

Software Agents in Enterprises, and Organizational Sociology

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Abstract

The emergence of agent technology and its increased use in business applications arises the question whether (and how) the existence of intelligent agents may affect the definition, the structure, the interaction patterns, and the dynamics of social systems of enterprises. This paper aims to work out some of the relationships between Organizational Sociology, and the use of organizational metaphors in Distributed AI/Multiagent Systems Theory. To this purpose, the paper first introduces into selected approaches to organizational theories (section 2). It then presents a summary of the use of social, and organizational metaphors in DAI/MA theory (section 3). On this basis, it draws some conclusions for further research on sociological, and organizational issues in DAI/MA theory (section 3).

1 Introduction

The technology of intelligent agents, as they are being developed in AI and in Distributed AI / Multiagent Systems (DAI/MAS), provides us with software systems exhibiting properties which distinguish them clearly from conventional software programs. Based upon autonomy and bounded rationality intelligent agents act intentionally. They also exhibit what is called their social capabilities, i.e., their ability to be aware of other agents, to relate themselves to and to interact with their environment, and to form groups, coalitions and even ‘artificial’ organizations [Kirn 1998]. And, in contrast to most conventional applications, agents are like a continuously running UNIX process: they are permanently ‘alive’.

While the real differences between software agents and a human beings can not be bridged in general, this is quite different to the situation where agents act on behalf of a formally constituted body, e.g. of an enterprise. In such cases, agents may adapt themselves to formal roles, and they may perform activities in order to contribute to the aims and goals of the embedding company. Numerous examples thus already show that the difference between *observable* human behavior and *observable* agent behavior is decreasing in many cases. E.g., it is already impossible today to clearly identify

whether an information, a message, or an email arriving at a local desktop has been generated and sent out by an agent, or by a human being.

The agents considered in this paper are part of an enterprise. In contrast to traditional approaches in organizational and management science we believe, however, that agents are not merely just like 'intelligent machines' belonging to the technical infrastructure of the enterprise. Instead, we assume that the behavior of agents can only be described, analyzed, and controlled appropriately if one addresses their particular social capabilities and problem solving strategies. Hence, the basic assumption of this paper is,

that intelligent agents (as far as we can observe it from outside) increasingly perform 'human-like' behavior. They thus exhibit a particular 'organizational quality' which requires enterprises to treat, to integrate, and to control them in a different way than conventional software programs: as 'artificial members' of enterprises.

In this perspective, agents are embedded in, related to, or associated to the organizational system of an enterprise. Hence, it seems fruitful to coordinate research in the respective disciplines: Distributed Artificial Intelligence on the one hand and (organizational) sociology on the other hand. However, up to now organizational theory in general as well as organizational sociology in particular have only considered social relationships among humans. Technical systems have sometimes been incorporated as contingency factors. So far, it is thus still not common to consider them as a particular 'artificial' type of members of a social system. Examples are the socio-technical system metaphor, and contingency approaches to organizational theories in management science.

The emergent use in business applications, however, arises the question whether (and how) the existence of intelligent agents may affect the definition, the structure, the interaction patterns, and the dynamics of social systems of enterprises. As this paper cannot provide the full answer to these and related questions, it aims to work out some of the relationships between organizational sociology, and the use of organizational metaphors in DAI/MAS theory. To this purpose, the paper first introduces into selected approaches to organizational theories (section 2). It then presents a summary of the use of social, and organizational metaphors in DAI/MA theory (section 3). On this basis, it draws some conclusions for further research on sociological, and organizational issues in DAI/MA theory (section 3).

2 Organizations from the Perspective of Sociology

2.1 The approach of GIDDENS

According to [Giddens 1995, p.12] sociology deals with the social life of human beings and with groups and societies. A social group is a number of frequently interacting people, leading to an entity of its own. Members of the social group expect special behaviours which they don't expect of non-members. A classification of social groups can be made by the differentiation in primary groups (like families) showing emotional relations and secondary groups without personal relations [Giddens 1995, p.305-306].

An organization is, according to [Giddens 1995, p.307], an association of many people with an impersonal management, which has been founded to assert specific goals. It is an important characteristic of organizations, that they are mostly planned. Organizations are necessary to coordinate activities and resources, which are important to satisfy the needs of the people living today. To achieve their goals, organizations tend to be bureaucratic. According to the most influential theses of Max Weber, the expansion of bureaucracy is unavoidable in modern societies, caused by the administrative necessities of great social systems.

To enhance Weber's work, [Giddens 1995, p.310-311] is referring to different empirical studies, showing that formal relationships (which are mostly regarded in Weber's work) are not the only relevant ones. On the contrary, a study of [Blau 1963] shows that in the analyzed office the officials were using informal ways to get their problems solved by discussing them with their colleagues. This was done in spite of the official regulations, that they should only discuss these problematic cases with their superiors.

Another interesting phenomenon is the division of power in organizations [Giddens 1995, p.311-313]. According to Robert Michels, there exists a tendency of a correlation between the power concentration in and the size of an organization [Michels 1979]. But there exist empirical studies, that power is delegated in greater corporations more often [Pahl & Winkler 1974].

Central to organizational sociology is the identification of important impacts on organizations in these days. Giddens isolates three very strong factors for organizational sociology, namely professionals, information technology, and physical prerequisites of organizations [Giddens 1995, pp.316-320]. Professions and academic personal have passed a very long and high education. They are members of (international) associations defining their work domain. So their work is not reducible to fulfilling bureaucratic duties. The power of professionals results in their role as gatekeepers to their qualification and their knowledge. So organizations have to be flexible to adapt to professionals. The development of information technology allows spatially distributed and virtual organizations. This could have an impact on decentralizing organizations.

There exists some work about interdependencies of organizational structures and the buildings the organizations reside. So there is a specific influence of organizations on the architecture of their buildings.

The last central points in Giddens discussion of organizations are surveillance and discipline. Surveillance is dealing with the extent of direct control of the work of lower ranked persons for their superiors. Surveillance is an important determinant of modern organizations, because they are based on discipline - a coordinated regulation of human behaviour [Giddens 1995, pp.320-322].

2.2 The approach of REED

Reed presents a different and more structured view of the domain of organizational sociology. He also starts with reflecting the historical facts leading to organizations [Reed 1992, pp.1-35]. But then he proceeds to identify the thematic continuities in organizational sociology. These continuities consist of rationality, alienation, anomie, and power [Reed 1992, pp.36-71].

Rationality is the underlying concept of bureaucratic organizations, leading to a mechanical view of an organization as a machine-like body. A consequence of this rationality is alienation, as an offspring of the comprehensive regulations which are not able to provide spiritual or ethical foundations for social actions. A possible contrary problem is anomia, limiting moral regulations and social control, caused by uncontrolled competition, intense class conflicts and degrading work. A result of every organization is power. This is caused by the organizational structure of domination and control, leading to translating intentions of some actors into practical outcomes.

Following, [Reed 1992, pp.72-129] presents different restricted analytical views on organizations, leading to different research programmes. First, he analyses organizations as social systems, directed to the achievement of collective goals or the fulfilment of institutional needs for the society. Then, he shows that organizations can be viewed as social units, which are created and sustained by social interactions. In this view, change is an important issue for every organization. Organizations may also be viewed as structures of power and domination, having the goal of protection and advancement of dominant economic, political and social interests. Another possible interpretation of organizations is that of being symbolic constructions. So they are constituted through values, ideologies, rituals and ceremonies, leading to being a resource for participating within a collective enterprise. An integrating perspective is presented by viewing organizations as social practices. This perspectives concentrate on a learning organization, adapting to transform the conditions, under which collective action is made possible. The goal is the assembly of the practices to transform the environmental conditions.

The different problematics in these analyses of organizations are shown in Table 1:

Framework	Problem focus
Systems	Adaptation
Negotiated order	Construction
Power and domination	Control
Cultural / symbolic	Meaning
Practice	Assembly

Table 1: Problematics in organizational analysis [Reed 1992, p.119]

Following these different views on organizations, many research groups working on these concepts are presented and their work is analysed [Reed 1992, pp.130-197].

2.3 The approach of TÜRK

An in-depth presentation of the viewpoint of organizations as structures of power and domination is shown in [Türk 1995]. Organizational sociology is viewed as an area in the domain of general sociology of modern societies. Main task is the critical interpretation of modern societies under the aspect of dominance of organizational capitalism. Organizations are viewed as central institutional regulators. Organization is viewed as a medium to exert power. The differentiation between organizations and the society (as a cause of organizational action) is criticised as being prejudiced by playing the role of the management. This idea is stressed by looking at organizations as being a social interaction, leading to a shift of responsibility for actions from the acting subjects to the organization. This results in a view of the organization as being an individuum. Organizations are built to influence non-members [Türk 1995, pp. 10-16].

2.4 The approach of LUHMANN

[Luhmann 1993] is viewing organizational sociology in the subdomain of organization and decision. Based on intensified research, the domain of organizational theories is divided into several subdomains. Organizational theory and social theories are splitted. This leads to a differentiation between an organizational perspective and the relevant social aspects, resulting in an view of the society as „environment". Organizational theories are further divided into economic an sociological organizational research. This leads to a focus of organizational sociology on the difference between formal and informal organizational structures, thus contrasting the shown behavior of the organizational members with the official rules for the behavior. Research on organizations from the perspective of business administration leads to an interest in the correlation between organizations and decision theory.[Luhmann 1993, pp.335-337]

Following, organizational systems are characterized as social systems consisting of decisions and connecting these decisions mutually [Luhmann 1993, pp.339-340]. These connections can not be made for all decisions, so there have to be incorporated a temporal factor, enabling an incremental building of these connections, resulting in more rational decisions. Rationalism requires a decomposition of decisions by facts. This results in an increased number of decisions. (The decision is parted into several parts, each part being a decision itself.) Another perspective of decisions is the social dimension. This leads to the inclusion of many people in the decision process. Both effects together result in ever-growing organizations [Luhmann 1993, pp.346-347]. To solve this dilemma, Luhmann propagates an innovation-oriented decision approach [Luhmann 1993, p.374-375].

3 Organizational Perspectives in Multiagent Systems

3.1 Example

3.1.1 A mobile trading agent

Supposed there is a mobile trading agent travelling across the internet. This agent may have been conceptualized, and designed as an intentional system. We assume that it also exhibits a significant degree of individual autonomy in order to be able deciding on its own how to solve goal conflicts, how to behave in unknown situations, etc. The agent may also be able to interact with other agents, and even with humans in order to identify, to contact, to communicate, and to perform negotiations with potential business partners.

3.1.2 The trading agent is owned by an enterprise!

This paper assumes, that agents are owned (in general) by enterprises. We name such agents 'organizational agents'. Enterprises will only invest their money in agents if they will get back a reasonable return of investment. I.e., these agents are supposed to act on behalf of their owners. This can be done, for example, by fixing aims and goals to be approached, by allocating competencies and resources to agents, by imposing constraints on their behaviors, by prioritizing its interaction channels, and by changing their individual task loads.

Firstly, this seems to be in conflict with agent autonomy. However, just because agents *are* autonomous, there is no significant difference to the situation of humans. It is just up to the agent whether or not it wants committing itself to an external constraint. In our example we assume, that the agent has some pre-defined intentions which have been implemented by the software developer. Further, it may have adopted additional intentions of the enterprise, and of its human user. Due to its owner's intentions we assume that the prior task of our agent is to buy and sell financial services from and to interested third parties. Its current top level goal is to maximize its long-term turnover.

Its human user may further be willing to invest a minimum of 20% of the turnover per time period in financial services being related to developing countries.

3.2 Organization as partitioning of problem spaces

3.2.1 Distributed problem solving

Distributed problem solving proceeds through five sequential phases: task definition, task decomposition, subtask allocation, subtask solution, and synthesis of subsolutions into one overall result [Davis & Smith 1983, Durfee, Lesser & Corkill 1989, Erman et.al. 1980].

In that perspective, "organization is a precise way of dividing the problem space without specifying particular problem subtrees. Instead, agents are associated with problem types, and problem instances circulate to the agents which are responsible for instances of that type" [Gasser 1992]. Hence, our agent may possess a particular capabilities profile, e.g., the ability to deal with a particular type of financial services, or to efficiently operate an electronic market. *As problem types are key ingredients of organizational design, this perspective provides a possibility to embed agents into the organizational system of an enterprise.*

3.2.2 Roles

In order to organize the process of distributed problem solving three types of roles have been suggested: managers of a task, bidders, and contractors. Typically, agents may apply not only to one, but also to all three of these roles at a time. This relates to the basic level of coordination [Smith 1979]. Until now, many agent system designers have used such role concepts for long-term coordination in their systems [e.g., de Jong 1991, Gasser, Braganza & Herman 1987].

On a semantically higher level, our agent may act as a seller or as a buyer of financial services, or as a mediator in the market. Of course, our agent may apply to any of these roles at a time, too. This reveals that the concept of roles in Distributed AI is not the same as in organizational theory where roles refer to the definition of expected behaviors of a member of a system. *Therefore, the DAI concept of roles is not appropriate to relate agents to the organizational system of enterprises.*

3.3 Organization as a pool of resources

In contrast to DPS, cooperative distributed problem solving (CDPS) aims to integrate pre-existing agents into an overall framework to make synergetic use of their individual abilities [Durfee, Lesser & Corkill 1989]. This bottom-up perspective on creating a CDPS-system is accompanied by a top-down perspective on coordinating the activities of problem solving [Wanka 1998].

This requires agents to provide portions of their individual capabilities to the system, but also to expose themselves under a global coordination regime which accesses individually owned resources, and which distributes the global profit (or loss) among the system members. Related perspectives do exist in organizational theory. *The problem, however, with this approach is that we still lack a well-developed motivational theory for software agents so far (despite the fact, that already a lot of research has been performed on individual and joint intentions [Jennings 1992]).*

3.4 Organization as a social metaphor

3.4.1 Self organization

Organization has often been thought of as a top down concept which has led to the top-down approach of distributed problem solving system. However, there are many problems in which large parts of the problem space are unknown. In such cases agent societies need to emerge bottom up [Conte & Castelfranchi 1995, Ishida, Gasser & Yokoo 1992]. Such systems are called 'multi-agent systems' [Bond & Gasser 1988]. In such systems, also the process of problem solving emerges as a self organizing search process. An important difference to distributed problem solving, however, is that it is generally assumed here that new agents may join the global system at any time, and that agents being already integrated may also leave it at any time just based upon their local decisions.

The conceptualization, and implementation of self organization in multi-agent systems reflects important differences between agent-based systems performing on computers (technical systems), and humans being employed in enterprises (social systems). *It thus may be difficult or even impossible to cross these boundaries as the respective design tasks are too closely related to the particular characteristics of the system types that are constructed, coordinated, and controlled.*

3.4.2 Structure versus organization

Chaib-draa (1996) claims that it is critical to develop frameworks that make DAI systems more adaptable, following some basic notions of organization and organizational change. To this purpose he distinguishes an organization from a structure. A structure is a pattern of information and control relationships that exist between agents, and the distribution of problem solving capabilities among them. The structure thus has to ensure that the multi-agent system can meet the necessary conditions that are essential to successful problem solving: task coverage (all parts of the problem need be addressed), connectivity (all subsolutions must be integrated into the overall result), and capability (task coverage and connectivity must be achievable within the resources and skills available in the system). More general, the structure must specify roles and relationships to meet these conditions.

Compared to this, an organization is less structured in perspective and more related to behavioral approaches of organizational theory. Gasser (1992) views an organization „as a particular set of

settled and unsettled questions about the beliefs and actions through which agents view other agents. Organizational change means opening and/or settling some different set of questions in a different way, giving individual agents new problems to solve and a different set of basic assumptions about the beliefs and actions of other agents“. The concept of organization, in this perspective, is embedded in the beliefs, intentions, and commitments of agents themselves. As such, it represents a sociological perspective on agent organizations. This is different to the theory of organizational design, which also conceptualizes structures in order to design organizational systems [Mintzberg 1979].

The approach presented below integrates both, the perspective of explicit structural relationships (‘formal perspective’ of organizational design) as well as the perspective of how agents build up and maintain their individual models of an organization (‘sociological perspective’ of organizational design). *The main advantage of this approach is that it provides for distinguishing a multi-agent organization from the surrounding agent society, while at the same time it allows for modeling and studying the social, and sociological structures within a MA organization [Kirn 1996].*

4 Research Issues

The discussion of this paper has shown the great ‘conceptual distance’ between organizational sociology, and the use of social and organizational metaphors in DAI/MA theory. On the other hand, we have also seen that research across the boundaries of organizational sociology, and multi-agent systems is quite necessary because of two main reasons:

- Agents, and multi-agent systems are more and more penetrating social, and organized social systems (enterprises) as well as the rapidly emerging field of electronic business.
- In the past, DAI/MA research has mainly been concerned with studying rather small multi-agent systems. In future, however, we will be concerned with large, and very large numbers of agents ‘living’ and interacting in the internet (and/or related electronic networks). We thus urgently need to develop appropriate theories, concepts, and mechanisms to keep track of, and to control the individual and collective behaviors of these agents.

Thus, referring to the empirical evidence of agent technology in all forms of e-business: From the DAI/MA perspective three main research directions on the intersection of organizational sociology, and DAI/MA theory can be identified:

- Research on how intelligent agents and multi-agent systems can be incorporated into the social, the informational, and the intentional systems of more or less formally organized social bodies (enterprises).

- Identification, and exploitation of the interrelationships of the different branches of social, sociological, and organizational research in DAI/MA with organizational sociology with respect to the DAI/MA tasks of describing, analyzing, and designing multi-agent systems.
- Definition, full development, and exploitation of an organizational sociology for ‘artificial’ multi-agent systems.
- Performing empirical studies how intelligent agents and multi-agent systems may affect the definition, the structure, the interaction patterns, and the dynamics of (organized) social systems.

5 References

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