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Contextual dynamics during health information systems implementation: an event-based actor-network approach

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Abstract

Despite its information-intensive nature and considerable investments, healthcare continues to lag behind other industries in effectively exploiting information technology (IT). This paradox suggests that the healthcare industry presents particular challenges for successful implementation of information systems. As a result, there is an increasing interest in research into how information systems implementation efforts are shaped in interaction with the healthcare context. This paper contributes to this emerging body of knowledge by applying Actor-Network Theory (ANT) to explore the implementation of a radiology network system in a Swedish hospital. The analysis of the *process* reveals how complex contextual dynamics had disruptive effects. First, we identified important dynamics related to implementation *content*; these were mainly expressed as tensions between the radiology network system and medical work practices. Second, we found important dynamics related to implementation *context*; these were mainly expressed as tensions between shifting networks of actors within the implementation project and the broader institutional setting. Seeking to understand contextual dynamics during healthcare information systems implementation, we use events to focus, structure, and present the ANT analysis. This event-based approach furthers our understanding of how researchers can apply ANT to study IT-based change in general.

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Introduction

Investment in healthcare information systems (HIS) is growing at a rapid pace. Sheldon I. Dorenfest & Associates report information technology (IT) investments in the healthcare industry were expected to reach U.S.$23.6 billion in 2003, rising at a rate of 9.3% from $21.6 billion expended in 2002 (Sheldon I. Dorenfest & Associates, Ltd., 2004). These growing investments are driven by the information-intensive nature of the industry (Anderson, 1997; Dwivedi *et al.*, 2001). Still, the healthcare industry continues to lag behind other industries in effectively exploiting IT to reduce costs and improve quality of services (Raghupathi, 1997; Menon *et al.*, 2000). This paradox suggests that the healthcare industry presents particular challenges for successful implementation of information systems (IS).

The challenges are well documented and relate to a variety of areas such as knowledge and management (Tanriverdi & Iacono, 1998; Dwivedi *et al.*,

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2001; Lorenzi & Riley, 2003), people and organizations (Lorenzi *et al*., 1997; Aarts *et al*., 1998; Berg, 2001), social communication patterns (Davidson, 2000), organizational structure and culture (Bangert & Doktor, 2003), resistance to change (Lapointe & Rivard, 2005), and divergent interests across stakeholder groups (Constantinides & Barrett, 2006). Our knowledge about HIS implementation is, however, still limited despite a small, but growing body of knowledge that systematically explores the context (Chiasson & Davidson, 2004). As a consequence, this paper seeks to contribute to the emerging contextual research on HIS by examining the intricate web of interactions between technical and non-technical factors (Paul, 2005). Our overall objective is to help understand the intriguing paradox of why the healthcare industry, despite extensive investments and implementation efforts, continues to lag behind other industries in effectively exploiting IT.

We rely on data collected from 2001 to 2005 in a Swedish hospital about implementation of a radiology network system. As our main interest lies in understanding the dynamics of this process (Robey *et al*., 2002), we adopt a dialectical epistemology in which we see the hospital as 'a pluralistic world of colliding events, forces or contradictory values that compete with each other for domination and control' (Van De Ven & Poole, 1995). Specifically, we use Actor-Network Theory (ANT) (Callon, 1986; Latour, 1987; Law, 1991) to investigate how the implementation process was shaped through contradictory interests and shifting configurations of agency. The complex contextual dynamics that is revealed through the analysis turned out to have severe and disruptive effects on the implementation of the radiology network system. Based on the analysis, we suggest implementation of HIS requires proactive leadership and significant dynamic capabilities to effectively learn about and adapt to the particular context in which the systems are embedded.

We use events to understand the contextual dynamics of the HIS implementation and to structure the ANT analysis, which like other process-oriented approaches easily become highly complex (Walsham, 1997; Langley, 1999). Event-based approaches have previously been used with success to address the complexities involved in process studies of organizational change (c.f. Peterson, 1998) and IT-based change (c.f. Newman & Robey, 1992); but event-based approaches remain unexplored in combination with ANT. In our analysis of the Swedish radiology network system, we specifically combine ANT with Newman & Robey's (1992) encounter-episode dichotomy. Encounters are critical events that challenge the path of a process and mark the beginnings and ends of episodes. The adopted event-based ANT approach helped us separate concerns during the analysis, it proved helpful in synthesizing key findings, and, we used it to structure the presentation of results. Another aim of this paper is therefore to further our understanding of how researchers can apply ANT to study IT-based change in general. To this end, we outline our event-based approach to ANT analysis together with the rationale for adopting it, and we discuss our experiences with this new approach to ANT analysis.

In summary, we have two specific research objectives: (1) to understand the contextual dynamics involved in HIS implementation, and (2) to explore how ANT combined with event-based analysis can help understand, structure, and present complex process data related to IT-based change. Having two quite different objectives in a single paper makes it challenging to structure the argument. We have therefore structured the paper inspired by Schultze's dual-objective research (2000) of knowledge work and confessional ethnographic accounts. First, we review the literature on HIS with particular focus on research into how the healthcare context shapes implementation processes. We then discuss the rationale for and characteristics of event-based approaches to ANT analysis. Next, we focus on the research context and our approach to data collection and analysis. We then present the results from our investigation of the implementation process at the Swedish hospital and discuss how it was shaped by contextual dynamics. Finally, we evaluate the event-based ANT analysis and discuss implications of our research for theory and practice.

Healthcare information systems

Anderson (1997) defines HIS systems as applications of IT in healthcare that builds on a wide range of disciplines including medicine, computer science, management science, statistics, and biomedical engineering. Acknowledging this complexity, Chiasson & Davidson (2004) define HIS research as a multidisciplinary body of knowledge related to the design, development, implementation, and use of information-intensive technologies in healthcare settings. Recently, the field of IS is witnessing an increasing number of contributions to HIS research, though the major contributions still come from other fields, mainly medical informatics (Chiasson & Davidson, 2004).

Despite the increasing number of contributions to research on HIS within the IS field, our collective and cumulative knowledge is still limited when it comes to systematically exploring the healthcare context (Chiasson & Davidson, 2004). Moreover, contextual approaches have generally eluded attention within the IS discipline (Avgerou, 2001; Avgerou & Madon, 2004; Crowston & Myers, 2004; Chiasson & Davidson, 2005). Contextual considerations are, however, particularly important for emerging research fields such as HIS. They can help us understand how adoption of IT-based innovations is shaped in interaction with the particular characteristics of the industry. Also, a contextual setting like healthcare can challenge, extend, and modify existing theories and provide opportunities of developing new IS theories (Chiasson & Davidson, 2004). As a consequence, Chiasson & Davidson (2004) suggest that

HIS research should balance the use of IS theory with an emphasis on contextual considerations.

Contextual research into HIS has so far primarily paid attention to furthering IS theory with only limited consideration given to how IS interact with the specific characteristics of the healthcare context (e.g. Coombs *et al*., 1992; Hepworth *et al*., 1992; Pichault, 1995; Sillince & Harindranath, 1998; Pouloudi, 1999; Atkinson, 2000; Paul & McDaniel Jr., 2004). In fact, we have only found a limited number of contextual studies of HIS implementation processes (i.e. Jayasuriya, 1999; Lau *et al*., 1999; Braa *et al*., 2004; Davidson & Chiasson, 2005; Fitzgerald & Russo, 2005; Constantinides & Barrett, 2006). Two of these studies, Braa *et al*. (2004) and Jayasuriya (1999), focus on the challenges related to implementing successful and sustainable HIS in developing countries while the other contributions are based on case studies in the industrialized world.

Constantinides & Barrett (2006) examined the interrelationships between the context, the practical use of a HIS, and the role played by different artifacts through a longitudinal case study of the implementation of a telemedicine system. Applying the theoretical lens of boundary objects (Star & Griesemer, 1989; Star & Ruhleder, 1996), their study identifies contextual factors such as power relations including national and regional political support, lack of continued financial support, and government reforms as important healthcare industry issues that shaped the implementation effort. Davidson & Chiasson (2005) employed technology use mediation theory by Orlikowski *et al*. (1995) to analyze two cases of electronic medical record systems implementation. Their analysis followed the technology use mediation stages of establishment, reinforcement, adjustment, and episodic change. The authors identified contextual factors that influence technology use mediation processes and outcomes, including the nature of the IT artifact (general purpose *vs* specialized), malleability of the software, institutional influences from the organizational environment, and organization size. Fitzgerald & Russo (2005) investigated the turn-around of the London Ambulance Service computer-aided dispatch system reapplying the exchange framework from an earlier failure analysis by Beynon-Davies (1995). Their analysis focused on the four elements of the framework and their relationships – supporters, project organization, information system, and the environment in which they operate. Concerning the environment, the authors discussed the similarities and differences between the failure in 1992 and the success in 1996 in terms of eight environmental factors: health system reforms, labor relations, IT responsibility, lack of a strategic vision, aggressive pace of change, lack of investment, 'fear of failure' on the part of management, and the assumption that changes in working practices could automatically be achieved by the use of IT. Lau *et al*. (1999) studied patterns of evidence-based practice in implementation of HIS by using the improvizational model for change management proposed by Orlikowski & Hofman (1997). Based on longitudinal data from two hub hospitals and several community hospitals in two Canadian health regions, the authors discuss the relationships between technology and organizational context and identify important areas to consider such as time availability, intended use, clinical champions, and environmental influence.

These studies share certain characteristics: they focus on HIS implementation processes; they are based on in-depth analyses of qualitative case data; they apply contextual approaches anchored in a process view; and, they adopt specific theoretical frameworks to make sense of how the implementation process was shaped by the healthcare context. We seek to extend this line of research, by exploring the role of *contextual dynamics* in HIS implementation, that is, how the interaction between the implementation process, its content, and the context (Pettigrew, 1985; Pettigrew, 1987; Pettigrew, 1990) is shaped over time through different forms of agency. To that end, we combine event-based analysis with ANT. This approach allows us to view the healthcare context through a dialectical epistemology emphasizing how colliding events, forces, or contradictory values compete with each other over time for domination and control (Van De Ven & Poole, 1995).

Event-based ANT analysis

ANT has its roots in sociology (Callon, 1986; Latour, 1987) and aims to understand the processes that lead to construction and transformation of socio-technical networks (Callon & Law, 1989). The focus is on how people and objects are brought together in stable, heterogeneous networks of aligned interests (Law, 1991) through processes of translations (Callon, 1986; Callon & Law, 1989). ANT has frequently been revised and extended, and there is, therefore, no unified body of knowledge. In a recent book, Latour discusses how ANT has developed over time and argues for its core as the understanding of sociology 'best defined as the discipline where participants explicitly engage in the reassembling of the collective' (2005, p. 247). ANT is viewed as a guide to study how things, people, and ideas become connected and assembled in larger units. In Table 1, we summarize some of the key concepts in ANT (adapted from Walsham, 1997) that form the basis for our study.

A core assumption is that no actor is different in kind from another. Instead, how size, power, or organization is generated should be studied unprejudiced (Law, 1992). The inclusion of non-humans in networks is explicitly an analytical stance, not an ethical position, and the term 'heterogeneous network' is used to articulate the inclusion of both humans and non-humans, that is, any material one cares to mention, and the ordering and organizing of these. The argument behind this view is that the social is not simply human; it is intrinsically related to all these other materials too (Law, 1992). Interactions between people are mediated through objects of various kinds and through additional networks

Table 1 Key concepts in actor network theory

Concept	*Description*
Actor (or actant)	Any material, that is, human beings or nonhuman actors
Actor-network	Related actors in a heterogeneous network of aligned interests
Translation	How actors generate ordering effects by negotiating or maneuvering others' interest to one's own with the aim to mobilize support
Inscription	Embodied translations into a medium or material
Enrolment	Mobilize support by creating a body of allies through translations
Irreversibility	The degree to which it is subsequently impossible to go back to a point where alternative possibilities exist
Immutable mobile	A materialized translation that can be interpreted in essentially the same way in a variety of contexts
Black box and punctualization	A temporary abstraction of a network that acts as a single unit so that the network efface into one actor

of objects and people. These networks both participate in and shape the social, and therefore, if the material in these networks would disappear, the so-called social orders would too (Law, 1992). Hence, the view in ANT is that a particular order is an effect generated by heterogeneous means. An actor is seen as produced from or as an effect of these heterogeneous relations between people and objects, and an actor is also, always, a network (Law, 1992).

Translation (Callon, 1986) implies transformation, which refers to how actors engage with other actors to generate ordering effects (Law, 1992). Callon (1991) emphasizes that translation goes beyond the traditional definition of action as it deals with mutual definition and inscription. Actors negotiate or maneuver others' interest to one's own with the aim of enrolling actors into a network. When such translations get embodied into a medium or material, they are referred to as inscriptions (Akrich, 1992). Such inscriptions prescribe a program of action for other actors, although they can vary in strength and flexibility (Hanseth & Monteiro, 1997). Inscriptions may lead to irreversibility, which refers to both the degree to which it is impossible in a certain situation to go back to a point where alternative possibilities exist, and the extent to which inscriptions shape and determine future translations (Callon, 1991; Hanseth & Monteiro, 1997). A materialized translation, hence mobile, that can be interpreted in essentially the same way in a variety of contexts (i.e. relatively stable in space and time) is referred to as an immutable mobile. Such immutable mobile entities often possess strong properties of irreversibility, for example, software standards. An actor-network that is known and predictable in a certain situation and context can be assimilated into a black box. Such a punctualization is a temporary abstraction of a network that acts as a single unit so that the network behind can be effaced into one actor (Callon, 1987; Callon, 1991; Law, 1992).

ANT analyses have provided valuable insights into the nature of IT-based change in organizations including: responsibility accounting and the constitutive role of accounting systems in hospitals (Bloomfield *et al.*, 1992); boundary disputes between the technical and non-technical in healthcare and financial services (Bloomfield & Vurdubakis, 1994); transformation of work (Boland & Schultze, 1996); infrastructure and classification (Bowker *et al.*, 1996); network building (Doolin, 1999); information infrastructure and inscriptions (Monteiro & Hanseth, 1996; Hanseth & Monteiro, 1997); temporal zones (Scott & Wagner, 2003); stakeholder maps in order to take into account multiple interests (Vidgen & Mcmaster, 1996); and embedded Trojan actor-networks to explain escalation (Mähring *et al.*, 2004). ANT has also been applied to IT-based change within public institutions and society at large, for example, concerning cash-cards in Sweden (Holmström & Stalder, 2001); the personal digital assistant industry (Allen, 2004); the shaping of the web browser (Faraj *et al.*, 2004); and implementation and use of geographical information systems in a district-level administration in India (Walsham & Sahay, 1999). Further, ANT has been applied to IT-based change within biotech, for example, concerning botanical plant categorization (Hine, 1995); the nature and social construction of time related to IT-based change in a pharmaceutical plant (Kavanagh & Araujo, 1995); and the reliability of lay health information on the Internet (Adams & Berg, 2004).

While these case studies demonstrate the feasibility of ANT as a framework for understanding IT-based change, they also raise a number of issues related to such studies (see e.g. Walsham, 1997): what is the unit of analysis, where do networks begin and end, what is the extension of an actor, on what level do you conduct the analysis, and how do you practically manage the veritable mass of details that the approach easily leads to because of its flexibility and the generic nature of its vocabulary? Most of these issues are not confined to ANT-guided studies, but relate to process studies in general. Data from process studies of organizational change are complex and making sense of them is a constant challenge (Langley, 1999). Process data deal mainly with sequences of events and these involve multiple levels and units of analysis whose boundaries are ambiguous. Moreover, the different levels of events can be temporally embedded in a number of ways; an event may be a merger, a decision, a meeting or a handshake, each on a different time-horizon (Langley, 1999). Finally, process data are eclectic, offering not only information about events but also a considerable variety of other types of qualitative and quantitative information (Langley, 1999).

How to separate what is really significant from what will be treated as merely noise (Leonard-Barton, 1990) is as a consequence an important issue in analysis and presentation of process data in general and ANT studies in particular. Events can play a key role in addressing this issue. The key challenge is defining and focusing on those events that make a difference (Isabella, 1990; Newman & Robey, 1992; Peterson, 1998). To this end, Newman & Robey's (1992) framework proposes to understand processes as sequences of encounters and episodes. Encounters challenge the path of a process marking the beginnings and ends of episodes, which in turn refer to sets of events that stand apart from others. However, the encounter-episode framework remains un-explored as a means to support ANT analyses.

Following Walsham's (1997) call to improve approaches to ANT analyses of IT-based change through methodological experimentation, we suggest that encounters and episodes may help researchers structure their analyses and sort out significant data from less significant data. Combining general approaches to dealing with complexity with the encounter-episode perspective, we suggest complementing ANT analyses of IT-based change by iteratively asking the following questions:

(1) *Separation of concerns*: What are the encounters that challenged the path of the change process?
(2) *Analysis of encounters*: How does each encounter impact the established network configurations through episodes of translations?
(3) *Synthesis of findings*: How can analyses of encounters and episodes be synthesized into an understanding of the overall change process?

In identifying candidate encounters, Gersick (1991) points out there are two different ways in which the temporary stability of processes can be disrupted. One is the attraction of newcomers to crisis situations and the other is the arrival to a temporal milestone that implies a change in the path of the process. Also, we suggest focusing on events that social actors or stakeholders perceive to challenge the current configuration of actor-networks. Subsequent analyses might reveal these encounters did not lead to substantial changes. They were resisted or rejected by actors resulting in only minor reconfigurations. Such encounters can, however, still turn out to provide valuable insights into the dynamics of the change process under consideration and they might be included as important contributions to understanding the change process.

Research method

Seeking contributions to our knowledge about implementation of HIS, this research investigates the following question: How is implementation of HIS shaped through interaction with the healthcare context in which the system is embedded? The how-nature of the question combined with the focus on contemporary events within the healthcare industry suggests that a case study approach is appropriate (Yin, 2003). Moreover, as our main interest is related to change processes, we adopt an interpretive approach (Walsham, 1995; Walsham, 2006) based on dialectical epistemology (Van De Ven & Poole, 1995; Robey *et al*., 2002; Cho *et al*., 2007).

The case centers on efforts to implement a radiology network system in a Swedish hospital during 2001–2005. We found this particular HIS interesting, as it links a radiology department to the professionals and clinics that requests radiology examinations. The system spans several professional and organizational boundaries, it relies on contemporary networking technologies, and we had the opportunity to follow the implementation efforts over 4 years. This gave us ample opportunity to explore how the implementation was shaped through interaction with the healthcare context in which the system was embedded.

The research started in October 2001. We adopted a combination of different techniques for collecting data: observations of daily work, interviews, participation in meetings and seminars, studies of documents and the IT system, and continuous informal discussions with the involved project managers and care professionals. The different data sources in the study are summarized in Table 2.

In line with the first principle of interpretive research (Klein & Myers, 1999), the process of data collection and subsequent analysis rested on the hermeneutical cycle in which we went back and forth between the whole and the parts to develop our understanding of the IS implementation. During autumn 2001 and spring 2002, we participated in 10 project meetings for the new radiology network system. Each meeting lasted 2–3 h during which we took notes. We were invited to talk about the study and relevant theories at a 2-day workshop for the personnel at the IT unit and the system administrators at the clinics; this provided an opportunity to engage in conversation with the organizational members about the ongoing process, tentative analyses, and interpretations. In May, June, and September 2002, we conducted 40 h of observation of daily work, also taking notes, of the different clinics and professional groups involved in using the new system. Hence, direct observations were a crucial component in the study; this enabled us to analyze work practices from different professional's point of view, and to engage in valuable discourse with organizational members (Geertz, 1988; Ngwenyama & Klein, 1994). Between February and May 2003, 12 semi-structured interviews were conducted, recorded, and transcribed, each between 30 and 90 min long. The interviews covered questions of how users perceived the system and its impact on work practice. In line with the sixth principle of interpretive research (Klein & Myers, 1999), these interviews involved representatives of the relevant professional groups: physicians, nurses, assistant nurses, and secretaries. In March 2004, three interviews with the IT director and two project managers were conducted, recorded, and transcribed. In

Table 2 Data sources

Data sources	*Description*
Participatory observations (Fall 2001–Spring 2002)	Participating in 10 project meetings, with representatives of all concerned professions, taking notes. Each meeting between 2 and 3 h long.
Workshop (May 2002)	Presenting the study and relevant theories at a 2-day workshop organized by the hospital for system administrators and personnel at the IT unit.
Participatory observations (May, June, and September 2002)	Conducting 40 h of observations, taking notes of daily work at the different departments at the clinic. Different professions (secretaries, assistant nurses, nurses, and physicians) were followed to allow for multiple interpretations.
Formal interviews (February–May 2003)	Conducting 12 semi-structured interviews, each between 30 and 90 min long, recorded, and transcribed. The interviews covered questions of how users perceived the system, its impact on their work practice, and how they experienced the implementation process. Different professions (secretaries, assistant nurses, nurses, and physicians) were interviewed to allow for multiple interpretations.
Formal interviews (March 2004)	Three interviews with the IT director and two project managers were conducted, recorded, and transcribed.
Workshop (March 2004)	Presenting the research and relevant theories at a seminar for the employees at the IT department at the hospital; generated a valuable opportunity to get feedback on the study and tentative analyses.
E-mail and phone (September 2001–October 2005)	During the entire study, different informal conversations via e-mail and telephone with the organizational members took place.
Project documentation (September 2001–October 2005)	The research project was provided with project documentation, planning documents, and progress documents during the process.
Technical design (September 2001–October 2005)	The research project was provided with technical and design documentation of the system under development.

addition to the formal data collection, we spent several days at the hospital with informal interactions with personnel and we had many follow-up contacts over telephone and e-mail with project management. In March 2004, we were invited to present the research and relevant theories at a seminar for the employees at the IT department at the hospital. This generated a valuable opportunity to get feedback on the study and tentative analyses. It also allowed for dissemination of IS research theories to practitioners, addressing the split between science and practice and contributing to the engagement between management researchers and practitioners (Pettigrew *et al*., 2001).

We have used ANT to understand the implementation process as continuous creation and maintenance of stable heterogeneous networks through the enrollment of allies and through translation of interests. A stable heterogeneous network is achieved when the involved actors have aligned their interests for a period of time. When encounters disrupt the temporary order of aligned interest, a new process of translation occurs until some new stable networks are achieved with different configurations. While most ANT analyses have focused on the efforts to achieve this order, we focused on disruptions through the use of encounters and episodes as a means to focus, structure, and present the analysis. An encounter, adapted from Newman & Robey (1992) to the context of ANT, refers to a critical event that has the potential to disturb existing network configurations. A simple example is the decision to replace the traditional paper-based radiology network system with a new electronically integrated system. This decision led to initiation of a pilot project that caused disturbance in the initial network configurations among the involved actors. Overall, the analysis approach relates to the fourth principle of interpretive research (Klein & Myers, 1999), about abstractions and generalizations of data through the use of theories. In the process of analysis, we also discussed and reflected on the interpretations of the data; this relates to the fifth principle of possible contradictions and the seventh principle of suspicion of bias (Klein & Myers, 1999).

In the data analysis, we looked for statements or events that indicated disruptions such as user statements or questions related to the change process, decisions in the change process, user rejections to decisions or explicit plans, or other disturbances that arose related to the change process. The final choice of encounters and episodes to structure the analysis and presentation of the case emerged through iteration in which we emphasized events that the involved actors perceived as critical, events that turned out to impact the outcomes of the process, and events that challenged the existing actor-network configurations.

We structured the event-based ANT analysis following the three questions stated in the section 'Event-based ANT analysis': the separation of concerns, the analysis of encounters, and the synthesis of findings. The first question was handled by identifying key encounters related to the implementation process. The second question was decomposed into sub-questions: What was the nature of the event? What actors were involved and

what were their interests? What translations took place? What were the effects of these translations? For the third question, we summarized the overall change process through the presented encounters and episodes and we explicated the major tensions that could explain how the implementation was shaped through interactions with the context over time.

Research context

The implementation process unfolded in a Swedish emergency hospital owned by the county council, serving a population of approximately 360,000. The background was the digitization of the radiology department that started in 1998. This involved the development of a radiology information system to streamline information processing within the radiology department, and a standard picture archiving communication system (PACS) to store and retrieve images. The subsequent replacement of the traditional paper-based system with a new one was expected to help the radiology department fully benefit from the digitization. The decision to implement the radiology networking system would allow radiology examination requests and responses to be communicated electronically hospital-wide and it was made at the top level by the hospital director and the managers from the involved clinics.

In the paper-based processing of radiology examinations, the physicians at the clinics made requests to the radiology department on standardized paper forms, often assisted by nurses or secretaries in various ways. Generally, requests were sent through a pneumatic tube system in the hospital to the radiology department. The receiving radiologists and assisting administrative and technical staff at the radiology department generated the response documents, and these were subsequently sent back through the pneumatic tube system.

The electronic radiology network system should connect the radiology department to all clinics via the electronic patient record system (EPR) (see Figure 1). The new system was expected to benefit the hospital as a whole as well as the radiology department. Specifically, the system should lead to improved services and time-savings for searching after lost and misplaced documents.

The new system was set up with access via the EPR requiring users to log on to the radiology network and the EPR to write or access a request or response (see Figure 1). Management's argument for user access via the EPR was related to safety issues and the intention to make users perceive the EPR and the radiology network as one integrated system.

Project management was divided into two sub-projects under the main project manager of the radiology digitization. One was responsible for the design process working with the supplier. The other was responsible for supporting the clinics in preparing for implementation. Project management chose the orthopedic clinic as a pilot site, based on the assumption that it would be the most challenging clinic in which to gain acceptance for the new system.

Case data and results: event-based ANT analysis

The chronological order of key encounters during the implementation process is illustrated in Figure 2. These encounters were perceived as important events that impacted the path of the process and shaped its outcome. Each encounter caused controversy and disrupted the temporary order in the actor-networks resulting in extensive translations to achieve new stability.

Pilot initiation

The first encounter was 'pilot initiation' (see Figure 2) in September 2001. The pilot disrupted a long, relatively stable episode of paper-based information processing of radiology examinations at the hospital and initiated discussions about possible changes and their impact. The project manager said, 'I had meetings with all the clinic managers at the hospital and they expressed how they felt that this was something the radiology department

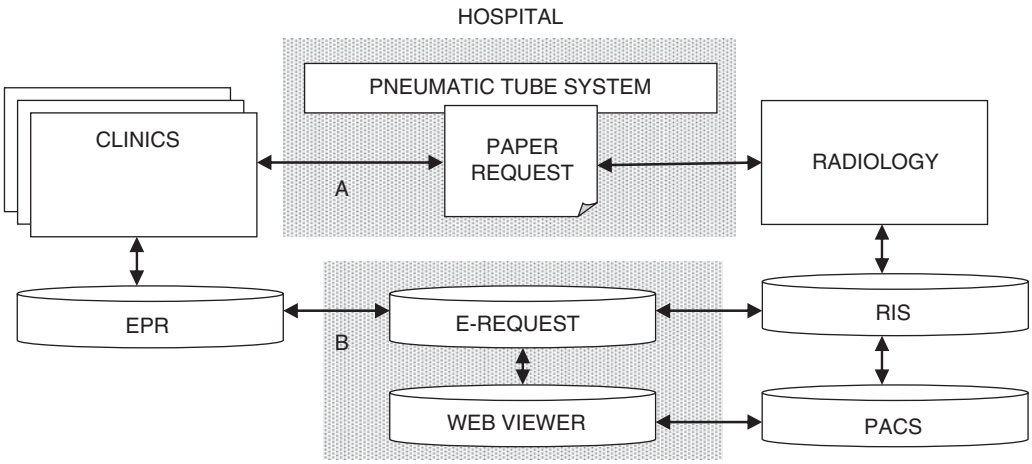

Figure 1 The traditional (Area A) and the new system (Area B).

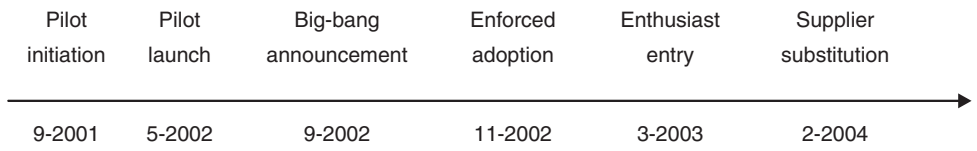

Figure 2 Encounters in chronological order.

had come up with and that they [the clinics] should take part in it just to facilitate the work flow for the radiology department.' Project management's intention was to prepare the clinics for replacement of the paper-based system and to learn about possible approaches to integrate the new electronic system with work practices. Project management formed a group of representatives from the orthopedic clinic, the pilot site. This group subsequently met about 10 times, approximately 2–3 h each time, and analyzed current routines, division of labor and responsibilities, and discussed possible changes as the system was implemented.

The project manager tried in this way to enroll representatives from the orthopedic clinic to create a project network with aligned interests by committing representatives to the project. This project network included the design of the new electronic system, project management, and representatives for different professional groups at the orthopedic clinic. However, the initial reactions to the new system varied across the professional groups. For example, while physicians were reluctant to commit, nurses, together with secretaries, were more positive and more active in the process. The reluctance of physicians to commit to the project was expressed implicitly by them not participating in meetings, by not discussing the issues with colleagues at the clinic between meetings as requested, or by being passive during meetings.

The pilot initiation was perceived by some as a threat toward the institutionalized actor-networks at the clinic. The new system challenged established professional roles and identities, specifically concerning how work and responsibilities were divided in the traditional orthopedic work practices as inscribed into the paper-based system. One simple illustration was the discussion whether physicians should single-handedly use the new system to process information regarding radiology examinations. One physician said, 'since one of the ideas with the system was to save time, this issue needs to be thought about, and it is usually more difficult for the physician to conduct these activities.' In the traditional work practices, secretaries and nurses assisted physicians and conducted much of the routine paper-based information processing. As a consequence, representatives translated their interests differently as they started to understand possible changes in responsibilities and division of labor. As one secretary said, 'I am concerned when we are asked to write a request from dictation and the physician rushes off. These situations are likely to remain also after the implementation of the system and how should that be handled?'

While physicians wanted to maintain traditional work practices, nurses wanted physicians to take responsibility for the entire information processing thereby improving their own ability to focus on patient interaction and care. One nurse said, 'even though it is the physicians' responsibility to write the requests in connection to the rounds at the departments, they seldom have (or take) the time to do it and often leave the department before this is done.' In fact, the nurses enrolled the secretaries as allies and together they actively promoted a change in division of labor and responsibilities by supporting that physicians, as the only professional group, were authorized to request examinations. The authorization issue became from that point a subject for continuous negotiation between the involved professional actor-networks.

The outcome of the pilot initiation was that the interests of nurses and secretaries became aligned and were inscribed into the new system. The physicians became the only actors authorized to request examinations. Nurses and secretaries were only authorized to read information from the system.

Pilot launch

The second encounter was 'pilot launch' (see Figure 2) into the orthopedic clinic in May 2002. A prototype of the new system was released at the pilot clinic, based on parallel adoption tactics to allow the prototype to be tested in coexistence with the original paper-based system. This encounter disrupted the long episode of paper-based radiology networking at the hospital in a very direct way by introducing alternative work practices. The intention of project management was to test the design of a prototype and related work routines in a real, medical setting and to identify possible improvements and needs for adjustment.

The prototype came largely as a surprise for people working at the clinic. The discussions within the group of representatives had not been successfully disseminated or paid attention to at the clinic and the professional networks reacted in different ways. Particularly the physicians, the assigned main user of the new system, reacted explicitly. In the prototype, the physicians had to manage requests for radiology services single-handedly. Compared with the traditional work practices with assistance from nurses and secretaries, this required a lot more time and effort from physicians. Moreover, the

physicians perceived the new system as unacceptable due to its instability and slow performance.

As one physician said, 'because of security and authorization concerns in all the computerizations, only I can do things related to my work and my patients. This means I cannot get the help I got before with routine tasks, e.g. bringing out the images and placing them appropriately. Although the tasks may be quicker than when somebody had to run away to get the images, the work is now placed on the physician instead. We physicians end up with less time for the patients, for example before we could manage 14 patients in a session, now we only manage 10 and still run over time. So, the benefits are made elsewhere in archive personnel, secretaries, or paper handling that was not the physicians' work before. The consequence of every computerization so far has been increased administration and computer work for the physicians, and when it is not working fast and smoothly it becomes extremely frustrating.'

Consequently, information was often forgotten or not properly registered, which hindered secretaries properly booking patients for radiology examinations. Since secretaries were only authorized to read in the prototype, they could not complete or adjust information as they used to do in the paper-based system. The nurses at the outpatient wards were influenced more positively as the new system enabled them to monitor status of patients. This improved their ability to coordinate work as they could see when a patient had finished a radiology examination and knew when patients were on their way to meet a physician. However, nurses at the inpatient wards were traditionally notified by telephone when a patient got an appointment at the radiology department. In the new system, they needed to check for new appointments, which required more effort from them. As it turned out, nurses were often too busy taking care of patients and had difficulties finding time to log on to the system to check for new appointments. In addition, the new system influenced the daily rounds with physicians at the inpatient wards, requiring the physician to sit down in the office after the round to deal with any radiology requests. In the traditional work practices, the nurses used to assist the physicians in-flight during the round to fill out forms in the paper-based system.

The physicians tried to maintain the paper-based system and avoid the prototype. The nurses at the outpatient wards were more positive and aligned with project management and the design of the prototype. In an attempt to enforce the physicians to use the new system and directly request radiology examinations, the nurses simply removed all paper-based forms placed conveniently at various places at the ward. The nurses at the inpatient wards complained it was difficult to keep checking for new appointments and many examination requests were delayed because physicians would rush off to other duties and emergencies instead of processing radiology requests after each round.

As a result, the actor-networks at the orthopedic clinic became unstable and translation of interests both in favor of and against the prototype took place. Some actors opposed the new system as an intruder from the outside, imposed on them by the 'the radiology department.' Others were more willing to negotiate the new system to become part of the configurations at the clinic. Project management and the management of the orthopedic clinic agreed to continue parallel adoption for some time to collect more experiences and increase commitment.

Big-bang announcement

The third encounter was 'big-bang announcement' (see Figure 2) when project management in September 2002 published a decision to implement the new system hospital-wide during the autumn. This encounter was disruptive because the new system was still perceived as being on trial and in need of further development. Project management's decision was driven by their interest in making progress combined with a limited appreciation of the dissatisfaction and turbulence the new system had caused at the orthopedic clinic. The big-bang implementation would involve all clinics at the hospital.

While perceptions of the prototype varied across the professional networks at the orthopedic clinic, there was a shared assessment that it was too slow and unstable. This assessment had disseminated to all clinics at the hospital, particularly among physicians. The announcement of the big-bang implementation was therefore generally perceived as a threat. Physicians at the orthopedic clinic were frustrated and considered the system to be unreasonably unstable and slow, and physicians from other clinics feared they would have to work with the new system in this unacceptable state. One physician said, 'it is unfortunate, and it has been the same in every implementation, that projects are rushed and therefore they implement half-finished products with too many shortcomings, and then they half-heartedly attend to the problems and perceive us as whining and grumbling for not thinking that it works well. They expect us to be pleased that ''one'' is saving a lot of time, somewhere else, and fail to understand why we [physicians at the clinics] find it negative to use, and that generates a bad start of the whole thing. Instead, they should introduce the system when there could be a real improvement somewhere, so one gets a benefit alongside some extra work required at the other end.' The reactions from various actor-networks were loud and unambiguous and resulted in aligned interests across clinics and professional groups to reject the big-bang decision from project management.

Project management was aware of problems with both performance and stability, and they were actively trying to improve the system. However, they had not understood how serious these problems were perceived across the actor-networks at the hospital. As a result, further implementation efforts were temporarily stopped and

project management agreed to postpone hospital-wide implementation. In their interest to enroll further support, project management promised to improve the system before proceeding with implementation.

Enforced adoption

The fourth encounter was 'enforced adoption' (see Figure 2) of a new version at the clinics starting November 2002. The new version was integrated with a standardized PACS web-viewer. After implementation of the first prototype, the physicians had continued to work with printed images and medical practices had reached a certain level of stability on that basis. The disruptive effect of this encounter was caused by project management's surprising decision to proceed rather quickly to implement digital images across clinics. Again, the idea was to test this new functionality of the system at the orthopedic clinic and subsequently implement the system into other clinics.

The new system was, however, still perceived as slow and unstable at the orthopedic clinic. Moreover, the replacement of analogue film to digital images had important implications for the physicians. The orthopedic clinic had not implemented any high-speed computers or high-resolution screens. To view images on regular personal computers radically slowed down physicians' work. It was all right to review single images, but large sets of images from, for example, a computer tomography could literally take hours to review. Consequently, physicians refused to review images on their own computers, and instead requested printed images from the radiology department. As one nurse said, 'physicians refuse to use the computer screens to view images. They demand to have the images in their hands. Then when we [nurses] have run several times up and down to the radiology department trying to get images on paper, it usually still ends with the physician going up to the radiology department to view the images on their screens – however, still refusing to bring out the images on their own screens.' Because the radiology department at the time had difficulties printing images in precise scale, physicians often ended up personally walking to review images on the screens located within the radiology department. In addition, the counterpart of manual templates of prosthesis that were used on analogue film to plan operations was not available.

In contrast to physicians, nurses at the inpatient wards were positively influenced because this design would allow them to view images of patients and discuss them with physicians during daily rounds. As one nurse said, 'we have started to view the images during the rounds at the department. Some physicians bring out the images and explain for example the fracture together with us, and that is very helpful for us nurses when we are taking care of the patients.' This gave nurses improved information about patients' condition. In the traditional medical practices, nurses rarely had the chance to review images since the only copy of each analogue image was dealt with by physicians or kept at the radiology department.

To put an end to printed images and to enforce the adoption of the new system, project management set a final date, after which only digital images were allowed. Requests for printed images after that date would be charged to the clinic. Some exceptions were allowed to enable the use of prosthesis templates to plan operations. The nurses quickly took advantage of this opportunity to develop work practices for inpatient ward rounds so they included review of digital images of patients. Because of these developments, a physician from the orthopedic clinic decided to become actively engaged in the group of representatives charged with improving the new system and related medical work practices.

Enthusiast entry

The fifth encounter was the 'enthusiast entry' (see Figure 2) engaging a key physician in increasingly shaping the implementation process. Since physicians were assigned as main users, the relation between physicians and the new system was crucial. By March 2003, the new system, despite its many problems, had been implemented hospital-wide. The enthusiast physician had at this point successfully translated physician interests to changes in the new system such as an authorization structure that would allow other professional groups to assist physicians in requesting radiology examinations. He said, 'it has been good, the project management has really listened to us and my input has really had an impact on the system at the clinic. They have been really great in listening to the main things about functionality and how information is presented. The problem is not within the project management. It is within the IT company. They have still not managed to accomplish an acceptable response time in the system even one year after the first introduction.'

However, the situation for physicians was still perceived as unacceptable due to continued instability and slow responses, with increasing numbers of system breakdowns and a series of new system versions that continued to inherit the same problems. All involved actor-networks were influenced in a domino effect, since the new system hindered or delayed people from doing their work properly, which again influenced other colleagues doing their work properly. Nurses at the inpatient wards were influenced by physicians not conducting their tasks satisfactorily and by the generally poor condition of the new system. One nurse said, 'now we have to remind the physicians – have you written the request – do you need to check here – for example if the patient is going home and need a radiology appointment before a scheduled follow up. So, it is not like when we had the paper based requests, which were placed in the patient record. Then physicians knew the routines and filled them in. They were then taken care of by nurses and secretaries sending the record to the archive and the requests to the radiology department. Now, the physician

is literally responsible for getting everything done, and we [nurses] need to remind them.' Similarly, secretaries were influenced when physicians did not complete the information needed for radiology requests so it was available when needed.

Hospital-wide, physicians complained loudly about the unsatisfactory condition of the system and many still avoided it. Some physicians conducted time studies of tasks and measured the cost of 'wasted time' based on physician salaries, and they reported these analyses to project management. One physician wrote an e-mail to the management, 'if approximately 1000 logins are conducted per day, and each login take 10 sec, this equals to approximately 3 man hours per day!!! Plenty more logins are conducted every day and the response times could be significantly less than 10 sec.' The actor-networks at the orthopedic clinic became more concrete in their demands of what improvements they needed. Although some demands were implemented into the new system, the main problem concerning stability was not improved by the efforts of the supplier.

While there were increasing concerns about the ability of the supplier to respond effectively to required changes, the actor-networks at the clinics had now become more stable with more aligned interests to improve the new system to be adequate and useful. Hence, the system had been enrolled in the actor-networks at the clinics together with significant demands on improvements. The process had changed from the original push from project management to a pull from the actor-networks at the clinics with demands on improved functionality, user interfaces, and overall system performance and stability.

Supplier substitution

The sixth encounter was 'supplier substitution' (see Figure 2) in early 2004. The repetitive trial-and-error implementation process that failed to deliver desired improvements and increase system stability influenced project management. The relationship with the supplier became increasingly strained and the two parties started to blame each other for the failure to improve the system. As the IT director said, 'we have been working a long time to reach acceptance and terminate the contract with the first supplier. In the process, a number of deficits were identified, which we are waiting for them to attend to. The problem has developed into a conflict where they are unwilling to attend to anything without payment and we are not willing to pay until things are attended to. Meanwhile, we have invited tenders based on the existing system and decided to continue to rebuild the system with a new supplier. The main purpose of rebuilding is to improve performance and stability.' Consequently, project management engaged a new supplier in February 2004 to rebuild the system and resolve the stability and performance problems.

Terminating the collaboration between project management and the old supplier was not easy. After more than a year of efforts to identify and correct problems without success, the collaboration was finally terminated by the end of 2003. Yet, some issues continued to influence the implementation process negatively. The two parties' difficulties to agree on responsibilities for the insufficiencies of the system had delayed and at points derailed the implementation process. In addition, the supplier failed to hand over an accurate version of the source code as agreed, which critically influenced the work with the new supplier. Project management had planned to use the source code and automatically convert as much as possible. Despite further discussions between project management and the old supplier, the source code was never made available and much of the work with the new supplier had to be conducted manually.

In December 2004, the rebuilt version of the new system was implemented at the hospital, and the following couple of months it was successfully adopted without any stability problems. Project management and the supplier were still working on improving performance, which had become acceptable, but needed further improvement.

Overall findings

The change process at the hospital was characterized by complex contextual dynamics that had severe and disruptive effects on the implementation effort. Many different configurations of actor-networks based on, for example, professional groups within and across organizational boundaries played important roles in the implementation process (see Figure 3). The identified encounters and subsequent episodes show how these actor-networks interacted and were transformed through translations as interests shifted over time. A number of key themes turned out to play important and recurring roles in the change process.

A first theme is the role played by various versions of the radiology networking system. Before the first encounter, a number of relatively stable networks with aligned interests were involved in the paper-based system at the clinic. These actor-networks involved in radiology examinations could, at that time, be black-boxed or punctualized into a single actor. However, starting from the first encounter, 'pilot initiation' (see Figure 2), professional actor-networks started to translate their fundamental interests into emerging work practices and the path of the implementation process. At the center of these efforts was the issue of what work practices to inscribe into the new radiology networking system.

A second theme is the ongoing translations involved in the implementation process. At the clinic, nurses and secretaries quickly created an alliance and acted proactively to translate their interests, while the physicians initially remained reactive. However, as physicians were confronted with the inscriptions that assigned them as primary users of the new system, they became increasingly engaged. It was, however, not until the enthusiast physician stepped forward and became actively involved with project management that the physicians became

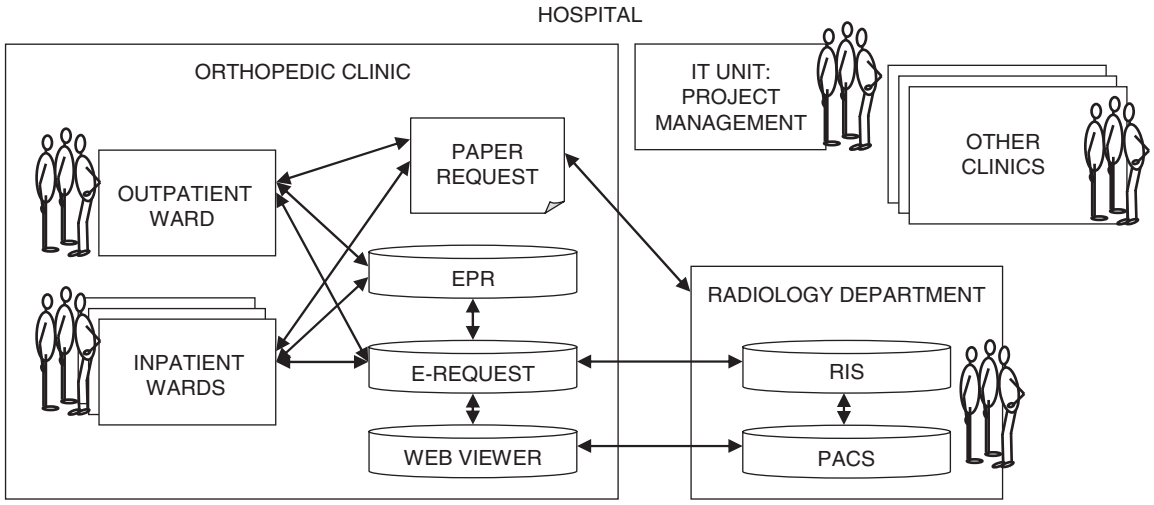

Figure 3 The overall hospital context.

seriously enrolled into the network. This helped project management, which for some time had struggled with the physicians' rejection of the new system. As the physicians became enrolled, they translated their interests to improve the system in line with their needs and preferences. Consequently, the nurses and secretaries became less influential in shaping the resulting change. Hence, an important aspect of the translations involved in the implementation process focused on how division of labor and responsibilities should be impacted by IT by transferring tasks previously performed by nurses and secretaries to a new configuration of actors with physicians in a central role.

A third theme is the role played by technical issues. After some time, the instability and slowness of the system moved to the foreground because of the supplier's limited capability to respond to required changes. At this point, the path of the change process was again disrupted when the contract with the supplier was terminated and a new supplier was integrated into the project network. Throughout the change process, the importance of high performance and stability of the system was emphasized and the hospital context showed no consent toward changes that would not contribute to improving efficiency and effectiveness of their services. In fact, as the implementation process unfolded, an agreement on emphasizing technical issues increasingly aligned various actor-networks into a stable project network configuration.

Finally, the case illustrates the dynamics of the forces that shaped the implementation process in interaction with the context. The process was initially driven by project management and their interests were expressed through a sequence of encounters that deliberately attempted to change the path of the change process. Mostly, project management was pushing the new system into the existing network configurations with little concern for how it would affect work practices or be received by the actors. Through these attempts, project management experienced how pushing harder did not accelerate social change. In fact, the harder project management pushed, the slower the change process seemed to unfold. It was only when the professional networks became sufficiently aligned and consistently pulled for improvements that the change process became irreversible. It was at that point project management's final intervention to change supplier made the overall implementation effort converge toward success.

Discussion

We have presented a case study of how implementation of a radiology network system was shaped through interaction with the Swedish hospital context. While the system was eventually successfully implemented, the analysis reveals how a sequence of critical events had severe and disruptive effects on the process. Pettigrew suggests that a contextualist approach is based on the analytical categories of content, context, and process (Pettigrew, 1985; Pettigrew, 1987; Pettigrew, 1990). Content refers to the particular areas of transformation under investigation, in our case the implementation of a radiology network system. Context refers to the social, economic, political, and competitive environment, in our case expressed through the interests of various actors related to the digitization of radiology practices in the Swedish hospital. Finally, process refers to how content and context interact and are shaped over time, in our case expressed through the description of a 4-year implementation effort at the hospital. Adopting Pettigrew's contextual framing, the presented event-based ANT analysis of the *implementation process* at the Swedish hospital revealed how *implementation content* and *implementation context* was shaped interactively. The analysis reveals, in

this way, the important role played by contextual dynamics during HIS implementation.

First, the study shows how implementation content, that is, the HIS, evolved during the implementation process. The design and realization of the system unfolded over the process and shifted based on different forms of agency. Ongoing negotiations between different medical groups revealed the institutionalized power structures in the profession-based networks. While nurses and secretaries took the opportunity to inscribe their interests in the prototype at an early stage, the physicians had no difficulties influencing outcomes later in the process. When the physicians became actively involved, they managed to get their interests inscribed and to some extent erase the nurses' and secretaries' interests. These contextual dynamics shaped the implementation content iteratively over time and they eventually led to transformation of traditional work practices and to the emergence of new medical practices.

Second, our study shows how the implementation context evolved through shifting configurations of actor-networks. Nurses and secretaries enrolled with the project network during project initiation to inscribe their interests in the prototype. Also, the secretaries later allied with the project network during pilot launch to enforce the physicians to use the prototype. Eventually, the enthusiast physician allied with the project network to adjust the prototype to suit physicians' needs and interests. Combined with shared interests in adopting an efficient and effective system, the latter eventually turned the entire process from a push from project management to a pull from the actor-networks at the clinics. Throughout this process there was a mixture of actor-networks that shifted between opposing implementation and making use of opportunities to change configurations in accordance with their interests. Some of these networks were formed based on organizational units. For example, the perception at the pilot clinic of the prototype as an intruder sent from the radiology department led to an opposing network against the implementation effort. Other networks were profession based and crossed the boundaries of organizational units. For example, the physicians from different clinics across the entire hospital allied, opposed the big-bang implementation plan, and demanded improvements to the prototype before it could be further implemented. Also, within the pilot clinic different profession-based networks were formed across the wards.

Previous studies have emphasized several contextual aspects in HIS implementation such as the important role played by power relations, financial issues, and government reform (Constantinides & Barrett, 2006), the nature and malleability of the IT artifact, institutional arrangements, and organizational size (Davidson & Chiasson, 2005), aggressive push and 'fear of failure' from project management (Fitzgerald & Russo, 2005), and time availability, intended use, and clinical champions (Lau *et al*., 1999). Our study confirms several of these findings. In particular, it demonstrates in detail how power relations are formed and transformed; it reveals how aggressive push from project management can be counterproductive; it provides insights into how professional and departmental interests interact and change; and, it shows the importance of individual commitment and participation from key medical actors. More importantly, however, our study provides a comprehensive and structured understanding of how contextual dynamics shape implementation of HIS. Relying on a dialectical epistemology, the study describes how colliding events, forces, and contradictory values competed with each other over time at the Swedish hospital to interactively shape the content, context, and process of implementing the new electronic radiology network system.

Evaluating the event-based ANT analysis

Quite a number of IS researchers have used ANT to study IT-based change (e.g. Bloomfield *et al*., 1992; Bloomfield & Vurdubakis, 1994; Walsham & Sahay, 1999; Holmström & Stalder, 2001; Mähring *et al*., 2004). While these studies demonstrate the feasibility of ANT as a framework in this domain, they also raise a number of issues (Walsham, 1997). Data from process studies are generally complex and making sense of them is a constant challenge (Langley, 1999). In addition, process data deal with sequences of events and involve multiple levels and units of analysis whose boundaries are ambiguous. On this background, we explored whether some of the issues in ANT studies of IT-based change can be resolved by drawing upon other approaches to process analysis. Specifically, we combined ANT analysis with temporal bracketing to present and analyze data in successive episodes separated by encounters (Pettigrew, 1990; Newman & Robey, 1992; Langley, 1999). In the following, we present key evaluations of the combined approach based on our use of it to analyze and present the implementation of the Swedish radiology network system.

The two approaches complement each other. Both approaches are open to complementary theoretical frameworks. The encounter-episode approach originally focused on conflict generation and resolution among users and analysts during systems development (Newman & Robey, 1992). Mapping into encounters and episodes can help researchers adopt other specialized theories (like ANT) that deal with events (e.g. translations, inscriptions, and enrollments) over time (Newman & Robey, 1992). Similarly, ANT can be complemented by other social theories to explore aspects ANT may not accommodate well (Walsham, 1997). For example, in their investigation of the development of a standard for EPRs in Norway, Hanseth *et al*. (2006) combined ANT with the theory of reflexive modernization. Combining ANT analysis and temporal bracketing into encounters and episodes is hence feasible. In our analyses and presentation of the Swedish case, we experienced the combination of the two approaches to be both practical and seamless.

The two approaches are conceptually well aligned. ANT is a process-oriented approach (Law, 1992; Latour, 2005). By delving into translations, inscriptions, and enrollments, ANT helped us consider questions like: how the actors mobilized and held together the bits and pieces of which they were composed; how the actors sometimes were able to prevent those bits and pieces from taking off; and how they sometimes concealed the process of translation and simplified the heterogeneous network of materials into one punctualized actor (Law, 1992). The encounter-episode approach is also process-oriented. During the analyses, it helped us understand the social dynamics involved by exploring how and why initial conditions were transformed into specific outcomes through sequences of encounters and episodes (Newman & Robey, 1992). In this respect, we found an immediate alignment between ANT and the encounter-episode approach. Translation, inscription, and enrollment from ANT constitute different and related types of events in ANT and applying Newman and Robey's approach challenged us to perceive each such event either as encounters or as part of episodes. We were in this way challenged to define and focus on those translations, inscriptions, and enrollments that make a difference (Isabella, 1990; Newman & Robey, 1992; Peterson, 1998).

The combined approach helps researchers structure and emphasize the analyses. The implementation of the radiology network system at the Swedish hospital illustrates the complex character and the difficulty of anticipating the path of IT-based changes. By focusing on one encounter and subsequent episode at a time, we could at each stage identify which actor-networks were relevant and shaped the interactions among implementation content, context, and process (Pettigrew, 1985; Pettigrew, 1987; Pettigrew, 1990). As a result, we arrived at a structured though rich and multi-dimensional understanding of the change process at the Swedish hospital as summarized in the section 'Overall findings.' Some ANT studies include events and describe them in chronological order (Vidgen & Mcmaster, 1996; Walsham & Sahay, 1999; Holmström & Stalder, 2001; Scott & Wagner, 2003; Mähring *et al.*, 2004). In these cases, events play different roles in the presentation of the involved cases. Some presentations are structured using project phases as they were planned or executed (Walsham & Sahay, 1999; Holmström & Stalder, 2001). Other presentations are structured using events the authors have identified or conceptualized as being of particular interest to the case (Vidgen & Mcmaster, 1996; Scott & Wagner, 2003). Events also play varying roles in the analyses of the cases. Events are used to analyze network formation stages in Mähring *et al.*'s (2004) study; they are used to characterize temporal zones in Scott & Wagner's (2003) study; used events to illuminate strengths and weaknesses of different theoretical perspectives; used events to distinguish and describe processes of enrollment; and events were not included in the analysis by Vidgen & McMaster (1996). Compared to these ANT studies, our encounter-episode analysis puts explicit emphasis on the role of events that demarcate or trigger the transition between different stages of change. The event-based ANT analysis helped us create 'focal point crests of high energy' (encounters) that separate different waves (episodes). Encounters became the main mechanism for emphasizing dynamics (Leonard-Barton, 1990; Newman & Robey, 1992) while less emphasis was put on events within each wave (Peterson, 1998). A key feature of the event-based ANT analysis was therefore that it explicated the mechanism and criteria by which data were filtered, analyzed, and presented.

A potential flip side of an event-based approach to ANT analysis is the possible de-emphasis of subtle changes taking place continuously within episodes. There is also the risk that deliberately emphasizing certain encounters means keeping quiet about others. Event-based ANT analyses can in this way be misused to carefully craft a desired conclusion, as a way of captation (Latour, 1987) referring to the skilful truth maker anticipating the reader's objections and controlling the reader's possible sense making. Each approach to analyses implies, however, its own form of blindness. Despite some potential limitations, we found that the encounter-episode perspective helped us structure the extensive data we had collected into manageable subsets of concern. It helped us focus the analysis on key dynamics of the actor-networks involved in the change process. Metaphorically speaking, the event-based approach helped 'scaffolding' our analysis.

Conclusions and implications

By successfully applying an event-based approach to ANT analysis for a complex HIS implementation in a Swedish hospital, our work demonstrates the feasibility of the combined approach. The three-step guideline can also help future researchers engage in event-based ANT analyses of IT-based change.

The implications of this research for theory lie primarily in two areas. First, it adds to our knowledge of how HIS implementation processes are shaped in interaction with the specific hospital context in which they unfold. As such, it can help explain why the healthcare industry, despite extensive investments and implementation efforts, continues to lag behind other industries in effectively exploiting IT. Second, it demonstrates how ANT analysis can be combined with encounter-episode analysis to address some of the challenges involved in focusing, structuring, and presenting studies involving complex process data. Other researchers are encouraged to adopt and further develop this approach to studies of IT-based change. So in conclusion, this study provides two important lessons for research: (1) *contextual studies of HIS implementation processes can make important contributions to explaining implementation outcomes*; and (2) *combining ANT and encounter-episode analyses is a useful approach to help understand, structure, and present complex process data related to IT-based change*.

Finally, the research has rather immediate implications for practice. Managers within the health industry are advised to take contextual dynamics into account before engaging in new HIS implementations: Which professional interests and which organizational units are involved within the hospital (context)? How will established medical work practices be supported and impacted (content)? And, how can design options and new medical practices best be explored and negotiated between the involved professional groups and departments (process)? The issues and opportunities involved are complex and they are likely to unfold in partly unpredictable ways. In conclusion, this study therefore provides two important lessons for managing HIS implementation: (1) *contextual inquiry can help managers within the health industry proactively address HIS implementation challenges*, and (2) *building dynamic capabilities into implementation efforts will help managers learn about and adapt to the context in which HIS are to become embedded*.

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