22 WORKING WITH TECHNOLOGY IN COMPLEX NETWORKS OF INTERACTION

Riikka Vuokko
Helena Karsten
University of Turku
Turku, Finland

Abstract *Contemporary issues such as increases in operational scope, connectivity, and dynamism in organizations have meant also a corresponding increase of complexity in producing everyday interaction. A simple task on the individual level can be approached as a part of complicated whole or even as adding to complexity on the organizational level. In this paper, we compare two strong metaphors for studying complex nonlinear interaction in heterogeneous networks: complexity theory and actor-network theory. Both examine socio-technical phenomena as evolving in ongoing negotiations of participants within complex networks. Understanding complex networks can add to our understanding of relationships between social actors and technical artefacts, that is, of information systems in use. As an example, we introduce a study of work practices in intensive care. We argue that this work is carried out as multiple and interdependent interactions further generating complexity in a network of humans, technical artefacts, and other materials. In such socio-technical networks, work practices, new technology, and work processes are negotiated or made irreversible through the actions of participants.*

Keywords Actor network theory, complexity theory, work practices, intensive care

1 INTRODUCTION

Research often strives for rationalization or simplification by ordering, dividing, and excluding in order to abstract or to reduce real world phenomena (Mol and Law 2002). But what if simplicity and complexity, or order and complexity, are not opposites? What if

Please use the following format when citing this chapter:

Vuokko, R., and Karsten, H., 2007, in IFIP International Federation for Information Processing, Volume 235, Organizational Dynamics of Technology-Based Innovation: Diversifying the Research Agenda, eds. McMaster, T., Wastell, D., Ferneley, E., and DeGross, J. (Boston: Springer), pp. 331-342.

production of organizational working life is a more complex matter, for the lack of a better word? At work, a phenomenon that is simple for one actor on a local level can be viewed by others as complicated or even as adding to complexity. Carrying out a specific task in an organizational process can be approached as a simple thing. But what if many actors carry out these same tasks, or if the single tasks add up to a more complicated whole? Then work can be approached as complicated and consisting of various clearly defined components, such as work processes, roles, and tasks, that add to the "system" as a whole. The perspective changes even more when we try to understand the organizational dynamics of a system that consists of a large number of interacting and overlapping parts whose actions cannot be predicted but who can share and retain information of their past and whose development can be seen as a continuum. Our object of study can be then described as complex.

Cilliers (1998) emphasizes that the notions *complex* and *complicated* have different meanings. A computer, for example, can be a complicated system that constitutes of a multitude of parts, but its functioning can be described and understood through its parts. A brain, for example, is a complex system that cannot be fully analyzed through understanding its components. The interactions within the system, with other systems, and with its environment are too complex to be understood simply by cutting up the system. Cilliers (p. 2) states that "complexity entails that, in a system, there are more possibilities than can be actualized." In the opinion of Mol and Law (2002, p. 1), "there is complexity if things relate but don't add up, if events occur but not within the process of linear time, and if phenomena share a space but cannot be mapped in terms of a single set of three-dimensional coordinates."

Contemporary trends and issues, such as changes occurring in the operational scope of organizations; increases in computing power and connectivity between people, applications and devices; and increased dynamism, uncertainty and discontinuity in organizational life have all contributed to the growth of complexity in working environments (Cohen 1999; Desai 2005; Jacucci et al. 2006; Merali 2004). As organizations change, the study of organizational dynamics needs new approaches. Traditional frameworks of technological innovations, such as diffusion of innovations (Gallivan 2001), approach socio-technical change from the perspective of individual autonomy and individual adoption or rejection, although that is hardly the case in organizations with a multitude of interconnected actors. Complexity is an increasingly common research theme in economics, organization science, and social theory (Anderson 1999; Jacucci et al. 2006), and although it is not entirely new in information systems either, the lack of a practically defined methodology has hindered its use (Merali 2004).

Information systems have been described as webs of socio-technical elements composed of both social and technical items (Kling and Scacchi 1982) or, for example, as work systems (Alter 1999) but applying complexity theory would mean a paradigm shift away from the classic definition of information systems as consisting of discrete components or subsystems to an approach of dynamically engaged and interconnected systems or networks of systems (Jacucci et al. 2006; Merali 2004). Anderson (1999, p. 217) states that modeling nonlinear outcomes of many interacting components and interdependent variables has proved to be difficult as "simple boxes-and-arrows causal models are inadequate." We propose that combining complexity with a network metaphor would increase understanding about the relationship between actors, technological artefacts, and information systems in use, or technology-in-practice (Orlikowski 2000).

Orlikowski argues that structuration theory (Giddens 1984) does not sufficiently describe technology as structure similar to social structures and as enabling or constraining action. Such an interpretation contradicts Giddens' original definition of structures as modalities of action, as memory traces. We argue that actor-network theory and complexity theory could provide a deeper understanding of socio-technical relations, or of information systems in use as complex and parts of working context.

Introducing new technologies to a working context can have manifold consequences. Star (1992) calls technological implementation a "Trojan door" with unexpected consequences, while she describes how the action and actors are dependent on their motivation, location, and causality of events as well as on their situated and distributed cognition. It is part of human nature to attempt to control system complexity and uncertainty (Tan et al. 2005) as an unknown creates discomfort and, especially in organizations, feelings of insecurity and powerlessness. Tan et al. (2005) note that although it is not always possible to control complex behavior, it may be possible to develop an understanding of its characteristics. Even in routine computing, individual tailoring and fitting occurs, and negotiations of shared work practices are needed. Karsten (2003) states that interdependencies between organizational actors and interdependencies between work tasks are being constantly formed and dismantled in working environments—especially when change "has become a way of life in organizations" (p. 437). According to Desai (2005), most naturally occurring processes are complex and an actor manages by being adaptable. In an organizational context, when dealing with complex situations, flexibility and adaptability are needed in a sense "that systems or processes are not frozen because they are too tightly constrained nor are they dysfunctional such that they disintegrate due to too little order" (Desai 2005, p. 34).

A recent topic in science and technology studies, and especially in studies framed with actor-network theory (Latour 2005; Moser and Law 2006) is complexity. In heterogeneous and socio-technical networks, all kinds of elements can interact in producing the social and the technical (Latour 2005; Law 1992). Knox et al. (2006) base the fascination of networks or network metaphor on the ubiquity of networks in the contemporary world, and state that one of the founding questions in network approaches is rearticulation of social relations as action and performance. The network metaphor has made it possible to address the mobility and complexity in social systems, and to describe socio-technical artefacts and relations.

Our research interest is to examine the dynamics and totality of interaction in a socio-technical network, which in our case is an intensive care unit in a university hospital. Orlikowski (1996) feels that complex work situations, environmental, technological, and organizational premises can facilitate patterns of working which cannot be "explained or prescribed by appealing to *a priori* plans and intentions" (p. 65). Instead, she continues, emergent change of working practices is approached as ongoing and grounded activities of organizational actors. This view demands reconceptualizing the use and development of information systems in the light of rising complexity (Jacucci et al. 2006). Heterogeneous socio-technical elements, such as system specifications and requirements, high costs and risks, several stakeholder groups with divergent interests, a large group of potential users, and different organizational resources like skills, may increase the level of complexity when implementing large-scale systems (Star and Ruhleder 1996) in established institutions (Chae and Lanzara 2006, Tan et al. 2005). Here, we examine the theories of complexity and actor networks to compare what kind of conceptual tools they could provide for studying socio-technical change in an institution with a long history. We then briefly introduce our research proposal for studying interactions in an intensive care unit where human and nonhuman actors engage every day in multiple ways.

2 APPROACHING COMPLEXITY

2.1 Complicated or Complex?

Jacucci et al. (2006) propose that the complexity of any technology utilization in contemporary organizations should be addressed from socio-technical and organizational viewpoints in environments where there are systems consisting of large numbers of self-organizing agents that interact in a dynamic, nonlinear fashion and share a path-dependent history (Cilliers 1998). To explore how intensive care nurses might experience working in an environment that consists of complex connectivity between various types of actors, the classic systems paradigm view is no longer sufficient (Merali 2004). According to Merali (2004), in the systems paradigm, information systems are conceptualized as holistic, well-defined systems that have clear boundaries that they strive for stability. Such systems can be complicated in that they consist of many components. In contrast to this, complex systems cannot be sufficiently understood by dividing them to components or subsystems. Merali describes the new information technology in organizations as a facilitator of complex, adaptive systems that have different features and that connect a diversity of entities through various and multiple channels. Behavior of a complex system is hard to predict because it is nonlinear and emergent (Anderson 1999; Kim and Kaplan 2006).

According to Cilliers (1998), complex systems are often systems that are grappling with their environment. There is a need to adapt to a changing environment simply to survive and to develop further. In order to adapt and to respond to changes, complex systems have to be able to gather and store information for future use, and to self-organize when necessary. Merali identifies five characteristics of complex adaptive systems grounded in a connectionist definition of networks. First, complex systems consist of interconnected "nodes" or actors that can communicate with each other and process information. Second, from the connectivity between a network's actors emerges a topology of the network. Third, as each actor within a network both constitutes and uses it, information circulating within a network gives rise to potential complexity, that is, to emergent diversity of information. The same message can be transmitted through various connections within the network, and the message is prone to change into multiple versions because the the interpretations given at different nodes by different actors. Fourth, the local action and the information diversity in a network can give rise to emergent global behavior, especially if we consider the actors of a network to have bounded rationality or limited knowledge and free will to take action. Fifth, boundaries are not useful in defining complex systems as holistic units. The relationship between a network system and its environment is reflexive and ambiguous. This relationship is also prone to change in time as a network's connectivity is dynamic.

Merali's (2004, p. 419) definitions of complex adaptive systems are grounded in complexity theory: "The 'science of complexity' is concerned with studying how collective behaviors of the focal system as a whole arise from the nonlinear interactions of its constituents with each other and with the environment." According to Merali, ontological constructs based on complexity theory would suggest a focus on complex network systems and on the dynamic and emergent properties within them. Epistemologically, this would mean studying such systems in their own environments, and focusing on emergent phenomena. This would also suggest describing network "dynamics in continuous time, as histories rather than snapshots" (Merali 2004, p. 439).

Complexity theory has not been used much in information system research but some examples can be found. Tan et al. (2005) combine complexity theory with chaos theory to outline the complexities of service delivery systems in health care organizations. Chae and Lanzara (2006) combine complexity theory with institutional theory to study large-scale technological change. Kim and Kaplan (2006) and Merali (2002) inspect the use of technology as or within a large complex system that includes the organization and its actors. Moser and Law (2006) combine complexity theory with actor-network theory to explore meaning and relevance of information in health care decision making. Kaghan and Bowker (2001) study the nature of socio-technical systems by comparing different research traditions of complexity and network metaphor. Kaghan and Bowker, Kim and Kaplan, and Moser and Law also suggest that complexity theory and actor-network theory are studying the same phenomena.

2.2 Studying Networks with Actor Network Theory

Actor network theory (Callon 1991; Latour 1991, 1992, 2005; Law and Callon 1995) has been used to study and describe large and complex networks of technological innovation and change. Especially in so-called "after ANT"—that is, the last 10 years' update in actor-network theory—there has been considerable attention given to complexity issues (Moser and Law 2006). In general, networks constitute a relevant social group (Bijker 1995) of actors that negotiate and interact with each other to solve a shared "problem." For example, in our study, the main social actors are the nurses and doctors. There are also other relevant actors in intensive care units such as technical artefacts, organizational rules, and scripts (Law and Callon 1995).

Howcroft et al. (2004) contend that a new technology is conceived when a relatively stable heterogeneous network of aligned interests is created and maintained. Development and implementation of technologies involves the building of alliances between various actors and this includes individuals and groups, as well as "natural" entities such as machines. Thus, both the social and the technical are involved as the actors are enrolled into a network. As the network evolves, the nature of the project and the identities and interests of the actors are themselves transformed (Law and Callon 1995). The results of the transformation process, translation, are subsequently inscribed into technologies (Walsham and Sahay 1999). Translation refers both to the process and the result of action (Latour 1991).

Black-boxing (Callon 1991; Howcroft et al. 2004; Kaghan and Bowker 2001) is another key process in actor-network theory that describes the effects of closure. When a phenomenon or a subnetwork becomes irreversible or has frozen elements, it is black-boxed or "closed" by drawing boundaries around it. This makes it possible for other actors within the network to treat the black box as a simple input/output device whose internal organization or operational rationality is indifferent to them. Black boxes are outcomes of socio-technical negotiations and as such, they can later be opened or renegotiated if new challenges appear within the network.

According to Scott and Wagner (2003), during the negotiation processes, many actors become involved and present varied interpretations of future. Translations are often accompanied by compromises and only some interests survive obligatory passage points. The temporalities that survive these trials develop strong characteristics of irreversibility. This indicates that if a translation of, for example, new working practices succeeds, it will be hard to cancel the development later on. Howcroft et al. argue that the emerging inscriptions (Akrich 1992) show the rationalizing effect of technology in a sense that social actors receive them as standardization or constraints of behavior. Scott and Wagner also note that durable time (Latour 1991) comes with a cost: the negotiations and compromises can become a hindrance to future development.

3 COMPARING COMPLEXITY THEORY AND ACTOR-NETWORK THEORY

Both complexity theory and actor-network theory deal with connected assemblages, that is, networks of interconnected nodes (Cilliers 1998; Latour 2005). From the interactions between the heterogeneous members of a network appear emergent properties shaping the future development. According to Kim and Kaplan (2006) and to Kaghan and Bowker (2001), both theories describe the unexpectedness of a change influenced by the local or situational features. Actor-network theory approaches the world as socio-technical, and in complexity theory the world is fundamentally organic.

These networks (Cilliers 1998; Latour 2005) are relatively stable but not in any way frozen in time or space. Instead, developing further is a continuum. Complexity theory does not describe an end-point that could be reached and in actor-network theory the process of translation is never-ending, the multiple and complex "ordering" is never finished (Moser and Law 2006). Both theories acknowledge, however, that the networks or the actions of networks' members can be constrained by previous choices and that, in a sense, networks are defined by path-dependency.

In complexity theory, it is not relevant to define the boundaries of a system or a network (Cilliers 1998; Merali 2004). More relevant is to explore the permeability of boundaries. In an organizational setting, this could mean studying how working over department or unit barriers is arranged and carried on. In actor-network theory, weight is put on defining a network or the group of "us" by setting clear boundaries. Non-members or "anti-group" (Latour 2005) have a role in underlining the differences between those included in and those excluded from a network.

Complexity theory provides a usable metaphor. Complex adaptive systems were first an area of interest in studies of organic systems, linguistics, and artificial intelligence (Anderson 1999; Cilliers 1998; Merali 2004). The idea of complex adaptive systems was used in laboratory experiments as simplification devices (Merali 2004; Mol and Law 2002), and the metaphor is "stretched" when studying individual agents and action in social settings (Anderson 1999; Kim and Kaplan 2006).

Network has been a prevailing metaphor for studies emphasizing connectedness in, for example, information science, organization science, and sociology (Castells 2000;

Cilliers 1998; Kling and Scacchi 1982; Merali 2004; Latour 2005). A network is dynamic, and has flexibility and adaptability to survive. In a network metaphor, interconnectivity has been described as negotiable, as voluntary or open-ended, or even as unpredictable. As such, the metaphor has fitted well to describe contemporary organizations and the changes in working life. In research, it means recognition of fragmentation and complexity (Knox et al. 2006).

The network metaphor has been criticized for a lack of clear definitions, or for having multiple meanings (Cohen 1999; Doolin and Lowe 2002; Kaghan and Bowker 2001; Latour 2005). There is no agreement about what kind of nodes and relations comprise a network. As such, power relations can be left undefined or even neglected when using the network metaphor. Kaghan and Bowker (2001) criticize that rationalist or functionalist approaches in network theories have tendencies of determinism, for example, when professionals or managers are portrayed as the "brains" that lead and regulate a change process. The network metaphor has also been criticized because it lacks the power to describe how change actually happens. Knox et al. (2006, p. 134) state this as follows: "As soon as the network itself becomes a blueprint for spatial relations, that is, as soon as it stops challenging and starts prescribing, then the productive capacity of the network is diminished."

Actor-network theory has been criticized from various viewpoints (Howcroft et al. 2004). First of all, there is the notion of symmetry. In actor-network theory, social and technical, or human and nonhuman, actors are seen as inseparable and thus they should be studied using same concepts. This has been seen as a radical explanation but at the same time intellectually and morally problematic as it allows human actors to be reduced to mere objects (Howcroft et al. 2004; Walsham and Sahay 1999). Latour (2005) explains that relevant actors within a network or in a given situation are all those present and participating without which it would be problematic to perform the task at hand. Thus, for example, to hit a nail, the hammer is as essential as the human actor with the knowledge to use the hammer.

Claims have been made that actor-network theory concentrates on micro-level or local studies, leaving out macro-level or global considerations (Howcroft et al. 2004; Knights and Murray 1994). This implies that social structures are not taken into consideration and that only a limited number of possibilities are accepted for the process of translation. Of the possibilities or technological trajectories available, only some are chosen, but actor-network theory does not clearly tell who or what is responsible of this choosing, or how the choices are later evaluated (Kim and Kaplan 2006). This is connected to the criticism that actor-network theory has an amoral stance as there is no regard to social consequences of technological choice, or about the inclusion or exclusion of members in a network. Star (1991) has described such irreversible networks of technological change as "networks of the powerful." Claims have been made that actor-network theory has a flat ontology because it takes institutions into consideration while studying how networks are constituted (Doolin and Lowe 2002; Knights and Murray 1994; Rose and Jones 2005). Similarly, it leaves out gender issues in technological change narratives (Howcroft et al. 2004).

Another characteristic common to in complexity theory and actor-network theory is that neither is a clearly defined theory, ready-to-use (Callon 2005; Cilliers 1998; Walsham and Sahay 1999). Instead both have been revised and further developed (Kaghan and Bowker 2001; Kim and Kaplan 2006).

4 STUDYING COMPLEXITY IN INTENSIVE CARE

Nursing work practices are being reformed as nurses are utilizing information technology in their working environment, for example, using electronic patient information systems. The work practices consist of a complex set of both standardized and situational arrangements—partly grounded in laws—that nurses carry out in their everyday work. An intensive care unit is a small component in the overall structure of health care, but at the same time, it is a complex system that involves surgeons and assisting physicians, anesthesiologists, nurses, supporting staff, and multiple mechanical or electronic devices. These actors are influenced by their roles, skills, and personality as well as hospital guidelines and situational arrangements. Berg (2004, pp. 36-37) describes the interwoven nature of information technology and care practices to be "such that it actually makes no sense to speak of the "consequences" or "impact" of information technology" as the development is "too complex for identifying such simple, causal lines." In the intensive care wards in Turku University Hospital, the co-construction of organizational practices and the use of information technology have not been previously studied from the perspective of complex interaction. Nursing documentation practices have been studied from the perspective of ethical issues in relation to intelligent systems and that of the possibilities of data mining of electronic patient records (e.g., Suominen et al. 2005, 2006). In intensive care, there are situations that require rapid action and care. It is essential to study how the nursing work practices are carried out *in situ*, how the nurses take action based on the information both from the situation and from electronic sources, and, in general, how information technology can be used to support nursing work.

In this study, we explore nurses working in three information environments (Lamb et al. 2003) as in intensive care there are different ways to arrange working, and various developmental stages of receiving and utilizing work information. First, in the intensive care unit for children, we can inspect a situation where work practices are being carried out "in the old way" and the use of electronic systems is still a matter under consideration. Second, the intensive care unit for adult patients already has experience using information technology as the various information systems have been a part of the everyday routine for some time now. It is possible in this environment to observe how information technology and other technological artefacts are being used together in care work.

From these initial cases, interesting questions arise. Using information technology affects working arrangements and organization of work. One aspect of technology use is that it can make work processes more transparent while at the same time hiding other aspects of work. Nurses have admitted feelings of losing their grip on the work when the care information has been transformed into electronic data. Based on a description of work practices, we can reflect on the differences of work practices in an environment where information technology is already in routine use and is considered an inseparable part of daily work with an environment only beginning to consider its use. In this context, we can study how information technology supports nurses' action-taking and decision-making.

While our aim is to understand how technology is used, it is not sufficient to only state that electronic records are used to support nursing work. More important is to find how textual and symbolic information is used, and what other type of information might be available to support fluid working. Both complexity theory and actor-network theory would suggest mapping out what other technologies are used and how these add to the picture of everyday working in the intensive care unit: what constitutes the integrated environment of interaction between heterogeneous actors? Furthermore, to assess further changes in work, it is important to inspect what information technology hides and reveals in the work, and how nurses react to these changes—for example, do they work around the problem situations, or does large-scale deconstruction of working practices take place? Or do they simply render technology to more simplified units through black-boxing it?

Third, in intensive care, the next step in health and medical informatics is the utilization of intelligent systems to receive technical support for daily care work. Intelligent systems are contemporary phenomena adding to rising complexity at work. Intelligent systems have largely stayed as a topic for more mathematically oriented research (e.g., Fenton et al. 2001), and in information systems they have attracted only moderate interest. No single reference sufficiently covers the research of intelligent systems from the viewpoint of supporting work practices and workers' action taking. Complexity theory suggests studying how interaction occurs in nonlinear fashion, how the actors adapt to changing environment, and how the actors are able to transform their practices, that is, the kind of new practices that emerge from action. Further, complexity theory suggests studying how emergent features are then transferred within the network and either what kind of diversity emerges, or what kind of path-dependence may constrain the development.

The plan is to carry out data gathering and analysis with qualitative ethnographic methods (e.g., Strauss and Corbin 1998) that aim for understanding a phenomenon in its everyday working context by observations and interviews. Using ethnographic methods fits well to theories of complexity and actor networks (Kaghan and Bowker 2001; Knox et al. 2006; Latour 2005) as in the former, emphasis is on emergent action in its environment, and in the latter, ethnographic analysis has longer traditions. The network metaphor provides a challenge to rigidity and as such it is a significant tool for analysis. The complexity metaphor allows us to analyze on-going interaction in open networks. Together, they make it possible to construct a picture of how large socio-technical networks are produced, and reproduced when innovations are introduced in them.

To summarize the conceptualization of our study plan, the main concepts derived from complexity theory and actor-network theory that will be used to guide the data gathering and the data analysis are listed in Table 1.

Table 1. **Conceptual Tools for the Study**

	Concepts for Studying Intensive Care Working
Actor-network theory	• Actor, actant (social and technical) • Network of shared interests • Transformation processes (translation, black-boxing)
Complexity theory	• Complex, nonlinear interaction • Self-organizing nature (reflexivity) • Adaptation to changing environment or situation • Bounded rationality of local action (path dependency) • Emergent interaction, emergent knowledge

5 CONCLUSIONS

In this paper, we have described work as carried out in multiple and interdependent interactions that further generate complexity in a network of humans, technical artefacts, and other materials. In such socio-technical networks, work practices as well as new technology or work processes are negotiated, constructed, and made irreversible through the actions of participants. The actors can respond to their environments in many unpredictable ways, so emergent behavior may result at various levels of the system. We argued that, for example, structuration theory has not been able to sufficiently describe the nature of information systems in use, and that combination of complexity theory and actor-network theory could provide an important new approach for studying changing work practices and innovations in contemporary organizations. We have also shown how this could be carried out by introducing our study in an intensive care context where new innovations are part of continuous change and negotiation of how work is best carried out.

References

Akrich, M. "The De-Scription of Technical Objects," in W. E. Bijker and J. Law (eds.), *Shaping Technology/Building Society. Studies in Socio-technical Change*, Cambridge, MA: The MIT Press, 1992, pp. 205-224.

Alter, S. "A General, Yet Useful Theory of Information Systems," *Communications of AIS* (1:13), 1999.

Anderson, P. "Complexity Theory and Organization Science," *Organization Science* (10:3), 1999, pp. 216-232.

Berg, M. *Health Information Management: Integrating Information Technology in Health Care Work*, London: Routledge, 2004.

Bijker, W. E. *Of Bicycles, Bakelites, and Bulbs. Toward a Theory of Sociotechnical Change*, Cambridge, MA: The MIT Press, 1995.

Callon, M. "Techno-Economic Networks and Irreversibility," in J. Law (ed.), *A Sociology of Monsters: Essays on Power, Technology and Domination*, London: Routledge, 1991, pp. 132-161.

Castells, M. "Toward a Sociology of the Network Society," *Contemporary Sociology* (29:5), 2000, pp. 693-699.

Chae, B., and Lanzara, G. F. "Self-Destructive Dynamics in Large-Scale Technochange and Some Ways of Counteracting It," *Information, Technology & People* (19:1), 2006, pp. 74-97.

Cilliers, P. *Complexity and Postmodernism: Understanding Complex Systems*, London: Routledge, 1998.

Cohen, M. "Commentary on the Organization Science," *Organization Science* (10:3), Special Issue on Complexity, 1999, pp. 373-376.

Desai, A. "Adaptive Complex Enterprises," *Communications of the ACM* (48:5), 2000, pp. 33-35.

Doolin, B., and Lowe, A. "To Reveal Is to Critique: Actor-Network Theory and Critical Information Systems Research," *Journal of Information Technology* (17), 2002, pp. 69-78.

Fenton, W. G., McGinnity, T. M., and Maguire, L. P. "Fault Diagnosis of Electronic Systems Using Intelligent Techniques: A Review," *IEEE Transactions on Systems, Man, and Cybernetics* (31:3), 2001, pp. 269-281.

Gallivan, M. J. "Organizational Adoption and Assimilation of Complex Technological Innovations: Development and Application of a New Framework," *Data Base for Advances in Information Systems* (32:3), 2001, pp. 51-85.

Giddens, A. *The Constitution of Society*, Cambridge, UK: Polity Press, 1984.

Howcroft, D., Mitev, N., and Wilson, M. "What We May Learn from the Social Shaping of Technology Approach," in J. Mingers L.Willcocks (eds.), *Social Theory and Philosophy for Information Systems*, Chichester, UK: Wiley, 2004, pp. 329-371.

Jacucci, E., Hanseth, O., and Lyytinen, K. "Introduction. Taking Complexity Seriously in IS Research. Information," *Technology and People* (19:1), 2006, pp. 5-11.

Kaghan, W. N., and Bowker, G. C. "Out of Machine Age? Complexity, Socio-Technical Systems and Actor-Network Theory," *Journal of Engineering and Technology Management* (18:3-4), 2001, pp. 253-269.

Karsten, H. "Constructing Interdependencies with Collaborative Information Technology," *Computer Supported Cooperative Work* (12:4), 2003, pp. 437-464.

Kim, R. M., and Kaplan, S. M. "Interpreting Socio-Technical Co-Evolution: Applying Complex Adaptive Systems to IS Engagement," *Information, Technology & People* (19:1), 2006, pp. 35-54.

Kling, R., and Scacchi, W. "The Web of Computing: Computer Technology as Social Organization," *Advances in Computers* (21), 1982, pp. 1-90.

Knights, D., and Murray, F. *Managers Divided: Organization Politics and Information Technology Management*, Chichester, UK: Wiley, 1994.

Knox, H., Savage, M., and Harvey, P. "Social Networks and the Study of Relations: Networks as Method, Metaphor and Form," *Economy and Society* (35:1), 2006, pp. 113-140.

Lamb, R., King, J. L., and Kling, R. "Informational Environments: Organizational Contexts of Online Information Use," *Journal of the American Society for Information Science and Technology* (54:2), 2003, pp. 97-114.

Latour, B. *Reassembling the Social. An Introduction to Actor-Network Theory*, Oxford, UK: Oxford University Press, 2005.

Latour, B. "Technology is Society Made Durable," in J. Law (ed.), *A Sociology of Monsters: Essays on Power, Technology and Domination*, London: Routledge, 1991, pp. 103-131.

Latour, B. "Where Are the Missing Masses? The Sociology of a Few Mundane Artifacts," in W. E. Bijker and J. Law (eds.), *Shaping Technology/Building Society. Studies in Socio-Technical Change*, Cambridge, MA: The MIT Press, 1992, pp. 225- 258.

Law, J. "Notes on the Theory of the Actor Network: Ordering, Strategy, and Heterogeneity," *Systems Practice* (5:4), 1992.

Law, J., and Callon, M. "Engineering and Sociology in a Military Aircraft Project: A Network Analysis of Technological Change," in S. L. Star (ed.), *Ecologies of Knowledge: Work and Politics in Science and Technology*, Albany, NY: State University of New York Press, 1995, pp. 281-301.

Merali, Y. "Complexity and Information Systems," in J. Mingers and L.Willcocks (eds.), *Social Theory and Philosophy for Information Systems*, Chichester, UK: John Wiley and Sons, Ltd., 2004, pp. 407-446.

Merali, Y. "The Role of Boundaries in Knowledge Processes," *European Journal of Information Systems* (11:1), 2002, pp. 47-60.

Mol, A., and Law, J. "Complexities: An Introduction," in J. Law and A. Mol (eds.), *Complexities. Social Studies of Knowledge Practices*, Durham, NC: Duke University Press, 2002.

Moser, I., and Law, J. "Fluids or Flows? Information and Qualculation in Medical Practice," *Information, Technology & People* (19:1), 2006, pp. 55-73.

Orlikowski, W. J. "Improvising Organizational Transformation Over Time: A Situated Change Perspective," *Information Systems Research* (7:1), 1996, pp. 63-92.

Orlikowski, W. J. "Using Technology and Constituting Structures: A Practice Lens for Studying Technology in Organizations," *Organization Science* (3:3), 2000, pp. 398-427.

Rose, J., and Jones, M. "The Double Dance of Agency: A Socio-Theoretic Account of How Machines and Humans Interact," *Systems, Signs & Actions*, (1:1), 2005, pp. 19-37.

Scott, S. V., and Wagner, E. L. "Networks, Negotiations, and New Times: The Implementation of Enterprise Resource Planning into an Academic Administration," *Information and Organization* (13), 2003, pp. 285-313.

Star, S .L. "Power, Technology and the Phenomenology of Conventions: On Being Allergic to Onions," in J. Law (ed.), *A Sociology of Monsters: Essays on Power, Technology and Domination*, London: Routledge, 1991, pp. 26-56.

Star, S. L. "The Trojan Door: Organizations, Work, and the 'Open Black Box,'" *Systems Practice* (5:4), 1992, pp. 395-410.

Star, S. L., and Ruhleder, K. "Steps Towards an Ecology of Infrastructure: Design and Access for Large Scale Information Spaces," *Information Systems Research* (7:1), 1996, pp. 111-134.

Strauss, A., and Corbin, J. *Basics of Qualitative Research: Techniques and Procedures for Developing Grounded Theory*, Thousand Oaks, CA: SAGE Publications, 1998.

Suominen, H. J., Lehtikunnas, T., Hiissa, M., Back, B., Karsten, H., Salakoski, T., and Salanterä, S. "Natural Language Processing for Nursing Documentation," paper presented at the Second International Conference on Computational Intelligence in Medicine and Health Care (CIMED), Lissabon, Portugal, June 29-July 1, 2005.

Suominen, H. J., Lehtikunnas, T., Hiissa, M., Back, B., Karsten, H., Salakoski, T., and Salanterä, S. "Theoretical Considerations of Ethics in Text Mining of Nursing Documents," paper presented at Nursing Informatics 2006, Seoul, South-Korea, June 11-14, 2006.

Tan, J., Wen, J., and Awad, N. "Health Care and Services Delivery Systems as Complex Adaptive Systems," *Communications of the ACM* (48:5), 2005, pp. 36-44.

Walsham, G., and Sahay, S. "GIS for District-Level Administration in India: Problems and Opportunities," *MIS Quarterly* (23:1), 1999, pp. 39-65.

About the Authors

Riikka Vuokko is a Ph.D. candidate in Turku University and TUCS. Her thesis topic is "Mobile Computing in Home Care: Longitudinal Study of Organizational Implementation." That work focuses on describing the emergent work processes after an implementation, and social issues such as interpretations of control, efficiency, and professional ethics. She participates in the Louhi project on text mining nursing documentation in intensive care (for additional information on the project, see http://www.med.utu.fi/hoitotiede/tutkimus/tutkimusprojektit/louhi/). Riikka can be reached by e-mail at riikka.vuokko@utu.fi.

Helena Karsten is a professor in Information Systems, with a focus on information technology and work, in the Department of Information Technology at the University of Turku, Finland. She is the leader of Zeta Emerging Technologies Adoption Laboratory in TUCS (see http://www.tucs.fi/research/labs/zeta.php). Her research interests include the interweaving of work and computers, the use of IT to support collaboration, and social theories informing theorizing in information systems. She is an associate editor for *The Information Society* and an editorial board member of *Information Technology & People*. Helena can be reached by e-mail at eija.karsten@cs.utu.fi.