

The Role of Organizational Semiotics and Social Constructs in the Social Awareness of Simulated Cognitive Plausible Actors

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Abstract. Today many computational organizational models exist and the complexity and numbers of these models is growing in time, but many models are only focusing on one aspect like communication, social networks or cognition, while not being aware of their ‘Semiotic Umwelt’ [18, 19]. This paper explains how organizational semiotics can contribute to implement norms and social constructs [10] as part of the decision-structure and social awareness of actors in a multi-actor system, based on the cognitive architecture ACT-R [1].

1. Introduction

Organizational semiotics can contribute to the models of cognitive plausible actors that already exist, because according to Carley and Newell [4], not only the cognitive architecture should increase the limitations of the capabilities of the actor in what the actor can know and when the actor can know. The knowledge about the social and organizational world, the actor carries, should constrain the actor in what types of actions are possible as well. As such, the actor should have the property of social awareness to deal with different role patterns in various contexts, in order to apply different norm-sets and social conventions.

The purpose of this paper is to extend the cognitive plausible actor with social awareness: (i) what is the role of social constructs in social awareness, (ii) what is the function of BDI theory (iii) how do BDI, social constructs and the cognitive architecture ACT-R complement each other and (iv) how will the simulation framework be implemented in order to study the behaviour of these simulated actors in a market environment.

Our aim is to develop a multi-actor simulation model based on actors with a cognitive architecture [1] equipped with a decision-structure of a plausible social actor that uses concepts of the BDI theory [15] and shows social behaviour, based on social constructs (as known in organizational semiotics). Our interest in this

simulation model has been described in 'Social constructs and boundedly rational actors' [10]

Social constructs can be seen as representations of cooperation and coordination, based on intertwined habits and mutual commitments that are often expressed in sign structures such as agreements contracts, and plans. At the level of description that organizational semiotics uses, these sign structures are seen as social constructs [8, 13]. Social constructs guide the formation and reinforcement of habits of individual actors that are aimed at cooperation, coordination, and socially accepted behaviour and can be modeled based on concepts and methods used in organizational semiotics.

Organizations only exist in the actor's mind, like beauty only exists in the mind of the beholder. In the actor's mind, an organization exists as a cluster of social constructs. These social constructs or social affordances have been explained by organizational semiotics as part of a wider network of social constructs (the so-called organizational ontology) and as consisting of a set of norms that regulate (but not determine) actor behaviour. A format for the specification of norms has been defined in organizational semiotics. If we can find a way to represent social constructs, their relationships, and the associated norms in a way that they can be represented in the actor's memory, and can be handled by the actor's cognitive architecture, we are a step further in the direction of a simulated actor with a cognitive architecture that shows social behaviour.

In section 2, social constructs, as building blocks for the social awareness about the world around the actor will be elaborated. Social constructs play an important role in the way an actor creates its intentions and in the way it acts accordingly towards the outside world, to make cooperation and coordination possible.

In section 3, the function of BDI theory will be discussed that is used as part of the design of a decision-structure of the extended ACT-R architecture.

In section 4, a blueprint of the framework of the decision structure of an intelligent actor is drawn up including its components: concepts of BDI, social constructs and the cognitive architecture and the way they interact and complement each other. The framework is the core of the actor and the implementation of the framework will be elaborated as an abstract architecture.

A small implementation of the framework will be explained in section 5. This implementation shows cooperation by negotiation about shared profits and the way a simple social construct, the company, is guiding the process of negotiation by defining the format of negotiation.

Finally, the discussion will give the answer to how social constructs and organizational semiotics contribute to cooperation and coordination in computational

2. Social Constructs, ACT-R and Norms

In organizational semiotics, the representations that guide the behaviour of people in organizations are described in terms of social constructs [12]. The social construct concept seems to be an efficient abstraction of shared knowledge in organizations that may be useful for implementing social behaviour in simulated actors [10].

A *social construct or social affordance* [8, 13] is a relatively persistent socially shared unit of knowledge, reinforced in its existence by its daily use. In organizations, social constructs take the form of, for instance, shared stories, shared institutions (behaviour rule systems), shared designs, shared plans, and shared artefacts. These social constructs support habits of action aimed at cooperation and coordinated behaviour. Each habit of action consists of a commitment to act in a certain way, and a more or less flexible action program that governs the actual acting.

Social constructs determine agreed social behaviour but do not totally determine personal behaviour. To extend social constructs, we have to incorporate also personal characteristics; the actor should have a personal construct that defines the personal characteristics, behaviour, attitudes (Beliefs, Desires and Intentions) and norms. The personal construct of course can inherit characteristics from other actors' personal constructs, and new or other (past) social constructs. The actor can build up a history of successful constructs inside its memory that has influence on its current habits.

Social constructs on the other hand play a role in a group, a relation or a society. They can be divided into three types of social constructs: plans and models as social constructs to which individuals or groups of actors can be committed, implemented as decision trees in the decision structure of the actor. Secondly, there are social constructs that form a relation between two actors, for instance contracts. The actors create obligations and a certain dependency between them. Thirdly, we distinguish behaviour rule systems or institutions that are shared in an organization, community, or social system.

Stamper [16] and Liu [13], state that authority is necessary to start or finish a social construct and the role the actor plays, during this interval, determines in a certain context which social constructs apply and therefore who has the authority to act.

Because social constructs consist of norms, norms have influence on behaviour of the actor and are determined by the role the actor plays in a certain context. To make sure that correct behaviour is stimulated, descriptions of punishment or rewards of (in) correct behaviour can be necessary to prevent violation of norms.

The social construct model is complicated, due to context dependent interactions between group and individual level. Figure 1 shows a model of actors X and Y committed to social constructs.

Keeping the model simple, gives the Multi- (social construct) Actor-System designer freedom to extension, and easiness in modifying the concept to its taste. This model is an abstraction from an organizational ontology for enterprise modeling [7], partly modified and extended with social constructs.

Context is defined as the community or group with a set of social constructs, a semiotic Umwelt and a physical environment. The context defines mainly the roles an actor can play and a context can be part of a larger context and is the situation in which the actor exists, for example work environment or country. A context determines the social construct (type 1) of a group to which individuals should act upon. Within a context, two actors can have a relationship and commit both to a shared social construct between each other (type 2), each playing its role, e.g. a contract. An actor can have many goals, but before an actor can make a goal active for execution, it has to take into account the social construct of the group and the relation it has with the actor it is dealing with. Further on, the personal or basic

construct of the actor gives guidelines for the personal behaviour of the actor. The personal construct plus the social constructs create the individual diversity.

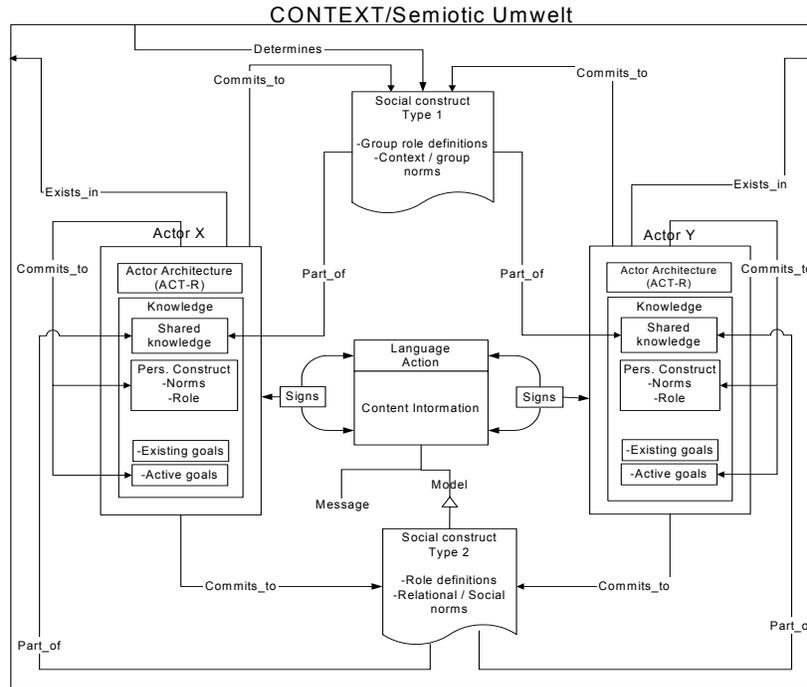


Fig. 1. Social construct model

The exchange of social constructs is based on signs that are communicated by exchanging messages that have a language action and content information part. The way messages are exchanged is part of forming the social constructs, explained in section 2.3.

2.1 Social Constructs and ACT-R

ACT-R consists of a cognitive processor, a declarative memory containing chunks, a procedural memory containing productions, and a goal stack [2]. Productions are selected to fire based on a match with the current goal. The units in declarative and production memory have an activation strength. Declarative activation processes link declarative and procedural memory. This architecture has been implemented in our research project in JAVA, requiring a transformation into an object-oriented software architecture. Declarative and procedural memory has been implemented using a common memory architecture consisting of nodes, paths over nodes, and activation strengths of nodes and paths. ACT-R is very well capable in cognitive reasoning and solving goals, but in the field of perception, action and language production, a

perception handler, an action handler, and a language handler are implemented as an extension of the cognitive processor. To be able to use social constructs and norms in the creation of a set of goals, and to handle multiple active goals in a decision process that results in the selection of a current goal that can be handled by the ACT-R cognitive processor, we have to implement a goal handler as an extension to the ACT-R cognitive processor as well.

Social constructs can be represented in the actor's mind, in casu ACT-R's memory, and in the semiotic Umwelt of the actor as sign structures in the form of messages moving between actors or documents that actors use. With respect to the representation in the actor's mind, we distinguish:

- a. knowledge about social constructs, the attached norms, the actor roles defined in a social construct, the assignments of actors to these actor roles, the commitments of actors to hold a norm, and the relationships between social constructs (normative knowledge);
- b. knowledge about norms that apply to a role the actor holds and that the actor commits to hold in his actions (goals); a norm that an actor commits to hold corresponds to a goal in the actor's mind;
- c. a selection of the goals referred to under b. that is selected as active goals based on the situation and state the actor is in (active goals).

In the semiotic Umwelt of the actor, we distinguish:

- d. knowledge about social constructs, the attached norms, the actor roles defined in a social construct, the assignments of actors to these actor roles, the commitments of actors to hold a norm, and the relationships between social constructs (normative information); this information is related to the knowledge referred to under a.

The normative knowledge of an actor does not only consist of social constructs, but also of basic actor constructs that represent the determination of the actor to survive and his basic attitudes towards other actors, for instance altruism.

2.2 Social Constructs and Norms

We see that there are two steps that lead from normative knowledge to active goals that can be handled by the (extended) ACT-R architecture. First, an actor has to commit himself to hold a norm, giving a goal, and second this goal must be selected as an active goal based on the current state of the actor. Within the current state of the actor, we distinguish triggers as elements of high attention value because they are recent, based on events that have happened recently.

Everything rests on basic elements in the form of norms or goals, and the other constructs are helpful in organizing these basic elements. Logical notations can be avoided as long as we stay at the level of "actor A knows that actor B is committed to hold norm C" and avoid reasoning about "actor A knows that actor B knows that . . .", which seems to be too complicated at this moment of development of our simulation model. The problem that remains is that we have to handle the obligations expressed by deontic operators once we have a set of active goals and the actor must decide what to do, based on these possibly conflicting goals.

Because social constructs consist of norms, the actors that are dealing with social constructs should have the characteristics of deliberative normative actors. Implementation of normative behaviour in multi-actor systems is an upcoming research field in which different approaches towards norms take place. We assume that norms are part of the cognitive memory of ACT-R and that they are subject to the way ACT-R addresses the memory, e.g. de-activation, reinforcement.

When actors are equipped with social constructs and norms, the following theories according to norms should apply [5] (slightly changed):

- *Norm / social construct formation.* Analogously, normative knowledge is involved in the process that gives rise to a new norm or social construct. Normative actors may not only decide whether to observe or violate existing norms, thereby reinforcing or extinguishing them, but also decide whether a world state is or should be a norm, or a social construct should be formed, e.g. by interaction with other actors.
- *Norm / social construct evolution:* actors' capacity to reason about, recognize and decide whether to accept or not, to observe or not, a norm may give insight about the process through which a norm is selected and possibly is modified. Autonomous and intelligent norm-based decision-making contributes to the evolution of norms no less than it contributes to the evolution of social constructs. If norms are implemented as mere action constraints in multi-actor systems, they cannot evolve since actors are not allowed to violate them. In our architecture, decrease or increase of activation of norms and social constructs do forget or reinforce them and can make an autonomous actor's action allow violation, which in turn allows norm evolution.
- *Norm-based social control and influence.* Normative knowledge allows actors to:
 1. Check the efficacy of the norms (the extent to which a norm is applied in the system in which it is in force) by monitoring one another's behaviours against the norms they have accepted, and possibly to
 2. Urge their fellows to obey the norms

Because norms are attached to social constructs, social constructs are formed, evolve, controlled and ended as well.

2.3 Social Constructs: Formation, Evolution, Control and Ending

The process of dealing with social constructs in the interaction of actors must be based on actor knowledge about how to do that; some basic knowledge about types of social constructs and interaction conventions must be present in the actor before it is able to do anything at all in this field and improve its knowledge based on learning.

A social construct has a time span with four phases: establishment/forming, evolving, controlling and ending the social construct, based on commitment scenarios used by Hägg [9] and Filipe [6].

The process of *forming* a social construct starts with the actor that wants to *propose, inform, or is requested* to inform/propose a social construct to another actor. After this process, a negotiation can be started, until a (dis) agreement is established.

After agreement, a social construct is established and an evolving process takes place. Hence, during the agreed time span, the social construct and attached norms are due to change, because attached norms may evolve or are violated, and if possible the actor can start to re-negotiate about other terms of the social construct in order to modify the social construct.

The process of control is vital for determining if the other actor(s) are still aware of the conditions and associated norms of a social construct. Control can be done by monitoring and requesting the other actor(s) about the conditions of the social construct and can be rewarded or punished.

The ending of a social construct can happen during the process of evolving, when an actor wants to re-negotiate and releases the social construct before the agreed time-span is reached. Secondly, the agreed time-span of a social construct can end and the involved actors decide to release the social construct. However, this does not mean that the actor is forgetting the success or failure or format of a social construct.

It is not only important which social constructs and norms an actor is aware of, but also the knowledge of context, or environment / group, the actor takes part in, is crucial for the actor to determine its role and social constructs and norms that apply to that particular context. For example, a police officer has different roles, regarding doing his job, or raising his kids. Hence, change of context triggers other roles and other social constructs and norms and authority. In an organizational model, we can implement the social construct principal-agent, to give the actors the ability to form hierarchical organization structures. However, this does not state that actors are not able to violate norms and social constructs if this social construct conflicts with other norms or constructs, due to group or personal norms.

At any time, the context of an actor plays an important role in the decision-structure of the actor and to make it possible for an actor to be aware of its context and create actions upon it. We adopt some concepts of BDI-theory to make the actor more social aware and build on top of the cognitive architecture, ACT-R, that gives the actor the ability to learn and forget and to represent the dynamic data structures that are necessary for norms and social constructs to be formed and evolve. BDI is suitable, because it defines the framework in which social constructs can take part.

In the next section, the theory of BDI will be highlighted shortly to show what the function of BDI theory is as part of our decision-structure framework in section 4.

3. BDI Theory

A number of different models and architectures have emerged during the studies of autonomous actor-oriented systems. In order to create autonomous actors and let them make decisions without human intervention, we need a theory that limits the choices and models all relevant aspects of the environment as mental attitudes. Because the dynamic environment changes either during the selection or the execution of actions, the decision-making actor needs to deliberate to either reconsider the previous

decisions, also called intentions, or continue the commitment to those decisions (intentions). This deliberation process leads to either a reconsideration of the intentions or the continuation of the commitment to the intentions. This decision aspect is argued by Bratman [3] to be crucial to realize stable behaviour of decision-making actors with bounded resources. This approach has led to what is called BDI theory.

The BDI model [14, 17] figure 2, views the system as a rational actor having certain *mental attitudes* of Belief, Desire and Intention (BDI), representing, respectively, the information, motivational, and deliberative states of the actor. The second argument for adopting this theory is because of its proven practical use in a number of large-scale applications, including a system for space shuttle diagnosis [11], air-combat modeling [15], and business process management.

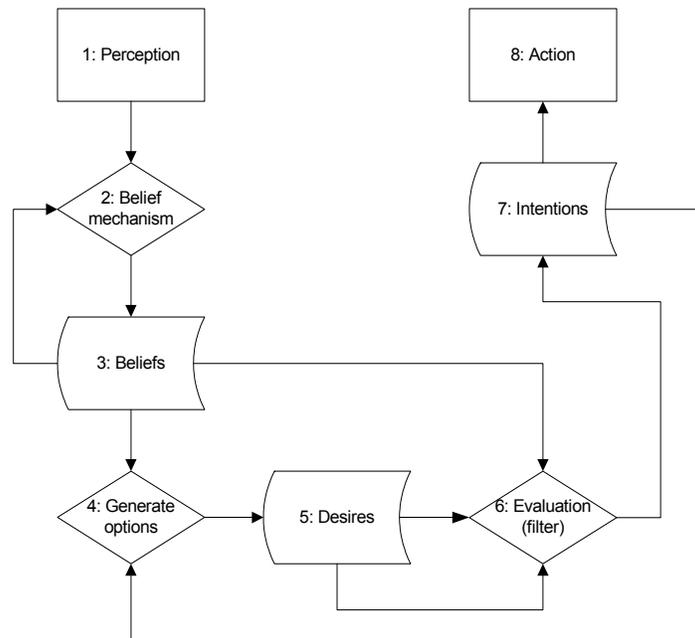


Fig. 2. BDI-model

BDI creates different mental attitudes but does not order mental attitudes on preference; hence for example many intentions can be achievable and executed at the same time. Our aim is to use the conceptual framework of BDI with social constructs and a cognitive architecture to: (1) filter these attitudes and bring order in attitudes, (2) to make the actor more socially aware and (3) to make the actor boundedly rational.

BDI is in this paper more in focus than ACT-R, because BDI copes with perceiving the environment, its social aspects and deliberation, while ACT-R deals with memory of social shared knowledge and the cognitive architecture that regulates

the storage of this knowledge BDI is built on top of this cognitive architecture, in order to give ACT-R better sensors and goal reasoning, e.g. deliberation process. ACT-R its strongest points are in cognitive reasoning, while BDI is strong in perceiving the world and deciding about which intentions will be created. However, the principles of BDI-logics will be limited into our model to first-order (propositional and predicate) logic, because it is out of scope of this research. For a BDI equipped actor, to function properly, the actor needs *beliefs* (3: Beliefs about the state of the environment that will be updated (2: Belief mechanism) after each sensing action (1: Perception). Rao and Georgeff [15] state that such a component may be implemented as a variable, a database, a set of logical expressions or some other data structure and beliefs are viewed as the *informative* component of the system state. In our model, the beliefs are modeled as knowledge that is not defined as beliefs for the actor, but states as true knowledge of the world around the actor.

In our implementation, we use the declarative memory of ACT-R to store facts about the environment, and giving the actor the capabilities of forgetting and learning and creating a dynamic data structure. The system also needs to have information about the objectives to be accomplished and what priorities or payoffs are associated with the various current objectives. These objectives can be generated instantaneously (4: Generate options), functionally e.g. with the help of decision theory or trees. This component of the system is called the system's *desires* (5: Desires), which can be thought of as representing the *motivational* state of the systems. This decision-tree with choice and chance nodes can also be stored in the declarative memory part of ACT-R with each semantic link representing utility values. However in real-time systems, as Rao and Georgeff correctly state, the environment may change in possibly significant and unanticipated ways either (1) during execution of the selection function itself or (2) during the execution of the course of action determined by the selection function.

Because of the many desires, there has to be a component of system state that represents the currently chosen course of action; that is, the output of the most recent call to the selection function (6: Evaluation (filter)). The additional state component is the system's *intentions* (7: Intentions) and is in essence the *deliberative* component of the system.

Similar to the abstract architecture, Rao and Georgeff proposed, the total system comprises three dynamic data structures however based on ACT-R, representing the actor's beliefs, desires, and intentions. Besides these knowledge bases the mechanisms and functions or filters are crucial for decision-making, especially in the way the actor deals with its environment. Because heavy accurate selection functions use much computer power and hence thinking power of the actor, the actor can easily be out of sync with the outside world. However if plans are not reconsidered at all, the actor can fail to achieve its objectives.

As suggested before, BDI theory is generating different mental attitudes, but is not stating anything about how to order these mental attitudes, or how to store attitudes in the memory of the actor. Social constructs with associated norms give the ability to order mental attitudes of BDI, while the memory structure can be maintained by ACT-R. BDI, social constructs and ACT-R complement each other and the integrated (decision) structure is elaborated in the next section.

4. The Framework of the Decision-structure of the Actor

The decision-structure of an actor is probably the most complex part of the whole architecture of an actor. BDI takes an important part of creating intentions out of accessible belief worlds. However BDI does not focus much on norms, and other attitudes and does not study explicitly the cognitive architecture of the actor. Our framework has to take into account all concepts: concepts of BDI, the cognitive architecture and the social constructs, see figure 3.

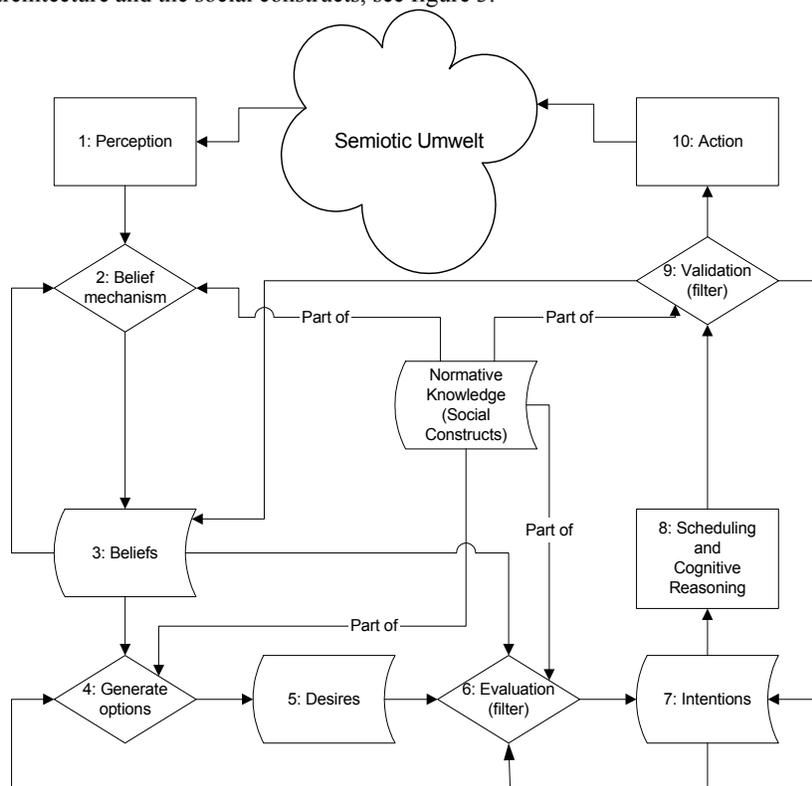


Fig. 3. Decision structure of the actor

The difference between our framework and BDI lies in the fact that the beliefs in our model are defined as true knowledge instead of beliefs that can be true or not. The desires in our model are goals that are structured in a decision tree created out of the beliefs. The intentions in our model are the current active goals that are scheduled and solved. The outcome is again validated based on the social constructs, norms and social conventions that finally decide if an intention can be transformed into an update of the beliefs or an action towards the outside world or not.

Desires are generated by transforming beliefs and feedback of intentions, but are quite abstract and are not taking into account the restrictions of social constructs that

determine if a desire can become an intention. The evaluation filter is extended with social constructs, norms and attitudes of the actor and relationships that makes it possible for the actor to adjust its social behaviour. Secondly, desires are transformed into active goals that are inputs for the cognitive system to reason internally if a goal fails or is successful. In this way, reasoning takes place at a functional level and not at the intentional level. The whole architecture is becoming more plausible in that sense that goals of ACT-R are filtered out by BDI in combination with social constructs.

Thirdly, validation takes place, with the help of social constructs, that even if an objective can be successful, there is a possibility that the intention leading to that objective will be dropped when the actor is not allowed to achieve that objective, caused by its own personal constructs and social constructs of groups and relations with others.

Regarding our question, how do BDI, social constructs and ACT-R complement each other, an explanation of figure 3 will be necessary to show where and how in the total decision-structure, BDI, ACT-R and social constructs interact.

In (1) perceptions and events are queuing and are filtered out by a belief-mechanism (2) and create a so-called (temporal) knowledge tree of accessible worlds. Social constructs and especially perceptual norms are triggered by perceptions and events in a context and update constantly the current knowledge (beliefs) of the actor. This knowledge (3) is stored in an a-cyclic hierarchical tree inside declarative memory of the cognitive architecture, making it possible to reinforce knowledge or make it forget. A subset of the knowledge (beliefs) is a candidate for desires (5) or existing goals and can be generated (4) based on their accessibility according to their activation in declarative memory and based on the current knowledge and current social constructs and norms that are triggered by the perceptions of the environment or context and the role the actor is engaged in. After desires are created and stored in declarative memory of the actor, intentions (7) are created by a filter (6) that is based on knowledge, a subset of desires, and social constructs and norms that apply to the current role the actor is in engaged in a certain context.

As long as the actor has intentions, the intentions will be scheduled (as many the cognitive schedule capacity of the actor can handle) and the cognitive architecture (8) starts trying to solve the goal(s) and will succeed or fail in solving the goal(s). However, before going towards action (10), the actor needs to reconsider (9) the outcome and see if he is allowed according the social constructs and its (private) norms to execute the action. For example, committing business fraud is something you do by keeping secrets inside a selected group. All the time an action that could shed light on the fraud would damage the status of the actor self but also the other actors involved. As long as the social construct is active and there is no trigger from the environment, the actor will keep the secret and not take any action to reveal the fraud while at the same time he has intention to do so. The validation filter (9) will update the intentions and the knowledge (beliefs) of the actor.

The total framework is the basis for making decisions about what to know (believe), what to desire, what to intend to do, when and how to fulfill it and if it is allowed to fulfill it.

The creation of an autonomous actor is important from a non-deterministic simulation perspective. An example of how autonomous actors, equipped with this

decision structure of BDI, social constructs and ACT-R is implemented, is described in the next section.

5. An Implementation of Negotiation and Cooperation

The implementation model¹ is less complicated than the framework discussed in this paper and is a first step to make the actor social aware and to create social constructs, that are based on relations between actors. The context related social construct is the construct that every actor *has to* cooperate to survive by the goal of cooperation and negotiation. The model exists out of x actors each with its own personal construct, memory (knowledge), knowledge about how to make deals (procedures), perceptions of the environment (awareness of available actors) and cognitive architecture (activation of knowledge makes it able to forget and learn).

The aspects are implemented at a very simplistic level to enable pre-calculation of the results and to assure a clear data collection process. Every cooperation, or working together on a particular task, is the same task; only experience can decrease the time to finish a task.

The actor is part of a pre-defined stable world and it perceives other actors in this world and is able to communicate with other actors and gather information by proposing deals with other actors to create synergy and make profit.

First of all, the actor has two different types of knowledge: personal and relational knowledge (knowledge about others). This knowledge is stored in the memory of the cognitive architecture of ACT-R, hence bounded rationality is active and makes knowledge to be forgotten or reinforced.

The personal knowledge exists out of the following (market related) components:

1. Risk factor: is the actor risk averse – 0% – or risk seeking – 100% – or somewhere in between.
2. Minimum and maximum solid-threshold: two values representing an amount of capital, at which the actor changes its risk factor, e.g. below 1000, risk averse; above 10000, risk seeking.
3. Profit: fixed amount of profit equal in every negotiation.
4. Pay-off: percentage of profit when working together.
5. Capital: the amount of available money to the actor. If this value becomes equal or smaller than zero, the actor is bankrupt.
6. Burnrate or variable costs: a percentage of decrease in capital of the actor at every time step
7. Fixed Burnrate or fixed costs: a fixed amount of decrease in capital of the actor at every time step
8. Activation decay / decayrate: a variable that decreases the activation of each memory chunk (forgetting)
9. Bidrate: a percentage the actor uses to alter its negotiating percentage of the payoff

¹ Implementation based on the Rbot model © 2004 programmed by G.B.Roest & J.M.Helmhout

10. Desired profit: a percentage that is the starting point of the negotiating percentage of the pay-off.
11. Status: a Boolean representation whether the actor is negotiating or available. The actor has also knowledge about other actors to base its decisions on:
 1. Pay-off-history: Percentage of payoff in dealing with other actors
 2. Social construct-history:
 - 2a. How many negotiation cycles (time) were needed in the previous negotiations?
 - 2b Behaviour of the other actor: risk averse or risk seeking depending on the bidrate of the other actor, desired profit and behaviour ending the social construct before it reaches the agreed time with the attached amount of fine paid.
 3. Relation availability-history: when the actor tries to negotiate with another actor, but fails because the other actor is already negotiating (status: busy), this percentage decreases
 4. Time of the working together depending on frequency. If worked more often, experience is built up and this time decreases.

Secondly, the actor has some personal norms that regulate the status of the actor during the simulation:

1. Survival with as derivatives:
 - Make as much profit as possible.
 - Avoiding risks, depending on factors, e.g. the more capital the more allowance for risk.
2. Help other actors as much as possible, if the actor is altruistic.
3. Only one-to-one relationships are possible; a restriction forced by the model.

The environment, constructed as a market (a social construct), takes care of (but not determining) the connections between the actors' perceptions. The actors are frequently trying to start negotiations, when not negotiating already, and are continuously gathering information about the other actors. By implementing activation decay, the actor is releasing the information gathered, making place for new opportunities.

The actor has to have some 'procedural' norms that make it possible for the actor to create a scenario and to make actions, such as cooperation possible.

In the model we extinguish different states in which the actor makes decisions:

1. Select a partner
2. Agree on the conditions for cooperation and store them in a social construct, e.g. a contract
3. Do work with this partner based on the norms of the social construct
4. Distribute the resulting profits based on the norms of the social construct.
5. Learn, based on the experience with the specific buyer, update if necessary shared and personal knowledge.
6. Return to state 1 after the social construct is finished.

The norms attached to the social construct are norms attached to a simple form or organization, the company in a market situation. A *company* (Italian: com pugno, eat bread together) is characterized by low inequality of the cooperating actors and a relatively persistent existence. Actor A offers a certain effort and time and gets a

percentage of the profit or loss of the company and Actor B also offers a certain effort and time and gets a percentage of the profit or loss of the company.

The norms attached to the social construct can vary from relaxed towards strict, like sanctions. In our simulation the attached norms for example can be the following:

1. When an agreement is made on terms, e.g. shared profit, agreed time, the participants are obliged to work together for a certain amount of time
2. Sanction: if one of the two breaks the agreement, a fine has to be paid.

Following scenario sketches a scenario of cooperation between two actors.

1. The selection of a partner is depending on many factors.

This part is specifically where BDI, social constructs and ACT-R work together to order all possibilities and make a choice.

First of all the actor can calculate an estimation of its own life span, the amount of time alive when an actor is making no profit at all. When time is sufficient, the actor can explore and try to gain information from other actors (request-inform) to ask their desired profits (their preferable social construct). Secondly, if the actor has pay-off history, it can estimate where to get the most profit and when frequency of working together is high, the estimated time needed to gain the profit is lower. Thirdly, when the actor has an availability history, it can estimate which actor is most of the time available. Fourthly, the actor can estimate the behaviour of the actor based on the social construct history e.g. risk averse or risk seeking behaviour. All these factors influence the decision of the actor and with help of decision theory the actor can make a choice about which actor to choose.

2. After a choice is made, negotiations take place and reconsideration of beliefs, desires and intentions (BDI) takes place in creating a final intention to work together yes or no. When actor A decides to work with actor B, actor A sends a social construct with a certain desired-profit percentage. Actor B can reject, confirm or counter-propose, until a (dis) agreement is reached. Behaviour of the actor can be stored: negotiation cycles, desired profit, and if possible agreed shared profit and agreed time.
3. Work together for the agreed time but if one of the actors ends the social construct, a certain amount of fine has to be paid to the other. In this stage, ACT-R is already busy by trying to solve the goal (working together on a problem) and reconsideration about working together can take place; BDI and social constructs are still active and can stop the process when an actor ends the social construct before the agreed time.
4. If the social construct time ends, the actors share the profit according to the social construct.
5. A successful or failed outcome can be stored and also the information that is necessary for a new selection can be stored. Personal, relational and social construct information can be updated.
6. Go to the selection state again and try to find a new candidate actor.

The simulation will give us new insights in the behaviour of our software model that is still under construction. As stated before that the model is simple, actually that is not true, because during the simulation many factors are interdependent. Secondly, the model has three layers: (1) a perception part; a simplified BDI model that interacts with the environment, (2) together with social constructs BDI decides what goals

should be active, (3) on functional level, the ACT-R architecture that solves goals and maintains the declarative and procedural memory of every actor.

The goal of the simulation is to show that the combination of BDI and social constructs make the cognitive architecture social aware and in the second place, because the simulation is taking into account all the concepts of computational organization theory, it is possible to test theories or hypotheses, e.g. about how organizations are formed, and broken down again.

In this model we can try to see if actors are more exploring and risk seeking when their expected life-span (when they are rich) is large and are behaving opportunistically, while actors having a short expected life-span (poor), are easier satisfied, loyal and are taking less risks in negotiations and exploring, as assumed in a market environment.

Furthermore, testing of this simulation can make clear whether or not our proposed decision-structure framework in section 4 has to be revised.

6. Discussion and Further Work

In this paper we showed a framework that connects different theories, BDI, ACT-R and social constructs. We have stated that social constructs do give us new guidelines in how to create social aware actors. While BDI theory is a good candidate for interpreting the environment and possible future states, giving assumptions about which actions to perform next by reasoning on a plan to reach the selected goal state, there is no decision rule in ordering the given possible states. The realism constraint of BDI states that a goal state can be selected if it is believed to be achievable. However many states can be achievable and BDI leaves these states deliberately open to allow for a variety of actor types. In this paper we apply social constructs to fill that gap and make the actor select a goal (state) based on the social constructs it is equipped with. Social constructs make the actor not only aware of its personal norms, but also about its obligations and permissions, expressed in relational and group norms, in relations between actors and interaction between and in organizations.

BDI and social constructs together create active goals that are dealt with by ACT-R. The role of ACT-R is to maintain the actor's declarative and procedural memory, and to solve goals.

The actor has to cooperate, compete and coordinate in an organizational setting, and as such it needs a mechanism, the decision-structure framework, that defines the way it must and can operate in this setting. Organizational semiotics interprets signs of other actors and the semiotic Umwelt and with help of social constructs these signs are transformed into declarations and procedures how the actor should cope with the semiotic Umwelt.

This research about the decision structure is part of a project that aims to simulate organizational behaviour in order to assist organization behaviour researchers as well as organization designers. This modular computational organization-simulation toolkit can be configured for many different computational organizational theory settings and can serve as a blueprint for organizational researchers and designers as well.

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