Sustainability Networks and the Emergence of Knowldege *)

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Introduction

"How can we protect our descendants against ourselves?" was the question a US commission of experts headed by Gregory Benford was asked when it was assigned the task of developing a signalling and defence system to protect the American repositories for radioactive waste against accidental intruders in 1999 (Benford 1999). The challenge the commission was facing consisted of ensuring efficient protection throughout the entire, risky half−life of the substances involved, i.e. a period of ten thousand years. But how can knowledge about the dangers that repositories for radioactive waste pose be communicated over such a length of time? What must symbols look like that are still supposed to be understood ten thousand years later on? More generally, how can knowledge be objectified and established in society outside certain common contexts of action?[2] In the course of the project, it has become apparent that the usual form of societal objectification and communication of knowledge in the shape of symbols does have its weaknesses. Perhaps these weaknesses are inevitable. But this can only be revealed when alternatives have been looked for. In today's world, which is characterised by global problems and high risks, this weakness is increasingly becoming a problem, and the quest for alternatives is therefore getting more and more important. The developers of the Maya codices and the builders of Stonehenge, the Chinese Wall or the Egyptian pyramids only managed to pass on fragments of their knowledge to us. We do not know what knowledge we have therefore been denied. Neither do we know if it would have fundamentally changed our lives if we had known it. But one thing does seem certain. In today's situation, under the conditions of the modern age with the risks it has created itself and its global problems, inter and intra−generative communicability of knowledge is gaining vital importance. And this turns knowledge in its societal dimension into a crucial topic.

So far, only little research has been carried out on the societal dimension of knowledge, i.e. knowledge embedded in the structures of social systems.[3] However, the current debate on sustainable development has placed this issue on the scientific agenda for two reasons. First, the vision of sustainable development is committed to a global ethic that refers both to the relations between generations (inter−generative) and to the relations within a generation (intra−generative). "Current generations should meet their needs without compromising the ability of future generations to meet theirs" (Brundtland Report 1987). The second reason is the close intermeshing of global and local events, resulting in greater complexity. Globality is reflected on the one hand in the interaction between various causal factors and ubiquitous consequences occurring world−wide. They become apparent in global problems (e.g. reductions in biodiversity) and complex syndromes (e.g. the rural exodus). On the other hand, it is becoming increasingly difficult to locally restrict the problem solution strategies in which knowledge needs updating. This means that complexity can no longer be dealt with using old patterns. A society−wide enhancement of resonance and reflexivity is required. To achieve sustainability and to be able to react with long−term strategies to global risks such as climate change or societal cohesiveness, society must gain knowledge of itself, especially of its environmental, economic and social affairs, of the available problem solving alternatives, of the potentials of activities, and of the societal realization conditions. But how is that possible?

In this context, knowledge is becoming an increasingly big problem. On the one hand, there is talk of an exponential growth of knowledge, of its generation being accelerated, of changes in how it is communicated and of improvements in how it is evaluated. On the other hand, it is conceded that what is at issue here is not so much knowledge itself but merely the *potential* that knowledge bears. And the problem is that this potential is not, or only insufficiently, being made use of in social systems, whether it be organisations, communities, social networks or society as a whole. As a rule, social

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*) This paper was presented at the third international conference on sociocybernetics, Leon, Mexico, June 24 − July 1, 2001 (www.unizar.es/sociocybernetics)

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[2]Anyone who has seen the ruins of Teotihuacán in Mexico will have gained an impression of how difficult it is to communicate social knowledge over several generations. However, this also applies to no lesser a degree to communication within a generation. For example, the symbol commonly used world−wide for radioactivity is not even generally understood today. In a series of tests conducted by the Benford commission of experts the question was asked why anyone would want to bury so many ship propellers. And the objection was raised that the skull and crossbones could also be mistaken for a reference to an ancient pirates' treasure rather than a warning of a life−threatening danger (Schirrmacher 2000).

[3]The lack of investigating the societal dimension of knowledge can be shown in Radermacher 2001. But there are promising approaches in Luhmann 1990, Baecker 1999, Willke 2001. Baecker refers to this knowledge as "social knowledge" (1999: 78). However, he also speaks of "societal knowledge" at the same time, although he is not implying the social dimension here but the factual dimension of knowledge (71).

systems do not know what they know. Organisations are suffering from this insecurity in particular, for their ability to work (i.e. above all the absorption of insecurity) depends considerably on the ability to select knowledge (Ahlemeyer 2000; Baecker 1999: 69). This is why the new catchword it is hoped will solve the problem is "knowledge management", and it turns both the *cognitive*[4] and the *communicative* foundations of knowledge into a research topic.

For lack of other options to access the world, knowledge can also be referred to as a "simulation of access to the world" (Nassehi 2000). Unlike with individual knowledge, the most important quality characteristic of social knowledge is that it needs to be communicated in order to have an impact, no matter what that impact may be. And this is precisely where the problem lies. For in their day−to−day actions, social systems have to decide what communicative knowledge they want to resort to, what data they intend to process and what information they wish to draw conclusions from (Baecker 1999:69). They have to make decisions on accepting and turning down communication offers. Moreover, they have to decide what knowledge they wish to introduce into the process of communication and what they do not.

In the following, I want to assess how successful a cybernetics of knowledge can be in complex social systems, above all in organisations, but also in networks of various kinds. And here, the issue at stake is that of to what degree new technologies in information and communications can help us understand the emergence of knowledge in social structures and, as a consequence of this, employ knowledge more efficiently to achieve sustainable development. After a theoretical elaboration, this is to be demonstrated with an example.

1. How can a society know anything?

Knowledge is usually linked with action contexts and individual carriers. Knowledge refers to "what the respective actor uses to generate action, behaviour, solutions, etc." (Segler 1985: 138). This is not necessarily restricted to scientifically established insights. Many authors also regard this condition fulfilled when "practical rules and techniques as well as patent recipes, aide−mémoires, views of life, customs, superstitions and religious or mystical notions of all kinds" (Segler 1985: 138) are used.

This approach is (still) dominant in almost all scientific disciplines dealing with knowledge. In addition to philosophy, they above all comprise psychology (cognitive psychology), sociology (sociology of knowledge) and informatics (AI research). Sociology only entered the interaction of these disciplines at a late stage, in correspondence with the degree to which the issue of knowledge was extended to social systems and knowledge was no longer viewed solely as an attribute of individuals or cognitive systems but also as a communicative phenomenon. This perspective had been given hardly any consideration in research done previously, which had been dominated by cognition psychology issues. Although in the mid−eighties, here too, the focus was turned to emergent phenomena[5], knowledge was nevertheless seen as the product of individual learning and thinking. The subsequent question (and this was above all interesting for informatics) was how knowledge is objectified, i.e. transformed, as context neutral as possible and via suitable presentation and storage, into *information* in order to subsequently be once again turned back into practice−relevant *knowledge* in other contexts. Over the last few years, this double transformation process has been made a subject of research in various fields of informatics (e.g. DataMining, CSCW, Geographic Information Systems). But there too, knowledge is still coupled with single actors who only objectify knowledge when they communicate with others. Here, the chief problem is not so much that of establishing the social character of knowledge but rather its transferability to various social contexts.

From a cognitivistic perspective, this approach comes as no surprise, even though a widening of the horizon is implicit in the theoretical approach of Distributed AI (Malsch 1997). It was above all the connectionist line of AI that gave up the attempt in the eighties of the last century to perceive knowledge

[4]as has already been the case in Artificial Intelligence and the sociology of knowledge
[5]This view particularly came to the fore in the fourth phase of the disciplinary development of AI, which dealt with topics such as how knowledge was situated and distributed (Görz 1995).

as a whole consisting of different elements of knowledge. The alternative was to describe it as a neuronal network. The Physical Symbol System Hypothesis (PSSH), which had hitherto been dominant, was discarded (Forrest 1990; Mahr 1989; Neumann 1995; Varela 1990).[6] What is rather more astonishing is that the sociology of knowledge, which arose in the twenties of the last century, has also addressed the emergence of knowledge at only a very rudimentary level. Although it has taken up the cause of "examining the relations between knowledge and society" (Lieber & Wolff 1972: 929), especially the influence of "non−intellectual factors on thought" "Kurucz 1989: 828), but it has not really developed a genuinely sociological concept of knowledge. Merton holds that the issue is the "existential basis of intellectual products", their latent and manifest interrelations. Mannheim had also spoken of the "Seinsverbundenheit des Wissens", of knowledge being tied to an existential context. But here the emphasis is always on the knowledge of individual actors. The social character is addressed when the "exchange of knowledge" among the individuals is taken up. Although Stehr explicitly speaks of "collective knowledge", he defines it as the "cumulative ability to act" (Stehr 1994: 213).

On the other hand, reference is often made in everyday language to collective actors as if they disposed of a common knowledge of action. "The stock market rapidly responds to reductions of interest rates" or "the country has to nail its colours to the mast" or "The consciousness of the working class is changing" are phrases in which this is reflected. Are these merely metaphorical formulations? Or is a phenomenon expressed in them that can clearly be experienced practically but has not yet been described adequately with scientific means?

2. On the social character of knowledge

The possibility of social knowledge is already considered in European philosophical tradition. While knowledge is not linked with individual actors here, it is clearly associated with the transcendental subject. Knowledge is described as "the sum of insights on the world the individual or society dispose of respectively of objectively real objects as perceived by the subject acquiring insights (objects, process, structures) (...) and the self−insight of the subject" (Thom 1990: 903). Knowledge is understood as the condensation of observations the correspondence of which with the facts one could be certain of. Knowledge is valued more than opinions or faith.

With Kant (Kant 1781), the conditions of acquiring insights that are inherent in all individuals and the way that they are made use of act as a basis for the possibility of knowledge coinciding at societal level. Since reason can only recognise what it produces according to its own construction, the object is, as it were, modelled. This means that in Kant’s view, the generation of knowledge is a synthetic process of associating intellectual functions that are given a priori (power of judgement) with pure perception (spatial and temporal ordering of what has been perceived − Thom, p. 907). With Hegel (Hegel 1970), "the constitution of knowledge" implies working historically with concepts in the process of human development.

Today, it is still common to define social knowledge as a "possibility". Stehr refers to knowledge as an "action resource" (Stehr 1994), while Bechmann & Stehr speak of it as the possibility to "get something going" (Bechmann & Stehr 2000). But how does the possibility of knowing something become real knowledge? According to Stehr, objectification processes occur as social communication progresses when knowledge is stored in a textual, language or graphic form, i.e. when it is represented symbolically. This is how society is supposed to succeed in establishing an enormous "amount of objectified knowledge" (...) that acts as a mediator between humans and nature (Stehr 2000: 78p.).

[6]The debate at the time focused on the issue as to whether the approaches up till then to model intelligence by reconstructing the processes of symbol processing in a cognitive system could be promising. The notion of characterising intelligent systems as an instancing of a physical, symbol−processing system is confronted with the connectionist position of tracing the symbol processing of cognitive systems back to the neuronal processes on which it has been established and of modelling these processes. This objective is based on the hypothesis that cognitive systems consist of a multitude of simple subsystems in a massive parallel interaction relation and form a highly networked structure (Charniak & McDermott 1985, Lischka & Diederich 1987; Palm 1988).

But is this really knowledge? Max Weber already pointed out that increases in knowledge by no means represent "an increasing general knowledge of living conditions" but "knowledge of or trust in being able to acquire this knowledge at any time if one wants to (...)" (Weber 1973: 594). If knowledge is defined by how it relates to practice, then storing knowledge in the shape of data, texts and illustrations can initially result in nothing but information. For that person who has generated the information it represents *knowledge* (due to its context−related significance). But this need not be the case for others. As soon as the elements of knowledge have been de−contextualised, i.e. liberated from a specific action context, knowledge assumes the form of symbolic representations. If memos or copies of agreements are made and other documents are stored in an organisation, this is information, not knowledge. Only when this information is once again brought into a context, e.g. for a consultation or as a reminder of a deadline that is expiring knowledge will be reconstructed. Based on this reconstructed knowledge, the respective organisation or the clerk responsible in it now has a more or less adequate action resource at his disposal. The respective clerk will not lose this knowledge as long as he can remember. The situation is different for the organisation. As soon as the respective clerk leaves the organisation for whatever reason, this knowledge is no longer available to the organisation. Nevertheless, it still disposes of the information in the filing cabinet that enables it to generate new action knowledge. Knowledge cannot be "objectified" in the narrow sense. The only way to try this is to deprive it of its knowledge character.

3. Communicating knowledge as a double transformation

This is also the reason for the disillusionment of initial AI euphoria in the field of knowledge representation for expert systems in the eighties. The attempt to transfer knowledge from human actors to machines, i.e. to transform it into information, met with only limited success. In particular, what is referred to by Polyani (Polyani 1967) as "tacit knowledge" jibs to a large degree at being transformed into a symbolic representation.[7] Corresponding basic assumptions in AI that situations can be described with terms used for identifiable facts with well−defined features had already been criticised in the eighties (Dreyfus 1979; Searle 1986; Winograd & Flores 1986). The connectionist line in AI in particular rejected the Physical Symbol System Hypothesis, i.e. the notion that knowledge was established mentally in the shape of symbolic representation and could thus be explicated via the formal manipulation of symbolic representations on the basis of rules. In contrast, connectionism does not regard mental processes as being represented by units but by the (parallel) interaction of units within a network. This was inspired by the model of the nerve cell. In a similar way to with the cell, there are threshold values and activating values as indicators for the passing on of information. The system’s behaviour is not governed by rules. Rather, the individual representatives are themselves active, generating their own particular connectivity patterns as a consequence of learning processes in which the operations link up. Here, it is *emergence* that assumes a central role (Varela 1990).

So every attempt to communicate knowledge involves a twofold transformation. First of all, knowledge has to be turned into information. And then, someone has to transform this information into new action knowledge. This is the eye of a needle that social knowledge has to go through. With regard to selection required here, Luhmann distinguishes between three steps. First, information is generated, second, a suitable medium of transmission needs to be selected, and third, the information has to be understood. Provided that the conditions mentioned are fulfilled, Luhmann calls this three−step selection process "communication". Although the resulting product can be referred to as a "condensation of observations" (Luhmann 1990: 123), this still does not solve the problem of "fluidity and contextual intensity" (Willke 2001: 79). In this theoretical framework Willke regards communication referring to common contexts of experience as the indispensible prerequisite for the development of social knowledge. Only when information has been integrated into a "community of practice" of immediate and interactive common experiencing can "collective knowledge" be formed (Willke 2001: 90).

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[7]In his own theoretical framework Luhmann redefines Polany´s term "tacit knowledge" as "structural coupling of thinking systems (conscious) and communicating systems (society) (Luhmann 1990: 41p).

4. Knowledge as a condensation in the communicative space of society

Foucault suggested a theoretical description of such a "community of practice" in his theory of discourse (Foucault 1981). Foucault intends to describe knowledge as a quasi−objective fact, as a "fait social" in Durkheim's sense, and separates it from its subjective carriers. He views the social discourses as subject−free systems of statements representing part of the cultural knowledge system of society. These linguistic structures are the carriers of action in society.[8] Discourses are combinations of statements, linguistic systems, in which several statements are linked up with each other according to certain rules, forming a specific coherence that Foucault calls a "discursive formation", following the Marxist term of societal formations.[9] To Foucault, a discourse is a flow stretching over time and space, a highly selective organisational form of linguistic events, that is constituted by "a number of series of signs (..), provided that they are statements, i.e. provided that they can be attributed special existential modalities", and "that they belong to one and the same formative system" (Foucault 1981: 156). Discourses have a contingent factuality that is external to subjects. In addition to the meanings that they have been assigned by the subjects immediately involved in the discourse, there are meaningful contexts that need to be "excavated".[10]

Knorr−Cetina (Knorr−Cetina 1999) describes an example of such communicative practice contexts in a comparative sociology of science study on knowledge production in the fields of high energy physics and molecular biology.[11] She describes a form of knowledge production in which the individual vanishes as an epistemological subject. "Papers reporting experimental results will have all members of the collaboration listed on the first page(s) of the paper" (Knorr−Cetina 199: 167). In some projects, there are two or three pages with several hundred names.

Habermas is somewhat more sceptical. He also regards common communicative practice as the crucial issue. However, he distinguishes between life−world "background knowledge" and "rational knowledge". We normally use background knowledge "without being aware of the possibility of its being wrong. Assuming that all knowledge is fallible and is known as such, background knowledge does not constitute any knowledge at all in the narrow sense. It lacks reference to the possibility of becoming problematic because it is only confronted with criticisable claims of validity the moment it is uttered but no longer acts as a life−world background in this moment of being put into context but decomposes in its modality as background knowledge. Background knowledge as such cannot be falsified. It decomposes as soon as it enters the whirlpool of options to become problematic by assuming a thematic character" (Habermas 1992: 39). This decomposition that Habermas refers to is obviously the key problem. Does this imply that the possibility of social knowledge is restricted to immediate interaction contexts? If this is the case, how can social knowledge be thought at all?

Of course social knowledge cannot mean that everyone knows and thinks the same. Rather, the issue is that of knowledge that is condensed in the communicative space of society (Nassehi 2000). From a cybernetic angle, this refers to what is seen by what observers in this way and not in any other way under what circumstances. In order to give any answer to this question, one has to have access to the

[8]Foucault combines this perspective with a critique of society in which the social individuals are observed as persons affected by discursive chains of events. The individual subjects are viewed as if they were subordinated to comprehensive linguistic rules. The critical potential of discourse analysis then lies in the reconstruction of the formative rules of the discourse that link up the individual statements in a system.

[9] For Foucault, the "discursive formations" are the "historic a priori", i.e. the totality of conditions given in a certain epoch or situation for the formation of statements and discourses. He focuses on the discursive regularities in their openness, changeability and diversity. There are also non−discursive practices, such as house rules, institution rules, highway codes, service rules and regulations, etc.

[10]This is why Foucault also refers to his method as "archaeology".

[11]Her central concept is that of culture. In contrast with Foucault, who concentrates on the objectified forms of knowledge − albeit in its discursive distribution − she also wants to explain the process of making, generating and using knowledge. To her, knowledge is more than just a sort of product. This is why the method Knorr−Cetina favours is not an archaeology, as is the case with Foucault. She works with ethnographic methods. Oral statement at the Symposium "Szenarien der Wissenschaft" in Munich, 28th October 20 Knorr−Cetina, K.: Epistemische Kulturen. Presentation at the Symposium "Szenarien der Wissensgesellschaft" in Munich, 28th October 200.2000.

observations of others. Thus social knowledge cannot have any meaning other than that of the construction of a recursive network of autonomous systems each of which has its own modes and results of observation. Only via such a network can the world observe itself and learn to know what it knows.[12] What consequences does this basic insight have regarding the establishment of strategies for sustainable development?

5. Sustainable development in a network of autonomous systems

Sustainable development can only be achieved via a far−reaching modification in the life−styles of people, via fundamental changes in dominant production and consumption patterns and via a re−orientation of planning and decision−making processes. Regarding the issue of how such far−reaching transformation can be possible, debates focus on institutional innovation. Both in sociology and in political science and economics, institutions are seen as an option to control individual or collective behaviour. This is already picked out as a central theme in the final document of the 1992 Rio Conference (Agenda 21 1992; Jörissen 1999).

Jörissen et al. describe five basic principles for the institutional innovations required of which I would only like to refer to the two most general ones in the following: 1. enhancing resonance and 2. enhancing reflectivity.

Resonance describes the property of social systems to perceive changes in their natural or social environment and respond to them. How they respond depends on various conditions inherent in the system. What is crucial is the degree to which the interference signals, perturbations (Maturana 1990) or irritations (Luhmann 1995) are perceived by society or the social subsystems and are turned into an object of internal considerations and changes in behaviour of their own. The advantage of this self−referential type of resonance generation is that the respective system responds swiftly (and usually inevitably[13]). The disadvantage here is that this only occurs in a highly selective and one−sided way. This means that not all problems can be dealt with in this way and that the mode of response of the individual systems might well be problematic for society as a whole. In connection with strategies for a sustainable development, a further characteristic of modern societies therefore becomes important that we refer to as reflexivity (Jörissen et al. 1999: 160pp.).

Reflexivity is a central category in the current debate on how to achieve sustainable development. Lash calls it a "condition for the continuation of modernisation" (Lash 1996: 199). With reflexivity we refer to the consideration of the consequences of actions of a social subsystem, an organisation or a person for other areas of society, organisations or persons. Reflexivity implies that these consequences are already anticipated before the actions are performed. Here, the issue is not merely that of delimiting other actors or social systems from each other but also encompasses the thematic borders (Jörissen et al. 1999: 163pp.). One example of attempts to enhance reflexivity in science is the approaches to combine certain global problems as complexes of syndromes (Schellnhuber & Wenzel 1998). Although it is possible to assign the problems themselves to various spheres (e.g. the atmosphere, the biosphere or the anthrosphere), they can only be understood if they are regarded in their mutual relations, which is then expressed in so−called syndromes (e.g. in the so−called Sahel Syndrome or the Favela Syndrome). In this way, one−sided assessments that often focus on certain problematic areas of individual dimensions (of an ecological economic or social nature) can be avoided, while integrated problem solutions can be attempted.

Sustainable development points to the need to make knowledge generated at a particular point or level in society available to society as a whole. The difficulty here is that its production and use are separate, which results in a fundamental difference between knowledge and lack of knowledge in problem solving situations. Knowledge that is generated in certain contexts is required at another localisation of other contexts (but with similar problems). Often, the potential use of knowledge initially remains concealed

[12]Cf. also reading on the network society − Castells 2000; Messner 1995; Stefik 1999.
[13]Which does not mean that it always responds in a predictable way.

from the actors generating it. Although one can make assumptions, one will still not know where and when. What also remains concealed, now albeit from another angle, is whether knowledge required to solve certain problems may have already been acquired in other situations. And here too, the statement applies that one can assume it but does not know where and when. The conclusion to be drawn from this state of affairs is that society does not know what it knows.[14]

Basically, there is nothing new about this problem. Historically, society always found a way out with hierarchies. Social systems had their defined selection rules. In accordance with their hierarchical level, they knew whom they could get the required (i.e. appropriately pre−selected according to its specific function) knowledge from, and they knew whom they had to pass knowledge processed on this basis on to. Another type of knowledge processing is only relatively young, having emerged with the development of bourgeois society, i.e. just under 250 years ago. It is oriented on the concept of the public and does not work hierarchically. The science system has developed a special type in which scientific discourses that are above all based on texts emerge in thematically focused networks of mutual observation.[15] However − and this is the crucial point − all these forms have collapsed in the course of the information technology revolution (which nobody really believed in but which has occurred nonetheless). Even if it were desirable, knowledge processing would not be able to resort to the old patterns. But what new ones are there?

One crucial point will be that of networking knowledge (Castells 2000) (Messner 1995; Stefik 1999). Sustainable development is a particularly good example of how communication and action contexts that are networked world−wide are emerging owing to the close link between local action and global consequences or, vice versa, global problems and local consequences. Generating, processing and communicating knowledge no longer follows the old patterns of industrial society (above all the hierarchical modes of establishing and distributing knowledge). Over the last few years, network structures have come to the fore more and more (examples are the UN’s "Sustainable Development Networking Programme" <SDNP>, the "Global Development Network", in which both government and non−governmental organisations are involved, regional networks covering issues of the Local Agenda 21 as well as a number of self−help networks). Networks are to make knowledge on problems and problem solution strategies that has been generated individually and in a decentralised way available to society and enable it to flow into concrete decision−making processes wherever these may be in progress in the world. Networks are becoming means and forms of designing a sustainable society.

6. Information and communications technology access: the example of "City Traffic"

One illustrative example of the mutual networking of autonomous systems is the modern traffic system in conurbations. With this example, the question can be formulated more accurately as to the degree to which the employment of information and communications technology can contribute to understanding the emergence of knowledge in social networks.

The traffic system in conurbations is a highly complex socio−technical system with a wide range of influential factors (motorists, public passenger transport, cyclists, city traffic guidance systems, traffic lights etc.). Small local changes can have a considerable impact on the system as a whole (chaos effects). Within just a few minutes, an accident in a busy crossroads or a lane blockage can cause considerable irritation to the system as a whole in a conurbation. As a rule, owing to the general contingence of the system, any forecast on how individual road−users will act in a situation is only possible for the region immediately affected and over a very limited period. A forecast on the behaviour of the system as a

[14] For organisations Luhmann quotes Karl E. Weik: »An organization can never know what it thinks or wants until it sees what it does.« (Luhmann 1990: 186).

[15] However, what is special about the scientific system is not that it produces especially true knowledge (which it indeed does too), but that it always has to formulate knowledge within a relation to non−knowledge. Knowledge has to face critical questions from which research requirements are deduced and on the basis of which applications for third−party funding are formulated. Merton once called this "co−formulation of specific non−knowledge" "organised scepticism" (Luhmann 1995: 177p).

whole would only be possible under three conditions: First, a sufficient amount of empirically established figures relating to similar situations would have to be available, second, the other nodal points at which bifurcation may occur in the overall system would have to be observed, and third, these up−to−date observations would constantly have to be compared with the stored empirically established figures.

On this basis forecasts could then be made that would also make successful control interventions feasible. And it would by no means be necessary for the available repertoire to exceed the usual measures. It ranges from the employment of traffic policemen through modified traffic light switching, changes in directions of travel, modifications of lanes, announcements on indicator boards to electronic traffic guidance systems. The basic difficulty is that of contingence in the behaviour of all participants. All guidance is self−guidance that is influenced by the social availability of knowledge.

In a pilot project that the GMD is currently running with the City of Bonn, it has been possible to identify or create such ideal conditions (City−Traffic 2001). The City of Bonn is one of the towns in Germany in which almost all important crossroads with traffic lights are equipped with sensors capable of reporting the respective traffic situation to the city traffic guidance system. As a rule, these observations enable a relatively swift response to changed situations. However up to now − and this is important − such a response was normally restricted to a *certain location.* So far, a reflection in the sense described above that would also consider the behaviour of the system as a whole has not been possible. Any attempt to accomplish this would have presupposed co−ordinating communication the complexity of which would have been impossible to deal with.

This is where the option of microsimulation comes in. The information technology challenge here is that of networking local information and linking up stored data with the data of events established by the sensors. Among other things, this coupling enables forecasts to be made from the angle of individual road−users. For example, a road−user who still has to see to something downtown can have the parking situation in one of Bonn's car−park garages in an hour's time calculated. On the basis of data referring to past situations and current parameter adjustments (e.g. the state of the weather, snow or rain, current events, e.g. a football match or a political demonstration), forecasts can be made here that go beyond the usual attempts made so far.

Most simulation concepts used nowadays are not capable of providing a highly detailed blanket coverage of a respective region. When models are formed, many aspects have to be treated in a strongly abstract way.

- Individual vehicles cannot be simulated, so that medium flows of traffic are used.
- The real behaviour of light signal systems cannot be modelled true to their function over an entire area. Instead, typical switching behaviour or simple traffic queue models are used.
- The geometry of real roads, involving, for example, filter lanes, can only be considered in a small number of cases.

Simplifications of this kind strongly restrict the ability of the simulation results to yield forecasts, so that a large number of interesting problems cannot be simulated closely enough to reality. Only a precise micro−simulation in which the individual vehicles can be modelled in numbers that would be typical of large cities can change this situation. The geometry of real roads − for instance the length of filter lanes and the position and function of sensors − can be modelled in an artificial reality, and decision−making behaviour can be tried out. This enables the consequences of different alternatives for action to be anticipated on the basis of a microscopic description.

Nowadays, the use of cluster computers and modern agent software allows for such technical modelling. In a traffic simulation of the kind currently being realised in the GMD's "City−Traffic" project, this means that the system can model real traffic movements true to scale and function, in real−time and covering an entire area on the basis of several thousand software agents. So

- individual, technically different vehicles and different types of drivers can be simulated,
- light signal systems and the geometry of roads are modelled true to scale and function,

- the flow of individual vehicles is gained from sensor data of real traffic and can be co−ordinated in real−time.[16]

The system is a hybrid comprising real−time coupled traffic monitoring /guidance technology and micro−based simulation. The artificial reality that is created enables a holistic treatment of the relevant aspects of urban mobility. In addition to traffic guidance technology, this also covers management of the light signal systems and parking space and can simultaneously be used as a citizen's information system.

Here, simulation is not one of the usual abstractions but a detailed (simulated) approach to the world. The simulation enables different observers' perspectives to be taken up. By fading out or changing a respective parameter, the user of the simulation model can observe a (simulated) observer, i.e. realise a sort of observation of second order on the basis of assumed observation points. Of course these arrangements are also simplifications. Nevertheless, a much greater number of relevant details can be considered than would be the case with classic models. Karl E. Weick's sceptical statement that social systems cannot know what is happening if they have not been doing it could be refuted at this point.

References

Agenda 21 − The Global Programme of Action on Sustainable Development. www.un.org/esa/sustdev/agreed.htm

Ahlemeyer, H. W.: Managing Organized Knowledge: A Systemic Proposal. Journal of Sociocybernetics. 1, No. 2 (2000). pp. 1−11

Baecker, D.: Organisation als System. Frankfurt am Main 1999: Suhrkamp

Bechmann, G.; Stehr, N.: Risikokommunikation und die Risiken der Kommunikation wissenschaftlichen Wissens. Zum gesellschaftlichen Umgang mit Nichtwissen. GAIA. 9 (2000). pp. 113−121

Benford, G.: Deep time : how humanity communicates across millennia. New York 1999: Avon

Brundtland−Report: Our Common Future. The Report of the World Commission on Environment and Development. New York (www.un.org/esa/sustdev/agreed.htm) 1987:

Castells, M.: The Rise of the Network Society. 2nd Edition. Oxford, UK 2000: Blackwell

Charniak, E.; McDermott, D.: Introduction to Artificial Intelligence. Reading, Mass. 1985: Addison−Wesley

City−Traffic. Integriertes System für Verkehrs−Planung, −Managment und −Information in urbanen Ballungsräumen. GMD−Institute for Autonomous intelligent Systeme

Dreyfus, H. L.: What Computer can´t do. The Limits of Artificial Intelligence. New York 1979: Harper & Row

Forrest, S.: Emergent Computation: Self−Organizing, Collective, and Cooperative Phenomena in Natural and Artificial Computing Networks. Physica D. 42. pp. 1−11

Foucault, M.: Archäologie des Wissens. Frankfurt am Main 1981: Suhrkamp

Görz, G.; Wachsmuth, I.: Einführung in die Künstliche Intelligenz: Einleitungskapitel. In: Görz, G. (Ed.): Einführung in die Künstliche Intelligenz. 2. Aufl. Bonn 1995: Addison−Wesley. pp. 1−13

Habermas, J.: Faktizität und Geltung. Beiträge zur Diskurstheorie des Rechts und des demokratischen Rechtsstaates. Frankfurt am Main 1992: Suhrkamp

Hegel, G. W. F.: Phänomenologie des Geistes. Hegel Werke. Band 3. Frankfurt am Main 1970: Suhrkamp

Jörissen, J.; Kopfmüller, J.; Brandl, V.; Paetau, M.: Ein integratives Konzept nachhaltiger Entwicklung. FZKA 6393. Dezember 1999. Forschungszentrum Karlsruhe

Kant, I.: Kritik der reinen Vernunft. Band 1. Frankfurt am Main 1781: Suhrkamp

Knorr−Cetina, K.: Epistemic Cultures. How the Sciences Make Knowledge. Cambridge, Mass. (USA) 1999: Harvard University Press

Knorr−Cetina, K.: Epistemische Kulturen. Vortrag auf dem Symposium "Szenarien der Wissensgesellschaft" in München, 28. Oktober 200. 2000,

Kurucz, J.: Wissenssoziologie. In: Endrweit, G.; Trommsdorff, G. (Ed.): Wörterbuch der Soziologie. Stuttgart 1989: Enke. pp. 828−834

[16]After two minutes of computer time, a forecast can be made in this way that covers a period of 20 minutes.

Lash, S.: Reflexivität und ihre Doppelungen: Struktur, Ästehtik und Gemeinschaft. In: Beck, U.; Giddens, A.; Lash, S. (Ed.): Reflexive Modernisierung. Eine Kontroverse. Frankfurt am Main 1996: Suhrkamp. pp. 195−286

Lieber, H. J.; Wolff, K. H.: Wissenssoziologie. In: Bernsdorf, W. (Ed.): Wörterbuch der Soziologie. 2. Aufl. Stuttgart 1972: Enke. pp. 929−937

Lischka, C.; Diederich, J.: Gegenstand und Methode der Kognitionswissenschaften. GMD−Spiegel. 2/3−1987. pp. 21−32

Luhmann, N.: Soziale Systeme. Grundriß einer allgemeinen Theorie. Frankfurt am Main 1984: Suhrkamp

Luhmann, N.: Die Wissenschaft der Gesellschaft. Frankfurt am Main 1990: Suhrkamp

Luhmann, N.: Die Soziologie des Wissens: Probleme ihrer theoretischen Konstruktion. In: Luhmann, N. (Ed.): Gesellschaftsstruktur und Semantik. Band 4. Frankfurt am Main 1995: Suhrkamp. pp. 151−180

Mahr, B.: Chaos−Connection. Einwände eines Informatikers. Kursbuch 98. pp. 83−99

Malsch, T.: Die Provokation der "Artificial Societies". Warum die Soziologie sich mit den Sozialmetaphern der Verteilten Künstlichen Intelligenz beschäftigen sollte. Zeitschrift für Soziologie. 26 (1997). pp. 3−21

Maturana, H. R.; Varela, F. J.: El arbol del conocimiento : las bases biológicas del conocimiento humano. Madrid 1990: Editorial Debate

Messner, D.: Die Netzwerkgesellschaft. Wirtschaftliche Entwicklung und internationale Wettbewerbsfähigkeit als Probleme gesellschaftlicher Steuerung. 2. Köln 1995: Weltforum Verlag

Nassehi, A.: Was wissen wir über das Wissen? Vortrag auf dem Symposium "Szenarien der Wissensgesellschaft" in München, 28. Oktober 2000. 2000,

Neumann, B.: Bildverstehen. In: Görz, G. (Ed.): Einführung in die Künstliche Intelligenz. 2. Aufl. Bonn 1995: Addison−Wesley. pp. 559−702

Palm, G.: Modellvortellungen auf der Basis neuronaler Netzwerke. In: Mandl, H.; Spada, H. (Ed.): Wissenspsychologie. München − Weinheim 1988: Psychologie Verlags Union. pp. 488 − 502

Polanyi, M.: The tacit dimension. Garden City, NY 1967: Doubleday

Radermacher, F. J. (Ed.): Management von nicht−explizitem Wissen: Noch mehr von der Natur lernen. 3 Volumes. Bonn 2001: Federal Ministry for Education and Research

Schellnhuber, H.−J.; Wenzel, V. (Ed.): Earth System Analysis: integrating science for sustainability ; completed results of the Symposium on Earth System Analysis, organized by the Potsdam−Institut für Klimafolgenforschung (PIK), Potsdam 1997. Berlin 1998: Springer

Schirrmacher, F.: Zehntausend Jahre Einsamkeit. Wie wir unsere Nachkommen vor uns selber schützen wollen − Ein Bericht an den Kongreß. Frankfurter Allgemeine Zeitung (Feuilleton). Dec. 8, 2000

Searle, J. R.: Geist, Hirn und Wissenschaft. Frankfurt am Main 1986: Suhrkamp

Segler, T.: Evolution von Organisationen. Frankfurt am Main 1985:

Stefik, M.: The Internet Edge. Social, Technical, and Legal Challenges for a Networked World. Cambridge, MA 1999: MIT−Press

Stehr, N.: Arbeit, Eigentum und Wissen. Zur Theorie von Wissensgesellschaften. Frankfurt am Main 1994: Suhrkamp

Stehr, N.: Die Zerbrechlichkeit moderner Gesellschaften. Weilerswist 2000: Velbrück

Thom, M.: Wissen. In: Sandkühler, H. J. (Ed.): Europäische Enzyklopdie zu Philosophie und Wissenschaften, Vol. 4 (R−Z). Hamburg 1990: Meiner. pp. 903−911

Varela, F.: Kognitionswissenschaft − Kognitionstechnik. Frankfurt am Main 1990: Suhrkamp

Weber, M.: Wissenschaft als Beruf. In: Weber, M. (Ed.): Gesammelte Aufsätze zur Wissenschaftslehre, 4. Aufl. Tübingen 1973: Mohr (Siebeck). pp. 582−613

Willke, H.: Atopia. Studien zu atopischen Gesellschaft. Frankfurt am Main 2001: Suhrkamp

Winograd, T.; Flores, F.: Understanding Computers and Cognition. A New Foundation for Design. Norwood (NJ) 1986: Ablex