

### Where the action is: distributed agency between humans, machines, and programs

Rammert, Werner

Veröffentlichungsversion / Published Version  
Arbeitspapier / working paper

#### Empfohlene Zitierung / Suggested Citation:

Rammert, W. (2008). *Where the action is: distributed agency between humans, machines, and programs*. (TUTS - Working Papers, 4-2008). Berlin. <https://nbn-resolving.org/urn:nbn:de:0168-ssoar-12331>

#### Nutzungsbedingungen:

Dieser Text wird unter einer Basic Digital Peer Publishing-Lizenz zur Verfügung gestellt. Nähere Auskünfte zu den DiPP-Lizenzen finden Sie hier:  
<http://www.dipp.nrw.de/lizenzen/dppl/service/dppl/>

#### Terms of use:

This document is made available under a Basic Digital Peer Publishing Licence. For more information see:  
<http://www.dipp.nrw.de/lizenzen/dppl/service/dppl/>

*Werner Rammert*

**Where the action is: Distributed agency between humans,  
machines, and programs\***

The Technical University Technology Studies  
Working Papers

**TUTS-WP-4-2008**

# Where the action is: Distributed agency between humans, machines, and programs<sup>\*</sup>

*Werner Rammert*

## 1. Distributed agency: A concept beyond human action and technical means

Usually, the action is where the humans are. Action means moving the body, making something, being initiative, bringing about an alteration by force, and expressing oneself thereby. Action becomes particularly visible, when there is unexpected reaction to something or resistance to somebody's will. In the humanities and social sciences, action is closely associated with the anthropological concepts of man the artist and tool-maker or the speaker and symbol-communicator (cf. Leroi-Gourhan 1980). Human action – defined to be intentional and creative – is often sharply distinguished from animal behavior that is characterized as instinct-driven and only tool-using and from machine operation that is described as a repetitive and pre-programmed activity. If we continue to define action by the demanding features of intentionality, rationality or reflexivity that are attributed to humans only, then – no wonder – all other uses of the term action in everyday life and actual technology developments would be only metaphors or even categorical mistakes. In this case we would miss and misunderstand the massive changes in intelligent machine design and interactive media use that open up Pandora's box filled with thousands of agents. These software or hardware agents equipped with belief, desire and intention algorithms are able to take part in manifold actions and even to change their action programs by case-based learning. Surely, they are different from human actors, but they are also different from classical machines and media. Both features, their particular capacities of being active and interactive and their growing population in everyday gadgets and in the worldwide web of the internet, justify the following enterprise to develop a more symmetrical and sophisticated concept of agency.

What are people talking about when they use the word 'action' in everyday life? Do the youngsters still mean the good old human action, when they are acting in videogames inducing an avatar to follow and fight other creatures only by button-pushing? It is evident that button-pushing in this case is not the one single and simple instrumental action of fighting with swords, but one activity under many others: It activates a cascade of programs which themselves activate characters that show contingent action in a virtual action environment. The players surely know the fundamental difference between the other human actors and the artificial agents in the game; but they are more interested in the interactivity and the particular high level of agency that they experience during their interaction with both kinds of partners or adversaries: the humans and the agents.

We learn something about the meaning of action, when we listen to people talking about the genre of action movies. They do not only mention the human actors who are in states of super-activity like running, jumping, or shooting and who are entangled in highly interactive situations like chasing one another or fighting with one another. Action includes

---

<sup>\*</sup> I thank Cornelius Schubert for critical comments and Kristina Brandt for technical assistance. This paper would not have been written without the DFG-support „Technik in Aktion“ and the invitation to the ZiF research group „Science in the Context of Application“ at the University of Bielefeld.

more than human bodies in interaction. It is closely connected with the activities of high-speed vehicles, explosives and firing weapons as we know so well from James Bond movies. Action of this special kind emerges from accelerated sequences of action of all kinds of acting units. The impression and fascination of action is finally produced by the many interactivities between the mixed agencies, not by the human interaction alone.

Actually, computer and media scientists use the vocabulary of human action when they describe the features of new technologies. Are software agents e.g. really acting like human actors, when they ask the user for tasks, when they cooperate and compete with one another in the artificial society of agents, and when they assist persons in their daily actions of sorting out e-mails, searching for optimal traffic connections, looking for best prices, booking tickets and buying investment papers? Is it correct when interface designers speak about Human-Computer-Interaction (HCI) and students of Distributed Artificial Intelligence call their programs 'agents' or 'multi-agent-systems' because they are constructed with the explicit intention to act like a person who is acting in the name of an other person? Action can be composed of different acts, and some can be delegated. Collective actions can be unified in a corporate actor like an organization. They can be divided between principal and executive agents (cf. Coleman 1990). If the actions are distributed between human actors and nonhuman agents (cf. Latour 1988), why should we treat this 'hybrid constellation' not as a particular kind of a collective actor?

Answering the main question 'where the action is' seems actually more complicated than before. The introducing considerations have alluded to four relevant changes in the sphere of human-technology-relations that ask for some conceptual revisions:

- The number of acting units and the kinds of action are increasing for the first time, since modernity and enlightenment have successfully diminished it by banning moving objects and talking trees, inviting nymphs and punishing gods, speaking oracles and helpful angels out of the sphere of action into the world of fetish and fiction.
- Instrumental actions between active people and passive objects are turned more and more into relations of interactivity between two heterogeneous sources of activities. The analysis and design of these relations require a more balancing approach of interactive contingency than a hierarchical one of instrumental causality.
- Actions are fragmented in many pieces and delegated to myriads of pro-active and cooperative agents on the back stage where they perform parts of the action by mimicking human agency and interpersonal interaction.
- Actions emerge out of complicated constellations that are made of a hybrid mix of agencies like people, machines, and programs and that are embedded in coherent frames of action. The analysis of these hybrid constellations is better done with a gradual concept of distributed agency than with the dual concept of human action and machine's operation.

In this paper it is argued that the advanced technologies take part in the course and constellation of human action and that they do this with real effects, not only metaphorically. The first part starts with the search for a useful concept of agency that enables the researcher to describe and classify all activities that contribute to the performance of an action. The concept shall include different levels of human agency as well as different levels of technologies in action (2). The following chapter treats the consequences that these activations of technologies have for the human-technology-

relation. If technologies change their role from passive means into agents and mediators, then the narrow concept of instrumental action should be replaced by a broader concept of inter-agency (3). This part of the paper culminates in the presentation of a gradual model of agency that can be used to describe and discriminate between different levels and grades of action without any regard to the ontological status of the acting unit, may it be human-like or machine-like (4).

In the second part of the paper the question ‘What is the adequate unit of action?’ is answered. It starts with a thought experiment about the question: Who is really flying the Airbus? We learn from both views, the humanist’s and the technologist’s one, that what is usually called action, like flying 240 tourists to Tenerife airport, consists of many distributed actions that have to be coordinated by social organization or technical configuration (5). The concept of distributed agency is spelled out during three steps: It presupposes many loci of agency, not one actor (5.1). It declares the hybrid constellations made of the mixed human and material agencies to the adequate research unit, neither the homogeneous social organizations nor the technical configurations (5.2). Finally, a third mode of integration called ‘framed interactivity’ is elaborated that may emerge between the hierarchical mode of master-slave-relation and the open mode of autonomous systems (5.3).

## 2. Technologies in action: From artifacts to agents

Human action and technological operation belong to two different worlds: the realm of freedom and the realm of forces. Following Kant’s definition, human action is characterized by its moral autonomy from external forces and laws. Although humans are subjected to these forces, they have the capacity (free will) to give themselves the rules of action that may become the general maxims for others, too. Referring to Reuleaux’s definition, machines follow the very idea of forced movements. Heteronomy is the characteristic of von Foerster’s “trivial machines” that are completely determined systems (cf. von Foerster 1985). The dichotomy of tool-maker and artifact is completed by the dichotomy of rule-making und rule-following.

This fundamental dichotomy may be helpful to divide between the ontological spheres of morality and causality. But it should not be applied to our questions of empirical changes and practical consequences. If we want to analyze the gradual changes of advanced technologies, the qualitative changes of the interaction between people and technologies, and even more, the re-configurations of the hybrid constellations from which action emerges, then we have to overcome this dual concept of action and operation. Thus we start with a symmetrical concept of agency that permits us to describe and classify what could be meant with the feature ‘in action’. On this low level, we look for features of self-movement, activeness and self-acting.

How can we decide whether advanced technologies have changed and under which aspects? Let us take the five aspects that are often used in the engineering literature: technology as motor/driver (“Motorik”), as actuator (“Aktorik”), as sensor system (“Sensorik”), as information processor (“Informatik”), and as communicator (“Telematik”). Under the aspect of motion, we can state that the gadgets and machines have gained higher degrees of self-movement: from one central stationary steam engine towards distributed systems of many engines empowered by electric drive, from externally driven carts and coaches to self-driven vehicles, called automobiles. Under the aspect of acting and working,

we make out a strong drift from crafted tools over mechanical machines to automatic systems.

The next three aspects seem to be of critical importance for the level of technologies which are subsumed under the label of “smart machines”, “intelligent systems”, “new electronic media”, or “high technology” (cf. Rammert 1992). Under the aspect of context sensibility, we actually realize a strong tendency away from systems that are completely blind to ones that are equipped with a feed-back mechanism up to highly sensible systems that are able to realize situations and to adapt their action to changing environments. The greatest steps in the direction of activating technical objects have been made under the aspect of information-processing: Looking backward, we reconstruct the movement as a loop from hard-wired tools and machines whose plans of activities are incorporated in the design of the artifact, via flexible machines that are programmed by cards and records towards highly autonomous systems that are strongly self-controlling their activities by nested systems of computer programs. Last, but not least, the aspect of communication between objects has emerged. Communication about the state of the machines’ activity has been the task of people observing them at the work bench or in the office of the factory supervision. The direction is now inverted: the machines, the gadgets and even the products themselves observe the states, places and times of their actual activity and communicate them to the people and also with one another via cable (Internet) or radio frequency (RFID).

<b>ASPECTS</b>	<b>From</b>	<b>Change</b>	<b>Towards</b>
<b>Motor</b>	stationary gadget		mobile agent
<b>Actuator</b>	passive instrument		pro-active agent
<b>Sensor</b>	blind machine		context sensible agent
<b>Processor</b>	hard-wired artifact		programmed agent
<b>Communicator</b>	single apparatus		cooperating agent

*Figure 1: Aspects of technological change*

The actual advanced technologies show signs of increased self-activity under each aspect. As they are human-made technologies, they remain artifacts. But they loose their passive, blind, and thumb character and gain the capacities to be pro-active, context-sensible and co-operative. Insofar as the technical artifacts have been put into action by these changes, it is justified to define them as agents.

What are ‘agents’? From a technological view, agents are particular computer programs. They are written with the intention that software agents can execute actions like human agents. That means that actions are delegated to them. The agents divide and delegate the action among other agents. They cooperate with one another, thereby moving, being initiative and addressing others. They coordinate the cooperation themselves and communicate the result of their activities to the human user. In a seminal text on intelligent agents, the main characteristics are presented as relative “autonomy”, a particular

“reactivity” to the environment, “pro-activeness”, and “sociability” (cf. Wooldridge and Jennings 1995). From a sociological view, agents are persons who act in the name of a principal, e.g. the owner of an enterprise or as an informant of a party in a strategic spy game (cf. Goffman 1969). The business and the secret service agent are bound to the general aims of the principal, but they are free to choose the adequate actions. Their actions are not blind executions of the principal’s will. Agent-oriented programming and the design of architectures for multi-agent-systems follow this social concept of an agent and take over other mechanisms of society like cooperation, competition, trust or community in order to establish more flexible systems of distributed artificial intelligence. The up to now dominant design of a master-slave-architecture is slowly replaced by open systems of distributed and cooperating agents. The higher grade of activeness given to the software agents motivates the software engineers and the system designers to transfer those social and sociological concepts which have been proven as successful mechanisms of coordination (cf. Schulz-Schaeffer 2002).

Technologies are changing on the level of technical systems, not only as concrete tools, machines, media, and sign processors. They show higher levels of complexity, they are more heterogeneously combined, and they are more complicatedly nested with one another. A review of the advanced technological and media systems hardens the impression of a radical change in quality, not only in quantity and diffusion of technical objects. The Airbus is highly complex in a different way than a cathedral that is also made of millions of stones, glass pieces, and thousands of fixed relations between them, or than a Cadillac car in the fifties that is assembled out of thousands of exchangeable parts and tackles hundreds of variable relations between them. The cathedral and the Cadillac, however, combine heterogeneous materials and technologies, but the construction of an Airbus requires the integration of much more diverse technologies in an incomparable way. Especially, the embedding of so many different programmed physical and information systems in one plane produces the system’s opacity that favors the interpretation to be confronted with an autonomous being. Stanley Kubrick has obviously demonstrated this strange feeling in his “Odyssey in Space” when the computer system HAL that was a part of the automated space ship had to cope with contradictory rules in his program, then resisted to human control and started to follow its own rules of action.

It is precisely to escape such fantasies of autonomous action on the one side and the stubborn notion that technologies show no sign of agency on the other side, why a more differentiated approach to the problem of technology in action should be developed. A scale with five levels of agency is presented here that may be seen as a first step on this route. The principle of its construction refers to the performance of technical objects and systems, not to their function. It also refers to the above mentioned aspects and their interrelatedness. Examples from different technological domains are given for reasons of understanding. This scale shall raise the awareness about different levels of agency and can be used for descriptive and classificatory reasons.

<b>LEVEL OF AGENCY</b>	<b>Description</b>	<b>Examples</b>
<b>Passive:</b>	Instruments completely moved from outside	Hammer; Punching card
<b>Semi-active:</b>	Apparatus with one aspect of self-acting	Machine tool; Record-Player
<b>Re-active:</b>	Systems with feed back loops	Adaptive heating system
<b>Pro-active:</b>	Systems with self-activating programs	Car stabilization; Help agent
<b>Co-operative:</b>	Distributed and self-coordinating systems	Mobile robots; Smart Home

*Figure 2: Levels of agency for technical objects*

It is not so easy to give examples that are typical of the particular level. The position in the scale depends on the precise description of the equipment and the connectedness between its parts. A brake can be a simple tool that functions mechanically. It can also be activated by a little motor; then it changes to the level of a semi-active hydraulic machine. When the brake is connected with a feed-back measurement instrument, then it operates on the level of re-activeness. Actual brake systems in the ICE or TGV trains are to be allocated on higher levels: They are pro-active, because they start their action themselves after having monitored and computed critical dates of inner and outer states. When there is also communication between the brake systems at the different wheels, then we can speak of a distributed and co-operative system. What can be learnt from this example? New insights cannot be gained talking about agency on the first two or even three levels. It is completely sufficient to use the mechanical vocabulary of operation and determined movements. When the parts of a technical system, however, can behave not only in one pre-fixed way, but more flexible, when the interaction with other parts or the interaction with the environment changes the behavior, and when some parts actively search for new information to select their behavior and even more to change their pre-given frame of action, then and only then it makes sense to use the vocabulary of agency and interaction in the world of objects.

### 3. Types of Inter-Agency: From instrumentality to interactivity

What makes it happen that a move, a behavior or any other activity is recognized as a significant gesture or a meaningful action? How do we know that a twinkling eye is only a body reflex or an intended signal to be willing to flirt? How do we know whether a twinkling sign on our screen of our PC is a mechanical mistake, a routine recommendation to continue writing at this point or the triggered sign of an unexpected spy software? If one follows the social theory of pragmatism, the answer would be: One has to observe the sequence of three acts and relate them with one another as a circle of interaction. It is only at the end of this threefold interaction process that one can attribute the label causal effect, instinctive behavior or meaningful action to the initial move.



*Act 1: Twinkling eye      Act 2: Twinkling back      Act 3: Twinkling and laughing*

*Act 1: Twinkling eye      Act 2: Twinkling back      Act 3: Looking away*

*Act 1: Twinkling eye      Act 2: Looking ashamed away      Act 3: Looking also away*

These three sequences demonstrate that the meaning of the twinkling eye in act 1 can be only ascertained after the next two acts: In the first line, the additional laughing completes the interaction circle and makes the first twinkling to a significant part of a social interaction called flirting. Act 3 in the second line constitutes the same meaning, but a different attitude to it, namely to be not interested in flirting. The two following acts of looking away in the third line seem to constitute a different meaning to the twinkling eye in act 1: It is an illness of nerves why one does not want to stigmatize the person. What is important to state in our context of argumentation, that is the central message of pragmatic interactionism: The observed and practiced interactions between the units of agency make critical differences and constitute the relevant meanings, not the single act.

This approach is usually applied to interpersonal interactions between human actors only, like in the case above. But one can find some hints in the literature that the approach can be also transferred to relations between people and objects (cf. McCarthy 1984). For systematical reasons and for our particular purpose, three types of inter-agency should then be distinguished:

- *Interaction* between human actors,
- *Intra-activity* between technical agents, and
- *Interactivity* between people and objects.

*Interpersonal interaction* constitutes the social world of ‘inter-subjectivity’. It is populated by human actors, expectancies and communications; it is structured by institutions, social systems and cultural meanings; it is the classical subject of the social sciences. Technical objects are principally excluded from this sphere of pure sociality; they figure either as neutral means for purposeful action, either as irritating objects from outside the society, or they are interpreted as mere carriers of meanings.

*Intra-activity* is a quite unusual term: In analogy to the relations between people it can be confined to the relations between objects, especially between technical agents. It constitutes the material world of ‘inter-objectivity’ (cf. Latour 1996; cf. Rammert 1998). In so far as the objects show low levels of agency – according to our scale – and in so far as they are strongly coupled in linear, sequential or otherwise aggregated ways, one need not open the black box to study the internal operations. If they, however, display higher levels of agency and show more loosely coupled relations between the units, like in the cases of complex and high risk systems or in cases of distributed and multi-agent systems, one should also follow the activities of the objects and describe their intra-activities. Otherwise one could not understand the differences which come up, when people get into use relations with these kinds of technical systems. For it makes a difference whether people encounter an encapsulated system or a cooperating ensemble of agents, a hierarchical fixed order or an open network with case-based learning.

*Interactivity* is the term that is reserved for the cross-relations between people and objects. It belongs to the hybrid world of “interfaces”, “human-computer-interaction” and “socio-technical systems”. This boundary territory is widely occupied by the engineering sciences and their techno-morph approaches, like the ergonomic models of the user as a body machine and a sensory mechanism, or the psychological models of “human factors” and “adaptive organism”. It seems that the social sciences have given up this terrain at the limits of the social sphere, supposedly because they fear the contagious contact with “objectuality” (cf. Knorr Cetina 1998) and “materiality” (cf. Pickering 1995). Exceptions from this theoretical withdrawal can typically be discovered in the cultural media and the science and technology studies. Bruno Latour has developed the most ambitious approach to re-present the things in the polity and to “re-assemble the social” including human and nonhumans (cf. Latour 1994; cf. Latour 2005). In my view, his actor-network methodology succeeds very well in bringing the “missing masses” (cf. Latour 1992) into the collective play, but the semiotics of actants (cf. Akrich and Latour 1992) cultivate a certain blindness towards observable actions and interactions and underrates processes of sense-making. Basing social theory in pragmatism may perhaps help to overcome such weaknesses (cf. Rammert 2007).

Pragmatism’s social theory of interaction has been shown to be fruitful to explain the production of social meaning by interpersonal interactions. This approach can also be used to analyze the relations of interactivity between people and physical objects. Georg Herbert Mead is famous for his comparative interaction analysis of two dogs fighting with one another and of two men boxing and faking against one another (cf. Mead 1963). He has developed a not so well-known, but remarkable piece of theory about human interaction with physical objects: Children start to draw distinctions between different kinds of objects (own body, outside objects, moving, and living objects), after they had learnt the interpersonal role-model of social interaction (cf. Joas 1989; cf. Mead 1932). They analyze the activities and attributes of physical objects by taking over the role of them, as they have learned it by playing mother’s or sister’s role. Being heavy, flexible, moving, having an outer surface and an inner kernel, making noises and behaving in an un-anticipated way, all these features of objects are experienced in the children’s play with stationary, mobile and interactive objects. Socialization encompasses both processes, the interpersonal interaction between people, but also the interactivity with physical and symbolic objects.

This integrated view on inter-agency has implications for our own enterprise here, namely the inquiry into the changing character of advanced technologies and its consequences for the human-technology-relations. As long as technologies, like simple tools and machines, can be characterized as passive or semi-active means, they are used in an instrumental mode: People take and handle them to attain their goals at work or in other everyday life situations. The effective action of a tool or a machine is incorporated in its design, like the hammer’s long shaft and heavy weight at the end or the engine’s encapsulated explosion and the spark generated by the turn of the key. Therefore, the user can integrate these objects as mere instruments into his action. One can immediately take this kind of technology in use, and one can rely on the fixed function and the repetitious operations. One has neither to choose options out of a menu of options, nor is one involved in a dialogue with the machine. The only resistance or unexpected re-action of the technology would come up, if the machine is out of function or the user is completely incompetent. When sociologists speak of “instrumental action”, then they refer to this kind of *unmediated instrumental relation* between a man and a machine or a woman and a tool.

Gadgets and machines with higher complexity must be instructed before they start their efficient and useful activities. Simple versions of instruction can be already found at the classical tool machines: The craftsman instructed the machine by turning wheels and tuning measurement instruments. What started as a slow specialization of instructing machines by Jacquard cards, paper stripes or record play-back that was revolutionized by the invention of computer control and software programming since the 1940ies. The instruction of the machines' activities became a separate domain. In the long run, the devices were miniaturized and integrated in nearly every machine and gadget. They were turned into programmable machines, interactive media or smart objects. The instrumental use was changed: It was the beginning of an *instructive-communicative relation* between people and objects.

The rise of a third kind of relation can be observed when the machine asks back: Can I help you? Do you really want to delete the document? Please, tell me what makes you so sad? What looks like a dialogue between a woman at the reception and a guest, an assistant and his boss or a doctor and a client, that was the beginning of a new kind of relation between people talking to the machine on the one side and software programs that took over the roles of communicators, coordinators and agents of all kinds on the other side. Weizenbaum's ELIZA-program showed only marginal changes on the program's side (cf. Weizenbaum 1977). The program's reaction was restricted to take up some key words of the client's answer and to integrate them in a set of pre-given question sentences. Nowadays, the software agent technology has developed a much wider range of capacities to show higher levels of agency. The agents can deviate from the standard expectations. They can choose an activity out of a bundle of activities. They can assimilate their behavior to the personal user. They can normalize their behavior by drawing from statistics, and they can change their behavior by case-based reasoning. These features of agency force the user to conceive the relation, as if an intelligent agent or partner were acting on the other side. Under these conditions of contingency and interagency, *interactive-communicative relations* are emerging.

Human-technology-relations change, when technologies are turned into more active agents and agencies. The instrumental relation that is typical for using tools at craft work and using machines like a tool is fading or only stage-managed as an illusion. The push on the button, the foot on the brake, and the click with the mouse trigger the activities between several agencies that more or less guide the machine, delegate the information-finding to Google's search algorithms, or confront the user with unexpected offerings and assistance because the profiling programs have made the user to an object. The user of this type of advanced technologies is neither the master of the machine nor the slave of the technological system, neither the sovereign of his action nor the victim of media's manipulation. A different concept is needed to decide the question of mastery or manipulation, case by case. The wider concept of inter-agency replaces the narrow one of instrumental use and of the perversion of means and goals. The more precisely both activities, the agency of objects and the inter-agency between objects, can be observed, the more the human-technology-relation shows features of complex and contingent interactivity. Then the instrumental relation is only one particular case of an interrelationship. Relations of instructive and communicative interactivity are the other cases. They shall dominate in the future, because nearly all kinds of technical objects shall

be equipped with programmed agency and shall be made able to communicate with their environment (cf. Adelman, Floerkemeier and Langheinrich 2006).

#### 4. A gradual model of agency: Analyzing humans, machines, and programs in action

The level of human agency is not necessarily always higher than the agency of machines and programs. Now we bring together the two lines of argumentation that have been presented before separately. When people are in action, their level of agency is not always the highest possible one. They may act routinely, like handing over five 100 Euro notes at the bank counter. Or they may even do something without any intention, because they follow a hidden curriculum of a repressed desire. Reflexive action takes place, when problems arise or irritations emerge in the course of action. Then people can switch from subconscious or routine action over to the next higher level of agency, searching for alternative courses of action or reflecting on the moral meaning. If one would count the activities of people, only five percent could be classified as actions with reflected intentions. The rest follows practical reasons that could be mostly explained if asked for, or it follows everyday routines that often lack even practical reasons (cf. Kaufmann 2008).

When machines and programs are in action, their level of agency can be higher than usually perceived. Cash machines hand over the money like the human actor, at the same time examining the client's identity and credit line, varying the number of notes, signaling misuse, and stopping its activities. Even more, video surveillance cameras can be combined with pattern recognition software, interactive data-banks, and programs that process and mail notices of payment dues. They execute and coordinate actions a lot of police men on the street and employees in the offices would be needed for. Very simple dispositions are inscribed in this really existing London City law enforcement system. One can imagine multi-agent-systems to assist space flights or financial brokering whose software agents are equipped with even higher ranges of belief, desire and intention capacities in order to learn from reactions of other agents and from changing environments.

When the fundamental duality should be overcome to give all action to the people and no parts of the action to the objects, then a concept of agency is required that also works with lower qualifications of the case what an action is, on the one side. At the other side, it has to be more sophisticated about the question what kind of action do we observe. Thus a gradual and three-level model of agency was developed, thereby referring to and distancing from Giddens' three-level model of action and Latour's flattened concept of agency (cf. Rammert and Schulz-Schaeffer 2002). Giddens distinguishes three levels of an action: a first one where a difference of state is produced, a second one where a difference of options is possible, and a third one where actors can give an explanation for their action if asked (cf. Giddens 1984). We do not understand these levels as a necessary condition of action, but we interpret them as different levels of agency. We call these three levels "causality", "contingency" and "intentionality". Latour, however, pleads for a methodological and ontological symmetry and reduces all action to his flattened concept of agency (cf. Latour 1988; cf. Latour 2005). We share his anti-dualistic methodology, but we insist on levels and degrees of agency.

On the first level of *causality*, we start with a weak term of action. Agency of this kind means an efficient behavior, a behavior that exerts influence or has effects, like in the Latin

term “agere” or in Latour’s term “actant” or Callon’s term “translation” (cf. Callon 1986). Under the performative aspect on this level, it doesn’t make any difference whether humans, machines or programs execute the action. The money is handed over either by cash machines or by bank employees. The situation changes when greater irritations and more options come into play.

On the second level of *contingency*, the criterion of contingent action is required, that means the capacity to act in a different way and to choose between options. When the environment changes, the routine action program has to be changed and adapted to it, by people as well as by programs. Another possibility arises, when the own action program is changed in such a way that its consequences are not immediately transparent and accountable for the others. When technologies reach this level of contingency, they can no longer be used as immediate instruments and do not follow the paradigm of command and execution, as has been demonstrated in the previous chapter. Instrumentality is replaced by relations of interactivity. Dialogical inter-faces and internal user-modeling increase the action level. Interactive videogames create spaces of high virtual contingency (cf. Esposito 1995) that simulate human user’s action. These technologies function like a Turing test (cf. Turing 1950): They make it nearly impossible to discriminate between human enacted and computer enacted characters in the play.

On the third level of *intentionality*, the species of reflexive and intentional action is allocated. As long as intentionality is by definition ascribed to conscious and knowledgeable human actors only, this level is the domain of meaningful action that is oriented to the supposed meaningful action of other actors. Chess playing programs cannot literally have the intention to win a play, but they can be constructed as if they had an intentional structure – the philosopher Dennett calls it “from an intentional stance” (cf. Dennett 1995). Software agents cannot bodily cooperate with others and trust them under the explicit belief to augment their chances to reach a common goal. But they can be equipped with an intentional vocabulary by which they really coordinate and communicate their activities like human actors do with similar semantics. On this level, we plead against a substantial definition of action that excludes inquiries into agency. Instead we follow pragmatism, what means to follow all kinds of agencies and to focus on the observable practices at which cases the vocabulary of intentionality is used for the control or interpretation of activities of people as well as of technical objects (cf. Rammert and Schulz-Schaeffer 2002; cf. Schulz-Schaeffer 2007).

<b>LEVELS</b>	<b>low</b>	<b>DEGREES</b>	<b>high</b>
<b>III.</b>		up to guidance by complex semantics	
<b>Intentionality:</b>	from ascription of simple dispositions		
<b>II.</b>		up to self-generation of actions	
<b>Contingency:</b>	from selection of pre-selected options		
<b>I.</b>		up to permanent re-structuring of action	
<b>Causality:</b>	from short-time irritation		

*Figure 3: Levels and grades of agency (cf. Rammert and Schulz-Schaeffer 2002)*

This gradual and multi-level model of agency gives us the possibility to escape the dilemma either to reserve agency up to the humans or to flatten the concept of agency unnecessarily. We are neither forced to claim that the activities of humans, machines and programs are substantially the same kind of behavior. Nor do we have to stick to the conception that human action and technical operation are fundamentally different from one another. This gradual concept of agency opens up a wide range of possibilities to identify and to classify kinds and intensities of agency without regards to the substantial character of the unit that is in action. Thus the question where the action is can be transformed into an empirical question.

## 5. Distributed agency: The very idea

The question where the action is cannot be answered, when a second question has not been clearly decided: What is the adequate unit of action? Conventionally, we suppose a single human actor as the adequate unit of action: the philosopher who is thinking and ergo knows that he exists, the employee who hands over the bank notes, the pilot who flies two hundred tourists to Tenerife airport, and so on. But let us look more precisely at the streams of actions wherefrom an action arises. It arises as a distinct action, because it is put into brackets, later-on emphasized, and ascribed to a single unit, an actor or an author.

We would have never heard of Descartes' thought act, if he had not written down his famous sentence with a pencil on a paper. Even more, the working actions of dozens of printers were needed to distribute the phrase in hard-covered editions. Additionally, the teaching of hundreds of philosophy professors was necessary to diffuse the message under many thousands of students. Perhaps this thought act never took place as a single action at one place. Descartes was connected with a lot of thinkers receiving their arguments and reading their papers. Perhaps the foundational thought act that is ascribed to him could have been discovered at many loci in that time, as if it would be very much up in the air (cf. Merton 1957). The act of writing interrupts this continuous chain of acts and turns it into the unique philosophical thought action that changed the world or at least the world view. The act of writing the sentence down by one single actor is emphasized, but both, the flux of thought acts before and the sequences of actions afterwards, like printing, distributing, reading, teaching and learning, were put into brackets and neglected. It is an efficient strategy of teaching and tradition-building to attribute a thought act to one author because it reduces cognitive and social complexity. But if we are doing research and inquire into the places, faces and activities where the action really is, we should follow all possible actors and agencies to the many loci of agency (cf. Latour 1987; cf. Rammert and Schubert 2006; cf. Schubert 2007).

## 5.1 Distributed agency I: From a single actor to many loci of agency

A thought experiment shall introduce the second part of the paper: Let us answer precisely the question: Who or what is acting in the case of flying the tourists to Tenerife?

<b>PEOPLE</b>	<b>MACHINES</b>	<b>PROGRAMS</b>
Pilot?	Jet engine?	Auto-pilot software?
Co-pilot?	Elevator, Rudder?	Navigation card and system?
Radio operator?	Radio equipment?	Radio signals and codes?
Flight-controller?	Radar unit?	Radar screening?
Tourist office?	Booking machine?	Reservation software?
Airline company?	Aviation technology?	Technological R&D plans?
Aviation industry?	Air traffic system?	Roadmaps for infrastructure?

*Figure 4: List of actors and agencies in the flight case*

Humanists and social scientists focus on the people's side in the list. Their first and most plausible answer shall be that the human pilot is the acting unit that flies the tourists to Tenerife. He is conscious of the goal, the methods and instruments. He reflects on possible interventions and deviations. Finally, he can be made responsible for the flight because he has the power of command and control. But a first uncertainty comes up when confronted with the question: the captain, doesn't he have at least one radio- operator on his side? We know from some cases of accidents that the communicative actions between pilot and co-pilot or between pilot and flight-controller have been critical for the flight action: the consequence can be to escape a collision or not. So we learn that agency can be divided between several human actors. The acting unit then is either the team at board or the locally dispersed assembly of people at board and at several control centers on earth. A further question raises other doubts about the single heroic actor: Does the captain or this group of navigators and controller really plan the flight action? No, it was the air line which planned the route, the time and the final departure. It needs more than 200 paying passengers that the action can take place. In comparison to this powerful principal agent the other actors fall back in the role of executing agents. The company is the so-called collective actor which plans, decides, and controls the flight action to Tenerife. In sum, four different units of action can be distinguished on the people's side: a single human actor, a social group or team, a dispersed association of people being in interaction by a division of work, and a collective actor that coordinates activities towards a goal. Certainly, human agency is multiplied, divided, distributed, and connected.

Encouraged by our gradual concept of agency, one may dare to insist on a more precise answer to the question what actors and other agencies contribute to the flight action. Engineers and scientists probably would emphasize the role of machines and programs. Their first and most plausible answer would be: No pilot and no flight without up currents or artificial drivers, like propellers or jet propulsion! Elevators and rudders give the air plane the direction, and the radio and radar equipment enables the plane to find its position and to correct its route. As we have discussed earlier, the agency on this low level of causality doesn't really add some new explanatory power. But the situation changes

completely, when these machine technologies and communication media are in close intra-activity with the agencies that are enlisted on the programs' side. For the most time of the flight, the flight action and the many sub-actions are delegated to the auto-pilot. That is a compilation of many different software programs that are continually measuring, monitoring, and computing, but also actively correcting the height, tempo and direction of the flight. The automatic landing system sometimes even restricts the human pilot from intervening into the action. In sum, the unit of technical agency is constantly changing and growing towards a highly combinatory and relatively autonomous technological system. It starts with wings and rudders. It develops into an aggregated technological system integrating many sub-units like propulsion, navigation, and communication systems. A qualitative shift in the level of agency is achieved at the end, when advanced computer programs take over the planning, control and navigation activities, especially their intelligent coordination, and even more when the flying plane itself is turned into one agent in a more extended and self-regulating air traffic system.

At the end, we see that it is not so easy to define a human and, in particular, a social action. Philosophical and sociological textbooks may help to think about the criteria. The authors usually start with a concept of action that is isolated from the stream of other actions and that is idealized in a certain way. The "ego" is the unit that creates changes, chooses and defines the situation, like God the creator. One can call this concept of action "agency ex nihilo" and contrast it with an alternative one "agency in medias res" (cf. Fuller 1994) that reconstructs action out of the many activities before and around the focused action. Flying 200 tourists to Tenerife is not the instrumental action of a pilot navigating the plane to Tenerife airport. It is one activity that is combined with other activities of controlling and communication. It is additionally integrated in the commercial activities of an airline company. Finally, it is also nested in the activities of a highly complex organized system of the air traffic, the aviation sector and the tourist industry. Looking on the activities under this perspective, one discovers many loci of agency instead of one single actor. One can reconstruct the flight action as a commercial action of a collective actor or even a network of organizations (cf. Teubner 2003) which hire people, invest in new planes, lobby for public support, advertise cheap charter flights, and organize the flight route.

Looking on the technical side of the list, the talk of gadgets and machines as simple means of action underrates both, the complexity of aggregated technical systems and the self-activeness of programmed and nested systems. The collection of many devices and the compilation of different types of technologies cannot be handled like bigger tool-boxes with an increasing number of instruments in it. These interrelated parts build highly complex systems with many planned intra-activities and some unforeseen interferences (cf. Perrow 1986), so that they lose the clear transparency of an instrument and require strategies of interactivity for their control. The combination of nearly all parts with computing and communication capacities converts them into pro-active agents that often are connected in relatively autonomous systems on a higher level, like the automatic landing system or the internet based reservation and booking system. As the advanced technologies mostly simulate the human actions, the different tasks, roles and competencies and actually also the social mechanisms of coordination, it makes sense to describe these activities and intra-activities with the vocabulary of action and inter-agency. It is the adequate way to discover the many loci of technological agency.



## 5.2 Distributed agency II: From homogeneous agency to hybrid constellations

In the pre-dominant dualist tradition of thought, the social and cultural world of human action and the material and artificial world of technological operation are separated from one another. On the one side, social scientists focus on the motives and expectations of people, like pilots and flight ticket sellers, and on the kinds of social organization. They reconstruct a homogeneous world of symbolic interaction and communication purified from physical objects. On the other side, engineering scientists are preoccupied with questions of setting something going, like air planes or software programs, and of improving the effectiveness or safety of technological configurations. They construct a homogenous world of forced movements and functioning technological systems purified from social interests and human users. Facing the growing interrelatedness of problems of nature and of society like man-made climate change or artificial stem cell growing and facing the co-construction of socio-technical systems made of people, machines and programs, one may, however, ask whether a non-dualist conceptual approach could help to make these hybrid constellations a sound subject of research.

At the borders between the two academic cultures we already observe regular border traffic and even conceptual bridge-building. From research in technology and organizations, approaches are pushed forward that respond to the strong interdependency between the material and the social, like the Tavistock approach of socio-technical systems (cf. Trist 1981), the concept of large technical systems consisting of people, organizations, material and symbolic artifacts (cf. Hughes 1987; cf. Mayntz and Schneider 1988), and comparative analysis of high risk systems screening them along aspects of complexity and interaction between human and nonhuman elements (cf. Perrow 1984). The most influential approaches departed from research in science and technology. Some researchers of this area argue against bridging and proposed a radical change of the perspective (cf. Callon and Latour 1992; cf. Collins and Yearley 1992), like particularly the adherents of the ANT-approach, but also of the concepts of “objectuality” (cf. Knorr Cetina 1998), “socio-technical agency” (cf. Girard and Stark 2007; cf. Preda 2006), and of “material agency” (cf. Pickering 1993). Research in media and culture is actually a growing third branch where hybrid constellations are the new subjects, like being a “cyborg”, “technoscience” or living in “virtual life” (cf. Haraway 1991; cf. Haraway 1997; cf. Ihde and Seliger 2003; cf. Turkle 1995). Bridge-building and trans-disciplinary concept-development can be also observed at the science side of the border. Particularly the engineering sciences cross the border and take up concepts of the humanities and the social sciences. Interface-designers integrate psychological concepts of cognition and sociological concepts of routine-building and role-specialization. Designers of software agents apply philosophical concepts of mind, belief and intention. And the architectural designers of multi-agent-systems use sociological concepts of trust, contractual, and market relations.

From the dualist point of view, it makes sense to keep the two territories separated. A lot of arguments can be mobilized for this decision, like the ontological differences between people and machines (cf. Collins and Kusch 1998), the epistemological differences between the disciplines, the institutional differences between social organizations and technical configurations, and so on. But these differences loose their relevance under certain conditions: When human actions, machine operations and programmed activities are so closely knit together that they form a “seamless web” (cf. Hughes 1986), then it makes sense to analyze this hybrid constellation as a heterogeneous network of activities and

interactivities. When a human action like flying an Airbus or searching for a certain piece of information in hundreds of libraries, millions of books, and trillions of files, when these actions can only be executed with the assistance and intervention of hundreds of other agencies, then it is urgent to develop a concept of agency that acknowledges all these agencies, though they are made out of heterogeneous stuff. And finally, when programmed machine operation is developed as if it should execute delegated actions under conditions of contingency, and when it is implemented in open systems that are constructed by the interactions between the software agents, then one should integrate these agencies into the framework of analysis. Therefore I here plead for a concept of distributed agency only under these conditions of advanced technologies and instituted hybrid constellations.

Returning to our flight action example, the answer to the question what is the adequate unit of action can now be given: It is the hybrid constellation of people, machines, and programs. It is the mode how the agencies of the heterogeneous instances are distributed and connected with one another and the level of agency that is given to them in certain situations. It is neither the single or the collective human actor, nor the technical artifact alone or the combined technical system. It is the mixed ensemble made of both elements on both sides of the border. One can call it a *collective agency* alluding to the term collective actor. This collective is constituted by the distributed activities of heterogeneous units in comparison to the other one that is built out of the homogeneous stuff of human actions.

### 5.3 Distributed Agency III: From hierarchy to framed interactivity

Two modes can be distinguished how actions can be divided and integrated: a hierarchical mode whereby specialized activities are strongly integrated and an interactive mode whereby distributed modal units are weakly coupled. In the sociology of organizing, they are often referred to when distinctions are made between bureaucratic and organic models or between strongly or weakly coupled systems ( cf. Perrow 1986; cf. Weick 1976). Observing complex organizations, one learns very quickly that the hierarchical integration is only the most effective mode for divisions with fixed inputs, routine processing and stable environment, like the mass-production of things. Units that are confronted with changing inputs, many variations in the process and dynamic environments require a more interactive, flexible and open mode of organizing, like R&D departments or creative industries. Most of the modern organizations show a mix of both modes of integration, mechanizing the routine parts and learning by interactivity with the environment.

It was taken for granted up to now that the hierarchical mode was the only and one best mode how to specialize and integrate technologies. It has yet been the paradigm for the first machine made of the forced movements of dividedly working people to build the pyramids and also for the ongoing process we call mechanization (Giedion 1948). Technologies are defined by their capacity to force different activities into a mechanical form that is reliable, accountable and disposable as a mean to solve particular problems in an effective and expected way (cf. Rammert 2001). Tasks are divided between many specialized parts and integrated by linear chains of operations and hierarchical schemes of processing. But this dominant mode and its supposed universality are challenged now. Some technical configurations and socio-technical constellations can be observed that are integrated in a different mode that resembles the above mentioned interactive mode.

One can already observe small deviations from the strong mechanical mode looking at the feed-back loops of cybernetic systems. The sandwich architecture of the computer also shows a loosening of point to point determination between its physical machine level and the logical level and the program language level (cf. Winograd and Flores 1986). A further milestone on the path of breaking the linearity was the concept of “*distributed computing*”(cf. Rumelhart and McClelland 1986). It started with the simple problem of distributing computing time, but gained its momentum when a new generation of software programs were developed that used fuzzy logic, distributed artificial intelligence, agent-oriented programming, and models of socionics in order to admit distributed activities and parallel processes. Particularly in social computing (cf. Hewitt 1977; cf. Star 1989) and in socionics ( cf. Malsch 2001; Meister et al. 2007; cf. Rammert 1998), many modes of interactive integration were developed that were in opposition to the hierarchical mode.

Another milestone was the development of the concept of “*distributed cognition*” (cf. Hutchins 1996). The psychologist Hutchins criticizes the dominant model of individual problem-solving in the cognitive sciences that supplies the artificial intelligence community with a construction plan. It presupposes separated and functional specialized activities that can be easily aggregated. Being also an ethnographer, Hutchins observed the techniques of navigation “in the wild” and “in medias res”: He studied precisely how the Polynesian long-distance sailors performed navigation in the wide Pacific ocean though they had no sophisticated nautical instruments, and how a navigation team on a warship maneuvered their long ship into the small harbor entrance of San Diego though its nautical system was damaged. Thereby he discovered a mode of self-organized integration between distributed processes of cognitive activities. The cognitive action of positioning was organized as a distributed process that was performed by some people with different practices, natural objects and technical instruments. The critical point for our argumentation here is his observation that these distributed processes did not require any planning, functional specialization or hierarchical integration. Their mode of integration was described as a natural process of loose coupling, over-lapping activities, experimental adaptation, and a step by step stabilization of a common frame for the interactions (cf. Hutchins 1998).

The concept of “*distributed agency*” that is presented in this paper follows the lines that were started by those concepts of “distributed computing” and “distributed cognition”. The first step to construct this concept of distributed agency has been to demonstrate that human action is distributed between many loci and instances that plan, control, and execute the activities. Distributed action means that someone is searching for significant marks, someone other is measuring the angles, a third one is plotting by drawing a line, and others are counting, communicating and correcting the data. All these interactions between them constitute an observable unit of action called navigation. This kind of distribution can also be transferred to computer operations. The action of sending a message to a certain person can be broken down into many activities at different places, like encoding, packaging, addressing, transporting, and reading TCP/IP protocols at the PC, at the server, at the local area network, or at one of the knots of the worldwide web.

The second step has been to cross the Rubicon between the two homogenous spheres of human action and technological operation: Distributed agency then refers to hybrid constellations made of heterogeneous units of agency. Moving objects like the sun and the streams of water, measuring instruments, counting tables, and carved records were participating in the action of navigation. As we have argued before, objects participate more

actively and on a higher level of agency, when the nautical pilot program and the automatic navigation system are in action and in close intra-activity with one another.

The third step now emphasizes two modes of integration. They differ in how the units are divided, how they are processed, and how they are connected with one another. The dominant hierarchical mode of integration prolongs the traditional line that admits us to treat even complex technologies and hybrid constellations as reliable means and robust mechanisms. The mode of framed interactivity is rarely implemented because it deviates from the well-known and trusted master-slave-relation. The technological units are given more freedom of choice and higher levels of agency in order to enrich their capacity of assistance and to strengthen their role as relatively autonomous agents.

<b>MODES:</b>	<b>HIERARCHY</b>	<b>FRAMED INTERACTIVITY</b>
<b>Type of Differentiation</b>	Division of work Functional specialization	Distributed activities Fragmented units
<b>Type of Organization</b>	Mechanical Bureaucratic	Organic Open System
<b>Type of Connection</b>	Linear sequences Strongly coupled Fixed and general rules Pre-Programmed	Parallel processes Loosely coupled Flexible, situated and specific rules Framed Self-adaptation

*Figure 5: Two modes of integration*

Though the mode of framed interactivity is rarely implemented up to now, this mode may become a new paradigm for the design of future constellations. Actually it is inquired at many different places: in laboratories of distributed intelligence, in research and development clusters on robotics, man-machine-interfaces, or new media design as well as in the studios of interactive artists, in the media labs of the entertainment industry, and at the software benches of videogame developers. This mode of framed interactivity shall get its chance of diffusion when the next generation of technologies is consciously designed and implemented under the perspective of distributed agency, when the frames of heterogeneous agencies are balanced and consented, and when a new generation of users is coming up that is used to the new experiences with interactivity.

## References:

- Adelmann, Robert, Christian Floerkemeier, and Marc Langheinrich. 2006. "Toolkit for Bar Code Recognition and Resolving on Camera Phones - Jump Starting the Internet of Things." *GI Jahrestagung* 2:366-373.
- Akrich, Madeline, and Bruno Latour. 1992. "A Summary of a Convenient Vocabulary for the Semiotics of Humans and Nonhuman Assemblies." Pp. S. 259-264 in *Shaping Technology - Building Society*, edited by Wiebe E. Bijker and John Law. Cambridge (Mass.): MIT Press.
- Callon, Michel. 1986. "Some Elements of a Sociology of Translation: Domestication of the Scallops and the Fishermen of St. Brieux Bay." Pp. S. 196-229 in *Power, Action, and Belief*, edited by John Law. London: Routledge.
- Callon, Michel, and Bruno Latour. 1992. "Do not throw out the baby with the Bath School! A reply to Collins and Yearley." Pp. S. 343-368 in *Science as Practice and Culture*, edited by Andrew Pickering. Chicago: University of Chicago Press.
- Coleman, John S. 1990. *Foundations of Social Theory*. Cambridge, Mass.: The Belknap Press of Harvard University Press.
- Collins, Harry M., and Martin Kusch. 1998. *The Shape of Actions. What Humans and Machines Can Do*. Cambridge, Mass.: MIT Press.
- Collins, Harry M., and Steven Yearley. 1992. "Epistemological Chicken." Pp. 301-326 in *Science as Practice and Culture*, edited by Andrew Pickering. Chicago: University Press.
- Dennett, Daniel. 1995. *The Intentional Stance*. Cambridge, MA.
- Esposito, Elena. 1995. "Illusion und Virtualität: Kommunikative Veränderungen der Fiktion." Pp. S. 187-216 in *Soziologie und künstliche Intelligenz*, edited by Werner Rammert. Frankfurt/M.: Campus.
- Fuller, Steve. 1994. "Making Agency Count. A Brief Foray into the Foundation of Social Theory." *American Behavioral Scientist* 37:S. 741-753.
- Giddens, Anthony. 1984. *The Constitution of Society, Outline of the Theory of Structuration*. Cambridge: Polity Press.
- Giedion, Siegfried. 1948. *Mechanization takes command : a contribution to anonymous history*. New York: Oxford University Press.
- Girard, Monique, and David Stark. 2007. "Socio-technologies of Assembly: Sense-Making and Demonstration in Rebuilding Lower Manhattan." Pp. 145-176 in *Governance and Information: The Rewiring of Governance and Deliberation in the 21st Century*, edited by David Lazar and Viktor Mayer-Schoenberger. Oxford: Oxford University Press.
- Goffman, Erving. 1969. *Strategic Interaction*. New York: Routledge.
- Haraway, Donna J. 1991. *Simians, Cyborgs, and Women: The Reinvention of Nature*. New York: Routledge.
- . 1997. *Modest\_Witness@Second\_Millennium. FemaleMan\_Meets\_OncoMouse. Feminism and Technoscience*. New York: Routledge.
- Hewitt, Carl E. 1977. "Viewing Control Structures as Patterns of Passing Messages." *Artificial Intelligence* 8:S. 323-364.
- Hughes, Thomas P. 1986. "The Seamless Web: Technology, Science, Etcetera, Etcetera." *Social Studies* 16:S. 281-292.
- . 1987. "The Evolution of Large Technological Systems." Pp. S. 51-82 in *The Social Construction of Technological Systems*, edited by Wiebe E. Bijker, Thomas P. Hughes, and Trevor. J. Pinch. Cambridge: MIT Press.

- Hutchins, Edwin. 1996. *Cognition in the Wild*. Cambridge, Mass.: MIT Press.
- . 1998. "Learning to Navigate. Understanding Practice. Perspectives on Activity and Context." Pp. S. 35-63 in *Understanding Practice. Perspectives on Activity and Context*, edited by Seth Chaiklin and Jean Lave. Cambridge: Cambridge University Press.
- Ihde, Don, and Evan Seliger. 2003. *Chasing Technoscience: Matrix for Materiality*. Bloomington: Indiana University Press.
- Joas, Hans. 1989. *Praktische Intersubjektivität. Die Entwicklung des Werkes von G. H. Mead*. Frankfurt/M.: Suhrkamp.
- Kaufmann, Jean-Claude. 2008. *Was sich liebt, das nervt sich*. Konstanz: UVK-Verlag.
- Knorr Cetina, Karin. 1998. "Sozialität mit Objekten. Soziale Beziehungen in post-traditionalen Wissensgesellschaften." Pp. S. 83-120 in *Technik und Sozialtheorie*, edited by Werner Rammert. Frankfurt/M.: Campus.
- Latour, Bruno. 1987. *Science in Action: How to Follow Scientists and Engineers Through Society*. Cambridge, Mass.: Harvard University Press.
- . 1988. "Mixing Humans and Nonhumans together: The Sociology of a Door-Closer." *Social Problems* 35:S. 298-310.
- . 1992. "Where are the Missing Masses? The Sociology of a Few Mundane Artifacts." Pp. S. 225-258 in *Shaping Technology - Building Society*, edited by Wiebe E. Bijker and John Law. Cambridge, MA: MIT Press.
- . 1994. "On Technical Mediation: The Messenger Lectures on the Evolution of Civilization." *Common Knowledge* 3:S. 29-64.
- . 1996. "On Interobjectivity." *Mind, Culture, and Activity* 3:S. 228-245.
- . 2005. *Reassembling the Social. An Introduction to Actor-Network-Theory*. Oxford: Oxford University Press.
- Leroi-Gourhan, André. 1980. *Hand und Wort. Die Evolution von Technik, Sprache und Kunst*. Frankfurt/M.: Suhrkamp.
- Malsch, Thomas. 2001. "Naming the Unnamable: Socionics or the Sociological Turn of/to Distributed Artificial Intelligence." *Autonomous Agents and Multi-Agent Systems* 4:S. 155-186.
- Mayntz, Renate, and Volker Schneider. 1988. "The Dynamics of System Development in Comparative Perspective: Interactive Videotex in Germany, France, and Britain." Pp. S. 263-298 in *The Development of Large Technical Systems*, edited by Renate Mayntz and Thomas P. Hughes. Boulder, Colorado: Westview Press.
- McCarthy, E. Doyle. 1984. "Toward a Sociology of the Physical World: Mead on Physical Objects." *Studies in Symbolic Interactionism* 8:105-121.
- Mead, George H. 1932. *The Philosophy of the Present*: ed. by Arthur E. Murphy, La Salle (Ill).
- . 1963. *Mind, self and society*. Chicago: University of Chicago Press.
- Meister, Martin, Kay Schröter, Diemo Urbig, Eric Lettkemann, Hans-Dieter Burkhard, and Werner Rammert. 2007. "Construction and Evaluation of Social Agents in Hybrid Settings: Approach and Experimental Results of the INKA Project." *Journal of Artificial Societies and Social Simulation* 10.
- Merton, Robert K. 1957. "Priorities in Scientific Discovery: A Chapter in the Sociology of Science." *American Sociological Review* 22:S. 635-659.
- Perrow, Charles. 1984. *Normal Accidents: Living With High Risk Technologies*. . Princeton: Princeton University Press.
- . 1986. *Complex Organizations. A Critical Essay*. New York: Random House.

- Pickering, Andrew. 1993. "The Mangle of Practice: Agency and Emergence in the Sociology of Science." *American Journal of Sociology* 99:S. 559-589.
- . 1995. *The Mangle of Practice: Time, Agency and Science*. Chicago: The University of Chicago Press.
- Preda, Alex. 2006. "Socio-technical Agency in Financial Markets: The Case of the Stock Ticker." *Social Studies of Science* 26:S. 753-782.
- Rammert, W. 1992. "From Mechanical Engineering to Information Engineering: Phenomenology and the Social Roots of an Emerging Type of Technology." Pp. 193-205 in *New Technology at the Outset. Social Forces in the Shaping of Technological Innovations.*, edited by M. Dierkes, Hoffmann, U. (Hg.). Frankfurt/M. und Bolder: Campus und Westview.
- Rammert, Werner. 1998. "Giddens und die Gesellschaft der Heinezmännchen. Zur Soziologie technischer Agenten und Systeme Verteilter Künstlicher Intelligenz." Pp. S. 91-128 in *Sozionik. Soziologische Ansichten über künstliche Sozialität*, edited by Thomas Malsch. Berlin: Sigma.
- . 2001. "Relations that Constitute Technology and Media that Make a Difference: Toward a Social Pragmatic Theory of Technicization." Pp. S. 271-290 in *Advances and Problems in the Philosophy of Technology*, edited by Hans Lenk and Matthias Maring. Münster: LIT Verlag.
- . 2007. *Technik - Handeln - Wissen. Zu einer pragmatistischen Technik- und Sozialtheorie*. Wiesbaden: VS Verlag.
- Rammert, Werner, and Cornelius Schubert. 2006. *Technografie. Zur Mikrosoziologie der Technik*. Frankfurt/Main: Campus.
- Rammert, Werner, and Ingo Schulz-Schaeffer. 2002. "Technik und Handeln - Wenn soziales Handeln sich auf menschliches Verhalten und technische Artefakte verteilt." Pp. S. 11-64 in *Können Maschinen handeln?*, edited by Werner Rammert and Ingo Schulz-Schaeffer. Frankfurt/M.: Campus.
- Rumelhart, David, and James McClelland. 1986. *Parallel Distributed Processing. Vol I. Foundations*. Cambridge, MA: MIT Press.
- Schubert, Cornelius. 2007. "Risk and safety in the operating theatre. An ethnographic study of socio-technical practices." Pp. 123-138 in *Biomedicine as culture. Instrumental practices, technoscientific knowledge, and new modes of life*, edited by Regula V. Burri and Joseph Dumit. London: Routledge.
- Schulz-Schaeffer, Ingo. 2002. "Innovation durch Konzeptübertragung. Der Rückgriff auf Bekanntes bei der Erzeugung technischer Neuerungen am Beispiel der Multiagentensystem-Forschung." *Zeitschrift für Soziologie* 31:S. 232-251.
- . 2007. *Zugeschriebene Handlungen. Ein Beitrag zur Theorie sozialen Handelns*. Weilersvst: Velbrück.
- Star, S. L. 1989. "The Structure of Ill-Structured Solutions: Boundary Objects and Heterogeneous Distributed Problem Solving." Pp. S. 37-54 in *Distributed Artificial Intelligence*, edited by Michael Huhns and Les Gasser. Menlo Park: CAL: Morgan Kauffman.
- Teubner, Gunther. 2003. "Hybrid Laws. Constitutionalizing Private Governance Networks." in *Legality and Community*, edited by Robert Kagan and Kenneth Winston: California University Press.
- Trist, Eric. 1981. *The Evolution of Socio-Technical Systems*. Toronto.
- Turing, Alan. 1950. "Computing Machinery and Intelligence." *Mind* 59:S. 433-460.
- Turkle, Sherry. 1995. *Life on the Screen. Identity in the Age of Internet*. New York: Simon & Schuster.

- von Foerster, Heinz. 1985. *Sicht und Einsicht. Versuche zu einer operativen Erkenntnistheorie*. Braunschweig: Vieweg.
- Weick, Karl. 1976. "Educational Organizations as Loosely Coupled Systems." *Administrative Science Quarterly* 21:S. 1-19.
- Weizenbaum, Joseph. 1977. *Die Macht der Computer und die Ohnmacht der Vernunft*. Frankfurt/M.: Suhrkamp.
- Winograd, Terry, and Flores Flores. 1986. *Understanding Computers and Cognition. A New Foundation for Design*. Reading: Addison & Wesley.
- Wooldridge, Michael, and Nicholas Jennings. 1995. "Intelligent Agents: Theory and Practice." *The Knowledge Engineering Review* 10:S. 115-152.

**In der Reihe „Working Papers“ sind bisher erschienen:**

4/2008	Werner Rammert	Where the action is: Distributed agency between humans, machines, and programs* Bestell-Nr.: TUTS-WP-4-2008
3/2008	Ingo Schulz-Schaeffer	Technik als Gegenstand der Soziologie Bestell-Nr.: TUTS-WP-3-2008
2/2008	Holger Braun-Thürmann	Die Ökonomie der Wissenschaften und ihre Spin-offs Bestell-Nr.: TUTS-WP-2-2008
1/2008	Werner Rammert	Technik und Innovation Bestell-Nr.: TUTS-WP-1-2008
8/2007	Jörg Potthast	Die Bodenhaftung der Flugsicherung Bestell-Nr.: TUTS-WP-8-2007
7/2007	Kirstin Lenzen	Die innovationsbiographische Rekonstruktion technischer Identitäten am Beispiel der Augmented Reality-Technologie. Bestell-Nr.: TUTS-WP-7-2007
6/2007	Michael Hahne Martin Meister Renate Lieb Peter Bioniok	Sequenzen-Routinen-Positionen – Von der Interaktion zur Struktur. Anlage und Ergebnisse des zweiten Interaktivitätsexperimentes des INKA-Projektes. Bestell-Nr.: TUTS-WP-6-2007
5/2007	Nico Lüdtke	Lässt sich das Problem der Intersubjektivität mit Mead lösen? – Zu aktuellen Fragen der Sozialtheorie Bestell-Nr. TUTS-WP-5-2007



4/2007	Werner Rammert	Die Techniken der Gesellschaft: in Aktion, in Interaktivität und hybriden Konstellationen. Bestell-Nr. TUTS-WP-4-2007
3/2007	Ingo Schulz-Schaeffer	Technik als sozialer Akteur und als soziale Institution. Sozialität von Technik statt Postsozialität Bestell-Nr. TUTS-WP-3-2007
2/2007	Cornelius Schubert	Technology Roadmapping in der Halbleiterindustrie Bestell-Nr. TUTS-WP-2-2007
1/2007	Werner Rammert	Technografie trifft Theorie: Forschungsperspektiven einer Soziologie der Technik Bestell-Nr. TUTS-WP-1-2007
4/2006	Esther Ruiz Ben	Timing Expertise in Software Development Environments Bestell-Nr. TUTS-WP-4-2006
3/2006	Werner Rammert	Technik, Handeln und Sozialstruktur: Eine Einführung in die Soziologie der Technik Bestell-Nr. TUTS-WP-3-2006
2/2006	Alexander Peine	Technological Paradigms Revisited – How They Contribute to the Understanding of Open Systems of Technology Bestell-Nr. TUTS-WP-2-2006
1/2006	Michael Hahne	Identität durch Technik: Wie soziale Identität und Gruppenidentität im soziotechnischen Ensemble von Ego-Shooterclans entstehen Bestell-Nr. TUTS-WP-1-2006
7/2005	Peter Biniok	Kooperationsnetz Nanotechnologie – Verkörperung eines neuen Innovationsregimes? Bestell-Nr. TUTS-WP-7-2005
6/2005	Uli Meyer Cornelius Schubert	Die Konstitution technologischer Pfade. Überlegungen jenseits der Dichotomie von Pfadabhängigkeit und Pfadkreation Bestell-Nr. TUTS-WP-6-2005
5/2005	Gesa Lindemann	Beobachtung der Hirnforschung Bestell-Nr. TUTS-WP-5-2005
4/2005	Gesa Lindemann	Verstehen und Erklären bei Helmuth Plessner Bestell-Nr. TUTS-WP-4-2005

3/2005	Daniela Manger	Entstehung und Funktionsweise eines regionalen Innovationsnetzwerks – Eine Fallstudienanalyse Bestell-Nr. TUTS-WP-3-2005
2/2005	Estrid Sørensen	Fluid design as technology in practice – Spatial description of online 3D virtual environment in primary school Bestell-Nr. TUTS-WP-2-2005
1/2005	Uli Meyer Ingo Schulz-Schaeffer	Drei Formen interpretativer Flexibilität Bestell-Nr. TUTS-WP-1-2005
3/2004	Werner Rammert	Two Styles of Knowing and Knowledge Regimes: Between ‘Explicitation’ and ‘Exploration’ under Conditions of ‘Functional Specialization’ or ‘Fragmental Distribution’ Bestell-Nr. TUTS-WP-3-2004
2/2004	Jörg Sydow Arnold Windeler Guido Möllering	Path-Creating Networks in the Field of Text Generation Lithography: Outline of a Research Project Bestell-Nr. TUTS-WP-2-2004
1/2004	Corinna Jung	Die Erweiterung der Mensch-Prothesen-Konstellation. Eine technografische Analyse zur ‚intelligenten‘ Beinprothese Bestell-Nr. TUTS-WP-1-2004
10/2003	Cornelius Schubert	Patient safety and the practice of anaesthesia: how hybrid networks of cooperation live and breathe Bestell-Nr. TUTS-WP-10-2003
9/2003	Holger Braun-Thürmann Christin Leube, Katharina Fichtenau Steffen Motzkus, Saskia Wessäly	Wissen in (Inter-)Aktion - eine technografische Studie Bestell-Nr. TUTS-WP-9-2003
8/2003	Eric Lettkemann Martin Meister	Vom Flugabwehrgeschütz zum niedlichen Roboter. Zum Wandel des Kooperation stiftenden Universalismus der Kybernetik Bestell-Nr. TUTS-WP-8-2003
7/2003	Klaus Scheuermann Renate Gerstl	Das Zusammenspiel von Multiagentensystem und Mensch bei der Terminkoordination im Krankenhaus: Ergebnisse der Simulationsstudie ChariTime Bestell-Nr. TUTS-WP-7-2003

6/2003	Martin Meister, Diemo Urbig, Kay Schröter, Renate Gerstl	Agents Enacting Social Roles. Balancing Formal Structure and Practical Rationality in MAS Design Bestell-Nr. TUTS-WP-6-2003
5/2003	Roger Häußling	Perspektiven und Grenzen der empirischen Netzwerkanalyse für die Innovationsforschung am Fallbeispiel der Konsumgüterindustrie Bestell-Nr. TUTS-WP-5-2003
4/2003	Werner Rammert	Die Zukunft der künstlichen Intelligenz: verkörpert – verteilt – hybrid Bestell-Nr. TUTS-WP-4-2003
3/2003	Regula Burri	Digitalisieren, disziplinieren. Soziotechnische Anatomie und die Konstitution des Körpers in medizinischen Bildgebungsverfahren Bestell-Nr. TUTS-WP-3-2003
2/2003	Werner Rammert	Technik in Aktion: Verteiltes Handeln in soziotechnischen Konstellationen Bestell-Nr. TUTS-WP-2-2003
1/2003	Renate Gerstl, Alexander Hanft, Sebastian Müller, Michael Hahne, Martin Meister, Dagmar Monett Diaz	Modellierung der praktischen Rolle in Verhandlungen mit einem erweiterten Verfahren des fallbasierten Schließens Bestell-Nr. TUTS-WP-1-2003
9/2002	Werner Rammert	Gestörter Blickwechsel durch Videoüberwachung? Ambivalenzen und Asymmetrien soziotechnischer Beobachtungsordnungen Bestell-Nr. TUTS-WP-9-2002
8/2002	Werner Rammert	Zwei Paradoxien einer Wissenspolitik: Die Verknüpfung heterogenen und die Verwertung impliziten Wissens Bestell-Nr. TUTS-WP-8-2002
6/2002	Martin Meister, Diemo Urbig, Renate Gerstl, Eric Lettkemann, Alexander Osthrenko, Kay Schröter	Die Modellierung praktischer Rollen für Verhandlungssysteme in Organisationen. Wie die Komplexität von Multiagentensystemen durch Rollenkonzeptionen erhöht werden kann Bestell-Nr. TUTS-WP-6-2002

5/2002	Cornelius Schubert	Making interaction and interactivity visible. On the practical and analytical uses of audiovisual recordings in high-tech and high-risk work situations Bestell-Nr. TUTS-WP-5-2002
4/2002	Werner Rammert Ingo Schulz-Schaeffer	Technik und Handeln - Wenn soziales Handeln sich auf menschliches Verhalten und technische Artefakte verteilt. Bestell-Nr. TUTS-WP-4-2002
3/2002	Werner Rammert	Technik als verteilte Aktion. Wie technisches Wirken als Agentur in hybriden Aktionszusammenhängen gedeutet werden kann. Bestell-Nr.: TUTS-WP-3-2002
2/2002	Werner Rammert	Die technische Konstruktion als Teil der gesellschaftlichen Konstruktion der Wirklichkeit Bestell-Nr. TUTS-WP-2-2002
1/2002	Werner Rammert	The Governance of Knowledge Limited: The rising relevance of non-explicit knowledge under a new regime of distributed knowledge production Bestell-Nr. TUTS-WP-1-2002
2/2001	Ingo Schulz-Schaeffer	Technikbezogene Konzeptübertragungen und das Problem der Problemähnlichkeit. Der Rekurs der Multiagentensystem-Forschung auf Mechanismen sozialer Koordination Bestell-Nr. TUTS-WP-2-2001
1/2001	Werner Rammert	The Cultural Shaping of Technologies and the Politics of Technodiversity Bestell-Nr. TUTS-WP-1-2001
10/2000	Frank Janning Klaus Scheuermann Cornelius Schubert	Multiagentensysteme im Krankenhaus. Sozionische Gestaltung hybrider Zusammenhänge Bestell-Nr. TUTS-WP-10-2000
9/2000	Holger Braun	Formen und Verfahren der Interaktivität – Soziologische Analysen einer Technik im Entwicklungsstadium Bestell-Nr. TUTS-WP-9-2000
8/2000	Werner Rammert	Nichtexplizites Wissen in Soziologie und Sozionik. Ein kursorischer Überblick Bestell-Nr. TUTS-WP-8-2000
7/2000	Werner Rammert	Ritardando and Accelerando in Reflexive Innovation, or How Networks Synchronise the Tempi of Technological Innovation Bestell-Nr. TUTS-WP-7-2000

5/2000	Jerold Hage Roger Hollingsworth Werner Rammert	A Strategy for Analysis of Idea Innovation, Networks and Institutions National Systems of Innovation, Idea Innovation Networks, and Comparative Innovation Biographies Bestell-Nr. TUTS-WP-5-2000
4/2000	Holger Braun	Soziologie der Hybriden. Über die Handlungsfähigkeit von technischen Agenten Bestell-Nr. TUTS-WP-4-2000
3/2000	Ingo Schulz-Schaeffer	Enrolling Software Agents in Human Organizations. The Exploration of Hybrid Organizations within the Socionics Research Program Bestell-Nr. TUTS-WP-3-2000
2/2000	Klaus Scheuermann	Menschliche und technische ‚Agency‘: Soziologische Einschätzungen der Möglichkeiten und Grenzen künstlicher Intelligenz im Bereich der Multi-agentensysteme Bestell-Nr. TUTS-WP-2-2000
1/2000	Hans-Dieter Burkhard Werner Rammert	Integration kooperationsfähiger Agenten in komplexen Organisationen. Möglichkeiten und Grenzen der Gestaltung hybrider offener Systeme Bestell-Nr. TUTS-WP-1-2000
1/1999	Werner Rammert	Technik Stichwort für eine Enzyklopädie Bestell-Nr. TUTS-WP-1-1999