doi:10.1111/j.1365-2575.2007.00245.x

Multi-contextuality in boundary-spanning practices

Rikard Lindgren,* Magnus Andersson† & Ola Henfridsson‡

*Viktoria Institute, Hörselgången 4, 417 56 Göteborg, Sweden, email: rikard.lindgren@viktoria.se, †Viktoria Institute, Hörselgången 4, 417 56 Göteborg, Sweden, email: magnus.andersson@viktoria.se, and ‡Viktoria Institute, Hörselgången 4, 417 56 Göteborg, Sweden, e-mail: ola.henfridsson@viktoria.se, and Jönköping International Business School, Jönkoping University, P.O. Box 1026, SE-551 11 Jönköping, Sweden, e-mail: ola.henfridsson@ihh.hj.se

Abstract. *The capability to establish boundary-spanning practices within and across organizations has for long been recognized as a key strategic resource. As organizations are becoming distributed and dynamic, they will be increasingly populated by multiple functional, geographical, hierarchical and professional boundaries. The inherent complexity of such settings makes it difficult for organizations to leverage their boundary-spanning practices. Information technology (IT) systems have been hailed as a critical enabler of boundary spanning. However, there is little knowledge on how organizations are affected by the introduction of different types of IT systems. Building on an interpretive case study of Swedish transport organizations, this paper explores consequences of sensor technology for boundary spanning. The paper contributes with an understanding of what coexisting use contexts mean for boundary-spanning practices. A theoretical implication is that such multi-contextuality requires an integrative view on boundary spanning that combines insights from the organizational innovation and work practice literatures.*

Key words: boundary spanning, innovation, multi-contextuality, sensor technology, ubiquitous computing environments, work practice

INTRODUCTION

As an effect of increased specialization and distribution of work, organizations will be increasingly fragmented by multiple functional, geographical, hierarchical and professional boundaries. It is therefore necessary to develop capabilities for combining multiple sources of expertise (Kogut & Zander, 1992) and establishing boundary-spanning practices (Levina & Vaast, 2005a).

Given the importance of boundaries, there is a significant body of research that examines boundary-spanning activities in organizational innovation (see e.g. Leifer & Delbecq, 1978;

Tushman & Scanlan, 1981; Cohen & Levinthal, 1990; Friedman & Podolny, 1992) and everyday work practices (see e.g. Carlile, 2002; Pawlowski & Robey, 2004; Balogun *et al*., 2005) Early on, the innovation literature identified the significance of environmental information gathering and assimilation to organizational renewal. Such information gathering and assimilation is associated with specific boundary-spanning roles at different stages in the innovation process (Tushman, 1977). Later on, practice perspectives have focused on boundary spanning as a sense-making activity that situates new information in embedded and local work practices. Such sense-making is dependent on human agents' capacity to establish new recurrent cross boundary practices based on shared institutional meanings (Carlile, 2002; Pawlowski & Robey, 2004).

In view of the increasing ubiquity of information technology (IT) in organizational life, it is not surprising that its role in boundary spanning has attracted recent attention in the literature. In particular, IT artefacts have been recognized as having the potential to be adapted to local needs, while at the same time providing a source of common identity across boundaries (cf. Star, 1989). In the work practice literature, the notion of boundary object has been used to capture this potential and to advance the idea of IT as an important resource for boundary spanners in establishing practices that bridge communities-of-practice (Pawlowski & Robey, 2004; Levina & Vaast, 2005a).

Despite the recent interest in IT's role in boundary-spanning practices, it is fair to say that the extant literature pays little attention to differences between types of information systems (IS). The danger in doing this is the inattention to potential consequences of specific qualities of the technology when studying boundary-spanning practices. In this paper, we explore ubiquitous computing environments as a specific type of IS and trace its implications for boundary-spanning practices. This is motivated by the multiple dimensions of boundary spanning that ubiquitous computing environments encompass when adopted and used in organizational settings (Fano & Gershman, 2002; Lyytinen & Yoo, 2002). In particular, we concentrate on the multi-contextuality, i.e. the coexistence of multiple use contexts, of ubiquitous computing environments (Henfridsson & Lindgren, 2005) and the particular challenges associated with sensor technology use in boundary-spanning practices. We propose that the coexistence of multiple use contexts requires an integrative view on boundary spanning in which insights from the organizational innovation and work practice literatures are combined. In this vein, this paper addresses the following research question: what does sensor technology mean for boundary-spanning practices in distributed settings? Building on an interpretive case study (Walsham, 1995; Klein & Myers, 1999) of Swedish transport organizations, the contribution of this paper is an analysis of the complex relationship between boundaries of coexisting use contexts and technology support in organizational boundary spanning.

The paper proceeds as follows. First, we review related research on boundary spanning and the use of IT in boundary-spanning practices. This is followed by an examination of the notion of multi-contextuality and its relation to boundary spanning. Thereafter, we describe the research context and details about the method applied. Then, we present the result from our study and analyse the role of sensor technology in boundary-spanning processes. In our concluding sections, we discuss implications for research and practice.

PERSPECTIVES ON BOUNDARY SPANNING

Over the years, the notion of boundaries has been a central phenomenon in attempts to theorize organizations. Using various theoretical lenses, researchers have explored the nature of boundaries as the demarcation between an organization and its environment (Scott, 1992). In the literature, distinct conceptions like efficiency, power, competence and identity have been proposed to offer unique perspectives on organizational boundaries (Santos & Eisenhardt, 2005).

However, as modern organizations are becoming increasingly fragmented by multiple functional, geographical, hierarchical and professional boundaries, recent literature has developed broader views of boundaries as to provide a deeper understanding of organizations (see e.g. Santos & Eisenhardt, 2005). While multiplicity of boundaries can be traced to increased specialization of work, it creates the need for organizations to develop capabilities enabling integration of multiple sources of expertise. Indeed, the capability to leverage boundary-spanning practices within and across organizations has for long been recognized as a central competitive dimension of firms in the knowledge economy (Kogut & Zander, 1992).

On a general level, boundary spanning can be seen as the activity of making sense of peripheral information that is perceived relevant to expand the knowledge at the centre of a given organizational context. In reviewing extant research contributions, boundary spanning has attracted a great deal of attention in a variety of literatures including decision science (Choudhury & Sampler, 1997), human relations (Russ *et al*., 1998), logistics (Morash *et al*., 1996), organizational innovation (Cohen & Levinthal, 1990), psychology (Voydanoff, 2005) and work practice studies (Kellogg *et al*., 2006). Focusing on different aspects of this multifaceted topic, innovation and work practice theories are dominant theoretical perspectives underlying such research and of particular interest to this investigation (see Table 1).

The innovation literature recognizes boundary spanning as something essential to organization renewal. The innovation perspective views boundary spanning as an information gathering activity aimed at linking new, typically environmental, information to prior knowledge for stimulating innovation. Underlying this view is an assumption that acquiring and assimilating new information is central to competitive advantage. Cohen & Levinthal's (1990) seminal work on absorptive capacity epitomizes this tradition. They define absorptive capacity as the 'ability of a firm to recognize the value of new, external information, assimilate it, and apply it to commercial ends' (p. 128). In this vein, an organization's absorptive capacity depends both on the organization's direct interface with the external environment and on the transfer of knowledge across and within organizational boundaries. Many innovation studies focus on the boundary and communication channels between the organization and its environment (Leifer & Delbecq, 1978; Cohen & Levinthal, 1990; Rosenkopf & Nerkar, 2001). Such cross boundary communication can often involve several special boundary roles over different phases in the innovation process (Tushman, 1977; Tushman & Scanlan, 1981; Friedman & Podolny, 1992). This activity is performed by so-called boundary spanners, i.e. individuals who operate at the periphery or boundary of an organization, relating the organization with elements outside it (see e.g. Tushman, 1977; Cohen & Levinthal, 1990). Essentially, these individuals scan the

Table 1. Theoretical perspectives on boundary spanning

Theoretical perspective	Key references	View on boundary spanning
Innovation	Cohen & Levinthal (1990) Friedman & Podolny (1992) Leifer & Delbecq (1978) Malhotra *et al*. (2005) Rosenkopf & Nerkar (2001) Tushman (1977) Tushman & Scanlan (1981)	An information gathering activity aimed at linking new, typically environmental, information to prior knowledge for stimulating innovation. The possession of information is central to competitive advantage.
Work practice	Balogun *et al*. (2005) Carlile (2002) Hayes (2001) Kellogg *et al*. (2006) Levina & Vaast (2005a) Levina & Vaast (2005b) Orlikowski (2002) Pawlowski & Robey (2004)	A sense-making activity aimed at situating general information in the context of local work practices. Situated representation of information is central to learning.

environment for new information, attempting to determine its relevance vis-à-vis information already assimilated in the organization. In this boundary-spanning process, the individual, the organization and the environment are parts of a network of interactions and organizational knowledge creation (Cohen & Levinthal, 1990).

The work practice literature recognizes boundary spanning as something essential to learning. Boundary spanning is typically seen as a sense-making activity aimed at situating information in the context of local work practices. In this regard, this stream of research primarily focuses on boundary spanning across internal boundaries of the organization (Balogun *et al*., 2005). Indeed, a distinguishing feature of the practice lens perspectives is their emphasis on situated or embedded work practices (Carlile, 2002; Schultze & Orlikowski, 2004; Kellogg *et al*., 2006). This means that acquisition, interpretation and meaningful use of context information is best described as interactive processes involving individuals or groups who routinely transform such information into action through their enacted and situated knowledge (cf. Orlikowski, 2002). Such processes are not necessarily accomplished by nominated boundary spanners, but typically emerge when individuals, boundary spanners-in-practice, accommodate the interests of their counterparts (Levina & Vaast, 2005a). These boundary spanners-in-practice can be described as knowledge brokers who facilitate information flows across boundaries within organizations (Pawlowski & Robey, 2004).

In sum, reflective of different origins and research traditions, the innovation and work practice perspectives represent two broad streams of boundary-spanning research. The innovation literature views boundary spanning as an information gathering activity that links environmental information to prior knowledge in order to stimulate innovation. In this regard, the development, assimilation and exploitation of information are central elements to gain competitive advantage. In what follows, we refer to this ambition as the competitive information problem. The work practice literature is focused on cross boundary sense-making. In particular, this literature approaches boundary spanning as an activity aimed at situating information in the context of local work practices. We refer to this ambition as the situated adaptation problem throughout this paper.

BOUNDARY SPANNING AND THE PROBLEM OF MULTI-CONTEXTUALITY

Wide accessibility and geographical reach of IT systems make them a key enabler of boundary spanning. Research studies that explore the role of IT in boundary spanning have tended to focus on competitive information (see e.g. Malhotra *et al*., 2005) *or* situated adaptation (see e.g. Hayes, 2001; Levina & Vaast, 2005a,b). As an example of the former, Malhotra *et al*.'s (2005) absorptive capacity perspective on the RosettaNet B2B initiative in the context of supply chain management illustrates how new partner-enabled market knowledge creation and sharing can be supported by internet technology. The authors' analysis is focused on how inter-organizational systems can support different forms of boundary-spanning partnerships between manufacturers, distributors and retailers for business innovation. With regard to the situated adaptation problem, however, they convey a relatively ignorant stance. In fact, in the context of standard electronic business interfaces, Malhotra *et al*. (2005, pp. 155–156) write that 'such standards reduce the need to reprocess information received from diverse partners. Prescribed formats make it easy to interpret and manipulate data, which enhances the acquisition and assimilation capabilities of the receiving enterprise'.

Looking at the work practice literature, situated adaptation is at the centre of attention. For instance, Levina & Vaast (2005a) explore how boundary-spanning practices emerge locally as an outcome of human agents' accommodation to the interests of their counterparts. In the two case studies, the so-called boundary objects-in-use were intranet applications for information sharing. Using Bourdieu's notion of field, Levina & Vaast's (2005a) exploration is geared towards the construction of joint fields as necessary conditions for successful boundary spanning.

Despite significant differences between the two perspectives, they both virtually overlook potential differences between technologies supporting boundary-spanning activities. The competitive information studies basically view IT as a tool that provides particular information processing capabilities that are subject to managerial control. The work practice studies tend to focus on how IT, or boundary objects, become resources in local meaning-creation. The risk taken here is that insufficient attention is paid to differences between types of IT artefacts and the potential of new boundary-spanning opportunities and problems emerging with new technologies.

A candidate technology with potential for opening up a new perspective on boundary spanning is industry-wide ubiquitous computing environments. Being capable of leveraging digital representations of context information across time and place through sensor technology, such environments have been envisioned to become the eyes and ears of organizational actors in the realm of distributed organizing (Fano & Gershman, 2002). There is growing evidence that organizations seek to erect ubiquitous computing environments comprising heterogeneous elements such as office, mobile, sensor technologies as to leverage business propositions and increase customer value (Lyytinen & Yoo, 2002).

One example is Jonsson *et al*.'s (2004) study of a shipboard crane supplier's attempt to design and install a remote diagnostic environment as a means of creating innovative business missions through sensor technology. By integrating sensor technology into the physical goods (i.e. shipboard cranes) that catered for transfer of sensor information to office applications, the supplier was able to develop new customer offers that enable the delivery of lifting services rather than shipboard cranes. An additional example of how sensor technology can render value creation in business settings is reported in Andersson & Lindgren (2005). Using the term ubiquitous transport systems, they discuss seamlessly integrated computing environments applicable to the transport industry. By integrating sensor technology embedded in trucks with mobile and stationary transport systems, the transport organizations viewed the potential of improving mobile resource evaluation and dispatcher-driver communication.

Partly unlike approaches taken in the extant literature, these two studies illustrate that emerging boundary-spanning IS such as ubiquitous computing environments require that the problems of competitive information and situated adaptation are handled simultaneously. First, sensor technology promises to enable efforts to record and archive digital traces of socio-technical activities and interactions in distributed environments for real-time or subsequent review by those not present (Grudin, 2002). As Jonsson *et al*. (2004) note, ubiquitous computing environments thus cater for networked business settings that exceed organizational boundaries in time and space. In this way, ubiquitous computing allows for collection and transfer of context data that are useful to a multitude of actors including user organizations and suppliers of technology. However, this usefulness cannot be exploited unless the context data are situationally adapted in local use contexts of each of these actors. Second, once stored in a repository and shared via networks, digital traces can enhance organizations' understanding of the different contexts in which they act (Jessup & Robey, 2002). While the identification and sharing of context data may prove difficult enough, delivering such data that can be meaningfully interpreted by a multitude of actors is a grand challenge in itself. As Andersson & Lindgren (2005) observe, simply adding more sensors would never entirely eliminate the challenge of interpreting and understanding the complexity of different contexts. This insight must be understood in light of multiple actors' competitive information strategies.

The presence of competitive information and situated adaptation in these studies can be traced to the multi-contextuality of ubiquitous computing environments, i.e. the coexistence of different use contexts (Henfridsson & Lindgren, 2005). Given that the extant literature pays little attention to this multiplicity of boundary practices centred around a single technology, it is worthwhile to further explore consequences of multi-contextuality for the use of sensor technology in boundary-spanning practices. The purpose of our fieldwork and data analysis was to understand the complex relationship between boundaries of coexisting use contexts and technology support in organizational boundary spanning. This can help us to address the question as to how organizations can better utilize sensor technology in ubiquitous computing environments to make distant events to take place ‘here and now’.

METHODOLOGY

Research setting

A well-functioning transport system is a central component in supporting the mobility of people, competence, goods and capital across nations, regions and growth centres. Following the ongoing integration of economies around the world, new emergent transnational institutions and networks challenge the business of local and regional actors. For instance, the Swedish transport industry undergoes changes occasioned by the European Union’s ‘open market’, where foreign transport firms have increased their market share considerably. This increase is not only a result of lower cost levels in nearby countries but also a result of other firms’ closeness to more densely populated areas. In this context, major logistics companies like DHL and Schenker have strengthened their positions on the market.

It is therefore not surprising that Swedish transport organizations are faced with increasing pressures to leverage their business propositions and operations at different points in the supply chain. Whether these pressures concern increased customer service or cost reduction, their operations typically involve an increased utilization of different technologies for coordination of distributed mobile units on a daily basis. Such IT support includes services that offer overviews of their mobile resources by positioning individual trucks, route calculation services to minimize time and fuel expenditures of assignments, and vehicle performance recording services. These services reflect a prevailing distinction between the stationary and mobile contexts in a transport setting (Andersson & Lindgren, 2005), where frequent and timely transfer and exchange of information between the two contexts is important to get the job done. In addition, information is also exchanged between the mobile context and the sensor technology provider. The technology provider typically has an interest in using the sensor data in managing customer relationships and new product development. This is an example of multi-contextuality in transport settings.

Figure 1 provides a simplified overview of the technology-mediated information flows between different contexts in a transport setting. While there exist a number of different roles in transport organizations, users can be divided into three broad categories: managers, dispatchers and drivers. Managers are responsible for issues such as assembling supply chains, system portfolio management, and overall strategic planning and management, meaning that their use of sensor-fed context data typically can be found at an aggregated level geared towards account analysis and benchmarking. Responsible for the tactical operations management, dispatchers utilize sensor-fed stationary computational representations to tap into the ongoing flow of activities in the mobile field operations. Thus, dispatchers are a key user group of such technology in the ongoing information flow across the mobile and stationary contexts found in transport organizations. Drivers, on their part, transport goods, which involves loading,

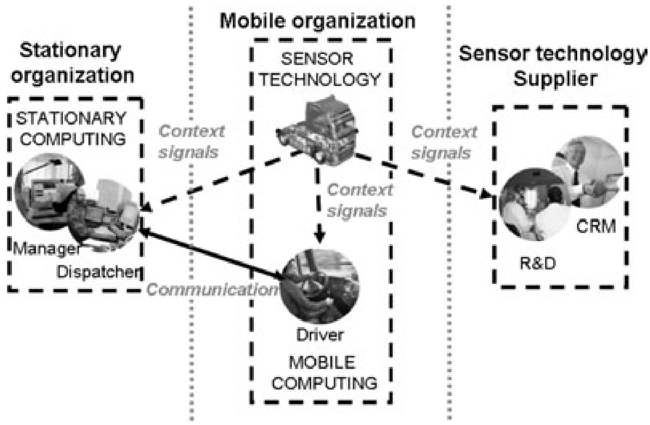

Figure 1. Overview of research setting.

unloading, driving and planning the routes, as well as interacting with clients. Apart from the actual driving, drivers spend much of their time interacting with dispatchers and other drivers in order to handle their daily work. In this interaction, mobile technology support for messaging and order management is routinely used.

Research design

The data for this study come from an empirical investigation undertaken within an ongoing action research project called 'Value-Creating IT for Road Haulage Firms', involving a set of road haulage companies and system vendors. The data originate from a distinct phase of the project intended to facilitate an in-depth understanding of the role of IT in daily transport operations. Given the explorative character of this project phase, the study can be described as interpretive in nature, seeking to explore the research phenomena in question through investigating the different meanings people assign to them (Orlikowski & Baroudi, 1991). This emphasis builds on the assumption that people act-in-the-world on the basis of their subjective and intersubjective creation of meaning.

The interpretive case study builds on data from four road haulage companies. There are two properties of the selected sites that made them particularly useful for studying the role of sensor technology in boundary-spanning practices. First, all companies utilized sensor technology to convey digital traces of mobile operations. In this regard, these organizations relied on an assemblage of sensor, mobile and stationary applications, which taken together can be seen as an emerging ubiquitous computing environment at the business level (see Table 2). Second, all companies had implemented technologies provided by system vendors that were part in the overall research project. This fact gave us access to system vendor views on the role and promises of these technologies for transport business. Multiple voices, not only among differ-

Table 2. Overview of case organizations

Case	Fleet size	Transports	Sensor technology	Computing environment: Mobile applications	Computing environment: Stationary applications
A	300	Goods	Barkfors fleet • Positioning	Barkfors fleet • Mobile order management	TDXlog • Order management
B	325	Bulk, foods, oil, goods	CoDriver • Fuel consumption • Distance travelled • Speed	CoDriver • Messaging Sadata • Mobile order management	SAdata • Order management
C	100	Foods, goods	Dynafleet • Positioning • Fuel consumption • Distance travelled • Speed	Dynafleet • Mobile order management • Messaging	Transport 2000 • Order management
D	40	Foods, goods	FAS • Positioning • Fuel consumption • Distance travelled • Speed		In-house system • Order management • RouteLogics

Table 3. Respondents

Category	Number of interviews
Drivers	4
Dispatchers	6
Managers	4
Vendor representatives	6

ent actor groups within the user organization, are an important criterion in interpretive field studies (Klein & Myers, 1999).

Data sources and analysis

The study included field research, where interviews, written documentation, technology and system demonstrations, as well as project meetings were the most important sources of data. The interview study included 20 semistructured interviews with users in the case organizations (managers, dispatchers and drivers) and system vendor representatives (see Table 3). All interviews were recorded and later transcribed. Lasting between 1 and 3 h, the interviews covered experiences of technology use, technology strategy, work practice and communication practices. The interviews with system vendor representatives (area or product managers) concerned current design strategies employed, relations to other technologies and envisioned usages of the technology. Key questions on these topics were followed by questions that depended on respondent answers.

As recognized in the literature on interpretive research, the interpretations of the researcher are based on interpretations of the respondent (Van Maanen, 1979). As interpretations are implied in any verbal communication, our interpretations of sensor technologies are likely to have influenced the respondents' interpretations during the course of the study. Referred to as double hermeneutics (Giddens, 1976), we tried to hamper such tendencies by conducting the interviews in an open-minded manner as to avoid any over-directing, which potentially would trigger testimonies that depict presuppositions of the researcher rather than respondent views. Even though this risk cannot be fully excluded in any study, the complementing data sources including written documentation, technology and system demonstrations, and project meetings were important points of triangulating the results from the interview study. For instance, the videotaped vendor representatives' technology demonstrations were useful for comparing the language they use in everyday technology discourse with that used in our interviews with them.

In terms of data analysis, the empirical categories were generated over time in working with this material in an iterative fashion. Concurring with the hermeneutic circle (Klein & Myers, 1999), initial conceptions based on literature reviews and collaborative project planning were used to develop initial semistructured interview protocols and the basic set of complementary data sources. With an increased understanding of the setting in the course of collecting the material, these conceptions were refined to better reflect the work practices existing and emerging with the use of the studied technologies. Over such cycles of deepened insight generated in working with the material, our analysis was gradually geared towards the role of sensor technology in boundary-spanning practices.

FINDINGS

This section of the paper outlines an interpretation of the role of sensor technology in the boundary-spanning processes unfolding in the case organizations. A closer description of the organizational usage of sensor technology is followed by an attempt to make sense of its role in boundary spanning.

The dispatcher as boundary spanner

Dispatchers are the social hub between stationary and mobile contexts in transport organizations. Using mobile order management systems and mobile phones, dispatchers typically coordinate the mobile resources in that they distribute customer assignments to specific drivers. The practice of such assignment involves consideration of available fleet capacity, driver locations, driver work schedules, transportation legislation and regulation, as well as environmental care. In managing this complex array of issues, the daily work of dispatchers involves considerable interaction with a range of actors including management, customers, drivers and others. As commented by dispatchers at case organizations A and C:

> Express deliveries are always special cases. It is phone conversations and sometimes I write on the computer simultaneously and sometimes I write notes first. It depends on the customer because some are confused and then it is easier to take notes and transfer it into the system in your own time. Express delivery customers are always in a hurry. They like to give the information in two seconds and hang up.

> Sometimes drivers get fewer goods than specified, or more for that matter. He has to communicate that and check if he can load it. If the driver has not yet got the full load specification he doesn't know if he has space enough at the next stop, which causes problems too. [. . .] We [dispatchers] help each other out. You listen and cooperate. If someone calls me who has talked to someone else earlier, I have to know what was said to be able to answer. So you have to be attentive to what is going on all the time. It might sound messy, and it is. It is a messy world we live in.

Dispatchers also monitor and evaluate mobile fieldwork (i.e. operational performance of drivers and vehicles, as well as load capacity utilization); this is done as to improve efficiency through corrective measures at the tactical level. A dispatcher commented:

> He [one of the dispatchers] goes through all assignments performed throughout the day. He checks them for any inconsistencies before sending the information on to management. Every month he collects fuel lists and calculates average consumption.

Generally, being a competent dispatcher requires a thorough understanding of the mobile context in the midst of time-critical decision-making. Such understanding is typically displayed in the capacity to enact situated knowledge through the routinely monitoring of the ongoing flow of assignments, driver interaction, management reporting, performance monitoring and so on.

With the introduction of sensor technology providing measures such as fuel consumption, goods temperature and position, the transport organizations envisioned new and more time-effective boundary-spanning processes that would help them handle the increased pressures from global competition. In what follows, we take a closer look at four instances of mediating boundary spanning through ubiquitous computing technologies. Concurring with prevailing notions of anytime-anywhere computing, the introduction of such technologies in the case organizations was associated with a number of hopes related to timeliness and contextual richness of information. As our findings show, they still struggle with making sensor technologies part of the ongoing stream of experience of transport practice.

Case A

Case organization A confronted problems related to the use of ubiquitous computing technologies in their boundary-spanning processes. At the time of our study, case organization A had employed a mobile system from Barkfors Fleet to optimize their mobile resource allocation. Utilizing GPS technology, dispatchers were able to continuously pinpoint the location of individual trucks on a dynamically updated map representation of the aggregated mobile context. The dispatchers were to gain knowledge of the mobile work context to inform timely order management. The CEO pointed out that dispatchers would no longer have to rely on extensive verbal negotiations with drivers to transfer information from the mobile context to their own, thus speeding up the allocation process:

> Then we decide who gets which assignments and send them on to the vehicle that will do the job. The driver who gets it [the assignment] decides if he accepts it or not. And when it is done, he sends a confirmation.

However, there was more to the mobile context than positioning. With the new system, drivers had the option to decline a given assignment from the dispatcher. According to dispatchers, such organizing mechanisms would diminish the perceived utility of a sensor-fed representation of the mobile work context:

> We question their option to decline. Now you have to call them all the time and ask: 'Why did you decline? What are you going to drive instead? What have you got that we do not know about?' and then we have lost the whole point.

In essence, the introduction of a sensor-fed stationary representation of the mobile context illuminated a more complex negotiation process. As the perceived efficiency gains of the system were endangered, dispatchers wanted the interpretation found in the stationary systems representation to enforce their organizing logic and deprive the mobile actors the opportunity to engage in communication and thus collective boundary spanning. The emphasis on the stationary representation was also evident with the vendor of the transport planning system:

> What we are targeting [with our system] is actually all that is going on in the office. We have little control of what goes on in the vehicles. [. . .] Of course, they [the customers] ask us what we find appropriate for them to have in the vehicles, but we do not really care.

Even though the sensor technology acquiring the context data were integrated with the stationary system, the representations were in effect still separated. The utilization of sensor technology was essentially subject to the prior understanding of work practice embedded into the design of the stationary system. Essentially, the sensor data were meant to replace much of the ongoing negotiation between dispatchers and drivers. Thus, the data were not intended to facilitate boundary spanning; rather it was intended to solve a predefined allocation problem by disregarding other means of gaining knowledge of the mobile context. This clashed with the current work practice of drivers and dispatchers alike.

Case B

Case organization B wanted to increase their knowledge of the mobile activities performed by the organization. Comprising embedded vehicle sensors, driver feedback and stationary reporting tools, Vehco's CoDriver system was therefore implemented in order to understand and improve driver performance. A central objective with the introduction of this technology was to facilitate knowledge creating boundary spanning between the mobile context and the stationary. More specifically, the system recorded and displayed real-time fuel consumption and speed metrics from the trucks. For the purpose of reducing fuel consumption, dispatchers were to utilize these measures to monitor and improve the driving skills of drivers. However, as pointed out by a dispatcher, this objective was hard to satisfy; while the collection of data was satisfactory, the meaning and utility of that data was less straightforward:

> I have got the follow up figured out fairly well. The parameters are ready made. The fuel consumption and distance driven; you cannot change that. But to make a good presentation to drivers who are actually using the system . . .

The fuel consumption metrics was a simplification of driving behaviour that was perilous to draw conclusions from. In fact, the dispatchers' interpretation of the sensor-fed representation of the mobile context did not in itself provide an explanation:

> Of course, driving badly . . . They can just say 'I loaded 30 tonnes more than you did'. And there are some circumstances too that make you consume fuel.

While the sensor-fed representations were to generate detailed knowledge of the mobile context, the divergent frames of dispatchers and drivers required the interpretation of sensor data to be negotiated. With regard to the complexities involved in understanding the mobile context, its representation was felt limited. Even though the system supported the timely acquisition of environmental data, it was not an easy task for dispatchers to create a shared understanding of the mobile practice together with the drivers. In effect, whereas the representation was expected to stimulate the boundary spanning of coexisting contexts, it could at most serve as a starting point in negotiating the meaning of the mobile setting.

Considering the existence of divergent frames, it might be noted that data that could enrich the dispatcher's frame existed within the organization. However, data that could possibly enable a more useful interpretation of the immediate situation of drivers were scattered in several other applications of the computing environment. The following quotation from the vendor of the sensor technologies employed by the organization provides a perspective on the reason for this fragmentation:

> We want to sell our stuff. We have got a good solution that works very well. Another vendor says 'buy our solution'. The transport organization then says that we have got one solution for this need and another for that.

From the organization's view, the sensor data were envisioned as an enabler for time efficient management of fuel consumption. In this way, the newly found data were meant to stimulate boundary spanning between mobile and stationary contexts. However, being designed to be utilized in a predefined fashion, the digital traces found in the systems were deemed limited with regards to meaning creation across contexts.

Case C

As early as in the mid-1990s, case organization C pioneered Volvo's Dynafleet system for order management and messaging, as well as vehicle and driver performance management. With a fleet consisting of 100 vehicles, C management felt that the communication between dispatchers and drivers also needed to be mediated through other media than mobile phones. It was perceived that the everyday practice of allocating assignments involved too much redundancy and mixed messages, ultimately resulting in both high costs and customer dissatisfaction. Over the years, the order management functionality of the system has essentially met the initial expectations, especially after that Dynafleet was integrated with stationary systems. The CEO commented:

> Well, the main advantage is that we save a lot on reduced telephone costs. And reliability. You can be sure that you actually sent the assignment to the driver. Before [the integration of Dynafleet and the stationary systems] you had to record the assignment twice. You received a customer order and entered it once more when sending it to the driver through the Dynafleet system [. . .] Now, it is done instantly. You save a lot of time.

The system also included vehicle sensor-fed functionality for driver and vehicle performance monitoring. At the time of this study, case organization C was dissatisfied with the sensor technologies involved. The CEO conveyed dissatisfaction with the context data provided:

> When he [the driver] stops to load or deliver, it is not included in the system today . . . what kind of stop it is. Since the contract is designed to consider miles driven, hours away, stops, and allowance. If they could get that too . . . I can see all the stops, but why he stops? He might just be on a break.

As illustrated by the quotation, the CEO felt that receiving vehicle sensor data about occurrences and lengths of stops is necessary but not sufficient for analysing fleet performance. Because stops are related to pay incentives, allowances, as well as transport legislation, the uncertainty about stop causes was an impediment to straightforward utilization of the information provided. In fact, rather than supporting competent decision-making, the decontextualized sensor data risked to cut both ways for actors involved.

Given these and other related difficulties, the sensor-fed functionality of Dynafleet was essentially not used at the time of the study. Management was largely at a loss with regard to the sensor information; this was partly a result of the fact the technology supplier was unable to present a viable vision of its intended use. Indeed, the vendor focused on time-efficient sensor data capture rather than context. A vendor representative commented:

> That is what Dynafleet is all about, to get performance data nonstop. You can see it all the time. And then you can put it into reports in the office. It is a good tool. [. . .] Our focal point has been what we see in the truck.

Aside from the multifaceted use contexts found within user organizations, it was clear that the vendor had many use contexts to take into account, both external and internal:

> When we centralize it we see internal benefits. Our retailers can get meter readings from the trucks and act proactively and see the benefit of marketing Dynafleet. You can get vehicle data to gauge if you have sold this customer the wrong vehicle. His driving style is completely different from that which it was designed for.

> We talk a lot about segmenting external customers. But very much internal as well. We have leasing companies, we have car rentals. When we own a retailer we can produce unique solutions. Telematics will play an important part, especially when we move towards complete reliability responsibility in leasing agreements. How can we ensure this? By plugging in to see how it is feeling or by making sure it notifies us when it is not.

Reflective of its vehicle manufacturer origin, the prime concern of Dynafleet representatives was the acquisition of sensor data for customer relations and product development. The tool perspective echoed in these quotes was apparently at odds with case organization C's agenda. Thus, the use of context data proposed by the design of the acquiring technology was not congruent with the objectives of the user organization. In practice, no meaningful interpretations of the acquired context data could be made. The decontextualized signals provided through the sensor technology were not interpreted as useful information in their boundary-spanning processes and the organization therefore ceased using them.

Case D

Case organization D had a clear ambition to integrate sensor, mobile and stationary computing to facilitate time efficient management by continuously monitoring distance travelled, speed and fuel consumption. The introduction of the sensor technology was motivated by a need to more accurately gauge the estimated efficiency of vehicles and drivers. Although initially appreciative, they soon experienced shortcomings of the sensor-fed representations of the mobile context. In particular, the mobile context was considered to include numerous complex interactions with essentially external conditions. Weather conditions, topology, road conditions and other parts of long range haulage practice were elusive in terms of overall context interpretation. In some cases, the system representations could render false analyses and potentially badly informed decisions:

> It is rather difficult, since there are more things to consider. We include road toll costs. If you choose a small, nontoll, road to save costs, you will most likely cause an increase in fuel consumption instead. All in all, with our kind of traffic, it is not that simple.

The dispatcher was highly sceptical to the practical utility of fully automated computing environments for enabling boundary spanning. Sensor-fed context data were not perceived useful for making context interpretations. Indeed, in conveying this cautiousness, the dispatcher emphasized the complexity of the context surrounding any given mobile worker:

> Every trip is a new one. I know some distances by heart nowadays, but other than that, every trip is unique. They have never driven exactly the same way twice.

In view of these problems, the vendor, whose primary business was truck manufacturing, felt that more data would overcome the experienced problems:

> There are lots of different things like logistics systems, scales, refrigeration equipment . . . a virtually endless list. For starters, we concentrate on the low-hanging fruit.

Reflecting the core competence of the vendor, acquisition of context data was its primary concern. To the extent that use of context data was considered, it concerned application areas that could be closely associated with technical engine functionality:

> You can also see the percentage of time spent on the green rpm-area, which is also how well you have used the engine. So, it gives you a good explanation [to high fuel consumption]. But it requires someone to help customers interpret these numbers.

The motivation for delivering context information was closely related to the relationship between the user organization and the manufacturer. Indeed, utilizing vehicle sensor data internally was perceived an important part of retaining customers.

> We are able to sharpen our services such as service agreements and maintenance if we get vehicle data in. We can become consultants to our customers and help them utilize their vehicles more efficiently . . . to get a higher utilization and lower costs. That is perhaps the most important aspect from the manufacturer's point of view. It's not about selling computers, but rather about reinforcing customer relations.

Clearly, there existed divergent user and vendor views. While the user organization pinpointed the importance of enriching boundary spanning through more contextualized aggregations, the vendor seemed to experience this as a problem of adding more parameters to the existing ones.

DISCUSSION

Being a time-critical and knowledge-intensive activity, boundary spanning has been portrayed as the capability of organizations to respond to dynamic change and derive long-term value from context information (Cohen & Levinthal, 1990). Indeed, such capability is critical to virtually all organizations involved in any intellectual work comprising knowledge creation and transfer in distributed settings. However, one of the challenges for organizations today is how to tackle the increased heterogeneity of work contexts. Thus, a central concern for IS research and practice is to advance the current understanding of how IT systems can allow such organizations to be sensitive to the contextual settings in which they operate, so that their operations can be attuned to these variations.

Reflecting that IT systems need the capability to sense and respond to changes in the context, IS researchers have recognized that organizations today are increasingly dependent on intelligent environments based on anytime, anywhere computing (March *et al*., 2000; Yoo & Lyytinen, 2005). Optimistically forecasted to seamlessly integrate organizations, people and systems across traditional boundaries, ubiquitous computing has been promoted as the technology for the realm of distributed organizations. While the introduction of ubiquitous computing is likely to blur both physical, social and temporal boundaries of an organization and its environment (Lyytinen & Yoo, 2002; Henfridsson & Lindgren, 2005), the major promise of ubiquitous computing in boundary spanning is the capability to (more or less) automatically acquire a broad range of context information about distributed work activities in real-time.

Whereas sensor technology has been utilized to detect or sense signals of internal conditions or performance in a multitude of industries for decades, there is growing evidence that organizations include such technology in their information environments as to leverage business propositions and increase customer value (Lyytinen & Yoo, 2002). Studies reported in Andersson & Lindgren (2005) and Jonsson *et al*. (2004) show that ubiquitous computing environments may grant organizations detailed digital traces of distributed operations through positioning technology, embedded sensor networks and similar technologies. Indeed, as these accounts indicate, monitoring digital traces offers the possibility of improved processes of boundary spanning. These two studies document that competitive information and situated adaptation are pressing in the context of ubiquitous computing environments. However, somewhat contrasting the approaches taken in the innovation (see e.g. Malhotra *et al*., 2005) and work practice (see e.g. Levina & Vaast, 2005a) literatures, such environments require that these problems are handled simultaneously.

The entanglement of competitive information and situated adaptation problems can be traced to the multi-contextuality of ubiquitous computing environments, i.e. the coexistence of different use contexts (Henfridsson & Lindgren, 2005). While the notion of multi-contextuality was originally coined for understanding consumer adoption of personal telematics services, our paper contributes to the boundary-spanning literature with an understanding of what the coexistence of different use contexts means for boundary-spanning practices in industry settings. It illustrates that the introduction of sensor technology in boundary spanning coincides with changes in the complex relationship between boundaries and technology support:

- Redefined boundary understanding. Configuration of IT-enabled boundary-spanning support such as sensor technology will alter boundary spanners' understanding of their environment. Over time, the technology will redefine the contextual cues with which boundary spanners make sense of remote information. For instance, the introduction of sensor technologies in cases A and B introduced negative side-effects for the mutual sense-making between dispatchers and drivers. Dispatchers were therefore inclined to introduce workarounds to compensate for their perceived loss of context understanding. However, it can be expected that continued use of sensor technology in the name of optimization will gradually diminish the former understanding of context and in this sense redefine boundary understanding practices.
- Negotiated boundary practices. Single organizations will have less control over their boundary-spanning practices as they emerge in interorganizational relationships. Internal communication channels crossing boundaries are traditionally controlled by the organization. However, the use of sensor technology influences organizational control. Looking at Case D, the use of sensor technologies for improving the efficiency of vehicles and drivers did not satisfy the contextual precision needed for accurate evaluation and control. In approaching the vendor (and vehicle manufacturer) for negotiating the data collection and interpretation, the transport organization was introduced to other sensor data sources including logistic systems, refrigeration equipment and so on. Given that such data are controlled and provided by other actors, it is

clear that sensor technology-enabled boundary-spanning practices require negotiation with multiple providers.

- Blurred boundaries. The distinction between internal and external boundaries becomes less useful. In case C, the vehicle manufacturer providing the Dynafleet system greatly valued the information provided by the sensor technology embedded in the vehicles sold to the transport organization. The information was useful for both customer relations and new product development. However, the same sensor data can be considered internal or external depending of its intended use. When used for customer relations, the information must be considered as external in the sense that it reflects the needs of an external customer. In the case of product development, it can be considered as internal in the sense that the transport organization's fleet of vehicles basically works as a test environment. In sum, the fact that sensor data generated in one organizational unit are used in multiple organizations or organizational units for different operational and strategic purposes blurs boundaries in an ambiguous way.

As these consequences are most likely not unique to the transport context, we believe that they have important theoretical and practical implications for the utilization of different types of IT systems as support for boundary spanning in distributed settings. On the theoretical side, the three consequences summarized above illustrate the dependency between information gathering activities for gaining competitive advantage and sense-making activities intended to situate decontextualized information in local work practices. Traditionally, these issues have largely been treated separately in the extant literature on boundary spanning. However, this dependency calls for integrative approaches for theorizing and rethinking linkages between IT systems and boundary-spanning practices. Relating the notion of multi-contextuality (Henfridsson & Lindgren, 2005) to the innovation (see e.g. Leifer & Delbecq, 1978; Tushman & Scanlan, 1981; Cohen & Levinthal, 1990; Friedman & Podolny, 1992) and work practice (see e.g. Carlile, 2002; Pawlowski & Robey, 2004; Balogun *et al.*, 2005) literatures, this paper extends the current understanding of boundary spanning in IS by taking the first steps to such theory development.

In terms of practical implications, our findings offer insights about side-effects surrounding attempts to seamlessly integrate organizations, people and systems. Because distributed use contexts are typically separated by a multiplicity of boundaries within and between organizations, the consequences identified provide evidence for the idea that support systems for boundary spanning need to reflect these boundaries. However, the issue of how to avoid the pitfall of configuring boundless elements in ubiquitous computing environments is a challenge in itself. Collaborative industrial-academic research projects are therefore encouraged to produce guidance for how the infusion of seams between elements in large-scale complex socio-technical systems may allow for bounded interactions in distributed settings.

CONCLUSION

This paper contributes to the boundary-spanning literature with an understanding of what multi-contextuality means for boundary-spanning practices in industry settings. Building on an interpretive case study of Swedish transport organizations, the paper has presented an analysis of organizational consequences of competitive information and situated adaptation problems in ubiquitous computing environments. Lying at the heart of the complex relationship between boundaries and technology support, the multi-contextuality of ubiquitous computing environments has important theoretical and practical implications for implementation and use of IT systems in boundary spanning.

Our study suggests that the successful deployment of IT systems in boundary spanning will rely on complex interactions involving multiple organizational actors, including technology suppliers, blurring the boundaries of the organization and in effect complicating the acquisition and use of context information. Therefore, integrative approaches are needed that combine insights from the innovation and work practice literatures to theorize the multi-contextual nature of technology in heterogeneous and competitive boundary-spanning practices.

REFERENCES

Andersson, M. & Lindgren, R. (2005) The mobile-stationary divide in ubiquitous computing environments: lessons from the transport industry. *Information Systems Management*, **22**, 65–79.

Balogun, J., Gleadle, P., Hope Hailey, V. & Wilmott, H. (2005) Managing change across boundaries: boundary-shaking practices. *British Journal of Management*, **16**, 261–278.

Carlile, P.R. (2002) A pragmatic view of knowledge and boundaries: boundary objects in new product development. *Organization Science*, **13**, 442–455.

Choudhury, V. & Sampler, J.L. (1997) Information specificity and environmental scanning: an economic perspective. *MIS Quarterly*, **1**, 25–53.

Cohen, M.D. & Levinthal, D.A. (1990) Absorptive capacity: a new perspective on learning and innovation. *Administrative Science Quarterly*, **35**, 128–152.

Fano, A. & Gershman, A. (2002) The future of business services in the age of ubiquitous computing. *Communication of the ACM*, **45**, 83–87.

Friedman, R.A. & Podolny, J. (1992) Differentiation of boundary spanning roles: labor negotiations and implications for role conflict. *Administrative Science Quarterly*, **37**, 28–47.

Giddens, A. (1976) *New Rules of Sociological Method*. Basic Books, New York, NY, USA.

Grudin, J. (2002) Group dynamics and ubiquitous computing. *Communications of the ACM*, **45**, 74–78.

Hayes, N. (2001) Boundless and bounded interactions in the knowledge work process: the role of groupware technologies. *Information and Organization*, **11**, 79–101.

Henfridsson, O. & Lindgren, R. (2005) Multi-contextuality in ubiquitous computing: investigating the car case through action research. *Information and Organization*, **15**, 95–124.

Jessup, L.M. & Robey, D. (2002) The relevance of social issues in ubiquitous computing environments. *Communications of the ACM*, **45**, 88–91.

Jonsson, K., Westergren, U.H. & Holmström, J. (2004) Technologies for value creation: an exploration of embedded systems use in a business model context. Presented as Plenary Paper at the 27th Information Systems Seminar in Scandinavia (IRIS 27), 14–17 August, 2004, Falkenberg, Sweden.

Kellogg, K.C., Orlikowski, W.J. & Yates, J. (2006) Life in the trading zone: structuring coordination across boundaries in postbureaucratic organizations. *Organization Science*, **17**, 22–44.

Klein, H.K. & Myers, M.D. (1999) A set of principles for conducting and evaluating interpretive field studies in information systems. *MIS Quarterly*, **23**, 67–93.

Kogut, B. & Zander, U. (1992) Knowledge of the firm, combinative capabilities, and the replication of technology. *Organization Science*, **3**, 383–397.

Leifer, R. & Delbecq, A. (1978) Organizational/environmental interchange: a model of boundary spanning activity. *Academy of Management Review*, **3**, 40–50.

Levina, N. & Vaast, E. (2005a) The emergence of boundary spanning competence in practice: implications for implementation and use of information systems. *MIS Quarterly*, **29**, 335–363.

Levina, N. & Vaast, E. (2005b) Turning a community into a market: a practice perspective on information technology use in boundary spanning. *Journal of Management Information Systems*, **22**, 13–37.

Lyytinen, K. & Yoo, Y. (2002) Research commentary: the next wave of nomadic computing. *Information Systems Research*, **13**, 377–388.

Malhotra, A., Gosain, S. & El Sawy, O.A. (2005) Absorptive capacity configurations in supply chains: gearing for partner-enabled market knowledge creation. *MIS Quarterly*, **29**, 145–187.

March, S., Hevner, A. & Ram, S. (2000) Research commentary: an agenda for information technology research in heterogeneous and distributed environments. *Information Systems Research*, **11**, 327–341.

Morash, E.A., Dröge, C. & Vickery, S. (1996) Boundary-spanning interfaces between logistics, production, marketing and new product development. *International Journal of Physical Distribution and Logistics*, **27**, 350–369.

Orlikowski, W. (2002) Knowing in practice: enacting a collective capability in distributed organizing. *Organization Science*, **13**, 249–273.

Orlikowski, W.J. & Baroudi, J.J. (1991) Studying information technology in organizations: research approaches and assumptions. *Information Systems Research*, **2**, 1–28.

Pawlowski, S.D. & Robey, D. (2004) Bridging user organizations: knowledge brokering and the work of information technology professionals. *MIS Quarterly*, **28**, 645–672.

Rosenkopf, L. & Nerkar, A. (2001) Beyond local search: boundary-spanning, exploration, and impact in the optical disk industry. *Strategic Management Journal*, **22**, 287–306.

Russ, G.S., Galang, M.C. & Ferris, G.R. (1998) Power and influence of the human resources function through boundary spanning and information management. *Human Resource Management Review*, **8**, 125–148.

Santos, F.M. & Eisenhardt, K.M. (2005) Organizational boundaries and theories of organization. *Organization Science*, **16**, 491–508.

Schultze, U. & Orlikowski, W.J. (2004) A practice perspective on technology-mediated network relations: the use of Internet-based self-serve technologies. *Information Systems Research*, **15**, 87–106.

Scott, W.R. (1992) *Organizations – Rational, Natural, and Open Systems*, 3rd edn. Prentice Hall, Englewood Cliffs, NJ, USA.

Star, S.L. (1989) The structure of ill-structured solutions: heterogeneous problem-solving, boundary objects and distributed artificial intelligence. In: *Readings in Distributed Artificial Intelligence*, Huhns, M & Gasser, L. (eds), pp. 37–54. Morgan Kauffman, Menlo Park, CA, USA.

Tushman, M.L. (1977) Special boundary roles in the innovation process. *Administrative Science Quarterly*, **22**, 587–605.

Tushman, M.L. & Scanlan, T.J. (1981) Characteristics and external orientations of boundary spanning individuals. *Academy of Management Journal*, **24**, 83–98.

Van Maanen, J. (1979) The fact of fiction in organizational ethnography. *Administrative Science Quarterly*, **24**, 539–550.

Voydanoff, P. (2005) Consequences of boundary-spanning demands and resources for work-to-family conflict and perceived stress. *Journal of Occupational Health Psychology*, **10**, 491–503.

Walsham, G. (1995) Interpretive case studies in IS research: nature and method. *European Journal of Information Systems*, **4**, 74–81.

Yoo, Y. & Lyytinen, K. (2005) Social impacts of ubiquitous computing: exploring critical interactions between mobility, context and technology – a special issue for information and organization. *Information and Organization*, **15**, 91–94.

Biographies

Rikard Lindgren is a Research Manager at the Viktoria Institute, Göteborg, Sweden. He is also Associate Professor of Information Systems at Dalarna University and at the IT University of Göteborg. His research focuses on action research, design science, knowledge management and ubiquitous computing. Dr Lindgren has published his research in *MIS Quarterly*, *Information and Organization*, *European Journal of Information Systems*, *Information Systems Management*, *Scandinavian Journal of Information Systems* and other journals in the information systems discipline. Currently, Dr Lindgren serves on the editorial boards of *Journal of Information & Knowledge Management* and *Scandinavian Journal of Information Systems*.

Magnus Andersson is a researcher with the Transport Group at Viktoria Institute in Göteborg, Sweden. Dr Andersson holds a PhD in Informatics from the IT University of Göteborg since 2007. He studies organizational impacts of integrated stationary, mobile and embedded computing environments, focusing on the transport industry and has been involved in a longitudinal action research project concerned with open standards in this area. Dr Andersson has published his research in *Journal of Strategic Information Systems* and *Information Systems Management* and proceedings of conferences such as the European Conference on Information Systems and IFIP WG 8.2.

Ola Henfridsson is the Research Manager of the Automotive Group at the Viktoria Institute, Sweden. He is also a Professor of Informatics at Jönköping International Business School, Jönköping University. His research interests include IT innovation, IT and organizational change, as well as action and design research. Dr Henfridsson has published his research in *Information and Organization*, *Information Systems Journal, IT and People*, *Journal of Strategic Information Systems*, *MIS Quarterly,* and other journals in the information systems discipline. He is an Associate Editor at the *MIS Quarterly* and serves as a Region 2 Representative on the AIS Council.

