Enrolling software agents in human organizations: the exploration of hybrid organizations within the socionics research program

Schulz-Schaeffer, Ingo

Veröffentlichungsversion / Published Version
Arbeitspapier / working paper

Ingo Schulz-Schaeffer

Enrolling Software Agents in Human Organizations. The Exploration of Hybrid Organizations within the Socionics Research Program

Technical University Technology Studies
Working Papers
TUTS-WP-3-2000
Institute for Social Sciences
Technische Universität Berlin

Berlin 2000

Herausgeber:

Fachgebiet Techniksoziologie
Prof. Dr. Werner Rammert

Technische Universität Berlin
Institut für Sozialwissenschaften
Franklinstraße 28/29
10587 Berlin

Sekretariat Rosemarie Walter

E-Mail: rosemarie.walter@tu-berlin.de

Abstract

To a considerable degree, complex organizations are characterized by internal incoherence, by differences between the individual departments' preferences and patterns of actions and by inconsistencies of the organization's goals. On the contrary, information technology is intended to operate in a coherent way, and, therefore, information systems, designed to support organizational processes, usually proceed from the assumption of organizational coherence. The more traditional approaches to implement information systems in organizations often lead either to dysfunctional restrictions imposed on the organization by the information system's need to establish firm cause/effect relationships. Or, reversely, they lead to incoherence imposed on the information system by the organization's structure. With agent technology, however, we have a chance to arrive at organizational information infrastructures that allow for both sides. The paper describes the theoretical background of the INKA research project (which is part of the socionics research program funded by the DFG) that aims at developing a solution to the problem sketched above by modeling and exploring hybrid forms of interaction between humans and artificial agents within organizational settings.

1. Introduction

Multiagent systems are distinguished from most of the prior technological artifacts and approaches by one basic feature: The components they consist of, the agents, can be modeled to interact in a way that imitates mechanisms of social interaction between human actors. This specific feature of multiagent systems has to be considered in combination with an observation that applies to technology in general: It is a well-known fact in the social studies of technology that technological innovation comprises necessarily the development of a new socio-technical system. Each new technology has to meet certain conditions of the social context of its use (e.g. interests, practices or social rules that influence the user's behavior) to be of use. Together, these two points lead to an interesting, but so far mainly unexplored question: Do we face in the field of multiagent technology a new type of socio-technical systems, one that is characterized by the fact that not only the interrelations between the participating humans, but the interrelations of the technical components too are structured (or can be structured) by means of social interaction? And as a result, will the walls between social action and technical performance break down, confronting us with socio-technical hybrids, systems that "do not distinguish between interactions with humans and interactions with artificial agents" (Parunak 1996: 150)?

There are good reasons, I will turn to later (ch. 6), that it is favorable to start with social interaction in organizations, if one wants to explore hybrid forms of interrelations between humans and agents. To this end, the INKA project (Integration kooperationsfähiger Agenten in komplexen Organisationen)[1], a research project within the new socionics research program, has been established. In the present paper I want to describe the general idea of this project (ch. 3) and show that organizational software agents are an interesting object of research, not only for computer scientists looking for innovative technological solutions (ch. 7), but also for organizational researchers concerned with the question of how to adjust organizational structures to information technology or vice versa (ch. 5), and last

1 The members of the project team are: Hans-Dieter Burkhard, Werner Rammert, Gabriela Lindemann-von Trzebiatowski, Klaus Scheuermann, Markus Hannebauer, Ines Münch, Joscha Bach and the author.

but not least for social scientists in the field of technology studies, who are investigating the interrelations between technology and society (ch. 4). But let me begin with a short outline of the socionics research program.

2. Socionics as frame of reference

Socionics aims at modeling and exploring artificial societies, i.e. social settings that cannot be established or understood without considering the actions of artificial agents (cf. Malsch et al. 1996; Müller et al. 1998). It is a new interdisciplinary field of research which combines sociological knowledge and multiagent technology in three different, but interrelated ways:

Firstly, socionics is concerned with the question of how to use mechanisms of coordination and social exchange between human actors to develop innovative strategies of multiagent problem solving. Here, the rationale is the same as in bionics: Take a principle you have found to structure biological events (or in our case: social events), look if there is a technological problem where this principle may help to come to a solution, and transform it into a technological procedure. Human societies can be viewed as a vast reservoir of methods of joint problem solving between distributed entities (human actors). If you know their structuring principles, i.e. if you have sociological concepts describing them adequately, then there are good chances to use them as models of joint problem solving between distributed technical entities (artificial agents).

While in the first area of socionical research sociological knowledge serves as a means of developing multiagent systems, in the second strand of socionics the means-end relation is in reverse order. Here, the aim is to employ multiagent systems as tools for the simulation of human society or parts thereof, and to use these simulations to improve sociological concepts and theories. The basic assumption is that multiagent systems are “more able to ‘mirror’ societies and groups of people than their alternatives” (Doran/Gilbert 1994: 10). One of the main advantages of multiagent simulation consists in the possibility to deal with the micro-macro gap, one of the central problems in social theory. Multiagent simulation allows “to cross the micro-macro bridge” (Drogoul/Ferber 1994: 6), that is to model interrelations between individual action and social structure. This opens up new opportunities of testing sociological hypotheses and may help to overcome some of the restrictions of previous work in the field of social simulation.

The third research perspective combines aspects of the first two fields of study and adds a new focus of interest directed at hybrid systems of human actors and artificial agents. I raised the main questions of this strand of socionics already in the first paragraph of this paper: How do socio-technical systems change, if they consist of humans and agents that interrelate their behavior by means of social interaction? And what are the soci(ologic)al and technological preconditions and consequences, the prospects and risks of such a development?

The idea that it may be fruitful for sociological research as well as for multiagent research to bring both fields of study together, has already been discussed in the eighties within a group of American computer scientists and sociologists (cf. Strübing 1998). But it took almost another decade to invent a name for the then "Unnamable" (Bendifallah et al. 1988), the term "socionics" coined by Thomas Malsch (cf. Malsch et al. 1996). He and the author developed the framework of socionics outlined above that led to the socionics research program funded by the Deutsche Forschungsgemeinschaft (DFG-Schwerpunktprogramm Sozionik). Within this research program that started in the fall of 1999 there are eight projects, the INKA project being one of them. Each project consists of an interdisciplinary team of sociologists and computer scientists. Each one has its main focus on one of the three socionical perspectives. In our case it is the third one and I myself am a member of the sociological subteam of our project.

3. The INKA project

Generally speaking, the INKA project aims at exploring the conceptual and technological foundations for agent-based systems which are able to deal successfully with problems of the incoherence and heterogeneity of complex organizations. The aim is not only to think about useful multiagent architectures, but about hybrid structures: forms of interaction that are characterized by interrelations between the activities of human actors and artificial agents. A research project like ours can easily lead to mere speculation. To avoid this, it is crucial to base the issues under consideration on empirical research. Therefore, we chose to focus on a concrete domain of application: the field of medical therapy-planning within the complex organization of hospitals.

To a considerable degree complex organizations are characterized by internal incoherence, by differences between the individual departments' preferences and patterns of actions and by inconsistencies of the goals of the organization as a whole. On the contrary, information technology is intended to operate in a coherent way, and, therefore, information systems designed to support organizational processes usually proceed from the assumption of organizational coherence. The discrepancy between the given incoherence of complex organizations and the coherence information technology assumes and requires either leads to the effect that the organizational structures will be forced to adapt to the structures of the information system or vice versa. In the first case, the consequence is that social mechanisms of successfully dealing with organizational incoherence (e.g. negotiation, coalition formation, strategic politics of information, informal structures) will be overruled and invalidated. This weakens the organization's capabilities of self-adjustment because it would be naïve to believe that information systems will cause organizational incoherence to simply disappear. In the second case the information system will adopt incoherent features of the organization which then affects the systems performance.

We hope to contribute to the solution of this problem by reconceptualizing computer supported organizations as hybrid systems of human actors and artificial agents. With agent technology there is a chance of processing organizational data and of supporting organizational decision-making without the need to homogenize the relevant data and the information infrastructure first. The strategy is to replace the globally planned information system with software agents, where each agent in the interactions with other agents represents the interests of its own user (an individual or collective actor). In this way each agent itself can be designed as a coherent piece of software, that is to say as representation of consistent sets of interests and patterns of actions held by an organizational department or a professional. On the global level, however, the missing coherence will at least partially be compensated by the agents' capabilities to interact.

The design of agents as assistants of humans in contexts of social interaction necessarily has to deal with two conflicting goals: On the one hand, the agents are supposed to do what they are intended to do. On the other hand, they shall be capable of behaving adequately in the respective interaction with their users. Hence, the designers have to face a trade-off between restricting the agents' programs of action and conceding them a certain range of autonomous decision-making. The same trade-off also applies to the structuring of human action in organizations. Taking this similarity as a basis for our research, we hope to contribute to developing an empirical foundation for the yet mainly hypothetical questions concerning the options and limitations of hybrid cooperation.

4. The agency of technology in socio-technical hybrids

Usually, we assume technology to be a more or less useful means, a tool controlled by human users which is well-constructed, if it produces the expected effects in a predictable and repeatable manner. From this point of view, the claim that technological artifacts may possess agency seems to be an absurdity or science fiction at best. Nevertheless, at the second glance this perspective turns out to be too narrow even in the face of well-established technology because it does not take into account interdependencies in the behavior of technological artifacts and human actors.

An important step in the direction of a new perspective on technology has been taken by Charles Perrow in his work on organizations. He not only considers human actors, their routines and programs of action to be the components of complex organizations, but technical components – pumps, mains, or computers – as well. Perrow holds that within complex organizations, such as power plants, chemical factories or hospitals, the overall behavior of the system is defined more by the characteristics of the relations between the heterogeneous components than by the single human's actions or the single machine's conduct (cf. Perrow 1986: 146 ff.). By dissolving the traditional boundary between human and material components of organizations, he is able to successfully explain structural causes of organizational accidents. This is a persuasive argument for his concept of technology.

Several researchers in the field of science and technology studies have taken further steps in this direction. With his historical reconstruction of the development of the electric power system, Thomas Hughes has exemplified the advantages of a view that focuses on interrelationships between heterogeneous components of socio-technical systems (cf. Hughes 1987). But the most radical approach in this line of argument is the actor network theory which has been developed by Michel Callon and Bruno Latour (cf. Callon 1987; Latour 1988). Here, the distinction between technology and society is completely dismissed. All components of socio-technical ensembles are viewed as "actants", that is as "entities that do things" (Latour 1988: 303). The authors claim that only with such a symmetrical approach it is possible to describe "techno-social imbroglios" (ibid. 309) in an unbiased way and thereby adequately recognize the contributions of non-human actants (the technical components for instance) to the development and stabilization of socio-technical networks (cf. Schulz-Schaeffer 2000).

The actor network theory employs the weakest possible concept of agency. It considers each event that is caused by an identifiable entity and that influences a given state of affairs as its action. In everyday life and in sociology alike, we usually presuppose at least one additional condition to be met if to concede agency: that the actor could have done otherwise. In the words of Anthony Giddens (1984: 9): "Agency concerns events of which an individual is the perpetrator, in the sense that the individual could, at any phase in a given sequence of conduct, have acted differently." Finally, in human interaction a third criterion can be and will be employed, if there are doubts concerning questions of agency: "it is expected by competent agents of others ... that actors will usually be able to explain most of what they do, if asked." (ibid. 6)

The technological artifacts of everyday life which are the main examples of the actor network theory (door-closer or seatbelts) obviously are actors only in the first sense. In the case of program-controlled technology, the second criterion begins to be applicable, even though their degree of freedom to make a choice is normally limited to pre-planned alternative ways of conduct. This situation changes at least with agent technology, where the autonomy of the agents to decide between different options, their pro-activeness (cf. Wooldridge / Jennings 1995: 2), is taken to be the main point of research and development. In this case, as the BDI approach has shown, it no longer seems to be absurd, to develop and understand technology by using human-centered concepts such as belief, desire and intention (cf. Haddadi / Sundermeyer 1996).

Agency of technology becomes an even more interesting (and difficult to answer) question if you take into account that there is not one monolithic notion of human agency. Rather, each of the three criteria mentioned above represents aspects thereof which do not sum up easily. In particular, it is important to understand that not each human behavior has to meet all the three criteria to pass for an individual's action. Even the first concept of action, where agency is nothing more than the acting unit's capability to make a difference, cannot simply be dismissed as an undue simplification of human affairs. On the contrary, a considerable part of what is usually considered to be human action does not fulfil conditions other than that the individual in question is regarded as having caused it.

Considering the question, whether or nor it makes sense to attribute agency to a specific entity within a socio-technical ensemble, these are reasons not simply to react affirmative (in the case of humans) or negative (in the case of technology), but to assume a continuum of more or less agency on both sides (cf. Rammert 1998: 115f.). Against this background agent technology – as the most ambitious reaching attempt to enable technological artifacts to act – becomes the paradigmatic field for research concerned with the topic of technological agency and with exploring hybrid forms of interrelations between human actors and technological artifacts (cf. Schulz-Schaeffer 1998).

5. Technology in the context of organizational incoherence

Rational choice theories describe organizations as institutions pursuing goals which are well-defined by stable and internally consistent sets of preferences. It is assumed that organizational decision-making is driven by always looking for the best way to reach the organization's goals (cf.. March/Simon 1958: 136ff.; March 1971/1990: 282f.). Empirical studies of organizations, however, support the opposite view that the preferences of organizations are anything but consistent and stable (cf. March 1990: 13f.). Some organizations are "characterized by problematic preferences, unclear technology, and fluid participation" (Cohen et al. 1972: 1) to a degree that makes it feasible to view them as "organized anarchies" (ibid.). In contrast to what rational choice theories suggest, such organizations "can be described better as a loose collection of ideas than as a coherent structure" (ibid.). They "operate() on the basis of simple trial-and-error procedures, the residue of learning from the accidents of past experience, and pragmatic inventions of necessity" (ibid.). The authors claim these properties of organized anarchy to be particularly conspicuous in public organizations, but nevertheless to be "characteristic of any organization in part - part time" (ibid.). Therefore, a "theory of organized anarchy will describe a portion of almost any organization's activities, but will not describe all of them" (ibid.).

Organizational incoherence constitutes a particular problem for implementing technology. The problem is that technology relies on managing causal relationships, pinpointing goals and controlling initial conditions in a way that has proven to be unrealistic for a wide range of organizational conduct. Hence, the crucial question is how to ensure the proper functioning of technology in complex organizations, where preferences often are only vaguely defined, different and possibly conflicting patterns of action are employed and shifting coalitions of interest are to be faced.

According to James D. Thompson the embedding of technology in complex organizations relies on a specific form of internal differentiation: "organizations cope with uncertainty by creating certain parts specifically to deal with it, specializing other parts in operating under conditions of certainty or near certainty" (Thompson 1967: 13). Every formal organization "contains a suborganization whose 'problems' are focused around effective performance of the technical function ... such as the materials which must be processed and the kinds of cooperation of different people required to get the job done effectively" (ibid.: 10). To ensure the efficiency of the technical core exogenous variables that may interfere with the technology as a closed system of cause/effect relationships have to be excluded as far as possible: "Under norms of rationality, organizations seek to seal off their core technologies from environmental influences." (ibid.: 19) An example of this strategy is the stockpiling of materials and supplies as a means to buffer input-disposal uncertainties (cf. ibid.: 20).

However, with the spread of information technology, organizations are more and more confronted with the employment of a kind of technology towards which the strategy of buffering no longer applies. Where information technology is used to support organizational operation, to structure the flow of information and to organize the organization's memory, technology and organization often interpenetrate in a way that doesn't allow to separate a technical core: "Aspects, previously hold to be distinct:

‘technology’ (equipment) and ‘organization’ (control structure) increasingly are merging ... The so-called new technologies extend technology to organizational processes in such a manner that the sociological notion of technology has to be reconceptualized radically. The organizational and social implications of computer-based information technology in the production and in the office are calling for a new sociological definition of technology as ‘fait social’.” (Behr et al. 1991: 159ff.).

There seem to be only two overall strategies of implementing information systems, if one has to assume that in the case of information technology organizational change and technological change are inseparably connected: The first strategy is what has been called “systematische Rationalisierung” (cf. Altmann et al. 1986). It is the attempt to use the information technology’s power of rationalization to restructure the organization’s procedures in a systematic way. For that purpose, it is necessary to formalize processes of organizational decision-making accordingly, to integrate heterogeneous patterns of conduct, to align distinct domains of action and so on. The second way consists in adjusting the information technology to the given organization, what implies to reproduce the organizational structure as the structure of the information system. Where it occurs, this way of implementing information technology mostly is something that just happens unintended and incidentally, rather than an explicit strategy.

Both ways entail some serious problems. The first one underestimates the features of incoherence mentioned above which, especially in complex organizations, are a continuous source of resistance against attempts to systemize processes and states of affairs (cf. Behr et al. 1991: 26, 46). The most important disadvantage of the second way is that the incoherence of the organization’s structure is inherited by the information system, but at the same time the technology does not inherit the mechanisms to deal with it. The individual or collective actors of an organization can cope with inconsistencies and uncertainties of goals, interests and programs of action by using informal modes of coordination, by temporarily forming coalitions and so on. Incoherent structures of information systems, on the other hand, are only weakening the cause/effect relationships technology is based upon and are leading to a loss of efficiency of the system in question.

6. Organizational software agents as starting point for the exploration of hybrid systems

The development of agents which are capable of acting in a certain way entails a crucial difficulty: On the one hand, software agents are supposed to differ from more convenient technological artifacts in that they are not intended to simply execute predetermined technological procedures, but more or less autonomously to perform specific tasks. On the other hand, these agents are not supposed to posses unbounded autonomy. They shall “not really behave freely as humans may” (Burkhard 1995: 299), but support human activities of problem solving. Hence, for a wide range of agent technology applications it seems reasonable to steer a middle course that avoids undue control of agents but undue autonomy as well (Schulz-Schaeffer/Lührs 1998: 22ff.).

As stated above, this trade-off between autonomy and control applies in a similar way to the organizing of concerted human action. For this reason organizations are especially well-suited to serve as the vantage point for the endeavor to integrate artificial agents in human contexts of action. The overall strategy of the INKA project is to exploit this similarity: to restrict or to open up the artificial agents' capabilities to act in a way which matches the restrictions or the degrees of freedom human actors in organizations are facing.

Members of complex organizations are rarely acting as freely as the average competent individual in modern societies is expected to be (at least in principle) able to. Rather, their agency is restricted to specific scopes of duties, they are in some degree urged to follow predefined procedures, the resources at their disposal are limited, and it is regulated by the organization's formal structure what has to be done by order of others. If we understand how the organization members' conduct is structured by such patterns of restricted action, we can hope to design software agents which fit into the organization's frame of reference. With respect to the goal of constructing hybrid systems, an important feature of domains of restricted action is that they make it a lot easier to integrate artificial agents. One main problem of developing software agents, designated to perform as team mates of humans, is to provide them with the capabilities necessary to behave adequately in such a setting. Obviously, this problem is less pressing, where the social setting in question by itself restricts the involved individuals capabilities to act.

As a rule, domains of restricted action are most visible within the subdivisions of a complex organization. On the other hand, problems caused by inconsistent goals and distinct modes of action occur predominantly, where coordination between departments is at stake. Here, especially, we face the kind of organizational coordination problems which cannot easily be solved by given rules and procedures, but demand for actors who are to a certain degree free to evaluate the situation at hand and to act accordingly. Therefore, actors who are confronted with the need to coordinate their department's work with tasks performed by other subunits of the organization have to develop a double orientation of heteronomy and autonomy. On the one hand, they act heteronomously in that they represent their subunits' interests and goals. On the other hand, they are less committed to the goals of the other departments involved, what opens up a certain space for negotiations. In this way complex organizations are able to establish several technological cores – the domains of restricted action – and at the same time to deal with the problem of internal incoherence.

Agent technology allows to model this double orientation and thereby to design information technology that works efficiently in the face of organizational incoherence. On the one hand, the agents have to be designed to act as representatives of their (individual or collective) users. That means, their capabilities to act are restricted by the represented subunits' rules and procedures of goal-attainment. On the other hand, they have to be enabled to autonomously represent their users' interests and goals in the interaction with other (human or artificial) members of the organization. To interrelate the components of the information system we then do not need a pre-planned overall structure, but can use suitable mechanisms of social exchange and social negotiation between agents (and human actors).

The agents' behavior has not necessarily to be very complex in order to contribute to an organization's information infrastructure in such a manner. Where organizations impose restrictions on their members' agency, the entry barriers for integrating artificial agents are comparably low. Therefore, it seems to be a promising strategy to begin with modeling hybrid systems in organizational domains where the humans' (and correspondingly the agents') behavior is regulated to a large extent, and then gradually to enhance the agents' capabilities to act.

7. Agent-based medical therapy planning

As a result of internal functional differentiation of hospitals, there are always several physicians, nurses, diagnostic facilities, and administrative units involved in the treatment of a patient. Within the different departments plenty of electronic data are generated. However, these data often are filed only in the departments' local databases. To transmit such data to other departments or their representatives respectively, they then have to be manually copied, filled into paper forms, and delivered for example by the hospital's pneumatic post system. This is a time-consuming procedure and leads to undesirable delays in the patients' treatment. The hospital, we chose to be our domain of application, employs modern network technology. Nevertheless, incompatibilities between the local databases, the data formats, the query languages used, and the like are obstacles to electronically transmit patient-related data between the hospital's departments.

It is important to understand that this heterogeneity of the information systems is not simply an engineering problem solvable by means of data integration. Rather, it results to a considerable degree from organizational incoherence affecting the information infrastructure. Each department has its own routines of dealing with the data generated there, and often it is a matter of habit to prefer a certain database system. Be it for habitual or rational reasons, the kind of data-processing employed by a department consequently is believed to be more suitable to the own work processes than the other departments' systems. If it is true that in practice it is not possible to eliminate such inconsistencies – and this has to be presupposed in complex organizations to be realistic – then we have to look for information technology which supports gathering and exchanging data within a heterogeneous and incoherent information infrastructure and which does not need to globally integrate the data. This is what agent technology promises to be able to.

The fewest difficulties in assigning tasks to software agents will occur in the case of simple organizational routine, tasks which at present often require a lot of paperwork: requesting and confirming dates in the process of scheduling a patient's medical treatment; gathering the patient's medical data from different departments where they are generated and stored; converting heterogeneous data formats into the format the department in question does use (without manually typing them in again); dealing with the problem of updating (an important problem if it cannot be avoided that similar information is stored at different places), and so on. From this basis we hope to gradually enhance the agents' capabilities to adopt tasks within the process of medical therapy planning which require more deliberation (planning of time-schedules, occupancy planning, medication planning, surgery planning).

8. Conclusion

Agent technology promises to offer a solution for the above mentioned problem of linking organization and technology. The more traditional approaches to implement information systems in organizations often lead either to dysfunctional restrictions imposed on the organization by the information system's need to establish firm cause/effect relationships. Or, reversely, they lead to incoherence imposed on the information system by the organization's structure, what reduces the efficiency of the technology. With agent technology, however, we have a chance to arrive at organizational information infrastructures that allow for both sides. In this respect, an important feature of employing software agents has to be seen in the new opportunities of connecting an organization's local and global processes of coordination.

As shown by a large amount of empirical research on complex organizations, it is not very realistic to believe organizations to be rationally structured means designed to achieve well-defined sets of goals. On the other hand, this does not imply that organizations are completely irrational. Rather, we will usually find organizational domains which are governed in an internally consistent way by certain common norms of rationality. These are the domains of restricted action I referred to above. Within such domains, the chances are good to establish chains of cause and effect, that is to coordinate people and processes technically. Outside of them, the same has not to be true, so that here the more complicated forms of coordination are to be expected.

Unlike more traditional information technology, software agents can be made to fit into this double structure. This means to design agents which on the one hand support their local domain's work processes, and, on the other hand, represent their domain within the organization's information infrastructure. Within such a setting, the agents are directly assisting only the work of certain actors or groups of actors respectively. This considerably reduces the capabilities to act, they need to perform adequately, because the agents have to perceive their environment only very selectively: only as far as needed to contribute to solving specific tasks within specific domains of restricted action. At the same time, each domain's work is more or less interrelated with work to be done in other parts of the organization, and this applies to the organization's information processing as well. As processes of coordinating the work of different organizational subunits often take place under the condition of heterogeneous local norms of rationality, and competing local interests and preferences, they require socially negotiated solutions. The research on modeling mechanisms of social interaction as means of multiagent coordination offers various ideas which hopefully will turn out to be useful in supporting this kind of coordination problems within a complex organization's information infrastructure.

As you will have noticed, the preceding considerations do not come up with results in the sense of describing a hybrid organization already modeled. Rather, the purpose of the present paper was to show that there are good reasons not to view hybrid systems as a subject of pure futuristic speculation, but as a subject of research that has the power theoretically to lead to new insights and practically to result in innovative technologies. In particular, I wanted to stress three lines of argument:

(1) The traditional notion of technology as a passive means to human ends is no longer sufficient to understand the role of technological artifacts within socio-technical systems. For this reason, a strand of research has been developed which uses the concept of technological agency to describe the interrelation of technology and society. Agent technology as an explicit attempt to model agency technically, and hybrid systems as an attempt to connect human and technological agency may help to shed light onto this debate.

(2) As a result of the computer-based information technology's new capabilities to support administrative and planning processes of organizations, organization and technology become mingled in a way which no longer allows to strictly separate the technical procedures from the surrounding organizational activities. Consequently, the organization's information infrastructure has to deal simultaneously with two competing requirements: ensuring technical efficiency and handling organizational incoherence. Reconceptualizing organizational information systems by implementing software agents seems to be a good idea to tackle this problem (and at the same time to explore basic features of hybrid organizations).

(3) It relies heavily on the domain of application whether or not hybrid systems will be developed successfully. On the one hand, it has to be taken into account that even the most sophisticated agents' capabilities to act are far from reaching the taken for granted capabilities of the average human actor. Therefore, we have to look for domains of restricted action, where there is a chance for artificial agents to behave adequately. On the other hand, without looking for tasks where a certain amount of autonomous action is required from the agents in question, there is no reason why to use agent technology at all. In both respects, we assume organizations to be the most suitable starting point for integrating artificial agents into contexts of human interaction.

Bibliography

Altmann, N. / M. Deiß / V. Döhl / D. Sauer (1986): Ein „Neuer Rationalisierungstyp" - neue Anforderungen an die Industriesoziologie, in: Soziale Welt 37, 191–206.

Behr, M. / M. Heidenreich / G. Schmidt / H.-A. Graf von Schwerin (1991): Neue Technologien in der Industrieverwaltung. Optionen veränderten Arbeitskräfteeinsatzes, Opladen: Westdeutscher Verlag.

Bendifallah, S. / F. Blanchard / A. Cambrosio / J. Fujimura / L. Gasser / E. M. Gerson / A. Henderson / C. Hewitt / W. Scacchi S. L. Star / L. Suchman / R. Trigg (1988): The Unnamable: A White Paper on Socio-Computational 'Systems', Research Note 60, DAI Group, University of Southern California, unpublished draft manuscript available from Les Gasser, Department of Computer Science, University of Southern California, Los Angeles.

Burkhard, H.-D. (1995): Agent-Oriented Programming for Open Systems, in: M. J. Wooldridge / N. R. Jennings (Hg.): Intelligent Agents. Proc. of the ECAI-94 Workshop on Agent Theories, Architectures, and Languages, Berlin: Springer-Verlag, 291–306.

Callon, M. (1987): Society in the Making: The Study of Technology as a Tool for Sociological Analysis, in: W. E. Bijker / Th. P. Hughes / T. J. Pinch (Eds.): The Social Construction of Technological Systems. New Directions in the Sociology and History of Technology, Cambridge, Mass.: The MIT Press, 82-103.

Cohen, M. D. / J. G. March / J. P. Olsen (1972): A Garbage Can Model of Organizational Choice, in: Administrative Science Quarterly 17(1), 1-25.

Doran, J. / N. Gilbert (1994): Simulating Societies: An Introduction, in: N. Gilbert / J. Doran (Hg.): Simulating Societies. The Computer Simulation of Social Phenomena, London: UCL-Press, 1-18.
Drogoul, A. / J. Ferber (1994): Multi-Agent Simulation as a Tool for Modeling Societies: Application to Social Differentiation in Ant Colonies, in: C. Castelfranchi / E. Werner (Hg.): Artificial Social Systems, 4th European Workshop on Modelling Autonomous Agents in a Multi-Agent World, MAAMAW '92, S. Martino al Cimino, Italy, July, 29-31, 1992, Selected Papers, Lecture Notes in Artificial Intelligence 830, Berlin: Springer-Verlag, S. 3-23.

Giddens, A. (1984): The Constitution of Society: Outline of the Theory of Structuration, Cambridge: Polity Press.

Haddadi, A. / K. Sundermeyer (1996): Belief-Desire-Intention Agent Architectures, in: G. M. P. O'Hare / N. R. Jennings (Eds.): Foundations of Distributed Artificial Intelligence, New York: John Wiley & Sons, 169-210.
Hughes, Th. P. (1987): The Evolution of Large Technological Systems; in: W. Bijker / Th. P. Hughes / T. Pinch (Eds.): The Social Construction of Technological Systems, Cambridge, MIT 1987, 51-82.

Latour, B. (1988): Mixing Humans and Nonhumans Together. The Sociology of a Door-Closer, in: Social Problems 35(3), 298-310.

Malsch, Th. / M. Florian / M. Jonas / I. Schulz-Schaeffer (1996): Sozionik: Expeditionen ins Grenzgebiet zwischen Soziologie und Künstlicher Intelligenz, in: Künstliche Intelligenz KI 2/1996,. 6-12.
March, J. G. (1971/1990) : Die Technologie der Torheit, in: J. G. March (Ed.) (1990): Entscheidung und Organisation. Kritische und konstruktive Beiträge, Entwicklungen und Perspektiven, Wiesbaden, 282–295 (first published in: Civilökonomen 18, 1971).
March, J. G. (1990): Einführung. Eine Chronik der Überlegungen über Entscheidungsprozesse in Organisationen, in: J. G. March (Ed.): Entscheidung und Organisation. Kritische und konstruktive Beiträge, Entwicklungen und Perspektiven, Wiesbaden, 1–23.
March, J. G. / H. A. Simon (1958): Organizations, New York: John Wiley & Sons
Müller, H. J. / Th. Malsch / I. Schulz-Schaeffer (1998): Socionics: Introduction and Potential, in: Journal of Artificial Societies and Social Simulation 1(3).

Parunak, H. Van Dyke (1996): Applications of Distributed Artificial Intelligence in Industry, in: G. M. P. O'Hare / N. R. Jennings (Eds.): Foundations of Distributed Artificial Intelligence, New York: John Wiley & Sons, 139-164.
Perrow, Ch. (1986): Complex Organizations. A Critical Essay, 3rd Ed., New York : Random House.

Rammert, W. (1998): Giddens und die Gesellschaft der Heinzelmännchen, in: Th. Malsch (Hg.): Sozionik. Soziologische Ansichten über künstliche Sozialität, Berlin: Edition Sigma, 91–128.

Schulz-Schaeffer, I. / R. Lührs (1998): Sozialvorstellungen in der Verteilten Künstlichen Intelligenz, in: Proceedings zum Workshop Sozionik auf der 22. Jahrestagung Künstliche Intelligenz, 15..-17.9.1998 in Bremen, 14-26.
Schulz-Schaeffer, I. (1998): Akteure, Aktanten und Agenten. Konstruktive und rekonstruktive Bemühungen um die Handlungsfähigkeit von Technik, in: Th. Malsch (Ed.): Sozionik. Soziologische Ansichten über künstliche Sozialität, Berlin: Edition Sigma, 128-167.
Schulz-Schaeffer, I. (2000): Akteur-Netzwerk-Theorie. Zur Koevolution von Gesellschaft, Natur und Technik, in: J. Weyer (Ed.): Soziale Netzwerke. Konzepte und Methoden der sozialwissenschaftlichen Netzwerkforschung, München: R. Oldenbourg Verlag, S. 187-209.

Strübung, J. (1998): Multiagenten-Systeme als „Going Concern“. Zur Zusammenarbeit von Informatik und Interaktionismus auf dem Gebiet der Verteilten Künstlichen Intelligenz, in: Th. Malsch (Ed.): Sozionik. Soziologische Ansichten über künstliche Sozialität, Berlin: Edition Sigma, 59-89.

Thompson, J. D. (1967): Organizations in Action. Social Science Bases of Administrative Theory, New York: McGraw.

Wooldridge, M. J. / N. R. Jennings (1995): Agent Theories, Architectures, and Languages: A Survey, in: M. J. Wooldridge / N. R. Jennings (Eds.): Intelligent Agents. ECAI-94 Workshop on Agent Theories, Architectures, and Languages, Amsterdam, The Netherlands, August 8-9, 1994, Proceedings, Berlin: Springer-Verlag, 1-39.