of an interaction scheme to one of its constitutive binding relations, and the basic binding structure has always to be consider in its various *dimensions*: objective dependence relations, elementary social functions, exchange value-based dependence relations, functional rights and duties.

SOME ADDITIONAL RELATED WORKS

The idea that interaction schemes build binding structures on the basis of their operational structures comes from three sources. Firstly, from Durkheim's explanation of the importance of the division of social labor for the integration of societies [18]. Secondly, from Kelsen's explanation of the coercive nature of the legal orders. Thirdly, from Elias' [11] idea of the *integration level* of a social context.

In all three cases, emphasis is put both on the persistent and relational nature of the operational structure of the social interactions that are relevant for the organization of societies, and on the binding nature of the various social relations that accompany such social interactions.

What the paper does, in this respect, is to organize such binding relations in a systematic way, with the concept of binding structure.

Of particular importance, here, is to notice the difference between the extensional, observational approach adopted here – in the vein of Durkheim and Kelsen –, and the intensional, subjectivist approach adopted in may other works on socially binding relations developed in the area of multiagent systems, in particular the works about commitments (e.g., [2], [20]), teamwork [5], and responsibility in the joint performance of tasks (e.g., [16]).

The approach adopted here allows for the exploration of the part that positive norms (both moral and legal) play in the construction of binding structures, as explained in the Conclusion.

DISCUSSION

The *Producer-Consumer* interaction scheme is a general one, capable of modeling a large number of interaction situations.

The well-known *Client-Server* interaction scheme, for instance, is a particular application of the *Producer-Consumer* scheme, with the *Client* taking the place of *Consumer*, *Server* taking the place of *Producer*, the flow of *client requests* taking the place of the flow of empty slots, and the flow of storage places filled with products going from the *Server* to *Client*.

The basic *Producer-Consumer* interaction scheme that we considered in the paper is a restricted, sequential and synchronized version, of the general *Producer-Consumer* scheme. It served, however, the purpose of simplifying the study of the binding structure that builds on its operational structure, when it is put into operation in a social system. In this respect, the paper restricted itself to the basic binding structure associated with the basic Producer-Consumer scheme.

However, in the basic Producer-Consumer scheme it is a central feature that the interaction that it organizes is assumed to be *persistent* in time, a necessary feature of all social relations that structure agent societies (cf., e.g., [1], where economic exchanges are treated just as one-shot events, thus not leading to their view as supports for binding structures).

Some other features of the binding structure should be contemplated in future work, in particular, the separation of functional rights and duties into legal and moral rights and duties, allowing for a the distinction between legal and moral systems in agent societies.

The clarification of the role of norms in the derivation of binding structures is also a future work that merits immediate research effort, to allow a better understanding of the derivation scheme.

Finally, we should mention the importance of the adoption of the two place operator *RD*, for the denotation of functional rights and duties, that makes explicit the co-occurrence of those two notions in functional interactions.

The *RD* operator should be contrasted with the one place operator *Obl* that usually denotes obligations in normative systems. The contrast between them makes clear that functional rights and duties are not respectively reducible, in a simple minded way, to obligations and permissions, which may occur in isolation of each other.

CONCLUSION

There seems to be two main kinds of macro-level social structures, studied in social sciences: one seems to appear as unintended effects of social interactions that occur between individuals, at the micro-level. In the context of social simulation, this type of structures have been studied for a long time, e.g., [13].

A second type of macro-level structures, however, seem to appear as deliberately constructed and imposed (possibly by force) by intentional processes carried on by certain individuals or groups of individuals. Law, as explained by Kelsen [17], is one important example of those intentionally constructed and deliberately imposed macro-level structures.

It seems to us that the right way to deal with such deliberately constructed macro-level structures in simulation model is to have them explicitly represented in data objects generally made accessible for the agents that constitute the population of the simulated social systems. This should be essentially not different from the explicit representation of positive law in legal documents, as it occurs in the legal systems of modern human societies.

One purpose of identifying binding structures of interaction schemes, a problem that this paper tackled at a basic level, is to identify their components and, so, allow for the identification of data objects suitable for their explicit representation in simulation models, thus allowing simulated agents to access and take into account those deliberately constructed binding structures in their simulated interactions.

We notice a special concept developed for dealing with explicit representations of macro-level structures, namely, the so-called "organizational artifacts" [14], that seem adequate for our purpose (cf. an application of this idea of macro-level artifacts to the modeling of public policy processes in [10]).

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