8-16-2007

A Contextualist Approach to Telehealth Innovations

Sunyoung Cho

PERMISSION TO BORROW

In presenting this dissertation as a partial fulfillment of the requirements for an advanced degree from Georgia State University, I agree that the Library of the University shall make it available for inspection and circulation in accordance with its regulations governing materials of this type. I agree that permission to quote from, to copy from, or publish this dissertation may be granted by the author or, in his/her absence, the professor under whose direction it was written or, in his absence, by the Dean of the Robinson College of Business. Such quoting, copying, or publishing must be solely for the scholarly purposes and does not involve potential financial gain. It is understood that any copying from or publication of this dissertation which involves potential gain will not be allowed without written permission of the author.

_____
Sunyoung Cho

NOTICE TO BORROWERS

All dissertations deposited in the Georgia State University Library must be used only in accordance with the stipulations prescribed by the author in the preceding statement.

The author of this dissertation is:

Sunyoung Cho
3093 Flowers Rd S. Apt W
Atlanta, GA 30341

The director of this dissertation is:

Lars Mathiassen
Center for Process Innovation
J. Mack Robinson College of Business
Georgia State University
PO Box 4015
35 Broad Street, NW
Atlanta GA 30302-4015

A CONTEXTUALIST APPROACH TO TELEHEALTH INNOVATIONS

BY

SUNYOUNG CHO

A Dissertation Submitted in Partial Fulfillment of the Requirements for the Degree

Of

Doctor of Philosophy

In the Robinson College of Business

Of

Georgia State University

GEORGIA STATE UNIVERSITY
ROBINSON COLLEGE OF BUSINESS
2007

ACCEPTANCE

This dissertation was prepared under the direction of the candidate's Dissertation Committee. It has been approved and accepted by all members of that committee, and it has been accepted in partial fulfillment of the requirements for the degree of Doctoral of Philosophy in Business Administration in the Robinson College of Business of Georgia State University.

_____
Dean: H. Fenwick Huss

DISSERTATION COMMITTEE

_____
Chair Dr. Lars Mathiassen

_____
Dr. Michael Gallivan

_____
Dr. Daniel Robey

_____
Dr. Youngjin Yoo

ACKNOWLEDGEMENTS

I owe this achievement to many people and would like to take this opportunity to thank them.

First, I would like to thank my family members - my son Junwon (Peter), his two grandmothers, and my husband. Their emotional and physical support made this achievement possible.

My special thanks go to my advisor Dr. Lars Mathiassen, who constantly inspired and supported my research throughout the program. He became the role model for life as a teacher, researcher and human being. I have found one of the most important social assets during my study.

I must thank my dissertation committee members, Dr. Robey, Dr. Gallivan and Dr. Yoo. It was an honor for me to have such accomplished researchers on my committee and had opportunities to work with them. I learned from them so many aspects of being a researcher.

Lastly but not the least, I also would like to thank those who were involved in this particular research. I want to express my thanks to Dr. Stachura, Dr. Khasanshina and Dr. Hess at the Medical College of Georgia and Dr. Jayant, Mr, Peifer, Mr. Wilson, and Mr. Rao from Georgia Institute of Technology. Without collaboration with and support from them, this research would not have been implemented. I also thank those who participated in interviews and workshops working in the hope of making the world a better place.

Thank you all.

Table of Content

Abstract

A Contextualist Approach to Telehealth Innovations

By

Sunyoung Cho

June 2007

Committee Chair: Lars Mathiassen

Major Academic Unit: Center for Process Innovation

Healthcare is considered one of the most important social issues in the U.S. as well as in other societies with ever-increasing costs of medical service provision. The information-intensive nature of the healthcare industry and the perception of information technology (IT) as a way to ease up healthcare costs and improve quality have lead to increased use of and experiments with IT-based innovations. These activities present interesting research opportunities for IS researchers and they have led to an increasing body of knowledge on healthcare information systems. This research aims at contributing to this line of research by adopting a contextualist approach to examine the adoption, use, and further diffusion of telehealth innovations.

A contextualist approach provides a particularly interesting and relevant perspective to study adoption and diffusion processes of healthcare innovations. The adopted contextualist approach is process-oriented, it applies multiple levels of analysis, and it accommodates different theoretical lenses to make sense of the two telehealth innovations under investigation. A key assumption is that innovations should be understood as ongoing processes of change, not just technologies, or isolated change events with clear boundaries. Healthcare innovations have in this view much broader connotations, including development of IT-based applications, their adoption and diffusion over time, and the interactions between many stakeholders and organizations that shape the innovation in a specific context. The contextualist approach suggested by Pettigrew is adopted as an overarching framework for multiple studies based on empirical investigation of two telehealth innovations; the main focus is on a telestroke innovation in the U.S. while a radiology innovation in Sweden serves as a complementary case. Each study is documented as an independent research publication with its own theoretical perspective and contributions. The overall contextualist approach and the related findings are then summarized across the individual studies.

Telehealth innovations are particularly interesting examples of healthcare information systems. They leverage contemporary network infrastructures and interaction devices to allow provision of healthcare services, clinical information, and education over distance, thereby reducing the costs and improving the availability of medical services. The two telehealth innovations are investigated through in-depth case studies. This theses summary presents the theoretical background for the studies; it motivates and details how the qualitative case studies based on critical realist assumptions were designed and conducted; it outlines the resulting research publications; and it discusses the contributions of investigating telehealth innovations from a contextualist approach.

Keywords: Contextualist approach, telehealth innovation, hospital networks, interpretive case study, multi-paper model.

Part I: Research Summary

Chapter 1: Research Focus

Research Domain

The United States has the highest per capita spending on healthcare compared to other industrialized nations, but it lags behind others by as much as a dozen years in its efforts to implement healthcare information systems (Anderson et al. 2006). In 2003, U.S. spending per capita was $5,635, which was two-and-a-half times the comparable median for OECD countries at $2,280 (Anderson et al. 2006). The U.S. healthcare spending also represented a significantly large 15 percent of gross domestic product in 2003. Still, the U.S. healthcare service quality was lower than that of the median OECD country with fewer physicians, nurses, and hospital beds (Anderson et al. 2006). With an aging population and increasing social spending, healthcare has become one of the most important and controversial social issues in the U.S. society.

The use of information technology (IT) is perceived to represent a potential breakthrough to help improve service quality and reduce healthcare costs in the U.S. For example, electronic patient record systems are considered to better support effective patient care and cut healthcare costs significantly. Also, new ways of delivering healthcare over distance using telecommunication technology are perceived to address problems such as disproportionate distribution of healthcare resources, limited access to those resources, and ever-increasing costs of healthcare paid by the public and private sector (Maheu et al. 2001). Rapid increase in IT investments in healthcare in the U.S. is a reflection of a gap between current IT use and perceived potentials. IT investments were expected to reach 23.6 billion USD in 2003, rising at a rate of 9.3 percent from $21.6 billion expended in 2002 (Sheldon I. Dorenfest & Associates, Ltd. 2004). Still, adoption of IT in healthcare only proceed slowly, and difficulties in successful adoption of IT-based innovations in healthcare are well-documented (Aarts et al. 1998; Anderson 1997; Berg 2001; Davidson 2000; Lorenzi et al. 2003; Lorenzi et al. 1997; Menon et al. 2000; Raghupathi 1997; Tanriverdi et al. 1998).

The growing investments in IT lead to increased use of and experiments with IT-based innovations. Healthcare has as a consequence emerged as an increasingly important domain in information systems (IS) research with a steadily growing body of knowledge (Chiasson et al. 2004). In this research, we focus on telehealth innovations, which represent a subset of IT-based innovations in the healthcare domain. Telehealth innovations have existed for about four decades, and the 1990s witnessed a renaissance of such innovations due to technology advances in network technologies, advanced interfaces, and mobile technology (Maheu et al. 2001). Increased use of IT to deliver healthcare services over distance has created a slew of new, but conceptually overlapping terms such as telemedicine, telehealth, and e-health (Anderson 1997; Bashshur 2000; Maheu et al. 2001). Though exact definitions and boundaries of those terms are elusive (Bashshur 2000), telemedicine is defined as provision of healthcare services, clinical information, and education over distance using telecommunication technology, whereas telehealth is seen as being a more encompassing term (Maheu et al. 2001). Maheu et al. point out that the term telehealth has grown in popularity and is now used as a synonym for telemedicine. Telehealth encompasses the distant delivery of health services including clinical, educational, and administrative services, through transfer of various forms of information (e.g. audio, video and graphics) via telecommunication (Bali et al. 2001).

Telehealth innovations are worthy of additional rigorous research efforts for a number of reasons. First, telehealth innovations, as an emerging research domain, provide a fertile ground for exploring and expanding IS theories and building new theories. New research domains always challenge the validity and applicability of existing theories and provide rich contexts for new theory-building opportunities. Second, telehealth innovations modify, alternate, and replace existing processes in healthcare organizations, and they therefore provide an interesting basis for studying IT-based process innovation. Third, telehealth innovations as well as IT-based innovations in healthcare in general are an under-researched IS area justifying more research efforts. Even though healthcare IS research is steadily growing, it is still disproportionate to other IS research areas (Chiasson et al. 2004; Davidson 2000). We lack a thorough understanding about this particular domain and more empirical studies are needed to address questions like: How are telehealth innovations adopted and diffused? In what contexts are those innovations embedded? Are these contexts significantly different from other contexts for IT-based innovations? Finally, healthcare remains an important aspect of contemporary societies with many challenges and opportunities related to adoption of IT-based innovations, telehealth innovations in particular; research into this particular domain therefore has the potential to make significant contributions to society.

Research Perspective

Telehealth innovations are in this research approached from a process point of view. Generally, an innovation refer to ideas, practices, or objects that are perceived as new by an individual or other unit of adoption (Rogers 2003). In comparison with this static view of an innovation, a number of process-oriented perspectives on innovation also exist. Van de Ven et al. (1999b) state that innovation is "encompassing and includes the process of developing and implementing a new idea" (Van de Ven et al. 1999b). Innovation includes in this view events performed by many people over extended time periods. It is not the discrete acts of a single entrepreneur on a particular date and at a particular place. Also, when innovation development work begins, the process does not unfold in a simple, linear sequence of stages and sub-stages. Especially, after the activity to develop an innovative idea in a rather simple and unitary manner, the process diverges into multiple, parallel, and interdependent paths of activity (Van de Ven et al. 1999b). In a similar line of thought, Avgerou and Madon (2004) argue that IT-based innovations go beyond the design and implementation of a new technology to also address issues of information and knowledge, and interest in IT-related changes of the organization and content of work tasks (Avgerou et al. 2004).

This research subscribes to this line of process-oriented thinking on IT-based innovations. Telehealth innovations, as ongoing change processes, do not refer to particular technologies, or to specific IT-based change events with clear boundaries. Rather, they are seen as change processes with blurry boundaries of beginning and end, involving many stakeholders and organizations in shaping the innovation, and unfolding in complex, multi-layered social contexts. Such conceptualization of telehealth innovations requires a research approach that supports process-orientation and allows multi-level analysis of the contexts in which innovations unfold.

On this background, a contextualist approach is adopted in combination with different theoretical lenses to arrive at a comprehensive, process-oriented understanding of the two telehealth innovations investigated in this research. The key contributions of the research is

presented in five papers that are included in full-length in Part II and summarized in Chapter 4. An approach suggested by Pettigrew (referred to as 'the contextualist approach' in the following) has been adopted to characterize and summarize the individual studies because it fits well with the objectives of this research (Pettigrew 1985b; Pettigrew 1987; Pettigrew 1990; Pettigrew et al. 2001). This contextualist approach emphasizes the interaction between context and innovation as an ongoing process and it supports multi-level analysis. The approach is also flexible in use of complementary theories allowing multiple interpretations and explorations of the research phenomena under investigation.

Given the research domain and the research perspective as described above, this research addresses the following overarching research question through multiple studies:

- How can a contextualist approach help investigate telehealth innovations?

We summarize the contributions of each of the five studies in relation to this overarching question in Chapter 4. Drawing upon Pettigrew's framework (1987), we summarize the contributions on an aggregate level across the individual studies in Chapter 5 by addressing the following more specific questions:

1. How do processes of adopting and further diffusing telehealth innovations unfold over time?
2. How do the context and content of telehealth innovations manifest themselves and interact over time?
3. How can contextual analyses inform research on and practical management of telehealth innovations?

Research Design

A U.S. telestroke innovation was chosen as the focal case to explore these research questions and was subsequently complemented by a more limited study of a Swedish radiology innovation. While the radiology case represents a traditional example of IT-based innovation in hospitals, the telestroke case represents a high-impact medical innovation with the potential of saving lives of stroke patients and reducing both fiscal and social costs of stroke incidents. The telestroke case study was established, designed, and conducted by this author as the core of this thesis. The collected data were mostly qualitative including interviews, workshops, and other sources such as patient demographic information, local newspaper articles, academic papers on this particular innovation and organizational newsletters. The complementary study of the radiology innovation was based on collaboration with a Swedish researcher who organized and conducted the underlying data collection. The telestroke innovation has been adopted by a network of collaborating hospitals (one hub and nine rural hospitals) and has been in use for some years. It exemplifies the inter-organizational characteristics of telehealth innovations, where multiple stakeholders and organizations are connected through information systems to provide appropriate medical services over distance. The innovation has also been going through a commercialization process, which provides rare opportunities to study further diffusion of a telehealth innovation. Overall, this research setting provides a fertile ground for exploration of the research questions.

The research method chosen to study the telestroke innovation is qualitative case study. Case study has advantages over other research methods such as surveys, experiments, and others in answering questions of "how" and "why" (Miles et al. 1994; Yin 2003). In this way, the research questions presented here justify the method. Moreover, case study research is generally well suited to study the interactions between IT-related innovations and organizational contexts (Darke et al. 1998) and it is also acknowledged to be particularly appropriate for the study of information systems development, implementation, and use in organizational settings (Benbasat et al. 1987).

The research resulted in four papers of the focal innovation, which the author has been following since spring 2004, and one paper based on the Swedish case. Klein and Myers (1999) propose the principle of dialogical reasoning for interpretive field research, which requires the researcher to confront his or her preconceptions that guided the original research design with the data that emerge through the research process. Following this principle, the multi-paper design provides opportunities to explore different interpretations of the data with different theoretical lenses.

The research contributes to the existing body of knowledge in the information systems field. First, it expands our knowledge on healthcare innovations, telehealth innovations in particular. The research consisting of multiple case studies based on empirical investigation of the two telehealth innovations aims to improve our understanding of multi-faceted processes of adoption and diffusion of telehealth innovations, an emerging topic for IS research. By adopting a contextualist approach which emphasizes contextual embeddedness, the research also provides insights on the context of telehealth innovations and its interaction with the innovations over time. It expands our knowledge on telehealth innovations by exploring and developing information systems theories in relation to the domain of telehealth innovations, therefore leading to a number of other theoretical contributions. Emerging research domains provide opportunities to further explore the validity, applicability, and boundaries of existing theories and to build new theories as well. The concept of organizational resilience linked to successful adaptation behaviors is challenged and process-oriented aspects of resilience are emphasized. Van de Ven's industry infrastructure theory is adapted and applied to a single case study, departing from the originally intended theory level. An event-based approach to ANT analysis is suggested as one particular approach to handle the complex process data usually involved in such analysis. Applying Pettigrew's framework to explore context and its interactions with telehealth innovations, the five individual studies show a variety of ways to apply this approach, and they demonstrate how the framework effectively supports process-oriented studies of telehealth innovations. Finally, the research has some practical implications as well, which may provide insights for organizational implementation and diffusion of other telehealth innovations.

Chapter 2: Theoretical Foundation

Healthcare Information Systems

Increasing investments in IT and consequent increase in IT-based innovations in healthcare are also reflected in IS research, as the number of publications is on the rise. Chiasson and Davidson (2004) have shown that there exists a small but growing body of knowledge on healthcare information systems through an extensive review of all the publications on healthcare information systems in 17 IS journals from 1985 to 2003. They define healthcare[1] information systems research (HISR) as the multidisciplinary body of knowledge related to the design, development, implementation, and use of information-intensive technologies in healthcare settings. Even though research on healthcare information systems is multidisciplinary drawing from various research fields such as medical informatics, information systems, medicine, and information and library science (Chiasson et al. 2004), the discussion of healthcare information systems research is restricted to the field of IS in the following if not mentioned otherwise.

The review by Chiasson and Davidson (2004) is particularly interesting in relation to this research and their findings inspire and encourage our approach. By examining 17 IS journals, Chiasson and Davidson identified 165 healthcare IS publications, which represents only 1.2 % of all the publications in 17 leading journals over the examined period. The identified healthcare information systems research is classified further into four categories based on the assessment of how the interplay of IS theory and the healthcare context is dealt with. The four categories are IS only, IS-healthcare, healthcare-IS, and healthcare only. IS only papers focus on generalizable theory without consideration of interaction with the healthcare context. The authors of these papers do not explore how the study's healthcare context might influence theoretical constructs, assumptions, or analysis. IS-healthcare papers primarily focus on developing or testing IS theories with some consideration given to the interaction with the healthcare context. These researchers consider how the healthcare context might influence application or interpretation of IS theory. Healthcare-IS papers more systematically consider the healthcare context by applying IS theory to analyze issues in the healthcare context. The authors of these papers explicitly take into account unique aspects of healthcare settings in order to develop, test, and extend theory through the application of a general IS topic. Healthcare only papers focus on describing the design, development, implementation, and use of information-intensive technologies in healthcare settings without significant use of IS theories in the analysis.

In this research, the efforts by Chiasson and Davidson have been extended with a review of healthcare IS publications in the 17 leading journals in their original study during the period from 2004 to 2006 (Table 1). Two bibliographic databases (ABI Inform and Ebsco Host/Business Source Premier) were used for searching healthcare information systems research publications using combinations of index terms (health, healthcare, telemedicine, and telehealth). Table of contents of several of those 17 journals were manually examined since some publications, especially IS-only group papers, are elusive from search-term based search.

---

[1] In their study, Chiasson and Davidson use the term 'health information systems research'.

	1985-2003	2004-2006
CACM	36	11
Database	5	1
Decision Support Systems	19	1
European Journal of IS	7	4
Human Relations	2	3
Information and Management	17	1
Information and Organization	7	2
ISR	2	0
IT & People	12	2
International Journal of Information and Management	11	2
JMIS	9	4
Journal of Organizational and End User Computing	10	2
Journal of Systems Management	9	Discontinued (August 1996)
MISQ	8	5
Organization Science	2	0
Organization Studies	3	0
The Information Society	6	2
Total	165	40

Table 1. HISR publications in leading IS journals

A total of additional 40 HISR publications were identified. The comparatively large number of additional HISR publications over the relatively short, most recent time period confirms Chiasson and Davidson's finding of an upward trend in HISR publications in the field of IS as a reflection of the increasing investments in and experiments with IT-based innovations in healthcare. The identified articles have been classified into the four categories described above (Table 2). The distribution of articles during the more recent period is similar to, but slightly different from that of Chiasson and Davidson's study (Table 2). Given the rather short time period considered (2.5 years), it is probably too early to make firm conclusions.

	HISR publications (1985 – 2003)	% of all HISR articles (1985 – 2003)	HISR publications (2004 – 2006)	% of all HISR articles (2004 – 2006)
IS only	29	17.6%	9	22.5%
IS-healthcare	46	27.9%	6	15%
Healthcare-IS	29	17.6%	10	25%
Healthcare only	61	36.9%	15	37.5%

Table 2. IS theory and context relationships in HISR papers

Of the four categories of HISR published in leading journals, two are not of interest for this research. IS only papers, which account 22.5 % of recent HISR publications, de-

contextualize healthcare settings focusing on generalizable IS theories. Brown et al.'s study (2004) could be cited as an example. Through a study of telemedicine, they develop propositions predicting that personality type affects individual's disposition of trust, perceived trustworthiness, and communication and therefore affects willingness to collaborate and the sustainability and productivity of the collaboration (Brown et al. 2004). In this case, telemedicine is de-contextualized in the sense that the authors do not take the uniqueness of the healthcare setting into account, but focus on general issues related to virtual collaboration. In fact, the specific aspects of the study setting in healthcare are not reflected into the propositions; instead, the healthcare context is abstracted into a generic form of virtual collaboration. Healthcare only articles accounting for the largest portion with 37.5 %, on the other hand, are mostly descriptive, lacking theoretical perspectives on the context or the IT-based innovations under investigation. Consistent with Chiasson and Davidson's finding (2004), a majority of HISR papers in Communications of the ACM, are grouped as this category such as (Egyhazy et al. 2004; Goldschmidt 2005; Mercuri 2004; Pratt et al. 2006).

The IS-healthcare and healthcare-IS categories are relevant to this research, since they explore the interplay between IS theory and the healthcare setting to some degree. 40% of the recent HISR publications in the review were identified as either IS-healthcare or healthcare-IS. The percentage of the articles belonging to the two categories is not significantly different from Chiasson and Davidson's (45.5%). Paul and McDaniel's paper is an example of an IS-healthcare study (Paul et al. 2004). They examine the relationship between interpersonal trust and dyadic collaborative relationship performance in telemedicine project settings. The healthcare setting is used opportunistically to pursue theory development and testing in relation to virtual collaborative relationships. The difference between Paul and McDaniel's study and Brown et al.' (2004) is the emphasis on the context. In Paul and McDaniel's study, unique characteristics of the healthcare delivery context is mentioned which make the creation and maintenance of trust difficult. However, the healthcare setting is also presented as a type of virtual collaboration relationships and the main focus of the study is still on general IS research topics.

Ten out of the forty, recent HISR publications were classified as healthcare-IS category (e.g. Braa et al. 2004; Constantinides et al. 2006; Fitzgerald et al. 2005; Josefsson 2005). In these papers, the authors analyze empirical findings and explore contextual influences by applying and elaborating IS theories within an empirical study in healthcare (Chiasson et al. 2004). For example, Constantinides and Barrett (2006) explicitly address the interaction between an IT-based innovation and its context with focus on the relationship between structure and culture and the relationship between power and politics. They view the process of development, implementation, and adoption of a telecardiology innovation as an ongoing process of negotiations between multiple actors and their technological choices. IS theories (practice lens, boundary objects, and ANT) are applied to frame the process of negotiations.

Chiasson and Davidson (2004) argue that IS-healthcare and healthcare-IS approaches are more balanced between contextual specificity and general IS theory than the other two approaches, though they consider healthcare-IS the better approach to explore context specificities in the healthcare sector. The healthcare context provides a niche for IS researchers where they can extend, refine, and develop IS theories (Chiasson et al. 2004). However, the field of IS is still short on contextual approaches in healthcare information systems research. IS-healthcare and healthcare-IS account for 40% of the recent HISR publications (45.5% in Chiasson and Davidson's study), but the number of papers in absolute term is low, which justifies more empirical studies with attention to the unique context of the healthcare sector.

Moreover, if the discussion is scoped down to telehealth innovations, the number of studies across the published papers in the 17 journals during the period from 2004 to 2006 goes down to just a few (Adewale 2004; Brown et al. 2004; Chau et al. 2004; Liang et al. 2006; Mbarika 2004; Paul 2006; Paul et al. 2004). Only a few of these are empirical studies with some consideration of the interaction between IT-based innovation and the context (e.g. Chau et al. 2004; Constantinides et al. 2006).

Contextualist Approach

Emphasis on context, in its broad definition, has long been reflected in IS research. Many situated, process-oriented IS studies (e.g. Cule et al. 2004; Newman et al. 1992; Orlikowski 1993; Orlikowski 2000; Robey et al. 2001; Sabherwal et al. 2003) are contextual in the sense that they are typically case studies examining how a focal innovation is situated and unfolds in its context. Situated approaches involve the analysis of the specific circumstances of innovation, focusing on actors embedded in a particular social and organizational setting, and emphasizing the significance of context-specific actions, such as improvisation, tinkering, and negotiation (Avgerou et al. 2004).

It can be argued that contextualist approaches have been practiced in this rather broad research tradition. Even though the understanding and degree of emphasis on context and methodological suggestions vary significantly, a minimal, common set of characteristics can be identified, seeing this broad line of research as contextualist in its broadest definition. The focal phenomena of such situated, process-oriented studies are typically IT-based organizational change. Analysis is usually done at the levels of individual organizations, or groups, or individuals. In such studies, embeddedness of IT-based innovations in their context is usually emphasized and the trajectory of change is investigated through process analyses (e.g. Cule et al. 2004; Orlikowski 1993). However, the perception of the context varies as some studies consider it as given without explicit mentioning of the context while others (e.g. DeSanctis et al. 1994; Orlikowski 2000; Orlikowski 2002) recognize the emergent nature of context. The study proposed here has found inspiration in those studies that examine IT-based organizational change with consideration of the interaction between the context and the innovation drawing upon multiple levels of analysis. Detailed, methodological advice on how to design and effectively conduct studies that emphasize the interplay between context and innovation is, however, limited in this line of research.

Studies like (Avgerou 2001; Avgerou et al. 2004; Chiasson et al. 2005; Covi et al. 1996; Crowston et al. 2004; Lamb et al. 2003; Van de Ven 2005) have a more explicit emphasis on the context of IT-based innovations. They do in many ways not represent a distinct line of research from the situated, process-oriented studies just mentioned; but they have a more explicit emphasis on context and they emphasize what constitutes the specifics of the context in each study. These studies can be characterized as institutional studies, often with specific industry characteristics considered as important parts of the contextual space (Chiasson et al. 2005; Crowston et al. 2004; Van de Ven 2005). With some variation, these studies implicitly or explicitly outline what DiMaggio and Powell calls an "organizational field" (DiMaggio et al. 1983). An organizational field is identified when "organizations, in the aggregate, constitute a recognized area of institutional life: key suppliers, resource and product consumers, regulatory agencies, and other organizations that produce similar services and products." One advantage of

employing the concept of organizational field is that it directs researchers' attention to identify and investigate the totality of relevant actors, individuals, groups, organizations, and networks that interact to shape the innovation under consideration (DiMaggio et al. 1983). These studies recognize the embeddedness of IT-based innovations beyond organizational boundaries; the processual emphasis varies; and the emergent nature of the context is often less obvious as the interaction between context and innovation can be difficult to trace.

Building on these strands of IS research, we have chosen to primarily base this research on the work of (Pettigrew 1985b; Pettigrew 1987; Pettigrew 1990; Pettigrew et al. 2001). In relation to the larger landscape of contextual approaches within IS research, his approach has some distinct characteristics and advantages. Pettigrew suggests contextualist analysis in studying strategic changes in organizations, criticizing that few studies of organizational change actually allow the change process to reveal itself in any kind of substantially temporal or contextual manner (Pettigrew 1987). In line with his critiques, Pettigrew's contextualist approach (referred to as 'the contextualist approach' in the following) consists of three analytical categories of content, context, and process (Figure 1).

Content refers to the particular areas of transformation under investigation. It could be organizational changes surrounding new technologies, manpower, products, geographic positioning, or organizational culture. In this research, the content is telehealth innovations, a specific type of IT-based change in organizations within the healthcare sector.

Context is composed of outer and inner contexts. Outer context refers to the external organizational circumstances and conditions where the organization(s) operates such as the social, economic, political, and competitive environment, whereas inner context refers to the intra-organizational circumstances and conditions such as structure, organizational culture, and political circumstances. Context in this approach is not conceptualized as a static, descriptive background against which an innovation occurs, nor does it represent deterministic forces constraining the change. Rather, there is a constant unfolding of interaction between context and content and this interaction is both constrained by and shape the context. It is worth pointing out distinctions between the context proposed by Pettigrew and similar terms like environment and population ecology. One of the most common perspectives which underlies some dominant theories of organization-environment relations is the modernist view in which environment is defined by its elements (Hatch 1997). Three of the most common elements are the inter-organizational network, the general environment, the international/global environment. The inter-organizational network consists of suppliers, customers, partners, competitors, unions, special interests, partners, and regulatory agencies; the general environment includes culture, economy, technology, cultural, political, social, physical and legal elements; and the international/global environment includes aspects of the environment that cross national boundaries (Hatch 1997). Environment defined in this way roughly corresponds to outer context in Pettigrew's framework as it is assumed to be something outside the organizational boundaries. Population ecology, analogous to Darwin's survival of the fittest, is a way to theorize the relations between organizations and their environment assuming that the environment has the power to select from a group of competitors those organizations that best serve its needs. Pettigrew's conceptualization of context is more generic and broader in that it also includes reference to within-organizational circumstances and that the direction of interaction is assumed to be two-way (context both shaping and being shaped) rather than one-directional as in population ecology theory.
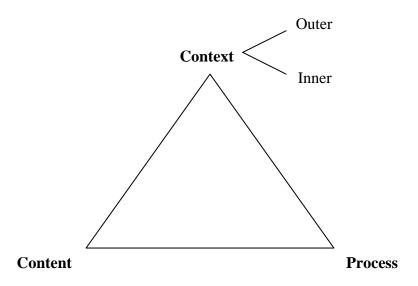
Figure 1. Pettigrew's contextualist approach

Process refers to the actions, reactions, and interactions from various interested parties as they seek to change the organization from one state to another. Pettigrew's contextualist approach was proposed as a methodological suggestion, or as a theory of method, for conducting processual studies of organizational change. Pettigrew argues that it is one of the core requirements for the contextualist approach to understand the emergent, situational, and holistic features of a process in its context rather than dividing the process into limited sets of variables separated from context (Pettigrew 1985b).

To achieve such an emergent, situational, and holistic understanding of a process in its context, the contextualist approach draws on two different dimensions of analysis, the vertical and horizontal analysis. The vertical dimension refers to the interdependencies between higher or lower levels of analysis on phenomena to be explained; the horizontal dimension refers to the sequential interconnectedness among phenomena in historical, present, and future time. Pettigrew argues that an approach that offers multilevel (or vertical) analysis and processual (horizontal) analysis can be said to be contextualist in character.

According to Pettigrew, any wholly contextualist analysis would have the following four characteristics (Pettigrew 1985b; Pettigrew 1987). First, it would require clearly delineated, but theoretically and empirically connectable analysis levels. Within each level, depending on the focus of explanation, there would be a specified set of cross-sectional categories. Second, it would require a clear description of the processes under examination. The process is seen as a continuous, interdependent sequence of actions and events that is being used to explain the origins, continuance, and outcome of some phenomenon. At the level of individual actors, the language of process is most obviously characterized in terms of the verb forms interacting, acting, reacting, responding, and adapting, while at the system level, the interest is in emerging, elaborating, mobilizing, continuing, changing, dissolving, and transforming. Third, the processual analysis requires a motor, or theory, to drive the process of change. Fourth, it is crucial that the ways the contextual variables and categories in the vertical analysis are linked to the process under observation in the horizontal analysis.

The contextualist approach leads to a process of inquiry where scientific knowledge is created through sense-making rather than being discovered. Meanings in research settings are

situational and multi-faceted. Acceptable definitions of acts emerge as concepts and meanings are shared and traded in the research process. Philosophical assumptions of the contextualist approach are therefore in line with epistemological relativism in broader sense.

The contextualist approach has been adopted to present and summarize this research because of its strong and explicit emphasis on process-oriented analysis of IT-based innovations in context. First, the definition of context as inner and outer is flexible and inclusive, even though it at first sounds rather mechanistic. Such conceptualization of context can overcome the criticism for many situated studies of information systems which limit their analysis to the immediate environment of an innovation process such as an organization or a group (Avgerou et al. 2004). It is also comprehensive enough to include discussion of outer context such as the institutional context at multiple levels, such as inter-organizational, national, and even global. Second, the contextualist approach, as a theory of methodology, is not bound by a particular theory or theories. It requires a theory or motor to drive the change process under investigation (Pettigrew 1985, 1987, 1990). This allows for dialogical reasoning with multiple interpretations of research phenomena by adopting different theoretical lenses (Klein et al. 1999). Third, it has definite advantage over many existing process-oriented studies by combining horizontal (processual) and vertical (multi-level) analysis. Such combination of analysis, a key characteristic of Pettigrew's contextualist approach, is rare in empirical research on telehealth innovations, even though there exist some studies that incorporate Pettigrew's contextualist approach to examine other types of IT-based innovations (Jayasuriya 1999; Scheepers et al. 2003; Walsham et al. 1994).

The contextualist approach is particularly well suited to study network-level innovations involving multiple organizations and stakeholders as in the case of the focal telestroke innovation as well as the complementary Swedish radiology innovation. Comprehensive understanding of the innovation requires a multi-level analysis of the processes of adoption and diffusion. Also, the ontological and epistemological assumptions of this research are well aligned with those of the contextualist approach as discussed in the next chapter in more detail. Overall, the individual papers of this dissertation fit well with the contextualist approach, even though they do not equally emphasize all characteristics of the contextualist approach.

Theoretical Perspectives for Individual Papers

Social Systems Perspective

First Paper
Title: The Role of Industry Infrastructure in Telehealth Innovations: A Multi-level Analysis of a Telestroke Program
Authors: Sunyoung Cho and Lars Mathiassen

In the first paper, the telestroke innovation process has been looked at from Van de Ven's industry infrastructure perspective, which is considered an institutional theory. According to Hatch (1997), institutional theory is one of the three most influential theories in intensive studies on organization-environment relations from the late 1970s till today. Some recent IT studies with emphasis on context consider the institutional setting as an important contextual component.

Crowston and Myers (2004) propose three research perspectives to study the relationship between IT and industries, namely, an economic perspective, an institutional perspective, and a socio-cultural perspective. As the three different perspectives indicate, the use of the term "institutional" is narrowly defined in their study compared with others by limiting the institutional context mostly to legal and regulatory arrangements. However, they emphasize all three perspectives are needed to study the relationship between IT and industries.

Lamb el al. (2003) adopt Scott's open systems framework (2001, 1987) to examine environmental influences of online information use. They argue that all organizations take shape through variations in their technical and institutional environments. Institutional environments are defined in that study as an elaborate set of rules and requirements organizations must conform to in order to attain support and legitimacy (Lamb et al. 2003). The sources of institutional requirements include regulatory agencies, professional or trade associations, or general belief systems held by society.

Chiasson and Davidson (2005) suggest that industry provides an important contextual space to build new IS theory and to evaluate the boundaries of existing IS theory based on the embedded view of technology artifacts such as (Orlikowski et al. 2001) and (Benbasat et al. 2003). Chiasson and Davidson adopt Scott's definition of industry and propose to use his framework of material-resource environment and institutional environment to investigate industry influences on IT artifacts and related topics.

In line with these studies' emphasis on institutional setting as an important context, the first study adopts Van de Ven's industry infrastructure framework (Van de Ven 2005; Van de Ven et al. 1999a), which provides an interesting institutional lens to study the telestroke innovation. The framework was initially introduced based on studies of the development of the cochlear implant technology as part of the Minnesota Innovation Research Program (Van de Ven et al. 1989), and later extended and refined in subsequent studies. The framework is also labeled as the community infrastructure and social-system perspective. The framework synthesizes three dominant theoretical perspectives for technology innovations (technological imperative perspective, institutional determinism perspective, and resource endowments perspective into this framework), as all three are highly interdependent and therefore must be analyzed within a context of continuing interaction (Van de Ven et al. 1999a). Hence, the industry infrastructure framework incorporates the various components of an industrial infrastructure for technological innovation; (1) institutional arrangements to legitimize, regulate, and standardize a new technology, (2) public-resource endowments of basic scientific knowledge, financing mechanisms, and a pool of competent labor, (3) market mechanisms to educate consumers and stimulate demand for a new technology, and (4) proprietary research and development, manufacturing, marketing, and distribution functions by private entrepreneurial firms to commercialize the innovation for profit (Van de Ven et al. 1999a). The main proposition of the industry infrastructure framework is that the success in developing a technological innovation depends primarily on the extent to which relevant components of the infrastructure are established at the industrial-community level.

This study also utilizes the methodological suggestions for research using the framework (Van de Ven et al. 1999a). Van de Ven et al. (1999) propose two levels of analysis to investigate the process of innovation: (1) the behavior of individual entrepreneurs and firms, and (2) the system level looking at the community infrastructure as a whole and the interrelations among its components or functions.

The industry infrastructure perspective matches well the approach of this research. First,

institutional theory is one way to conceptualize organizational context (Hatch 1997), providing an important contextual space for IS research (Chiasson et al. 2005). Second, as the methodological suggestions by the authors of the theory indicate, the industry infrastructure theory assumes a multi-level view of the context of industry or community-level infrastructure. Such multi-level embedded views of innovations are well aligned with the contextualist approach. Third, the theoretical framework helps us understand the telestroke innovation and its interaction with the unfolding context, effectively addressing the three components of Pettigrew's contextualist framework. The contextual understanding based on the industry infrastructure theory may provide an alternative explanation to reported difficulties of adoption and diffusion of telehealth innovations.

Dialectics of Resilience Perspective

Second Paper
Title: Dialectics of Resilience: A Multi-level Analysis of a Telehealth Innovation
Authors: Sunyoung Cho, Lars Mathiassen, and Daniel Robey

In the second paper, dialectics and resilience have been employed to analyze the initial adoption of the telestroke innovation. In the following, theories of dialectics and resilience are briefly reviewed with particular emphasis on the alignment of these theories with the contextualist research approach.
    Dialectics has been adopted as one approach to understand and study social phenomena in general, and it has proven particularly useful as a framework to understand issues related to social change. Dialectics has been adopted in many organizational studies (e.g. Das et al. 2000; Fiol 2002; Ford et al. 1994; Lewis 2000) as well as in many information systems studies (e.g. Bjerknes 1991; Chae et al. 2006; Dahlbom et al. 1993; Mathiassen 1998; Robey et al. 1999; Robey et al. 2001; Sabherwal et al. 2003). The core concept in dialectics is contradiction, for which a variety of definitions have been applied. Robey et al. (1999) view contradiction from a broad perspective as a general term referring to a statement expressing or asserting the opposite of another statement and they broadly consider paradox, irony, hypocrisy, oxymoron, conflict, inconsistency, double blind, and dilemma as types of contradictions. Whichever form they take, contradictions are important in understanding real life situations which do not fit into neatly-built rational models, or prescribed set of assumptions. One of the strengths of dialectical approaches is their focus on tensions created by contradictions as the driving forces behind change. Researchers are stimulated to look for tensions related to contradictions to develop more encompassing theories (Poole et al. 1989).
    Dialectics assumes that organizations exist in a pluralistic world of colliding events, forces, or contradictory values that compete with each other for domination and control (Van de Ven et al. 1995). The organizational consequences of IT can, therefore, be explained by reference to the relative strength of opposing forces, some promoting change and others opposing change (Robey et al. 1999). Other researchers build on Mao Tse Tung's notion of contradiction to analyze social processes (Bjerknes 1991; Israel 1979; Mathiassen 1998). Contradictions in these studies are seen as totalities that consist of two opposing elements. The opposites of a contradiction have two qualities – the identity of, and the struggle between the opposing elements. The identity refers to the contradiction as a whole and explains the paradox

in which opposing elements co-exist. The struggle emphasizes the dynamics that drive change. In any given situation, the relationship between the two opposites is usually uneven so that one of the opposites exerts more influence. As time passes, the relationship between the opposing elements might change as a result of their mutual struggle. Also, there are typically several contradictions in any given situation, each with elements becoming more or less dominant as the situation evolves.

The different notions of contradictions discussed above are complementary. The main commonality underlying these understandings is their perspective that change is the outcome of contradictory forces. Put differently, the struggle between contradictions and between the opposites of each contradiction are the main forces driving change. Dialectics has been adopted in the second paper to analyze the situation where the telestroke innovation was adopted by multiple organizations. Following (Van de Ven et al. 1995), the key assumption is that dialectics would help reveal the contradictions involved and that this, in turn, can lead to an understanding of key forces involved in shaping the present situation and the future trajectory of the telehealth innovation.

Dialectical approaches to telehealth innovation fit well with a contextualist perspective. The theory is process-oriented focused on change and well suited to examine the interactions between innovation processes and context. The dialectical perspective denies predefined sequencing of change events whether it is deterministic or probabilistic laws, and emphasizes instead the emergent nature of innovation as a change process develops (Van de Ven et al. 1995). Opposing forces shaping the process of innovation could be at various levels of abstraction and analysis, including politics, culture, institutional arrangement, and organizational learning (Robey et al. 1999), therefore allowing multi-level analysis. Dialectics in combination with the contextual approach is capable of answering the 'how' and 'why' questions of IT-based innovations.

In this particular paper, dialectics is applied to investigate the resilience of the adoption process. Resilience research has its origin in psychology (Coutu 2002). It started with pioneering studies by Norman Garmezy of different responses and attitudes of children whose parents were schizophrenic. Garmezy concluded that resilience played a role in the mental health of those children. Since then, many studies have been carried out and theories abound about characteristics of resilience (Coutu 2002). The majority of these studies are at the individual level. Horne III and Orr (1998) note that the term resilience began to be applied as an organizational quality in the early 1990s. More recently, the concept of the "resilient organization" has gained popularity as a quality that might help organizations survive and thrive in difficult or volatile environments (Riolli et al. 2003).

Most definitions of resilience as an organizational quality emphasize its relationship with effective adaptation. Mallak (1998) defines resilience as the ability of an individual or organization to expeditiously design and implement positive adaptive behaviors matched to the immediate situation, while enduring minimal stress. Mallak considers organizational resilience as closely related to individual employees' resilience (Mallak 1998a). Hamel et al. (2003) define resilience as the ability to dynamically reinvent business models and strategies as circumstances change. Starr et al. (2003) use the term "enterprise resilience" as the ability to withstand systemic discontinuities and adapt to new risk environments. Horne III (1997) defines resilience as "a fundamental quality of individuals, groups, organizations, and systems as a whole to respond productively to significant change that disrupts the expected pattern of events without engaging in an extended period of regressive behavior" (p.31). In general, these definitions carry positive

connotations. The underlying assumption is that resilient organizations thrive in dynamic environments.

In this research, we have adopted the process-oriented view of resilience of Reinmoeller et al. (2005). Reinmoeller et al. defines resilience as a process capability, instrumental in overcoming barriers to change and in developing multiple sources of competitive advantage (Reinmoeller et al. 2005). The concept of resilience was decoupled from the concept of effective adaptation, since the authors believe that organizational resilience should be conceptually distinct from the outcomes with which it is associated. If it is not conceptually distinct, resilience becomes conflated and confounded with effective adaptation and its explanatory powers are removed. There are three advantages to this approach. First, resilience is related to the process of change, where specific capabilities may play roles in overcoming barriers to change. Second, resilience is multi-faceted, not a single quality. Thus, organizations may possess some resilient capabilities and not others. Third, in a process perspective resilience becomes a capability that may be related to both successful and unsuccessful adoption behaviors. For example, under conditions of external threat, an organization might quickly adopt an innovation without any certainty that it will be sustained in the long run. Indeed, resilient responses in the short run might neglect more fundamental organizational capabilities related to long-term performance.

The concept of resilience has been applied to the organizational adoption of the telestroke innovation. The concept of resilience as a process capability fits well with the contextualist approach adopted in this research. First, resilience is not an abstract organizational capability and context is emphasized as important in understanding resilience. Second, resilience is used as a multi-level construct in this particular research, as the considered telestroke innovation, as well as most other telehealth innovations, is networked and distributed, and their adoption is enacted through complex social networks of multiple organizations and stakeholders. These adoption processes therefore need to be interpreted as specific and complex interactions between different levels of adoption behavior including individuals, groups, and organizational units. Third, the processual focus has been emphasized, because resilience is not easily conceived as a general organizational quality. Rather, resilience emerges from an organization's involvement in change processes and its attempts to recognize and resolve the contradictions involved in such efforts. In relation to the considered telestroke innovation, resilience is conceived as an ongoing process in which specific contradictions are confronted and resolved, at least temporarily. Therefore, resilience emerges from stakeholders' involvement in change processes and its attempts to recognize and resolve the contradictions involved in such efforts. Resilience from such a process point of view is not only beneficial to understand the dynamics of adoption of innovations; it also fits well with the processual emphasis of the contextual approach.

Actor-Network Perspective

Third Paper
Title: Contextual Dynamics during Health Information Systems Implementation: An Event-Based Actor-Network Approach
Author: Sunyoung Cho, Lars Mathiassen, and Agneta Nilsson

In the third paper, Actor-Network Theory (ANT) is applied to explore how the implementation of a radiology network system was shaped through interaction with a hospital context in Sweden.

Seeking to understand contextual dynamics during healthcare information systems implementation and adoption processes and recognizing that ANT analyses like other process-oriented approaches easily become highly complex, we suggest use of events to focus, structure, and present the ANT analysis. The adopted event-based approach is intended to further our understanding of how researchers can apply ANT to study IT-based change in general.

Actor-network theory (ANT) is a relational, process-oriented sociology that treats agents, organizations, and technologies as interactive effects (Law 1992). 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, i.e. 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 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).

The networks that lie behind and make up an actor, whether it is people, organizations, or technologies, are sometimes invisible and sometimes visible. For example, a television conceived as a single and coherent object quickly turns into a network of electronic components and human interventions when it breaks down. The appearance of unity and the disappearance of network are due to simplification, in which the network acts as a single unit and is replaced by the action itself or the author of the action. Such effects of simplification are called punctualization in ANT terms (Law 1992). Whether the complex networks behind an actor is visible or not, there exists an on-going process made up of uncertain, fragile, controversial, and ever-shifting ties between the materials (Latour 2005). Therefore, any social structure is not free-standing, but a site of struggle, a relational effect that recursively generates and reproduces itself (Law 1992). Any form of social order like devices, organizations, institutions, and agents is not complete, autonomous, and final, but must rather be considered as an on-going process, which is often called translation, a core concept of ANT.

Analysis of struggle, or translation, is central to actor-network theory with its focus on exploring and describing local processes of patterning, ordering, and resistance (Law 1992). By delving into the process of translation, ANT theorists answer questions like: how actors and organizations mobilize, juxtapose, and hold together the bits and pieces out of which they are composed; how they are sometimes able to prevent those bits and pieces from taking off; and how they manage to conceal for a time the process of translation itself and simplify the heterogeneous network of materials into one punctualized actor (Law 1992).

Key characteristics of actor-network theory match the contextualist approach of this research well. First, ANT is a heavily process-oriented theory and focuses on tracing trajectories of interactions and associations of network elements. Therefore it suits well process studies to answer questions like how interactions and associations generate change and achieve order, be it technologies, organizations, or people. Second, ANT approaches are advantageous in situation where innovations proliferate, where boundaries are uncertain, and where the range of entities to

be taken into account fluctuates (Latour 2005). This fits the situation where an IT-based innovation unfolds, especially when the innovation is shaped across organizational units like in the case of the Swedish radiology innovation. This is also aligned with the adopted conceptualization of innovations that are seen as more than simply technologies or clearly bounded events, including multi-faceted aspects of development, implementation, and adoption processes. Third, ANT analysis can be multi-layered as each element or material of the network itself represents a network. ANT analyses hence become contextual through their emphasis on interactions and relationships among different materials of networks. Without these interactions and relations, what is under analysis (the focal radiology innovation) becomes meaningless from an ANT perspective.

Diffusion of Innovation Perspective

Fourth Paper
Title: From Adoption to Diffusion of a Telehealth Innovation
Author: Sunyoung Cho, Lars Mathiassen, and Michael Gallivan

In this paper, we have investigated the transition process of the telestroke innovation from its initial adoption at a number of nearby hospitals into a larger population of organizations through commercialization. The examination of the transition processes from adoption to wider diffusion is framed as a diffusion of innovation study.

Research on innovation adoption and diffusion has been established as one of the major research streams in the field of IS with a large body of knowledge accumulated (refer to (Fichman 2000; Fichman 2004; Gallivan 2001) for summaries of diffusion of innovation research stream). In his classical model, Rogers define diffusion as the process in which an innovation is communicated through certain channels over time among the members of a social system (Rogers 2003). In a similar vein, Fichman (Fichman 2000) defines diffusion as the process by which a technology spreads across a population of organizations. We adopt this notion of diffusion with its focus on a larger population of organizations, which is clearly distinguished from the notion of adoption that is more oriented towards innovation adopting entities whether they be individuals, or organizations. For example, Davis' Technology Acceptance Model (Davis 1989) as well as Rogers' Diffusion of Innovation theory (Rogers' theory covers both individual and organizational level adoption) is among the most dominant frameworks to explain individuals' adoption and acceptance of technology and these individual level adoption research approaches focus on innovation characteristics and other contextual adoption factors (Fichman 2000; Gallivan 2001). Another approach to innovation adoption research at the organizational level is from a process perspective, which this study subscribes to. Rogers proposed five stages for innovation adoption in organizations and Kwon and Zmud (Kwon et al. 1987) and Cooper and Zmud (Cooper et al. 1990) suggest another classical six-stage adoption process model.

These dominant theories of diffusion of innovations are criticized for their lack of explanation power beyond the conditions of their conception (Fichman 2000; Fichman 2004; Gallivan 2001; Lyytinen et al. 2001). Fichman (2000) criticizes that the innovation research based on Rogers' classical model focus mainly on simple innovations being adopted autonomously by individuals and therefore it is less relevant to technologies adopted by

organizations. Motivated by limitations of assumptions of the dominant theoretical frameworks to explain more complex technologies and adoption scenarios, Gallivan (2001) also argues that we need to expand processual understanding of innovation adoption and diffusion and suggests a process approach to complement factor-oriented research into organizational adoption of innovations. Lyytinen and Damsgaard (2001) also recognize limitations of Rogers' diffusion of innovation theory which are not aligned with those of complex and networked technologies such as EDI. They argue that complex and networked technologies contain messy, complex problem-solving elements and such technologies are socially constructed and shape society. They strongly suggest process-based approaches to study complex, networked technologies to achieve accuracy, which is often traded for simplicity and generalizability in traditional diffusion of innovation research (Lyytinen et al. 2001).

In this paper, telehealth innovations are argued to have a number, if not all, of the characteristics of complex, networked technologies suggested by Lyytinen and Damsgaard (2001). First, telehealth innovations are inter-organizational in nature. Second, telehealth innovations require considerable alignment of organizational procedures and policies by electronically linking multiple organizations and their work processes. Third, telehealth innovations require a considerable user mass to be efficiently deployed. Some characteristics of telehealth innovations are, of course, unique compared with many other complex, networked technologies. Most importantly, they are situated in institutional environments governed and strongly influenced by multiple regulatory and government-sponsored agencies (Bali et al. 2001; Bashshur et al. 1997).

A process-based approach, therefore, is chosen to examine the adoption and diffusion process of the telestroke innovation as a prime example of complex and networked technologies. The process-oriented approach, as a theoretical framing of the study,is well-aligned with the overall research design and the chosen contextualist approach., In particular, the chosen research framing contributes to our understanding of the transition process of the telestroke innovation from its initial adoption as a pilot to its wider diffusion through commercialization. Also, the process-oriented approach is suited to explore contextual specificities of an innovation where events occur and causal linkages and temporal relationships unfold (Gallivan 2001). Overall, the process-oriented diffusion of innovation research approach is useful to explore dynamics of change in relation to adoption and diffusion of the telestroke innovation by addressing the three components of the contextualist framework.

Chapter 3: Research Methodology

As noted earlier, this thesis includes the study of a focal telestroke innovation, and four of the five included papers draw upon this case. In addition, the thesis includes a complementary paper about implementation of a radiology innovation; this research is based on collaboration with a Swedish researcher who organized and conducted the underlying data collection of this case. While the adopted research in both these cases are consistent, we focus in the following on the research design of the telestroke case, which was organized and conducted as the key part of this thesis.

Research Design

Mason argues against the idea of a research design as a single blueprint document or as a priori design and strategy decisions (Mason 2002). Instead, decisions about design and strategy are ongoing and grounded in the content, context, and process of the research itself, not a contract fixed at the start of research. This holds particularly true for this research, where the adoption and diffusion of a telehealth innovation has been followed since early 2004 when the data collection began by obtaining preliminary project documents. Research questions and themes have been modified and refined and different studies of the case have emerged and have been designed as this research is unfolding. Despite such emergent and evolving nature of the research, the overall design maintains consistency by aligning research elements such as research questions, topics, assumptions, and research methodology, which needs to be satisfied for decent research with rigor (Mason 2002).

  The key elements of this research are summarized in a diagram based on (Walsham 1993) (Figure 2). The topic and questions of the research is telehealth innovations and research questions are formulated around this topic. This element was introduced in Chapter 1 and the detailed description of the innovation under investigation is presented below. A contextualist approach is chosen as the methodological approach and was discussed in-depth in Chapter 2. The research is multi-level including groups, organizations, adopting network, and beyond. This research element was also discussed in Chapter 2. The value of IS theories as the overall premise of the research, is further discussed in Chapter 4 and Chapter 5 in conjunction with the contributions of this research. In this section, the research elements of philosophical assumptions and strategy and method are discussed. First, ontological and epistemological assumptions are discussed and then we provide an in-depth discussion on qualitative case study as our research strategy and method.

Topic & Questions	Philosophical assumptions	Strategy & Method
Telehealth innovations	Critical realist	Qualitative case study

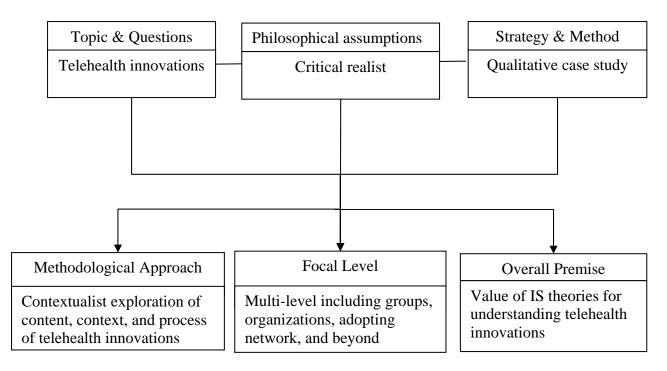| Methodological Approach	Focal Level	Overall Premise
Contextualist exploration of content, context, and process of telehealth innovations	Multi-level including groups, organizations, adopting network, and beyond	Value of IS theories for understanding telehealth innovations

Figure 2. Research scheme (based on Walsham (1993))

Philosophical Assumptions

Positivist research has been a dominant perspective in IS research, particularly in the U.S. (Mingers 2004; Orlikowski et al. 1991; Walsham 1995a). Assessing use of different research approaches in major IS journals, Orlikowski and Baroudi points out dominance of the positivist approach has limited what we have seen as aspects of the information systems phenomena and how we have studied them (Orlikowski et al. 1991). During the 1980s and 1990s, interpretivism emerged as an influential alternative based on different philosophies (Klein et al. 1999; Lee 1991; Orlikowski et al. 2001; Walsham 1995a; Walsham 2006). Across positivist and interpretivist studies, problems are often recognized with the underlying philosophies. Conspicuous are criticisms of naïve view of ontology and causality and extreme constructivist and postmodern positions which deny fundamental tenets of science and rationality. Critical realism is proposed as a way to resolve some of these issues by combining and reconciling ontological realism, epistemological relativism, and judgmental rationality (Archer et al. 1998) (p.xi). This research subscribes to the basic ontological and epistemological assumptions of critical realism as described in the following (Bhaskar et al. 1998; Dobson 2001a; Dobson 2001b; Fleetwood et al. 2004; Mingers 2004; Sayer 2000).

Critical realism distinguishes between the world and human knowledge about it. It is realism in that it acknowledges the real - the realm of objects, their structures, and powers, whether they are physical or social. Critical realism holds a stratified view on reality; the real, the actual, and the empirical (Sayer 2000). The real is whatever exists, be it natural or social, regardless of whether we understand its nature or not. The real is the realm of objects, entities, and structures that exist (though unobservable sometimes) and generate events. These objects and entities have certain structures and causal powers, that is, capacities to behave in particular

ways, and passive powers, that is, specific susceptibilities to certain kinds of change. Examples of the real could be physical, like buildings or social, like bureaucracies. Whereas the real refers to structures and powers of objects, the actual refers to what happens if and when those powers are activated, to what objects do, and to what eventuates when they do it. The powers possessed by objects and entities may exist unexercised, hence what has happened does not exhaust what could happen or have happened (Sayer 2000). For example, individuals with their physical make-up, socialization, and education have capacities to work, even when they are currently unemployed. Labor power they possess from physical and mental structures exist in the real, while working (labor) belongs to the domain of the actual with such power being exercised. The empirical refers to the domain of experience. Humans may be able to observe some structures, relationships and events, though others are not observable. The empirical, therefore, is a subset of the actual and the actual a subset of the real as the totality. An important implication of the stratified ontological view of reality is the recognition of the limitations of human knowledge capacities.

Critical realism differentiates from naïve realism by denying objective, unmediated access to truth or the real world. Having established the intransitive ontological dimension by acknowledging existence of the world beyond human recognition, critical realism builds the transitive epistemological dimension by admitting limited access to the existing world (Bhaskar 1998; Mingers 2004). Such a position maps to the fundamental distinction between the intransitive and transitive dimension of science (Sayer 2000). The objects of science, or things we study – physical processes or social phenomena – form the intransitive dimension of science. They are typically structured and intransitive in that they are irreducible to patterns of events and act independently of their identification by human beings (Bhaskar 1998). When theories (transitive dimension) change, it does not necessarily imply that what they are about (intransitive dimension) changes too. Otherwise, rival theories, or different transitive objects, cannot be rivals (Sayer 2000). In other words, it is unlikely the phenomena researchers study will change significantly when they change their mind and use different theories.

The epistemological assumptions are implied in a process-oriented view of science and knowledge creation. The process of scientific knowledge creation is the domain of humans. The process which involves drawing on existing theories and knowledge is therefore always historically and socially bounded (Mingers 2004). Production of scientific knowledge depends on the employment of antecedently exiting cognitive materials such as theories, discourses, and available physical tools (Bhaskar 1998). Bhaskar (1998) describes it as a three-phase schema of development. Typically, the construction of an explanation involves the building or adaptation of a model, utilizing cognitive materials. Then the reality of the explanation becomes subjected to empirical scrutiny. The explanation, in turn, becomes the phenomenon to be explained.

Critical realism recognizes social phenomena are intrinsically meaningful. Meaning has to be understood, not measured or counted. There is always an interpretive or hermeneutic element in social science. Epistemic relativism of critical realism is, in this way, aligned with the interpretivist research tradition, but distinguishes itself from extreme relativist position that all explanations are based on individual's beliefs and actions and that there is no such thing as an intransitive social structure (Mingers 2004). Many human activities, say language most obviously, are based on the existence of a structured, intransitive domain of resources, concepts, practices, and relationships. In addition, there are also shared social attributes that are only intelligible within the context of a social institution or practice, for example, 'banker', 'bachelor', or 'nun' (Mingers 2004). This view of intransitive social structures is shared by many

interpretivist researchers. Miles and Huberman acknowledge that lawful and reasonably stable relationships exist amongst social phenomena, though not quite in natural science. "Social phenomena, such as language, decisions, conflicts and hierarchies exist objectively in the world and exert strong influences over human activities because people construe them in common ways" (Miles and Huberman 1994). Chua (Chua 1986) also agrees that there are stable structures of reference that enable human beings to understand one another. He succinctly describes the process of emergent and constructed social reality in the following:

> …However, in everyday life actions do not take place in a vacuum of private, subjective meanings. While human beings are continuously ordering and classifying ongoing experiences according to interpretive schemes, these schemes are essentially social and intersubjective. We not only interpret our own actions but also those of others with whom we interact, and vice versa. Through this process of continuous social interaction, meanings and norms become objectively (intersubjectively) real. They form a comprehensive and given social reality which confronts the individual in a manner analogous to the natural world. In addition, despite continual refinement and modification of this social stock of knowledge, there are some temporarily stable constructs which become institutionalized, taken for granted, and used to typify (structure) experiences. These typifications are an essential part of the social frameworks within which actions are made intelligible.

It is important examining research implications of critical realism when applied to social science. The concept of causation is relevant when discussing goals of research and theories (Figure 3). Critical realists view objects as structures, or part of structures (Sayer 2000). Structures suggest a set of internally related elements whose actual powers, when combined, are emergent from those of their constituents. For example, hierarchical structures might enable delegation, division of labor, surveillance, and efficient output of work. However, it depends on other conditions whether these powers are exercised or not. Even when causal powers are activated, the results depend on other conditions. The critical realist view on causation is distinguished from that of the positivists, who assume regularities among sequences of events and try to prove causation by gathering data on regularities or repeated occurrences (Sayer 2000).
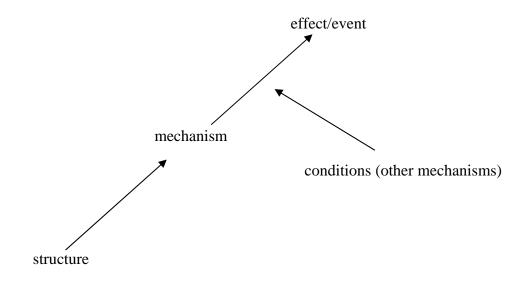

Figure 3. Critical realist view of causation (from Sayer 2000)

Critical realism recognizes differences between objects of social studies and those of natural sciences (Dobson 2001b; Sayer 1992; Sayer 2000). The object of social sciences, be they wars, discourse, institutions, economic activities, identifies, kinship or whatever, are the product of multiple components and forces and hence social systems are always open and usually complex and messy (Sayer 2000). Due to this openness, individual components of a social system cannot be isolated and examined under controlled conditions. Therefore, social scientists rely heavily on abstraction and careful conceptualization, on attempting to abstract out the various components or influences. By considering how these combine and interact, social scientists make sense of the concrete, many-sided object or phenomena under investigation (Sayer 2000). In the open systems of the social world, the same causal power can produce different outcomes, and different casual mechanisms can produce the similar result according to context or spatio-temporal relations among objects. The goals of social science, therefore, are to identify causal mechanisms and how they work, and to discover if they have been activated and under what conditions. Social science is an ongoing and developing process of explanation and enlightenment rather than the derivation of immutable scientific laws (Dobson 2001). Such view on social science results in a unique view on theories.

In critical realism, theory is valued because of its explanatory power, rather than its predictive power. The underlying assumption is that it is impossible to artificially create closed systems, special conditions which only enable consistent regularities. Regularities in open social systems are approximate and limited in duration and are usually the product of deliberate efforts to produce them (Sayer 2000). Therefore, the criteria for a good theory should be explanatory with the predictive use of theory limited to identifying likely tendencies (Dobson 2001). Some theories are considered having more explanatory power than others. Theory A is better than theory B, if it can explain most of what theory B explains about the phenomena under investigation and in addition can explain something that theory B cannot. Though bounded by spatio-temporal boundaries, theories are comparable, and competing theories can be evaluated based on their explanatory power, hence judgmental rationalism.

In this subsection, basic philosophical assumptions of critical realism have been introduced including its ontological and epistemological assumptions as well as its research implications and the role of theories for social studies. Critical realism by nature of its epistemological assumptions has strong interpretivist elements and emphasizes process-orientation and context specificity of social studies. The philosophical assumptions of critical realism therefore support and are well aligned with the research elements of this research presented in Figure 2.

Research Strategy & Method

Often, we use the terms 'qualitative' and 'interpretive' interchangeably with no clear distinction. However, qualitative is not a synonym for interpretive (Klein et al. 1999) though the two concepts overlap in some ways. Qualitative research is oriented towards the methodological perspective, while interpretive research indicates the philosophical assumptions of the research and researchers. Much qualitative research is based on interpretivist assumptions, but qualitative research on a positivist stance is not rare. On the other hand, interpretive research is practiced

through qualitative research, and, technically speaking, interpretive research based on quantitative research method is possible, if not practiced in reality.

It is agreed that qualitative research is not a unified set of techniques or methods (Markus et al. 1999; Mason 2002) and it is difficult to define being qualitative (Mason 2002). Mason lists the least common denominators of qualitative research, while emphasizing the rich variety of qualitative research strategies and techniques. First, qualitative research is grounded in a philosophical position that is broadly interpretivist in the sense that it is concerned with how the social world is interpreted, understood, experienced, produced, or constituted. Qualitative research is most commonly associated with what is known as the interpretivist sociological tradition (Mason 2002). Second, it is based on methods of data collection which are both flexible and sensitive to the social context in which data are produced. Third, it is based on methods of analysis, explanation, and argument building which involve understanding of complexity, detail, and context.

Qualitative research is appropriate for this research, because of its characteristics of being exploratory, fluid and flexible, data-driven, and context-sensitive (Mason 2002, p. 25). Mason (2002) argues that qualitative research has the following advantages, which suit the other research elements of this study. First, it is better to investigate wide dimensions of the social, including the texture and weave of everyday life, the understandings, experiences, and imaginings of our research participants, the ways social processes, institutions, discourses, or relationships work, and the significance of the meanings that they generate. Second, qualitative research emphasizes the strategic significance of context in the development of our understanding and explanations of the social world. It is capable of producing very well-founded cross-contextual generalities by examining how things work in particular contexts. Sayer (Sayer 1992; Sayer 2000) also suggests qualitative analysis as one of the typical methods for 'intensive' research whose common research questions include: How does a process work in a particular case or small number of cases? What produces a certain change? And, what did the agents actually do?

This research uses case study as its method. Case studies are endorsed and employed by researchers with a variety of philosophical assumptions. In the field of IS in particular, much of the discussion of case study research has centered on different philosophical perspectives, the positivist and interpretive approaches in particular (Darke et al. 1998). Case studies methodology has been used and advocated from multiple philosophical perspectives, from interpretivist studies (Klein et al. 1999; Walsham 1995a; Walsham 2006) including those based on critical realism (Dobson 2001a; Dobson 2001b; Sayer 1992) to positivist studies (Benbasat et al. 1987; Lee 1989; Lee 1991; Sarker et al. 1998; Yin 2003). However, the methodological distinction in practical use of case studies along philosophical differences is not clear (Walsham 1993) and case research often lacks any explicit epistemological base (Easton 2000). Still, some comprehensive reflections on case methods like Yin's are valued and widely cited by researchers from various philosophical camps (Easton 2000; Walsham 1993). Case study is considered as a major research method for social sciences helping explain causal mechanisms of objects acting in certain contexts and under certain conditions (Easton 2000).

One of the most used definitions of a case study is that it is an empirical inquiry that investigates a contemporary phenomenon within its real-life context, especially when the boundaries between phenomenon and context are not clearly evident (Yin 2003). Case studies have some distinct advantages over other methods. Fundamentally, the need for case studies arise out of a desire to understand complex social phenomena (Yin 2003). The IS field has seen a

shift from technological to organizational and social issues, for which case studies are well-suited (Benbasat et al. 1987; Walsham 1995b). Generally, case studies are a preferred way of research when how and why questions are being posed. Moreover, it is the most common research method for qualitative studies (Benbasat et al. 1987; Darke et al. 1998). It is also widely acknowledged that case studies are suited to understand the interactions between IT-related innovations and contexts (Benbasat et al. 1987; Darke et al. 1998; Kaplan et al. 1998; Walsham 1993; Yin 2003). Such advantages of the case study method perfectly match the themes and phenomena of this research, which is process-oriented and focused on understanding a contemporary phenomenon, telehealth innovation, in context.

More specifically, this research is designed as an embedded single case (Figure 3). A single-case design is justified for a longitudinal case study where the research interest is on how certain changes occur over time; and embedded case study design is recommended when the case study involve more than one unit of analysis (Yin 2003). Embedded design is justified as the considered telestroke innovation (REACH) unfolds on multiple social layers. The REACH network consists of the hub hospital, the adopting rural hospitals, and the organizations to commercialize REACH (two commercial firms emerged over time). Also, within each organization different groups of people were identified based on their distinct positions regarding REACH and their potentially different perceptions of the innovation. The examination of the different units on different levels is important to obtain a comprehensive understanding of the processes of adoption and diffusion in this particular context as well as other telehealth innovations that have similar settings spanning multiple organizations.

Figure 3. Embedded case design with multiple units of analysis

The case study is guided by the use of IS theory (overall premise in Figure 2). Theories have multiple functions in research guiding research design and data collection during initial stages, playing a role in iterative processes of data collection and analysis, and often becoming a final product of the research (Eisenhardt 1989; Walsham 1995b). In this research, theories are

utilized in all three forms. When conceptualized, the research was initially informed by the studies of (Cule et al. 2004; Orlikowski 1993). As part of an iterative process of data collection and analysis, different theories are adopted and have played different roles in the individual papers. The theoretical explanations or models of each individual paper can be considered as outcomes of the research, if theory is used in its broad definition.

In summary, we have discussed the research elements of philosophical assumptions and research strategy and method underpinning this study (Figure 2). The ontological and epistemological assumptions of critical realism have been presented as well as their research implications. Then qualitative case study has been argued as an appropriate research strategy and method that is well aligned with the philosophical assumptions as well as the other research elements depicted in Figure 2. Critical realism and qualitative case studies are well suited to exploring processes related to a telehealth innovation in a particular context. The contextual methodological approach is also well aligned with the research strategy and method and the philosophical assumptions discussed above. Specifically, a single case study is appropriate to gain a comprehensive understanding of processes related to the telehealth innovation over the adopting network of organizations. Especially, the embedded case design facilitates multilevel analysis of the telestroke innovation involving multiple organizations and multiple levels of analysis. The overall premise is that IS theories guide the design of the case as well as the analyses. The validity of the research design has been argued in this section by discussing how and why the qualitative case study based on critical realist assumptions is a valid way to pursue the investigation of a specific telehealth innovation in its context and by showing how the design is well aligned with other research elements (Mason 2002).

Case Description

The investigation of the focal telestroke innovation began in early 2004 as a ramification project of a larger project this author has been involved since summer 2003. The umbrella project is funded by Georgia Research Alliance, a state funding agency, with three distinct fields of expertise forming a project team to study and help develop telehealth innovations at the Medical College of Georgia, a medical institution in the eastern part of Georgia. The project team consists of three research groups of distinct capabilities; one technology-oriented group with telecommunication expertise from Georgia Institute of Technology; another with medical expertise from Medical College of Georgia; and a third with IT-based innovation management expertise from Georgia State University (consisting of me and my supervisor). As a member of the third group, this author has been involved in the project, which is still ongoing. The project team became interested in REACH (Remote Evaluation for Acute Ischemic Stroke), as they were planning a similar innovation for the pediatric department. Data collection began in early 2004 and is still underway as the innovation has taken another turn for further diffusion through commercialization. Three different studies have been designed out of this ongoing investigation on REACH (Papers 1, 2 & 4). In addition, early results were communicated to the telehealth community in collaboration with the involved neurologists (Paper 5). The following is the detailed description of the focal innovation.

In March 2003, the department of neurology at the Medical College of Georgia (referred to as the hub hospital) launched a telehealth innovation named REACH by implementing a specific telestroke system in one of the nearby rural hospitals. This telestroke system allows

neurologists from the hub hospital to use telecommunication to participate in real-time stroke assessments for patients in rural hospitals. The innovation was first implemented in one rural hospital and gradually expanded to a number of hospitals, with initial technical problems being detected and resolved effectively. By the time our study was first initiated, seven rural hospitals were participating in the REACH network and now it has been expanded to cover nine rural hospitals in total.

The need for REACH was justified by the critical lack of stroke specialist expertise in most rural areas and in many urban areas as well. This contributes to a higher rate of stroke deaths in rural and underserved communities (Casper et al. January 2003). For the case of non-bleeding, or ischemic, stroke, a blood-clot dissolving agent called tPA (tissue Plasminogen Activator) greatly reduces chances of severe disabilities if it is administered within three hours from the first show of stroke symptoms. However, it is estimated that only two percent of stroke patients receive its benefits, partly due to a lack of on-site stroke specialists. It is essential that a stroke specialist examines each stroke patient before tPA is applied. It is far from trivial to distinguish non-bleeding from bleeding cases, and applying tPA to a bleeding case will have immediate and most likely lethal consequences. Providing the services of stroke specialists over distances can therefore significantly increase the rate of tPA use, save many lives, and reduce chances of permanent disabilities. Between March of 2003 and May of 2004, doctors used REACH to evaluate 75 patients and to qualify 12 of them for treatment. In late 2006, more than 400 patients have been evaluated at 9 rural hospitals with 55 having been treated with tPA.

The REACH system makes the hub hospital's stroke specialists available to examine patients at distant rural hospitals around the clock. It enables these neurologists to hear and see the patients in real time (Figure 4). A patient admitted to one of the participating rural hospitals gets a CT (computerized tomography) scan to help pinpoint the cause and location of the stroke, while the hub hospital is notified about the incident and the on-call neurologist is connected. The patient is then moved to a room where the telestroke cart is located, and an emergency room nurse enters the patient's information and lab results into the system. The hub hospital neurologist, now connected to the rural hospital through REACH, evaluates the patient on a standardized stroke scale through video-based interactions while seeing CT scan results and lab data on a screen (Figure 5). Voice communication between the neurologist and the clinicians and patient at the rural hospital is conducted over a land-line telephone. Decisions on tPA administration and possible patient transfer are then made by the neurologist.
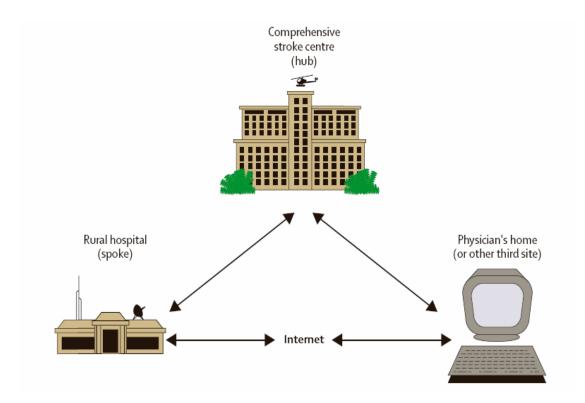
Figure 4. The REACH network

Figure 5. REACH interface on neurologist computer (the hub hospital)

The implementation and operation of the REACH system was financed by the hub hospital, except that each rural hospital was responsible for the CT scanner and system infrastructure, including the fast network connection. The cost of building the telestroke cart with all necessary telecommunication, data processing, and video equipment for each rural hospital was paid by the hub hospital, and technical trouble-shooting was covered by the hub hospital's dedicated systems developer.

In January 2005, two entrepreneurs sponsored by Georgia Research Alliance joined the effort and formed a company (referred to as *BrainCare Inc.* in the following) to commercialize REACH. The hub hospital and the two entrepreneurs have gone through several rounds of negotiations throughout the year, but have failed to reach an agreement on licensing and operation terms and conditions. The negotiation finally ended in December 2005. As a result, the sponsorship of the state fund to the company discontinued. A few months after the first failed commercialization attempt, the REACH initiators (a group of neurologists at the hub hospital) established another company (referred to as *BrainConsult* in the following) to continue commercialization of the innovation. Gaining some momentum from winning a state technology competition, the initiators found their first potential customers in September 2006 and continue to plan to expand their market nationwide.

Data Sources and Collection

It is typical that case research utilizes multiple data sources (Miles et al. 1994; Yin 2003), whereas interviews are considered as the primary data source for interpretive case studies (Walsham 1993; Walsham 1995b). In this study, multiple data sources have been sought to ensure triangulation (Yin 2003). Data sources include systems documentation, public articles, stakeholder interviews, and workshops (Table 3). All available documents were analyzed such as those related to system documentation, financial documents, and articles from news media, and academic papers concerning REACH. Interviews were planned and carried out by this author in collaboration with my supervisor and assisted by the two research collaborators from Medical College of Georgia. These initial interviews and data collections were influenced and guided by theoretical models of (Cule et al. 2004; Orlikowski 1993; Yin 2003) focusing on participants' evaluation of the REACH innovation and the related implementation and initial adoption processes. For the initial adoption process, 26 individuals in five hospitals (hub and four rural hospitals) were interviewed: seven doctors, six administrative staff, three IT staff, nine nurses, and a radiology technician. As the innovation was going through commercialization process with creation of two different firms, this author and my supervisor had a series of meetings with the two entrepreneurs from *BrainCare Inc.* in the forms of workshops and follow-up meetings and later 7 interviews with five individuals from *BrainConsult* (repeat interviews with two individuals). The total number of individuals the researchers have met to investigate the adoption and diffusion process of the telestroke innovation is 31 excluding undocumented informal meetings and conversations. Refer to Table 4 for detailed breakdown of interviewee profiles. Individualized interview protocols have been developed before interviews through discussions and iterations between the two GSU researchers (see Appendix for sample interview protocols).

Interviews		
	Number of interviewees	*Time period*
	31	Oct 2004 – Dec 2006
Workshops & Follow-ups (with the two entrepreneurs)		
	Number of workshops	*Time period*
	12	Jan 2005 – Oct 2006
Other Sources		
	Types	*Source*
	Project documents	Project initiators
	Grant application based on REACH	Project initiators
	Memorandum of Understanding	Hub hospital
	Research articles regarding REACH	Project initiators (the neurologists)
	Hospital demographic information	Rural hospital and the Center for Telehealth (at the hub hospital)
	Local news articles	The Augusta Chronicle and the Atlanta Journal-Constitution
	Hospital newsletter	Hub hospital website
	Business plans for commercialization	The two entrepreneurs from *BrainCare Inc.* and the project initiators

Table 3. Data sources

Interviewee Position	Number of interviewees	Organization
Doctor	7	Four neurologists at the hub hospital Three physicians at the rural hospitals
Nurse	9	Rural hospitals
Administrative staff	6	One vice president at the hub hospital One associate vice president at the hub hospital One middle manager at the hub hospital Two CEOs at two of the rural hospitals One CFO at another rural hospital
IT staff	3	Two at the hub hospital One at a rural hospital
Radiology technician	1	Rural hospital
Members of *BrainConsult*	5	CEO, IT staff, Board members
BrainCare Inc.	2	Two entrepreneurs

Table 4. Interviewee profiles

One of the hub hospital neurologists, the champion of REACH and head of the neurology department, arranged interviews with the other project initiators, all of whom are coauthors of the patent filed for REACH. He also provided the researchers with the list of contact persons for

each of the four rural hospitals. Then, this author asked the contact persons to arrange three to four interviews at each site. It was requested that potential interviewees should have experiences with REACH and represent four different groups of administrative staff, IT staff, doctors, and nurses. Senior administrators at the hub hospital were subsequently contacted through the Medical College of Georgia researchers from the umbrella project and the head of the neurology department. Some of the interviewees became closely involved in the establishment of *BrainConsult* later and one of them, the hub hospital neurologist, arranged a number of interviews with the members of the company. Interviews were semi-structured, typically lasted 30-60 minutes, and were tape-recorded. Most interviews were individual and some of the core REACH project initiators have been interviewed more than once.

The Georgia State University research team has held 12 advisory workshops and follow-up meetings with the two entrepreneurs of *BrainCare Inc.* to help them develop business plans and strategy (Table 5). The meetings have been held at the GSU campus in downtown Atlanta or Alpharetta, Georgia. A couple of individual from the Medical College of Georgia were interviewed for detailed account on the part of the hub hospital about REACH commercialization. More interview data may continue to be collected as commercialization efforts continue beyond the scope of this dissertation. All the interviews and workshops that had been carried out up to date have been transcribed.

Number of Workshop and Follow-up Meetings	Date
1	January 10, 2005
2	January 20, 2005
3	February 22, 2005
4	March 17, 2005
5	April 15, 2005
6	April 21, 2005
7	May 26, 2005
8	December 5, 2005
9	February 7, 2006
10	April 25, 2006
11	July 14, 2006
12	October 18, 2006

Table 5. Workshops with two entrepreneurs

Data Analysis

Interview notes have been made during and immediately following interviews and workshops. In most situations, this author and my supervisor engaged in debriefing sessions exchanging summaries of major points of each interview and workshop. This practice helped develop a rounded and multi-faceted understanding of data and enhanced inter-subjectivity in the initial interpretation of data.

The process of data collection and analysis is characterized by some key features. First, it is guided by theories (Walsham 1993; Yin 2003). As stated above, the initial data collection was

influence by studies of Orlikowski (1993) and Cule and Robey (2004) and interview protocols were developed based on these studies. Subsequent analysis of data, which was done for each individual paper, was also guided by theories that were adopted to support the purpose and perspective of each individual paper. The papers employed different theoretical frameworks to answer specific and distinct sets of research questions (see Chapter 2). Iteration is another key feature of the analysis process, which involves movement to and from the data, the existing literature, and emerging theories for the case. The researchers (each paper has different groups of authors) had rounds of discussion among themselves to theorize data, identifying major constructs or concepts, and to group them into higher constructs. This procedure requires multiple rounds of discussion to resolve differences in individual researchers' ideas and opinions. Finally, inter-subjectivity was sought by using multiple data sources as well as by having debriefing sessions for interviews and workshops among the participating researchers. For example, to verify local reimbursement practices identified in interviews, the researchers analyzed the patient demographic information for the participating rural hospitals. Discussion and debriefing among the researchers contributes to this aspect of research. In this way, triangulation has been practiced throughout the analysis with its broad definition of the use of a combination of methods (Mason 2002).

Individual papers, in general, followed the principles and characteristics of the data analysis discussed above. Two levels of data reading was done for individual studies as suggested by Mason (2002). First, the data from different sources were subject to literal reading. This approach direct researchers to be interested in the literal form, content, structure, style, and layout of data, even though it can be argued that purely literal reading is not possible because the social world is always interpreted and because what we see is shaped by how we see it (Mason 2002). The level of reading was practiced through debriefing sessions between this author and my supervisor exchanging summaries of major points of each interview and workshop. In addition, the two researchers carefully went through documents and interview notes focusing on the meaning of the data that the authors such as interviewees and the document authors tried to convey. Then, an interpretive reading was done. Interpretive reading involves researchers in constructing what they see the data mean or represent based on the theoretical framework chosen. Researchers may be concerned with what they see as interviewees' interpretations and understandings or their versions and accounts of how they make sense of social phenomena, or you may place more emphasis on your own interpretations.

Though exact analysis procedures could be different because of different data sets and time periods covered, the first general step was to identify a key event list, which could provide insight into "what led to what, and when" (Miles and Huberman 1994). Such listing provides basis for depicting the sequence where the focal phenomena unfolded. The next major analysis involved qualitative pattern matching between theory and data (Miles et al. 1994; Yin 2003). The themes or coding schemes were developed based on the chosen theory's constructs or components. Active mental efforts and exercises then followed for matching and coding of the available data. For example, three researchers analyzed data based on a dialectical framework of contradictions in the paper titled 'Dialectics of Resilience: A Multi-level Analysis of a Telehealth Innovation.' A couple of rounds of analysis and discussion revealed an initial set of ten intra-organizational and five inter-organizational contradictions. These two sets of contradictions related to adoption of the telehealth innovation were then grouped into more abstract categories of contradictions through rounds of discussions among all three authors. Disagreements amongst the authors were resolved with arguments based on evidence from the

collected data. Through several iterations, a final set of three intra-organizational and three inter-organizational contradictions of relevance to the study were produced. For the analysis of results based on the chosen theoretical scheme, major stakeholders, and their activities regarding the innovation development were also identified and analyzed with regard to development and resolutions of the identified contradictions.

The characteristics of data analysis of theory-guidance, iteration among researchers, and triangulation were consistently practiced in data analysis procedures for each individual paper. They resulted in refinement of the overall analysis schemes and, therefore, contributed to accurately conveying and strengthening the arguments of the research.

Chapter 4: Contributions

This chapter provides a summary of the research contributions of the individual papers focusing on the overarching research question in Chapter 1. Five papers are included in the dissertation (Table 5) and all of them are in the format of completed manuscripts. Two of them are published in journals, two have been published at conferences, subsequently revised, and are now under review at journals, and paper 4 is submitted to a conference. The papers in their current status are included in Part II. This author is the lead author on papers 1, 2, 4, and 5, while paper 3 was developed in equal collaboration between the three authors. The target audience for papers 1-4 is information systems researchers, while paper 5 was developed in collaboration with colleagues at Medical College of Georgia to report early results to the telemedicine community.

Paper	Authors	Previous version	Current publication status
1	Sunyoung Cho Lars Mathiassen	Published at AMCIS 2006	Submitted to *European Journal of Information Systems*. Revised version under development based on first round of review
2	Sunyoung Cho Lars Mathiassen Daniel Robey	Published at IFIP 8.6 Conference 2006	Published at *Journal of Information Technology*
3	Sunyoung Cho Lars Mathiassen Agneta Nilsson	Published at AMCIS 2005	Revised version submitted to *Information and Organization* based on first round of review
4	Sunyoung Cho Lars Mathiassen Michael Gallivan		Submitted to HICSS 2008
5	Sunyoung Cho Elena V. Khasanshina Lars Mathiassen David C. Hess Sam Wang Max E. Stachura	Poster presentation at the 11th Annual International Meeting & Exposition of the American Telemedicine Association	Accepted for publication at *Journal of Telemedicine and Telecare*

Table 5. Authorship and status of individual papers

Paper 1. The Role of Industry Infrastructure in Telehealth Innovations: A Multi-level Analysis of a Telestroke Program

Research Questions	1. How do key actors address industrial infrastructure issues during adoption of the telestroke innovation? 2. How do industrial infrastructure factors shape the adoption of the telestroke innovation?
Theoretical Framing	The industry infrastructure theory (Van de Ven 1999, 2005) was adopted to explore how the innovation unfolded in interaction with its context.
Contributions	• Enhanced understanding of the context of the telestroke innovation with focus on its industry-level context 　o Analysis of four industrial components of resource endowments, proprietary activities, institutional arrangements, and market components 　o Unbalance of maturity of components impacts further diffusion of the innovation • The industry infrastructure theory applied to a telehealth innovation 　o Scope of the theory interpreted differently from its origin: industry-level theory used to support a multi-level analysis of a single IT-based innovation as an integral part of the network of hospitals and institutions in which it is embedded.

This study examines the focal telestroke innovation from an institutional theory perspective. Van de Ven's industry infrastructure theory (Van de Ven 2005; Van de Ven et al. 1999a) was adopted to analyze the adoption process. The theory is also referred to as the social-systems or community infrastructure perspective. The framework has its roots in three dominant perspectives on innovation, namely the technological imperative, the institutional determinism, and the resource endowments perspective. The industry infrastructure theory incorporates various components of the three theories into four categories that influence technological innovation: (1) institutional arrangements to legitimize, regulate, and standardize a new technology; (2) public-resource endowments of basic scientific knowledge, financing mechanisms, and a pool of competent labor; (3) market mechanisms to educate consumers and stimulate demand for a new technology; and (4) proprietary research and development, manufacturing, marketing, and distribution functions by private entrepreneurial firms to commercialize the innovation for profit.

The industry infrastructure theory was chosen to examine a paradox in adoption of the telestroke innovation. Despite its mission-critical features and life-saving potentials, the innovation was at the point of investigation (as of Winter 2005) faced with dwindling financial support from the hub hospital for further expansion, and the efforts to commercialize the innovation were derailed making negotiations among stakeholders difficult and complicated. A multi-level process analysis was conducted to answer the specific research questions raised.

The first contribution of this study is the insights it provides into the telestroke innovation and its interaction with the unfolding context. The case analysis shows that activities in the components of proprietary activities and resource endowments were sufficiently effective to explain the successful development and initial adoption of the innovation. However, the

components of institutional arrangements and market mechanisms were not mature enough. Nor were influential actors or activities engaged to effectively develop these components. Two entrepreneurs formed *BrainCare Inc.* to address and nurture these components, but their initial efforts failed without tangible results. The unbalanced maturity of the four industry infrastructure components created major barriers for wider adoption of the innovation. This confirms the main proposition of the industry infrastructure framework that the success in developing a technological innovation depends primarily on the extent to which the necessary components of the infrastructure are established at the industrial-community level (Van de Ven et al. 1999a).

The study also provides some insights into how negotiations between actors and artifacts, between development and use, and between traditional and new medical practices shaped the innovation process and its outcome. Negotiations took center stage in the process between the innovators and the hub hospital, between the hub and the rural hospitals, and at a later stage between the two entrepreneurs on the one side, and the innovators and the hub hospital on the other side. Telehealth innovations like REACH are, indeed, particularly difficult because they cross organizational boundaries and challenge established configurations of aligned interests.

The study contributes to our understanding of how the industry infrastructure theory applies to IT-based innovations within healthcare, telehealth innovations in particular. Further diffusing and commercializing innovations like REACH requires resources that are beyond the capabilities of one hospital or a small group of innovations. It requires collective action across organizational boundaries and established configurations of aligned interest to successfully build an infrastructure that can facilitate continued innovation. This study also expands the boundaries of the theory by showing how the industry-level framework in its original form also can be used to support multi-level analysis of a single IT-based innovation as an integral part of the network of hospitals and institutions in which it is embedded. This leads to new and quite useful interpretations of Van de Ven's basic propositions.

With its contributions discussed above, the study may provide a plausible explanation of why the healthcare industry is lagging behind in adopting and using IT by indicating that institutional arrangements are an important barrier, possibly more rigid within healthcare than in other industries.

Paper 2. Dialectics of Resilience: A Multi-level Analysis of a Telehealth Innovation

This study adopts the concept of organizational resilience in conjunction with dialectical analysis to investigate adoption of telehealth innovations. According to the literature, resilience refers to the capability of individuals, groups, or organizations to adapt quickly to changes in their environments (Coutu 2002; Hamel et al. 2003; Horne III 1997; Mallak 1999; Riolli et al. 2003; Starr et al. 2003). We based our analysis on an in-depth case study of the telestroke innovation adopted in a network of collaborating hospitals. The adopting organizations arguably demonstrated considerable resilience, resulting in successful implementation. However, many indicators suggested at the time of analysis (as of Winter 2005) that the innovation reached a temporary and in some respects fragile acceptance, from which it might be unable to progress. To understand this situation, we conducted a dialectical analysis of the major contradictions that characterize this particular adoption initiative. We analyzed contradictions at two levels: within each adopting hospital, and between the adopting organizations.

Research Questions	1. How is resilience manifest at the organizational and inter-organizational levels of analysis in the adoption of the telestroke innovation?
	2. How can the use of dialectics augment the analysis of resilience in the adoption of the telestroke innovation?
Theoretical Framing	The concept of organizational resilience in combination with dialectical analysis was used to examine the adoption process of the telestroke innovation.
Contributions	• Understanding organizational resilience as an important process capability in the context of telehealth innovations
	o Multi-faceted, dynamic nature of resilience; changing evaluation of resilience over time
	o Levels-of-analysis issue raised in relation to organizational resilience
	• Use of dialectics augments a process perspective of organizational resilience
	o Analysis of intra- and inter-organizational contradictions by employing a dialectical perspective to understand organizational resilience
	• Understanding of the challenges involved in adopting and managing telehealth innovations in an inter-organizational context

Through the analysis of the case, we argued that the initiating project group, the individual hospitals, and the entire network of adopting organizations exhibited resilience in adopting the telehealth innovation. However, our analysis also shows that the telehealth innovation had arrived at a critical juncture where it could either continue to be used and further diffused as a successful telehealth innovation, or it could be abandoned due to diminishing financial support and sagging enthusiasm among key stakeholders. We argue that this crucial point in the innovation process arose because of the inherent contradictions within and across the network of adopting hospitals. In conclusion, we suggest that the future of the innovation and further evaluation of resilience of key stakeholders to a large extent depends on how these contradictions would develop.

The study makes a number of distinct contributions. First, it contributes to research on organizational resilience (Coutu 2002; Hamel et al. 2003; Horne III 1997; Mallak 1998b; Mallak 1999; Riolli et al. 2003; Starr et al. 2003; Weick 1993) by exploring and challenging the concept in relation to organizational adoption of IT-based innovations. We suggest that resilience in relation to adoption of innovations is an elusive concept inviting interpretations from multiple and often contradictory perspectives. Resilience is best conceived as an ongoing process in which specific contradictions are confronted and resolved, at least temporarily. Given the interplay among multiple contradictions, each ebbing and flowing over time, resilience is not easily conceived as a general organizational quality. Rather, resilience emerges from an organization's involvement in change processes and its attempts to recognize and resolve the contradictions involved in such efforts. Specifically, we argue that contemporary definitions of resilience raise interesting issues related to the dynamics of adoption behaviors and to interactions between different levels of analysis. The concept of resilience is not simplistic or static, allowing different interpretations by different stakeholders. Even the interpretation of the same stakeholder(s) may vary over time. Resilience therefore is argued as a dynamic process

capability, which may be shaped by existent and emerging contradictions among the involved stakeholders.

Second, the study adds to our knowledge of dialectics, which is already established as a useful approach to IS research (Bjerknes 1991; Dahlbom et al. 1993; Mathiassen 1998; Robey et al. 1999; Robey et al. 2001; Robey et al. 2002; Sabherwal et al. 2003) and to organization studies in general (Das et al. 2000; Ford et al. 1994; Lewis 2000; Rond et al. 2004). Building on this tradition, we demonstrate a detailed approach to conceptualizing, identifying, and analyzing contradictions to uncover the complex dynamics involved in adoption of IT-based innovations. Dialectical contradictions augment the analysis of organizational resilience since resilience does not exist in a vacuum. Resilience should be understood in a particular context where it is analyzed in relation to the IT-based innovation of interest. Context-specific contractions have been identified in this study on two levels: three intra-organizational contradictions (medical vs. business interests, emerging vs. institutionalized work practices, IT-based innovation vs. established IT infrastructures) and three inter-organizational contradictions (economic incentives of hub hospital vs. rural hospitals, emerging medical practices vs. institutionalized insurance practices, and hub hospital interests vs. commercial explorations). The development of these contradictions shaped the trajectory of the innovation and the evaluation of organizational resilience.

In terms of practical implication, the study adds to our understanding of the challenges involved in adopting and managing telehealth innovations in an inter-organizational context. Our study suggests that healthcare information systems research, especially related to telehealth innovations, can be informed by dialectical analyses that go beyond organizational boundaries to provide a more comprehensive understanding of adoption processes.

Paper 3. Contextual Dynamics during Health Information Systems Implementation: An Event-Based Actor-Network Approach

Research Objectives	1. Understanding the dynamics of the implementation process of a Swedish radiology innovation 2. Understanding how researchers can apply ANT to study IT-based change
Theoretical Framing	ANT in combination with the encounter-episode approach by Newman and Robey (1992) was used to investigate how the implementation of the radiology innovation was shaped through contradictory interests and shifting configurations of agency.
Contributions	• Enhanced contextual understanding of healthcare information systems ○ Understanding of how different interests and forms of agency interactively shape the context, context, and process of implementing the radiology innovation • Event-based approach to ANT studies to help structure the analysis • Practical implications: managers need to adopt a contextual perspective from the start to proactively manage and address agency and contextual issues

ANT was adopted to explore how the implementation of the radiology innovation in the complementary case was shaped through interaction with the hospital context. Seeking to understand contextual dynamics during HIS implementation and recognizing that ANT analyses

like other process-oriented approaches easily become highly complex (Langley, 1999; Walsham, 1997), we used events to focus, structure, and present the ANT analysis. In our analysis of the radiology innovation, we combine ANT with Newman and Robey's (1992) encounter-episode dichotomy to understand the implementation process as a sequence of events. 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.

The case centers on efforts to implement a radiology innovation in a Swedish hospital during 2001-2005. The innovation links a radiology department to the professionals and clinics that request radiology examinations, thereby spanning several professional and organizational boundaries. The case was analyzed and presented anchoring on six key encounters, each of which caused controversy and disrupted the temporary order in the involved actor-networks resulting in extensive translations to achieve new stability. The study shows how the design and realization of the innovation unfolded over time and shifted based on different forms of agency. Notably, ongoing negotiations between different medical groups revealed the institutionalized power structures in the profession-based actor-networks in the hospital. The involved actor-networks continued to reconfigure by shifting between opposing implementation and making use of opportunities to change configurations in accordance with their interests. The analysis reveals how complex contextual dynamics had severe and disruptive effects on the efforts to implement the innovation.

This study makes a number of contributions. Drawing on Pettigrew's contextual approach (1985, 1987), the analysis provides an understanding of how different interests and forms of agency interactively shaped the content, context, and process of implementing the healthcare information system. The process analysis of the implementation revealed important dynamics related to the implementation content expressed as tensions between the radiology innovation and medical work practices. It also identified important dynamics related to the implementation context expressed as tensions between shifting networks of actors within the immediate implementation context and the broader institutional setting.

Another contribution is the proposed event-based approach to ANT analysis to address some of the challenges in focusing, structuring, and presenting studies involving complex data common in ANT studies. Event-based approaches have 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. The study provides the rationale for and feasibility of such a combination of approaches. It also demonstrates through an in-depth case study how ANT analysis can be combined with encounter-episode analysis as suggested.

Finally, the study has practical implications by suggesting that practitioners adopt a contextual perspective from the start to proactively manage and address the dynamics related to implementation content and context. The findings suggest healthcare information systems implementation requires proactive leadership and significant dynamic capabilities to effectively learn about and adapt to the particular context in which these systems are embedded.

Paper 4. From Adoption to Diffusion of a Telehealth Innovation

Whereas the three papers introduced above focus on the process of implementation and adoption of a telehealth innovation by the initial network of organizations, the focus of this study is on the

transition process of the telestroke innovation from its initial adoption as a pilot system to wider diffusion through commercialization. The study is motivated by a paradox for telehealth innovations: While technology advancements have contributed to increased experiments with telehealth innovations, their potential impacts for improved business and product development, commercialization, sales, and job creation have not yet materialized (Jennett et al. 2006). In a typical life trajectory of telehealth innovations, many die out as they move out of the pilot project status after initial funding is exhausted though they are considered medically and technically sufficient innovations. Despite this unsatisfactory situation, we lack understanding of how a telehealth innovation is further diffused growing out of its initial adoption as a pilot. Nor do we understand what it takes for successful innovations to further diffuse into a larger population of healthcare organizations. To fill this gap, the study followed the transition process of the focal telestroke innovation from its initial adoption to wider diffusion through commercialization efforts (up until late 2006), framing the research as diffusion of innovation research.

Research Questions	1. How is the telestroke innovation developed from its initial adoption by a small network of hospitals to wider diffusion into a larger population of organizations? 2. What lessons can we suggest on how to successfully transition from initial adoption to wider diffusion of a telehealth innovation?
Theoretical Framing	Diffusion of innovation theory based on a process perspective was adopted to examine the transition process of the telestroke innovation from its initial adoption to subsequent further diffusion
Contributions	• A process-oriented approach to understand the transition of the telestroke innovation from its initial adoption as a pilot to wider diffusion through commercialization • Practical insights by identifying and highlighting context-specific facilitating factors and challenging issues for transition from initial adoption to wider diffusion of a telehealth innovation

Dominant diffusion of innovation theories are criticized for their lack of explanation power beyond the conditions similar to those of their conception (Fichman 2000; Fichman 2004; Gallivan 2001; Lyytinen et al. 2001). To overcome this limitation, a process-based approach to diffusion of innovation was adopted to study the transition process from initial adoption to wider diffusion. We presented the unfolding of the innovation in four phases – adoption, implementation, commercialization, and diffusion – and identified what actors encountered what issues, how those issues were resolved, and what were the outcomes for each phase. Through the analysis of this process, we also identified for each phase a number of key context-specific factors that enabled the process from adoption to diffusion as well as key challenges stakeholders were faced with.

In response to the two questions raised, this research makes a number of contributions. First, it contributes to the growing body of IS research on telehealth innovations. Many existing studies report cases of initial adoption in a single organization or a network of initial adopting organizations (e.g. Chau et al. 2004; Constantinides et al. 2006; Davidson et al. 1999; Lapointe et al. 2005; Robey et al. 1999). There are few studies, however, that investigate the transition from initial adoption to wider diffusion into a larger population of organizations. By examining a case of such transition through commercialization, this study sheds light on how a pilot telehealth innovation can successfully develop into a wider diffusion mode through commercialization.

Second, the presented study expands the body of knowledge on diffusion of innovation research. Many researchers argue that we lack understanding of diffusion of innovation processes that go beyond the scope where traditional diffusion models are conceived and involve technologies that are highly complex, networked, and learning-intensive (Fichman 2000; Fichman 2004; Gallivan 2001; Lyytinen et al. 2001). Dominant diffusion of innovation theories do not provide adequate constructs to explain collective adoption and diffusion of complex and networked technologies (Lyytinen et al. 2001). In response, this study adopts a process-oriented approach to understand the development of a complex, networked telehealth innovation from its initial conception to rather different conditions, in this case through commercialization. The process-oriented approach helps achieve greater accuracy and deeper insights into diffusion of such complex, networked technologies like the telestroke innovation compared to dominant variance approaches that aim for simplicity and generalizability (Lyytinen et al. 2001). With an emergent perspective on causal agency (Markus et al. 1988), we present a four-staged model of the transition from adoption to diffusion, which is process-based, contextual, and non-deterministic in nature.

This study also offers practical contributions for stakeholders involved in IT-based innovations within the healthcare industry. We summarized these insights into six practical recommendations for other organizations to consider as they adopt telehealth innovations with the ambition to further diffuse them through commercialization.

Paper 5. Negotiating Business Issues in a Telestroke Innovation Project

Research Objectives	Understanding important internal and external organizational issues for successful implementation and adoption of a telehealth innovation
Theoretical Framing	Process models for organizational change by Orlikowski (1993) and Cule and Robey (2004) guided the investigation
Contributions	• Inter-disciplinary communication and sharing of research outcome • Enhanced contextual understanding of telehealth innovation by identifying internal and external organizational issues • Practical implications

The thesis includes a final, fifth paper based on data collected on the focal telestroke innovation and co-authored with some of the main actors in that innovation project. We examined the implementation and adoption of REACH in terms of internal and external factors drawing on insights from process models for organizational change by Orlikowski (1993) and Cule and Robey (2004). Internal factors considered easier to control include organizational, technical, and education issues and external factors include economic, legal, and market issues.

The study is the weakest of the five included in the thesis in terms of theoretical contribution. However, by publishing the study in a journal outside the information systems area we seek to communicate and share research findings with the wider telehealth research community. It is important for any multi-disciplinary research project to share its findings with other disciplines and to consider its main stakeholders as part of an effective communication strategy. The paper is included to document this interest and to advance our contextual understanding of the telestroke innovation by identifying internal and external organizational

issues, roughly corresponding to inner and outer context in Pettigrew's framework (Markus et al. 1988; Pettigrew 1985a; Pettigrew 1985b; Pettigrew 1987). The paper also makes practical contributions by arguing that the early identification and negotiation of business issues related to implementation of a telehealth innovation are likely to be important in sustaining and further diffusing the innovation.

Chapter 5: Discussion

In this chapter, we discuss the research as a whole across the five papers, through the lens of the contextualist approach, by summarizing contributions in relation to the detailed research questions (see Chapter 1). First, we assess each individual paper against the criteria for contextualist studies (Pettigrew 1985a; Pettigrew 1987; Pettigrew 1990; Pettigrew et al. 2001). Next, we summarize insights on the process dynamics of the studied telehealth innovations (research question 1), followed by a summary of insights on how telehealth innovation content and context interacted over the process of adoption and diffusion (research question 2). Finally, we discuss the dissertation research in terms of its impact on both research and practice (research question 3).

Assessing Contextualist Approach

As introduced in Chapter 2, Pettigrew set out four criteria to evaluate contextualist studies; 1) a clearly delineated, but theoretically and empirically connectable set of levels of analysis, 2) a clear description of the processes under examination, 3) use of a motor, or theory, to drive the process of change, and 4) connection of the contextual variables (conditions) in the vertical analysis to the process under observation in the horizontal analysis. The assessment of each paper against these criteria is summarized in Table 6 and elaborated below.

Criteria	Paper 1	Paper 2	Paper 3	Paper 4	Paper 5
1) Levels of analysis	√	√			√
2) Descriptive process	√	√	√	√	
3) Theory driving the process	√	√	√	√	
4) Interaction of contextual variables with process	√	√	√	√	∇

(Legend: √ -explicit, ∇ - implicit)
Table 6. Qualification of individual papers as contextualist studies

Paper 1 satisfies all four criteria; the data analysis was carried out at the actor-level and the context-level (or industry-level); major events were identified to anchor the context-level analysis of the infrastructure and the interactions between the four components of the industry infrastructure framework; the framework was used to explain how change unfolded with focus on actors' promoting or opposing advancement of each component; and, in that way, the four infrastructure components were as contextual variables tied to the process of innovation demonstrating strong mutual influence between the two.

Paper 2 also satisfies all four criteria; resilient adoption of the focal telestroke innovation was analyzed at individual, organizational, and network levels; the adoption process presented chronologically mainly from a resilience perspective and based on identification of major events;

dialectical tensions of opposing elements in identified contradictions were considered as driving forces of the process of change; and development and resolution of the three intra-organizational contradictions (medical vs. business interests, emerging vs. institutionalized work practices, IT-based innovation vs. established IT infrastructures) and the three inter-organizational contradictions (economic incentives of hub hospital vs. rural hospitals, emerging medical practices vs. institutionalized insurance practices, and hub hospital interests vs. commercial explorations) were argued as being contextual conditions that shaped the trajectory of the adoption process.

In paper 3, the levels-of-analysis issue was not explicitly addressed. However, the paper satisfies the other three criteria; the implementation process of the radiology innovation in the complementary case was analyzed and presented in six episodes demarcated by encounters, that is, pilot initiation, pilot launch, big-bang announcement, enforced adoption, enthusiast entry, and supplier substitution; translation of interests by actors, a core concept in ANT was seen as the driving force behind the process of change; contextual variables were identified in the form of implementation context expressed as tensions between shifting networks of actors within the implementation project and the broader institutional setting. These contextual dynamics shaped the implementation process and eventually led to transformation of traditional work practices and to emergence of new medical practices.

Paper 4 is also implicit in addressing levels of analysis with its focus on the transition process of the telestroke innovation from its initial adoption to wider diffusion. The other criteria are well documented, however; the transition process was clearly delineated in the form of four stages of adoption, implementation, commercialization, and diffusion and major events were identified at each stage; diffusion of innovation theory from a process perspective was used to explain the overall development process as a complex, networked innovation; and, contextual variables were identified in the form of context-specific enabling factors such as highly motivated project initiators, recognition through winning a state technology competition, and factors contributing to challenging issues that shaped the trajectory of the innovation such as a passive funding strategy and misalignment of the innovation with rural hospital interests and processes.

The final paper aiming at broader audiences within the field of study as well as practitioners is less rigorous in terms of Pettigrew's criteria. Though not explicitly presented as a process study, it identified issues with the telestroke innovation at both the internal and external levels. These issues also served as contextual variables and it was argued that early identification and management of the issues would impact further diffusion and sustainability of the innovation.

Hence, while the five studies constituting the dissertation represent contextualist studies they also demonstrate different ways to apply and implement Pettigrew's contextualist framework. In the following, we synthesize insights and learning from the research as a whole in relation to the posed research questions.

Understanding Process of Adoption and Diffusion

All the papers except paper 5 are designed as process studies, and they mainly contribute to expanding processual understanding of telehealth innovations, addressing the first question of how processes of adopting and further diffusing telehealth innovations unfold over time. This particular research question mainly addresses the process component in Pettigrew's framework.

Process is seen as a continuous, interdependent sequence of actions and events that is being used to explain the origins, continuance, and outcome of some phenomenon (Pettigrew 1985, 1987). At the level of agency, researchers need to pay attention to how actors act, react, interact, respond, and adapt, while at the higher level (what Pettigrew calls the system level) the interest is in emerging, elaborating, mobilizing, continuing, changing, dissolving, and transforming.

The process analysis of the individual studies paid attention to who the main actors were and what they did. For the focal telestroke innovation, a number of stakeholder groups with different perspectives and interests were identified. The neurologists as the main project initiators, the hub hospital management, participating rural hospitals, *BrainCare Inc*. (the two entrepreneurs), the state research funding agency, and *BrainConsult* emerged over time, roughly in that order. For the complementary case, profession-based actor groups were presented as having different interest and motivation for implementation and adoption of the innovation. They included doctors (at the pilot clinic and the rest of the units in the hospital), nurses (at the inpatient and outpatient wards), secretaries, and the projects management team.

Activities of the identified actors were analyzed to explain the origins, continuance, and outcome of the phenomena, or the chronological unfolding of the innovations studied. Such analysis was done in a variety of ways from different points of view. Actions, reactions, and interactions of the involved stakeholders were analyzed as promoting and developing industry infrastructure components (paper 1 (Van de Ven 2005; Van de Ven et al. 1999a)). The activities were interpreted as a process of building resilient capability by managing emerging contradictions related to the innovation (paper 2 (Bjerknes 1991; Hornby 1988; Reinmoeller et al. 2005; Robey et al. 1999; Robey et al. 2002)). Behind the process of transitioning from initial adoption by a small network of hospitals to wider diffusion into a larger population we identified conflicting and emergent interests and actions by key stakeholders (paper 4). In the case of the complementary innovation (paper 3), activities were viewed as a continuous process of translation through which actors negotiated and attempted to align their interests to implement and adopt the innovation (Latour 1991; Latour 2005; Law 1992; Law et al. 2005).

In summary, the processual analyses of the individual studies focusing on the main actors and their activities over time provide detailed descriptions of how initial adoption of the telestroke innovation unfolded and how it was transformed from a pilot to a commercial product, and how the radiology innovation was negotiated and implemented from a pilot clinic to the other clinics. However, it is rather abstract and incomplete to discuss innovation processes without revealing interactions with the content of the innovations and the context they are embedded in, which is a key proposition of Pettigrew's contextualist approach. In the following, the processual understanding becomes more concrete and contextualized by identifying and discussing contextual conditions and their interaction with the innovation content over time.

Understanding Interaction Between Context and Content

The research expands our understanding of context and its interaction with telehealth innovation content over time, thereby addressing the second research question. For the focal telestroke innovation, contextual variables were identified in a number of different forms. From Van de Ven's industry infrastructure perspective (Van de Ven 2005; Van de Ven et al. 1999a), institutional arrangements, resource endowments, proprietary activities, and market mechanisms were analyzed as contextual variables. The analysis shows that the existing levels of scientific

knowledge and technology advancements (resource endowments) in combination with proactive management and involvement by the enthusiastic neurologists (proprietary activities) enabled successful implementation of the telestroke innovation at an early stage. The lack of alignment between the innovation and institutional arrangements and non-existent market mechanisms turned out to be inhibiting conditions for further adoption and diffusion. This role of the four infrastructure components for the innovation process and efforts by stakeholders to promote them were explicated in paper 1. Overall the existing levels of development of the four components, which in turn were in the making through activities by the stakeholders, impacted the rate and scope of the innovation adoption.

Another set of contextual insights were identified for the focal innovation in the form of intra-organizational contradictions (medical vs. business interests, emerging vs. institutionalized work practices, IT-based innovation vs. established IT infrastructures) and inter-organizational contradictions (economic incentives of hub hospital vs. rural hospitals, emerging medical practices vs. institutionalized insurance practices, and hub hospital interests vs. commercial explorations). In the early development stages, medical interests by the neurologists dominated with business interests of the hub hospital not being reflected into the innovation. On the technology side, the innovation also was in more focus than was the IT infrastructure it depended on for efficient and effective operation. During later stages, struggles between opposing elements in these contradictions became more obvious. In adoption of the innovation by the network of rural hospitals, the contradictions regarding economic incentives, medical vs. insurance practices emerged as important forces shaping the process. Contradiction between the hub hospital interests and the commercial exploration emerged later as *BrainCare Inc.* entered the stage and the struggle between the two opposing elements resulted in failed negotiations. The analysis shows that the emergence and resolutions of the contextual conditions in the form of the identified contradictions affected the trajectory of the innovation over time.

For the complementary innovation, important contextual dynamics were identified during its implementation, which were expressed as tensions between shifting networks of actors within the implementation project and the broader institutional setting. For example, negotiations between different medical groups revealed the institutionalized power structures in the profession-based networks. While nurses and secretaries successfully inscribed their interests in the prototype at an early stage, the physicians had no difficulties influencing the outcome later in the process. These contextual dynamics critically shaped and impacted the implementation content over time and eventually led to transformation of medical work practices.

Summarized in this section were the key contextual findings from the research as well as interactions between the context and the innovations over time. It was discussed how the unfolding of the interactions over time shaped the trajectory and content of the innovations as well as the context.

Learning from Contextualist Analyses

Finally, we discuss how the dissertation impacts research into and practical management of telehealth innovation.

Most importantly, this research contributes to the growing body of IS research on telehealth innovations. Through empirical investigations into the focal and complementary telehealth innovations, the research expands our processual understanding of telehealth

innovations as well as how such processes interacts with the healthcare context in which they are embedded. The results are detailed above and they were arrived at by using a number of different theories such as dialectics, organizational resilience, industry infrastructure theory, and ANT. The research contributes to these theories by validating, extending, and challenging their usage. While theories are bounded by the context in which they were created and developed, they are constantly modified and refined with other researchers' efforts to apply, expand, enhance, and sometimes refute them in new research contexts.

The industry infrastructure theory (Van de Ven 2005; Van de Ven et al. 1989; Van de Ven et al. 1999a; Van de Ven et al. 1999b), originally proposed for industry-level analysis, was applied to a multi-level analysis of a single IT-based innovation as an integral part of the network of hospitals and institutions in which it was embedded. Applied in this way, the theory was proven to have decent explanation power in the first individual study. In the second study, common definitions of resilience as an organizational quality linked with effective adaptation were challenged (Coutu 2002; Horne III 1997; Horne III et al. 1998; Mallak 1998a; Mallak 1999; Riolli et al. 2003). The advantage of defining resilience as a process capability (Reinmoeller et al. 2005) in the context of adoption of IT-based innovations was argued with emphasis on the multi-faceted, dynamic nature of resilience and the changing evaluation of resilience over time. In the third study, an event-base analysis based on Newman and Robey (1992)'s encounter-episode approach was suggested to be used for ANT studies as a way to resolve some of the known issues of handling and reporting large, often messy process data they deal with. The suggested event-based approach, less explored in combination with ANT, contributes to ANT analysis. The fourth study contributes to diffusion of innovation research by empirically investigating adoption and diffusion of a telehealth innovation, an example of complex and networked technology that is not as well researched from a diffusion of innovation perspective (Lyytinen et al. 2001). The study complemented the traditional variance approach to diffusion of innovation research with a process-based approach and an emergent perspective on causal agency in IT and organizational change (Fichman 2000; Fichman 2004; Gallivan 2001; Lyytinen et al. 2001). The paper presented a context-specific and non-deterministic four-stage diffusion model as a result of the investigation. In doing so, it expanded the traditional diffusion of innovation research scope by covering the transition from initial adoption as a pilot to wider diffusion through commercialization in four stages in a single case study.

Overall, the research is positioned as part of the process-oriented research stream on IT-based innovations. Hence, it contributes to a research tradition that emphasizes embeddedness of innovations in their context (Avgerou 2001; Avgerou et al. 2004; Chiasson et al. 2005; Crowston et al. 2004; Cule et al. 2004; Newman et al. 1992; Orlikowski 1993; Orlikowski 2000; Robey et al. 2001; Sabherwal et al. 2003). This aspect was achieved by adopting the contextualist approach suggested by Pettigrew to summarize findings related to the adoption and commercialization processes of the focal and complementary telehealth innovations. The five individual studies show a variety of ways to apply Pettigrew's contextualist approach, and they demonstrate how the framework effectively supports process-oriented research. The contextual approach to telehealth innovations is justified based on critical examination of the emerging literature on healthcare information systems and the complex nature of the setting in which the telehealth innovations under consideration unfolded.

Finally, the research findings have been discussed in terms of their practical implications. Each paper discusses practical implications with paper 4 and 5 most conspicuous in emphasizing the practical implications. One of the significant insights is related to more proactive

management of rural hospital interests. In the case of the telestroke innovation, the hub hospital and the innovators were successful in initially motivating and managing relationships with the rural hospitals. As in many other cases, however, the focal innovation was pushed through and presented to the rural hospitals as an established outcome excluding early involvement of rural hospitals. Rural hospital interests such as their business interests, work practices, IT infrastructures were not sufficiently considered for the design and development of the telestroke innovation creating barriers for further adoption and diffusion in later stages. Similar issues were identified related to professional and departmental interests in implementation of the Swedish radiology innovation. Another interesting finding for practice is that the telestroke innovation lacked a long-term vision or plan to make it sustainable. In line with the theoretical framework of the research, practitioners are advised to adopt a contextual perspective from the very beginning of the process and proactively manage and address agency and contextual issues for successful implementation, adoption, and diffusion of telehealth innovations.

In this chapter, the overall contributions of the research were discussed in a number of ways. The research helps us understand multi-faceted aspects of telehealth innovation processes as they are embedded in and interact with their context by providing comprehensive analyses of the adoption and diffusion processes of the two telehealth innovations investigated. With the five independently designed studies with different theoretical framing, the research also makes contributions in terms of theory and practice. The research offers , in this way, alternative and complementary explanations to the more general questions of why IT use and adoption in healthcare is lagging behind other industries (Kohli et al. 2004; Menon et al. 2000; Raghupathi 1997) and why potential impacts of telehealth innovations for improved business and product development, commercialization, sales, and job creation have not yet materialized (Jennett et al. 2006).

References

"Healthcare Information Technology Spending is Growing Rapidly," Sheldon I. Dorenfest & Associates, Ltd.

Aarts, J., Peel, V., and Wright, G. "Organizational issues in health informatics: a model approach," *International Journal of Medical Informatics* (52:3) 1998, pp 235-242.

Adewale, O.S. "An internet-based telemedicine system in Nigeria," *International Journal of Information Management* (24:3) 2004, pp 221-234.

Anderson, G.F., Frogner, B.K., Johns, R.A., and Reinhardt, U.E. "Health Care Spending And Use of Information Technology In OECD Countries," *Health Affairs* (25:3) 2006.

Anderson, J.G. "Clearing the way for physicians' use of clinical information systems," *Communications of the ACM* (40:8) 1997, pp 83 - 90.

Archer, M., Bhaskar, R., Collier, A., Lawson, T., and Norrie, A. (eds.) *Critical Realism: Essential Readings* Routledge, New York, 1998.

Avgerou, C. "The Significance of Context in Information Systems and Organizational Change," *Information Systems Journal* (11) 2001, pp 43-63.

Avgerou, C., and Madon, S. "Framing IS studies: understanding the social context of IS innovation," in: *The Social Study of Information and Communication Technology,* C. Avgerou, C. Ciborra and F. Land (eds.), Oxford University Press, 2004.

Bali, R.K., and Naguib, R.N.G. "Towards gestalt telehealth: considering social, ethical and cultural issues," Canadian Conference on Electrical and Computer Engineering, 2001, pp. 1367 -1371.

Bashshur, R., L. "Telemedicine Nomenclature: What Does it Mean?," *Telemedicine Journal* (6:1) 2000, pp 1-3.

Bashshur, R.L., Sanders, J.H., and Shannon, G.W. (eds.) *Telemedicine: theory and practice*. Charles C. Thomas, Springfield, IL, U.S.A, 1997.

Benbasat, I., Goldenstein, D.K., and Mead, M. "The Case Research Strategy in Studies of Information Systems," *MIS Quarterly* (11:3) 1987, pp 369-386.

Benbasat, I., and Zmud, R. "The Identity Crisis Within the IS Discipline: Defining and Communicating the Discipline's Core Properties," *MIS Quarterly* (27:2) 2003, pp 183-194.

Berg, M. "Implementing information systems in health care organizations: myths and challenges," *International Journal of Medical Informatics* (64:2-3) 2001, pp 143-156.

Bhaskar, R. *The Possibility of Naturalism: A Philosophical Critique of the Contemporary Human Sciences*, (3rd ed.) Routledge, 1998.

Bhaskar, R., Archer, M., Collier, A., Lawson, T., and Norrie, A. (eds.) *Critical Realism: Essential Readings* Routledge, 1998.

Bjerknes, G. "Dialectical Reflection in Information Systems Development," *Scandinavian Journal of Information Systems* (3) 1991, pp 55-77.

Braa, J., Monteiro, E., and Sahay, S. "Networks of Action: Sustainable Health Information Systems Across Developing Countries," *MIS Quarterly* (28:3) 2004, pp 337-362.

Brown, H.G., Poole, M.S., and Rodgers, T.L. "Interpersonal Traits, Complementarity, and Trust in Virtual Collaboration. ," *Journal of Management Information Systems* (20:4) 2004, pp 115-137.

Casper, M.L., Barnett, E., Williams, G.I.J., Halverson, J.A., Braham, V.E., and Greenlund, K.J. "Atlas of Stroke Mortality: Racial, Ethnic, and Geographic Disparities in the United States ", D.o.H.a.H. Services (ed.), Centers for Disease Control and Prevention, January 2003.

Chae, B., and Bloodgood, J.M. "The paradoxes of knowledge management: An eastern philosophical perspective " *Information and Organization* (16:1) 2006, pp 1-26.

Chau, P.Y.K., and Hu, P.J.-H. "Technology Implementation for Telemedicine Programs," *Communications of the ACM* (47:2) 2004, p 87.

Chiasson, M.W., and Davidson, E. "Pushing the contextual envelope: developing and diffusing IS theory for health information systems research," *Information and Organization* (14:3) 2004, pp 155-188.

Chiasson, M.W., and Davidson, E. "Taking Industry Seriously in Information Systems Research," *MIS Quarterly* (29:4) 2005, pp 591-605.

Chua, W.F. "Radical Developments in Accounting Thought.," *Accounting Review* (61:4) 1986, pp p601, 632p.

Constantinides, P., and Barrett, M. "Negotiating ICT development and use: The case of a telemedicine system in the healthcare region of Crete," *Information and Organization* (16:1) 2006, pp 27-55.

Cooper, R.B., and Zmud, R.W. "Information Technology Implementation Research: A Technological Diffusion Approach.," *Management Science* (36:2) 1990, pp 123-139.

Coutu, D.L. "How resilience works," *Harvard Business Review* (80:5) 2002, pp 46-55.

Covi, L., and Kling, R. "Organizational Dimensions of Effective Digital Library Use: Closed Rational and Open Natural Systems Models," *Journal of American Society for Information Systems* (47:9) 1996, pp 672-689.

Crowston, K., and Myers, M.D. "Information Technology and the Transformation of Industries: Three Research Perspectives," *Journal of Strategic Information Systems* (13) 2004, pp 5-28.

Cule, P.E., and Robey, D. "A Dual-Motor, Constructive Process Model of Organizational Transition," *Organization Studies* (25:2) 2004, p 229.

Dahlbom, B., and Mathiassen, L. *Computers in Context: The Philosophy and Practice of Systems Design* Blackwell Publishing, Cambridge, MA & Oxford, UK, 1993.

Darke, P., Shanks, G., and Broadbent, M. "Successfully completing case study research: combining rigour, relevance and pragmatism," *Information Systems Journal* (8:4) 1998, pp 273-289.

Das, T.K., and Teng, B.-S. "Instabilities of Strategic Alliances: An Internal Tensions Perspective," *Organization Science* (11:1) 2000, pp 77-101.

Davidson, E.J. "Analyzing Genre of Organizational Communication in Clinical Information Systems," *Information, Technology, and People* (13:3) 2000, pp 196-209.

Davidson, E.J., and Chismar, W.G. "Planning and Managing Computerized Order Entry: A Case Study of IT-Enabled Organizational Transformation," *Topics in Health Information Management* (19:4) 1999, pp 47-61.

Davis, F.D. "Perceived Usefulness, Perceived Ease-of-Use and User Acceptance of Information Technology," *MIS Quarterly* (13:3) 1989, pp 319-339.

DeSanctis, G., and Poole, M.S. "Capturing the Complexity in Advanced Technology Use: Adaptive Structuration Theory," *Organization Science* (5:2) 1994, pp 121-147.

DiMaggio, P.J., and Powell, W.W. "The Iron Cage Revisited: Institutional Isomorphism and Collective Rationality in Organizational Fields," *American Sociological Review* (48:2) 1983, pp 147-160.

Dobson, P.J. "Longitudinal Case Research: A Critical Realist Perspective," *Systemic Practice and Action Research* (14:3) 2001a, pp 283-296.

Dobson, P.J. "The Philosophy of Critical Realism - An Opportunity for Information Systems Research," *Information Systems Frontiers* (3:2) 2001b, pp 199-210.

Easton, G. "Case research as a method for industrial networks: a realist apologia," in: *Realist perspectives on management and organizations,* S. Ackroyd and S. Fleetwood (eds.), Routledge, New York, 2000, pp. 205-244.

Egyhazy, C., and Mukherji, R. "Interoperability Architecture Using RM-ODP," *Communications of the ACM* (47:2) 2004, pp 93-97.

Eisenhardt, K.M. "Building Theories from Case Study Research," *Academy of Management Review* (14:4) 1989, pp 532-550.

Fichman, R.G. "The Diffusion and Assimilation of Information Technology Innovations," in: *Framing the Domains of IT Management: Projecting the Future Through the Past,* R.W. Zmud (ed.), Pinnaflex Educational Resources, Inc., Cincinnati, OH, 2000.

Fichman, R.G. "Going Beyond the Dominant Paradigm for Information Technology Innovation Research: Emerging Concepts and Methods," *Journal of the Association for Information Systems* (5:8) 2004, pp 314-355.

Fiol, C.M. "Capitalizing on Paradox: The Role of Language in Transforming Organizational Identities," *Organization Science* (13:6) 2002, pp 653-666.

Fitzgerald, G., and Russo, N.L. "The turnaround of the London Ambulance Service Computer-Aided Dispatch system (LASCAD)," *European Journal of Information Systems* (14:3) 2005, pp 244-257.

Fleetwood, S., and Ackroyd, S. (eds.) *Critical realist applications in organisation and management studies / edited by* Routledge, London, 2004.

Ford, J.D., and Ford, L.W. "Logics of identity, contradiction, and attraction in change," *The Academy of Management Review* (19:4) 1994, pp 756-785.

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

Goldschmidt, P.G. "HIT and MIS: implications of health information technology and medical information systems," *Communications of the ACM* (48:10) 2005, pp 68-74.

Hamel, G., and Valikangas, L. "The quest for resilience," *Harvard Business Review* (81:9) 2003, pp 52-63.

Hatch, M.J. *Organization Theory: Modern, Symbolic and Postmodern Perspectives* Oxford University Press, 1997.

Hornby, A.S. *Oxford Advanced Learner's Dictionary of Current English* Oxford University Press, Oxford, U.K., 1988.

Horne III, J.F. "The coming age of organizational resilience," *Business Forum* (22:2/3/4) 1997, pp 24-28.

Horne III, J.F., and Orr, J.E. "Assessing behaviors that create resilient organizations," *Employment Relations Today* (24:4) 1998, pp 29-39.

Israel, J. *The Language of Dialectics and the Dialectics of Language* Munksgaard, Copenhagen, 1979.

Jayasuriya, R. "Managing Information Systems for Health Services in a Developing Country: a Case Study Using a Contextualist Framework," *International Journal of Information Management* (19:5) 1999, pp 335-349.

Jennett, P., and Watanabe, M. "Healthcare and Telemedicine: Ongoing and Evolving Challenges," *Disease Management & Health Outcomes* (14:Suppl 1) 2006, pp 9-13.

Josefsson, U. "Coping with Illness Online: The Case of Patients' Online Communities," *Information Society* (21:2) 2005, pp 133-153

Kaplan, B., and Duchon, D. "Combining qualitative and quantitative methods in information systems research: a case study," *MIS Quarterly* (12:4) 1998, pp 571-586.

Klein, H.K., and Myers, M.D. "A Set of Principles for Conducting and Evaluating Interpretive Field Studies in Information Systems " *MIS Quarterly* (23:1) 1999, pp 67-93.

Kohli, R., and Kettinger, W.J. "Informating the Clan: Controlling Physicians' Costs and Outcomes," *MIS Quarterly* (28:3) 2004, pp 363-394.

Kwon, T.H., and Zmud, R.W. "Unifying the Fragmented Models of Information Systems Implementation," in: *Critical Issues in Information Systems Research,* R.J. Boland and R.A. Hirscheim (eds.), John Wiley and Sons, New York, 1987, pp. 227-251.

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

Lapointe, L., and Rivard, S. "A Multilevel Model of Resistance to Information Technology Implementation," *MIS Quarterly* (29:3) 2005, pp 461-491.

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

Latour, B. *Reassembling the Social: An Introduction to Actor-network-theory* Oxford University Press, 2005.

Law, J. "Notes on the theory of the actor-network: Ordering, strategy, and heterogeneity," *Systemic Practice and Action Research* (5:4) 1992, pp 379 - 393

Law, J., and Singleton, V. "Object Lessons," *Organization* (12:3) 2005, pp 331-355.

Lee, A. "A Scientific Methodology for MIS Case Studies," *MIS Quarterly* (13:1) 1989, pp 33-50.

Lee, A.S. "Integrating Positivist and Interpretive Approaches to Organizational Research," *Organization Science* (2:4) 1991, pp 342-365.

Lewis, M.W. "Exploring Paradox: Toward a More Comprehensive Guide," *Academy of Management Review* (25:4) 2000, pp 760-776.

Liang, H., Xue, Y., and Berger, B.A. "Web-based intervention support system for health promotion," *Decision Support Systems* (42) 2006, pp 435-449.

Lorenzi, N.M., and Riley, R.T. "Organizational ISSUES=change," *International Journal of Medical Informatics* (69:2-3) 2003, pp 197-203.

Lorenzi, N.M., Riley, R.T., Blyth, A.J.C., Southon, G., and Dixon, B.J. "Antecedents of the People and Organizational Aspects of Medical Informatics: Review of the Literature," *Journal of the American Medical Informatics Association* (4:2) 1997, pp 79-93.

Lyytinen, K., and Damsgaard, J. "What's wrong with the diffusion of innovation theory?," IFIP TC8 Working Group 8.6 Conference, Banff, Canada, 2001, pp. 173-190.

Maheu, M.M., Whitten, P., and Allen, A. *E-Health, telehealth, and telemedicine : a guide to start-up and success* Jossey-Bass, San Francisco, 2001.

Mallak, L. "Putting organizational resilience to work," *Industrial Management* (40:6) 1998a, pp 8-13.

Mallak, L.A. "Measuring resilience in health care provider organizations " *Health Manpower Management* (24:4) 1998b, p 148.

Mallak, L.A. "Toward a theory of organizational resilience," Management of Engineering and Technology, 1999. Technology and Innovation Management. PICMET '99. Portland International Conference on, Portland, OR, USA, 1999, p. 223.

Markus, M.L., and Lee, A. "Special Issue on Interpretive Research in Information Systems: Using Qualitative, Interpretive, and Case Methods to Study Information Technology Forward," *MIS Quarterly* (23:1) 1999, pp 35-38.

Markus, M.L., and Robey, D. "Information Technology and Organizational Change: Causal Structure in Theory and Research," *Management Science* (34:5) 1988, pp 583-598.

Mason, J. *Qualitative Researching*, (2nd ed.) Sage, 2002.

Mathiassen, L. "Reflective Systems Development," *Scandinavian Journal of Information Systems* (10:1&2) 1998, pp 67-118.

Mbarika, V.W.A. "Is Telemedicine the Panacea for Sub-Saharan Africa's Medical Nightmare?," *Communications of the ACM* (47:7) 2004, pp 21-24.

Menon, N.M., Lee, B., and Eldenburg, L. "Productivity of Information Systems in the Healthcare Industry," *Information Systems Research* (11:1) 2000, pp 83-92.

Mercuri, R.T. "The HIPAA-potamus in Health Care Data Security," *Communications of the ACM* (47:7) 2004, pp 25-28.

Miles, M.B., and Huberman, A.M. *Qualitative Data Analysis*, (2nd ed.) Sage, 1994.

Mingers, J. "Real-izing information systems: critical realism as an underpinning philosophy for information systems," *Information and Organization* (14:2) 2004, pp 87-103.

Newman, M., and Robey, D. "A social process model of user-analyst relationships," *MIS Quarterly* (16:2) 1992, pp 249-266.

Orlikowski, W., and Iacono, S. "Desperately Seeking the 'IT' in IT Research: A Call to Theorizing the IT Artifact," *Information Systems Research* (12:2, June) 2001, pp 121-134.

Orlikowski, W.J. "CASE Tools as Organizational Change: Investigating Incremental and Radical Changes in Systems Development," *MIS Quarterly* (17) 1993, pp 309-340.

Orlikowski, W.J. "Using technology and constituting structures: A practice lens for studying technology in organizations," *Organization Science* (11:4) 2000, pp 404-428.

Orlikowski, W.J. "Knowing in practice: Enacting a collective capability in distributed organizing," *Organization Science* (13:3) 2002, pp 249-273.

Orlikowski, W.J., and Baroudi, J.J. "Studying Information Technology in Organizations: Research Approaches and Assumptions," *Information Systems Research* (2) 1991, pp 1-28.

Paul, D.L. "Collaborative Activities in Virtual Settings: A Knowledge Management Perspective of Telemedicine," *Journal of Management Information Systems* (22:4) 2006, pp 143-176.

Paul, D.L., and McDaniel Jr., R.R. "A Field Study of the Effect of Interpersonal Trust on Virtual Collaborative Relationship Performance," *MIS Quarterly* (26:2) 2004, pp 183-227.

Pettigrew, A.M. "Contextualist Research and the Study of Organizational Change Processes," in: *Research methods in information systems : proceedings of the IFIP WG 8.2 Colloquium,* E. Mumford (ed.), Elsevier Science Pub. Co., Amsterdam ; New York : North-Holland ; New York 1985a.

Pettigrew, A.M. "Contextualist Research: A Natural Way to Link Theory and Practice," in: *Doing Research That is Useful for Theory and Practice,* E.E. Lawler (ed.), Jossey-Bass, San Francisco, 1985b.

Pettigrew, A.M. "Context and Action in the Transformation of the Firm," *Journal of Management Studies* (24:6) 1987, pp 649-670.

Pettigrew, A.M. "Longitudinal Field Research on Change: Theory and Practice," *Organization Science: A Journal of the Institute of Management Sciences* (1:3) 1990, pp 267-292.

Pettigrew, A.M., Woodman, R.W., and Cameron, K.S. "Studying organizational change and development: Challenges for future research " *Academy of Management Journal* (44:4) 2001, pp 697-713.

Poole, M.S., and Van de Ven, A.H. "Using Paradox to Build Management and Organization Theories," *Academy of Management Review* (14:4) 1989, pp 562-578.

Pratt, W., Unruh, K., Civan, A., and Skeels, M.M. "Personal health information management," *Communications of the ACM* (49:1) 2006, pp 51-55.

Raghupathi, W. "Health care information systems," *Communications of the ACM* (40:8) 1997, pp 80 - 82.

Reinmoeller, P., and Baardwijk, N.v. "The Link Between Diversity and Resilience," *MIT Sloan Management Review* (46:4) 2005, p 61.

Riolli, L., and Savicki, V. "Information system organizational resilience," *Omega : The international journal of management science* (31:3) 2003, pp 227-233.

Robey, D., and Boudreau, M.-C. "Accounting for the Contradictory Organizational Consequences of Information Technology: Theoretical Directions and Methodological Implications," *Information Systems Research* (10:2) 1999, pp 167-185.

Robey, D., and Holmstrom, J. "Transforming municipal governance in global context: A case study of the dialectics of social change," *Journal of Global Information Technology Management* (4:4) 2001, pp 19-31.

Robey, D., Ross, J.W., and Boudreau, M.-C. "Learning to Implement Enterprise Systems: An Exploratory Study of the Dialectics of Change," *Journal of Management Information Systems* (19:1) 2002, pp 17-46.

Rogers, E.M. *Diffusion of Innovations*, (5th ed.) The Free Press, New York, 2003.

Rond, M.d., and Bouchikhi, H. "On the Dialectics of Strategic Alliances," *Organization Science* (15:1) 2004, pp 56-69.

Sabherwal, R., and Newman, M. "Persistence and change in system development: a dialectical view," *Journal of Information Technology* (18:2) 2003, pp 69-92.

Sarker, S., and Lee, A. "Using a Positivist Case Research Methodology to Test a Theory About IT-Enabled Business Process Redesign," International Conference on Information Systems, Helsinki, Finland, 1998.

Sayer, A. *Method in Social Science: A Realist Approach* Routledge, London, 1992.

Sayer, A. *Realism and Social Science* Sage Publications 2000.

Scheepers, R., and Scheepers, H. "Contexts of Relevance in Explanatory Case Studies in IS: Ubiquitous Information Technology Implementation in Organizations " Proceedings of the 24th International Conference on Information Systems, Seattle, WA., 2003, pp. 25-35.

Scott, W.R. *Institutions and Organizations*, (2nd ed.) Sage Publications, 2001.

Starr, R., Newfrock, J., and Delurey, M. "Enterprise Resilience: Managing Risk in the Networked Economy," in: *strategy+ business*, 2003, pp. 1-10.

Tanriverdi, H., and Iacono, C.S. "Knowledge Barriers to Diffusion of Telemedicine," International Conference on Information Systems, Helsinki, Finland, 1998, pp. 39-50.

Van de Ven, A.H. "Running in Packs to Develop Knowledge-Intensive Technologies," *MIS Quarterly* (29:2) 2005, pp 365-378.

Van de Ven, A.H., and Garud, R. "Innovation and Industry Development: The Case of Cochlear Implants," *Research on Technological Innovation Management and Policy* (4) 1989, pp 295-325.

Van de Ven, A.H., Polley, D.E., Garud, R., and Venkataraman, S. "Building an Infrastructure for the Innovation Journey," in: *The Innovation Journey*, Oxford University Press, Oxford, NY, 1999a.

Van de Ven, A.H., Polley, D.E., Garud, R., and Venkataraman, S. *The Innovation Journey* Oxford University Press, 1999b.

Van de Ven, A.H., and Poole, M.S. "Explaining Development and Change in Organizations," *Academy of Management Review* (20:3) 1995, pp 510-540.

Walsham, G. *Interpreting Information Systems in Organizations* Wiley & Sons, 1993.

Walsham, G. "The Emergence of Interpretivism in IS Research," *Information Systems Research* (6:4) 1995a, pp 376-394.

Walsham, G. "Interpretive Case Study in IS Research. Nature and Method," *European Journal of Information Systems* (4) 1995b, pp 74 - 81.

Walsham, G. "Doing interpretive research," *European Journal of Information Systems* (15:3) 2006, pp 320-330.

Walsham, G., and Waema, T. "Information Systems Strategy and Implementation: A Case Study of a Building Society," *ACM Transactions on Information Systems* (12:2) 1994, pp 150 - 173.

Weick, K.E. "The collapse of sensemaking in organizations: The Mann Gulch disaster," *Administrative Science Quarterly* (38:4) 1993, pp 628-652.

Yin, R.K. *Case Study Research Design and Methods*, (3rd ed.) Sage Publications, Inc., 2003.

Part II: Research Papers

Paper 1. The Role of Industry Infrastructure

Title: The Role of Industry Infrastructure in Telehealth Innovations: A Multi-level Analysis of a Telestroke Program

This paper is coauthored by Sunyoung Cho and Lars Mathiassen

The Role of Industry Infrastructure in Telehealth Innovations: A Multi-level Analysis of a Telestroke Program

Abstract

The information-intensive nature of the healthcare industry and the potential of information technology (IT) to reduce costs and improve quality of services have increased the focus on IT-based innovations. Yet, our ability to understand and manage how IT-based innovations unfold in the context of healthcare is still limited. In this paper, we apply Van de Ven's industry infrastructure framework to investigate a telehealth innovation that provides remote medical assistance to stroke patients in a network of collaborating hospitals. The resulting multi-level analysis reveals a highly complex process of interactions between key actors and healthcare industry infrastructure. Despite the innovation's strong potential, the process is mainly push-driven with minimal pull from potential adopters. Moreover, the push is created by a small group of medical innovators with limited technological and financial resources and little infrastructural support. The study contributes to explaining why the healthcare industry despite considerable investments continues to lag behind other industries in adoption of IT-based innovations. Based on the study, we suggest healthcare entrepreneurs apply an industry infrastructure perspective to proactively manage IT-based innovations as integral parts of the organizational networks in which they are embedded.

Keywords
Telehealth innovations, healthcare industry, industry infrastructure, multi-level analysis.

Suggested running head: The Role of Industry Infrastructure

INTRODUCTION

Several studies emphasize the importance of understanding IT-based innovations as integral parts of the context in which they are embedded (Avgerou 2001; Avgerou et al. 2004; Chiasson et al. 2004; Chiasson et al. 2005; Crowston et al. 2004; Lamb et al. 2003; Van de Ven 2005; Van de Ven et al. 1999). As the adoption of IT-based innovations vary across industries, economies, and organizations (Avgerou 2001), contextual studies may reveal insights which were unnoticed or not explained in previous studies (Chiasson et al. 2004; Chiasson et al. 2005). Identification of variations in adoption patterns across contexts can also help managers improve new innovation initiatives.

IT can enable potential breakthroughs in quality improvement and cost reduction of healthcare services. As a result, IT investments in healthcare are growing at a rapid pace. IT investments were expected to reach 23.6 billion USD in 2003, rising at a rate of 9.3 percent from $21.6 billion expended in 2002 (Sheldon I. Dorenfest & Associates, Ltd. 2004). Still, adoption of IT in healthcare proceeds slowly, and difficulties in successful adoption of IT-based healthcare innovations are well-documented (Aarts et al. 1998; Anderson 1997; Berg 2001; Brown et al. 2004; Davidson 2000; Lorenzi et al. 2003; Lorenzi et al. 1997; Menon et al. 2000; Raghupathi 1997; Tanriverdi et al. 1998). There are, therefore, particular good reasons to use contextual approaches to study IT-based innovations within the healthcare industry (Chiasson et al. 2004). Contextual insights might help us understand the particular characteristics that make it difficult to successfully adopt IT-based innovations within the healthcare industry.

On this backdrop, we apply a contextual lens to investigate a telehealth innovation that provides remote medical assistance to stroke patients in a network of collaborating hospitals (Cho et al. 2007). Telehealth innovations are particularly challenging because they require collaboration and knowledge sharing across organizational boundaries (Paul 2006), they pose particular challenges related to ensure the trust needed in medical practices (Brown et al. 2004; Paul 2006), and they raise delicate issues related to how investments and reimbursements are distributed and shared (Chau et al. 2004). With its mission critical features, this innovation has a great potential to be life-saving and become widely diffused. In fact, efforts to commercialize the innovation have been going on for a while. While the conception and implementation of innovation into the initial network of collaborating hospitals is a success, further diffusion of the innovation is slow and negotiations to commercialize the innovation are complicated. To understand this apparent paradox, we apply Van de Ven's industry infrastructure framework (Van de Ven 2005; Van de Ven et al. 1999) and engage in an investigation of how the innovation process was shaped through interactions between key actors and the surrounding healthcare infrastructure. Specifically, we conduct a multi-level process analysis related to the following research questions:

1. Actor-level analysis: How do key actors address industrial infrastructure issues during adoption of the telehealth innovation?

2. Context-level analysis: How do industrial infrastructure factors shape the adoption of the telehealth innovation?

The study contributes to healthcare information systems (IS) research through a detailed analysis of the telestroke program. The analysis reveals a complex innovation process that contributes to

explaining why the healthcare industry lags behind other industries in effectively adopting and using IT (Aarts et al. 1998; Berg 2001; Lorenzi et al. 2003; Raghupathi 1997; Tanriverdi et al. 1998). Also, the paper shows how Van de Ven's framework (Van de Ven et al. 1999) can be used to study interaction between agency and industrial infrastructure in the real-life context of one specific telehealth innovation. Based on the analysis, we suggest that healthcare entrepreneurs apply an industry infrastructure perspective to proactively manage innovations as integral parts of the healthcare network in which they are embedded.

The paper is structured as follows. The next section reviews healthcare IS research and presents Van de Ven's infrastructure framework (Van de Ven et al. 1999). Next, we outline the design of the case study and present the multi-level analysis of the telehealth innovation under investigation. Finally, we discuss contributions and implications for both research and practice.

THEORETICAL FOUNDATION

Healthcare IS Research

Increasing investments in IT-based innovations in the healthcare industry are reflected in IS research. Chiasson and Davidson (2004) have reviewed 17 leading IS journals from 1985 to 2003 to identify contributions to healthcare IS research, i.e. the multidisciplinary body of knowledge related to the design, development, implementation, and use of information-intensive technologies in healthcare settings. They identified a total of 165 papers (1.2 %) that represent healthcare IS research. They classified these into four groups based on how IS theory and the healthcare context was emphasized. The four categories are IS-only, IS-healthcare, healthcare-IS, and healthcare-only.

IS-only papers focus on generalizable theory without specific consideration of the healthcare context. The authors of these papers do not explore how the healthcare context influences theoretical constructs, assumptions, or analysis. IS-healthcare papers primarily focus on developing or testing IS theories with some consideration given to interactions with the healthcare context. These researchers consider how the healthcare context might influence application or interpretation of IS theory. Healthcare-IS papers more systematically consider the context by applying IS theory to analyze healthcare issues. The authors of these papers explicitly take into account unique aspects of healthcare contexts in order to develop, test, and extend theory through the application of a general IS topic. Finally, healthcare-only papers focus on describing the design, development, implementation, and use of information-intensive technologies in healthcare without significant use of IS theories in the analysis.

Chiasson and Davidson (2004) argue that IS-healthcare and healthcare-IS approaches are more balanced between contextual specificity and general IS theory, but they consider healthcare-IS as the better approach to explore context specificities within the healthcare industry. In addition, they emphasize that the healthcare context provides a niche for IS researchers to extend, refine, and develop IS theories (Chiasson et al. 2004). To provide further background for this study, we have brought Chiasson and Davidson's review up to date by systematically considering IS publications in the 17 leading journals during the period 2004 to 2006. Our review added another 40 healthcare IS research contributions (2.1%). Table 1 summarizes the complete overview of healthcare IS papers in leading IS journals from 1985 to 2006.

	Healthcare IS papers (1985 – 2003)	% of papers (1985 – 2003)	Healthcare IS papers (2004 – 2006)	% of papers (2004 – 2006)	Total % of papers
IS-only	29	17.6%	9	22.5%	18.5%
IS-healthcare	46	27.9%	6	12.5%	25.4%
Healthcare-IS	29	17.6%	10	27.5%	19.0%
Healthcare-only	61	36.9%	15	37.5%	37.1%

Table 1. Healthcare IS research papers in leading journals

Two of the four categories of healthcare IS research are of minor interest to this study. IS-only papers de-contextualize IT-related phenomena by focusing on generalizable IS theory. Brown et al.'s study (2004) offers an example. Through a study of collaboration in telemedicine, they propose that personality type affects trust, perceived trustworthiness, and communication and thereby affects individual's willingness to collaborate and the sustainability and productivity of the collaboration (Brown et al. 2004). The authors do not take the uniqueness of the healthcare setting into account, but focus on general issues related to virtual collaboration. In fact, the specific aspects of the study setting in healthcare are not discussed in the paper. Healthcare-only papers, on the other hand, are mostly descriptive, lacking theoretical perspectives on the context or the IT-related phenomena under investigation. Chiasson and Davidson (2004) point out that a majority of healthcare IS research papers in Communications of the ACM fall under this category (Egyhazy et al. 2004; Goldschmidt 2006; Mercuri 2004; Pratt et al. 2006).

The two other categories of healthcare IS research have more direct relevance to this study. Paul and McDaniel's paper is an example of an IS-healthcare study (Paul et al. 2004). They examine the relationship between interpersonal trust and dyadic collaborative relationship performance in telemedicine project settings. The healthcare setting is used opportunistically to pursue theory development and testing in relation to virtual collaborative relationships. The difference between this study and Brown et al.'s study (2004) is the emphasis on context. In Paul and McDaniel's study, unique characteristics of the healthcare delivery environment are emphasized and shown to make the creation and maintenance of trust difficult. However, the healthcare setting is still mainly seen as a virtual collaboration environment and the focus of the study is on general IS research topics.

An increasing part of recent publications (10 or 25.0 %) were classified as healthcare-IS (e.g. Braa et al. 2004; Constantinides et al. 2006; Fitzgerald et al. 2005; Josefsson 2005). In these papers, the authors analyze empirical data and explore contextual influences by applying and elaborating IS theories to understand the healthcare industry (Chiasson et al. 2004). For example, Constantinides and Barrett (2006) address the interaction between an IT-based innovation and its context with focus on the relationship between structure and culture and the relationship between power and politics. They view the development, implementation, and adoption of a telecardiology innovation as an ongoing process of negotiations between multiple actors and their technological choices. IS theories (i.e., practice lens, boundary objects, and Actor Network Theory) are applied to frame the analysis of the process of negotiations.

Considering all IS-healthcare and healthcare-IS papers (91 or 44.4%) and focusing on studies of

telehealth innovations, there are rather few studies available (Adewale 2004; Brown et al. 2004; Chau et al. 2004; Liang et al. 2006; Mbarika 2004; Paul 2006; Paul et al. 2004). Only a few of these are empirical studies with some consideration of the interaction between telehealth innovations and context (e.g. Chau et al. 2004; Constantinides et al. 2006). This justifies that more empirical research is needed to better understand the contextual challenges related to adoption of telehealth innovations and, if possible, to use such studies to extend, refine, and further develop IS theory in the healthcare context (Chiasson et al. 2004).

Industry Infrastructure Framework

As our interest lies in investigating the interactions between agency and context in relation to a specific telehealth innovation, we adopt an institutional lens in line with a number of other IS studies (Avgerou 2001; Avgerou et al. 2004; Chiasson et al. 2005; Covi et al. 1996; Crowston et al. 2004; Lamb et al. 2003; Van de Ven 2005). With some variation, institutional studies implicitly or explicitly relate to what DiMaggio and Powell calls an "organizational field" (DiMaggio et al. 1983). An organizational field is identified when "organizations, in the aggregate, constitute a recognized area of institutional life: key suppliers, resource and product consumers, regulatory agencies, and other organizations that produce similar services and products." A focus on specific organizational fields direct researchers' attention to the totality of relevant actors, individuals, groups, organizations, and networks that within that particular context interact to shape the innovation under consideration (DiMaggio et al. 1983). Hence, these studies recognize the embeddedness of IT-based innovations beyond organizational boundaries; they assume that process characteristics vary; and they see context as emergent and the interaction between context and innovation as difficult to trace.

Building on this tradition, we apply a particular institutional approach, Van de Ven's infrastructure framework (Van de Ven 2005; Van de Ven et al. 1999), to analyze the telehealth innovation under investigation. The framework was developed through studies of cochlear implant technology (Van de Ven et al. 1989) and later extended and refined. The framework is also referred to as social-systems perspective. The framework emphasizes the "community infrastructure" or the "industry infrastructure" incorporating three dominant perspectives on innovations, namely the technological imperative, the institutional determinism, and the resource endowment perspectives. Van de Ven et al. argue that these three perspectives are highly interdependent and therefore must be analyzed within a context of continuing interaction (Van de Ven et al. 1999). As a result, the framework incorporates a variety of industrial infrastructures for technological innovations (see Figure 1): (1) institutional arrangements to legitimize, regulate, and standardize a new technology; (2) resource endowments of basic scientific knowledge, financing mechanisms, and a pool of competent labor; (3) market mechanisms to educate consumers and stimulate demand for a new technology; and (4) proprietary research and development, manufacturing, marketing, and distribution functions by entrepreneurial firms to commercialize the innovation for profit. The main proposition of the industry infrastructure framework is that success of technological innovations depends on the extent to which the necessary components of the industrial infrastructure in which the innovation is embedded are available and mature (Van de Ven et al. 1999).

The industry infrastructure framework belongs to the "collective action" perspective on institutional change and it was conceived to illuminate the social, economic, and political infrastructure that can sustain members of a technological community (Van de Ven et al. 2004). The framework provides an appropriate theoretical lens to examine telehealth innovations; first,

because of its emphasis on explaining technological innovation within a specific industrial context (Van de Ven et al. 1999); second, because of its focus on networked technologies in increasingly knowledge-intensive industries (Van de Ven 2005).

Figure 1. Industry Infrastructure for Technological Innovation (Van de Ven 2005)

While the framework is designed for industry-level analyses of innovations across organizations, we apply the framework on the level of an individual, situated innovation to analyze its conception, implementation, and further diffusion within a network of collaborating organizations. The intention behind Van de Ven's framework was to provide an augmented view of an industry to help us "understand how industrial infrastructure emerges to support and constrain innovation" (2005, p. 369); but the focus of this paper is not on the healthcare industry and telehealth innovations in general. Instead, inspired by Van de Ven's (1999) methodological suggestion we apply the framework to analyze a telestroke program on two different levels: (1) an actor-level focusing on how entrepreneurs and organizations interacted with industrial infrastructure components, and (2) a context-level focusing on how industrial infrastructure components shaped the development and adoption of the innovation. Specifically, we are interested in: (1) how and when different components in the industrial infrastructure emerged and were organized over time; (2) how actors created, performed, or related to these components; and (3) what impact the industrial infrastructure components had on the adoption of the telehealth innovation under investigation.

RESEARCH METHOD

CONTEXT OF STUDY

There is a critical lack of stroke specialist expertise in most rural areas and in many urban areas as well. This contributes to a higher rate of stroke deaths in rural and underserved communities (Casper et al. January 2003). For the case of non-bleeding stroke, or ischemic stroke, TPA (Tissue Plasminogen Activator), a blood-clot dissolving agent, greatly reduces chances of severe disabilities if it is administered within three hours from the first show of stroke symptoms. It should, however, be avoided for bleeding patients, because it is fatal to them. Despite the potential benefits of the drug for ischemic stoke patients, it is estimated only 2% of stroke patients receive its benefits, due to lack of on-site expertise of stroke specialists who can discern ischemic and non-ischemic strokes.

In March 2003, the department of neurology at a large university hospital (referred to as the hub hospital) in the state of Georgia in the U.S. launched a telehealth innovation, called REACH (the Remote Evaluation for Acute Ischemic Stroke Program). REACH provides round-the-clock neurological service to rural hospitals in near-by areas through a telemedicine system. It makes centrally-located neurologists available to ER staff at rural hospitals enabling the central neurologists to hear, see, and receive data about patients over distance in real time. CT scan and other vital information about the patient at the rural hospital are transferred to the central expert over REACH and the neurologist makes a decision on the administration of TPA and follow-up treatments. The initial conception and implementation of REACH into the network of collaborating hospitals was largely a success; the involved neurologist at the hub hospital and the ER staff at the rural hospital found the system easy to use; and, more than 100 patients were successfully examined and subsequently treated during initial usage of REACH.

By the time of writing this paper, nine rural hospitals had joined the program. The innovators were at this point actively seeking ways to further diffuse REACH and the hub hospital was preparing to establish another hub by joining forces with another large hospital in the state. In January 2005, two entrepreneurs sponsored by a state R&D funding agency joined and formed a company (referred to as the Firm in the following) to commercialize REACH. The hub hospital and the two entrepreneurs went through several rounds of negotiations, but failed to reach an agreement on licensing and operation terms and conditions. As a result, the sponsorship of the state to the Firm deceased and the two entrepreneurs instead sought partnership with another company which possessed a similar technology.

RESEARCH DESIGN

A single case study (Yin 2003) was planned to study this telehealth innovation involving multiple organizations. Case study research is well suited to understand IT-based innovations in organizational contexts (Darke et al. 1998) and single cases allow researchers to investigate phenomena in depth to provide rich description and understanding (Walsham 1995).

There were three main data sources for the research: documents, interviews, and participant observation. All available documents were analyzed such as those related to system development and project management, financial documents, and publicly available articles from news media. 25 individuals in five hospitals including the hub and four rural hospitals were interviewed. Seven were doctors, five administrative staff, three technical staff, nine nurses, and one

radiology technician. All interviews were semi-structured, lasted typically between 30 and 60 minutes. The majority of interviews were individual and a few were group interviews of two to four. Interview notes were prepared right after each interview. The researchers also held nine advisory workshops with the two entrepreneurs of the Firm and these were documented in field notes. All interviews and workshops were recorded and transcribed. One of the authors had continued interaction with the state research funding agency having opportunities to learn about its position and support of the entrepreneurial launch for REACH.

The data were then analyzed to develop an institutional analysis of REACH. First, individual, key actors were identified and data were analyzed according to the four main components of the social-system framework based on research question 1. Second, major events were identified to anchor the context-level analysis of the infrastructure and the interactions between the components following research question 2. Differences among the researchers were resolved through discussions that resulted in iterative refinements of the overall analysis. This multi-level analysis helped us understand how the innovation was shaped in this particular context.

RESULTS

Actor-level Analysis

The core project group consisting of a group of neurologists and a system developer (referred to as the innovators in the following), the hub hospital, the rural hospitals, the Firm, and the state R&D funding agency sponsoring the entrepreneurial initiative of the Firm were the main actors driving the telehealth innovation. The innovators were treated as a separate stakeholder, as their interest in and perspective of REACH were distinct from those of the hub hospital as an institution, even though they were part of the organization. In the following, these actors are analyzed in terms of the four components of the industry infrastructure framework (see Table 2).

The innovators with the most enthusiasm and interest in REACH were active in relation to all four components. They were proactive in terms of proprietary activities by developing the web-based, cost-effective innovation. In developing REACH, they were able to leverage resource endowments by successfully appropriating scientific and technological knowledge and available competent labor and mobilizing those resources into their project. Scientific and technological research provided the knowledge needed to develop the telehealth innovation. For example, the system developer pointed out that LCD monitors and wireless network had become affordable in the market, making the innovation economically affordable. Overall, however, the innovators were effective in leveraging resources that were easily available; they did not manage to promote resource endowments to create a stronger and more sustainable platform for development. Also, in the early stages of the process they did not effectively take the institutional arrangements and market consumption components of the project into account. For example, REACH was designed as one-way system and therefore misaligned with the current insurance reimbursement scheme which required two-way video stream for reimbursement; only later in the process did the innovators engage in negotiations and explorations with insurance institutions and government agencies to resolve this reimbursement issue. When first conceived, the innovators did not vision REACH as a for-profit program and no formal business transactions were put in place to cover REACH installation and maintenance in the rural hospitals. Yet, driven by the medical interest in providing remote medical services to stroke patients, the innovators wanted to

enroll as many rural hospitals as possible into the REACH program. In this sense, the innovators did proactively address the market component of the framework.

	Innovators	*Hub hospital*	*Rural hospitals*	*Emerging Firm*	*Funding Agency*
Proprietary activities	Proactive	Supportive	Reactive	Proactive	Reactive
Resource endowments	Leverage	Provide	Leverage	Mobilize	Provide
Institutional arrangements	Negotiate	Indifferent	Concerned	Negotiate	Legitimize
Market consumption	Proactive	Supportive	Reactive	Proactive	Supportive

Table 2. Actor-level Analysis

The hub hospital supported the innovators' proprietary activities as they sponsored and hosted the development of the telehealth innovation. Also, the hospital financed provision of equipment and installation and maintenance of REACH in the participating rural hospitals. In doing so, the hospital leveraged available technological knowledge and resources and its activities related to resource endowments were at a similar level as the innovators'. The hub hospital gave little consideration to governance and legitimization issues and there were, as a result, no effective alignment of the innovation with institutional arrangements regarding reimbursement. The hub hospital and the innovators engaged in filing a patent, but no serious efforts were made to develop technology standards that could facilitate further diffusion of the program. In terms of the market consumption component, there were at this point no serious efforts to create a commercial market for REACH. The expansion of REACH was, however, supported by the hub hospital's outreach unit, promoting increased collaboration between the hub and near-by rural hospitals.

The rural hospitals were the most passive of the involved actors. They did not engage in any proprietary activities as the innovation was entirely developed and financed by the hub hospital. They were operating under similar conditions as the hub hospital and the innovators in terms of resource endowments, but they faced tougher conditions. Most of the rural hospitals had financial problems and they would most likely not have invested in the required infrastructure, such as digitized CT scanners and fast-network connections, had these not been provided for free by the hub hospital. Several rural hospitals also reported problems in maintaining IT resources; they had little IT staff (none or a single IT staff member); and, they experienced very high turn-over ratios of IT staff. Their limited budgets and operation deficits prevented them to taking actions to effectively resolve these issues. As the rural hospitals started to treat more patients through REACH, they also became aware that the U.S. government sponsored insurance programs like Medicare and Medicaid did not sufficiently reimburse the services provided. However, the rural hospitals did not take individual or collective actions to rectify these problems. Finally, other than participating in the new hospital network, they did not actively seek to further develop a market for the new innovation.

The Firm was established by two entrepreneurs in January 2005 to commercialize REACH. This commercialization initiative was sponsored by the state R&D funding agency. The two entrepreneurs were highly active and engaged like the innovators, though their activities were short-lived as the negotiation with the hub hospital and the innovators ended without results at the end of 2005. Their initial activities concentrated on developing a viable business and marketing plan and carving out a contract with the hub hospital about licensing and operational terms. The entrepreneurs were proactive in terms of proprietary activities, as they tried to engage in the business functions of marketing and sales on behalf of the hub hospital. They were also proactive in creating resource endowments, as they tried to mobilize resources to commercialize REACH by negotiating with potential investors including venture capitalists and angel investors. The ultimate goal of the entrepreneurs was to create a commercial market demand for REACH and to that end they explored all the components of the industry infrastructure framework.
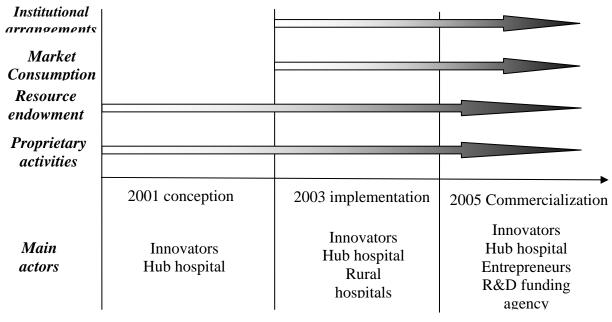
There were not many other actors involved at this point of the process. Since the innovation was new-to-the-world it had not yet created serious attention and response from potential actors such as regulatory agencies and insurance institutions within the healthcare industry. Only the state R&D funding agency emerged as an actor by sponsoring the two entrepreneurs to commercialize the innovation. By financing the firm, the agency clearly affected the resource endowments component and indirectly supported marketing and distribution activities in the proprietary component. The agency played a more conspicuous role in terms of the other two components of the industry infrastructure. The state funding agency's involvement in commercializing REACH lent some legitimacy and increased visibility to the innovation. Later, the funding agency was engaged in mediating the negotiations between the entrepreneurs and the hub hospital. Such activities are critical for new-to-the-world innovations because they help attract a critical mass of researchers to the field and build consumers' trust in the market (Van de Ven et al. 1999). The funding agency indirectly supported the activities to create the market consumption component.

Context-level Analysis

Next, we look at the industry infrastructure as a whole and the relations among its components and functions during the innovation process. Overall, there were three major stages of the innovation: the conception of the innovation in 2001, the system rollout and implementation during 2003, and the commercialization efforts in 2005. Figure 2 summarizes how the major activities and actors relate to these stages and involved the four industry infrastructure components. In the following, we detail this analysis further as summarized in Table 3.

The telestroke innovation was conceived by the neurologists at the hub hospital in 2001 and the development of the system began in 2002 financed by the neurology department. The core project team consisting of four stroke specialists and one system developer was formed around the investment. The development project was driven mostly by pure scientific and humanitarian motivations amongst the core project team members. During the period from the conception to the first roll-out of the innovation, the main activities were concentrated on system development, hence in the two industry infrastructure components of proprietary activities and resource endowments. The innovators and the hub hospital were the main actors involved. The two actors funded the development and equipment purchase to build the system and the hub hospital later financially supported most of the installation and the equipment for rural hospital rollout. However, other than the funding, the development activities were solely carried out by the innovators and no other business functions at the hub hospital like IT or Public Relations were

engaged at this point. The innovators did consider business process integration with practices in the adopting network of hospitals, but little attention as paid to develop a sustainable, long-tem business model for investments, expenses and rewards across the participating hospitals. The development was successful due to mature resource endowments, in particular in science and technology such as relevant neurological expertise and affordable hardware, software, and fast-access communication network services. In that sense, the two actors successfully appropriated resource endowments, but their activities were quite isolated without any collaboration with other actors, and also without active consideration of other components of the industry infrastructure. At this stage, no other actors emerged as significant except the hub hospital. Activities were concentrated in the proprietary components with resource endowments through the hub hospital.

	2001 conception	2003 implementation	2005 Commercialization
Institutional arrangements			
Market Consumption			
Resource endowment			
Proprietary activities			
Main actors	Innovators Hub hospital	Innovators Hub hospital Rural hospitals	Innovators Hub hospital Entrepreneurs R&D funding agency

(Note: the darker color of the arrows indicate increased level of activities)

Figure 2. Actors and Activities in relation to Stages and Infrastructure Components

The system rollout began in March 2003 with the first installation in a rural hospital and it continued to include nine rural hospitals by summer 2005. The innovators had the ambition to expand the innovation to the entire state and even to other states. New actors, namely the adopting rural hospitals, joined and interaction between the hub and the rural hospitals increased to handle complicated issues like contracts, legal issues, installations, and training of medical staff at the rural hospitals. During the initial adoption and expansion of the innovation, the involved actors began to show some activities in all the four components, including institutional arrangements and market components. With the growing use of REACH, both the hub and the rural hospitals began to realize the misalignment between the innovation and the institutional arrangements such as insurance reimbursement issues. The innovators engaged to remedy the situation by filing petitions to the insurance agencies like Medicaid and government agencies. However, the actions on the part of the other actors, the hub and the rural hospitals, remained minimal. No regulatory agencies and other institutions such as state regulatory or insurance-

related agencies were involved to resolve the problems as the innovation failed to generate much attention. Misalignment with institutional arrangements such as these emerged as potential barriers to further adoption of the innovation. In terms of the market component, the group of participating rural hospitals could be considered as an initial or potential market segment for the innovation, but transactions were implicit rather than explicit, indicating before-market stage of development. Market consumption with critical mass and demand could potentially have large impact on institutional arrangements by directing influential actors to pay attention and actively seek resolutions. For now, the four components began to witness activities to some degree, but underdevelopment and non-alignment of these components delayed further adoption and diffusion of the innovation.

In early 2005, two entrepreneurs sponsored by the state R&D funding agency created the Firm with an ambition to commercialize the innovation. The arrival of the two new actors greatly increased the level of activities in all four components. However, their activities were short-lived. The negotiations between the Firm and the hub hospital were difficult due to a gap in understanding between the two parties on issues like licensing and operating terms. The R&D funding agency tried to mediate the negotiation of a license agreement, a critical and principal resource to launch the Firm's activities. These attempts failed to reach agreement and the agency ceased to provide funding for the firm, leading to a halt of all the activities by the Firm. As a consequence, the hub, the Firm, and the agency lost this opportunity for continued diffusion of the innovation. The lack of collaboration and coordination among major actors (or the absence of mindset for collaboration) contributed to this lost opportunities.

	Context-level Analysis	Consequences
Proprietary activities	• *The innovation was not supported by general R&D activities within the hub hospital.* • *No or little influence from other business functions like IT or public relations.* • *Resources provided through hub hospital and funding agency.*	• *The innovation initiative was driven by a small group of people within the Neurology Department; this group subsequently engaged in attempts to diffuse the innovation through a commercial firm.* • *Proprietary activities were only minimally facilitating the development and implementation process.*
Resource endowments	• *Technology was sufficiently mature for stakeholders to appropriate, adopt, and provide for the innovation.* • *Financing of commercialization of the innovation was very limited.* • *Skilled human IT resources were available in the hub hospital to develop REACH, but the rural hospitals experienced difficulties maintaining the necessary human IT resources.*	• *The innovation was developed and initially adopted with actors leveraging existing industry resources.* • *Level of activities was the lowest compared with that in other components.*

Institutional arrangements	• *The innovation was not aligned with relevant laws and regulations such as insurance schemes.* • *The innovation was in later stages getting some attention from the state government R&D funding agency.* • *No standards exist for the innovation since it is among the first few of its kind.*	• *Lack of major efforts in the early stages and lack of coordination among actors limited further institutionalization and diffusion of the innovation.* • *Potential influencing actors such as insurance institutions and government agencies have not yet emerged.*
Market consumption	• *No transaction-oriented market other than the initial adopting organizations serving as a pre-market or the first market segment.* • *Not yet any explicit cultural norms among educated and informed customers.* • *Competition not emerged yet because similar technologies are localized or in their early commercialization stages.*	• *Efforts to engage early adopters (expanding REACH into more rural hospitals) were hampered by lack of alignment of the innovation with the strategic vision and business processes of participating organizations.* • *The first attempt to commercialize the innovation ended in a failure.*

Table 3. Context-level Analysis

DISCUSSION

We have presented a case study of a telehealth innovation that makes real-time, remote neurological expertise accessible to multiple rural hospitals. The innovation has been successfully developed and implemented into a network of hospitals. However, despite its affordable and easy-to-use technical features and potential life-saving medical benefits, the innovation's further diffusion rate is slow and a first attempt to commercialize the innovation failed. To understand why, we used the industry infrastructure framework (Van de Ven 2005; Van de Ven et al. 1989; Van de Ven et al. 1999) in an attempt to broaden our knowledge about telehealth innovations.

Understanding Telehealth Innovations

The first contribution of this research is the insights it provides into telehealth innovations. Earlier studies have emphasized how telehealth innovations can help provide medical services to rural communities (Adewale 2004; Chau et al. 2004; Mbarika 2004), the need to effectively support knowledge sharing across the boundaries of the adopting hospitals (Paul et al. 2004), and the importance of effectively establishing trust between the participating medical experts and patients (Brown et al. 2004; Paul 2006). In the case of REACH, the key driving force behind the innovation was to make scarce neurological expertise readily available to rural hospitals so that non-bleeding stroke patients could take advantage of TPA treatment within the available three hour window. Rural hospitals can not support the neurological expertise required to distinguish between bleeding and non-bleeding stroke cases, and without the collaboration with neurologists at hub hospitals, stroke patients in these areas cannot benefit from TPA treatment. REACH also

illustrates how neurological and general clinical knowledge can be shared between hub and rural hospitals, and the system is also conceived and implemented in a way that facilitates the required level of trust between the involved persons. The interesting insights from our analysis of REACH are, however, not related to these well-known aspects of telehealth innovations. Instead, our analysis adds to the emerging understanding of how telehealth innovations unfold and are shaped over time through interactions with the healthcare context (Chau et al. 2004; Constantinides et al. 2006).

The study by Chau et al. (2004) examined lessons learned from implementation of a neurology telemedicine program in Hong Kong. Using Cooper and Zmud's process model of technology diffusion (1990), they identified important issues related to initiation, adoption, adaptation, acceptance, routinization, and infusion of the innovation. They found that a number of factors played a key role in ensuring successful implementation (Chau et al. 2004): the motivation and drive of the neurological innovator; consensus amongst the core adopters; physician participation in adoption decision making and subsequent adaptation activities; effective electronic connectivity between sites; adequate financing of development, implementation, and subsequent servicing; and, effective integration of the new telemedicine service with existing medical processes and technological infrastructures. In the case of REACH, most of these factors were carefully managed to ensure successful implementation into the initial network of hospitals. The weakest aspects of REACH implementation were that adequate financing was provided mainly through dedicated hub hospital resources thereby jeopardizing the long-term sustainability and further diffusion of the program.

The study by Constantinides et al. (2005) investigated the implementation of a telemedicine system into the region of Crete, Greece, emphasizing the role played by power, by resistance to new medical practices enabled by IT, and by different forms of IT-artifacts. The key contribution of this study is the insights it provides into how negotiations between actors and artifacts, between development and use, and between traditional and new medical practices shaped the innovation process and its outcomes. Not surprisingly, negotiations also took center stage in the implementation and subsequent attempt to commercialize REACH. Negotiations took place between the innovators and the hub hospital, between the hub and the rural hospitals, and at a later stage between the two entrepreneurs, on one side, and the innovators and the hub hospital on the other side. Telehealth innovations are, indeed, particularly difficult because they cross organizational boundaries and challenge established configurations of aligned interests.

While our study of REACH in this way confirms emerging insights into telehealth innovation processes, it also provides new and important insights that can help us further explain the challenges involved. Most importantly, this study has provided a broader perspective on telehealth innovations as compared to earlier studies. First, in addition to the initial conception and implementation of the telestroke program our study has also emphasized continued attempts to further diffuse the innovation to make it readily available in other healthcare contexts. Second, we adopted a two-level analysis of the innovation process in terms of the four components of industry infrastructure: proprietary activities, resource endowments, institutional arrangements, and market consumption (Van de Ven et al. 1989; Van de Ven 2005). The resulting analysis shows that efforts related to proprietary activities and resource endowments were sufficiently effective to explain the successful development and initial implementation of the innovation. However, the other components of institutional arrangements and market consumption were not sufficiently mature, nor were influential actors engaged to effectively develop these components

to facilitate further diffusion of the innovation. Some actors emerged in attempts to address these components, but their initial efforts failed without tangible results. We suggest on that basis that this unbalance between the components of the industrial infrastructure created major barriers for further and wider adoption of the telestroke program.

The Industry Infrastructure Perspective

As a theory application study, this research also contributes to our understanding of how institutional theory, the industry infrastructure framework in particular, applies to IT-based innovations within healthcare. The industry infrastructure framework was initially proposed for industry-level analyses of emerging market segments and knowledge-intensive IT innovations (Van de Ven et al. 1989; Van de Ven 2005). Our study shows how the framework also can be used to support a multi-level analysis of a single IT-based innovation as an integral part of the network of hospitals and institutions in which it is embedded. This leads to new and quite useful interpretations of Van de Ven's basic propositions.

Van de Ven proposes that "actors who run in packs will be more successful than those who do it alone" (2005, page 370). In the context of industry-level analyses this means that entrepreneurs should simultaneously cooperate and compete with each other as they seek to develop and commercialize particular types of technological innovations. Such arrangements are analogous to the way competing bicycle racers cue their pace to one another and share the burden of breaking the wind until they reach the final stage of a race (2005, page 371). In contexts like REACH, focusing on a single IT-based innovation and its interaction with the industrial context, running in packs means that innovators should proactively address all industrial components, they should as early as possible engage in collaboration or negotiation with relevant actors, and they should seek to align interests to facilitate subsequent further diffusion of their innovation. This insight is emphasized by Van de Ven's second proposition: "actors with political savvy - an ability to recognize the interests of key actors and enroll them to one's viewpoint - will be more successful in effecting institutional change and realizing their goals than actors without political savvy" (2005, page 371). Further diffusing and commercializing innovations like REACH typically require resources that are beyond the capabilities of one hospital or a small group of innovators. It requires collective action across organizational boundaries and established configurations of aligned interest to successfully build an infrastructure that can facilitate continued innovation.

Overall, the industry infrastructure perspective can provide plausible and alternative explanations of why the healthcare industry is lagging behind in adopting and using IT. Healthcare entrepreneurs are therefore advised to apply the perspective to proactively manage IT-based innovations as integral parts of the organizational networks in which they are embedded. Doing so can expand their understanding of the complex and demanding conditions for IT-based innovations within the healthcare industry and it can help them identify and address institutional arrangements that represent important barriers to innovation.

Limitations and Further Research

As all other research, this study has limitations. Most importantly, the argument relies on a single case of a telehealth innovation that unfolded in a specific healthcare environment in the US. While we found Van de Van's industry infrastructure framework useful in this case as a lens to understand how agency and context interacted, some of the components and factors included in the framework might not apply equally well to other healthcare environments. Also, we have limited ourselves to analyze the case from the point of view of the components and factors

explicated in the industry infrastructure framework. We have not, at this point, attempted to systematically explore whether there are different components or factors that can help us understand how healthcare industry infrastructure shapes IT-based innovation. Further research is needed to further develop the framework as a useful approach the healthcare innovation. Such efforts should study other cases of IT-based healthcare innovations based on the framework, explore the usefulness of the framework in different healthcare environments (like for example Europe (Constantinides 2005), Asia (Chau 2004), and Africa (Adewale 2004; Mbarika 2004), and, investigate whether the components and factors of the framework could be tailored to better represent the specifics of the healthcare industry.

REFERENCES

(2004) Healthcare Information Technology Spending is Growing Rapidly. Sheldon I. Dorenfest & Associates, Ltd.

AARTS J, PEEL V and WRIGHT G (1998) Organizational issues in health informatics: a model approach. International Journal of Medical Informatics 52(3), 235-242.

ADEWALE OS (2004) An internet-based telemedicine system in Nigeria. International Journal of Information Management 24(3), 221-234.

ANDERSON JG (1997) Clearing the way for physicians' use of clinical information systems. Communications of the ACM 40(8), 83 - 90.

AVGEROU C (2001) The Significance of Context in Information Systems and Organizational Change. Information Systems Journal 11), 43-63.

AVGEROU C and MADON S (2004) Framing IS studies: understanding the social context of IS innovation. In: The Social Study of Information and Communication Technology (AVGEROU C, CIBORRA C and LAND F, Eds),Oxford University Press.

BERG M (2001) Implementing information systems in health care organizations: myths and challenges. International Journal of Medical Informatics 64(2-3), 143-156.

BRAA J, MONTEIRO E and SAHAY S (2004) Networks of Action: Sustainable Health Information Systems Across Developing Countries. MIS Quarterly 28(3), 337-362.

BROWN HG, POOLE MS and RODGERS TL (2004) Interpersonal Traits, Complementarity, and Trust in Virtual Collaboration. . Journal of Management Information Systems 20(4), 115-137.

CASPER ML, BARNETT E, WILLIAMS GIJ, et al. (January 2003) Atlas of Stroke Mortality: Racial, Ethnic, and Geographic Disparities in the United States SERVICES DOHAH (ed.), Centers for Disease Control and Prevention.

CHAU PYK and HU PJ-H (2004) Technology Implementation for Telemedicine Programs. Communications of the ACM 47(2), 87.

CHIASSON MW and DAVIDSON E (2004) Pushing the contextual envelope: developing and diffusing IS theory for health information systems research. Information and Organization 14(3), 155-188.

CHIASSON MW and DAVIDSON E (2005) Taking Industry Seriously in Information Systems Research. MIS Quarterly 29(4), 591-605.

CHO S, MATHIASSEN L and ROBEY D (2007) Dialectics of Resilience: A Multi-level Analysis of a Telehealth Innovation. Journal of Information Technology Forthcoming).

CONSTANTINIDES P and BARRETT M (2006) Negotiating ICT development and use: The case of a telemedicine system in the healthcare region of Crete. Information and Organization 16(1), 27-55.

COOPER RB and ZMUD RW (1990) Information Technology Implementation Research: A Technological Diffusion Approach. Management Science 36(2), 123-139.

COVI L and KLING R (1996) Organizational Dimensions of Effective Digital Library Use: Closed Rational and Open Natural Systems Models. Journal of American Society for Information Systems 47(9), 672-689.

CROWSTON K and MYERS MD (2004) Information Technology and the Transformation of Industries: Three Research Perspectives. Journal of Strategic Information Systems 13), 5-28.

DARKE P, SHANKS G and BROADBENT M (1998) Successfully completing case study research: combining rigour, relevance and pragmatism. Information Systems Journal 8(4), 273-289.

DAVIDSON EJ (2000) Analyzing Genre of Organizational Communication in Clinical Information Systems. Information, Technology, and People 13(3), 196-209.

DIMAGGIO PJ and POWELL WW (1983) The Iron Cage Revisited: Institutional Isomorphism and Collective Rationality in Organizational Fields. American Sociological Review 48(2), 147-160.

EGYHAZY C and MUKHERJI R (2004) Interoperability Architecture Using RM-ODP. Communications of the ACM 47(2), 93-97.

FITZGERALD G and RUSSO NL (2005) The turnaround of the London Ambulance Service Computer-Aided Despatch system (LASCAD). European Journal of Information Systems 14(3), 244-257.

GOLDSCHMIDT PG (2006) HIT and MIS; implications of health information technology and medical information systems. communications of the ACM 48(10), 68-74.

JOSEFSSON U (2005) Coping with Illness Online: The Case of Patients'Online Communities. Information Society 21(2), 133-153

LAMB R, KING JL and KLING R (2003) Informational Environments: Organizational Contexts of Online Information Use. Journal of the American Society for Information Science and Technology 54(2), 97-114.

LIANG H, XUE Y and BERGER BA (2006) Web-based intervention support system for health promotion. Decision Support Systems 42), 435-449.

LORENZI NM and RILEY RT (2003) Organizational ISSUES=change. International Journal of Medical Informatics 69(2-3), 197-203.

LORENZI NM, RILEY RT, BLYTH AJC, et al. (1997) Antecedents of the People and Organizational Aspects of Medical Informatics: Review of the Literature. Journal of the American Medical Informatics Association 4(2), 79-93.

MBARIKA VWA (2004) Is Telemedicine the Panacea for Sub-Saharan Africa's Medical Nightmare? Communications of the ACM 47(7), 21-24.

MENON NM, LEE B and ELDENBURG L (2000) Productivity of Information Systems in the Healthcare Industry. Information Systems Research 11(1), 83-92.

MERCURI RT (2004) The HIPAA-potamus in Health Care Data Security. Communications of the ACM 47(7), 25-28.

PAUL DL (2006) Collaborative Activities in Virtual Settings: A Knowledge Management Perspective of Telemedicine. Journal of Management Information Systems 22(4), 143-176.

PAUL DL and MCDANIEL JR. RR (2004) A Field Study of the Effect of Interpersonal Trust on Virtual Collaborative Relationship Performance. MIS Quarterly 26(2), 183-227.

PRATT W, UNRUH K, CIVAN A, et al. (2006) Personal health information management. Communications of the ACM 49(1), 51-55.

RAGHUPATHI W (1997) Health care information systems. Communications of the ACM 40(8), 80 - 82.

TANRIVERDI H and IACONO CS (1998) Knowledge Barriers to Diffusion of Telemedicine. International Conference on Information Systems, Helsinki, Finland, pp. 39-50.

VAN DE VEN AH (2005) Running in Packs to Develop Knowledge-Intensive Technologies. MIS Quarterly 29(2), 365-378.

VAN DE VEN AH and GARUD R (1989) Innovation and Industry Development: The Case of Cochlear Implants. Research on Technological Innovation Management and Policy 4), 295-325.

VAN DE VEN AH and HARGRAVE TJ (2004) Social, Technical, and Institutional Change: A Literature Review and Synthesis. In: Handbook of Organizationl Change and Innovation (POOLE MS and VAN DE VEN AH, Ed^Eds),Oxford University Press, Oxford, NY.

VAN DE VEN AH, POLLEY DE, GARUD R, et al. (1999) Building an Infrastructure for the Innovation Journey. In: The Innovation Journey, Ed^Eds),Oxford University Press, Oxford, NY.

WALSHAM G (1995) Interpretive Case Study in IS Research: Nature and Method. European Journal of Information Systems 4(2), 74 - 81.

YIN RK (2003) Case Study Research Design and Methods, Sage Publications, Inc.

Paper 2. The Dialectics of Resilience

Title: Dialectics of Resilience: A Multi-level Analysis of a Telehealth Innovation

This paper is coauthored by Sunyoung Cho, Lars Mathiassen, and Daniel Robey

THE DIALECTICS OF RESILIENCE: A MULTI-LEVEL ANALYSIS OF A TELEHEALTH INNOVATION

Abstract: *Resilience is commonly portrayed as a positive capability that allows individuals, groups, and organizations to thrive in dynamic contexts. This paper questions this oversimplified view based on a dialectical analysis of a telehealth innovation within a network of collaborating hospitals. We analyze the major contradictions that characterize the adoption of the innovation. First, we analyze contradictions between individuals and groups within each adopting organization. Second, we analyze contradictions between the adopting organizations. This multi-level analysis leads to a deeper understanding of resilience as a dialectical process. The analysis of the case shows that, although the participating individuals, groups, and organizations demonstrated apparent resilience in adopting the telehealth innovation, the innovation remained in a fragile state where it was unclear whether it would continue to diffuse, stabilize as-is, or slowly deteriorate. Hence, while resilience facilitated swift and successful adoption, it also created tensions that endangered further diffusion and the long term sustainability of the telehealth innovation. We suggest that understanding the future success of the innovation would be facilitated to a large extent by a dialectical analysis of the involved contradictions.*

Topic/Keywords: Resilience, dialectics, telehealth innovation

1. __INTRODUCTION__

The use of information technology (IT) within healthcare is increasing because of the information-intensive nature of the industry (Anderson 1997; Dwivedi et al. 2001). The investments in IT within healthcare have grown rapidly and were expected to reach 23.6 billion USD in 2003, rising at a rate of 9.3 percent from $21.6 billion expended in 2002 (News release of Sheldon I. Dorenfest & Associates, Ltd. http://www.dorenfest.com/pressrelease_feb2004.pdf). This growth is not surprising and will likely accelerate given that IT infrastructure and services in healthcare are estimated to be 10-15 years behind other industries such as banking, airlines, and manufacturing (Raghupathi, 1997). Since the late 1990s, telehealth innovations that include provision of health care services, clinical information, and education over distance using telecommunication technology have attracted special attention (Maheu et al., 2001).

The growing investment in IT within healthcare has led to increasing research interests in and experiments with healthcare and telehealth innovations (Chiasson and Davidson, 2004). Many of these studies investigate the particular problems that are related to implementation of IT-based innovations within the healthcare industry (Aarts and Peel, 1999; Berg, 2001; Lorenzi and Riley, 2003; Tanriverdi and Iacono, 1998). Different types of explanations for implementation problems are provided, including knowledge barriers and management issues (e.g. Tanriverdi and Iacono, 1998; Dwivedi et al. 2001), people and organizational issues (e.g. Lorenzi et al., 1997; Aarts et al. 1998; Berg, 2001), social communication patterns (Davidson 2000), organizational structure and culture (Bangert and Doktor, 2003), and enactments of different structures of reference by different stakeholder groups (Constantinides and Barrett, 2006). These studies point to the importance of organizational processes in explaining the success and failure of telehealth innovations.

The purpose of this study is to continue this line of research by investigating the relationship between organizational resilience and adoption of telehealth innovations. According to the literature, resilience refers to the capability of individuals, groups, or organizations to adapt quickly to changes in their environments (Coutu 2002; Hamel and Valikangas, 2003; Horne III, 1997; Mallak, 1998; Riolli and Savicki, 2003; Starr et al., Spring, 2003). We base our analysis on an in-depth case study of a telehealth innovation adopted in a network of collaborating hospitals. The adopting organizations and the key groups and individuals involved arguably demonstrated considerable resilience, resulting in successful implementation. However, many indicators suggest that the innovation reached a temporary and in some respects fragile acceptance, from which it might be unable to progress. To understand this outcome, we conduct a dialectical analysis (Bjerknes, 1991; Israel, 1979; Mathiassen, 1998; Robey and Boudreau, 1999; Robey et al., 2002) of the major contradictions that characterize this particular adoption initiative. We analyze contradictions at two levels of analysis: within each adopting organization, and between the adopting organizations. This analysis is guided by the following research questions:

1. How is resilience manifest at the organizational and inter-organizational levels of analysis in the adoption of a telehealth innovation?
2. How can the use of dialectics augment the analysis of resilience in the adoption of a telehealth innovation?

We argue that the future of the innovation depends upon the development and resolution of the involved contradictions. This analysis leads us to an understanding of the dialectics of resilience in relation to adoption of IT-based innovations in organizational contexts.

The study makes three distinct contributions. First, it contributes to research on organizational resilience (Contu, 2002; Mallak, 1998; Horne III, 1997; Hamel and Valikangas, 2003; Riolli and Savicki, 2003; Weick, 1993) by exploring the concept in relation to organizational adoption of IT-based innovations. We suggest that resilience in relation to adoption of innovations is an elusive concept inviting interpretations from multiple and often contradictory perspectives. Specifically, we argue that contemporary definitions of resilience raise interesting issues related to the dynamics of adoption behaviors and to interactions between different levels of analysis. Second, the study adds to our knowledge of dialectics, which is already established as a useful approach to IS research (Bjerknes, 1991; Mathiassen, 1998; Robey and Boudreau, 1999; Robey and Holmstrom, 2001; Robey et al., 2002; Sabherwal and Newman, 2003) and to organization studies in general (Das and Teng, 2000; Ford and Ford, 1994; Rond and Bouchikhi, 2004). Building on this tradition, we demonstrate a detailed approach to conceptualizing, identifying, and analyzing contradictions to uncover the complex dynamics involved in adoption of IT-based innovations. Finally, the study adds to our understanding of the challenges involved in adopting and managing telehealth innovations in an inter-organizational context.

The argument is structured as follows. The next section presents the theoretical foundation for the study by reviewing the literature on organizational resilience and on the use of dialectics in organization studies. After a discussion of the adopted research approach we continue with a dialectical analysis of resilience in relation to adoption of the telehealth innovation under examination. Finally, we discuss the contribution of this research and its implications for both research and practice.

2. <u>THEORETICAL FOUNDATION</u>

In this section, we review the two lines of research that this study builds on and contributes to: the literature on organizational resilience and the literature on the use of dialectics in organization studies.

<u>*Resilience*</u>

Resilience research has its origin in psychology (Coutu 2002). It started with pioneering studies by Norman Garmezy of different responses and attitudes of children whose parents were schizophrenic. Garmezy concluded that a quality of resilience played a role in the mental health of those children. Since then, many studies have been carried out and theories abound about characteristics of resilience (2003; Coutu 2002). The majority of these studies are at the individual level. Horne III and Orr (1998) note that the term resilience began to be applied as an organizational quality in the early 1990s. More recently, the concept of the "resilient organization" has gained popularity as a quality that might help organizations and groups within organizations survive and thrive in difficult or volatile environments (Riolli and Savicki, 2003).

Most definitions of resilience as an organizational quality emphasize its relationship with effective adaptation. Mallak (1998) defines resilience as the ability of an individual, group, or organization to expeditiously design and implement positive adaptive behaviors matched to the

immediate situation, while enduring minimal stress. Mallak considers organizational resilience as closely related to individual employees' resilience. Hamel and Valikangas (2003) define resilience as the ability to dynamically reinvent business models and strategies as circumstances change. Starr et al. (2003) use the term "enterprise resilience" as the ability to withstand systemic discontinuities and adapt to new risk environments. Horne III (1997) defines resilience as "a fundamental quality of individuals, groups, organizations, and systems as a whole to respond productively to significant change that disrupts the expected pattern of events without engaging in an extended period of regressive behavior" (p.31). In general, these definitions carry positive connotations. The underlying assumption is that resilient organizations thrive in dynamic environments.

For the sake of theoretical clarity, it would be better if the concept of resilience were decoupled from the concept of effective adaptation. Organizational resilience should be conceptually distinct from the outcomes with which it is associated. If it is not conceptually distinct, resilience becomes conflated and confounded with effective adaptation and its explanatory powers are removed. Reinmoeller and Baardwijk (2005) offer from that point of view a more promising approach in which resilience is regarded as a *process capability*, instrumental in overcoming barriers to change and in developing multiple sources of competitive advantage. Three advantages to this approach seem apparent. First, resilience is related to the process of change, where specific capabilities may play roles in overcoming specific barriers to change. Second, resilience is multi-faceted, not a single quality. Thus, organizations may possess some resilient capabilities and not others. Third, in a process perspective resilience becomes a capability that may be related to both successful and unsuccessful adoption behaviors. For example, under conditions of external threat, an organization might quickly adopt an innovation without any certainty that it will be sustained in the long run. Indeed, resilient responses in the short run might neglect more fundamental organizational capabilities related to long-run performance.

The process perspective on resilience is consistent with the usage of the term in ordinary language. *The Advanced Learner's Dictionary of Current English* defines resilience as the "quality or property of quickly recovering the original shape or condition after being pulled, pressed, crushed etc." (Hornby, 1988). In the context of adoption of IT-based innovations, this definition allows for two different and quite opposite interpretations. On the one hand, this definition can imply that a resilient organization is able to adopt an innovation and quickly recover from the interruption and return to serving its mission. On the other hand, this definition can also imply that a resilient organization is able to absorb or reject an innovation without any significant change. The ordinary language definition is neutral, allowing quite opposite interpretations of how organizations manage innovation adoption challenges. In either case, however, the question remains: is it in the long term interest of an organization to resiliently adopt (or abandon) the innovation in question?

When applied to organizational adoption of IT-based innovations, the concept of resilience remains elusive and raises two specific issues of interpretation. First, there are interesting issues related to the dynamics of adoption of innovations, as when organizations successfully implement innovations and later return to traditional practices because the innovations were not sufficiently institutionalized. In such cases, there is potential benefit to interpreting resilience over time from a process point of view. Second, there are interesting issues related to human agency in adoption practices. Resilience is not an abstract organizational capability. It needs to be interpreted as specific and complex interactions between different levels

of adoption behavior including individuals, groups, and organizational units. In other words, the analysis of resilience requires researchers to address levels-of-analysis issues (Klein and Myers, 1999). Resilience can be a single-level or a multi-level construct depending on the research context. As many IT-based innovations are networked and distributed, their adoption is enacted through complex social networks of multiple stakeholders. There is, therefore, a need to address issues related to level of analysis when applying resilience as a theoretical lens in this particular domain.

In summary, resilience is employed in this paper as a framework for studying adoption of IT-based innovations. We tentatively accept Reinmoeller and Baardwijk's definition of resilience as process capabilities existing at multiple levels of analysis including individuals, groups, and organizations. However, we augment this definition with a consideration of dialectics and contradictions to support a process view that decouples resilient adoption behaviors from adoption outcomes and allows us to engage in opposing interpretations of how organizations manage innovation adoption challenges.

Dialectics

Organizational change has been the subject of extensive research in the fields of both management (Ford and Ford, 1994; Van de Ven and Poole, 1995) and information systems, due to IT's role in organizational change (Mathiassen, 1998; Robey and Sahay, 1996). Dialectics has been adopted as one approach to understand and study social phenomena in general, and it has proven particularly useful as a framework to understand issues related to social change. Dialectics has been adopted in many organizational studies (Chae and Bloodgood, 2006; Das and Teng, 2000; Ford and Ford, 1994; Rond and Bouchikhi, 2004) as well as in many information systems studies (Bjerknes, 1991; Chae and Bloodgood, 2006; Mathiassen, 1998; Robey and Boudreau, 1999; Robey and Holmstrom, 2001; Robey et al., 2002; Sabherwal and Newman, 2003).

The core concept in dialectics is contradiction, for which a variety of definitions have been applied. According to Van de Ven and Poole (1995), dialectics assumes that organizations exist in a pluralistic world of colliding events, forces, or contradictory values that compete with each other for domination and control. The organizational consequences of IT can, therefore, be explained by reference to the relative strength of opposing forces, some promoting change and others opposing change (Robey and Boudreau, 1999). Other researchers build on Mao Tse Tung's more elaborate notion of contradiction to analyze social processes (Bjerknes, 1991; Israel, 1979; Mathiassen, 1998). Contradictions in these studies are seen as totalities that consist of two opposing elements. The opposites of a contradiction have two qualities – the identity of, and the struggle between the opposing elements. The identity refers to the contradiction as a whole and explains the paradox in which opposing elements co-exist. The struggle emphasizes the dynamics that drive change. In any given situation, the relationship between the two opposites is usually uneven so that one of the opposites exerts more influence. As time passes, the relationship between the opposing elements might change as a result of their mutual struggle. Also, there are typically several contradictions in any given situation, each with elements becoming more or less dominant as the situation evolves.

We see the different notions of contradictions discussed above as complementary. The main commonality underlying these understandings is their perspective that change is the outcome of contradictory forces. Put differently, the struggle between contradictions and between the opposites of each contradiction are the main forces driving change. In this study, we

adopt dialectics to analyze a situation where a telehealth innovation has been adopted by multiple organizations. Following Rond and Bouchikhi (2004), our assumption is that dialectics will help reveal the contradictions involved and that this, in turn, can lead to an understanding of key forces involved in shaping the present situation and the future trajectory of the telehealth innovation.

To support a detailed analysis of relevant contradictions, we follow Bjerknes' (1991) suggestion for identifying and analyzing contradictions. This analytic process occurs in three steps: 1) define specific contradictions, 2) analyze each contradiction's identity and struggles involving the two opposing elements, and 3) synthesize by considering all contradictions involved in the situation. To identify contradictions in the situation under investigation, we combine two sources. First, Bjerknes (1991) proposes focusing on conflicts, or antagonistic contradictions, while putting less emphasis on contradictions in which potential conflicts are temporarily resolved. Second, Robey at al. (1999; 2002) suggest that opposing forces may align with specific interest groups, or they can be conceived more abstractly, e.g., as cultural assumptions, institutionalized values or organizational memory. However conceived, contradictions can be identified and analyzed between different levels of social analysis (Bacharach et al. 1996).

3. RESEARCH METHOD

Research Context

In March 2003, the department of neurology at a large university hospital (referred to as the hub hospital) in the state of Georgia in the U.S. launched a telehealth innovation named REACH (the Remote Evaluation for Acute Ischemic Stroke Program). This "telestroke" system allowed neurologists from the hub hospital to use telecommunication to participate in real-time stroke assessments for patients in rural hospitals. The innovation was first implemented in one rural hospital and gradually expanded to a number of hospitals, with initial technical problems being detected and resolved effectively. At the time of our study between December 2004 and February 2005, the innovation had been adopted by seven rural hospitals. Between March of 2003 and May of 2004, doctors had used REACH to evaluate 75 patients and to qualify 12 of them for treatment.

The need for the REACH system was justified by the critical lack of stroke specialist expertise in most rural areas and in many urban areas as well. This contributes to a higher rate of stroke deaths in rural and underserved communities (Casper et al. 2003). For the case of non-bleeding, or ischemic, stroke, a blood-clot dissolving agent called tPA (tissue Plasminogen Activator) greatly reduces chances of severe disabilities if it is administered within three hours from the first show of stroke symptoms. However, it is estimated that only two percent of stroke patients receive its benefits, partly due to a lack of on-site stroke specialists. It is essential that a stroke specialist examine each stroke patient before tPA is applied. It is far from trivial to distinguish non-bleeding from bleeding cases, and applying tPA to a bleeding case will have immediate and most likely lethal consequences. Providing the services of stroke specialists over distances can therefore significantly increase the rate of tPA use, save many lives, and reduce chances of permanent disabilities.

The REACH system makes the hub hospital's stroke specialists available to examine patients at distant rural hospitals around the clock. It enables these neurologists to hear and see the patients in real time. A patient admitted to one of the participating rural hospitals gets a CT

(computerized tomography) scan to help pinpoint the cause and location of the stroke, while the hub hospital is notified about the incident and the on-call neurologist is connected. The patient is then moved to a room where the telestroke cart is located, and an emergency room nurse enters the patient's information and lab results into the system. The hub hospital neurologist, now connected to the rural hospital through REACH, evaluates the patient on a standardized stroke scale through video-based interactions while seeing CT scan results and lab data on a screen. Voice communication between the neurologist and the clinicians and patient at the rural hospital is conducted over a land-line telephone. Decisions on tPA administration and possible patient transfer are then made by the neurologist.

The implementation and operation of the REACH system were financed by the hub hospital, except that each rural hospital was responsible for the CT scanner and system infrastructure, including the fast network connection. The cost of building the telestroke cart with all necessary telecommunication, data processing, and video equipment for each rural hospital was paid by the hub hospital, and technical trouble-shooting was covered by the hub hospital's dedicated systems developer.

Case Study Design

A case study approach was adopted to study this telehealth innovation in the social context of the hub and rural hospitals. This choice is consistent with Yin's suggestion to consider three conditions to choose a proper research method: (1) the type of research questions posed, (2) the extent of control an investigator has over actual behavioral events, and (3) the degree of focus on contemporary as opposed to historical events (Yin 2003). First, a case study has advantages over other research methods such as surveys and experiments in answering questions of "how" and "why." Our research questions deal with explaining how a telehealth innovation is influenced by organizational processes traced over time. Second, our control over certain variables is not of concern in this study and we have no intention or ability to manipulate the involved behaviors. Finally, we are interested in a contemporary phenomenon of a telehealth innovation within a real-life context as opposed to historical events. In addition, there is broad consensus among researchers that a case study approach is particularly well suited to study the development, implementation, and use of IT-based innovations in organizational contexts (Benbasat et al. 1987; Darke et al. 1998)).

The research was designed as a single case study with multiple sites involved. Thus, we define the case as the network of adopting hospitals. This definition allows us to examine relationships at different levels of analysis within the network and within individual hospitals. Despite some limitations, single cases allow researchers to investigate phenomena in depth to provide a rich understanding of them (Walsham 1995). Data sources included complete analysis of the telestroke encounter process, systems documentation, demonstration of REACH, site visits to the hub hospital and four rural hospitals, stakeholder interviews, and other sources (see below).

Two of the authors participated in the field interviews. We interviewed 27 individuals in five hospitals including the hub and four rural hospitals. Seven were doctors, five administrative staff, three technical staff, nine nurses, one radiology technician and two entrepreneurs. Table 1 summarizes the profiles of the interviewees. All interviews were semi-structured, lasted typically between 30 and 60 minutes, and were recorded on audio tape. Most of the interviews were individual except for four group interviews with either two or four participants. We generated field notes immediately after each interview to summarize the key content and to suggest possible interpretations. Later, all the interviews were transcribed.

To support and verify interviews, other sources were sought and analyzed as well. For example, to verify local reimbursement practices, we obtained the patient demographic information for the participating rural hospitals. The project related documents, and scientific grant proposals for REACH were also analyzed. In addition, local newspaper articles and the hub hospital newsletters were analyzed, providing supplementary information about the rollout of REACH.

Interviewee Position	Number of interviewees	Organization
Doctor	7	Four neurologists at the hub hospital Three neurologists at the rural hospitals
Nurse	9	Rural hospitals
Administrative staff	5	One vice president at the hub hospital One middle manager at the hub hospital Two CEOs at two of the rural hospitals One CFO at another rural hospital
IT staff	3	Two at the hub hospital One at a rural hospital
Radiology technician	1	Rural hospital
Entrepreneur	2	A start-up independent of the hub hospital

Table 1. Interviewee profiles

Based on the interview notes and all related documents, the two field researchers developed content coding categories related to resilience in the adoption of the telehealth innovation. As a result, a comprehensive list of existing and potential contradictions for organizational resilience in the telehealth adoption was developed. This process was guided by the suggestions of (Bjerknes, 1991; Robey and Boudreau, 1999; Robey et al., 2002) with focus on contradictions among different stakeholder groups. The analysis revealed an initial set of ten intra-organizational and five inter-organizational contradictions. These two sets of contradictions related to adoption of the telehealth innovation were then grouped into more abstract categories of contradictions through rounds of discussions among all three authors. Disagreements amongst the authors were resolved with arguments based on evidence from the collected data. Through several iterations, a final set of three intra-organizational and three intra-organizational contradictions of relevance to the study was produced. These contradictions are summarized in Table 2 in the following section, which also presents the results of our analysis.

4. RESULTS

In this section, we provide a multi-level analysis of the adoption of REACH. First, we consider the resilience of the project initiator group; we then analyze the identified intra-organizational contradictions within each of the adopting organizations; finally we analyze the identified inter-organizational contradictions within the network of adopting organizations, including a new organization that emerged to commercialize the innovation.

Resilient Adoption
REACH was conceived by two neurologists working at the hub hospital. They were aware that the blood-clot dissolving drug, tPA, was extremely underused in rural areas because of a lack of stroke specialists. Their medical vision was to demonstrate the possibility of applying tPA through the use of telehealth innovations. In 2001, they launched a systems

development effort sponsored by the neurology department and the hub hospital. A core team was formed consisting of four stroke specialists and a dedicated systems developer to lead and conduct the innovation effort. All team members were patent owners of REACH, and they championed the innovation by visiting, persuading, and training clinicians and medical staff in the rural hospitals. The core team was also able to garner support for the project from CEOs of some rural hospitals within a two-hour driving distance from the hub hospital.

The individuals in the core team were very enthusiastic about REACH, its features, and its considerable potential for providing the neurological expertise required to apply tPA treatment in remote stroke incidents. They all shared the clinical and scientific vision that REACH could save stroke patients' lives and save many from permanent brain damage. They also realized the potential of telehealth services in other clinical practices and took pride in being pioneers in providing neurological services remotely. The members of the core team reacted swiftly to new technological opportunities in their environment; they formed a vision for telehealth innovation that could effectively extend available treatment opportunities (tPA) beyond current medical practices; and they created funding and formed a project that successfully realized that vision in collaboration between the hub and rural hospitals. In this way, the core group and the involved individuals demonstrated resilient adoption behavior.

The hub hospital also demonstrated resilience by proactively adopting telehealth innovations. The vice president of the hub hospital noted that "creation of a virtual delivery system is an ultimate goal and it is a win-win strategy in competition." According to him, the hub hospital had not sufficiently exploited its highly qualified medical staff because it served a rather small population base in competition with several other large hospitals. Forming alliances with rural hospitals and clinics seemed like a viable business model and growth strategy for the hub hospital. This would allow the hub hospital to provide clinical services to rural hospitals through systems like REACH and thereby effectively increase the number of patient referrals. Hence, the hub hospital recognized opportunities and threats in the environment, searched for new business models, and financially supported innovations like REACH, evidencing its resilience.

The network of participating rural hospitals also saw new opportunities related to this particular telehealth innovation. They were in many ways enthusiastic about REACH. According to one CFO at a rural hospital, about two-thirds of the rural hospitals were operating in the red and two of the four rural hospitals involved in REACH reported operational deficits in the previous fiscal year. It was common for regional hospitals to have severe shortages of specialists like neurologists, psychiatrists, and pediatricians. One nurse said that many rural hospitals were considered by local patrons as a "band-aid station," providing only temporary treatment. The rural hospitals saw opportunities to compensate for shortages of stroke specialists through REACH and to provide better clinical service and build their reputations through such telehealth innovations, even though they had no explicit revenue model for using the REACH system. In this sense, the rural hospitals demonstrated resilience by improving their practices and expanding their client base through adoption of the telehealth innovation.

Given these findings and the track record of 75 evaluated patients and 12 tPA treatments, it is fair to say that the individuals, groups, and organizations involved demonstrated the resilience required to successfully develop and adopt REACH, a radically new type of IT-based innovation that differed from previous practices at both the hub and the rural hospitals. But how sustainable was the innovation? Despite the project initiators' enthusiasm and support, the system subsequently faced problems of financing continued expansion. The volume of usage

remained low, generating problematic cost-benefit comparisons. Moreover, issues related to turning REACH into a fully institutionalized medical practice remained unresolved. To understand these issues more completely, we explore the demonstrated resilience from a process perspective by analyzing the contradictions involved in REACH. The major contradictions identified in REACH on both the intra- and inter-organizational levels are summarized in Table 2.

Level	Contradiction	Identity	Struggle	Consequence
Intra-organizational	Medical versus business interests	The long term survival of any healthcare organization depends on two opposites: provision of quality medical services and a sustainable business model.	The medical interests of the initiators of the innovation were not aligned with the business interests of the hub hospital.	Had more influence in development and early adoption stages.
	Emerging versus institutionalized work practices	IT innovations are contextualized against existing work practices, transforming them to some degree.	The emerging work practices around the telehealth innovation departed from the existing, institutionalized work practices.	Could be observed but had not yet emerged as significant.
	IT-based innovation versus established IT infrastructures	IT innovations build on and require changes in an organization's IT infrastructure.	The telehealth innovation was not designed with the existing IT infrastructure and capabilities of the adopting organizations in mind.	Had been recognized during the adoption at each rural hospital and will continue to impact further adoption initiatives.
Inter-organizational	Economic incentives of hub hospital versus rural hospitals	Urban hospitals and rural hospitals constitute different, but mutually dependent parts of the U.S. healthcare system.	The telehealth innovation implied different economic incentives for the hub hospital and the rural hospitals.	Had been recognized but not addressed.
	Emerging medical practices versus institutionalized insurance practices	Institutionalized insurance practices provide primary support for medical services, but they also define the conditions under which such services must be provided.	The emerging medical practices resulting from the telehealth innovation were not aligned with current insurance regulations for reimbursement.	Had been recognized from early on but was emerging as an issue.
	Hub hospital interests versus commercial explorations	Any commercialization effort must be aligned with the interests of the initiating hub hospital.	Conflicts of interests between the hub hospital and commercialization explorations derailed the negotiation process.	The first commercialization initiative failed.

Table 2. *Contradictions in adopting REACH*

We identified three major contradictions related to REACH within the hub hospital and the adopting rural hospitals.

Medical versus business interests. Provision of high quality and state-of-the-art medical services is central to any healthcare organization. At the same time, however, the organization should have a sustainable business model to maintain its long term existence. In that sense, the medical interests and the business interests are mutually dependent. This intrinsic relationship between two opposites constitutes the identity of this contradiction. In this case, we found these opposing elements to be in struggle. The medical interests had driven the development of the innovation without being aligned with the business interests of the hub hospital. REACH was first conceived as an academic pilot project, and the initiators did not explicitly consider the system's underlying business model. The following remark by one of the hub hospital neurologists illustrates the lack of consideration for business interests among the project initiators and champions:

> *"I don't have any business savvy. I know the system has been pushed through. I think it's been in the pipeline now for a year and a half or two years to get a patent on it. I don't know what to do with the patent after we have it."*

The medical interests dominated the business interests in the early development and adoption phases. Subsequently, when the system was actually being used at multiple sites, the struggle between the two opposites emerged as a conflict. One problem was that medical services provided from the hub hospital through the system were not properly reimbursed. In fact, the services that the central neurologists provided over the system were not properly reimbursed. Also, the hub hospital only had vague estimates of the system's impact on referrals, and the rural hospitals expressed concerns about the low reimbursement for stroke patients from Medicare and Medicaid.

Emerging versus institutionalized work practices. Adoption of IT innovations does not occur in a vacuum. Innovations are introduced into the context of existing work practices, transforming them to some degree. The newly emerging and the existing work practices constitute in this way two opposites that eventually need to be reconciled in new, institutionalized work practices for the adoption to be successful. This intrinsic relationship between old and new work practices constitutes the identity of this contradiction. The struggle between the opposites was in this case expressed as differences between emerging and existing work practices at the rural hospitals. REACH required extensive inter-departmental and inter-organizational communication and coordination, a practice that was quite different from existing work practices in the involved rural emergency rooms (ERs). One interviewee at a rural hospital said that, before REACH, they had not experienced such intensive communication and coordination between the emergency medical service unit, the radiology department, and the ER staff. Training and education of staff was an essential mechanism to overcome the gap between old and new practices. Initial training of rural hospital staff was provided by the hub hospital, and many of the rural hospitals later conducted their own training as needed. However, the struggle was not effectively resolved. In one rural hospital the volume of system usage was extremely low, with only three cases over an eighteen months period of system operation. One

nurse expressed concerns about using REACH following so few actual encounters with the system:

> *"Yeah, we probably do need to set up an annual training program. (It) would be good just so everybody—this is how you do it, you know…. Anything that you don't use often, you know, can bring that feeling on like, oh, am I going to do it right."*

Overall, the struggle of the opposites had yet to become manifest as a serious conflict because of the recent adoption of REACH and the small number of adopting hospitals. The institutionalized work practices were, however, only changing slowly, due in part to limited use and to limited opportunities to learn new practices.

IT-based innovation versus established IT infrastructures. Like any other IT-based innovation, REACH built on and required changes in the rural hospitals' IT infrastructure. The mutual dependency between the telehealth innovation and the capabilities of the available IT infrastructures within each rural hospital constitutes the identity of this contradiction. The two opposites were in struggle as REACH was not designed with the existing IT infrastructure of the rural hospitals in mind. REACH required certain IT capabilities and infrastructures in place for its operation, for example, high speed internet connections and digital CT scanners. However, some of the adopting rural hospitals lacked these capabilities. Also, most of the rural hospitals did not have fulltime IT employees. Those that did experienced high turnover of IT staff, making it difficult for the rural hospitals to maintain the needed IT capabilities. This struggle between the telehealth innovation and the IT infrastructure of the adopting hospitals was recognized from the early adoption stages. This struggle was expressed by the technology manager, who was hired by the hub hospital and provided the technical support for the participating rural hospitals through frequent visits:

> *"You must have a high speed bandwidth, at least 512 or 768. You must have the appropriate network drops in the CT scan room and in the emergency room. You must have the appropriate interfaces so that you can interface the CT scanner to the interface, and they were not able to or have been hesitant about providing those things."*

Inter-organizational Contradictions

We identified three major contradictions related to REACH involving the adopting hospitals, the hub hospital, and other related organizations.

Economic incentives of hub hospital versus rural hospitals. Urban hospitals and rural hospitals constitute different parts of the U.S. healthcare system. Rural hospitals serve smaller population bases and are geographically scattered around the nation, whereas urban hospitals serve larger populations with more resources and a more diverse portfolio of medical expertise. Urban hospitals support rural hospitals as well. Urban and rural hospitals are mutually dependent in that they cannot efficiently serve the entire population without each other. This interdependence between the economic incentives of the hub hospital and the rural hospitals to adopt telehealth innovations constitutes the identity of this contradiction. The introduction of REACH engaged the opposing incentives in a struggle, as the innovation generated increased

revenue for the hub hospital through stroke patient referrals. This is illustrated by the following informal economic estimate about REACH by a hub hospital administrator:

> *"Return on investment (of REACH) is very high. A patient that's referred, that actually is a stroke patient that comes into the net as a result of REACH being out there, ends up….we ended up looking at the first six patients at about a (several thousand dollars) net positive."*

By the same token, REACH implied lost revenue for the rural hospitals. A CFO of one rural hospital expressed deep concern over the revenue loss from using REACH at the rural hospitals:

> *"The program is very expensive. The costs of the drugs are very expensive and many times the patients that we're dealing with have no insurance or, in the cases of Medicare or Medicaid, are paid by DRG and that barely covers the cost of the drug itself. So, the economic impact of that is negative to our facility."*

According to this CFO, the population base of stroke patients at many rural locations was mainly elderly and insured by Medicare and Medicaid programs. Because those institutions' reimbursement was below the incurred cost, rural hospitals lost money on these patients. The CFO added that the hospital would have reconsidered their adoption of the innovation if this problem had been understood in advance. Similar complaints were echoed by the other rural hospitals. This contradiction did not emerge as significant in the development and early adoption stages because system installation and equipment were financed by the hub hospital with virtually no extra cost for the rural hospitals. However, it became an issue later as the innovation diffused.

Emerging medical practices versus institutionalized insurance practices. The U.S. healthcare system is currently sustained by public insurance systems, such as Medicare and Medicaid, and private insurers that reimburse providers of medical services. Medical practices and institutionalized insurance practices are mutually dependent and constitute an important identity in the U.S. healthcare system. These opposing elements are inherently in struggle. The emerging medical practices related to REACH were misaligned with insurance regulations for reimbursement. The reimbursement scheme required telemedicine systems to be based on two-way video interaction, a requirement that REACH failed to meet. One of the project initiators commented:

> *"Medicare says we need two-way video for this to be reimbursable and I think that's because that was always the way telemedicine was conceived, you know, that there would be two points…Either we get around that or we build a second in the video, but the other way, from the physician to the ER, and I think either one will take a while."*

In addition, the neurologist on the hub side, according to existing regulations, was required to have a medical license in the state in which the patient incident occurred and also be accredited by the rural hospital to participate (via telehealth services) in providing medical

service for their patients. As REACH was used more frequently, the struggle of these opposites became more pronounced.

Hub hospital interests versus commercial explorations. From the technology adoption life cycle and market development life cycle perspective (Moore, 1999; Moore, 2004), a successful innovation satisfies the interests of both the owners of the innovation and the stakeholders involved. By the same token, the interests of the hub hospital, the interests of future adopting hospitals, and any commercial exploration of REACH constitute an important identity in attempts to make the telehealth innovation commercially successful. Sponsored by state funds, two entrepreneurs were engaged to commercialize REACH. Rather late in the process of building a business plan for a commercial initiative, negotiations between the hub hospital and the entrepreneurs ended. The hub hospital and the involved entrepreneurs were unable to agree on a business plan that would satisfy the interests of both parties and effectively balance the economic interests between hub and rural hospitals in future adoptions of the innovation. The following remark by a hub hospital administrator indicated the deteriorating relationship between the two parties:

> *"So over a series of meetings and telephone calls, the relationships overall began to deteriorate, so it was in a sense (the hub hospital) camp saying we really need some changes in the business plan. The business model just needs some work, and their viewpoint, I assume, was that they didn't need our advice. They knew how to write business plans and, they just said, hurry up and give us this license and let us get to work, and we said—I said, my office is not going to cut a license with any company if it doesn't have what we think is a valid business plan... So our relationship started off nicely and then it took a nose dive."*

Without explicating the details of these negotiations, the break-down was an expression of the struggle between the two opposites of this contradiction manifest mainly between the hub hospital and the emerging new organization led by the two entrepreneurs, but also including the complex issue of balancing economic incentives between hub and rural hospitals in future adoptions of the innovation. The contradiction eventually led to failure of this attempt to radically change the underlying business proposition of the telehealth innovation.

Relationships between Contradictions

In addition to the dynamics related to the struggle between the opposites within each contradiction, there are also important dynamics of interaction between contradictions in a given situation (Bjerknes, 1991; Israel, 1979; Mathiassen, 1998). At any point in time, some contradictions may exercise more influence on the situation than others, and the relative salience of contradictions may change as the situation continues to unfold. We can therefore complement the analysis of individual contradictions by considering relationships between the contradictions involved in adoption of REACH. This analysis further helps us understand the dialectics of resilience as it played out in this particular case of a telehealth adoption.

The contradiction between the medical and the business interests dominated the adoption of REACH from its earliest development. The key stakeholders paid little attention to this contradiction as their promotion of the medical interests shaped the initiative. The contradiction was never resolved and appeared to threaten the long term success of REACH. This

contradiction was also related to the contradiction between economic incentives of the hub hospital and the rural hospitals. While this contradiction remained latent because the hub hospital absorbed most of the costs for equipment and installation, no attempts had so far been made to develop business models that would benefit all involved hospitals. Also, the contradiction between emerging medical practices and institutionalized insurance practices surfaced as a principal contradiction both in the hub and the rural hospitals. This contradiction made hospital management more conscious of the business interests for the telehealth innovation and led them to take a more conservative stance in financing the future of REACH. This in turn made the rural hospitals more attentive to the economic incentives for continued use of the innovation. While the contradiction between the economic incentives of the hub and the rural hospitals did not emerge as a major conflict, the business case for new rural hospitals to become involved remained weak as long as operational deficits continued and as long as the hub hospital expected the rural hospitals to share equipment and installation costs.

In the early adoption stage, the contradiction between the IT-based innovation and the established IT infrastructure emerged as a principal contradiction, as the project team had to deal with a variety of technological challenges in each adopting hospital. The impact of the contradiction was recognized by many stakeholders, but the fundamental contradiction was not resolved in time to avoid similar implementation issues as new rural hospitals became involved. The contradiction between the emerging and the institutionalized work practices and the contradiction between the hub hospital interests and commercialization explorations played minor roles in shaping the trajectory of REACH. However, there had so far not been any successful attempts to implement systematic training and education mechanisms for REACH. Also it had not so far been possible to involve new configurations of hub and rural hospitals as adopters of REACH because the contradiction between hub hospital interests and commercial explorations remained unresolved.

5. DISCUSSION

We have presented a case study of the adoption of a telehealth innovation. Through the analysis above, we have shown that the initiating project group, the individual hospitals, and the entire network of adopting organizations exhibited considerable resilience in adopting the telehealth innovation. However, our analysis also shows that the telehealth innovation arrived at a critical junction where it could either continue to be used and further diffused as a successful telehealth innovation, or it could be abandoned due to diminished financial support and sagging enthusiasm among key stakeholders. We argue that this crucial point in the innovation process arises because of the inherent contradictions within and across the network of adopting hospitals. The future of the innovation to a large extent depends on how these contradictions develop. From this perspective, resilience is best conceived as an ongoing process in which specific contradictions are confronted and resolved, at least temporarily. Given the interplay among multiple contradictions, each ebbing and flowing over time, resilience is not easily conceived as a general organizational quality. Rather, resilience emerges from one or more organizations' involvement in change processes and their attempts to recognize and resolve the contradictions involved in such efforts.

Our research contributes in this way to understanding organizational resilience as an important process capability in the context of adoption of IT-based innovations. Our study suggests that levels-of-analysis issues should be addressed explicitly in considering

organizational resilience. Resilience can be viewed as both a single-level and a multi-level construct depending on the research context. We agree with Klein and Myers (1999) that describing the target that a researcher aims to explain has become more critical as modern organizations increasingly interact within complex business networks. When researchers deal with network-level phenomena like telehealth innovations, the levels issue should therefore be carefully considered. As a consequence, our analysis of resilience included both the intra-organizational and inter-organizational levels.

Another important consideration in understanding resilience is the notion of time. We have shown how resilience can be understood in relation to the adoption of IT-based innovations from a process point of view, and demonstrated that the resilience of an entity can change over time. In the presented case study, a network of hospitals demonstrated initially high resilience by quickly and successfully adopting a telehealth innovation that in some respects transformed current medical practices. However, the analysis also indicated that the resulting new practices were in some respects fragile and that the adopting hospitals faced emerging contradictions that would influence the future trajectory of the innovation.

In addition, we have demonstrated how the use of dialectics can augment a process perspective. The main assumption behind our analysis is that contradictions are major influences on organizational change. By analyzing the opposing elements of each contradiction, we may understand the paradoxical identity of a phenomenon as well as the dynamic struggle between opposing forces. Moreover, the analysis of the relationships between multiple contradictions allows us to appreciate the shifting requirements of technical innovation (Bjerknes, 1991; Israel, 1979; Mathiassen, 1998). In this case, we identified six contradictions that shaped the adoption of a telehealth innovation, we analyzed the opposites involved in each contradiction, and we considered how the contradictions interacted during the adoption process. The relative importance of opposites and contradictions changed as the adoption process unfolded. In this way, we arrived at an understanding of the dialectics of resilience related to adoption of this particular telehealth innovation.

Finally, the contradictions presented in this study are supported by existing studies on implementation and adoption of healthcare innovations within individual organizations (e.g., Aarts et al. 1998; Berg 2001; Davidson and Chismar, 1999; Lorenzi and Riley, 2003; Lorenzi et al., 1997). Conflicts between emerging and existing work practices are well documented as main reasons of user resistance (Aarts et al., 1998; Berg, 2001; Kaplan et al., 2001; Lorenzi and Riley, 2003; Lorenzi et al., 1997), and other studies have also emphasized insufficient IT infrastructure within the healthcare sector (Anderson 1997; Fitzmaurice 1998) and critical issues related to reimbursement and alignment with regulations (Fitzmaurice 1998; Tanriverdi and Iacono, 1998). However, it is rarely documented how these issues relate and interact in complex processes of adopting healthcare innovations across networks of collaborating hospitals. Our study suggests that healthcare information systems research, especially related to telehealth innovations, need to go beyond organizational boundaries to provide a more comprehensive understanding of these issues in relation to adoption processes. Specifically, the study illustrates how important intra- and inter-organizational issues related to adoption of a telehealth innovation can be understood by employing a dialectical perspective on organizational resilience.

The study has its limitations as well. Most importantly, it draws upon a single case in a US context and it focuses on a particular type of telehealth innovation. Also, there are additional and relevant perspectives on resilience in relation to adoption of IT-based innovations – for example, operational versus strategic level considerations of resilience. Within the limitations of

the current study, however, all issues worthy of consideration could not be covered. Future research may pursue additional relevant perspectives on resilience.

6. <u>CONCLUSION</u>

This paper has addressed two questions: (1) How is resilience manifest at the organizational and inter-organizational levels of analysis in the adoption of a telehealth innovation? (2) How can the use of dialectical analysis augment the analysis of resilience in the adoption of a telehealth innovation? We argue that resilience can be a useful perspective to understand and explain key issues related to adoption of telehealth innovations and IT-based innovations in general. However, organizational resilience needs to be understood more broadly than is currently the case in the literature. Resilience applies across levels of analysis and it changes over time in the particular context of adoption of IT-based innovations. Resilience therefore lends itself well to a dialectical perspective in which the researcher uncovers the contradictions involved and explores how contradictions shape the adoption process. This approach leads to an understanding in which resilience facilitates swift and productive adoption of IT-based innovations while at the same time implicates tensions that endanger further diffusion and the long term sustainability of the innovation.

REFERENCES

Aarts, J., and Peel, V. (1999) Using a descriptive model of change when implementing large scale clinical information systems to identify priorities for further research, *International Journal of Medical Informatics* 56: 43-50.

Aarts, J., Peel, V., and Wright, G. (1998) Organizational issues in health informatics: a model approach, *International Journal of Medical Informatics* 52(3): 235-242.

Anderson, J.G. (1997) Clearing the way for physicians' use of clinical information systems, *Communications of the ACM* 40(8): 83 - 90.

Bacharach, S.B., Bamberger, P., and Sonnenstuhl, W.J. (1996) The Organizational Transformation Process: The Micropolitics of Dissonance Reduction and the Alignment of Logics of Action, *Administrative Science Quarterly* 41(3): 477-506.

Bangert, D., and Doktor, R. (2003) The role of organizational culture in the management of clinical e-health systems, in 36th Annual Hawaii International Conference System Sciences, (Island of Hawaii, U.S.A., 2003) 163 - 171.

Benbasat, I., Goldenstein, D.K., and Mead, M. (1987) The Case Research Strategy in Studies of Information Systems, *MIS Quarterly* 11(3): 369-386.

Berg, M. (2001) Implementing information systems in health care organizations: myths and challenges, *International Journal of Medical Informatics* 64(2-3): 143-156.

Bjerknes, G. (1991) Dialectical Reflection in Information Systems Development, *Scandinavian Journal of Information Systems* 3: 55-77.

Casper, M.L., Barnett, E., Williams, G.I.J., Halverson, J.A., Braham, V.E., and Greenlund, K.J. (2003) Atlas of Stroke Mortality: Racial, Ethnic, and Geographic Disparities in the United States, Department of Health and Human Services, Centers for Disease Control and Prevention.

Chae, B., and Bloodgood, J.M. (2006) The paradoxes of knowledge management: An eastern philosophical perspective *Information and Organization* 16(1): 1-26.

Chiasson, M.W., and Davidson, E. (2004) Pushing the contextual envelope: developing and diffusing IS theory for health information systems research, *Information and Organization* 14(3): 155-188.

Constantinides, P., and Barrett, M. (2006) Negotiating ICT development and use: The case of a telemedicine system in the healthcare region of Crete *Information and Organization* 16(1): 27-55.

Coutu, D.L. (2002) How resilience works, *Harvard Business Review* 80(5): 46-55.

Darke, P., Shanks, G., and Broadbent, M. (1998) Successfully completing case study research: combining rigour, relevance and pragmatism, *Information Systems Journal* 8(4): 273-289.

Das, T.K., and Teng, B.S. (2000) Instabilities of Strategic Alliances: An Internal Tensions Perspective, *Organization Science* 11(1): 77-101.

Davidson, E.J. (2000) Analyzing Genre of Organizational Communication in Clinical Information Systems, *Information, Technology, and People* 13(3): 196-209.

Davidson, E.J., and Chismar, W.G. (1999) Planning and Managing Computerized Order Entry: A Case Study of IT-Enabled Organizational Transformation, *Topics in Health Information Management* 19(4): 47-61.

Dwivedi, A., Bali, R.K., James, A.E., and Naguib, R.N.G. (2001) Telehealth systems: considering knowledge management and ICT issues, in 23rd Annual International Conference of the IEEE Engineering in Medicine and Biology Society, 25-28.

Fitzmaurice, J.M. (1998) Telehealth research and evaluation: implications for decision makers, in Medical Technology Symposium, 344 -352.

Ford, J.D., and Ford, L.W. (1994) Logics of identity, contradiction, and attraction in change, *The Academy of Management Review* 19(4): 756-785.

Hamel, G., and Valikangas, L. (2003) The quest for resilience, *Harvard Business Review* 81(9): 52-63.

Hornby, A.S. (1998) *Oxford Advanced Learner's Dictionary of Current English* Oxford University Press: Oxford, U.K.

Horne III, J.F. (1997) The coming age of organizational resilience, *Business Forum* 22(2/3/4): 24-28.

Horne III, J.F., and Orr, J.E. (1998) "Assessing behaviors that create resilient organizations," *Employment Relations Today* 24(4): 29-39.

Israel, J. (1979) *The Language of Dialectics and the Dialectics of Language* Munksgaard: Copenhagen.

Kaplan, B., Brennan, P.F., Dowling, A.F., Friedman, C.P., and Peel, V. (2001) Toward an Informatics Research Agenda: Key People and Organizational Issues, *Journal of the American Medical Informatics Association* 8(3): 235-241.

Klein, H.K., and Myers, M.D. (1999) A Set of Principles for Conducting and Evaluating Interpretive Field Studies in Information Systems, *MIS Quarterly* 23(1): 67-93.

Lorenzi, N.M., and Riley, R.T. (2003) Organizational ISSUES=change, *International Journal of Medical Informatics* 69(2-3): 197-203.

Lorenzi, N.M., Riley, R.T., Blyth, A.J.C., Southon, G., and Dixon, B.J. (1997) Antecedents of the People and Organizational Aspects of Medical Informatics: Review of the Literature, *Journal of the American Medical Informatics Association* 4(2): 79-93.

Maheu, M.M., Whitten, P., and Allen, A. (2001) *E-Health, telehealth, and telemedicine : a guide to start-up and success,* Jossey-Bass: San Francisco.

Mallak, L. (1998) Putting organizational resilience to work, *Industrial Management* 40(6): 8-13.

Mathiassen, L. (1998) Reflective Systems Development, *Scandinavian Journal of Information Systems* 10(1&2): 67-118.

Moore, G.A. (1999) *Inside the Tornado: Marketing Strategies from Silicon Valley's Cutting Edge* HarperBusiness: New York.

Moore, G.A. (2004) Darwin and the Demon: Innovating within Established Enterprises, *Harvard Business Review* 82(7/8): 86-92.

Raghupathi, W. (1997) Health care information systems, *Communications of the ACM* 40(8): 80-82.

Reinmoeller, P., and Baardwijk, N.V. (2005) The Link Between Diversity and Resilience, *MIT Sloan Management Review* 46(4): 61-65.

Riolli, L., and Savicki, V. (2003) Information system organizational resilience, *Omega : The international journal of management science* 31(3): 227-233.

Robey, D., and Boudreau, M.C. (1999) Accounting for the Contradictory Organizational Consequences of Information Technology: Theoretical Directions and Methodological Implications, *Information Systems Research* 10(2): 167-185.

Robey, D., and Holmstrom, J. (2001) Transforming municipal governance in global context: A case study of the dialectics of social change, *Journal of Global Information Technology Management* 4(4): 19-31.

Robey, D., Ross, J.W., and Boudreau, M.C. (2002) Learning to Implement Enterprise Systems: An Exploratory Study of the Dialectics of Change, *Journal of Management Information Systems* 19(1): 17-46.

Robey, D., and Sahay, S. (1996) Transforming Work Through Information Technology: A Comparative Case Study of Georgraphic Information Systems in County Government, *Information Systems Research* 7(1): 93-110.

Rond, M.d., and Bouchikhi, H. (2004) On the Dialectics of Strategic Alliances, *Organization Science* 15(1): 56-69.

Sabherwal, R., and Newman, M. (2003) Persistence and change in system development: a dialectical view, *Journal of Information Technology* 18(2): 69-92.

Starr, R., Newfrock, J., and Delurey, M. (2003) Enterprise Resilience: Managing Risk in the Networked Economy, in: *strategy+ business*, Spring 2003: 1-10.

Tanriverdi, H., and Iacono, C.S. (1998) Knowledge Barriers to Diffusion of Telemedicine, in International Conference on Information Systems (Helsinki, Finland, 1998), 39-50.

Van de Ven, A.H., and Poole, M.S. (1995) Explaining Development and Change in Organizations, *Academy of Management Review* 20(3): 510-540.

Walsham, G. (1995) Interpretive Case Study in IS Research. Nature and Method, *European Journal of Information Systems* 4: 74 - 81.

Yin, R.K. (2003) *Case Study Research Design and Methods*, (3rd ed.) Sage Publications.

Paper 3. Contextual Dynamics

Title: Contextual Dynamics during Health Information Systems Implementation: An Event-Based Actor-Network Approach

This paper is coauthored by Sunyoung Cho, Lars Mathiassen, and Agneta Nilsson

Note: All three authors made equal contributions and are listed in alphabetical order.

This version of the paper is a revised one based on the first round of reviews
and it was submitted to *Information and Organization*
on April 25th 2007

Contextual Dynamics during Health Information Systems Implementation: An Event-Based Actor-Network Approach

Abstract

Despite its information-intensive nature and considerable investments in technology, the healthcare industry continues to lag behind other industries in effectively exploiting information technology (IT) to reduce costs and improve quality of services. 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.

Based on data collected from 2001-2005 in a Swedish hospital, we apply Actor-Network Theory (ANT) to explore how the implementation of a radiology network system was shaped through interaction with the hospital context. The process analysis reveals how complex contextual dynamics had severe and disruptive effects on the efforts to implement the new system. 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. These findings suggest healthcare information systems implementation requires proactive leadership and significant dynamic capabilities to effectively learn about and adapt to the particular context in which these systems are embedded.

Seeking to understand contextual dynamics during healthcare information systems implementation and recognizing that ANT analyses like other process-oriented approaches easily become highly complex, we use events to focus, structure, and present the ANT analysis. The adopted event-based approach is intended to further our understanding of how researchers can apply ANT to study IT-based change in general.

Keywords: Healthcare information systems, Actor-network theory, Event-based analysis, IT-based change.

1. Introduction

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

The challenges related to successful implementation of IT-based innovations in healthcare are well-documented (Aarts, Peel, & Wright, 1998; Anderson, 1997; Berg, 2001; Davidson, 2000; Lorenzi & Riley, 2003; Lorenzi, Riley, Blyth, Southon, & Dixon, 1997; Menon et al., 2000; Raghupathi, 1997; Tanriverdi & Iacono, 1998). The reported challenges relate to a variety of areas such as knowledge and management (e.g. Dwivedi et al., 2001; Tanriverdi et al., 1998), people and organizations (e.g. Aarts et al., 1998; Berg, 2001; Lorenzi et al., 1997), 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 the implementation process in the particular context of the healthcare industry is, however, still limited despite a small, but growing body of knowledge that systematically explores context of HIS (Chiasson & Davidson, 2004). As a consequence, this paper seeks to contribute to the emerging contextual research on HIS by examining a particular information systems implementation effort. 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.

2. Research Objectives

We rely on data collected from 2001-2005 in a Swedish hospital about implementation of a radiology network system. As our main interest lies in understanding the dynamics of this implementation process (Robey, Ross, & Boudreau, 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; Callon & Law, 1989; 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 this analysis turned out to have severe and disruptive effects on the implementation of the radiology network system. Based on the insights from 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.

Seeking to understand contextual dynamics during HIS implementation and recognizing that ANT analyses like other process-oriented approaches easily become highly complex (Langley, 1999; Walsham, 1997), we use events to focus, structure, and present the ANT analysis. Event-based approaches have 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 therefore combine ANT with Newman and Robey's (1992) encounter-episode dichotomy to understand the implementation process as a sequence of events. 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.

Having two major objectives in a single paper makes it challenging to structure the argument. To address this challenge, we have 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.

3. 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 and 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 Information Systems (IS) is witnessing an increasing number of contributions to HIS research, though the major contributions still come from other fields, mainly medical informatics (Chiasson et al., 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 et al., 2004). Moreover, contextual approaches have more generally eluded attention within the IS discipline (Avgerou, 2001; Avgerou & Madon, 2004; Chiasson & Davidson, 2005; Crowston & Myers, 2004). 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 et al., 2004). As a consequence, Chiasson and 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 information systems interact with the specific characteristics of the healthcare context (e.g. Atkinson, 2000; Coombs, Knights, & Willmott, 1992; Hepworth, Vidgen, Griffin, & Woodward, 1992; Lapointe et al., 2005; Paul & McDaniel Jr., 2004; Pichault, 1995; Pouloudi, 1999; Sillince & Harindranath, 1998). In fact, we have only found a limited number of contextual studies of HIS implementation processes (i.e. Braa, Monteiro, & Sahay, 2004; Constantinides et al., 2006; Davidson & Chiasson, 2005; Fitzgerald & Russo, 2005; Jayasuriya, 1999; Lau et al., 1999). Two of these studies, i.e. 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 and Barret (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 process 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 and 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, reinforce, adjustments, and episodic change. The authors identified contextual factors that influences technology use mediation processes and outcomes, including the nature of the IT artifact (general purpose versus specialized), malleability of the software, institutional influences from the organizational environment, and organization size. Fitzgerald and 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 improvisational model for change management proposed by Orlikowski and 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, i.e. how the interaction between the implementation process, its content, and the context (Pettigrew, 1985, 1987, 1990; Pettigrew, Woodman, & Cameron, 2001) 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 et al., 1995).

4. Event-based ANT Analysis

ANT has its roots in sociology science (Callon, 1986; Latour, 1987) and aims to understand the processes that lead to construction and transformation of socio-technical networks (Callon et al., 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 et al., 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 relatively stable 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, i.e. 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 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).

Concept	Description
Actor (or actant)	Any material, i.e. 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
Enrollment	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 punctualisation	A temporary abstraction of a network that acts as a single unit so that the network efface into one actor

Table 1. Key Concepts in Actor Network Theory

Translation (Callon, 1986) implies transformation, which refers to how actors engage with other actors to generate ordering effects (Law, 1992). Callon (1991) emphasize 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 et al., 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, e.g. 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 punctualisation 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, 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, Coombs, Cooper, & Rea, 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, Timmermans, & Star, 1996); network building (Doolin, 1999); information infrastructure and inscriptions (Hanseth et al., 1997; Monteiro & Hanseth, 1996); temporal zones (Scott & Wagner, 2003); stakeholder maps in order to take into account multiple interests (Vidgen & McMaster, 1996); and embedded Trojan ac tor-networks to explain escalation (Mähring, Holmström, Keil, & Montealegre, 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,

Kwon, & Watts, 2004), and implementation and use of geographical information systems (GIS) 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 for example 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 et al., 1992; Peterson, 1998). To this end, Newman and Robey's framework (1992) views processes as sequences of events, classified as 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 considered change process?
2. *Analysis of encounters*: How did each of these encounters impact the established network configurations through episodes of translations?
3. *Synthesis of findings*: How can the analysis of encounters and episodes be synthesized into a comprehensive understanding of the overall change process?

In identifying candidate encounters, Gersick (1991) points out that 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 key temporal milestone that implies a change in the path of the change process. Also, we suggest focusing on events that social actors or stakeholders perceive to challenge the current configuration of the actor-networks. Subsequent analyses might reveal that 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.

5. Research Method and Context

Seeking contributions to our knowledge about implementation of HIS, this research investigates the following question: *How is implementation of healthcare information systems 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, 2006) based on dialectical epistemology (Cho, Mathiassen, & Robey, 2007; Robey et al., 2002; Van de Ven et al., 1995).

5.1 Research Method

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 four 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. In 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 email with project management.

During autumn 2001 and spring 2002, we participated in 10 project meetings for the new radiology network system. Each meeting lasted about two to three hours during which we took notes. In May, June, and September 2002, we conducted forty hours of observation of daily work, also taking notes, of the different clinics and professional groups involved in using the new system. Between February and May 2003, twelve semi-structured interviews were conducted, recorded, and transcribed, each between 30-90 minutes long. The interviews covered questions of how the users perceived the system and its impact on their work practice and they 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.

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 occur until some new stable networks are achieved eventually leading to modified or 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 and 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 amongst the involved actors.

In the data analysis, we looked for statements or events that indicated such 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 Section 4: 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.

5.2 Implementation 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 (RIS) 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 timesavings 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.
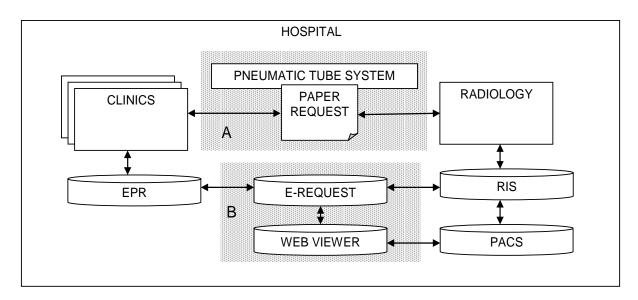
Figure 1. The Traditional (Area A) and the New System (Area B)

6. 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.

Figure 2. Encounters in Chronological Order

6.1 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. 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 ten times, approximately 2-3 hours 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 towards 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. 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. 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. 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 the 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.

6.2 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.

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 ward 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 logon 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 ward 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.

6.3 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 before implementation. 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 amongst physicians. The announcement of the big-bang implementation was therefore generally perceived as a threat. Physicians at the orthopedic clinic were frustrated and considered that the system was unreasonably unstable and slow, and physicians from other clinics feared that they would have to work with the new system in this unacceptable state. 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.

6.4 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. Single images were all right to review, but large sets of images from e.g. 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. Physicians would regularly ask nurses at the outpatient ward to request printed images. However, since 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. 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. Any 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.

6.5 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.

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 in the flow of work in 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. 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. 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.

6.6 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. 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.

6.7 Overall findings

The change process at the hospital was characterized by complex contextual dynamics that had severe and disruptive effects on the efforts to implement the new system. Many different configurations of actor-networks based on e.g. professional groups within and across organizational boundaries, established work practices, and project management 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.
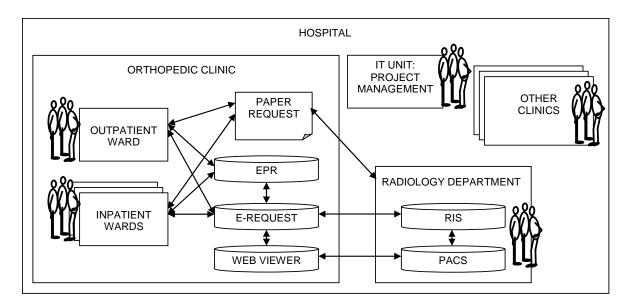
Figure 3. The Overall Hospital Context

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), the 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 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 interest 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 of the implementation process 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 towards 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 towards success.

7. 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 that a sequence of critical events had severe and disruptive effects on the process. Pettigrew suggests a contextualist approach based on the analytical categories of content, context, and process (Pettigrew, 1985, 1987, 1990; Pettigrew et al., 2001). 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 interacts and is shaped over time, in our case expressed through the description of a four 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 context, i.e. 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 interest in the prototype at an early stage, the physicians had no difficulties to influence 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 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 interest 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 a shared interest 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 et al., 2006), the nature and malleability of the IT artifact, institutional arrangements, and organizational size (Davidson et al., 2005), aggressive push and 'fear of failure' from project management (Fitzgerald et al., 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.

8. 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 et al., 1994; Holmström et al., 2001; Mähring et al., 2004; Walsham et al., 1999). 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 have explored whether some of the issues in ANT studies of IT-based change can be resolved by drawing upon other approaches to process analysis. We therefore combined ANT analysis with temporal bracketing to present and analyze data in successive episodes separated by encounters (Langley, 1999; Newman et al., 1992; Pettigrew, 1990).

A combination of these two approaches is feasible in the sense that both 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 et al., 1992). Mapping into encounters and episodes can help researchers adopt other specialized theories (like ANT) that deal with events (e.g. translations, inscriptions, and enrolments) over time (Newman et al., 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 electronic patient record systems in Norway, Hanseth et al. (2006) combined ANT with the theory of reflexive modernization.

A combination of the two approaches is also conceptually feasible. ANT is a process-oriented approach that focuses on tracing trajectories of interactions and associations of network elements (Latour, 2005; Law, 1992). Analysis of struggle is central to actor-network theory with its focus on exploring and describing local processes of patterning, ordering, and resistance (Law, 1992). By delving into translations, inscriptions, and enrolments, ANT theorists answer questions like: how actors and organizations mobilize, juxtapose, and hold together the bits and pieces out of which they are composed; how actors are sometimes able to prevent those bits and pieces from taking off; and how they manage to conceal for a time the process of translation and simplify the heterogeneous network of materials into one punctualized actor (Law, 1992). The encounter-episode approach is also process-oriented and helps

researchers understand the social dynamics involved in IT-based change by exploring how and why processes transform particular initial conditions into specific outcomes through sequences of encounters and episodes (Newman et al., 1992). In this respect, there is an immediate alignment between, on one hand, translations, inscriptions, and enrolments and, on the other hand, encounters and episodes. Translation, inscription, and enrolment constitute different and related types of events in ANT and applying Newman and Robey's approach challenges the researcher to perceive each such event either as an encounter that challenges the path of the process or as part of an episode triggered by some encounter. The researcher is in this way challenged to define and focus on those translations, inscriptions, and enrolments that make a difference (Isabella, 1990; Newman et al., 1992; Peterson, 1998).

The presented event-based ANT analysis of the implementation of a radiology network system at the Swedish hospital illustrates the character of ongoing change processes and the difficulty of anticipating the path of IT-based changes. The event-based analysis helped us identify important themes and present them in a structured and consistent manner aligned with general contextualist thinking (Pettigrew, 1985, 1987, 1990; Pettigrew et al., 2001). By focusing on one encounter and subsequent episode at a time, we could more easily at each stage identify which actor-networks were relevant and shaped the interactions between implementation content, context, and process. As a result, we arrived at a structured though rich and multi-dimensional understanding of the change process at the Swedish hospital.

ANT studies of IT-based change usually include events and describe them in chronological order (Holmström et al., 2001; Mähring et al., 2004; Scott et al., 2003; Vidgen et al., 1996; Walsham et al., 1999). 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 (Holmström et al., 2001; Walsham et al., 1999). Other presentations are structured using events that the authors have identified or conceptualized as being of particular interest to the case (Scott et al., 2003; Vidgen et al., 1996). Events also play varying roles in the analyses of the cases. Events are used to analyze network formation stages in Mähring et al's study (2004); they are used to characterize temporal zones in Scott et al.'s study (2003); Holmström et al. used events to illuminate strengths and weaknesses of different theoretical perspectives; Walsham et al's study used events to distinguish and describe processes of enrollment; finally, events were not included in the analysis by Vidgen and 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 a "focal point crests of high energy" (encounters) that separate different waves (episodes). Encounters became the main mechanism for emphasizing dynamics (Leonard-Barton, 1990; Newman et al., 1992) while less emphasis was put on events within each wave (Peterson, 1998). A key feature of our event-based ANT analysis is therefore that it explicates 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 and 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.

9. Conclusions and Implications

The objectives of this research were (1) to understand the contextual dynamics involved in HIS implementation, and (2) explore how ANT can be combined with event-based analysis to address some of the issues involved in focusing, structuring, and presenting such studies.

Our first contribution is the detailed analysis of the implementation of a radiology network system in a Swedish hospital. The analysis provides an understanding of how different interests and forms of agency interactively shaped the content, context, and process of implementing the new system. While the specific insights from the analysis of the case confirms findings from previous contextual studies of HIS implementation, this research also shows how HIS implementation dynamics can be understood as interactions between content, context, and process. The event-based process analysis revealed important dynamics related to the implementation content expressed as tensions between the radiology network system and medical work practices together with important dynamics related to the implementation context expressed as tensions between shifting networks of actors within the implementation project and the broader institutional setting.

The second contribution from this research is the proposed event-based approach to ANT analysis. This research has provided the rationale for exploring this new combination of process approaches, we have argued for the feasibility of such a combined approach, and we have offered a three-step guideline to help other researchers engage in event-based ANT analyses of IT-based change. Last, but not least, we have provided a practical example of how event-based ANT analysis was applied to a complex HIS implementation in a Swedish hospital.

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 makes a methodological contribution by demonstrating 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.

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. Managers should therefore adopt a contextual perspective from the start as a basis for proactively addressing them. At the same time, they should build significant dynamic capabilities into HIS implementation projects to effectively learn about and adapt to the particular context in which these systems are to become embedded. Such dynamic capabilities could include exploratory prototyping with alternative design options, exploration of alternative new work practices, iterations to include insights from pilots into better and more feasible design solutions, incremental implementation to reduce the risks involved in big-bang approaches, and, last but not least, active involvement of key stakeholders and amble room for negotiation between them.

editor and reviewers. These insights have greatly helped us frame the argument and streamline the presentation.

References

Aarts, J., Peel, V., & Wright, G. (1998). Organizational issues in health informatics: a model approach. *International Journal of Medical Informatics*, *52(3)*, 235-242.

Adams, S., & Berg, M. (2004). The nature of the Net: constructing reliability of health information on the Web. *Information Technology & People*, *17(2)*, 150-170.

Akrich, M. 1992. The de-scription of technical objects. In W. E. Bijker, & J. Law (Eds.), *Shaping technology / building society: studies in sociotechnical change*: 205-224. Cambridge Ma: The MIT Press.

Allen, J. P. (2004). Redefining the network: enrolment strategies in the PDA industry. *Information Technology & People*, *17(2)*, 171-185.

Anderson, J. G. (1997). Clearing the way for physicians' use of clinical information systems. *Communications of the ACM*, *40(8)*, 83 - 90.

Atkinson, C. J. (2000). The 'soft information systems and technologies methodology' (SISTeM): An actor network contingency approach to integrated development. *European Journal of Information Systems*, *9(2)*, 104-123.

Avgerou, C. (2001). The Significance of Context in Information Systems and Organizational Change. *Information Systems Journal*, *11*, 43-63.

Avgerou, C., & Madon, S. 2004. Framing IS studies: understanding the social context of IS innovation. In C. Avgerou, C. Ciborra, & F. Land (Eds.), *The Social Study of Information and Communication Technology*: Oxford University Press.

Bangert, D., & Doktor, R. 2003. The role of organizational culture in the management of clinical e-health systems. Paper presented at the 36th Annual Hawaii International Conference System Sciences, Island of Hawaii, U.S.A.

Berg, M. (2001). Implementing information systems in health care organizations: myths and challenges. *International Journal of Medical Informatics*, *64(2-3)*, 143-156.

Beynon-Davies, P. (1995). Information systems 'Failure': the case of the London Ambulance Service's Computer Aided Despatch Project. *European Journal of Information Systems*, *4(3)*, 171–184.

Bloomfield, B. P., Coombs, R., Cooper, D. J., & Rea, D. (1992). Machines and manoeuvres: Responsibility accounting and the construction of hospital information systems. *Accounting, Management and Information Technologies*, *2(4)*, 197-219.

Bloomfield, B. P., & Vurdubakis, T. (1994). Boundary Disputes: negotiating the boundary between the technical and the social in the development of IT systems. *Information Technology & People*, *7(1)*, 9-24.

Boland, R. J., & Schultze, U. 1996. From Work to Activity: Technology and the Narrative of Progress. In W. Orlikowski, G. Walsham, M. R. Jones, & J. I. DeGross (Eds.), *Information Technology and Changes in Organizational Work*. London: Chapman & Hall.

Bowker, G., Timmermans, S., & Star, S. L. 1996. Infrastructure and Organizational Transformations: Classifying Nurses' Work. In W. J. Orlikowski, G. Walsham, M. R. Jones, & J. I. DeGross (Eds.), *Information Technology and Changes in Organizational Work*. London: Chapman & Hall.

Braa, J., Monteiro, E., & Sahay, S. (2004). Networks of Action: Sustainable Health Information Systems Across Developing Countries. *MIS Quarterly*, *28(3)*, 337-362.

Callon, M. 1986. Some Elements of a Sociology of Translation: Domestication of the Scallops and eth Fishermen of St Brieuc Bay. In J. Law (Ed.), *Power, Action and Belief: a new sociology of knowledge*: 196-233. London: Routledge & Kegan Paul.

Callon, M. 1987. Society in the making. In W. E. Bijker, T. P. Hughes, & T. Pinch (Eds.), *The Social Construction of Technological Systems: New directions in the Sociology and History of Technology*. Cambridge, Mass: MIT Press.

Callon, M. 1991. Techno-economic Networks and Irreversibility. In J. Law (Ed.), *A Sociology of Monsters? Essays on Power, Technology and Domination*: 132-161. London: Routledge.

Callon, M., & Law, J. (1989). On the Construction of Sociotechnical Networks: Content and Context Revisited. *Knowledge and Society*, *9*, 57-83.

Chiasson, M. W., & Davidson, E. (2004). Pushing the contextual envelope: developing and diffusing IS theory for health information systems research. *Information and Organization*, *14(3)*, 155-188.

Chiasson, M. W., & Davidson, E. (2005). Taking Industry Seriously in Information Systems Research. *MIS Quarterly*, *29(4)*, 591-605.

Cho, S., Mathiassen, L., & Robey, D. (2007). Dialectics of Resilience: A Multi-level Analysis of a Telehealth Innovation. *Journal of Information Technology*.

Constantinides, P., & Barrett, M. (2006). Negotiating ICT development and use: The case of a telemedicine system in the healthcare region of Crete. *Information and Organization*, *16(1)*, 27-55.

Coombs, R., Knights, D., & Willmott, H. C. (1992). Culture, Control and Competition; Towards a Conceptual Framework for the Study of Information. *Organization Studies 13(1)*, 51-71.

Crowston, K., & Myers, M. D. (2004). Information Technology and the Transformation of Industries: Three Research Perspectives. *Journal of Strategic Information Systems*, *13*, 5-28.

Davidson, E., & Chiasson, M. (2005). Contextual influences on technology use mediation: a comparative analysis of electronic medical record systems. *European Journal of Information Systems*, *14(1)*, 6-18.

Davidson, E. J. (2000). Analyzing Genre of Organizational Communication in Clinical Information Systems. *Information, Technology, and People*, *13(3)*, 196-209.

Doolin, B. (1999). Sociotechnical networks and information management in health care. *Accounting, Management and Information Technologies*, *9(2)*, 95-114.

Dwivedi, A., Bali, R. K., James, A. E., & Naguib, R. N. G. 2001. Telehealth systems: considering knowledge management and ICT issues. Paper presented at the The 23rd Annual International Conference of the IEEE Engineering in Medicine and Biology Society.

Faraj, S., Kwon, D., & Watts, S. (2004). Contested artifact: technology sensemaking, actor networks, and the shaping of the Web browser. *Information Technology & People*, *17(2)*, 186-209.

Fitzgerald, G., & Russo, N. L. (2005). The turnaround of the London Ambulance Service Computer-Aided Despatch system (LASCAD). *European Journal of Information Systems*, *14(3)*, 244-257.

Gersick, C. (1991). Revolutionary Change Theories: A Multilevel Exploration of the Punctuated Equilibrium Paradigm. *Academy of Management Review*, *16(1)*, 10-36.

Hanseth, O., Jacucci, E., Grisot, M., & Aanestad, M. (2006). Reflexive Standardization: Side Effects and Complexity in Standard Making. *MIS Quarterly*, *30(Special Issue)*, 563-581.

Hanseth, O., & Monteiro, E. (1997). Inscribing behaviour in Information Infrastructure Standards. *Accounting, Management and Information Technologies*, *7(4)*, 183-211.

Hepworth, J. B., Vidgen, G. A., Griffin, E., & Woodward, A. M. (1992). The enhancement of information systems through user involvement in system design. *International Journal of Information Management 12(2)*, 120-129

Hine, C. (1995). Representations of Information Technology in Disciplinary Development: Disappearing Plants and Invisible Networks. Science. *Technology and Human Values*, *20(1)*, 65-85.

Holmström, J., & Stalder, F. (2001). Drifting technologies and multi-purpose networks: the case of the Swedish cashcard. *Information and Organization*, *11(3)*, 187-206.

Isabella, L. A. (1990). Evolving Interpretations As a Change Unfolds: How Managers Construe Key Organizational Events. *Academy of Management Journal*, *33(1)*, 7-41.

Jayasuriya, R. (1999). Managing Information Systems for Health Services in a Developing Country: a Case Study Using a Contextualist Framework. *International Jounral of Information Management*, *19(5)*, 335-349.

Kavanagh, D., & Araujo, L. (1995). Chronigami: folding and unfolding time. *Accounting, Management and Information Technologies*, *5(2)*, 103-121.

Langley, A. (1999). Strategies for theorizing from process data. *Academy of Management Review*, *24(4)*, 691-710.

Lapointe, L., & Rivard, S. (2005). A Multilevel Model of Resistance to Information Technology Implementation. *MIS Quarterly*, *29(3)*, 461-491.

Latour, B. 1987. Science in action : how to follow scientists and engineers through society. Cambridge, Mass.: Harvard University Press.

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

Lau, F., Doze, S., Vincent, D., Wilson, D., Noseworthy, T., Hayward, R., & Penn, A. (1999). Patterns of improvisation for evidence-based practice in clinical settings. *Information Technology & People*, *12 (3)*, 287-303.

Law, J. 1991. Introduction: Monsters, machines and Sociotechnical Relations. In J. Law (Ed.), *A Sociology of Monsters: essays on Power, Technology and domination*. London: Routledge.

Law, J. (1992). Notes on the theory of the actor-network: Ordering, strategy, and heterogeneity. *Systemic Practice and Action Research 5(4)*, 379 - 393

Leonard-Barton, D. (1990). A Dual Methodology for Case Studies: Synergistic Use of a Longitudinal Single Site with Replicated Multiple Sites. *Organization Science*, *1(3)*, 248-266.

Lorenzi, N. M., & Riley, R. T. (2003). Organizational ISSUES=change. *International Journal of Medical Informatics*, *69(2-3)*, 197-203.

Lorenzi, N. M., Riley, R. T., Blyth, A. J. C., Southon, G., & Dixon, B. J. (1997). Antecedents of the People and Organizational Aspects of Medical Informatics: Review of the Literature. *Journal of the American Medical Informatics Association*, *4(2)*, 79-93.

Mähring, M., Holmström, J., Keil, M., & Montealegre, R. (2004). Trojan actor-networks and swift translations - Bringing actor-network theory to IT project escalation studies. *Information Technology & People*, *17(2)*, 210-238.

Menon, N. M., Lee, B., & Eldenburg, L. (2000). Productivity of Information Systems in the Healthcare Industry. *Information Systems Research*, *11(1)*, 83-92.

Monteiro, E., & Hanseth, O. 1996. Social Shaping of Information infrastructure: On Being Specific about Tehcnology. In W. J. Orlikowski, G. Walsham, M. R. Jones, & J. I. DeGross (Eds.), *Information Technology and Changes in Organizational Work*. London: Chapman & Hall.

Newman, M., & Robey, D. (1992). A social process model of user-analyst relationships. *MIS Quarterly*, *16(2)*, 249-266.

Orlikowski, W. J., & Hofman, J. D. (1997). An Improvisational Model of Change Management: The Case of Groupware Technologies *Sloan Management Review*, *38(2)*, 11-21.

Orlikowski, W. J., Yates, J., Okamura, K., & Fujimoto, M. (1995). Shaping electronic communication: the metastructuring of technology in the context of use. *Organization Science*, *6(4)*, 423–444.

Paul, D. L., & McDaniel Jr., R. R. (2004). A Field Study of the Effect of Interpersonal Trust on Virtual Collaborative Relationship Performance. *MIS Quarterly*, *26(2)*, 183-227.

Peterson, M. F. (1998). Embedded Organizational Events: The Units of Process in Organization Science. *Organization Science*, *9(1)*, 16-33.

Pettigrew, A. M. 1985. Contextualist Research: A Natural Way to Link Theory and Practice, *Doing Research That Is Useful for Theory and Practice* San Fransisco, Washington, London: Jossey-Bass Publishers.

Pettigrew, A. M. (1987). Context and Action in the Transformation of the Firm. *Journal of Management Studies*, *24(6)*, 649-670.

Pettigrew, A. M. (1990). Longitudinal Field Research on Change: Theory and Practice. *Organization Science: A Journal of the Institute of Management Sciences*, *1(3)*, 267-292.

Pettigrew, A. M., Woodman, R. W., & Cameron, K. S. (2001). Studying organizational change and development: Challenges for future research *Academy of Management Journal*, *44(4)*, 697-713.

Pichault, F. (1995). The Management of Politics in Technically Related Organizational Change. *Organization Studies*, *16(3)*, 449-476.

Pouloudi, A. (1999). Information technology for collaborative advantage in healthcare revisited *Information & Management 35(6)*, 345-356.

Raghupathi, W. (1997). Health care information systems. *Communications of the ACM*, *40(8)*, 80 - 82.

Robey, D., Ross, J. W., & Boudreau, M.-C. (2002). Learning to Implement Enterprise Systems: An Exploratory Study of the Dialectics of Change. *Journal of Management Information Systems*, *19(1)*, 17-46.

Schultze, U. (2000). A Confessional Account Of An Ethnography About Knowledge Work. *MIS Quarterly*, *24(1)*, 3-41.

Scott, S. V., & Wagner, E. L. (2003). Networks, negotiations, and new times: the implementation of enterprise resource planning into an academic administration. *Information and Organization*, *13(4)*, 285-313.

Sheldon I. Dorenfest & Associates (2004) Healthcare Information Technology Spending is Growing Rapidly, Sheldon I. Dorenfest & Associates, Ltd.

Sillince, J., & Harindranath, G. (1998). Integration of requirements determination and business process re-engineering: A case study of an Ambulatory Care and Diagnostic (ACAD) centre. *European Journal of Information Systems*, *7*, 115-122.

Star, S. L., & Griesemer, J. R. (1989). Institutional Ecology, 'Translations' and Boundary Objects: Amateurs and Professionals in Berkeley's Museum of Vertebrate Zoology. *Social Studies of Science*, *19(3)*, 387-420.

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

Tanriverdi, H., & Iacono, C. S. 1998. Knowledge Barriers to Diffusion of Telemedicine. Paper presented at the International Conference on Information Systems, Helsinki, Finland.

Van de Ven, A. H., & Poole, M. S. (1995). Explaining Development and Change in Organizations. *Academy of Management Review*, *20(3)*, 510-540.

Vidgen, R., & McMaster, T. 1996. lack Boxes, Non-Human Stakeholders and the Translation of IT. In W. J. Orlikowski, G. Walsham, M. R. Jones, & J. I. DeGross (Eds.), *Information Technology and Changes in Organizational Work*. London: Chapman & Hall.

Walsham, G. (1995). Interpretive Case Study in IS Research: Nature and Method. *European Journal of Information Systems*, *4(2)*, 74 - 81.

Walsham, G. 1997. Actor-Network Theory and IS research: Current Status and Future Prospects. Paper presented at the IFIP TC8 WG 8.2 International Conference on Information Systems and Qualitative Research, Philadelphia, Pennsylvania.

Walsham, G. (2006). Doing interpretive research. *European Journal of Information Systems*, *15(3)*, 320-330.

Walsham, G., & Sahay, S. (1999). GIS for District-Level Administration in India: Problems and Opportunities. *MIS Quarterly*, *23(1)*, 39-66.

Yin, R. K. 2003. Case Study Research Design and Methods (3rd ed.): Sage Publications, Inc.

Title: From Adoption to Diffusion of a Telehealth Innovation

This paper is coauthored by Sunyoung Cho, Lars Mathiassen, and Mike Gallivan

This version of the paper was submitted to HICSS 2008

From Adoption to Diffusion of a Telehealth Innovation

CHO, MATHIASSEN & GALLIVAN

Computer Information Systems
J. Mack Robinson College of Business
Georgia State University

Please contact: sunyoung.cho@ceprin.gsu.edu

Abstract

Telehealth innovations promise to provide extensive medical benefits by increasing access to healthcare services and lowering costs at the same time. However, while many telehealth initiatives are considered technically viable and medically relevant, they often fail to go beyond the status of prototype applications. Motivated by our limited knowledge on how promising telehealth innovations are further diffused, this study offers a longitudinal investigation of a specific telehealth program and analyzes its initial adoption and further diffusion through commercialization initiatives. Framed as a diffusion of innovation study, the paper aims to offer research contributions as well as practical lessons. In terms of research, the paper expands our knowledge of the emerging IS research topic of telehealth innovations with an empirical investigation of a telehealth innovation. It also contributes to process-oriented diffusion of innovation research by challenging and expanding extant theories to a relatively new research context. In terms of practice, the study provides insights by detailing the transition process of a telehealth innovation from initial adoption to further diffusion and by identifying contextual issues that facilitates or challenges the transition.

Key words: Telehealth innovations, diffusion of innovation, commercialization, process model

Introduction

Telehealth innovations are considered to have great potential to help resolve important issues in healthcare. The potential benefits include enhanced accessibility to healthcare, reduced cost of care, and enhanced quality of care (U.S. Congress, Office of Technology Assessment, 1995; Bangert et al. 2003; Medicine 1996). Despite such potential, however, many telehealth innovations are either not accepted or not successfully implemented (Bangert et al. 2003; Medicine 1996). The reasons cited include poor technology performance, organizational issues, and legal barriers (Bashshur 2000). It is also widely acknowledged that users of such innovations, physicians and other medical staff in most cases, are notorious for their non-responsiveness to and resistance to use of information technologies (Anderson 1997, Lapointe and Rivard 2005).

Telehealth innovations originate from development in the manned space-flight program by the National Aeronautics and Space Administration (NASA) and from pioneering efforts of a few physicians using off-the-shelf commercial equipment (Zundel 1996). Telehealth projects vary with respect to goals, funding, and technology, but many large scale projects in the 1990s

were undertaken by large university hospitals with external funding from government agencies and industry (U.S. Congress, Office of Technology Assessment, 1995; Zundel 1996). Though telehealth has been practiced for more than 40 years, its status was until recently evaluated as being in the early stages of development (U.S. Congress, Office of Technology Assessment,1995). However, technology advances have now contributed to increased experiments with telehealth innovations that potentially can lead to improved business and product development, commercialization, sales, and job creation, though these impacts have not materialized yet (Jennett et al. 2006). In a typical life trajectory of telehealth innovations, many die out as they move out of the pilot project status after initial funding is exhausted despite being considered medically and technically viable solutions during the initial adoption stages. Unfortunately, we do not have enough understanding of this paradox. Nor do we understand what it takes for the successful innovations to further diffuse into a larger population of healthcare organizations. In other words, the processes from prototype development and initial adoption to further diffusion beyond the original source of telehealth innovations are not well understood. We have found no studies in the information systems (IS) literature that address this important issue directly. Motivated by this research gap, we investigate the following research questions in this study:

- ***Descriptive question:*** How is a telehealth innovation developed from its initial adoption by a small network of hospitals to wider diffusion into a larger population of organizations?
- ***Prescriptive question:*** What lessons can we suggest on how to successfully transition from initial adoption to wider diffusion of a telehealth innovation?

A case study was designed to answer these questions by closely following a telestroke innovation over two and a half years. The focal telehealth innovation was successfully developed and adopted by the initial network of hospitals and is currently undergoing a commercialization process. By closely following and examining these processes, this study aims at a number of contributions in terms of research and practice. First, it aims to contribute to telehealth innovation research by providing insights into what processes makes such an innovation survive the initial pilot stages and successfully undergo commercialization. There exist few studies that followed a longitudinal development of adoption and commercialization of a telehealth innovation. Second, this research aims to contribute to diffusion of innovation research, process-oriented approaches in particular, by examining the focal telehealth innovation from a diffusion of innovation perspective. The study expands this body of knowledge with an empirical investigation of technology diffusion in the field of healthcare, a relatively recent IS research domain. Specifically, the time boundaries of this research are expanded beyond the traditional diffusion of innovation research by covering initial adoption stages throughout diffusion of the innovation into a larger population of organizations. Finally, this study aims to provide practical insights by identifying and highlighting context-specific issues such as facilitating factors and obstacles for transitioning from initial adoption to wider diffusion of a telehealth innovation.

The study is structured as follows. The next section reviews telehealth innovation and diffusion of innovation research. Then, we discuss the case study design and the analysis framework in the research method section. Subsequently, we present our findings in the results section. We conclude this study with a discussion of its contributions and implications for both research and practice.

Theoretical Background

Telehealth innovations

The growing investments in information technology (IT) lead to increased use of and experiments with IT-based innovations. Healthcare has as a consequence emerged as an increasingly important domain in IS research with a steadily growing body of knowledge (Chiasson et al. 2004). In this paper, we focus on telehealth innovations as an important subset of IT-based innovations in the healthcare domain. Telehealth innovations have existed for about four decades. However, technology advances related to network technologies, advanced interfaces, and mobile technology have created a renaissance of such innovations since the 1990s (Maheu et al. 2001). As a result, increased use of IT to deliver healthcare services over distance have created new terminology such as telemedicine, telehealth, and e-health (Anderson 1997; Bashshur 2000; Maheu et al. 2001). Although exact definitions and boundaries of these terms are elusive (Bashshur 2000), telemedicine is broadly defined as provision of healthcare services, clinical information, and medical education over distance using telecommunication technology, whereas telehealth is seen as being a more encompassing term (Maheu et al. 2001). Telehealth encompasses the distant delivery of health services including clinical, educational, and administrative services, through transfer of various forms of information (e.g. audio, video and graphics) via telecommunication (Bali et al. 2001). Maheu et al. (2001) point out that the term telehealth has grown in popularity and is now used as a synonym for telemedicine.

Although the major contributions to telehealth innovation research comes from the field of medical informatics (Chiasson et al. 2004), the IS field has begun to offer contributions to this research topic (e.g. Adewale 2004; Brown et al. 2004; Chau et al. 2004; Constantinides et al. 2006; Liang et al. 2006; Mbarika 2004; Paul 2006; Paul et al. 2004). However, research questions and approaches vary significantly. Adewale (2004) and Mbarika (2004) discuss the potential and challenges of telehealth innovations in developing countries at national levels. Liang et al.'s study (2006) focuses on development of a web-based decision support system to encourage multiple sclerosis patients to continue a specific medication and provides the results of a preliminary evaluation of the system. Brown et al. (2004) propose hypotheses on individuals' interpersonal traits and their effect on willingness to collaborate and productivity of the collaboration in the context of telehealth innovations. Hence, these two studies analyze individual level adoption of telehealth innovations. In contrast, studies like Paul and McDaniel (2004) and Paul (2006) examine organizational performance of virtual collaboration through telehealth innovations. Other organization level studies approach the topic from the point of view of adoption and diffusion of telehealth innovations. For example, studies like Constantinides and Barrett (2006) and Chau and Hu (2004) investigate various aspects of organizational implementation of telehealth innovations. Constantinides and Barrett (2006) investigate the implementation process of a telehealth innovation in Crete with a focus on interrelationships between the context, the manner in which information systems are employed in practice, and the role of different technology artifacts. Chau and Hu (2004) analyze implementation of a Hong Kong-based telemedicine program using an IT diffusion model (Cooper et al. 1990; Kwon et al. 1987). These two studies analyze adoption of innovation into an initial adopting network of hospitals.

In the current literature, we found few studies which investigate how a telehealth innovation goes beyond its context of origin, how it gains sustainability, and how it migrates from a pilot state to a full-grown product through commercialization. This paper aims to fill this research gap by closely following a telehealth innovation from its initial adoption process through subsequent commercialization. We adopt a diffusion of innovation perspective in combination with a process-oriented perspective, a research approach that matches well the longitudinal nature of our case and the detail insights we have gained into the various stages of the process. Hence, drawing on the existing body of knowledge on diffusion of innovation, we seek to answer the posed research questions and in return contribute with new insights.

Diffusion of innovations

Research on innovation adoption and diffusion has been established as one of the major research streams in the IS field with a large body of knowledge accumulated (refer to summaries of this research stream by Fichman (2000) and Gallivan (2001)). In his classical model of innovation diffusion, Rogers defines diffusion as the process in which an innovation is communicated through certain channels over time among the members of a social system (Rogers 2003). In a similar vein, Fichman (2000) defines diffusion as the process by which a technology spreads across a population of organizations. We adopt this notion of diffusion with its focus on a larger population of organizations, which is clearly distinguished from the notion of adoption that is focused on innovation adopting entities whether they be individuals, or organizations. For example, Davis' (Davis 1989) Technology Acceptance model as well as Rogers' Diffusion of Innovation theory (Rogers' theory covers both individual level adoption and organizational level adoption) are the dominant frameworks explaining individuals' adoption and acceptance of technology and this individual-level research focuses on innovation characteristics and other contextual adoption factors (Fichman 2000; Gallivan 2001). Another approach to innovation adoption research at the organizational level is from a process perspective, which this study subscribes to. Rogers proposed five stages for innovation adoption in organizations and Kwon and Zmud (1987) and Cooper and Zmud (1990) have suggested another classical six-stage adoption process model.

These dominant theories of diffusion of innovations are criticized for their limited explanatory power (Fichman 2000; Fichman 2004; Gallivan 2001; Lyytinen et al. 2001). Fichman (2000) argues that innovation research based on Rogers' classical model focuses mainly on simple innovations being adopted autonomously by individuals and therefore it is less relevant to technologies adopted by organizations. Motivated by such limitations in the dominant theoretical frameworks, Gallivan (2001) argues that to explain more complex technologies and adoption scenarios we need to expand our processual understanding of innovations and he suggests a hybrid framework that incorporates processes and factors related to organizational adoption of innovations. Lyytinen and Damsgaard (2001) also recognize limitations of the assumptions underlying Rogers' diffusion of innovation theory which are not aligned with those of complex and networked technologies such as EDI. They argue that complex and networked technologies contain messy, complex problem-solving elements and such technologies are socially constructed as they shape and are shaped by society. Lyytinen and Damsgaard (2001) suggest process-based approaches to study complex, networked technologies; such approaches help achieve greater accuracy and deeper insights rather than simplicity and generalizability in traditional diffusion of innovation research.

Telehealth innovations exhibit a number of unique characteristics. Some of these characteristics fit well with the characteristics of complex, networked technologies suggested by Lyytinen and Damsgaard (2001). First, telehealth innovations are inter-organizational in nature. Second, telehealth innovations require considerable alignment of organizational procedures and policies by electronically linking multiple organizations and their work processes. Third, telehealth innovations require a considerable user mass to be efficiently deployed.

Somewhat unique to telehealth innovations is the fact that they are situated in complex institutional environments governed and strongly influenced by multiple regulatory and government-sponsored agencies (Bali et al. 2001; Bashshur et al. 1997). These additional characteristics are well addressed by a process-oriented research approach to capture the transition processes of the focal innovation from its initial implementation and adoption as a pilot project to further diffusion through commercialization. Process research analyzes sequences of events to explain how particular changes evolve over time (Markus et al. 1988; Mohr 1982; Newman et al. 1992) and it is valuable in investigating the context in which events occur and the causal linkages and temporal relationships unfold (Gallivan 2001). Specifically, this study adopts what Markus and Robey (1988) calls an emergent perspective on causal agency in IT and organizational change, which is well suited to the inter-organizational setting of this study. From an emergent perspective, behaviors of organizations emerge through dynamic interactions between diverse external circumstances and internal interests and motives.

Research Method

Case Study

An in-depth, longitudinal case study was designed to answer the proposed research questions. Generally, a case study is a preferred way of research when how and why questions are being posed (Benbasat et al. 1987; Darke et al. 1998) about a contemporary phenomenon in its context (Yin 2003). This is well aligned with the themes and phenomena of this process-oriented study focused on understanding the transition of a telehealth innovation from initial adoption as a pilot to further diffusion through commercialization. It is also desirable from the point of view that we as researchers did not have any control over the events and we seek to understand interactions between IT-related innovations and organizational contexts (Darke et al. 1998). Single case studies further allow researchers to investigate phenomena in depth to provide rich description and understanding (Walsham 1995).

Focal Innovation

In March 2003, the department of neurology at a large university hospital (referred to as the hub hospital) in the state of Georgia in the U.S. launched a telestroke program named the Remote Evaluation for Acute Ischemic Stroke Program, or REACH. This telestroke system allows neurologists from the hub hospital to participate in real-time stroke assessments of patients in rural hospitals. The innovation was first launched in one rural hospital and gradually expanded to a number of hospitals, with initial technical problems being detected and resolved effectively over time.

The need for the REACH system was justified by the critical lack of stroke specialist expertise in most rural areas and in many urban areas as well. This contributes to a higher rate of stroke deaths in rural and underserved communities (Casper et al. January 2003). For the case of

non-bleeding, or ischemic, stroke, a blood-clot dissolving agent called tPA (tissue Plasminogen Activator) greatly reduces chances of severe disabilities if it is administered within three hours from the first show of stroke symptoms. However, it is estimated that only two percent of stroke patients receive its benefits, partly due to a lack of on-site stroke specialists. It is essential that a stroke specialist examines each stroke patient before tPA is applied. It is far from trivial to distinguish non-bleeding from bleeding cases, and applying tPA to a bleeding case will have immediate and most likely lethal consequences. Providing the services of stroke specialists over distance can therefore significantly increase the rate of tPA use, save many lives, and reduce the risk of permanent disabilities. Between March of 2003 and May of 2004, doctors had used REACH to evaluate 75 patients and to qualify 12 of them for treatment. In late 2006, more than 400 patients have been evaluated through REACH at 9 rural hospitals with 55 having been treated with tPA.

In January 2005, two entrepreneurs sponsored by a state R&D funding agency joined and formed a company (referred to in the following by the pseudonym *BrainCare Inc.*) to commercialize REACH. The hub hospital and the two entrepreneurs went through several rounds of negotiations, but failed to reach an agreement on licensing and operation terms and conditions. As a result, the sponsorship of the state to *BrainCare Inc.* ceased by the end of 2005. A few months after the first failed commercialization attempt, the REACH initiators (a group of neurologists at the hub hospital) established another company (referred to in the following as the pseudonym *BrainConsult*) to continue commercialization of the innovation. Gaining some momentum from winning a state technology competition, the initiators found their first potential customers in September 2006 and continued expanding their market nationwide.

Data Collection and Analysis

It is typical that case research utilizes multiple data sources (Miles et al. 1994; Yin 2003). In this study, multiple data sources have been sought to ensure triangulation (Yin 2003). Data sources include systems documentation, public articles, stakeholder interviews, and workshops. A total of 26 individuals in five hospitals (hub hospital and four rural hospitals) have been interviewed to examine the initial adoption process of the innovation: seven doctors, six administrative staff, three IT staff, nine nurses, and one radiology technician. Detailed analyses of the initial adoption process of the innovation was reported in two previous studies (Cho et al. 2006; Cho et al. 2007)

Following the commercialization initiatives, the first two authors held 12 workshops and follow-up meetings with the two entrepreneurs of *BrainCare Inc.* to discuss business plans and strategy. The researchers also interviewed five individuals from *BrainConsult* including the CEO and members of the Board of Directors. Individualized interview protocols were developed before interviews through discussions and iterations between the interviewing researchers. All the interviews and workshops were recorded and interviews were transcribed for later analyses.

Interview notes were made during and immediately following each interview and workshop. In most cases, the two authors held debriefing sessions among themselves exchanging their summaries of major points of each interview and workshop. This practice ensured a rounded and multi-faceted understanding of data and enhanced inter-subjectivity in the initial interpretation of data.

The data were further analyzed later focusing on the process of initial adoption and further diffusion. First, events were identified to chronologically chart the process of adoption and diffusion of the focal innovation. According to Miles and Huberman (1994), such a listing of

events provides insights in terms of "what led to what and when." Key actors were then identified as well as their actions and implications for further diffusion. Then, a process model to describe and explain the initial adoption and further diffusion was established through rounds of discussions among all three researchers. Differences among the researchers were resolved through discussions that resulted in iterative refinements of the overall analysis. The analysis was hence an iterative process that continued until consensus was established among the researchers. The following are the results of this case analysis.

Results

The results are presented in four phases – adoption, implementation, commercialization, and diffusion (Table 1). For each phase, we identify the main actors and describe and analyze their actions. These results provide insights on how the process unfolded.

Phase & Key Events	Actors (who)	Actions (what)
Adoption • Innovation conceptualized • Hire graduate student • Hire full-time developer	• Neurologists • System developer • Hub hospital	• Conceptualized by hub-hospital neurologists • Relationships with target rural hospitals cultivated • Implemented by dedicated developer
Implementation • First roll-out • Gradual inclusion of rural hospitals	• Neurologists • System developer • Rural hospitals	• Roll-out one by one • Tried to resolve technology issues at rural hospitals • Tried to resolve financial issues at hub and rural hospitals
Commercialization • Firm established • Tech competition • Contract for system upgrade • Hire CEO	• Firms (*BrainCare Inc.* and *BrainConsult*) • State funding agency • Hospital administration • Neurologists	• Negotiations between the hub and *BrainCare Inc.* • Establishment of *BrainConsulIt* • System reengineering • Market development
Diffusion • First customer	• *BrainConsult* • Customers • Competitors	• Further market development • Negotiation between competitors

Table 1. Actors and activities involved in the telestroke innovation

Adoption

The first phase of adoption covers the initiation of the telestroke system development in 2000 to the roll out of the system to the first rural hospital in 2003. The innovation was driven by a group of four neurologists with one doctor serving as the champion of the innovation. The neurologists had long cherished the idea of a telestroke system that could link them effectively to rural hospitals and they started to implement this idea by hiring a technically skilled medical student for system development in 2000. A year later, after the student left for residency in another hospital, the neurology department employed a full time system developer. The system developer and the four neurologists quickly developed rapport and formed a committed and well-functioning team. In the first phase of adoption, the neurologists played a key role as the primary driving force. They were simultaneously the project champions and end-users, as well as heavily involved in the development process. The neurologists basically controlled the process and interacted constantly with the system developer by sharing their work practices and ideas and by providing feedback to support incremental development of the system. Also, in parallel to developing REACH, the neurologists cultivated relationships with nearby rural hospitals by visiting them and educating the medical staff on how to collaboratively diagnose and treat ischemic strokes. During frequent visits, the neurologists were able to understand the operational conditions at the rural hospitals as well as user (ER physicians) needs. The telestroke initiative was supported by top management at the hub hospital, more specifically the CEO and one vice president for service outreach. The neurologists were actively promoting REACH and were able to get financial support for system development and equipment purchase for rural hospital installation. The first phase of adoption was dominated by the activities of the small group of highly motivated neurologists. Through these activities and close collaboration with a few other stakeholders, they managed to successfully develop REACH as a medically feasible telestroke system.

Implementation

The phase of implementation covers the first rollout of the telestroke system in March 2003 and its continued expansion into a network of rural hospitals. During this phase, REACH was gradually rolled out to a total of nine rural hospitals as of December 2006. The neurologists continued to play an important role by negotiating the system launch with nearby rural hospitals. Once a rural hospital agreed to participate in the telestroke network, the system was provided and installed by the hub hospital without any costs shared by the rural hospital. The system developer played an increasingly important role by almost single-handedly managing system installation in each rural hospital as well as subsequent trouble-shooting and maintenance. As REACH expanded into more rural hospitals, two categories of issues emerged as being important for the involved stakeholders. One was technical issues and the other was reimbursement issues. The limited IT resources at rural hospitals surfaced as a serious problem. Most of the rural hospitals did not have full-time IT staff, and there was therefore no consistent communication interface to address technical issues between the hub hospital and the rural hospitals. As a consequence, the system developer at the hub hospital had to handle even minor technical problems at the rural hospitals, though later a full-time technician was hired by the hub hospital to oversee technical implementation and system trouble-shooting. In some cases, system installation significantly fell behind schedule due to lack of fast internet connection and digital CT scanners in the rural

hospitals. Over the process of gradual expansion, the knowledge base about REACH and its use continued to grow; but it remained difficult to leverage these experiences in the context of the rural hospitals. Another group of issues were related to reimbursement. The medical services provided by the neurologists through REACH were not reimbursed because the system configuration did not meet the two-way video link requirement for telemedicine to receive proper reimbursement. Also, the rural hospitals were under-reimbursed for their services through REACH because the majority of their patient base was covered by Medicare and Medicaid - government insurance institutions which were known for under-reimbursement of medical services. Despite these technical and financial issues, the telestroke system continued to expand into more rural hospitals. However, there were no systematic and successful attempts to develop and negotiate sustainable models that would effectively resolve the technical and financial issues related to the innovation.

Commercialization

The beginning of the commercialization phase was dominated by two entrepreneurs who established *BrainCare Inc.* to commercialize the telestroke system. Engaged by the neurologists and funded by a state R&D agency in the state of Georgia, the two entrepreneurs negotiated conditions with the hub hospital and the neurologists while developing a detailed business plan and searching for additional funding sources and potential customers. However, the relationship between the firm and the hub hospital deteriorated over issues of licensing and operation terms and the negotiations ended in failure at the end of 2005. The initial funding ceased and *BrainCare Inc.* was dissolved. As the neurologists ended negotiations with the two entrepreneurs, they started to explore alternative commercialization opportunities themselves. They filed for a Small Business Innovation Research (SBIR) grant from NIH by establishing a firm (*BrainConsult*) on their own. At the same time, the telestroke system almost reached a local saturation point with the single hub hospital covering nine nearby rural hospitals. At this point, the innovation faced funding problems for further local expansion and the neurologists increasingly emphasized diffusion of REACH nationwide based on its success within the local network. Applying for the SBIR grant created momentum for these efforts and required the neurologists to establish *BrainConsult* on March 2006. At the same time, the project initiators won a state-wide technology competition in May 2006, which created wider recognition of REACH and brought in prize money of $100,000. Winning the competition boosted enthusiasm and confidence among the various stakeholders. A new CEO with software development background was hired and the system was reengineered to increase reliability and scalability. Up to this point, the key stakeholders did not have business experience and were mainly driven by solid medical expertise and interest in how technology could become useful in treating ischemic stroke patients. The new CEO, who did not have any healthcare industry experience, brought much needed business experience and solid technological capabilities to the team. As a result, business plans and technology infrastructure were developed and during these activities potential customers started approaching *BrainConsult* in summer 2006. By the end of 2006, *BrainConsult* was still in the process of being shaped. The firm operated virtually without a physical office location, and the stakeholders were still looking for complementary funding. Slowly but surely, *BrainConsult* was being shaped with a solidified technological infrastructure, an emerging organizational structure, and a comprehensive business plan.

Diffusion

The telestroke innovation created attention on its own. Even before the commercialization attempts went into full gear, some hospitals in other U.S. states showed interest in REACH, though their interests did not lead to implementation and formal contracts. Later, while the system was being systematically reengineered, *BrainConsult* started interacting with potential customers. The Surgeon General of a northern state pushed for telemedicine systems for rural areas and REACH was seriously considered. In September 2006, *BrainConsult* signed a formal contract with this state as its first customer. The scale of the contract was relatively large with five hub hospitals, each of which would cover ten rural hospitals. Gradual development of the five hub-and-spoke systems were planned and by December 2006, two of them were up and running, generating revenue for *BrainConsult*. The first customer and further diffusion of the innovation outside of its originating context was a major milestone for the innovation. To support further diffusion, *BrainConsult* developed flexible business plans facilitating tailored pricing and operating models to individual customers.

Discussion

We have conducted a longitudinal case study of the development process of a telehealth innovation by following its transition from initial adoption to wider diffusion through commercialization efforts. We presented the unfolding of the innovation in four phases and identified what actors encountered what issues, how those issues were resolved, and the outcomes of each phase. Through the analysis of the process, we were able to identify for each phase key factors that enabled each phase as well as key challenges that stakeholders encountered (Table 2).

The focal innovation exhibited a number of context-specific factors that facilitated the transition from initial adoption to wider diffusion through commercialization. For example, the innovation was driven by highly motivated neurologists, who played multiple roles of champions, project drivers, and end-users. Their close involvement throughout the system development process resulted in functional feasibility of the innovation and their relationship-building with rural hospitals created commitments to participate at those hospitals. The successful pilot stage also created some public awareness of the innovation as well as an initial base of potential customers to support later commercialization. Finally, winning the state technology competition built considerable momentum for further diffusion. At the same time, the focal innovation faced some challenges during this process. Although system development involved the neurologists as future users and reflected hub-hospital interests and work practices, the rural hospital side was not taken into consideration during development. This turned out to be problematic in later adoption and diffusion stages. For example, technological and business issues in the rural hospitals emerged as important and quite challenging issues. More importantly, the misalignment of the innovation with institutional arrangements became a major issue that needed to be resolved in the later commercialization stage. These context-specific enabling factors and challenges are expressions of important forces that shaped the trajectory of the innovation. These findings provide the basis for answering the research questions posed at the beginning of this paper.

	Enabling Factors	**Challenges Faced**
Adoption	• Highly motivated, proactive project initiators • User-driven initiative • Close interactions among doctors	• Alignment with legal issues • Alignment with the insurance schemes • Alignment with rural hospital interests and processes
Implementation	• Rural hospitals lack neurologist expertise • Incremental expansion • Creation of knowledge base	• Rural hospital technical infrastructure • User training • New work practices
Commercialization	• Reengineering of system • Enhanced recognition through winning state technology competition • New independent firm established to commercialize the innovation	• No proven business models • Flexible, scalable business models • Limited funding – passive funding strategy
Diffusion	• Recognition built since pilot stage • Use of knowledge base built from earlier stages	• Aggressive marketing • Settled organization • Aligned interests among stakeholders (complicated medical setting-hospital, university)

Table 2. Enablers and challenges during telehealth innovation

In response to the first, descriptive research question ("How is a telehealth innovation developed from its initial adoption by a small network of hospitals to wider diffusion into a larger population of organizations?"), this research makes two distinct theoretical contributions. First, it contributes to the growing body of IS research on telehealth innovations. Many existing studies report cases of initial adoption in a single organization or a network of initial adopting organizations (e.g. Chau et al. 2004; Constantinides et al. 2006; Davidson et al. 1999; Lapointe et al. 2005; Lau et al. 1999). There are no studies, however, that investigate the transition from initial adoption to wider diffusion into a larger population of organizations. By examining a case of such transition all the way through commercialization, this study answers the question of how a pilot telehealth innovation can successfully develop into a wider diffusion mode through commercialization. Second, the presented study expands the body of knowledge on diffusion of innovation research. Adoption and diffusion of complex, networked and learning-intensive

technologies have not been examined from a diffusion of innovation perspective (Lyytinen et al. 2001). The focal innovation of this study is an exemplar case of a complex, networked, and learning-intensive technology. Dominant theories of diffusion of innovations are criticized for their lack of explanatory power beyond the conditions in which those theories originated (Fichman 2000; Fichman 2004; Gallivan 2001; Lyytinen et al. 2001). This study explores this research gap by providing initial understandings of the development of a complex, networked telehealth innovation from its initial conception to other conditions, commercialization in this particular example. In particular, we presented our findings in four stages; adoption, implementation, commercialization, and diffusion and we identified for each of these the key enablers and challenges faced in transitioning from adoption to the later stages of development. These insights can be further developed into a evolutionary model covering the stages of adoption to diffusion and they constitute what Markus and Robey (1988) call an emergent perspective on causal agency in IT and organizational change. Complex and networked technologies contain messy, complex problem-solving elements that are both socially constructed as well as shaped by context and society at large (Lyytinen et al. 2001). By outlining a four-staged model of the transition from adoption to diffusion in the context of telehealth innovations, we contribute to research focusing on such dynamic process from an emergent perspective.

In response to the second, normative research question ("What lessons can we suggest on how to successfully transition from initial adoption to wider diffusion of a telehealth innovation?"), this study also offers practical contributions for stakeholders involved in IT-based innovations within the healthcare industry. We can summarize these insights into the following recommendations for organizations to consider as they adopt telehealth innovations with further ambitions to diffuse them through commercialization at later stages:

- *Develop long-term plan for post-pilot stages:* Like many other telehealth innovations, REACH started its life as a pilot system. The project initiators engaged in this effort driven primarily by their medical knowledge and ambitions. To facilitate subsequent diffusion of similar IT-based health innovations, project initiators are advised to develop long-term plans for post-pilot stages including consideration of financial, legal, and technological issues.
- *Position innovation as win-win proposition:* REACH was supported by the hub hospital, but at some point it faced difficulties gaining financial support for further expansion. One reason was that the strategic alignment between hub hospital goals and the innovation were not convincingly explicated to gain sustainable support. The relationship between REACH and strategic rural hospital interests exhibited an even greater mis-fit. REACH was basically promoted by hub hospital initiatives and sources of funding; no explicit attempts were made to develop sustainable financial models for rural hospital involvement. Hence, telehealth innovators are advised to position their initiatives early on as win-win propositions in relation to both hub and rural hospital interests.
- *Align with rural hospital processes:* REACH was first developed by and at the hub hospital and later "pushed" to the rural hospitals. Because of this early framing, business processes and work processes in the rural hospitals were not actively considered or reflected in the technology during the system development phase, even though the innovation would affect rural hospital processes significantly during system operation. The earlier that rural hospitals can be involved in the innovation development, the easier it would be to align the innovation with relevant hospital process to facilitate subsequent adoption and further diffusion.

- *Accommodate rural area technology infrastructure issues:* The project initiators encountered unexpected problems with technology infrastructure at the rural hospital sites. In a case report, it took several months for a rural hospital to get fast network connection due to lack of infrastructure in the local area, not at the hospital, specifically. The lack of IT staff at the rural hospitals also created a bottle-neck effect for further addition of rural hospitals. Training and trouble-shooting became dominant issues for the limited available system development resources. Accommodating rural area technology infrastructure issues, both technically and knowledge-wise will likely facilitate both initial adoption and further diffusion efforts.
- *Consider institutional arrangements and legal issues:* The most commonly cited problems related to REACH were misalignment with institutional arrangements and legal issues. Reimbursement from insurance institutions was at the top of the list. The innovation starting as a pilot did not meet the reimbursement requirement for two-way video streaming. Since the neurologists failed to meet the requirement by designing the innovation one-way, their services were not reimbursed at all. Also, from a reimbursement point of view, REACH was not an attractive proposition for the rural hospitals due to many patients having insufficient insurance coverage. They either lacked insurance altogether, or were covered by government Medicare and Medicaid programs – which reimbursed only a fraction of the service costs. Considering institutional and legal issues as one important design dimension can therefore greatly support successful diffusion of new IT-based healthcare innovations.
- *Build and manage knowledge base from initial adoption:* Since adoption of REACH occurred incrementally, i.e. hospital by hospital, the hub hospital project team had the chance to build a knowledge base through experiential learning. As the innovation expanded to more hospitals, the project initiators developed important knowledge about system trouble-shooting and system configuration, which later turned out to be an asset for wider diffusion through commercialization. Experiences with initial development and adoption can hence be systematically managed and utilized at later diffusion stages.

Although our study only covers one telestroke innovation, our findings may provide useful guidelines for other telehealth initiatives. However, while telehealth innovations share a set of common characteristics, it is always important to understand and take into account the unique contexts in which they unfold. Further research is therefore needed to develop this research, both conceptually and in terms of practical implications.

References

"Bringing Health Care Online: The Role of Information Technologies," O.o.T.A. U.S. Congress (ed.), U.S. Government Printing Office, 1995.

Adewale, O.S. "An internet-based telemedicine system in Nigeria," *International Journal of Information Management* (24:3) 2004, pp 221-234.

Anderson, J.G. "Clearing the way for physicians' use of clinical information systems," *Communications of the ACM* (40:8) 1997, pp 83 - 90.

Bali, R.K., and Naguib, R.N.G. "Towards gestalt telehealth: considering social, ethical and cultural issues," Canadian Conference on Electrical and Computer Engineering, 2001, pp. 1367 -1371.

Bangert, D., and Doktor, R. "The role of organizational culture in the management of clinical e-health systems," 36th Annual Hawaii International Conference System Sciences, Island of Hawaii, U.S.A., 2003, pp. 163 - 171.

Bashshur, R., L. "Telemedicine Nomenclature: What Does it Mean?," *Telemedicine Journal* (6:1) 2000, pp 1-3.

Bashshur, R.L., Sanders, J.H., and Shannon, G.W. (eds.) *Telemedicine: theory and practice*. Charles C. Thomas, Springfield, IL, U.S.A, 1997.

Benbasat, I., Goldenstein, D.K., and Mead, M. "The Case Research Strategy in Studies of Information Systems," *MIS Quarterly* (11:3) 1987, pp 369-386.

Brown, H.G., Poole, M.S., and Rodgers, T.L. "Interpersonal Traits, Complementarity, and Trust in Virtual Collaboration. ," *Journal of Management Information Systems* (20:4) 2004, pp 115-137.

Casper, M.L., Barnett, E., Williams, G.I.J., Halverson, J.A., Braham, V.E., and Greenlund, K.J. "Atlas of Stroke Mortality: Racial, Ethnic, and Geographic Disparities in the United States "*, D.o.H.a.H. Services (ed.), Centers for Disease Control and Prevention, January 2003.

Chau, P.Y.K., and Hu, P.J.-H. "Technology Implementation for Telemedicine Programs," *Communications of the ACM* (47:2) 2004, p 87.

Chiasson, M.W., and Davidson, E. "Pushing the contextual envelope: developing and diffusing IS theory for health information systems research," *Information and Organization* (14:3) 2004, pp 155-188.

Cho, S., and Mathiassen, L. "Examining Barriers in a Telehealth Innovation: the Social-system Perspective," Americas' Conference on Information Systems, Acapulco, Mexico, 2006.

Cho, S., Mathiassen, L., and Robey, D. "Dialectics of Resilience: A Multi-level Analysis of a Telehealth Innovation," *Journal of Information Technology* (22:1) 2007, pp 24-35.

Constantinides, P., and Barrett, M. "Negotiating ICT development and use: The case of a telemedicine system in the healthcare region of Crete," *Information and Organization* (16:1) 2006, pp 27-55.

Cooper, R.B., and Zmud, R.W. "Information Technology Implementation Research: A Technological Diffusion Approach.," *Management Science* (36:2) 1990, pp 123-139.

Darke, P., Shanks, G., and Broadbent, M. "Successfully completing case study research: combining rigour, relevance and pragmatism," *Information Systems Journal* (8:4) 1998, pp 273-289.

Davidson, E.J., and Chismar, W.G. "Planning and Managing Computerized Order Entry: A Case Study of IT-Enabled Organizational Transformation," *Topics in Health Information Management* (19:4) 1999, pp 47-61.

Davis, F.D. "Perceived Usefulness, Perceived Ease-of-Use and User Acceptance of Information Technology," *MIS Quarterly* (13:3) 1989, pp 319-339.

Fichman, R.G. "The Diffusion and Assimilation of Information Technology Innovations," in: *Framing the Domains of IT Management: Projecting the Future Through the Past,* R.W. Zmud (ed.), Pinnaflex Educational Resources, Inc., Cincinnati, OH, 2000.

Fichman, R.G. "Going Beyond the Dominant Paradigm for Information Technology Innovation Research: Emerging Concepts and Methods," *Journal of the Association for Information Systems* (5:8) 2004, pp 314-355.

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

Jennett, P., and Watanabe, M. "Healthcare and Telemedicine: Ongoing and Evolving Challenges," *Disease Management & Health Outcomes* (14:Suppl 1) 2006, pp 9-13.

Kwon, T.H., and Zmud, R.W. "Unifying the Fragmented Models of Information Systems Implementation," in: *Critical Issues in Information Systems Research,* R.J. Boland and R.A. Hirscheim (eds.), John Wiley and Sons, New York, 1987, pp. 227-251.

Lapointe, L., and Rivard, S. "A Multilevel Model of Resistance to Information Technology Implementation," *MIS Quarterly* (29:3) 2005, pp 461-491.

Lau, F., Doze, S., Vincent, D., Wilson, D., Noseworthy, T., Hayward, R., and Penn, A. "Patterns of improvisation for evidence-based practice in clinical settings," *Information Technology & People* (12 3) 1999, pp 287-303.

Liang, H., Xue, Y., and Berger, B.A. "Web-based intervention support system for health promotion," *Decision Support Systems* (42) 2006, pp 435-449.

Lyytinen, K., and Damsgaard, J. "What's wrong with the diffusion of innovation theory?," IFIP TC8 Working Group 8.6 Conference, Banff, Canada, 2001, pp. 173-190.

Maheu, M.M., Whitten, P., and Allen, A. *E-Health, telehealth, and telemedicine : a guide to start-up and success* Jossey-Bass, San Francisco, 2001.

Markus, M.L., and Robey, D. "Information Technology and Organizational Change: Causal Structure in Theory and Research," *Management Science* (34:5) 1988, pp 583-598.

Mbarika, V.W.A. "Is Telemedicine the Panacea for Sub-Saharan Africa's Medical Nightmare?," *Communications of the ACM* (47:7) 2004, pp 21-24.

Medicine, I.o. "Telemedicine: A Guide to Assessing Telecommunications in Health Care," National Academy Press, Washington D.C., 1996.

Miles, M.B., and Huberman, A.M. *Qualitative Data Analysis*, (2nd ed.) Sage, 1994.

Mohr, L. "Approaches to Explanation – Variance Theory and Process Theory," in: *Explaining Organizational Behavior*, Jossey-Bass, San Francisco, 1982, pp. 35-70.

Newman, M., and Robey, D. "A social process model of user-analyst relationships," *MIS Quarterly* (16:2) 1992, pp 249-266.

Paul, D.L. "Collaborative Activities in Virtual Settings: A Knowledge Management Perspective of Telemedicine," *Journal of Management Information Systems* (22:4) 2006, pp 143-176.

Paul, D.L., and McDaniel Jr., R.R. "A Field Study of the Effect of Interpersonal Trust on Virtual Collaborative Relationship Performance," *MIS Quarterly* (26:2) 2004, pp 183-227.

Rogers, E.M. *Diffusion of Innovations*, (5th ed.) Free Press, New York, 2003.

Walsham, G. "Interpretive Case Study in IS Research: Nature and Method," *European Journal of Information Systems* (4:2) 1995, pp 74 - 81.

Yin, R.K. *Case Study Research Design and Methods*, (3rd ed.) Sage Publications, Inc., 2003.

Zundel, K. "Telemedicine: history, applications, and impact on librarianship," *Bulletin of the Medical Library Association* (84:1) 1996, pp 71-79.

Paper 5. Negotiating Business Issues

Title: Negotiating Business Issues in a Telestroke Innovation Project

This paper is coauthored by Sunyoung Cho, Elena V. Khasanshina, Lars Mathiassen, David C. Hess, Sam Wang, and Max E. Stachura

Negotiating Business Issues in a Telestroke Innovation Project

Sunyoung Cho, MS[1], Elena V. Khasanshina MD, PhD[2], Lars Mathiassen, PhD, Dr Techn[1],
David C. Hess MD[2], Sam Wang, MS[2], and Max E. Stachura, MD[2]
Georgia State University[1], Atlanta GA, and Medical College of Georgia[2], Augusta GA.

Abstract

Stroke treatment using tissue plasminogen activator within the available three hour window was successfully facilitated in seven rural Georgia communities. The Remote Evaluation for Acute Ischemic Stroke (REACH) program used broadband connectivity with real-time internet-based video to interact with patients, review CT scans, and perform a valid NIH Stroke Scale evaluation. As with many telehealth projects, REACH began as a sophisticated healthcare service pilot. While the champions hoped that the REACH program would self-sustain and expand, it did not prospectively address the business issues related to adoption of technological innovations. The current study aimed at understanding this problem and identifying solution strategies that would facilitate adoption and sustainability. We focused on the roles played by internal (organizational context, technical aspects, social networks) and external factors (legal, reimbursement, partnership, economic) over the program's development. Data sources included complete analysis of the patient encounter process, systems documentation, observation of systems use, and stakeholder interviews. Our conclusions highlight the importance of early identification and negotiation of business issues related to project implementation. In particular, regulatory, state legislative, and reimbursement issues require attention in order to effectively manage the transition of a telehealth project such as REACH from a sophisticated and innovative service pilot to a clinically and technically successful telehealth program that stands on a firm business footing. Only then can such a program take its place as a standard, self-sustaining component of the business of successful patient care.

Introduction

Health care institutions are information-intensive [1]. Their use of information technology (IT) has been, and continues to be, increasing because of industry characteristics [2]. The Healthcare Information Technology (HIT) market was estimated to reach $23.6 billion in 2003, rising 9.3% from the $21.6 billion expended in 2002 (News release of Sheldon I. Dorenfest & Associates, Ltd. http://www.dorenfest.com/pressrelease_feb2004.pdf). This pace is not surprising and may even accelerate given that IT infrastructure in the health care industry is said to be years behind other industries such as banking, airlines, and manufacturing [3]. As the use of information systems in the healthcare domain increases, a growing body of knowledge about health information systems research is accumulating [4]. However, many studies report difficulties in successfully implementing information systems in healthcare domains [5-8]. Some researchers argue that health care information systems face the same organizational issues that all industries encounter and which contribute to a consistent high rate of failure across industries [9]. Others state that the healthcare domain has a poorly understood and unique institutional context [4, 8]. Although a general body of knowledge is accumulating as use of health information systems

increases, our understanding of the more specific area of telehealth innovations remains limited. Specifically, we lack understanding of how telehealth systems are effectively implemented and we therefore continue to witness many cases where clinically successful telehealth systems do not achieve sustainable diffusion.

In this study we explored business issues encountered by the Remote Evaluation for Acute Ischemic Stroke (REACH) telestroke system, recently implemented and currently in use in several rural Georgia hospitals. These issues might facilitate or inhibit further diffusion of the system.

There is a critical lack of stroke specialist expertise in most rural areas. This lack contributes to a higher rate of stroke deaths in rural and underserved communities [10], and Georgia sits squarely in the U.S. Stroke belt (US Census Bureau Postcensal Population Estimates (ICD9 430-438.9) (1991-1995)) (Figure 1).
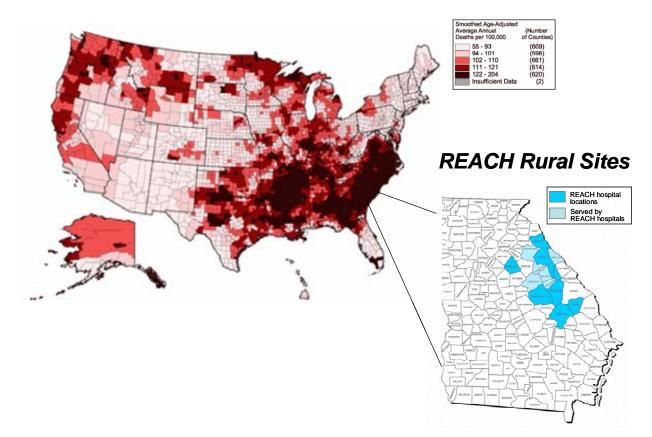

Figure 1. U.S. Stroke Belt and REACH Rural Sites

The prevalence of diabetes mellitus and hypertension in rural Georgia's heavily minority and aging population are contributing factors. Stroke incidence is increased 2.5- to 4-fold above, and recurrent stroke incidence is almost double the national average in this population [11]. Stroke is the third leading cause of death in the United States, the leading cause of disability, and costs $40.9 billion annually [12]. In the case of ischemic (non-bleeding) stroke, the blood clot dissolving agent tPA (tissue Plasminogen Activator) reduces the chance of severe post-stroke disability if it is administered within three hours of the onset of stroke symptoms. However, tPA is contra-indicated in hemorrhagic stroke where it can aggravate brain damage. It is estimated that only

2% of eligible stroke patients receive tPA, in part because of lack of on-site neurology expertise required to select appropriate candidate patients. This fact has led to innovative approaches using telecommunication technologies to make tPA available in rural communities [13-18]. REACH's central hypothesis is that by providing neurology expertise through telecommunication, the rate of tPA use can be significantly increased, thereby reducing the incidence of permanent disabilities.

The system is cost-efficient and clinically effective, but it is at a critical juncture from which it will either further diffuse or die-out, duplicating the fate of many other prototype telehealth systems. In this context, our research focus was narrowed to the following specific questions: What business issues must the telestroke system address in order to further expand and become self-sustaining? What strategies could be adopted to successfully address these issues?

Materials and Methods

The Network:

Starting in 2001, a small group of neurologists in the MCG Department of Neurology started an initiative to develop a telehealth application that would allow them to service stroke patients in remote hospitals. They received the necessary seed funding to pay for technical development and installation from the department,, In March 2003, the MCG Health System (MCGHS) and the MCG Department of Neurology launched REACH to make MCG stroke team members immediately available to examine patients at rural hospitals in real time around the clock (Figure 2). The seed funding from MCGHS made it possible to implement the system without imposing any start-up costs on the rural hospitals; each rural hospital only had to commit to minimal operating costs for connectivity.
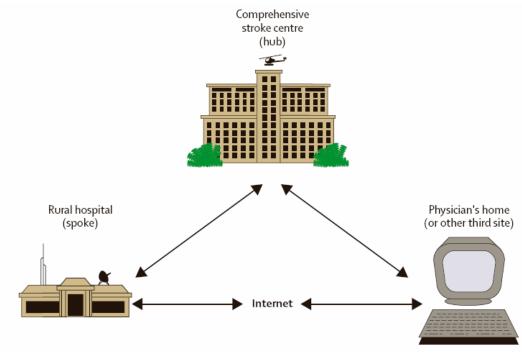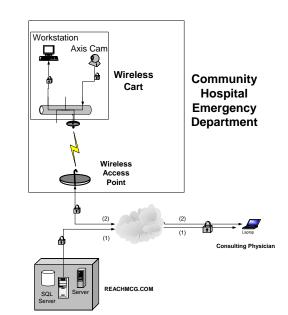

Figure 2. The REACH network

The REACH system was designed as a low cost solution that is mobile and robust. Moreover, the system design emphasized ease of use in response to emergent patients arriving at the rural hospitals. A mobile cart (Figure 3) is used in each rural hospital to capture video images and the cart is networked to transfer images and data to MCGHS. The communication between the hospitals is supported by the Internet and steps have been taken to ensure HIPAA-compliant (Health Information Portability and Accountability Act) secure and efficient transfer of video images and data. The neurologists at MCG accesses REACH from normal PC's (Figure 4).

Remote evaluation cart:
•*Axis 2130 Pan/Tilt/Zoom camera*
•*1.5 GhZ Dell PC workstation and LCD monitor*
•*Linksys WET11 wireless bridge*
•*Netgear 5 port switch*
•*Universal power supply*

Figure 3. REACH Mobile Cart

The Encounter:
Upon presentation to a local hospital equipped with CT (computed tomography) scan facilities, a suspected stroke victim receives computerized tomography of the brain while the hub hospital is notified and the on-call neurologist connected. On completion of the scan, the patient is moved to a room containing the REACH mobile cart. An ER nurse enters the patient's demographics, clinical information, and laboratory results into the system. The neurologist then performs an NIH stroke scale evaluation through video assessment, while simultaneously viewing the CT scan and laboratory data on the screen (Figure 4). Currently, voice communication between the neurologist and the rural clinicians and patient occurs over a land-line telephone. Decisions about the appropriateness of tPA administration and patient transportation are made by the neurologist.
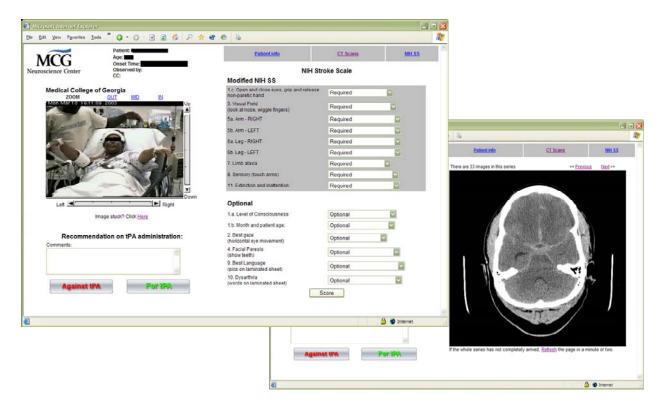
Figure 4. REACH Interface Screens on the Neurologist Computer (Central Hospital)

More specifically, video of the patient is viewed in real time with a camera operated by the consultant. Using a drop down National Institute of Health Stroke Scale, the consultant points and clicks to automatically tabulate and store the score. The CT scan is reviewed on the same screen after a point and click. Finally, a recommendation about whether to administer tPA is made. Patients with a hemorrhagic stroke are emergently transferred by ground or helicopter to MCGHS. Overall, the involved neurologists at the hub hospital and the doctors and nurses at the satellite hospitals found the quality of this internet-based consultation and of the transmitted video satisfactory and well-functioning.

Clinical Experience:
By the time our study was initiated, seven rural hospitals were participating in the REACH network. To date, more than 400 patients have been evaluated at nine rural hospitals with 65 having been treated with tPA (about 50% in less than 2 hours), only one of which (<2%) experienced the complication of intracranial hemorrhage, a rate consistent with experience elsewhere. [19, 20]. Prior to the advent of REACH, tPA was almost never used in these hospitals. The two instances where it was previously used occurred after telephone discussion, a less than adequate circumstance because the neurologist could see neither the patient nor their CT scan. When tPA is not recommended for administration, a reason is always provided to the rural hospital. These reasons include time beyond the 3 hour window, symptoms rapidly resolving, symptoms too mild, hemorrhagic stroke on CT scan, bleeding diathesis, recent surgical procedure, uncontrolled hypertension, seizures at onset, or a stroke mimic such as a conversion disorder or migraine with aura

The study aimed at understanding factors that could promote or inhibit successful diffusion of REACH and identifying feasible solution strategies. We focused on external factors that are difficult for the involved organizations to control and on internal factors that should be easier to control. External factors included economic, legal, and market issues. Internal factors included organizational, technological, and educational issues (Figure 5). This research model is based on existing information systems literature [8, 21, 22].
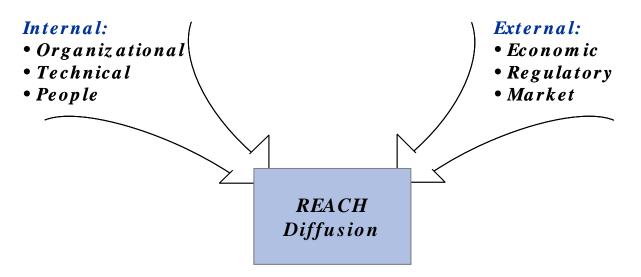

Figure 5. REACH Diffusion Model

Data sources included the encounter process, systems documentation, observation of system use, and stakeholder interviews. We interviewed 25 individuals in five hospitals (MCGHS and four rural hospitals): 7 doctors, 5 administrative staff, 3 technical staff, 9 nurses, and 1 radiology technician. Interviews were semi-structured, typically lasted 30-60 minutes, and were tape-recorded. Most interviews were individual. Two were with groups (2 and 4 individuals). A de-briefing note was created immediately after each interview to summarize key content and suggest interpretations.

We conducted a systematic, qualitative analysis [23] of the interviews. First, for each interview we identified issues based on the adopted model (Figure 5). Through that process we identified 3-7 observations for each internal and external factor. Second, we then discussed the related observations and aggregated them into an overall finding for each factor as presented below. In doing so, we used different data sources to increase the reliability of the findings [23].

Findings

We found that nurse and ER doctor user satisfaction was very high. The system was easy to use, fast, and equipped with appropriate features. Most users considered it a life-saving system. The implementation process had gone well so that rural users were well-motivated after on-site visits and education by the consulting neurologists. However, we also identified a number of business issues that have played a major role in shaping REACH's diffusion and might be critical for

further diffusion of the system. We present these below according to the aforementioned diffusion model (Figure 5).

Internal Issues

"Internal issues" refers to factors that individual organizations can control to some degree, including organizational, technological and educational issues.

- **Organizational Issues**

Effective operation of REACH required formal collaboration and standardized communication capabilities among stakeholders, and between the hub and satellite hospitals. Two levels of communication were important; intra-organizational and inter-organizational. At the intra-organizational level, each stroke event required effective communication between Emergency Medical Services (EMS), Emergency Room (ER), and Radiology staff at the rural hospital and communication between Neurology, Radiology, and EMS at the hub facility. At the same time, since the REACH system is inter-organizational, close collaboration to maintain technological and medical links between the hub and rural hospitals was critical. A protocol was developed to support these intra- and inter-organizational communications. We found that the established collaboration and communication capabilities were sufficient to maintain efficient and effective operation of REACH.

- **Technology Issues**

We identified a number of issues related to technology. First, the costs of implementing the REACH system were totally borne by the hub hospital, and the effort was driven by the small team of neurologists and the single developer. Some participating rural hospitals stated that they would not have become involved in REACH if they had been required to pay for the system. So, there was no immediate economic model in place for further diffusion of REACH to more rural hospitals within the existing network or to replicate it in other networks of hub and rural hospitals. Second, there were extensive variations and problems in technological infrastructures and service contracts at the rural hospitals. For example, rural hospitals had CT-scanners from different vendors. REACH needed therefore to allow different interfaces and the single developer had to communicate with all relevant vendors to resolve issues. Third, rural hospitals were entirely dependent on the hub for technological implementation and operating problems, and as a result routine maintenance and system troubleshooting was handled one-sidedly by the hub in the current configuration. The hub hospital would not, however, have sufficient technical staff to do so if REACH were to be implemented in many additional rural hospitals. REACH was in this way in its current configuration not sufficiently scalable. In fact, the current configuration was highly dependent on the skills and knowledge of the single developer, and no steps were taken to institutionalize these capabilities to ensure long-term sustainability.

There are many reasons for the lack of technical capability at the rural hospitals. First, there was a significant lack of IT staff in the rural hospitals, many of which had no full-time IT staff. In those with fulltime IT staff, turnover was so high that it was difficult to have a consistent technological interface between the hub and rural hospitals. This lack of IT competency made it necessary for the on-call neurologist to assist rural ER users in performing system troubleshooting. Second, the IT infrastructure and technological interface at rural hospitals for PAC (Picture Archive Communication) systems, high-speed networks, and digital CT scan images varied significantly. Each of these problems inhibited system scalability and contributed to diffusion difficulties for REACH. In sum, the operation of REACH suffered from insufficient technological capability at the rural hospitals.

- **Educational Issues**

Initial system education and training was done by a single hub hospital staff member, while continuing education and training for existing and new medical staff was performed at each local site. Continuous education and training was required due to constant inflow of new staff in rural hospital ERs. Re-education on a regular basis was also needed because of low rates of REACH system usage in most participating hospitals, and because of system updates. However, there were no systematic approaches in place for re-education and training.

Regarding varying system usage frequencies, many reasons were found (e.g. population size and demographics of patient base). However, staff at two rural hospitals where system usage was high attributed their high usage to patient and community education about stroke symptoms and the requirement for tPA use within the three hour time window.

External issues

External issues include factors that individual organizations may find difficult to control, such as economic, regulatory, and market issues.

- **Economic Issues**

While the hub and the rural hospitals held contrasting views of the economic aspects of REACH, both stakeholders experienced economic issues. The system did not generate direct revenue from medical consultation by the neurologists and the indirect revenue generated through subsequent referral of patients was not immediately apparent. REACH therefore needed stronger financial justification to receive continued central support at MCGHS for further diffusion initiatives. The reason the system did not produce direct revenue was that it did not initially provide two-way interactive video, a requirement for reimbursement under current reimbursement schemes. This initial design decision was coupled with a request for a waiver of the two-way video requirement, a request that eventually was denied. As a result, the neurologists' consultation was not reimbursable. Despite this problem, the system was arguably profitable for the hub hospital because most stroke patients evaluated through it were subsequently referred to the hub hospital which then generated indirect revenue. The hub hospital later started to review the system periodically from an accounting point of view and judged it to be a financial success. The hub hospital therefore considered the current configuration of REACH to be a successful system from both the central and rural hospital perspective.

On the other hand, some rural hospitals perceived the economic impact of REACH as negative because of the rural Georgia patient base profile. In general 20.1% of patients are covered by Medicaid, 52.6% are covered by Medicare, and 9.2% are self pay patients (Data provided by the East Georgia Health Cooperative, Inc http://eghealthcoop.org/). For the 81.9% of patients that did not receive tPA treatment at the rural hospital, REACH made no difference. However, for those patients that were treated with tPA the rural hospital received insufficient reimbursement to cover the considerable cost of the treatment. While the reimbursement scheme was later improved for tPA treatment, prior to that it actually aggravated financial woes in rural hospitals, two thirds of which were already operating in the red due to reduced funding from state and federal governments and reduced reimbursement by insurance firms. Therefore, use of the system was not financially attractive to all the rural hospitals, even though they recognized the value of linkage to specialists they could not afford to maintain locally.

- **Regulatory Issues**

REACH was not well aligned with current regulations. First, inability of the system to provide two-way interactive video caused one issue, in particular because the request for a waiver had been denied. While some efforts were under way within Georgia to revise existing reimbursement regulations, upgrade of the REACH system to comply with video requirements was needed to facilitate further diffusion. Second, because hub neurologists participated in the rural hospital's medical service, both central and rural work-arounds were required to accommodate reimbursement regulations. For example, one rural hospital reported that the consulting neurologist could not admit stroke patients being examined over the system unless the neurologist was on the rural hospital staff. Third, medical licensure was also an issue for wider diffusion of REACH. The hub hospital sits on the Georgia-South Carolina border, but the Georgia hub neurologist must be licensed in South Carolina to provide medical consultation in that state.

There were also issues requiring negotiation between the hub and rural hospitals. Memoranda of Understanding were negotiated with each individual rural site regarding (a) patient referrals, (b) implementation and maintenance costs, (c) the rural hospital's requirement to obtain consent from every patient for tPA administration, and (d) required compliance with HIPAA regulations including encryption and privacy issues. While the hub hospital knew how to deal formally with these issues, the rural hospitals needed support to address them and to subsequently institutionalize appropriate procedures.

- **Market issues**

While some rural hospitals had contacted MCGHS to help develop ways in which they could provide tPA treatments locally, REACH was not primarily driven and implemented in response to explicit regional market demands. The system, created as a pilot research project, was mainly pushed into rural hospitals and driven by the initiative of the small team of neurologists and single developer at the hub hospital. REACH was considered differently across the adopting rural hospitals. Some of these experienced operation deficits and some found that only those patients with private insurance coverage (currently 18.1%) generated enough revenue to cover the costs of medical service and provide some profit margin. Continued efforts to diffuse REACH would have to take these issues into consideration and possibly develop more selective inclusion strategies for rural hospital participation in the network. However, it is also worth noting that a recent Diagnosis-Related Group (DRG) modification (#559, implemented by Medicare on Oct. 1, 2005) has increased the reimbursement to the rural hospital for stroke patient treatment with tPA (patient must be admitted to the rural hospital, not transferred to hub for rural hospital to keep this payment). Previously DRG would pay $4,500. The new DRG pays $11, 400. This change provides additional financial incentives for hospitals to provide tPA treatment.

On the rural hospital side, the potential for profitability depended on patient profile and community awareness. Experience thus far suggests that it was necessary to continuously create REACH awareness in the local communities in order to capture patients within the required three hour window of tPA opportunity. There was considerable variability of system usage across the seven rural hospitals (from three to more than thirty cases) and promotion of REACH through local media and patient education seemed to be one of the important differentiating factors.

Discussion

There are obvious and good reasons to diffuse telehealth applications such as REACH. REACH makes it possible to provide effective medical responses to rural clinical incidents, i.e. effectively exploiting the three hour window of opportunity for tPA treatment of stroke. Moreover, such services are arguably economically attractive from the societal point of view of avoiding the high expenses implied if ischemic stroke patients are not treated with tPA.

The mean lifetime cost of ischemic stroke in the United States is estimated at $140,048 [24]. This estimate includes inpatient care, rehabilitation, and follow-up required for lasting deficits. Inpatient hospital costs for an acute stroke event accounts for 70% of the first year post stroke costs, with the first 30 days post-stroke costing more than $20,000 for severe ischemic strokes [25, 26]. The estimated total direct and indirect US cost of stroke in 2004 was estimated to be more than $50 billion. Given the significant financial burden that stroke places on society, economic analyses should accompany investigations of technological innovations that seek to increase the benefits of patient care [27, 28].

If an innovation to care has greater clinical effectiveness at a lower cost, and the measure of effectiveness is clinically compelling, the decision is clear. If the innovation has a slightly higher clinical effectiveness but at a substantially higher cost, the discussion of the advantages and disadvantages of adopting this intervention should be judged by comprehensive outcomes data comparing the two approaches and thus the value of the new compared to the current approach. Fagan and colleagues evaluated the economic implications of tPA when given to patients with ischemic stroke [29]. Their results revealed that tPA-treated patients had significantly shorter lengths of stay than placebo-treated patients (10.9 versus 12.4 days, p=0.02) and more tPA patients were discharged to home than to inpatient rehabilitation or nursing home (48% versus 36%, p=0.002). Their Markov model estimated an increase in hospitalization costs of $1.7 million and a decrease in rehabilitation costs of $1.4 million and nursing home costs of $4.0 million per 1,000 eligible treated patients. Thus, treating acute ischemic stroke patients with tPA within 3 hours of symptom onset promotes both clinical benefits to the patient, and potential net cost savings to the health care system.

However, our research has identified important business issues that REACH and other similar telehealth initiatives need to address in order to expand and become self-sustaining. These issues must be anticipated where possible and once identified successfully negotiated to facilitate diffusion. Strategies that would help address these issues include:

Internal:
- Organizational: Develop explicit and preferably standardized inter- and intra-institutional routines to support collaboration and communication between hub and satellite hospitals. These can take the form of committees, task forces, and protocols about responsibilities, roles, and approaches to problem-solving and improvement. Ensure inclusion of the telehealth program in the strategic outlooks of the hub and satellite hospitals.
- Technological: Provide a standard implementation package for new satellite hospitals and develop a portfolio of standardized hub support activities together with system features that enhance local trouble shooting capability. Ensure sufficient hospital technical staff dedicated to the telehealth innovation, e.g. permanently provide system troubleshooting capabilities, especially for rural hospitals during off-hours.
- Educational: Provide standard training packages for staff for both program implementation and regular updates. Provide community education about clinical

warning signs and symptoms, treatment availability, and the window of opportunity. For both types of educations, take advantage of existing education and training processes and facilities at the hospitals. Also, consider the use of on-site super-users, web-services, and local news media to facilitate education.

External:
- Economic: Develop a shared business model for the telehealth program that is sustainable at both the hub and satellite hospitals. Ensure hub and rural reimbursement by aligning with existing reimbursement schemes. Avoid permanent dependency on seed or grant funds, identify resources for expansion, and ensure hub profitability from the combination of program referrals and secondary good will referrals. Also, consider opportunities for commercialization to support further diffusion of the telehealth innovation.
- Legal: Develop and institutionalize sufficient legal expertise related to telehealth innovations at the hub to help satellite hospitals address legal issues and arrive at appropriate reimbursement schemes. Negotiate improved reimbursement policies with both insurance companies and regulatory bodies. Ensure in advance compliance with reimbursement, credentialing, licensing, and HIPAA regulations.
- Market: Adopt multi-channel marketing (e.g. media, local education, nursing homes, advertisement, and sales campaigns) to create and continually increase program awareness and need for program services. Promote the humanitarian and economic value of the program's services to the community at large.

Conclusion

We have analyzed business issues related to a particular telehealth innovation, REACH. The analysis covers internal organizational, technological, and educational issues as well as external economic, regulatory, and market issues. We argue that other telehealth innovations must carefully consider these business issues early in the process of their development in order to effectively manage the transition from sophisticated service pilots to clinically and technically successful telehealth programs. Based on the analyses of REACH, we recommend specific strategies that will help address these issues and more likely lead to successful telehealth projects that are sustainable as stand-alone entities.

Acknowledgement

References

1 Anderson JG. Clearing the way for physicians' use of clinical information systems. *Communications of the ACM* 1997;40(8):83 - 90.

2 Dwivedi A, Bali RK, James AE*, et al.* Telehealth systems: considering knowledge management and ICT issues. *The 23rd Annual International Conference of the IEEE Engineering in Medicine and Biology Society*. 2001; 4:25-28.

3 Raghupathi W. Health care information systems. *Communications of the ACM* 1997;40(8):80 - 82.

4 Chiasson MW, Davidson E. Pushing the contextual envelope: developing and diffusing IS theory for health information systems research. *Information and Organization* 2004;14(3):155-188.

5 Berg M. Implementing information systems in health care organizations: myths and challenges. *International Journal of Medical Informatics* 2001;64(2-3):143-156.

6 Lorenzi NM, Riley RT. Organizational ISSUES=change. *International Journal of Medical Informatics* 2003;69(2-3):197-203.

7 Aarts J, Peel V. Using a descriptive model of change when implementing large scale clinical information systems to identify priorities for further research. *International Journal of Medical Informatics* 1999;56:43-50.

8 Tanriverdi H, Iacono CS. Knowledge Barriers to Diffusion of Telemedicine. *International Conference on Information Systems*. Helsinki, Finland, 1998:39-50.

9 Plummer AA. Information Systems Methodology for Building Theory in Health Informatics: the Arguments for a Structured Approach to Case Study Research. *The 34th Hawaii International Conferenc on System Sciences*. Hawaii, 2001.

10 Casper ML, Barnett E, Williams GIJ*, et al.* Atlas of Stroke Mortality: Racial, Ethnic, and Geographic Disparities in the United States In: Services DoHaH, ed.: Centers for Disease Control and Prevention, January 2003.

11 Gamm LD, Hutchison LL, Dabney BJ*, et al.* Rural Healthy People 2010: A Companion Document to Healthy People 2010. Volume 2. In: Gamm LD, Hutchison LL, Dabney BJ, *et al.*, eds.: College Station, Texas: The Texas A&M University System Health Science Center, School of Rural Public Health, Southwest Rural Health Research Center, 2003.

12 Stroke Facts 2006: All Americans. The American Strok Association, 2006.

13 Choi JY, Wojner AW, Cale RT*, et al.* Telemedicine Physician Providers: Augmented Acute Stroke Care Delivery in Rural Texas: An Initial Experience. *Telemedicine Journal and e-Health* 2004;10(Supplement 2):S90-S94.

14 Lambrecht C. Emergency physicians' roles in a clinical telemedicine network. *Annals of Emergency Medicine* 1997;30:670-4.

15 LaMonte MP, Bahouth MN, Hu P*, et al.* Telemedicine for acute stroke: triumphs and pitfalls. *Stroke* 2003;34:725-8.

16 Levine SG. Telemedicine stroke: the application of telemedicine for stroke. *Stroke* 1999;30:364-9.

17 Schafermeyer R. Telemedicine and emergency medical care: improved care delivery, or just another video game? *Annals of Emergency Medicine* 1997;30:682-7.

18 Schwamm LH, Little EA, Petkovsk I*, et al.* Stroke neurologist review of brain CT via telemedicine accurately identifies candidates for IV t-PA. *International Stroke Conference*. Phoenix AZ, 2003.

19 Hess DC, Wang S, Gross H, *et al.* Telestroke:extending stroke expertise into underserved areas. *Lancet Neurol* 2006;5:275-78.

20 Hess DC, Wang S, Hamilton W, *et al.* REACH: Clinical Feasibility of a Rural Telestroke Network. *Stroke* Accepted in 2005.

21 Cule PE, Robey D. A Dual-Motor, Constructive Process Model of Organizational Transition. *Organization Studies* 2004;25(2):229-260.

22 Orlikowski WJ. CASE Tools as Organizational Change: Investigating Incremental and Radical Changes in Systems Development. *MIS Quarterly* 1993;17(3):309-340.

23 Miles MB, Huberman AM. *Qualitative Data Analysis: An Expanded Sourcebook,* 2nd ed. Newbury Park, CA: Sage Publications, 1994.

24 Taylor T, N., Davis PH, Torner JC, *et al.* Lifetime cost of stroke in the United States. *Stroke* 1996;27:1459-66.

25 Diringer MN, Edwards DF, Mattson DT, *et al.* Predictors of acute hospital costs for treatment of ischemic stroke in an academic medical center. *Stroke* 1999;30:724-8.

26 Leibson CL, Hu T, Brown RD, *et al.* Utilization of acute care services in the year before and after first stroke: A population-based study. *Neurology* 1996;46:861-9.

27 Evers S, Ament A, Blaauw G. Economic evaluation in stroke research: A systematic review. *Stroke* 2000;31:1046-1053.

28 Holloway RG, Benesch CG, Rahilly CR, *et al.* A systematic review of cost-effectiveness research of stroke evaluation and treatment. *Stroke* 1999;30:1340-9.

29 Fagan SC, Morgenstern LB, Petitta A, *et al.* Cost-effectiveness of tissue plasminogen activator for acute ischemic stroke. NINDS t-PA Stroke Study Group. *Neurology* 1998;50:883-90.

Appendix. Sample Interview Protocols

Interview guide for REACH users

Interviewee	
Role of interviewee	User at a local hospital
Interview themes	1, 2, 3, 4, 5, and 6
Interview Date	
Note	

Interview Themes and Questions

1. Theme 1 (System): System characteristics and features
    1.1. Does the system provide the features you need to carry out your task efficiently and effectively?
    1.2. What are the advantages and disadvantages of using the system in your work?
    1.3. How well are you satisfied with the system?
    1.4. What are the key factors that distinguish the system from other health systems you use or know?

    1.5. How long does it take to establish a connection between the hub and the remote site?
    1.6. Would a mobile platform improve access to physicians who might be off of the hub hospital campus?
    1.7. What are the most important areas for improvement based on your experiences and needs?

2. Theme 2 (System): Subjective user experience
    2.1. How extensive is your personal system experience?
    2.2. Is the system easy to use? Was it easy to learn to use the system? Do you experience any difficulties in using the system?
    2.3. Have enough training sessions and enough support been offered?
    2.4. Have you attended or will you attend such sessions if they are offered?
    2.5. Do you trust the system as a basis for your professional work?
    2.6. Do the patients and families trust the system?
    2.7. How does the system affect your work practice, your relations to colleagues, and the relation to the patient?

3. Theme 3 (System): Organizational context
    3.1. Who or which departments are involved in use of the system?
    3.2. Is it easy to share necessary information and cooperate with colleagues and patients involved in use of the system?
    3.3. What do you see as important organizational factors that need to be addressed for more efficient and effective systems use?

4. Theme 4 (System): Technological context
    4.1. How similar or different is the system compared to other systems used in your organization? How does that affect your assessment of the system?
    4.5 Does the delay in audio or video communication ever prevent adequate communication or assessment during the remote consultations you have participated in?
    4.6 Do motion artifacts in the video conferencing system ever prevent adequate communication or assessment during the remote consultations you have participated in?
    4.7 Is the picture resolution always adequate for stroke assessment?
    4.8 Is the color quality always adequate for stroke assessment?

5. Theme 5 (System): Legal and economic issues
    5.1. Are there important legal issues related to the use of the system?
    5.2. How are reimbursement issues handled for each application of the system use?
    5.3. Is the system generating revenue or profits for your service or for your organization?
    5.4. What are your recommendations regarding improved legal and economical conditions for the use of the system?

6. Theme 6 (Process): Development and implementation
    6.1 How did you see and experience the technical development process?
    6.3 Are there particular issues that stand out in the development and implementation of the system?
    6.5 Identify key enablers and barriers to efficient and effective development and implementation?

Interview guide for IS staff

Interviewee	
Role of interviewee	IT support staff in a local hospital
Interview themes	All except 2 and 5
Interview Date	
Note	

Interview Themes and Questions

o   Please tell me your name, position, and role in relation to the REACH system.

Theme 8 (Process): Technological factors
  o   What is your job or role in terms of the implementation, use and maintenance of REACH?

Theme 4 (System): Technological context
  o   Does your organization have appropriate IT infrastructure for the system, such as a proper communication network, IT staff, hardware and software?
  o   Are you aware of any problem such as connection quality, picture quality, etc.?
  o   How is a technological problem regarding REAH being handled, once it occurs?
  o   What do you think are important technical factors for implementation of a system like REACH?

Theme 6 (Process): Development and implementation
  o   How did you see and experience the technical implementation process?
  o   How did you see and experience the organizational implementation process?
  o   Are there particular issues that stand out in the implementation of the system?
  o   Any differentiating factors that distinguish the process from implementation of other healthcare systems you have experienced?
  o   Identify key enablers and barriers to efficient and effective development and implementation?

Theme 8
  o   How did IT units at the hub hospital and your hospital take part in the development and implementation process? How do you assess this collaboration?
  o   Were there major problems or conflicts of interest in coordinating system implementation with the hub hospital in terms of IT infrastructure (e.g. platform, network, application portfolio)?

Theme 7 (Process): Organizational factors
  o   What other organizations were involved in implementation process other than hospitals? (e.g. telecommunication company, consulting firms and governmental and institutional bureaus) What role does each organization played in the development and implementation of the system?
  o   Were there major problems with coordination and cooperation during development and implementation?

Interview guide for REACH commercialization

Interviewee	
Role of interviewee	
Interview Date	
Note	

1. Overview of why negotiation with *BrainCare Inc.* failed
   a. Overall chronology of negotiation process
      i. How did you get to know the two entrepreneurs from *BrainCare Inc.*?
      ii. When was first meeting
      iii. How often were there negotiation meetings?
      iv. Topics of the meetings
      v. When did the whole thing end?
   b. What was the biggest hurdle? Why did it end in a failure?
      i. Contract & terms
      ii. What about differences in understanding, for example regarding the REACH system rural hospital economic conditions and business scheme, etc?
      iii. Trust
         1. Your impression or evaluation of the entrepreneurs?
         2. Their competency?
2. Current status of *BrainConsult*
   a. How did it start?
   b. Visions of the company
   c. What would be the biggest difference from *BrainCare Inc.* business plan?
   d. Can we ask about business model?
   e. Implications of the new company – would it replace the current free installation and service provision to those rural hospitals?
   f. Response from the hospitals of the current REACH network, if they are aware of the commercialization efforts at the hub hospital?
   g. What do you see as critical success factors for *BrainConsult*?
   h. What would be expected difficulties?
   i. Your evaluation of the role of the company in term of wide diffusion and adoption of REACH?

3. Next steps for REACH?
   a. Any changes in terms of features and functions?
   b. Any new attempts to further align the system with current reimbursement and legal scheme?
   c. Expansion plan for other medical areas?
   d. Two way, wireless, maybe?
   e. Expansion plan to include more rural hospitals