Strategic shifts in digital infrastructures: Connecting discursive formations and lightweight IT

By

Egil Øvrelid

A thesis submitted in partial fulfilment of the requirements for the degree of

Philosophiae Doctor (PhD)

Faculty of Mathematics and Natural Sciences,

University of Oslo, Norway

Series of dissertations submitted to the
Faculty of Mathematics and Natural Sciences, University of Oslo
No. 2016

ISSN 1501-7710

Cover: Hanne Baadsgaard Utigard.
Print production: Reprosentralen, University of Oslo.

Contents

Acknowledgements

Even though completing a PhD process is in many respects a solitary process, colleagues, practitioners and friends participation is needed in order to do it successfully.

I first thank my supervisors Bendik and Ole for allowing me to take this journey. They have both been crucial for this project. Special thanks to Bendik for the patience and tranquility.

Many colleagues and friends in the Information systems group have helped me through this project. I will especially mention Terje Aksel Sanner and Alexander Kempton for always being prepared to share points of view, and discuss challenging theoretical and practical issues. I will also thank Margunn Aanestad, Mikael Hailu Gebre-Mariam, Ester Namatovu, Kristoffer Fossum, Petter Nielsen and Johan Sæbø. Eric Monteiro, Elena Parmeggiani and Bjørn Erik Mørk are also important to mention for their participation in PhD days and Research Days where feedback on paper drafts were given.

In addition, I would like to thank the Medicloud people, as well as the nurses, doctors, technicians and project managers at Kalnes Hospital and at Aker Hospital for responding patiently and engaged on my questions.

A special thanks to my dearest Eli-Ann for giving me the necessary freedom to work on a PhD.

Abstract.

Strategic shifts in large IT programmes are unusual, but they do occur, usually as a consequence of problems or misalignment. Examples are the termination of the British eHealth mega-program in 2011 (Greenhalq et al. 2010), and the demise of the German e-prescription initiative (Klein and Schellhammer 2017). In the private sector, an increasing number of disruptive digitalisation initiatives emerge, such as the case of the DBS Bank (Sia et al. 2016). Theoretically, these issues have been dealt with in various ways. One perspective is presented in the strategic management oriented IS literature, focusing on analysis and decisions (Peppard and Ward 2016). Another perspective is the *punctuated socio-technical information change* theory (Lyytinen and Newman 2008), describing the episodic character of IS evolution; it alternates between periods of incremental and dramatic change.

Discourse plays an important role in eHealth programs (Sauer and Willcocks 2007). What we know less about is the role of discourse in strategic shifts. The first interest in this thesis was thus to investigate and theorise the role of discourse in this process, i.e. how discourse is shaping the trajectories of infrastructures and vice versa how infrastructure evolution shape discourses.

Discourse must connect to some material form for a strategic shift to occur. The second interest, consequently, was to investigate the role of digital technology in actually changing the digital infrastructure. Building on these two interests, the role of discourse and the role of digital technology in strategic shifts, the research questions addressed in this thesis are:

RQ 1: How does discourse affect strategic shifts in digital infrastructures?

RQ 2: What characterizes a technological solution that is suitable for supporting strategic shifts within eHealth?

Strategic shifts are generally defined as significant changes in processes and technology. Within the research on information infrastructure, the focal point is the installed base (Aanestad et al. 2017). The research on the installed base emphasizes the continuity of large structures; focusing on cultivation rather than planning (Ciborra et al. 2000). As information infrastructures' evolutionary dynamics is non-linear and path dependent, the focus have been to address the bootstrap problem and the adaptability problem. The first concerns directly meeting users' needs when changes are required. The second entails acknowledging "local designs need to recognize II's unbounded scale and functional uncertainty" (Hanseth and Lyytinen 2010, p. 1). Within this framing, strategic shifts are not recommendable.

Disruptive shifts in large infrastructures, rather, have been conceptualised as digital innovation (Henfridsson et al. 2014, Tilson et al. 2010, Yoo et al. 2010), path creation (Henfridsson et al. 2009), innovation paths (Henfridsson and Yoo 2014), multiple value paths (Henfridsson et al. 2018) as well as the innovation capability (Svahn et al. 2017). This orientation is characterised by shifts to new configurations of actors and technology also driven by the features of digital technology.

The research approach in this thesis is a realist case study, with three cases from eHealth innovation. Data collection was carried out for two years, between 2015 and 2017. A total of 69 interviews were conducted, as well as about 100 hours of observations. In addition, a number of documents were analyzed. Results and implications are covered in 6 papers published in international conferences/proceedings with peer review.

The first research question was addressed using Foucault's archaeological methodology (1972) as an analytical lens for identifying the role of discourse. The archaeological method is about identifying action-oriented relationships. This entails investigating how a statement associate with an surrounding field of techniques, practices, institutions and strategic considerations, and gradually establish a *discursive formation*. Foucault's method was used both to identify the emerging discursive formations when an eHealth program encounter difficulties, and how they make impact on this eHealth program. In order to investigate how, where and in what sense discourse and infrastructure connects, the causal interaction between discursive formations and other mechanisms was investigated. By using the CMO-scheme from Pawson and Tilley (1997) the relation between contextual conditions, mechanism and outcome was identified.

The thesis offers two contributions. *First*, it outlines a framework to understand the role of discursive formations in strategic shifts, and then a set of configurations to explain how contextual conditions and

mechanisms contingently lead to strategic shifts are proposed. The *Second* contribution emerge through conceptualizing lightweight IT as a technological regime that makes change (and thus strategic shifts) easier. This is made possible in particular through three distinguishing characteristics: (i) as a process innovation technology, (ii) as a technology which gives the organization a better and more integrated approach to information on performance and production, and (iii) through being layered with modular loose coupling.

Preface

This thesis is submitted in partial fulfilment of the requirements for the degree of Doctor Philosophiae Doctor (Ph.D.) at the Faculty of Mathematics and Natural Sciences, University of Oslo, Norway. The University of Oslo funded this work. This dissertation consists of four papers as well as an introductory section. The papers, listed below, are included in appendices.

- Paper 1: Øvrelid, E., Bygstad, B. (2016) "Extending e-Health Infrastructures with Lightweight IT," Scandinavian Conference on Information Systems SCIS 2016: Nordic Contributions in IS Research pp 43-56
- Paper 2: Øvrelid, E., Bygstad, B., Hanseth, O. (2017) "Discursive formations and shifting strategies in e-Health programmes", Proceedings of the 25th European Conference on Information Systems (ECIS), Guimarães, Portugal, June 5-10, 2017 (pp. 873-886).
- Paper 3: Bygstad, B., Hanseth, O., Siebenherz, A., Øvrelid, E. (2017) "Process innovation meets digital infrastructure in a high-tech hospital," Proceedings of the 25th European Conference on Information Systems (ECIS), Guimarães, Portugal, June 5-10, 2017 (pp. 801-814).
- Paper 4: Øvrelid, E., Halvorsen, M., (2018) "Process innovation with lightweight IT at an emergency unit," Proceedings of the 51st Hawaiian Conference on System Sciences (HICSS 2018)
- Paper 5: Øvrelid, E., Sanner, T., Siebenherz, A., (2018) "Creating Coordinative Paths from admission to discharge: The role of lightweight IT in hospital digital process innovation," Proceedings of the 51st Hawaiian Conference on System Sciences (HICSS 2018)
- Paper 6: Øvrelid, E., Bygstad, B. (2017) "Strategic shifts in Digital Infrastructures - The role of Discursive Formations," Submitted to international journal.

1. INTRODUCTION

This thesis has as its central aim to investigate strategic shifts in eHealth digital infrastructures. eHealth infrastructures embedded in large eHealth programs are exposed to major challenges (Greenhalq et al 2010, Klein and Schellhammer 2017, Sauer and Willcocks 2007). The main reasons for the extensive challenges in eHealth programmes are that these structures are (i) much larger than single organization systems, (ii) technically more heterogeneous and (iii) organizationally more complex because of many stakeholders. Often, no single actor is in control, leading to long processes of power struggles, compromises and complex co-ordination.

The thesis has both a *personal*, *theoretical* and a *practical* motivation. The *personal* is over twenty years of work experience in the industry in Norway, around thirteen of them more or less directly related to IT challenges, and the last nine as a team managers and system developer in the IT sector developing solutions for the health sector. The work on planning, developing and implementing patient records provides insight into specific challenges workers are struggling with, but also the challenges local, regional and national management addresses through their strategies and big eHealth programs. According to George and Bennett (2005, p. 24) "selection with some preliminary knowledge of cases…allow much stronger research designs."

Even if Socrates stated that the only wisdom is in knowing you know nothing, our role as researchers and practitioners is to contribute in dealing with complex challenges, propose solutions, and reflect on learning. In my practice, both industrial and academic, I have often reflected upon what concretely make such eHealth programs run into difficulties. What are the issues that make it so difficult to change them? For example, why does it usually take a minimum of 2-3 years from a solution is proposed, until this solution has been implemented? Furthermore, is it possible to get out of this kind of "vicious circle"?

The health system is also surrounded by discourse, not least on how technology can be put to use in order to improve health system infrastructures. The *theoretical* motivation, consequently, is to identify discourse as a socio-technical phenomenon and investigate its role in strategic shifts in eHealth programs. Studies on the development of large eHealth infrastructures (Greenhalq et al. 2010, Sauer and Willcocks 2007) highlight the complex challenges these programs are dealing with. According to Sauer and Willcocks (2007), particularly three "Greek choruses" are visible in these public battle zones; the public officials who defend the programme, the internal institutions and medical professions that are "sympathetic critics" and the media, consultants and academics that constitute the "professional critics." These "choruses" also make use of the opportunity to bring forth scandals and dramas creating an even more challenging situation for health system politicians and entrepreneurs. The space of opportunity enabled in the bigger marketplace gives, on the other hand, an arena where discourse can prosper and be utilized by technological entrepreneurs and optimists to propose "swift" solutions to programs in crises. Therefore, discourse may have a central role in eHealth programme turbulence but also in how constructive solutions arise. It is, however, not clear how discourse makes an impact. In what way(s) are struggling eHealth programs conditioned by turbulent discourse? What is the role of discourse in proposing solutions to eHealth program challenges?

The identification of discourse as a socio-technical phenomenon and its role in strategic shifts in eHealth programs, entails investigating the interaction between discourse and the digital infrastructure. This thesis *practical* motivation, thus, is to contribute to improve the understanding the role of digital innovation in digital infrastructures. Concretely, this thesis investigates the particular characteristics needed of a technology in order to support a strategic shift. A way of framing digital innovation in digital infrastructures is to separate between the two knowledge regimes of heavyweight IT and lightweight IT. While heavyweight IT is related to classic software engineering approaches, lightweight IT is "a socio-technical knowledge regime, driven by competent users' need for solutions, enabled by the consumerisation of digital technology, and realized through innovation processes" (Bygstad 2016, p. 181). Lightweight IT enables more rapid implementation cycles, but an interaction with heavyweight IT is needed in order to support profound innovation. This thesis, then, looks at how digital innovation enfolds from when an eHealth program encounter crisis, the arising competition from the outside to solve this crisis, the strategies used to solve the crisis and the role of digital technology in this process. *Discourse* and *digital innovation* are connected in that discourse has a central role in how digital

innovation develops from mere visions and ideas aiming to solve a potential crisis, to enabling organizational transformation through digital technology.

After the initial sketch of some of the motivations, phenomena and challenges that drives this thesis, I continue with the research questions that lead me towards a deeper investigation. Then I will outline the structure of this thesis.

1.1 The research questions

I will now describe the background and interests that drives these research questions.

RQ 1: How does discourse affect strategic shifts in digital infrastructures?

Strategic shifts in large IT programmes or digital infrastructures are unusual, but they do occur. Examples are the termination of the British eHealth mega-program in 2011 (Greenhalq et al. 2010), and the demise of the German e-prescription initiative (Klein and Schellhammer 2017). In the private sector, there are an increasing number of disruptive digitalisation initiatives, such as the case of the DBS Bank (Sia et al. 2016).

From a practical perspective, such shifts are dramatic and costly. They occur in a sense of crisis, involve a large number of stakeholders, scapegoats are nominated, and the consequences may be serious for the owners of the initial initiative (Sauer and Willcocks 2007). However, these events may also show a way forward, as alternative approaches emerge. In one sense, this is the "creative destruction" of old IT solutions, making way for the next generation of solutions.

Theoretically, these issues have been dealt with in various ways. One perspective is presented in the strategic management oriented IS literature, focusing on analysis and decisions (Peppard and Ward 2016). Another perspective is the *punctuated socio-technical information change* theory (Lyytinen and Newman 2008), describing the episodic character of IS evolution; it alternates between periods of incremental and dramatic change.

Strategic shifts are generally defined as significant changes in processes and technology. Within the research on information infrastructure, the focal point is the installed base (Aanestad et al. 2017). The research on the installed base emphasizes the continuity of large structures; focusing on cultivation rather than planning (Ciborra et al. 2000). As information infrastructures evolutionary dynamics is nonlinear and path dependent, the focus have been to address the bootstrap problem and the adaptability problem. The first concerns directly meeting users' needs when changes are required. The second entails acknowledging "local designs need to recognize II's unbounded scale and functional uncertainty" (Hanseth and Lyytinen 2010, p. 1). Seen from this perspective, strategic shifts are unlikely and unwanted.

Disruptive shifts in large infrastructures, rather, have been conceptualised as digital innovation (Henfridsson et al. 2014, Tilson et al. 2010, Yoo et al. 2010), path creation (Henfridsson et al. 2009), innovation paths (Henfridsson and Yoo 2014), multiple value paths (Henfridsson et al. 2018) as well as innovation capability (Svahn et al. 2017). This orientation is characterised by shifts to new configurations of actors and technology also driven by the features of digital technology. At the bottom of these perspectives lies the question, *what does it take to change the course of a large programme?*

In his work *Falsification and the Methodology of Scientific Research Programmes* (1970) the philosopher Imre Lakatos argues, with the aim of identifying a middle ground between Popper and Kuhn, that scientific programs tend to continue until a viable alternative is presented. "The history of science," Lakatos says, "refutes both Popper and Kuhn: on close inspection both Popperian crucial experiments and Kuhnian revolutions turn out to be myths: what normally happens is that progressive research programmes replace degenerating ones" (Lakatos 1978, p. 6). "There is no falsification before the emergence of a better theory" (Lakatos 1970, p. 119).

Although Lakatos' context is different from ours, I take the insight to be true also for large IT initiatives and digital infrastructures; that a programme normally will continue until a better alternative is available. However, how does a new alternative emerge in this context? I believe that the role of *discourse* in these strategic shifts is under-researched in the literature. Or posed differently, how do new ideas lead to disruptive shifts?

From a practitioner point of view, a better understanding of this issue is needed to help politicians, managers and strategists who seek to manage the dynamic role of discourse in organizational and technological innovation. This applies particularly for public sector strategists and policy makers who often rely on creating documents that outlines necessary change and circulate these within the existing network.

To investigate this, strategic shifts of digital infrastructures were studied, understood as the process of transformation from one (socio-technical) infrastructure configuration to a new one. My interest was to investigate and theorise the role of discourse in this process, i.e. how discourse is shaping the trajectories of infrastructures, and, vice versa, how infrastructure evolution shapes discourses. The argument was developed building on Foucault's (1972) concept of discursive formation as the analytical lens.

The research question, *how does discourse affect strategic shifts in digital infrastructures,* is addressed using a critical realism approach, which presupposes an interest in causality. The identification of the contingent mechanisms needed in order to achieve strategic shifts, makes it possible to investigate the relationship between Foucault's discourse analyses and critical realism. To develop the argument discursive formations are regarded as mechanisms. Following Bhaskar (1998) a mechanism is defined as a causal structure (often unobservable) that generates observable events. Building on this, and a longitudinal case study from the health sector, a framework to explain the role of discursive formations in strategic shifts of infrastructures is proposed. This enables an analysis of the causal relationship between discursive formations and other mechanisms in the digital infrastructure.

RQ 2: What characterizes a technological solution that is suitable for supporting strategic shifts within eHealth?

Discourse must connect to the infrastructure in order to obtain strategic change (Øvrelid et al. 2017). The somewhat more practical interest in this dissertation, consequently, deals with what type of technology is suitable for supporting strategic shifts within eHealth. A particular point of departure is general hospitals where optimization of specialists and departments work processes, have received more attention than horizontal coordination. This have sometimes lead to patients who suffer from ill-defined or interrelated health issues being referred back and forth between seemingly uncoordinated professionals and departments for diagnosis and treatment. A common complaint from patients is thus that while the actual treatment was excellent, the coordination between units was slow, the waiting time long, and feedback almost nonexistent (Norwegian Ministry of Health 2015, Salazar et al. 2004). In Norway, these challenges have informed the establishment of national coordination reforms, as it is "particularly important to ensure good coordination when the responsibility for the patient moves between hospitals and municipalities and between departments and units within hospitals and municipalities" (Helsedirektoratet 2016).

In order to address coordination challenges that affect patient waiting time and health care expenditures, a number of initiatives have been implemented. Examples are patient logistics (Van Lent et al. 2012), clinical pathways (Rotter et al. 2010), and hospital supply chain management, which is a more systemic view of the flow of all types of resources (De Vries and Hujisman 2011). Hospital IT portfolios typically mirror hospitals emphasis on supporting clinical work processes rather than horizontal information sharing and coordination. Consequently, hospitals struggle to coordinate logistics both internally and externally (Van Lent et al. 2012). This is of concern to hospital administrators as more efficient workflows across departments can save costs, enhance efficient use of scarce hospital resources (e.g., radiology), lead to more effective diagnosis and treatment of patients, and reduce patient waiting time (Devaraj, Ow and Kohli 2013).

Efficient patient flow within hospitals relies on shared information of activities such as patient registration, patient prioritization, and allocation of a doctor or nurse to the patient, ordering of lab tests and x-rays and booking of resources such as operating rooms and beds for patient surveillance. This, in turn, relies on information sharing between heterogeneous hospital information systems for patient admittance, nursing, laboratory, radiology, pharmacy, Electronic Patient Records (EPR), human resource and billing. Typically, these systems have been obtained from a multi-vendor market with a focus on resilience, confidentiality and security, rather than efficient exchange of standardized information. In accordance with Bygstad (2016), robust hospital information repositories and the IT engineering and support tradition that envelops them, is labelled Heavyweight IT.

Addressing these challenges requires the optimization through redesign of processes using the power of IT, and modern innovative lightweight IT have shown promising tendencies in establishing process improvement (Bygstad 2016, France et al. 2005, Hertzum and Simonsen 2013). Lightweight IT solutions are characterized by rapid implementation cycles, and ubiquitous access to tailored information through user-friendly interfaces (Bygstad 2016).

These promising findings form a point of departure for this study, primarily by investigating the characteristics that is inherent in adaptable technology. This means further investigating the role of lightweight IT in process innovation, its ability to informate, and its modular arrangement. How can lightweight IT help *informate* across functional and professional boundaries in complex organizations such as general hospitals? Moreover, why is this important? In order to improve patient flow, the communication related to patient flow must be improved. To shed light on the relationship between lightweight IT and its communicative ability, Zuboffs notion of informate is drawn upon. It denotes the processes whereby IT not only helps digitalize manual work, "but simultaneously generates information about the underlying productive and administrative processes through which an organization accomplishes its work" (Zuboff 1988, p. 9-10). A third important element is innovative technology's modular arrangement. These three characteristics of lightweight IT will be investigated and elaborated in this thesis, in order to establish an argument for why and how lightweight IT is particularly suitable for supporting strategic shifts of digital infrastructures.

Structure of the thesis

This rest of the thesis is organized as followed:

Chapter 2. Related research: The focus of this chapter is the literature on information infrastructure that conceptualize IT systems as interconnected sociotechnical system collectives, and how strategic shifts can be understood from within this stream of literature. In order to forefront the particular role of technology in digital innovation, insights from the more recent research on digital infrastructure is drawn upon. Then earlier research on the role of discourse in strategic shifts of digital infrastructures, as well as on information systems, is discussed. Lastly, three characteristics of lightweight IT as a particular digital innovation regime is described.

Chapter 3. Theoretical framework: This chapter have two sections. First Foucault's archaeological approach is described and customized in order to enable an investigation of the role of discourse in strategic shifts of digital infrastructures. Second, critical realism is introduced and described as a particular way of understanding the role of causality in strategic shifts. Then, the context-mechanism-outcome configuration from Pawson and Tilley (1997) is outlined as a particular way of investigating the contingency of causality, and what it entails.

Chapter 4. Research Approach: This thesis addresses two aspects of digital innovation in the Norwegian health sector. To elaborate on these interests an in-depth case study (Wynn and Williams 2012) of three infrastructures, being part of a large multi-level (George and Bennett 2005) research initiative, was conducted. The cases was analysed through a critical realist investigation consisting of 6 steps (Bygstad et al. 2016). First during the investigation, the central role of discourse emerged, particularly when eHealth program difficulties was addressed. Second, it was observed that new innovative technology had a central role in changing the digital infrastructure.

Chapter 5. Research publications and findings: In this chapter, the main findings from the research papers are described. The findings from the first research question emerge first through applying the archaeological framework from Foucault in order to identify discursive formations (1972), and then by using the context-mechanism-outcome scheme from Pawson and Tilley (1997). The second research question is addressed by using insights from process innovation literature, then by applying the concept of informate from Zuboff (1988). The findings from this provide an improved understanding of the role of lightweight IT in digital innovation of digital infrastructures.

Chapter 6. Discussion: In this chapter, I return to the research questions, and give two contributions. First, a framework to understand the role of discursive formations in strategic shifts is outlined, and then a set of configurations to explain how contextual conditions and mechanisms contingently lead to strategic shifts are proposed. Second, some particular characteristics that lightweight IT contains, which make it suitable to support strategic shifts in digital infrastructures, are proposed. Finally, these findings

implication for the research on digital infrastructures are discussed, and the practical contributions are described.

Chapter 7. Conclusion: In this brief chapter, a conclusion is provided, and some limitations are described. Finally, some possible further research, are suggested.

Collection of published papers: This is a paper-based thesis and contains six papers. An overview of the papers is given in the preface section, above.

2. RELATED RESEARCH

2.1 Strategic shifts in digital infrastructures

Strategic shifts have been dealt with theoretically in several ways within the IS community. One perspective is presented in the strategic management oriented literature, focusing on analysis and decisions (Peppard and Ward 2016), or on disruptive technologies (Christensen et al. 2009). The first is occupied with obtaining operational efficiency through management effectiveness, and how information systems can be used to reach that goal. Disruptive technologies regards how IT can be used to implement affordable, simpler and more effective business models in health care through balancing complexity and simplicity. Another perspective is the *punctuated socio-technical information change* theory (Lyytinen and Newman 2008), describing the episodic character of IS evolution; it alternates between periods of incremental and dramatic change. These studies give broad and distinct insights into IS phenomena, but the dramatic contextual conditions for eHealth programs and strategies may lead to additional challenges. For instance, health systems are extensive infrastructures more or less digitalized, consisting of a large collection of users and units, and attached to the interests of a range of stakeholders giving it a critical role in the public sphere. The multitude of challenges may paradoxically sometimes lead to staunch belief in the existing programme logics, with long-term strategic goals and roadmaps guiding the way to a possible future solution. Put shortly, eHealth infrastructures embedded in large eHealth programs are exposed to major challenges and significant public turbulence (Greenhalq et al. 2010, Klein and Schellhammer 2017, Sauer and Willcocks 2007). In relation to this, several studies have demonstrated the difficulties of organizational transformation with the use of IT within the health sector (Agarwal et al. 2010, Best et al. 2012) partly caused by the non-adoption and sometimes abandonment of IT, as well as difficulties related to scaling and (lack of) sustainability (Greenhalq et al. 2017). Major eHealth programmes that aims to change health infrastructures are exposed to all this turmoil and must take a number of stakeholder views into consideration. Sometimes a strategic shift is necessary both to solve the extensive challenges the health system is exposed to, but also to reduce costs and handle complexity. IT systems have over time been seen as a significant actor in how such strategic shifts can be achieved. In this thesis strategic shifts is defined as *significant changes in processes and technology*, and it is framed within research on digital infrastructures. I proceed by introducing this research field, before I go on to describe some minor but important differences between "classic" infrastructure literature, and the more recent infrastructure research occupied with digital innovation, that is of importance to my framing.

Information infrastructures

Rather than seeing IT as isolated information systems operating within single organizations, or as "standalone systems" within larger organizations, the theory of information infrastructures (Ciborra et al. 2000, Hanseth 2002) conceptualize IT in terms of its networking effect. This change of perspective from seeing organizational and technological development separately, to conceptualize them as interconnected sociotechnical system collectives, had a broad impact on the field of information systems (Bygstad 2008, Henfridsson and Bygstad 2013). The understanding of IT as information infrastructure opened up for a richer and broader understanding of the interaction between technology and organization in the development of complex infrastructures. First, it changed the perspective from single organisations to organizational networks and from systems to infrastructures (Ciborra et al. 2000, Hanseth 2002, Hanseth and Lyytinen 2010). This also allows a global and emergent perspective on information systems (Ciborra et al. 2000). Second, it allowed research on different settings like health (Aanestad et al. 2017, Aanestad and Jensen 2011, Braa et al. 2007, Hanseth and Aanestad 2003), telecom (Nielsen and Aanestad 2006), government and manufacturing (Ciborra 2005, Henningsen and Hanseth

2011) and on different levels like practices (Aanestad and Hanseth 2000), organization (Henfridsson and Bygstad 2013), industry and society (Gal et al. 2008), and technologies (standards and internet) (, Hanseth and Lyytinen 2010, Hanseth and Monteiro 1997), to be performed under the general notion of information infrastructures (Henfridsson and Bygstad 2013).

Information infrastructures are defined as a "shared, open (and unbounded), heterogeneous and evolving socio-technical system (called installed base) consisting of a set of IT capabilities and their user, operations and design communities" (Hanseth and Lyytinen 2010, p. 4). This opens up for perspectives on organization and technology as open socio-technical systems, where related users operate upon an historical base (Aanestad et al. 2017, Ciborra and Hanseth 1998).

As noted above, the contribution within this body of literature is an impressive amount of broad, wide and deep perspectives, with a great variety in focus and contribution covering a complex multitude of fields and areas. There is however also some unresolved or less covered issues. Some differences between the approach often taken by writers associated with the "classic" information infrastructure literature and the more recent literature on digital infrastructures will be discussed. Next, some possible consequences of the change of perspective from information infrastructures to digital infrastructures will be described.

Digital infrastructures

The literature on information infrastructure often characterise processes related to design, development and implementation as driven by nonlinear dynamics and drift (Ciborra et al. 2000), risk (Hanseth and Ciborra 2007), complexity (Hanseth and Lyytinen 2010) and multiple interdependencies (Grisot et al. 2014). This is also caused by the embeddedness of technologies and practices and between different information infrastructures (Monteiro et al. 2013). This entanglement and embeddedness may also constrain an organizations ability to change (ibid). Since the complexity of the existing socio-technical arrangements mirrors the 'organizational identity' as well as the mode of production, it have to be the centre of attention during innovation (Grisot et al. 2014). Step-wise small-scale change is recommended in order to deal with this issue (Aanestad and Jensen 2011).

The layered embeddedness of socio-technical arrangements, practices, tools and regulations makes the distinct interactions between technology and organization, agency and structure a bit unclear, or at least difficult to trace on a general basis (Bygstad 2008). This also makes it difficult to understand what an information infrastructure is. Is it form or content? Is a technical structure or an organizational form? Is it an analytical perspective or a semantic network? (Bygstad 2008, Lee and Schmidt 2018). For instance, "it is a source of confusion to talk about tools and infrastructures as having a temporal dimension" (Lee and Schmidt 2018, p. 191). The notion that what matters is when, not what, is an installed base (Aanestad et al. 2017) confuses the relation between temporality and structure, since it implies that "things" only matters when they are object to practical activities.

Some of the complexity, then, may be caused by the analytical approach. The deep entanglement between practices and structure, content and form may itself be a source of complexity and confusion (Bygstad 2008, Lee and Schmidt 2018). This may also lead to difficulties of performing analytical precision. Since the study of large scale distributed IT systems is challenging, a distinct understanding of the relationship between practice and technology (also outside the temporal dimension) is particularly important (Lee and Schmidt 2018).

Literature on digital infrastructures (Henfridsson et al. 2014, Tilson et al. 2010) differs slightly from information infrastructures in focusing more on the specific features of digital technology. This literature introduces more market oriented concepts like 'path-changing innovation', 'future path of human activity' and 'innovation paths' (Henfridsson and Yoo 2014), 'multiple value paths' (Henfridsson et al. 2018) as well as 'innovation capability' (Svahn et al 2017), and draws attention to the "digital infrastructure as a category of IT artefacts" (Tilson et al. 2010:748). This orientation embeds a view of digital innovation as "the carrying out of new combinations of digital and physical components to produce novel products" (Yoo et al. 2010, p. 725). According to Yoo et al. (2010, p. 725) "digital innovation … requires a firm to revisit its organizing logic and its use of corporate IT infrastructures." A main motivation behind this orientation is to break away from established innovation paths (Svahn et al 2017), in order to enable rapid scaling (Huang et al. 2017).

While the literature on information infrastructures, then, frames technology as more or less entangled in a socio-technical system driven by the human and organizational agency (Henfridsson and Bygstad 2013); the literature on digital innovation in digital infrastructures are more occupied with how digitizing content breaks the tight coupling between physical or analog artefacts and information types (Fichman et al. 2014, Henfridsson and Bygstad 2013, Tilson et al. 2010). An additional aspect of the shift of focus from information (in its various types) to the digital is that elements earlier loosely coupled or non-coupled (work processes, manual processes, analog processes) are digitalized and brought together. Digital interconnectedness brings organizational actors and actions tighter together, something that may allow governance that is more systematic in order to achieve innovation (Henfridsson and Bygstad 2013, Henfridsson et al. 2014).

Digital innovation in digital infrastructures

Nonetheless, how information infrastructures or digital infrastructures evolve have been a central issue since the early 1990's. According to Henfridsson and Bygstad (2013, p. 909) "digital infrastructure evolution can be broadly referred to as a gradual process by which a digitally enabled infrastructure changes into a more complex form." The authors identified four streams in the literature by which infrastructures evolve, and provide a new contribution. The earlier information infrastructure research are categorized in three interpretivist framings - the complexity model, the network model and the relational model, and one positivist – the strategic asset model. In the three interpretivist framings, information infrastructures consist of the collaboration between organizational actors scattered throughout organisations. The way these actors collaborate makes it challenging to identify how the organization and the infrastructure are connected, and consequently how change should be facilitated. Local autonomy is central, but this autonomy emerge through interaction and may consequently be 'invisible' to both management, and sometimes even the actors themselves since part of the knowledge is tacit. In order to gain knowledge of the patterns of production and performance, and how they are connected to the infrastructure, 'deep insight' is needed. However, since achieving full and complete insight into this knowledge work is impossible, it is better to leave a lot of management to the actors or the work group. The management needs to be closely linked to the local interaction, "the patterned activity that results from situated actors' interaction and dealing with technology in their work settings" (ibid, p. 910). The strategic asset model, quite differently, sees the evolution of digital infrastructures as initiated and maintained by management. While organizations in this framing are quite ordered, the external business environment where the organization competes is very contingent and complex. Management have the prime insight into this environment, and a certain control of its own IT portfolio. Strategic alignment is about taking the necessary steps to align business and technology in order to be competitive. What these framings have in common is that they both are path-dependent, i.e. that change and innovation either have to be built on existing decentralized practices or that they have to compete in a complex but relatively stable market with certain rules.

Henfridsson and Bygstad praise the richness of the II literature but identify two shortcomings in these studies. First, these studies do not take into account structures operating beyond the "the rich texture of people's meaning-making of the sociotechnical world," and second they rely too much on events "directly observable in the empirical domain of infrastructures" (ibid, p. 910). Based on this premise, Henfridsson and Bygstad provide two main contributions. First, they use critical realisms' core insight of causality as explanation for why infrastructures evolve. They demonstrate this through identifying three generative mechanisms: innovation, adoption and scaling, and how these mechanisms are triggered during infrastructure expansion. A second insight is that it may take something extra to trigger the innovation mechanism. While tightly coupled architecture does not impede adoption and scaling, the architecture has to be loosely coupled in order to enable innovation (Henfridsson and Bygstad 2013).

Based on the review performed by Henfridsson and Bygstad, the earlier literature on information infrastructures and digital infrastructures can be categorized in two streams: information infrastructures as embedded and path dependent, dominated by historical and contemporary complexity; and the research on digital infrastructures more occupied with the innovation potential of digital artefacts and the consequent organizational change leading from this. Henfridsson and Bygstad manage through their comprehensive review of the II literature to highlight the tendency to focus on the sense-making level or the event-level of analysis. At the same time, they establish a new direction for this research stream, where agency and structure are more distinctly separated but interact through mechanisms.

Both the research on embeddedness, complexity and path dependency and the literature on digital innovation, recombination and path creation are occupied with the complex challenges resulting from interconnectedness, but while the first is more focused on the constraining and conserving mechanisms, the second is focused on particular digital characteristics that enable digital innovation within infrastructures.

The first stream occupied with cultivation of the installed base, with path dependency and embeddedness is based on the insight that infrastructures are never built from scratch (Hanseth 2002), and often becomes something completely different than forecasted in the initial plans (Ciborra et al. 2000). As infrastructures often deviate from their planned purpose, the corporate context should be looked at as a runaway learning organization (Ciborra et al 2000). As it is ineffective to use classic control efforts to plan the evolution of these heterogeneous networks, one should rather look at them as organisms to be *cultivated*. A central premise for this way of framing infrastructural evolution is the infrastructures inherent path dependent embeddedness (Monteiro 1998, Aanestad et al. 2017). Path dependency means that change and innovation initiatives have to relate to the existing installed base as a substantial formative core. The evolution and adoption is organic and natural (Star and Ruhleder 1996). An infrastructure is never built in the conventional sense, but "grows" as an "organic unfolding within an existing (and changing) environment" (Edwards et al 2009, p. 369).

As information infrastructures' evolutionary dynamics is nonlinear and path dependent, the focus have been to address the *bootstrap problem* and the *adaptability problem* (Hanseth and Lyytinen 2010). *Bootstrapping* (Hanseth 2002, Hanseth and Lyytinen 2010) is the bottom-up utilization of a particular momentum enabled within the installed base, and concerns directly meeting users' needs when changes are required. The prime example for information infrastructure expansion is Internets experimental, and evolutionary bootstrapping oriented strategy (Hanseth 2002, Hanseth and Lyytinen 2010). Bootstrapping and moods (Ciborra 2002) – the need to acknowledge the complexity and richness of tacit knowledge – contributes to infrastructure evolution through enabling creativity, and experimentation from within the organization. The *adaptability problem* entails acknowledging "local designs need to recognize II's unbounded scale and functional uncertainty" (Hanseth and Lyytinen 2010, p. 1).

The step-by-step change strongly recommended in this literature (Aanestad and Jensen 2011, Grisot et al. 2014) also applies when actors are gradually *enrolled* into the network through inscription and translation of interests (Monteiro 2000). Although infrastructures are dynamic, they resist innovation initiatives and strategic plans that come from top management (Ciborra et al. 2000). "Infrastructures should rather be built by establishing working local solutions supporting local practices which subsequently are linked together rather than by defining universal standards and subsequently implementing them" (Ciborra and Hanseth 1998, p. 315). Within this framing, strategic shifts are not recommendable.

Digitizing cow paths to protect status quo may impede innovation (Hammer and Champy 1993, Tilson et al. 2000). The research on digital innovation in digital infrastructures focuses, consequently, and in contrast, on agency and innovation, arguing that the seemingly sticky structures may also serve as contexts for action (Garud et al. 2009, Henfridsson et al. 2014) through recombination (Henfridsson et al. 2018), or even reconfiguration (Bygstad and Hanseth 2018) of the existing system portfolio. Such innovations are enabled by the re-programmability of software modules organized in patterns rather than in physical parts (Henfridsson et al. 2014, Tilson et al. 2010, Yoo et al. 2010).

A way of addressing these issues is to inspect how digital infrastructures evolve when generative mechanisms, such as innovation, adoption and scaling are triggered (Henfridsson and Bygstad 2013). These mechanisms are triggered when proper technology digitalize interaction between organizational services and customers. Within this perspective, digital infrastructures' dynamics also enable new ways of automation and innovation (Henfridsson et al. 2014, Tilson et al. 2010). The increasing redesign flexibility (Henfridsson et al. 2018, Henfridsson et al. 2014), their ability to provide changed control paradigms (Tilson et al. 2010), through distributed organization (Yoo et al. 2010) make digital infrastructures evolve in new ways, enabling new digital relation and improved collaboration. This also leads to new groups being linked, which again will expand the reach and range of the infrastructure.

Both information infrastructure studies and studies of digital infrastructures are occupied with network economics. However, while the first propose that critical mass will be reached through bootstrapping

strategies, the second focuses on the ability of digital technology to "quickly respond to emerging and varying customer needs in volatile environments" (Henfridsson et al. 2014, p.32). In a way, digital innovation extends the focus from being primarily on users to also include the customer or consumer.

In the health sector, the sector to which the current field study belong, there is an increasing focus on patient flow and logistics, and both politicians, health professionals, patient interest groups as well as IT professionals, strategists and entrepreneurs are looking for ways of dealing with these new challenges. A central aspect in this orientation is the increased focus on the patient as a core actor. Digital innovation is necessary in order to establish new relations between health units, health professionals and the patient in order to meet the requirements imposed on the health system. While discourse on technology is important in order to open up for creative solutions to big challenges, digital innovation is needed to solve these challenges. Especially when programs are in crisis, there is a need to "establish new cycles of positively reinforced feedback relations" (Boland et al 2007, p. 634). Some insight into how this may ensue is the core interest of this thesis.

This section (2.1) has been concerned with a central issue embedded in both research questions, namely how infrastructure evolves and how the conditions for change vary within the literature. A central issue in this review was to establish an analytical position from where the particular role of technology in digital infrastructure evolution could be better understood, also in order to enable an orientation that is compatible with critical realism. The next section (2.2) concerns related research on discourse and information systems. Section 2.3 is occupied with the role of lightweight IT in digital innovation of digital infrastructures.

2.2 Discourse in the literature on infrastructures and information systems

The literature framing evolution and innovation of infrastructures as embedded, path dependent, and conservative; and the literature on digital infrastructures more occupied with the flexibility of digital technology in digital innovation and new digital relations, are both abundant with metaphors conceptualising how infrastructures evolve. While metaphors like *cultivation*, *organic growth*, *path dependency* and *bootstrapping* (Ciborra et al. 2000, Hanseth and Lyytinen 2010) is aligned with the "runaway image" of information infrastructures; digital *innovation* (Henfridsson and Bygstad 2013) *path creation*, *innovation paths*, *value paths* (Henfridsson et al. 2009, Henfridsson et al. 2018, Svahn et al. 2017), generativity (Bygstad 2016, Henfridsson and Bygstad 2013) and *layered modularity* (Tilson et al. 2010, Yoo et al. 2010) are more occupied with the particular role of technology in digital innovation and disruption. In both perspectives, however, discourse is an implicit power operating within the theory, and its particular role in strategic shifts is not clear. The literature does not systematically analyse or explicitly theorize the role of discourse in how discourse and infrastructure interacts to enable infrastructural evolution. The actual role of discourse in providing causal links between ideas, visions, strategies, and infrastructure has not been investigated in a detailed way.

In the broader field of information systems (IS), however, the role of discourse has been brought into attention in several ways. While some studies have been concentrating on the use of narratives and buzzword in management practices (Baskerville and Myers 2009, Swanson 2002), others have looked at the relationship between discourse and practice during implementation of technology or technological routines in organizations (Ellingsen and Monteiro 2008, Gidlund 2015). For instance, Bissett (2002) discusses the role of discourse in hiding the consequences of war technology. These studies, often critical, inspects the difference between discourse and reality, such as the role of discourse as an element in concealing management's actual intentions, or as an 'existential' aid for the individual to handle change (Edenius 2002, Wastell 2002).

The research on *organizing vision* (Ellingsen and Monteiro 2008, Swanson and Ramiller 1997) or policy discourses (Klecun 2016) gives insight into the role of discourse in technological strategies and implementation. The success of organizing visions depends on the flexibility and legitimation enabled through the discourse, and reciprocal transformations over time maintain the vision among the stakeholders. The distinct role of respectively discourse and materiality is, however, not clear. Ellingsen and Monteiro's empirical case from the Norwegian health sector is a striking example of the use of technological vision in project implementation. In this study, however, the discursive strategies operate at two different levels, where one of them - operating in the 'hidden' - wins. These studies do not explicitly address the causal relationship between discourse and infrastructure.

Doolin et al. (2013), who investigates the role of discourse in organizational change, perform a similar approach. Through six different scenarios, or what they frame as "discursive changes" or "approaches", discourse' role as a translation device is investigated. The translations are possible because discourse is adapted to the social constructions of organizations. "Discourses provide the resources by which organizations and change programs are constituted, effectively in bringing them into being through the way in which they categorize and make sense of them" (ibid, p. 252). Such discursive changes view organizations "not as givens but as collective constructions of meaning and identities created and recreated through social interactions, which are embedded in sociomaterial practices and mediated by institutional, linguistic, and material artefacts" (ibid, p. 253).

Also in Actor-Network Theory (ANT) (Callon 1986, Latour 1993, Latour and Woolgar 1986) discourse has a role, but its causal implication is not easy to spot. ANT is primarily known for the tight interplay between social and technical means. Human and non-humans are linked together in networks conditioned by actors pursuing interests. The stabilisation of interests is about alignment through negotiations (Monteiro 2000). ANT provides a language for describing how this translation takes place on a quite specific level, and looks at the role of discourse in establishing scientific facts (Latour and Woolgar 1986); technological systems (Monteiro and Hanseth 1995); and how discourse is used in order to seduce and displace actors into a program (Callon 1986, Latour and Woolgar 1986,). The technology-in-the-making, this literature emphasize, is conditioned by socio-technical negotiation between a whole range of actors, and outlines the "open-ended character of this process – the stumbling, the compromises, the way non-technical interests get dressed up in technical disguise…" (Monteiro 2000, p. 71). This stream of literature also forms an opposition to management processes dominated by top-down, rational, decision making. The alignment is not obtained through facts, solution or beliefs alone, "order is an effect of an achievement – it is not given a priori" (ibid, p. 72). In his paper on the domestication of the scallops and the fishermen of St. Brieuc Bay, Callon (1986) looks at the "role played by science and technology in structuring power relationships", to understand "the emergence, development, and eventual closure of controversies" in the study of science and technology (Callon 1986, p.197). This happens through the establishment and alignment of networks in four moments: problematisation, interessement, enrolment, and mobilization.

Although discourse has an important role in this research stream (it is only mentioned *once* in Callon 1986), there are two challenges when it comes to identifying the role of the discourse. First, the role of discourse as a distinct force is unclear, both analytically and practically. Callon's philosophical and methodological point of departure is "the abandonment of all a-priori distinctions between the natural and the social" (ibid, 196). Callon describes the interplay between technical and social actors in equal terms. This conflation between the natural and the social, between subject and object, agency and structure may disturb the investigation of the causal role of discourse (Archer 1995, Elder-Vass 2015). Second, following the same line of argument, neither Callon (1986) or Latour and Woolgar (1986) provides an analytical framework for investigating discourse as a separate distinct force. Discourse is merged as an inseparable part of scientific or technical investigation. For Latour (1993, p. 64) the quasi-objects of reality are "simultaneously real, discursive, and social. They belong to nature, to the collective and to discourse." In the relatively recent research stream within IS on sociomateriality (Nyberg 2009, Scott and Orlikowski 2013, drawing on Barad 2007) a key issue is the entanglement between the social and the technical, i.e. the inseparability between meaning and matter (Nyberg 2009, Scott and Orlikowski 2013). Furthermore, in his paper on the role of discourse in a NHS project in the UK, Constantinides (2013) investigated how communicative action is mediated by and mediates IT in strategic projects. Through observing strategic meetings and analysing strategic documents, his main contribution is the insight that discourse and technology work in *constitutive entanglements* i.e. that narratives bring "the agency and power of material objects" (ibid, p. 216) to the forefront in specific organizational contexts.

The unwillingness, in sociomaterial (but also and to some extent the ANT stream, within social constructionism, and also in some parts of the "classic" literature on information infrastructures) research, to disentangle the social and the material leads, according to Faulkner and Runde (2012), to three distinct shortcomings. First, the perspective over-emphasizes the internal and necessary relations between social and technological objects, and neglects the external and contingent relations. Second, although technical objects are shaped by human activity, technical objects do in fact exist apart from

current interaction. Third, brute objects exist, and reality cannot be reduced to what we experience as practitioners or researchers. A consequence, thus, of the 'entanglement position' is that the distinctions between agency and structure become either unclear or 'conflated' (Archer 1995, Elder-Vass 2015, Mutch 2013).

ANT, sociomateriality and social constructionism is occupied with discourse on the social level as a rich, meaningful, multiple and heterogeneous force and its contribution in organizational maintenance and change. As Latour (1993, p. 97) claims,

> *"discourse is not a world unto itself but a population of actants that mix with things as well as with societies, uphold the former and the latter alike, and hold on to them both. Interest in texts does not distance us from reality, for things too have to be elevated to the dignity of narrative. As for texts, why deny them the grandeur of forming the social bond that holds us together?"*

One difference between the methodological interests that shapes research streams conditioned by social construction of reality, and critical realism, is that critical realism investigates regularities on the level of mechanisms, not on the level of sense-making. This might lead to loss of social granularity on the behalf of more structured causal regularities that brings about social, organizational and technical change. This positioning and some of the consequences will be discussed in Chapter 3.

In line with the critical realist perspective, I see activities in sociotechnical organizations as consisting of both social and material objects that may, or may not, be drawn upon in particular situations, but which also exists apart from this interaction. This means that rather than looking at the relationship between discourse and infrastructure as constitutively entangled in quasi-objects or texts i.e. that the interaction between the material and the discursive are entangled, the elements are analysed separately in order to see how they interact and change each other over time.

A way of conceptualizing discourse is to see it as "verbal performances" that participates distinctly in how society, politics and knowledge systems are transformed. In Chapter 3, Foucault's archaeological framework (1972) for analysing discourse will be outlined.

Technology matters, but what distinct characteristics are needed for a technology to support a strategic shift? This will be discussed next.

2.3 Lightweight IT in digital infrastructures

The modern society of today where the population is increasingly concerned about health, add an extra burden to the organization of health services, their accessibility, as well as the cost for providing these services (Anderson et al. 2007, Dobryzkowski 2012, Piening 2011, Kelly and Young 2017, Norwegian Directorate of Health 2016). The Healthcare System has traditionally been praiseworthy occupied with qualitative patient care, and the IT systems that surround clinical practice have primarily concentrated on clinical processes with the mission of securing practice. A drawback of this lack of focus on horizontal support is that hospitals are struggling with logistics both internally and externally (Van Lent et al 2012). A usual complaint from patients is thus that while the treatment was excellent, the coordination between units was slow, the waiting time long, and feedback in between encounters almost non-existent (Norwegian Ministry of Health 2015, Salazar et al. 2004,). This is partly caused by the significant difficulties in streamlining the supply chain (De Vries and Hujisman 2011). These "IT silos" makes change and innovation time consuming and expensive in that certain activities are favoured on behalf of others (Bannister 2001, Bowmann et al. 2011). This is exacerbated by the fact that no single stakeholder has the oversight, capacity or decision-making power to radically alter the status quo of such complex IT ensembles (Hanseth and Lyytinen 2010, Star and Ruhleder 1996;). One of the main consequences of these challenges is that innovation efforts in the health sector once initiated tend to lose steam, and slow down (Kelly and Young 2017, Piening 2011). Lack of information exchange across departments, even within the same hospital, is of concern to hospital administrators as workflows that are more efficient can save costs, enhance efficient use of scarce hospital resources (e.g., radiology), lead to more effective diagnosis and treatment of patients, and reduce patient waiting time (Dewaraj et al. 2013).

Put shortly, heterogeneous IT solutions technical arrangements and deep embeddedness in clinical practices makes change challenging. In essence, the inertia of extant solutions and practices "resists" external intervention, and changes need to be introduced in small and incremental steps (Aanestad and

Jensen 2011, Monteiro 1998). Although comprehensive and integrated EPRs have been proposed as a means for connecting heterogeneous systems in healthcare settings, they too have a tendency to become stagnant IT silos that sometimes curb innovation and fit badly with practice (Ash et al. 2004, Berg 1999).

The point of departure, then, is that public sector "silo" systems tend to counteract or slow down innovation initiatives. How can we motivate innovation efforts in eHealth infrastructures? What characteristics facilitate faster and more distinctive innovation?

The conservative influence of hospital IT portfolios have for some time been challenged by process innovation initiatives seeking to create coordinative paths in order to improve horizontal performance. Examples are patient logistics (Van Lent et al. 2012), clinical pathways (Rotter et al. 2010), and hospital supply chain management which is a systemic view of the flow of all types of resources (De Vries and Hujisman 2011). These initiatives typically address "horizontal" workflow processes, but often fail to interact with and leverage existing databases and functions.

In order to conceptualize the difference between silo challenges and slow innovation on one hand, and the faster innovation efforts on the other, Bygstad (2016) establish the terms heavyweight IT and lightweight IT. Heavyweight IT is defined as "a knowledge regime, driven by IT professionals, enabled by systematic specification and proven digital technology, and realized through software engineering" (Bygstad 2016, p. 181). As Bygstad (2016 p. 182) claims, "…developing heavyweight technology requires specialised IT competence, focusing on requirements, reliability and security." The consequence of this software engineering strategy is that the many clinical systems (like EPR, lab and chart systems) connected through integration, creates very expensive but also extensively time consuming development, implementation and adoption projects. In addition, the modules are often tightly interconnected making change in one part affecting functionality in another part. In a way, this is an explanation for some of the inertia of the installed base (Monteiro 1998).

In contrast to heavyweight IT, Bygstad defines lightweight IT as "a socio-technical knowledge regime, driven by competent users' need for solutions, enabled by the consumerisation of digital technology, and realized through innovation processes" (Bygstad 2016, p. 181). Lightweight IT uses consumer technology such as smart phones, tablets, apps and whiteboards, and operates largely outside heavyweight IT resources" (ibid, p. 182). It follows that lightweight IT prioritise innovation and usability to rigid requirements specifications, security and data consistency. The main point is, then, that the two regimes have independent strengths. While the regime of lightweight IT are formed by the generative relationship between knowledgeable end-user groups and entrepreneurs, the heavyweight IT regime is dealing with core systems and the activities related to stabilizing, securing and scaling them (Bygstad 2016, Bygstad and Iden 2017). Examples of strengths with lightweight IT are mobile apps that enables swift purchase of metro tickets, apps to improve service work or white collar work as well as improved welfare technology solutions (Bygstad and Iden 2017). Heavyweight IT, on the other hand, enables secure access to comprehensive information repositories. Consequently, both are needed in order to enable profound business innovation (Bygstad 2016).

Lightweight IT is an example of digital innovation (Bygstad 2015, Bygstad 2016). In general, digital technologies possess more innovative potential than their analog counterparts do (e.g., Sørensen, 2013, Tilson et al. 2010, Yoo et al., 2010), as digital services, applications and content can be reused and recombined and increase in breadth and value with the number of people involved in their production and consumption. Digital innovation is simply defined as "*an innovation enabled by digital technologies that leads to the creation of new forms of digitalization*" (Yoo et al. 2010B, p. 6). Digitalization is accordingly defined as *"the transformation of socio-technical structures that were previously mediated by non-digital artifacts or relationships into ones that are mediated by digitized artifacts and relationships*." Digitalization is not only about digitizing (encoding diverse types of analog information in digital format), but also how socio-technical structures are changed in addition to the artefacts themselves (ibid).

Discussions and debates regarding digital innovation and digitalization within the field of information systems have produced extensively broad and rich work (Nambisan et al. 2017). Examples are, but not limited to, product innovation and management issues related to this (Henfridsson et al. 2014; Svahn et al. 2017); focus on platform ecosystems (Tiwana et al. 2013) and their implications on the economy (Parker et al. 2016), or on distributed agency (Parker et al. 2017). Further, the role of technology in rapid

scaling of the user base (Huang et al 2017), and organizational consequences of innovation in a digitized world (Yoo et al. 2012) is addressed within this literature. Research on digital innovation in hospital infrastructures are less frequent, maybe also because its public sector affiliation with the particular challenges in that sector, makes digital innovation more challenging.

The investigation of the role of lightweight IT as a particular digital innovation knowledge regime within digital infrastructures, is motivated by the search for solutions addressing the "silo problem". Earlier studies have demonstrated lightweight IT's promising potential in establishing process improvement in hospitals (Bygstad 2016, France et al. 2005, Hertzum and Simonsen 2013). These studies have not to a sufficient degree focused on the process innovation potential of lightweight IT, and what characteristics of lightweight IT that make faster innovation possible.

The existing literature on lightweight IT indicates that it is a knowledge regime with at least three central characteristics:

- *One* is the nature of the artefact, its usability, its occupation with improving processes and its easiness in implementation. This technology has according to Bygstad (2016) the ability to bypass the existing infrastructure when it is implemented.
- The *second* characteristic is the providers' ability to quickly follow up pilots, and implementations, so that users and organizations may experiment and test new functionality. This also relate to the acquisition opportunity, the availability of the product on the commercial market (Bygstad 2016).
- A *third* important ability of lightweight IT is its easiness in implementation also caused by it being modular, facilitating loose coupling between systems components.

The aim of the second research question is to elaborate on these three characteristics. Not least in order to emphasize lightweight IT's ability to enable process innovation, its informating ability that also makes it easier to monitor and justify the process innovation, and its modular structure. Earlier literature have been mainly illustrative, concentrating on the ideal types of lightweight and heavyweight IT (Bygstad 2015, Bygstad 2016), the generative potential in their interaction (Bygstad 2016), or the business possibility the interaction enables (Bygstad and Iden 2017). Paper 3, 4 and 5 (see section 5.2) investigates the abilities that makes lightweight IT a particularly suitable solution for enabling innovation, and consequently a faster way of changing the digital infrastructure.

Process innovation

Lightweight IT is "a socio-technical knowledge regime…realized through innovation processes" (Bygstad 2016, p. 181). Digital process innovation is about using IT to improve business processes (Davenport 1993). According to Davenport (ibid, p. 5), a process is "a structured, measured set of activities designed to produce a specific output for a particular customer or market." This orientation implies more emphasis on *how* work is done than *what* is done, which is more product oriented (ibid). It also implies taking the customers point of view. Digital innovation is made possible when digital technology establish new digital links (Yoo et al. 2010). In the health sector, process innovation may refer to reducing the time spent between diagnoses, to treatment and follow-up. This may shortening the time from referral to admission and from admission to discharge.

According to Hammer (1990) there are (at least) six principles for implementing horizontal end-to-end processes using the power of IT. *First*, organize around outcomes instead of tasks. *Second*, those who use the output should perform the process. *Third*, make sure that real information producing work replaces information-processing work. *Fourth*, link instead of integrate parallel activities. *Fifth*, connect performance and decisions, and build control into the process. *Sixth*, capture information once, and at the source. Hammer and Champy emphasized, in their Business Process Reengineering (BPR) approach, the need to understand the services delivered to the customer in their totality, and modern technology's ability to exceed existing barriers in enabling organizational change. BPRs lack of organizational dimensions and the tendency of top down managerial sidedness was, however, a significant shortcoming (Iden 2013, Melao and Pidd 2000). As processes are complex organizational phenomena, where workers attached to different parts of the organizations collaborates, a more nuanced view of processes, and a systematic approach to understand them, was needed (Melao and Pidd 2000). A weakness in the BPR approach is the way they ignore the importance of historical learning and adaptation as well as the existence of rules, regulations, and technological components that has gradually accumulated. In the

literature on information infrastructures, this "installed base" (Hanseth and Lyytinen 2010) is an important point of departure, and acknowledges the step-by-step emergence of collaborative networks in organizations (Aanestad and Jensen 2011, Melao and Pidd 2000).

In public sector infrastructures, vertical silo systems supporting specialist practices has been prioritized more than horizontal systems supporting end-to-end flow processes (Bannister 2001). Accordingly, comprehensive vertical systems supporting functional activities have developed at the expense of cross-functional information flow (Bannister 2001), leading to path dependencies that makes change difficult (Bouwman et al. 2011). BPR have had limited impact in the health sector, maybe caused by the fear of disturbing or even obstructing clinical practice. Lightweight IT may solve some of these challenges, thus contributing to a revitalization of Hammer and Champy's ideas. This can lay the foundation for improvement, on horizontal performance, and provide a process innovation solution for the health sector. In section 5.2, this will be analysed, and in section 6.2, the contribution gained from seeing lightweight IT as a process innovation knowledge regime, will be discussed.

Informating with lightweight IT

"With a smile he commented, you know, when the large whiteboards are in everybody's sight all the time, they are hard to overlook" (Quote from Bygstad 2016, p. 189).

A second strength with lightweight IT is its characteristics to improve the transparency and insight into horizontal processes (Hertzum and Simonsen 2015). In order to investigate this particular ability Zuboff's (1988) notion *informate* is drawn upon. By informate, I denote the process of leveraging IT to make information about work visible and actionable across organizational functions and departments. Zuboffs informating framework indicates the need for management to be active in recognizing IT's potential to generate information about the underlying productive and administrative processes that were previously opaque. Informate, consequently, may concern the systematization and digitalization of underlying processes in order to more easily give insight into patterns of performance and production. Zuboff documents how the explicit representation of tasks, gathered from monitoring agent behaviour and/or outcomes, sets in motion a series of dynamics that will ultimately (re)configure the nature of work and social relationships that organize productive activity. In essence, Zuboff observes that informating will improve performance and the quality and autonomy of working life, when employees are obligated, and accept, the use of feedback from IT to adjust their work behaviour.

Informate, then, is a condition enabled through digitalization and automation of manual processes or through compiling digital processes or information earlier displayed separately. Digitalization of processes, or path creation (Garud and Karnøe 2001, Henfridsson et al. 2009), may entail struggling against existing social rules and taken for granted techniques and tools. In a way, entrepreneurial activities is about disembedding oneself from existing structures and mobilize support, rather than resistance from an inertia of work practices and systems. Hence, process innovation "is a collective effort where paths are continually and progressively modified as new technological fields emerge" (Ibid, p. 2).

Informate can both be a result of complex interacting processes i.e. integrated modules, and local resources made universal through enabling access across organizational units. Digital interconnectedness, thus, makes it possible to improve horizontal performance, but it also threatens stabilized local processes and departments (Henfridsson et al. 2014). The increasingly sophisticated insight into patterns of organizational processes and information may tempt managers to disturb complex and interdependent processes (Ellingsen and Monteiro 2005). On the other hand, the organization becomes more equipped to deal with vicious and virtuous outcomes of digitalization (Garud and Kumaraswamy 2005). Informate can both inspire new use of information, new forms of sharing and communication of the information, as well as new forms of knowledge. Achieving such a condition will thus be beneficial. However, this poses certain requirements to the shape of the technology. Technology organized in modules enables faster change and improved reuse of objects and information. This will be discussed in the next section.

Layered modular architectures

"A well-known tactics to reduce complexity in software design is the principle of loose coupling between modules (Parnas 1972). Loose coupling enable less interdependencies, reduce information flow and requires less coordination" (Bygstad 2016, p. 190).

The third prominent feature of lightweight IT is its modular structure. This constitution may inspire loose coupling between system components. The concept of loose coupling is used within a broad range of IS research to denote both technological and organizational aspects (a brief overview is provided in Øvrelid and Bygstad 2016B). The central focus within computer science in this regard has been to decompose system functionality in order to enable changes in one part of the system without affecting the whole system. Parnas (1972) highlights three key benefits in modular programming. First, it inspires systems that are more manageable and it shortens development time because separate groups can work on each module with limited need for communication. Second, it improves flexibility in that changes in one module not necessarily affect the others. Third, comprehensibility – the possibility to study one module at a time – is enabled. It is assumed that the whole system can be better designed when it is better understood, and when the system modules interact through distinct interfaces.

Gamma et al. (1995), and Larman (2004) extend this insight by highlighting the role of software patterns in enabling looser coupling between system components. Software patterns in digital arrangements replace relation between parts in more physical or manual infrastructures (Henfridsson et al 2014, Yoo et al. 2010). In the field of information systems both management oriented literature and the literature on digital innovation is increasingly occupied with the redesign flexibility, the ability to establish new digital relations, and the faster re-orientation of IT portfolio when market trend shifts (Øvrelid and Bygstad 2016B). Layered modular architecture (Yoo et al. 2010) differs from modular architecture by being more flexible, and software oriented something that enables faster re-programmability. This literature is, however, more occupied with product innovation than process innovation. My interest orbits around how digital infrastructures evolve and the particular challenges related to this addressed through digital innovation. Lightweight IT is a particular form of digital innovation in digital infrastructures, and can make it easier to innovate and informate also through its modular constitution.

In summary, this thesis is first about the role of discourse in promoting an alternative to an eHealth infrastructure in crises. These programs need new energy, maybe a new direction. eHealth programs are often surrounded by turbulent discourses (Sauer and Willcocks 2007). Much of the discourse will remain in the background although never absent and always challenging for the program in one way or another. My main interest is socio-technical discourse, and especially the one that deals with digital innovation. The second and more practical interest regards the characteristics needed of innovative technology in supporting a strategic shift. Further, a framework for studying discourse (presented in section 3.1), and the relation between discourse and infrastructure (presented in section 3.2), is introduced and described.

3 THEORETICAL FRAMEWORK

In our time, discourse on technology is comprehensible and ubiquitous. Not least in the public health sector where common ownership is particularly strong. This means that eHealth programs often become the centre of attention. The discourse is also turbulent because of the diversity of voices, expressed in media, raised and backed by political and social actors, embedded in political and social strategies. As mentioned in the introduction, (at least) three "Greek choruses" (Sauer and Willcocks 2007) are visible in these turbulent battle zones: the public officials who defend the programme, the internal institutions and medical professions that are "sympathetic critics" and the media, consultants and academics that constitute the "professional critics." These voices also use the opportunity to bring forth scandals and dramas creating an even more challenging situation for health system politicians and entrepreneurs. The space of opportunity enabled in the bigger marketplace gives, on the other hand, an arena where discourse can prosper and be utilized by technological entrepreneurs and optimists to provide "swift" solutions to programs in crises.

Discourse on technology contains power in that it proposes solutions to complex challenges. Therefore, discourse may have a central role in eHealth programme turbulence but also in how constructive solutions to extensive challenges arise. An investigation into the role of the discourse may, consequently, bring forth new insights in that particular claims, concepts, discourses and technologies are studied both individually and through their interactions. Discourse has become so integrated into the mind and language that it is difficult to investigate its explicit role in technological change. For instance, what is the concrete role of discourse when technological programs experience crisis? How can we analyse the content of these discourses and their consequences?

This chapter introduces a particular way of identifying and analysing discourses, the archaeological framework from Michel Foucault (1972). In order to investigate the causal relationships between discourse and infrastructure, that is, what it takes for discourse to obtain a certain strength and consequently participate in changing an eHealth program in crisis, critical realism will be applied. More concretely, the context-mechanism-outcome configuration from Pawson and Tilley (1997) will be used to investigate the relation between discourse and infrastructure. This enables an investigation into interactions as *causal* and *contingent*. In 3.2, I will consequently describe how. First, Foucault and his archaeological framework will be outlined.

3.1 Discourses and discursive formations

A way of conceptualizing discourse is to see it as discursive and relational, i.e. as having a distinct role in how society, politics and knowledge systems are transformed. In the research field on information systems, two main theories on discourse are dominant[1]; Habermas' theory on communication and Foucault's theory on the role of discourse. While Habermas is looking for the *ideal speech situation,* which is the "conditions under which rational agents would be able to find a consensus by using the exchange of arguments" (quoted in Stahl 2004, p. 4331); Foucault is more occupied with reality as-is. In his book "The Archaeology of Knowledge" (1972), he provides a framework for analysing the discursive elements, and consequently a way of understanding the desirability and legitimacy of discourse.

The section starts with an explanation for choosing Foucault's discourse analyses when studying the role of discourse in strategic shifts in digital infrastructures. This includes looking into thematic shifts within the Foucault curriculum, and particularly his initial focus on knowledge and truth production rather than power and discipline.

Foucault and IS, why the archaeological method?

Foucault builds on Kant's insight that the role of language is not merely to represent (empirical) objects (as in the classical age), but may also describe relations between the individual and the physical world. This means that ideas (phenomena) might be something different from the object (noumena). If the

[1] Other examples are Nigel Fairclough's "critical discourse analyses" (Fairlclough 2005, Fairclough 2003), where the central element is the text, and the role of language in discourse or discursive practices; and Alvesson and Karremans "Varieties of discourse" (2000) that analyses various forms of discourse as texts or as a way of making 'linguistic sense' of organizations (ibid, p. 1127). Alvesson and Karreman are, however, more occupied with the categorisation of discourses than a method for investigating them.

social (phenomena) is the sphere through which objects (noumena) are experienced and conceptualized, this also enables subjectivity: human beings are the (transcendental) subject of all knowledge, but also the (empirical) object of knowledge (Gutting 2013, Utaker 2009). Kant is occupied with the *possibilities* this transcendental and universal character of knowledge gives. Transcendental idealism denotes, consequently, an individualist and idealist mode (Bhaskar and Lawson 1998), i.e. it focuses mainly on the conditions of existence. Foucault, in his works, breaks this into two categories: conditions of *existence* (conditions d'existence) and conditions of *validity* (conditions de validité) (Utaker 2009). Even if language is a form that makes our linguistic freedom possible, this freedom is often captured by certain discourses that give us a space within certain relationships (ibid). The networks that enable discourse will also to a certain extent constrain discourse, and make the outcome dependent on the sense of the discourse in the given context. Discourses are both historical and contingent, and Foucault's main interest was the origins of such discourses[2], and the inter-relation between the different statements in accumulation of discourse.

Willcocks (2004) categorize Foucault's authorship in three periods[3]. The main use of Foucault in this thesis stems from the first of these periods, his occupation with understanding scientific and technological discourse and his archaeological framework to analyse the content of discourses. His book *The Archaeology of Knowledge* from 1972 outlines his method for performing these investigations. This book marks a transition in Foucault's authorship from the occupation of knowledge and discourse to the relation between knowledge, discourse and power (Gutting 1989). In the first part of his work, Foucault tried to understand the emergence of knowledge in modern times, as a way of handling societal, political and scientific challenges. The archaeology is the Foucauldian twist of using historical inquiries "in order to uncover the discursive practices that constitute the field of knowledge" (Willcocks 2004, p. 250) and to lay bare the empirical conditions under which (expert) statements come to be counted as true (Hacking 1986). This is done through studying discourses that he sees as practices performed by knowledge agents, "that systematically form the objects of which they speak" (Foucault 1972, p. 54).

Gradually Foucault analyse discourse as power, and in his inaugural speech at The College de France December 1970, he claimed that "Discourse is the power which is to be seized" (Foucault 1981, p. 53)…and "Discourse [is] a violence we impose on things, or in any case a practice…we impose on them…"(ibid, p. 67)[4].

The use of Foucault within the field of information systems have mainly been inspired by his second (genealogical) period, his focus on the exercise of power, the way technology and technological knowledge embodies disciplinarian tendencies and strengthens power relations (see Willcocks 2004 and Willcocks 2006 for a broad review).

The framing in this thesis is less oriented towards the exercise of power and more interested in the endeavours for addressing and solving technological challenges. That is, the discourse that arises when technological program struggles and its implications for technological change. The second period where Foucault's interest changes from being on the relation between words and things, subject and object; to the power relations established through these interactions, obscures some important empirical insights that the first period contains (Elder-Vass 2010).

---

[2] Foucault's approach is inspired by French theory of science from Koyre, Bachelard, Cavailles and Canguilhem. The physicist and chemist Bachelard worked on theories addressing what he called "epistemological breaks", and how epistemological obstacles prevented us from seeing the validity in new theories. Canguilhem worked within medicine and biology and was particularly interested in how old concepts was used in new theories but where the content of the concept was changed (examples are the Cartesian vs the modern use of the concept "reflexes", or the difference between Newton and Einsteins use of "mass"). Foucault, then, is in his "archaeological breaks" inspired by Bachelard, but have less faith in progress than Bachelard (Schaanning 2000). Moreover, Foucault is inspired by Canguilhem's "concepts", but turns them into "discourse" and investigates their attachment to a surrounding field, making them systematic "wholes" who is transformed.

[3] In the first period (1950s-1969), Foucault is mainly occupied with archaeology, discourse and knowledge. He then (1969-1976) moved through Nietzsche towards genealogy, power relations and power/knowledge. A new crisis emerged after the first volume of "history of sexuality" and in his last years (1976-1984) Foucault's main occupation was questions surrounding the self, ethics and care of the self (Willcocks 2004). This can also be supported in Foucault's own work as he in one of his last lectures distinguishes between three philosophical aspects of his work: "the production of truth, the exercise of power, the moral education - alètheia, politeia and ethos" (Eliassen 2016, 14, my translation).

[4] This signals a shift within Foucault's methodology from archaeology to genealogy. While "truth" in his archaeological period is to be understood as "a system of ordered procedures for the production, regulation, distribution and operation of statements"; it changes to be linked in a "circular relation with systems of power which produce and sustain it, and to effects of power which it induces and which extend it," in his genealogical period (Davidson 1986, p. 221).

There are, at least two main arguments for using Foucault when performing discourse analysis in research on digital infrastructure innovation. *First*, Foucault is, (at least in his first period) occupied with the empirical world more than the political and normative world. *Second*, Foucault investigates experimental and innovative discourses, discourses that challenge the existing. This also means that Foucault's in his work is occupied with how knowledge regimes emerge; how they challenge and substitute older regimes, and the role of discourse in this.

Statements, discourses and discursive formations

For Foucault epistemes or knowledge systems emerge through discourses (Østerberg 1988). Does this mean that truth production (Foucault's first period) emerges through discourses? Moreover, what type of truth is that we are talking about here? First, Foucault's archaeology is primarily grounded in historical practice more than philosophical theory (Gutting 1989). It is consequently not a theory of language, or of ideal philosophical conceptions of truth. Rather, Foucault's archaeology establishes techniques for revealing how a discipline develops validity and objectivity (ibid).

The archaeological method is, consequently, not about identifying singular statements and how they transcend and changes knowledge areas. Foucault's method is about seeing discourse as practice, as a way of attracting other elements in a network. The decisive factor is not the underlying intention, but the way the discursive actions enter into specific knowledge formations (Schaanning 2000). This could be seen both as a way of understanding the discourse' dependence on a reference field. When all references are changed or removed, the discourse must change. It could, however, also be seen as a consequence of Foucault's object of study, the historical changes in the human sciences and history of thought. If discourse is the study object, then the study of discourse will give indications of changes in the surrounding field.

In this thesis, two insights from Foucault's archaeological method are of particular importance. First, I am interested in how discourses become attached to a surrounding field and thus emerge into discursive formations. The second interest regards the content of discursive formations, that is, the accumulations of discourses that systematically operate within a knowledge area, and their abilities to participate in efforts to change them.

Three important unities in Foucault's archaeological framework are statements, discourses and discursive formations. *Statements* are "the atom of discourse" and defined as "a function that cuts across a domain of structures and possible unities, and which reveals them, with concrete contents, in time and space" (Foucault 1972, p. 98). This is not very clear, but at least it helps us see statements as a contingent linguistic element (a word, a concept, a claim) that have a function across a domain, and which is necessary in order to enable discourse. *Discourse*, is "constituted by a group of…statements…assigned to particular modalities of existence" (ibid, p. 121). Stuart Hall build on this to define discourse as "a group of statements which provide a language for talking about – i.e. representing – a particular kind of knowledge about a topic" (Hall 1992, p. 291). Since discursive formations are defined as "the enunciative system that governs a group of verbal performances," (Foucault 1972, p.130) we can understand discourse as a verbal performance consisting of several statements seeking or belonging to an associative field.

The statement leading to a discourse has to attach itself to a surrounding field – or a network, a *field of association* - in order to become discursive formations (see figure 1). First, this network includes *means* or *techniques* used in knowledge creation. Second, it contains *practices*, the organizational or cultural environments where such means are used systematically. Third, *strategic considerations* are connected to the use of *means* in the performance of practices. This relates to strategies, tactics or ways of thinking. The fourth constitutive element is *institutions*. An institution, in this context, is an apparatus that enable performance of specific discourses, thinking, strategies, practices and aids (Schaanning 2000). The fifth element is *discourse*, which is the speech and writing associated with the production of a particular knowledge.

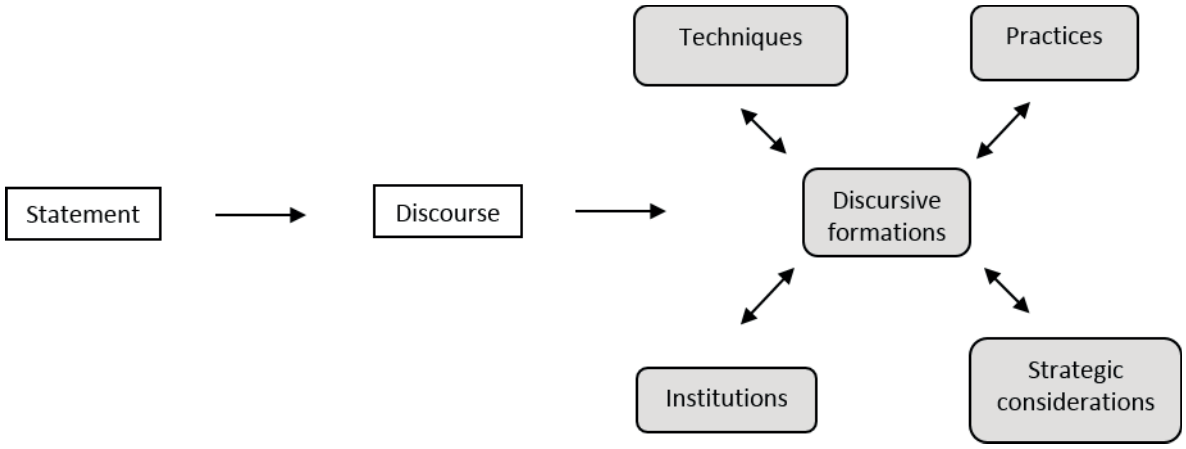


Figure 1: Statements, discourse and discursive formations

In summary, discursive formations emerge and their strength increases when discourse is attached to a surrounding field. Foucault's archaeological framework is a particular approach to identify and explain how this happens, through investigating the content of discursive formations, and its (contingent) relations to the external surroundings. Discursive formations are consequently also a *system of dispersion*[5].

A central core of discourse is, as we have seen, the statement, and the statements reference to a subject, a field and materiality. According to Foucault a "statement must have a substance, a support, a place, and a date" (Foucault 1972, 113), i.e. it must be 'anchored' to something material (Schaanning 2000). Foucault, then, is occupied with the field into which discourse enters, and the need to analyse the whole network to understand the content and the implications of the discourse. Even though this enables us to see possible connections between discourse and other formative elements, it remains to describe how discourses become *discursive formations*. What is the relation between discourse, the other formative elements in this network and discursive formations?

The anatomy of discursive formations

In the last section, a statement was defined as a contingent linguistic element (a word, a concept, a claim) that have a function across a domain, and which is necessary in order to enable discourse. Discourse was defined as a verbal performance consisting of several statements seeking or belonging to an associative field. In Foucault's own definition, a discursive formation is "is the general enunciative system that governs a group of verbal performances" (Foucault 1972, p. 130). The term is however also used in particular discourses governed by this principle, discourses where concerns, perspectives, concepts and themes are shared. This embed the insight that *verbal performances* needs to contain some sort of shared 'truth' in order to be adopted and *governed* within the *enunciative system*.

Put simply, a discursive formation is an accumulation of singular statements, which through time may turn into discourses when sufficient amounts of actors find the statements reasonable. These actors belong to certain institutional arrangements that may or may not accept the discourse. The living conditions of the discourse are dependent of the object that the discourse is connected to. "The object emerges under relational (both internally and externally) conditions and "juxtapose itself with other objects" (Foucault 1972, p. 50).

In practice, how do singular statements and discourses become discursive formations? What is that bring them together? What rules or patterns of interaction establishes and forms alliances?

Foucault proposes four analytical techniques to identify discursive formations (see table 1). First, discursive formations can be identified by its *area of interest*; what it is about, the object of its occupation. In Foucault's own work, these entities are Madness, Sexuality or The Clinic, but the main point is that these objects are constituted by the virtue of the different discourses on the object. What is

[5] "Whenever one can describe, between a number of statements, such a system of dispersion, whenever, between objects, types of statement, concepts, or thematic choices, one can define a regularity (an order, correlations, positions and functioning, transformations), we will say, for the sake of convenience, that we are dealing with a *discursive formation*" (Foucault 1972, p. 41).

the key challenge that is addressed? What is it one is talking about within this area of challenge? The identification of the object is done through investigating the areas (surface of emergence and surface of appearances) where these challenges are talked about, and identify how and from whom the forming of the object is done (authorities of delimitation). This can be done by analysing and relating the different ways actors talk about the object to one another, and what particular grid of specification the actors are leaning their knowledge on. Examples from Foucault's studies are psychiatrists studying the soul, clinicians studying the body or the history of disease within the patient's family (Schaanning 2000). The point is that the object consists of different logics of classification from different fields.

Second, the identification of *enunciative modalities* is about analysing the different actors. Who is speaking, with what right and qualification? From what institutional site are they speaking, and with relation to which possible networks? The actor's utterance is of special importance if we understand the actor's enunciative modality, that is, the mode of the actor, where, when, and why the utterance is made. Foucault is particularly interested in the relation between the speakers correspondence to the actual debate.

The third way of identifying and defining discursive formations could be to inspect how *concepts* are established and used. This might be done through investigating the relation between concepts (types of dependence); by investigating their coexistence, or by looking at the procedures of intervention between concepts. Coexistence entails looking at how discourses travels between disciplines or by how old discourses is given new life. Intervention is how concepts from other fields are brought in and radically changes the understanding of the object.

	Object	**Enunciative modalities**	**Concepts**	**Strategies**
Example:	Madness	Doctors, Judges, Experts	Older: genus, species Newer: Organism	Language conventions or economical discourse
Identified through investigating:	-What is the key challenge? -Who is forming the object and how? -How does the object of discourse relate?	-Who is speaking, with what right and qualification, and from where? -What are the actor's possible networks?	-Relations between concepts -Coexistence between concepts -Use of radical new concepts from other fields	-Points of diffraction -Economy of discursive constellations (why something lives or disappears) -Decimation (who decides what strategies that count, why and what is the result)
Result:	Identification of the object of discourse	How the relations between discourse and actors are established	Concepts in the discourse and the "logics" of their relations	Understanding of contents and reasons for epistemic (strategic) shifts

Table 1: Elements in Discursive Formations

Finally, the fourth way, the *formation of strategies*, is occupied with different social aspects; how the discourse is "spread" between fields, why something lives on and something disappears. Decimation deals with who decides which strategies are the most significant, why, and the result of these decisions.

All the work of understanding Foucault's archaeological approach would be of little use if it could not help explaining strategic shifts. Strategic shifts are generally defined as significant changes in processes and technology. This means that discursive formation, in order to participate in strategic shifts embeds some sort of causal significance. They enable a connection between words and things, between subject and object, in short, they have the power to connect to materiality[6].They may consequently be of help in identifying both random, arbitrary and more regular relationships.

[6] Foucault (1972) is inconsistent on the systematic relation between subject and objects of knowledge, and consequently of discourse. On one side, he seeks to 'disentangle' the subject and object: "I would like to show with precise examples that in analysing discourses themselves, one sees the loosening of the embrace, apparently so tight, of words and things, and the emergence of a group of rules proper to discursive practice"

The causal power of discourse

Discourse have a role in how infrastructures evolve (Øvrelid et al. 2017), and should be taken into account when inspecting the evolution and change of digital infrastructures. Discursive formations have according to Foucault transformative power, not only through discourse, but also through their relations and regularities in accordance with existing statements, utilities, practices and institutions (Foucault 1972, Schaanning 2000). This also means that discursive formations do not give a central role to subjects, i.e. it is not a linguistic phenomenon to be interpreted exclusively through hermeneutics (Elder-Vass 2010). Neither is it Foucault's singular purpose to document changing discursive practices; rather he wants to show that these changing practices *matter* (ibid p. 151).

Even though Foucault is compatible with a realist view of the world, realist critique of Foucault's archaeological method emphasize the lack of explanation for why discursive formations reach the level of power that they do, why they are able to change social or technical systems, or why they diminish or disappear (Elder-Vass 2010, Pearce and Woodiwiss 2001, Potter and Lopez 2001). This unclear ontological positioning of discursive formations will be addressed through describing the interaction between discourse and infrastructure. Some researchers might feel that using Foucault's discourse concept within a critical realist approach might simplify the complexity of the phenomenon too much. While agreeing that this is a risk, it could be argued that this undertaking enable an identification of the causal powers brought about by discursive formations.

In accordance with Elder-Vass (2010, p. 151) who claims that Foucault's project *requires* that discursive formations have causal power, the "ways in which discourse *interact* with other causal powers in the production of social (socio-technical) phenomena" (ibid, p. 144) is examined. This will be dealt with within a critical realist framework.

3.2 Critical realism and a Context-Mechanisms-Outcome (CMO) configuration

Foucault understood that a speaker's statement will always end up in a field where predefined rules and regulations exists, and that to have power, the ability to change or reform a field or a program, discursive formations have to relate to this pre-existing field (Hardy 2010). I take this as an argument to align discursive formations with the critical realist philosophy, and to integrate discursive formations as a constitutive part of the realist vocabulary. Seeing discursive formation as a *causal mechanism,* operating externally to or internally within sociotechnical programs, enables an investigation into the interrelation between discursive formations and other mechanisms. First, some important historical assumptions embedded in critical realism will be provided. Then I will describe a realist configuration for analysing relations between context, mechanisms and outcome.

In his famous essay on the two cultures, C.P Snow (2001/1959) describes human sciences and the natural sciences as two distinct and almost "incompatible" cultures. This incompatibility was a major hindrance to improve the sciences, and in making a better world. In the early 1960s, the social science, a third culture, experienced disruptive debates as to which of these two cultures they should associate. As a "compromise", the philosopher of science Roy Bhaskar establishes critical realism as a methodological and philosophical approach operating between the social and the natural world.

Building on Kant (as did Foucault), but with less individualist and idealist rigor, critical realism acknowledge that we never have access to the 'nature' of things. The natural world exists independent

(p 54). Sometimes these elements is constituted by and constitutes each other through practices (the knowledge workers behaviour, writings, techniques, institutions and means.): "Words and things' is the entirely serious title of a problem; it is the ironic title of a work that modifies its own form, displaces its own data, and reveals, at the end of the day, a quite different task. A task that consists of not – of no longer – treating discourses as groups of signs (signifying elements referring to contents or representations) but as practices that systematically form the objects of which they speak (p. 54)." In his book, "The Birth of the Clinic" the distinction between mere talk or speech and materiality is very clear. The clinical episteme changes when an intervention into the body is made possible. When the medical regime is able to intervene into the body, it is no longer sufficient for the doctor to describe and systematize the symptoms everybody can see, he (or she) must imagine what goes on within the body and possibly cut in human tissue to consider it further (Schaanning 2000B). This "deep gaze" changes the clinical episteme in three ways. First, diseases are not related to the fact that they have symptoms in common, but because they affect the same bodily tissue systems. Second, the diagnosis is not directed to symptom frequencies, but from the damaged tissue. Third, it is no longer a matter of registering a chronology of symptoms (some symptoms tend to come after others), "but to pursue the disease's manifestations" (Schaanning 2000B, p. 197). Through this, we can see at least two things. First, the discourse is separated from something material, but needs to be attached to it in order to be qualified as truth. Second, there is an attachment between language and tissue, between discourse and materiality, and the new discourse has to recognize this in order to be qualified.

of our knowledge of it, but our knowledge of it is formed in the social world (Wynn and Williams 2012). In critical realism, this motivates a distinction between the intransitive domain (natural world) and the transitive domain (social world). A central premise for critical realism is thus that although our knowledge of the world are conditioned by it being an open social system, the world exist, independent of human beings (Mingers 2004). As an example, natural selection as a causal law would exist even if Darwin's theory on natural selection did not exist (Bhaskar 1998B).

At the same time, critical realism is primarily a critique of positivism (although later also of social constructionism and its 'conflation' of epistemology and ontology, see Archer (1995)), and especially the Humean 'covering law' model of causality (Elder-Vass 2010). In this model, 'constant conjunction of events' obtained through experiments may enable prediction of law-like and exceptionless regularities. Since the regularities indicate that there are natural laws at work, the covering law model does not explain *why* the regularity occurred. Critical realism, rather, wish to provide an explanation, the cause for why some event(s) occurred. Bhaskar's main interest was to understand the complexities of open systems (like industry, hospitals, and universities) from a realist positioning. In open systems regularities may be disrupted, and create a multitude of confusing events. Consequently, it is not the empirical regularities scientists (studying open systems) are mainly interested in, but the causal mechanisms that produce them (Elder-Vass 2010). These mechanisms are unobservable, but yet fundamental to explain causality. So, how can we investigate the interactions between the transitive reality (social world) and the independent intransitive reality (natural world) in order to identify (unobservable) mechanisms?

First, critical realism relies on a stratified ontology, consisting of three domains: the real, the actual and the empirical. The empirical domain includes those events that we experience or observe. The actual is the domain of material existence, and the real includes the structures and mechanisms that generate the events (Elder-Vass 2010). Sayer (1992) built on this layered ontology to establish a methodology that explains the relations between events, mechanisms and structures (see figure 2). *Structures* are a "set of internally related objects or practices" (Sayer 1992, p. 92) that "constitute real entities we seek to investigate in a specific situation" (Wynn and Williams 2010, p. 790). Example could be a national health system, a single hospital or even a particular virus. *Events* are "cluster of observations," and may be methodologically challenging to identify in that they could be immediately observable or emerge during the data analysis. Moreover, events may remain un-actualized even though everything was done according to the book. What is needed for an event to be actualized is that mechanisms are triggered to instantiate it. A *mechanism* is "causal structures that generate observable events. A generative mechanism is "one of the processes in a concrete system that makes it what it is …" (Henfridsson and Bygstad 2013, p. 911). In 3.2, I will explain these principles in play within a particular configuration where contexts leading to specific outcomes are explained through mechanisms.

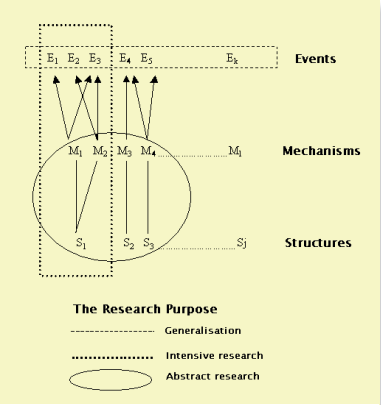


Figure 2: The layered ontology of Critical Realism (Sayer 1992)

A realist configuration

Critical realism is increasingly used in the field of information systems as a methodological approach to overcome the objectivism–relativism chasms (Mingers 2004). The combination of a realist ontology and an interpretive epistemology enables methodological approaches to observe and assess information systems not only focusing on observable events, but also the causal structures that generate such events. This approach signifies an interest in reality, i.e. preferring the question "what properties do societies and people possess that make them possible objects for knowledge" or "how can we assure ourselves that event regularities are based on necessary connections rather than simply coincidence"? (Mingers et al. 2013), instead of "how is knowledge possible?" (Danermark et al. 2002). Critical realism has been

used on a number of approaches in order to identify and explain information systems phenomena (see Bygstad 2016, Bygstad et al. 2016, Henfridsson and Bygstad 2013, Wynn and Williams 2013).

A particular promising framework is the Context-Mechanism-Outcome (CMO) scheme from Pawson and Tilley (1997). It focuses on the particular connection between interventions, the context of the intervention and the outcomes. The scheme is based on a particular understanding of social reality, social causation and social change explained through five headings: embeddedness, mechanisms, contexts, regularities and change.

The understanding of the social reality as stratified takes into account that all human action are *embedded* "within a wider range of social processes" (ibid, p. 64). An example is a bank cheque that not only needs subjects (the payer and the cashier) and objects (the cheque), but also a systematic organization known as the banking system. The action in such a system relies on both the object, the individuals and the social relations and organizational structures they form (ibid, p. 64). These systems also carry a history that may or may not be relevant for understanding the particular actions that take place.

The *mechanisms* are in social programs about identifying what it is that triggers a certain reaction from the subjects (ibid). According to Mingers (2014, p 54), "a mechanism may be said to consist of a structure of inter-related parts together with the powers or tendencies that the structure possesses." To identify mechanisms, thus, one need to explain how a particular association of these inter-related parts comes about in generating observable events. A mechanism is thus not only a variable, but also an account of the relationships and behaviour (Pawson and Tilley 1997).

The relationship between causal mechanisms and their effect is not fixed but contingent (ibid, p. 69). It follows that *contingency of causality* (Sayer 1992, Bhaskar 1998) is central, making the *context* a particularly important issue. Mechanisms may be triggered (actualized) or left alone (non-actualized) in a specific context, and the same mechanism may lead to different outcome in different contexts (multifinality) (Sayer, 1992, Henfridsson and Bygstad, 2013, George and Bennett 2005). Different mechanisms may also lead to the same outcome in different contexts (equifinality) (George and Bennett 2005). This indicates the existence of multiple causal paths. The triggering of mechanisms, i.e. turning the potential outcome into actual outcome, will always depend on the context (ibid).

One of the main goals, in realist methodologies is hence to *explain* social *regularities*. These regularities rely, however, on contextual contingency, i.e. how particular mechanisms are triggered in particular circumstances in producing a particular outcome. The regularity belongs at least partly to a certain context.

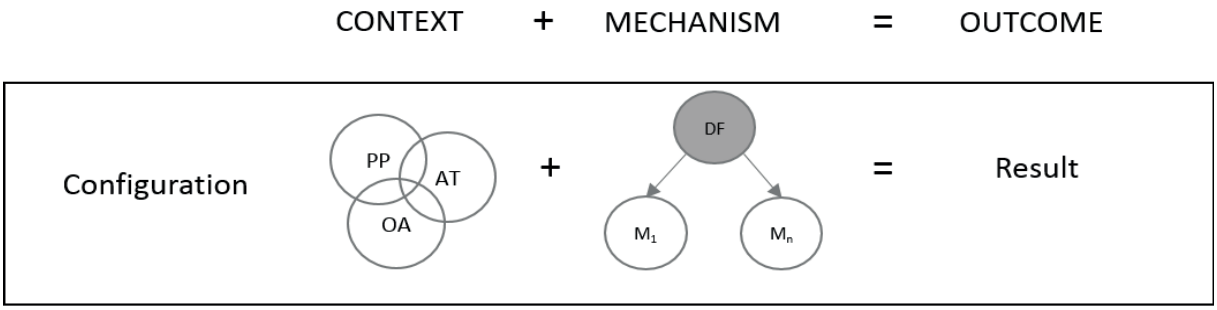
In accordance with critical realism, *change* happens in open systems because the "balance of mechanisms, contexts and regularities which sustain social order are prone to self-generated reshaping" (Pawson and Tilley 1997, p. 72). This means that the existing patterns, structures and regularities condition the evolution of social (or socio-technical) systems. It also means that interventions of subjects or objects may interact with the existing association in a way that make it evolve differently, and change its trajectory.

A methodological challenge, studying digital infrastructures using a critical realism approach, is consequently to investigate how different mechanisms are triggered to produce successful outcomes; or rather, which mechanisms influence the particular outcome of a certain program within a particular digital infrastructure.

As there may be many causal paths, a way to structure the approach is needed. Realistic evaluation is about identifying the mechanisms that generate regularity within a given context. However, realistic evaluation is also about identifying ways to intervene in order to obtain social transformation, and by evaluating the result of these interventions. Based on this, three crucial ingredients of any initiative, context(C), mechanism (M) and outcome (O) are established. This enables an identification of contextual variation within and between programs, the effectiveness of causal mechanisms triggered and how this affects outcomes. This gives realist research the task of modelling the different ways in which the Ms, Cs and Os come together, or are *configured* (ibid, 77). A configurational approach enables, in summary, analysis of possible configurations through focusing on mechanisms and relevant context variation to explain a particular outcome in a certain context (Pawson and Tilley 1997). The CMO configuration may be combined with El Sawy et al. (2010) approach that acknowledges the

centrality of digital infrastructures in both obtaining strategic advantage, and in gaining an improved understanding of the complexity associated with multiple causal paths.

Figure 3 (below) demonstrates the configurational approach used in this thesis. A discursive formation is seen as a *mechanism*, and the causal relationship between discursive formations and other mechanisms in producing a certain outcome is investigated. In critical realism, this process is called retroduction, and includes identifying and elaborating on tendencies that may have interacted creating the explicit event. Plausible mechanisms that may have generated the empirical events are suggested, identified, conformed or eliminated (Sayer 1992).



PP: Perceived problems
AT: Availability of technical solution
OA: Organizational anchoring

DF: Discursive formations
M : (other) Mechanisms

Figure 3: proposed CMO configuration

From the literature, three *contextual conditions* relevant for strategic shifts in digital infrastructures were identified. The first two conditions are based on Lakatos' (1970) claim that strategic shifts occur through acknowledging the existence of perceived problems (PP in figure 3) and through the introduction of a clear alternative (availability of a technological solution, AT). The perceived problems open up for external discourses which then relates itself to other mechanisms in the infrastructure. The third contextual factor is organizational anchoring. It is well documented in IS research that many innovation initiatives fail because of insufficient social, managerial or technical links to the main organisation (Cash et al. 2008, Böhl et al. 2016). Organizational anchoring is in this thesis understood as the degree to which a strategic shift initiative is supported by key actors in the related organisation or infrastructure. As shown in Figure 3, the three key factors are interrelated, but they are independent of each other. To summarize the configurational approach, strategic change ("Result") in digital infrastructures is caused by the interaction of a discursive formation with other infrastructural mechanisms, conditioned by three contingencies; perceived problems, availability of alternative solutions and organizational anchoring.

In section 5.2, this framework will be applied to the empirical work in analysing the first research question. In order to address the second more practical research question, in section 5.2, literature from the field of digital innovation and process innovation is applied.

4 RESEARCH APPROACH

4.1 Research approach and selection of cases

This thesis addresses two aspects of digital innovation in the Norwegian health sector. First during the investigation, the central role of discourse emerged, particularly when eHealth program difficulties was addressed. Second, it was observed that new innovative technology had a central role in changing the digital infrastructure. To elaborate on these interests an in-depth case study (Wynn and Williams, 2012) of three infrastructures, being part of a large multi-level (George and Bennett 2005) research initiative, was conducted. The case study (George and Bennett 2005) have (at least) four strengths. It enables conceptual validity, it helps deriving new hypotheses, and exploring causal mechanisms. Finally, it helps in modelling and assessing complex causal relations.

The selection criteria were that (i) the case should include an innovation initiative within an existing large infrastructure, (ii) there was an identifiable discourse and (iii) there should be a clear outcome of the initiative. Three cases that satisfied these criteria were investigated (Table 2). The shared background was a national and regional effort in Norway to standardise fragmented IT solutions. The largest program, called *Digital Renewal*[7], running from 2013 to 2018, and with a budget around 700 mill Euro, was conducted within the Health South-East region. The program was partly successful, but met resistance because the lack of attention to local needs for innovation. The three selected projects raised alternative discourses and tried to change the standardisation strategy of the larger digital infrastructure, during the period 2014-17.

Case	Description	Aim of initiative	Outcome
Medicloud	Innovation project	Establish boundary resources between regional clinical systems and 3rd party apps	A lively discourse, but no results
Aker	Emergency unit	Improve the patient flow within and outside the unit	A successful lightweight solution
Kalnes	Large hospital	Redesign and digitalise the clinical and logistic processes	A successful infrastructure

Table 2: Three cases

The *Medicloud* project was a small innovation initiative that emerged when shortcomings in the huge eHealth programme Digital Renewal was acknowledged. The aim of Medicloud was to enable app developers to access the central clinical systems. From 2013-2016 Medicloud was subject to increasing interest, arranging the popular "innovathon" track at the national eHealth conference in 2015 and arranging several well visited workshops in the autumn and winter 2015 and 2016. However, the initiative ran out of steam in 2017 and eventually led to no results.

The Samkad project at *Aker* was a successful innovation initiative at an emergency unit in Oslo, with the aim of improving patient flow internally, and with the city districts. However, from 2014 to 2016 Aker met significant resistance from the existing governance regimes, and had to apply for funding from councils and similar in order to initiate and complete the milestones. The funding enabled nevertheless Aker to implement a lightweight solution in order to improve patient flow processes, and later interaction with city districts.

The *Kalnes* case was a new large hospital in Østfold County, which adopted the full regional infrastructure, but – based on extensive process innovation – introduced a new layer of lightweight IT solutions for logistics and patient communication. The collaboration between all levels of the organization was relatively successful, and Kalnes was consequently outlined as a possible model for regional innovation strategies. While the hospital management used an incremental development strategy preparing for transition from the old hospitals to the new (2013-2015), they decided to perform a "big-bang" start-up in November 2015. This was relatively successful.

[7] Digital Renewal (2013-until now) is one of the biggest IT projects in Norwegian history. It aims to consolidate the existing system portfolio of several thousand systems. Several billions NOK have been used on the program.

4.2 Data collection

Data collection (Table 3) was conducted in the period 2015 to 2017, and included 59 interviews, in all around 130 hours of observation, 13 seminars and workshops, and analyses of a large number of documents. Managers, as well as clinicians and IT personnel, were interviewed. The focus was on how key actors in the projects initiated the discourse, how arguments were built, and alliances with decision makers and vendors were built. In addition, 10 interviews of vendors and regional management were performed, raising the total amount to 69.

Interviews

In each of the cases, the data collection started with interviews and discussions where management (top management or project management, depending on the case) presented the main goals as well as the organization of the IT oriented innovation initiative. This included an historical account of the project challenges, how they were addressed, and the result of this. Further, project managers were interviewed in order to investigate more thoroughly the challenges of implementation, and how they were addressed. These interviews also included experts like ward managers, or technical managers when needed. The interviews lasted from 30 minutes to 2.5 hrs; they were semi-structured or unstructured and started with the informant explaining her or his role in the particular project. Then particular questions regarding the project evolution was raised. The main challenge was to identify key events established through a chronological evolution. The same informant was interviewed several times if new issues were identified. Participation in workshops and seminars where regional or local challenges was discussed enabled access to key to regional or local authorities.

Observations

The observations were performed in the case of Medicloud among project participants and in the case of Aker and Østfold within the emergency unit and the wards, where challenges related to process flow was substantial. The initial management perspectives (Paper 3) were completed with a bottom-up-investigation where the effect of particular strategic choices could be seen. Core actors were identified, their requirements and views on the solution and fresh ideas related to shortcomings and challenges, was collected. Through the observations, the use of smart phones and electronic whiteboards and its impact on the work tasks, was investigated. Several activities were affected by the new digital infrastructure. The observations also enabled follow-up of particular issues. Examples are discussions during lunch breaks where the atmosphere was more relaxed and allowed elaboration on particular issues. In the case of Medicloud, the continual "shadowing" of project participants during the big eHealth conference "HelsIT" opened up for "honest" discussions regarding possibilities and shortcomings.

Document analyses

In addition, a broad range of organizational and technical documents was analysed in order to identify key challenges and possible solutions. The technical documents regarding design issues, rules and regulations, role descriptions, result of investigations, report and so forth gave a 'deep insight' into the interconnectedness resulting from digitalization efforts. Examples are plans, descriptions and milestones from projects, or templates and maps created by the organization during the project. Access was also given to background information like e-mails, notes from meetings and similar to describe the interactions for reaching agreement between different types of actors. Further, several design sketches and documentations describing the modular design of IT systems, like the Imatis solution, was read an analysed. Description of message standards and how they were configured in the particular system was investigated. Table 3 gives an overview of the activities per case.

CASE	Activity and Description	Participants	Data
MEDICLOUD	13 interviews.	Project members, app developers, project managers.	The evolution of Medicloud, important events and aim.
	7 Meetings and workshops with between 8 and 40 participants.	A broad range of suppliers, users and health system organizations.	Weaknesses and strengths of the Medicloud approach.
	29 hrs. of observation.	Following project members and potential Medicloud users during eHealth conference.	Challenges and requirements related to the Medicloud initiative.
	Slides and descriptions explaining the Medicloud initiative.		80 pages on technical and strategic goals.
AKER	16 interviews.	Project managers, clinicians, technical expertise, staff.	Goals, purpose, project implementation and results.
	27,5 hrs. of observation.	Clinicians, staff, physician on duty, emergency unit.	Views and results of the implementation.
	Analyzes of Organizational maps, technical descriptions, system design.		317 pages on treatment issues, system design and workshop descriptions.
KALNES	30 interviews.	CEO, CTO, Process manager, Project managers, clinicians, staff.	Goals and purpose of the project, strategic and organizational development and system implementation.
	43,35 hrs. of observation.	Clinicians, ward managers, workflow coordinators, secretaries and other staff.	Views and results of the implementation.
	Analyses of process design, system design and technical issues.		204 pages on system design, process descriptions, work descriptions.

Table 3: Data collection

4.3 Data analysis

In this thesis, there are two research questions:

RQ 1: How does discourse affect strategic shifts in digital infrastructures?

RQ 2: What characterizes a technological solution that is suitable for supporting strategic shifts within eHealth?

The *first* research question was analysed using Foucault's archaeological framework (1972), which enables a deep and broad investigation of emerging discourses, their content, and their consequent power to change system trajectories. To identify causal mechanisms and configurations, the technique of retroduction (Wynn and Williams 2012) was used. The *second* research question is answered primarily by using the lens of process innovation (Davenport 1993, Hammer 1990, Hammer and Champy 1993), and informate (Zuboff 1988), as well as digital innovation (Henfridsson et al. 2014, Tilson et al. 2010, Yoo et al. 2010). I will in the following describe the activities related to data analyses.

Research question 1: *How does discourse affect strategic shifts in digital infrastructures?*

The focus of this research question was to understand the relationship between discourse and infrastructure. This was done through a step-wise analysis of the cases (Bygstad et al. 2016), (see table 4). First, in each case historical key events were identified and described in order to understand the aim of the case, and how the events developed.

All three cases (see table 2) were examples of responses to difficulties experienced with "status quo". Medicloud was a response to lack of innovation in the big Digital Renewal program, the process innovation initiative at Aker addressed a problem related to poor capacity utilization and lack of overview of internal resources and activities. Finally, Kalnes was a modern hospital where process innovation strategies addressed challenges related to waiting time, as well as difficulties regarding patient flow and interaction between emergency unit and health wards. This research question was investigated through analyses performed in six steps (Bygstad et al. 2016).

Step 1 and 2 (see table 4) consisted of identifying key events and key entities in each case. It was of particular importance to identify the concrete aim of the initiative, and to identify the relation between the innovation initiative and the larger infrastructure.

Step 3 and 4 was about analysing the relationship between discourse and infrastructure. The discourse was analysed using Foucault's archaeological framework. This framework enables an understanding of the initiative (and its relation towards the larger infrastructure) as *discursive formations* (object, enunciative modalities, concept and strategies) where different parts of the aim are understood as elements in a larger discursive structure. Through this activity, it was observed that each case qualified to the status of a discursive formation.

The investigation of the cases and their outcome led to the establishment of a timeline where the historical evolution of the infrastructure and the challenges was mapped. At time 1, the infrastructure was in a normal state and taken care of by incremental adaptation to changes in the environment. At time 2, the infrastructure experienced a crisis where internal solutions to address the shortcomings were insufficient. At time 3 a strategic shift occurred. Time 4 was added to show that infrastructures might eventually re-enter into a normal state but with a new configuration (see figure 8 in chapter 6).

The first steps of the analyses, then, enabled a relatively structured categorization of activities, outcome and contingencies mapped on a timeline. The two key moments were time 2 – crisis, and time 3 - the strategic shift. Although all the cases addressed challenges with the status quo of digital infrastructures, it was clear from the outcome of the cases that they experienced different degrees of success. Put shortly, only two of the discursive formations were able to enter into the digital infrastructure and participate in the activities to change it.

Discursive formations consists of action-related verbal performances (Foucault 1972), which have, according to Foucault, the power to transform knowledge systems. This means that Foucault's project *requires* that discursive formations have causal power (Elder-Vass 2010). According to Elder-Vass, "Foucault has failed to show us how this could be" (ibid, p. 151). Based on this interest, the question, how can discursive formations have causal power, emerged. The question was formulated in order to examine "the ways in which discourse *interact* with other causal powers in the production of social (socio-technical) phenomena" (ibid, p. 144), and how this affects strategic shifts of digital infrastructures.

These interests led to a movement from step 3 (content of discursive formations) to step 4, where Pawson and Tilley's realistic evaluation was drawn upon. In this framework what is of central interest is the relation between contextual conditions and outcome. Based on this, possible mechanisms that may have caused the outcome given the contextual conditions were investigated.

From the literature[8], but confirmed in the empirical work, three *contextual conditions* relevant for strategic shifts in digital infrastructures were identified. The first two factors are based on Lakatos' (1978, p. 36) insight that programs cannot be "falsified … until we have a better one." This means that there is a shared recognition of shortcomings in the program. There is some kind of openness about the program's inadequacy. This contextual condition is referred to herein as "perceived problem" (PP in figure 3). Such an appreciation may lead to a more searching orientation towards possible solutions to the problem. This contextual condition, the existence of a clear alternative, is called "availability of a technological solution" (AT). The third contextual condition is organizational anchoring (OA). It is well documented in IS research that many innovation initiatives fail because of insufficient social, managerial or technical links to the main organisation (Böhl et al., 2016, Cash et al., 2008,). Organizational

[8] Contextual conditions can be obtained from both the empirical data (Pawson and Tilley 1997) and the literature (Henfridsson and Bygstad 2013), see Lacouture et al (2015) for reflections on these and other issues concerning Pawson and Tilley's realistic evaluation.

anchoring is understood as the degree to which key actors in the related organisation or infrastructure support a strategic shift initiative.

The outcome of the configurations was identified analysing the three discursive formations. Three different outcomes (results) were identified, and it was observed that the discursive formations had different degree of fulfilment of the contextual conditions. The outcome of the different discursive formations was also different, and there was a relation between the degree of success (the outcome) and the degree of fulfilment of the contextual conditions. Retroduction was performed to identify the mechanisms involved in bringing about the particular outcome given the contextual conditions. The activity of retroduction includes proposing candidate mechanisms that could explain the relation between the context and the outcome. Several mechanisms were tested and analysed. Examples were "emergence of discourse", "mobilization", and "expansion". "Emergence of discourse" was changed to "discursive formation". The Medicloud initiative was able to intervene into Health South-East seminars and workshops, attracting a range of stakeholders. They can be seen as a discursive formation, but lacked (despite several claims that they in fact were able to provide this interface technology) the needed technology for accessing precious core health data from the Electronic Patient Record systems. Since "mobilization" is a part of the content in discursive formation (discursive formations mobilize by attaching themselves to an associated domain), it was removed as a separate mechanism. Through the Aker case, where the availability of technology enabled interaction between discursive formations and the infrastructure, the "connection" mechanism was identified. The Kalnes case enabled the identification of a third mechanism. At Kalnes the discursive formation did not only connect to the infrastructure but was also contributing to a transformation of the hospital infrastructure because of the projects deep anchoring in organizational endeavours. Early on, this outcome was understood through the "expansion" mechanism. Expansion was later separated into respectively transformation and scaling. The mechanism of scaling was identified elsewhere (Henfridsson and Bygstad 2013), and only slightly modified to fit the new setting.

The analysis of the set of mechanisms (step 5 in table 4), enabled the explanation of the interactions and dependencies between context- mechanisms and outcome. Four configurations were identified, and only one of them led to a strategic shift. In Step 6 the analysis was performed against two criteria. (i) That the proposed mechanisms are clearly and accurately described as explanations for the generated outcome in the given context. (ii) That it offered better explanatory power than the other candidate mechanisms identified (Bygstad et al 2016, Wynn and Williams 2012). Detailed description of discursive formations and context – mechanisms - outcome is provided in section 5.2.

Stage	Activity/Outcome
1. Description of events and issues	• Chronological account of key historical key events in each case (Paper 3, 4 and 5, Section 5.2) • Description of key events, challenges and aims related to digital innovation issues and how they were addressed (Paper 3, 4 and 5, section 5.2)
2. Identification of key entities	• Key entities (i.e. actors, organization, artefacts) identified directed by the theoretical framework and drawing on observation and interview data. (Paper 3, 4 and 5, Section 5.2)
3. Theoretical re-description (abduction)	• Identify the influence of discourse when programs struggle. • How a particular form of discourse interplays with materiality in digital infrastructure evolution. • Analyse the discourse as discursive formations (when certain conditions are met) using Foucault's archaeological framework (section 5.2)
4. Retroduction: Identification of candidate mechanisms	
a. Identification of immediate outcomes	• Each case was analysed according to its outcome, first in isolation, then using the CMO (context-mechanisms-outcome) configuration (Pawson and Tilley 1997) • A timeline with four (T1-T4) moments was identified. It was used to analyse different points of time in strategic shifts and the consequences of these shifts. The four moments goes from normal state through crisis and transformation, back to normal state.
b. Analysis of interplay among entities	• Interplay among human and technical entities examined based on critical realist perspectives (Henfridsson and Bygstad 2013, Bygstad et al 2016)
c. Identification of candidate mechanisms	• Identification of contextual conditions (the C in CMO)(Pawson and Tilley 1997, Böhl et al. 2016, Cash et al. 2008, Lakatos 1970, Lakatos 1978) • Mechanisms and their actualization identified for each case using the CMO configuration (Henfridsson and Bygstad 2013, Pawson and Tilley 1997).
d. Identification of mechanisms stimulating and releasing conditions	• Identification of the relation between fulfilled contextual conditions and released actualization of mechanisms in giving a certain outcome.
5. Analysis of set of mechanisms	• Identification of four configurations that explains the relation between contextual conditions, the outcomes and the actualization of particular mechanisms
6. Assessment of explanatory power	• Empirical corroboration conducted to identify the mechanism with the strongest explanatory power for the observed events and outcomes

Table 4: Data analysis and findings

Research question 2: What characterizes a technological solution that is suitable for supporting strategic shifts within eHealth?

Regarding the *second* research question, the main interest was to identify the particular characteristics of a technological solution in supporting a strategic shift. Based on the case study and analyses, three central characteristics were identified. These characteristics formed the basis of the ability to change the infrastructure, but did also shed light on some configurational requirements needed to facilitate digital innovation and enable strategic shifts.

The point of departure for all the cases was digital innovation and how the architecture and the governance of the existing digital infrastructure made innovation difficult. Three cases of digital innovation in the health sector were investigated. Through interviews, a primary set of interests issued from top-managers and project managers, was identified. One fundamental challenge was to improve logistics, in order to improve horizontal flow. In the Aker case (Paper 4) capacity utilization was the

primary interest, while at Kalnes (Paper 3 and 5) the main issue was to reduce waiting time before emergency treatment and reduce the time from admission to discharge. Through the observations performed within the emergency unit at Aker, the emergency unit and wards at Kalnes, the practical challenges became clearer. Challenges related to bottlenecks (caused by manual processes) were improved by using lightweight IT.

In Paper 3, the point of departure was to both understand the patient logistics strategy at Kalnes, and the regional digital infrastructure at Health South-East. The investigation was built on multiple sources, and the analysis was performed in three steps. First, key events (chronology) of interaction between the process innovation initiative (local) and the digital infrastructure (regional) were identified. These key events and interaction highlighted some key challenges and conflicts between the local and the regional initiative. The conflicts were largely resolved, and we theorized on the causes for this. This was conceptualized as architectural and governance issues, and demonstrated how tensions were dealt with through a particular configuration of these issues. While the regional authorities were occupied with the long-term building of the regional digital infrastructure, Kalnes was given the freedom to follow their immediate needs for process innovation through the lightweight IT solution. This freedom was both constructive and solved some of the tensions. The insights into governance and architecture are derived using the lens of Tiwana 2013, and the configurational approach from El Sawy et al. (2010).

In Paper 4, the role of process innovation in improving capacity utilization was investigated (Davenport 1993, Hammer 1990, Hammer and Champy 1993). A chronology of three development phases was established, and five challenges identified through this investigation were analysed. Analysing these challenges I found first that Aker used internal resources extensively when preparing for process innovation. Even though hospitals are very complex institutions (Greenhalq et al. 2017), it was observed that also in hospitals there are manual processes that can be improved relatively fast. Melao and Pidd's (2000) insight was used to distinctly separate horizontal processes into four types, where different approaches can be used to improved them. Third, I saw that internal process innovation inspires creative thinking on how to improve interaction with external units, and that lightweight IT (Bygstad 2016) in certain situations can operate separately from the digital infrastructure. The findings demonstrates that lightweight IT ad speed to the innovation process, but that this strategy is cumbersome when resources like new technology, funding for projects and external personnel, have to be applied for in each case.

While Paper 3 investigates process innovation challenges from a managerial point of view (Davenport 1993), Paper 5 have workflow coordinators (from admission to discharge) as the unit of analyses. A chronology was established to understand the main challenges workflow coordinators, ward managers and staff struggled with. Three steps of digitalization were identified: Digitalization of manual processes or integration of earlier digitalized resources, improved informating ability, and increasing ability of self-management. The increased informating ability (Zuboff 1988), although challenging, bring constructive possibilities also when risky changes are introduced. The insightful understanding of performance and production makes it easier to switch back changes, or implement further functionality to deal with newly discovered side effects.

In summary, during analyses a lightweight front-end regime and a heavyweight back-end architecture emerged. This configuration enabled Kalnes to work relatively independently from the central authorities to improve their process performance. Process innovation adds speed to the innovation project, and it motivates further improvement. Not all processes in the health system are "complex"; some may be improved relatively fast, while others are more challenging and need other approaches.. Existing base of knowledge is important.

A note on method

I started the PhD with a background (master thesis in informatics) as an interpretive researcher. After 9 years as a developer and project manager in the IT sector, I soon found that the drift of the interpretive towards the social sphere had some shortcomings when describing the socio-technical conditioning of the technical on the social and of the social on the technical. In a way, it is a bit strange that even though individuals choose freely, their action nonetheless remains systematically aligned (Lopez 2001). What are the explanations for the regularities conditioning socio-technical systems?

Interpretive research is not restricted to the social sphere, but its way of engaging with informant's interpretation of the reality (Walsham 1995) may lead the focus of the research problem in a social

direction. In short, the use of interpretive methodology may inspire inspection of social rather than socio-technical phenomena, i.e. it conditions the orientation towards IS phenomena, and may leave technological complexity poorly understood (Kallinikos 2004). Large parts of the technological systems are not apparent at the level that humans work and interact with technology (ibid).

Internet (Abbate 2000) and the network society have further advanced the complexity of socio-technical system into emergent heterogeneous networks, where components, both human and technological, of different size and with varying impact are interacting through complex patterns. These networks can be understood as information infrastructures (II) (Ciborra et al. 2000, Hanseth and Lyytinen 2010). Also within the field of II, however, the predominant view is that IIs are phenomena that can be studied using interpretive methods (Henfridsson and Bygstad 2013). Henfridsson and Bygstad propose that studies within the field of information infrastructures has been masked in prior research by the adoption of philosophical assumptions "inattentive to structures operating beyond (i) the rich texture of people's meaning-making of the sociotechnical world (interpretivist streams), or (ii) events directly observable in the empirical domain of infrastructures (the positivist stream)" (ibid, 910). This may again lead to inattention towards the technical and structural aspects of digital infrastructure evolution (Henfridsson and Bygstad 2013).

This tendency may also come from the fact that while Information Infrastructures are very loosely coupled arrangements of technology and organization ("...shared, open (and unbounded), heterogeneous and evolving socio-technical system with a lot of localized user freedom (called installed base) consisting of a set of IT capabilities and their user, operations and design communities..") (Hanseth and Lyytinen 2010, p. 4), digital infrastructures, where artefacts, manual processes etc. to a larger degree are digitized, leads to a tighter coupling between users. This may also require a more systematic management of the infrastructure. At the same time, although digitalized infrastructures gives tighter connection and a more synchronized inter-action between users, the technology permits distributed innovation but now based on a central and common "core".

In the early studies, (see table 6 in section 5.1) a structured approach was used with an implicit but maybe not fully explicit realist orientation. It was only in the later part of the thesis, particularly the work on Paper 6 (see section 5), that critical realism was distinctively used as a methodological and philosophical positioning for understanding digital infrastructure evolution. Most of the papers in this thesis, consequently, do not take an explicit stand, but it is quite clear that social and structural conditions operating separately from the actors immediate sense-making, give implications for both the investigation and the interpretation of the cases.

Ethical consideration

FIGI is NSD approved[9]. In addition, confidentiality agreements were signed for each case. The research has not been dealing with individual privacy information, but has been occupied with general issues related to workflow coordination and the technology for supporting this. Before the observation, in particular units and wards I made it clear that they were free to ask me to leave if particular situations that could compromise privacy issues arose. The confidentiality agreements did, however, also cover these aspects.

4.4 Internal and external validation

This section briefly discusses some important issues concerning internal and external validity of the case findings and interpretations.

The focus of this research was to study the role of discourse in strategic shifts, i.e. how discourse connects to technology in order to change the digital infrastructure. The theoretical framework used for analysing this interaction was Foucault's archaeological framework (1972) for discourse analysis, and the CMO-scheme from Pawson and Tilley (1997) for investigating the relation between discourse and infrastructure. The findings are formed by these frameworks, and particularly by the application of the archaeological framework to a critical realist investigation. This might lead to loss of social granularity on the behalf of more structured causal regularities that brings about social, organizational and technical

[9] Norwegian Social Science Data Services

change. At the same time, the vocabulary and methodological techniques made available by critical realism enables a distinct analytical approach that could also be easier to verify.

According to Smith and Johnston (2014), *internal validation* is about making sure that the actual events that occurred in the case was caused by the mechanisms proposed by the theory. In this thesis, this activity consisted of analysing the data as outlined in the step wise model (table 4, section 4.3) from Bygstad et al. (2016). Some of the papers in this thesis are written together with practitioners from the hospitals, and key events and key objects were also discussed with other hospital actors who could confirm or correct. This includes sharing and discussing on draft papers. In case of doubt, additional actors were approached to verify data. In addition, I participated in several public workshops and seminars where discussions gave valuable feedback in order to be more precise. In section 4.3 the process of identifying candidate mechanisms that could explain the causal relation between key events and outcomes, was described. To assess the explanatory power of the mechanisms two criteria was applied. First, the proposed mechanisms must be clearly and accurately described as explanations for the generated outcome in the given context. The second criteria regards that it offered better explanatory power than the other candidate mechanisms identified (Bygstad et al. 2016, Wynn and Williams 2012). Detailed description of discursive formations and context – mechanisms - outcome is provided in section 5.2.

The *external* validation involves "establishing that the generative mechanism that explains events within the study also causes phenomena outside of that setting, particularly in the broader domain of practice about which research questions are usually formulated." (Smith and Johnston 2014, p. 20). Are the challenges in the Norwegian context similar to other contexts? We are part of an international community and papers presented at conferences and in journals are exposed to the scrutiny of knowledgeable reviewers. Although the background for digital innovation may be different in different countries, some of the challenges are similar. Hospitals are struggling to improve logistics, to improve the communication between internal wards and between hospitals. Hospitals infrastructures are also very difficult to transform in USA (Agarwal et al. 2010), in England (Greenhalq et al. 2010), in Germany (Klein and Schellhammer 2017) as well as in Norway. The challenges described through the cases in this Thesis are thus not unique. This also relates to validation of the identified mechanisms. To see discourse as a mechanism might be provoking to some, but the implications of discourse is much discussed in IS research. Although a lot of the IS research more or less engages in debates that also include discourse, the distinct implications of discourse and how it connects to materiality (apps, IT systems, infrastructures) have not been covered in sufficient depth. It is important to take into consideration that the proposed mechanisms are only triggered when some contextual conditions are fulfilled. To obtain transformation or scaling a deep anchoring in organizational structures are required. Again, the procedure for identifying mechanisms is described in 4.3. The findings are described in 5.2 and the contributions are discussed in Chapter 6.

In the next chapter, the research publications in this thesis are presented, and information about some structural conditions for the PhD project and explanations for how the thesis evolved will be provided. The two research questions and how they are addressed in the published papers will be explained, and then their interconnection will be described.

5 RESEARCH PUBLICATIONS AND FINDINGS

This chapter presents and summarize the six research papers. I will also give an overview of how the research publications are connected, as well as how my PhD project evolved, eventually leading to a synthesized approach. Finally, I will describe the findings related to my two research questions.

Nr.	Title	Published at
1	Øvrelid, E., Bygstad, B. (2016) "Extending e-Health Infrastructures with Lightweight IT"	Scandinavian Conference on Information Systems SCIS 2016: Nordic Contributions in IS Research pp 43-56
2	Øvrelid, E., Bygstad, B., Hanseth, O. (2017) "Discursive formations and shifting strategies in e-Health programmes"	Proceedings of the 25th European Conference on Information Systems (ECIS), Guimarães, Portugal, June 5-10, 2017 (pp. 873-886).
3	Bygstad, B., Hanseth, O., Siebenherz, A., Øvrelid, E. (2017) "Process innovation meets digital infrastructure in a high-tech hospital."	Proceedings of the 25th European Conference on Information Systems (ECIS), Guimarães, Portugal, June 5-10, 2017 (pp. 801-814).
4	Øvrelid, E., Halvorsen, M., (2018) "Process innovation with lightweight IT at an emergency unit"	Proceedings of the 51st Hawaiian Conference on System Sciences (HICSS 2018)
5	Øvrelid, E., Sanner, T., Siebenherz, A., (2018) "Creating Coordinative Paths from admission to discharge: The role of lightweight IT in hospital digital process innovation"	Proceedings of the 51st Hawaiian Conference on System Sciences (HICSS 2018)
6	Øvrelid, E., Bygstad, B. (2017) "Strategic shifts in Digital Infrastructures - The role of Discursive Formations"	Submitted to journal (2 nov 2017)

Table 5: List of publications

5.1 The papers and how they are related

The FIGI project, financed by "Regionale Forskningsfond Hovedstaden", had two objectives. The first objective was to re-conceptualize the IT silo problem[10] by identifying architectural solutions for the interaction between heavyweight and lightweight IT. The second was to establish a better theoretical understanding of how to build generative infrastructures. Although ambitious these goals enables a case curriculum with a relatively structured comparison (George and Bennett 2005). According to George and Bennett (2005), structured comparison is about establishing a research approach that is structured and focused. Structured in that the "general questions that reflects the research objective and that these questions are asked of each case under study to guide and standardize data collection, thereby making systematic comparison of the findings of the cases possible. The method is "focused" in that it deals only with certain aspects of the historical cases examined. The requirements for structure and focus apply equally to individual cases since they may later be joined by additional cases" (ibid, 67). I will next explain some of the implications of this for my PhD project.

[10] According to Bannister (2001:66) the IT-silo problem regards the 'combination of large, diverse, unintegrated and frequently ageing systems' caused by 'legacy of decades of introspective development'. This situation have become an obstacle to (i) patient -oriented IT solutions, (ii) the flow of information between different units and (iii) innovation of new services. (FIGI 2014)

Phase	Activity	Paper	Major finding(s)
Phase 1	Develop a methodological and theoretical framework for analysing relation between discourse and infrastructure	2	(i) Theoretical framework for analysing discourse. (ii) Identification of innovation period in Health South-East.
Phase 2	Investigate cases of digital innovation in Health South-East	1, 3, 4, 5	Digital innovation using lightweight IT
Phase 3	Synthetization of Paper 1,3,4,5 using framework developed in Paper 2	6	The role of discourse in digital innovation and strategic shifts
Phase 4	Thesis writing	All	The role of discursive formations and lightweight IT in strategic shifts.

Table 6: Phases of the PhD project

PHASE 1: 2015-2016:

What role does discourse have in eHealth program development and maintenance? From autumn 2015 to autumn 2016 this interest was inspected leading to the paper "Discursive formations and shifting strategies in e-Health programmes" (Øvrelid et al. 2017, paper 2 in this thesis). Earlier versions of the paper were published in 2016. The paper gave two practical insights. First, a relation between discursive strategies and the resulting digital infrastructure was identified. Second, it gave clear signs of the initiation of an innovation period in Health South-East specifically and Norway in general. The work also enabled the development of a theoretical and methodological framework based on Foucault's discourse analysis.

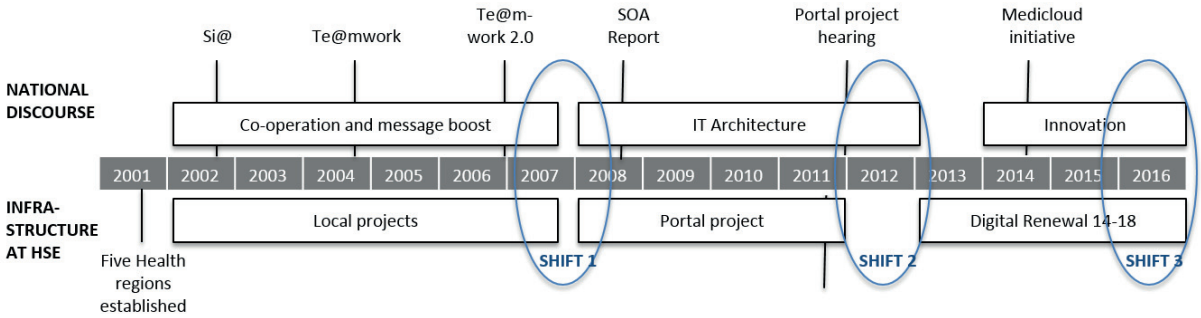


Figure 4: Discourse and infrastructure (Øvrelid et al 2017)

PHASE 2: 2015-2017

Innovation and more specifically digital innovation fit well with the FIGI theme of "generative infrastructures" in two ways. First, in digital innovation lightweight IT (Bygstad 2016), like smart phones and electronic whiteboards have shown promising tendencies as it enables faster implementation cycles and problem solving. Second, in hospital settings a broad range of clinical systems provides an extensive amount of information. In order to enable "generativity" then, lightweight IT has to interplay with heavyweight IT. This is a central premise for the FIGI project. With this as a starting point, I investigated three cases on digital innovation where lightweight technology participated in a central role. Case 1 (Medicloud) (Paper 1) mostly evolved around visions and ideas for how to create a lightweight interface towards health systems information. Case 2 (Aker) and Case 3 (Kalnes) (Papers 3, 4 and 5) describes projects where lightweight IT is implemented either separately from the existing digital infrastructure or as a part of a new digital arrangement, or configuration, where lightweight and heavyweight IT interacts.

PHASE 3 and PHASE 4: late 2016-2018

In late 2016 and through 2017 (Phase 3), i looked for a central theme or thread in my cases. The role of discourse in digital innovation was identified as a central issue. I used the theoretical and methodological framework developed in paper 2 to re-interpret the empirical work from papers 1, 3, 4 and 5. This resulted in paper 6. Paper 6 do not cover all central aspects of my PhD work. The thesis provides a

further contribution that concerns the power of innovative technology in contributing to shifts in digital infrastructures. Figure 5 below explains the relation between the papers and the synthesis provided by the thesis.

5.2 Findings and analyses

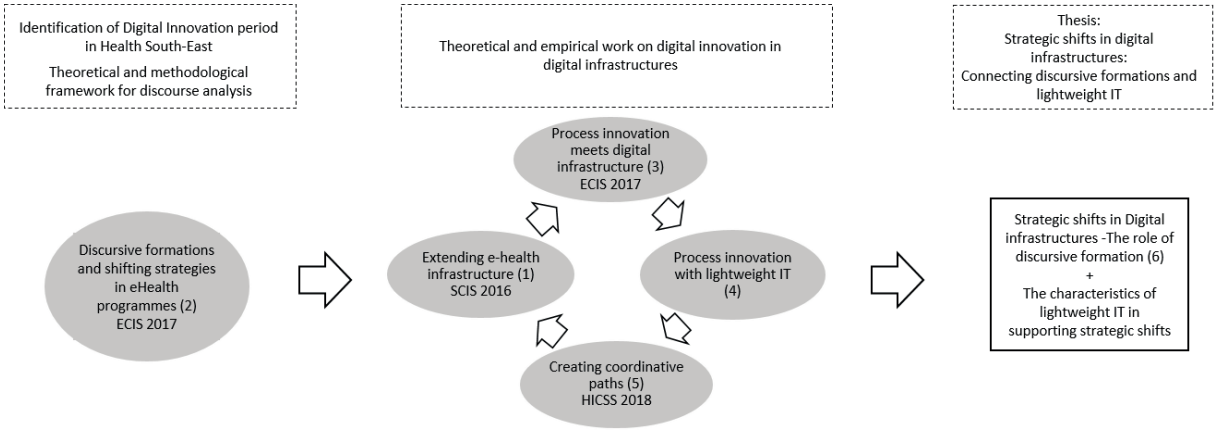


Figure 5: Relation between papers and contribution

Figure 5 gives an overview of how the papers (table 5) are related. Five of the papers are marked in blue, and their role in the overall design is described in white with dotted lines. Paper 6 provides the main theoretical contribution of the thesis.

In this section the content of each paper will be described, as well as how they contribute in answering the two research questions. The thesis have two contributions related to (i) the role of discourse in strategic shifts in digital infrastructures, and (ii) the role of lightweight IT as a particular suitable regime for supporting strategic shifts.

The first issue is dealt with using theoretical and methodological framework from paper 2 (to the left in figure 5), and by re-interpreting the theoretical and empirical work done in papers 1, 3, 4 and 5 (in the middle of figure 5) using Foucault discourse analysis (1972), and the CMO-scheme from Pawson and Tilley (1997). This is done in paper 6, which provides the main theoretical contribution in this thesis (to the right in figure 5).

The second issue – the role of lightweight IT in supporting strategic shifts - is dealt with the using the overall contributions of papers 1, 3, 4 and 5, but inspired by the digital innovation period in Health South-East, which was identified in paper 2.

The title of the thesis, "Strategic shifts in digital infrastructures: Connecting discursive formations and lightweight IT" mirrors the two contributions (to the right in figure 5). In section 5.2 the findings related to each research question is described, while Chapter 6 describes and discusses the contributions in this thesis. Further, in this section each of the papers included in this thesis and their relation to the overarching aim of the thesis, will be briefly described.

Paper 1: Extending e-Health Infrastructures with Lightweight IT

Purpose - The point of departure for this paper was that the management of the big regional eHealth program in Health South-East in Norway, called Digital Renewal, were exposed to increasing criticism because the program did neither address innovation or decentralized freedom for each hospital. A turbulent period where the Health Region management looked for improvements followed. Outside the program, several initiatives were started in order to solve these challenges. One of them was Medicloud.

Research approach - This qualitative case study was framed within the theory of information infrastructures as an interplay between lightweight and heavyweight IT. Callon's sociology of translation (1986) through four moments was used as a theoretical framework in order to investigate the gradual alignment between the Medicloud initiative and the bigger program. The tensions that emerged were analysed as both barriers against further evolution and resources for innovation (Edwards et al. 2007)

Findings - Three tensions were identified: knowledge regimes, scaling, security and privacy/security, and the paper suggest how tensions can be dealt with and how to overcome them through legitimation, new production models and fingerprints, chips or pins.

Research implications - The paper contributes to information infrastructure theory by identifying resources and barriers between a lightweight IT initiative and the existing heavyweight IT regime, and emphasizes the importance of enabling interaction between them while the separate strengths are maintained.

Practical implications – Big eHealth programs are struggling to establish robust IT portfolios and provide secure interaction between clinical systems. This may lead to lack of innovation and of distributed autonomy. Lightweight IT – a sociotechnical knowledge regime consisting of mobile phones, apps and whiteboards oriented towards business and practice innovation – have accumulated promising insights into how some of the challenges can be solved. The paper focuses on three: knowledge regimes, scaling, security and privacy. These can be solved by acknowledging the legitimacy of different knowledge regimes that can motivate new production models and fingerprints, chips or pins

Contribution to overarching research aim – The paper gives two contributions to the overarching research aim. First, it demonstrates some differences between the knowledge regimes lightweight IT and heavyweight IT, and gives some insights that can be used to establish interaction between them. Second paper 6 is using the empirical data from the case to investigate the role of discourse in providing an alternative to the heavyweight IT program Digital Renewal.

Paper 2: Discursive formations and shifting strategies in e-Health programmes

Purpose - This paper addresses challenges in large e-Health IT programmes that struggles with project failures and high costs, but also with the influence of public and sectorial discourses. Few IS studies have investigated how discourse conditions public programmes in much depth, and the aim of this paper is to contribute by investigating the relationship between discourse and infrastructure in such mega-programmes.

Research approach - The empirical evidence is a 15-year study of the growth of the national e-health infrastructure in Norway, where the interplay of the national eHealth discourse and the various programme initiatives was analysed. The qualitative case study was framed within information infrastructure theory, and Foucault's discourse analysis was used to investigate the role of discourse in information infrastructure evolution.

Findings – A temporal analysis of all the material was conducted in order to identify important events, both in the evolution of the e-health infrastructure, and the accompanying discourse. Three large shifts were identified in the 15-year period. The three shifts from *local projects* to *portal project* to *consolidation* were conditioned by a preceding discourse addressing the problems of the existing programs.

Research implications - The paper contributes to information infrastructure by first proposing an analytical framework for discourse analysis. The framework is built on Foucault's archaeological method for identifying discursive formations. Second, the framework is used to analyse the dynamics of discourse and infrastructure in strategy shifts in national e-health programmes. Doing this we demonstrate how shifts of discourse, combined with experienced problems in on-going programs may disrupt the trajectories of large information infrastructures.

Practical implications –The practical consequences of the findings are mainly relevant to policy makers, political strategists and decision makers who can investigate how major national strategies are materialized in eHealth programs.

Contribution to overarching research aim – The paper establishes an analytical framework for analysing the content and implication of discourse in digital infrastructure evolution. The work on the paper also led to the identification of an innovation period within Health South-East (and Norway).

Paper 3: Process innovation meets digital infrastructure in a high-tech hospital

Purpose – The papers main concern are challenges related to patient flow within and between hospitals. Co-ordination is hampered by manual routines and slow or circumstantial information exchange. The Kalnes case addressed these challenges by implementing a process innovation initiative and by striving to align this initiative with the underlying digital infrastructure.

Research approach - The empirical case is the new high-tech Kalnes hospital in Østfold, which opened autumn 2015. Data was collected for one year through interviews, observations and document analysis. The case was analysed using the framework of governance and architectural mechanisms to deal with conflicting forces within the process innovation initiative and the digital infrastructure.

Findings - Two types of mechanisms was identified, *governance mechanism* and *architectural mechanism*, and their content was described through comparing three common categories: mechanism, conflicting forces and solutions. The governance mechanism included interaction between the integrated project and the process innovation initiative. The architecture mechanism concerns the interaction between the system integration initiative and the lightweight IT initiative.

Research implications - First, the paper contributes to the digital infrastructure research by proposing a configuration for successful process innovation, in a complex e-health context.

Practical implications - Second, for practitioners it is shown that lightweight IT can serve as a mediating technology in the configuration.

Contribution to overarching research aim - The paper contributes by highlighting the interaction between the local process innovation initiative and the integrated solution from regional authorities. The lightweight IT frontend loosely coupled with the heavyweight IT backend, give local freedom and make it easier to change the systems when needed. The empirical insights are also used when analysing the relation between discourse and infrastructure in paper 6.

Paper 4: Process innovation with lightweight IT at an emergency unit

Purpose – The papers main concern are challenges related to patient flow within and between hospitals. Co-ordination is hampered by manual routines and slow or circumstantial information exchange. The paper investigate in particular the role of lightweight IT in process innovation in order to deal with these challenges.

Research approach - The empirical evidence is a qualitative case study at a primary care emergency service in Oslo where an innovation project was conducted. From November 2015 to January 2017, data was collected using qualitative methods. In total 20 interviews were conducted in addition to three rounds of observations (around 25 hrs.). Around 20 documents on workshop results, treatment regulations, political requirements as well as technical descriptions were analysed.

Findings – The case study identified five challenges addressed in three phases. The investigation led to the identification of different types of innovation challenges, and the way they were approached by the innovation project. The project started with analysing existing processes and this insight was important in order to make improvements. The process innovation project had ambitions to both improve processes of interaction within hospital wards as well as interaction between hospitals and community health centers.

Research implications – The paper gives two contributions. First, applying the lens of business process innovation to the literature on information infrastructures, the value of the installed base is emphasized, especially the knowledge and practices related to existing horizontal processes. Second, by demonstrating the role of lightweight IT in improving logistics and message interaction within and between health units, speed is added to the innovation project. The availability of lightweight IT on the commercial market makes acquisition and implementation faster. Based on this, a "bypassing strategy" where a new layer of technology is built separately from the existing infrastructure in order to effectively address process innovation efforts, is suggested and described.

Practical implications – The paper have practical implications in that the project demonstrates one way of approaching an innovation project. The installed base of knowledge on existing processes should be used to identify non-effective processes and then use innovative technology to digitalize them. Organized as a collaboration project, external units can be drawn upon to create better coordination of patient exchange.

Contribution to overarching research aim – The paper contributes by highlighting the role of lightweight IT in improving internal processes within wards and external processes between hospitals and health centers. The innovation project at Aker was used in Paper 6 to analyse the interaction between discourse and infrastructure.

Paper 5: Creating Coordinative Paths from admission to discharge: The role of lightweight IT in hospital digital process innovation

Purpose – The papers background is the challenges related to patient flow within and between hospitals. Co-ordination is hampered by manual routines and slow or circumstantial information exchange. The papers investigates in particular the role of lightweight IT in process innovation in order to deal with these challenges.

Research approach - In this paper, the role of IT in process innovation of patient flow from emergency care admission, through subsequent patient transfers, and discharge, is examined. In particular, it investigates how digital technology helps create and improve coordinative paths. This implies inspecting how the interplay between traditional heavyweight IT (resilient, secure and stable) and lightweight IT (mobile, context-aware and flexible), enable process innovation in complex health care settings. Drawing on Zuboffs *informate* perspective, the strength of digital information technology as a process innovation enabler is highlighted.

Findings – Through the data analyses three steps of digitalization to reach process innovation was identified: Digitalization processes, the informating ability of lightweight IT, and how self-management can be obtained.

Research implications - Two contributions are provided in this paper. First, the innovative capacity of lightweight IT as a flexible, dynamic and distributed technology for process innovation is described. Second, using Garud and Kumaraswamys framework of vicious and virtuous circles (2005), the potential positive and negative outcomes of process innovation is identified and discussed.

Practical implications – The paper describes challenges related to bottlenecks and other difficulties concerning patient flow, and how digital innovation challenges the robustness of existing processes.

Contribution to overarching research aim – The paper contributes by highlighting the role of lightweight IT in improving internal process within wards and external processes between units, and the role of heavyweight IT in feeding lightweight IT with relevant information. The *informate* concept is used to describe the powerful informating ability of the lightweight IT and heavyweight IT configuration. The empirical insights are also used when analysing the relation between discourse and infrastructure in paper 6.

Paper 6: Strategic shifts in Digital Infrastructures - The role of Discursive Formations

This paper investigates strategic shifts in large IT programmes or digital infrastructures, and is particularly interested in the role of discourse in these shifts. The interest in the paper is accordingly to investigate the role of discourse when digitalisation programs encounter problems. Building on Foucault's theory of discourse our research questions are, what is the role of discursive formations in strategic shifts? Which contingent mechanisms are needed in order to achieve strategic shifts? The research approach is a critical realist case study, with three cases from eHealth innovation. The analytical lens is Foucault's archaeological methodology (1972), which is used to identify the emerging discursive formations when programs encounter difficulties. This enables an analysis of the causal relationship between discursive formations and other mechanisms in the infrastructure. Two contributions are offered; first, a framework to understand the role of discursive formations in strategic shifts is outlined. Second, a set of configurations to explain how contextual factors and mechanisms contingently lead to strategic shifts, is proposed

Contribution to overarching research aim – This thesis main theoretical contribution is provided in this paper: the role of discourse in strategic shifts, and in particular how discursive formations are able to connect to the digital infrastructure through lightweight IT. This will be described next.

RQ 1: How does discourse affect strategic shifts in digital infrastructures?

In this section, findings related to the first research question will be described. The section is primarily derived from Paper 6, which uses the theoretical and methodological framework from Michel Foucault (1972). The framework was developed in paper 2, and is used to analyse empirical findings from paper 1, 3, 4 and 5. Table 7 give an overview of discursive formations and their content. The content will be explained, case by case.

Case	Object	Enunciative modalities	Concepts	Strategies
Medicloud	Boundary resources for innovation	*Public health:* Health South-East, Hospitalpartner *Vendors:* IBM, Cerner, Apple, Microsoft, many start-up firms	Broker Playground Experimentation. "Future innovation arena within national ICT"	Cloud-based architecture. "Radical opposition, and radical paradigm shift"
Aker	Capacity utilization	*Public health:* Oslo Municipality Dir. of Health, City districts *Vendors:* Imatis, Health South East, EPR providers, Sintef,	Improved logistics. "Improved interaction and coordination with Oslo city districts".	Process innovation (internally-externally)
Kalnes Hospital	Process innovation	*Public health:* CIO and CEO at Kalnes, Hospital Partner, Health South East, *Vendors:* Imatis, Dips, Metavision.	Process innovation, transparency, logistics	Local configuration with lightweight IT, loosely coupled to regional systems.

Table 7: Discursive formations

Case 1. Medicloud: Evaporation

Context: Medicloud addressed a significant shortcoming in the eHealth strategies in Health South-East; the lack of innovation and of local autonomy. The Medicloud initiative had not many resources, was only to a certain degree supported by the management but had nevertheless the ability to attract a range of technological and organizational actors to their seminar, workshops and conferences on digital innovation.

Object: Medicloud appeared as a fresh entrepreneurial-minded initiative early on, and labelled themselves both as an innovation arena and a provider of a technological platform for innovation. The proponents claimed they could provide an access point where app developers, in close collaboration with clinicians, could access health data. Consequently, they positioned Medicloud as a "broker" between app-entrepreneurs and Digital Renewal. From early on, it was unclear whether Medicloud was an innovation arena providing access to health organizations, or a platform providing access to health information. As one app-developer said, "We hope that Medicloud can provide an interface towards health information, but they are not there yet."

Enunciative modalities: Medicloud's role as a *boundary resource for innovation* attracted many stakeholders both internally - Health South-East managers, Hospital Partner employees and managers – as well as externally where professional IT organisations like IBM, Cerner, Apple and Microsoft participated with inspiration together with many start-up firms. They all saw Medicloud as a way of gaining access to precious core health information. The ability to attract these stakeholders strengthened the discursive formation decisively, but embedded at least to challenging conditions. First, large IT corporations presupposed that their rules were followed, i.e. renegotiating contract regulations on data access from 3rd party actors. Second, for this to occur, Medicloud had to become part of the *heavyweight* governance regime anchored in the existing organization.

Concepts: The discourse on Medicloud was conditioned by ambitious goals and big concepts. At the big Innovathon track on the HelsIT conference in Trondheim in 2015 it was claimed that Medicloud was the "future innovation arena within national ICT." Medicloud appeared as an "umbrella" for small

innovative health-IT initiatives, and claimed that they were able to create a playground for experimentation of health data that was supposed to be both educational and innovative.

Strategies: Medicloud positioned themselves early on as deliverer of "cloud-based architecture." This technological orientation – never put into production - was, however, often relegated to a subordinate position on behalf of radical discourse. Medicloud claimed that they would radically change the health IT governance by removing old systems, and start everything from scratch. Through 2016 and 2017 the ambivalent discourse of Medicloud continued, but the Medicloud initiative had lost some of its confidence and power, making Health South-East management look elsewhere for innovation initiatives usable in the Digital Renewal program

Mechanism: In the Medicloud case, *one* activated mechanism was identified: the discursive formation. The discursive formation of Medicloud is centered on Medicloud as a boundary resource for innovation. Health information is increasingly valuable for a broad range of actors from both the public and private sector. The organization of this boundary resource as well as its value creation is thus very important. Medicloud claimed they were a "future innovation arena within national ICT" as well as a radical opposition compared with existing regimes.

Outcome: Medicloud were not able to provide a technological platform where the discourse could be turned into infrastructural action. As time went by and no platform was made – they were not able to trigger mechanisms that could connect discourse and infrastructure – discourse gradually *evaporated.*

Case 2. AKER: Inspiration

Context: The Samkad project was established because the existing infrastructure did not solve challenges related to internal logistics and external coordination between Aker and City districts. The initiatives to improve the infrastructure met some resistance. The EPR providers refused to participate, Oslo Municipality and management at Aker collaborated only to a limited extent, leaving it to the project to establish financial means, and to plan and carry out the project. An enthusiastic project manager together with a doctor and the manager of the emergency unit cooperated in three ways. First they identified councils and similar to apply for funding. Then, because of the unwillingness from the EPR providers to participate, the project members identified needed technology for improving internal communication when receiving, treating and discharging patients. Finally, they engaged an expert organization on organizational processes to help them identify improvement areas. The planning and implementation enabled the different actors to customize themselves and their processes gradually. The loose coupling between the project and regular budgets meant that economic resources had to be procured for each project.

Object: At Aker the main object of the change processes was *capacity utilization*, to improve internal logistics in order to address the peak of tasks piled up during the day. The peak was a congestion of patient admissions, patient visits performed by the doctors and patient discharge. Manual routines dominated the registering of incoming patients, and patient discharge, and Aker struggled getting an overview of internal resources. The EPR system is mainly used for documentation, and not "optimal when working with several patients at the same time," according to a doctor.

Capacity utilization also regards improving the coordination between Aker and city districts. Aker and the districts interact through exchanging care-messages, but these messages include a lot of information and it is often difficult to grasp the most recent and important information. Consequently, the districts often called back to Aker asking about the patient condition, even though they had received the care-message. Aker wanted to improve the communication using a more transparent standard called ADL (activities in daily life) which covered most of the information the city districts needed.

Enunciative modalities: The discourse around the project grew gradually. Initially actors like Oslo Municipality and existing EPR suppliers refused to participate, partly in order to maintain rules and regulations protecting the existing infrastructure. Nevertheless, through a vital project manager, Samkad was able to attract a range of stakeholders. Samkad applied for research council founding, and identified the relevant IT-system to solve the capacity utilization and coordination challenges. The interest in the project grew both from organizations that wanted to cooperate with Samkad, and from other health care units that wanted to learn from the project.

Concepts: Samkad addressed two important shortcomings in the existing infrastructure: inadequate organization of internal logistics, and resource and energy intensive interaction with city districts. The concepts of *improved logistics*, and *improved coordination and interaction* was aligned with strategies issued from health ministries and audit authorities, which claimed that lack of coordination lead to a high amount of unnecessary resource use.

Strategies: Samkad took the task seriously, hired an expert organization on organizational processes and analyzed all their internal processes. The resulting *24 hrs. at KAD model* was used as a central map and "cognitive tool" to enable the organizational actors to participate in the process innovation. Their plans to include city districts reinforced the reputation of Samkad as an innovative project, and their confidence and ability to act impressed managers internally and externally.

Mechanisms: In the AKER case, two key mechanisms were identified: *discursive formation* and *connection*. Aker had a more concrete and less ambitious goal than Medicloud. Aker concentrated on defining concrete steps in order to improve logistics within the local emergency unit and then gradually improve the interaction with city districts. The connection mechanism is based on the fact that Aker was able to connect discourse and infrastructure through implementing a technological system – electronic whiteboards and mobile technology – which enabled *materialization* of discourse.

Outcome: At Aker the implementation of a *lightweight infrastructure* (Bygstad 2016), only to a small extent integrated with the underlying EPR-infrastructure, enabled them to come forward as an *inspiration* for other health units. Aker was visited and inspected by several national and international agencies. This inspirational role strengthened the discursive formation in that a technological program attached to discourse made the local and strategic credibility and usability of the constellation stronger. Samkad is gradually turned into a complex project where AKER cooperated with 4 hospitals, 60 nursing homes in 15 city districts and in total 660 general practitioners.

Case 3. Kalnes: Transformation

Context: A distinguishing aspect of the Kalnes project was its overarching focus on process innovation. An important actor incarnating the innovative initiative was the CEO. In 2011, he hired an energetic CIO and a process director as well as establishing a top management team built on process thinking and innovative technology. This also meant that the project both had regional endorsement and local autonomy with the existence of predictable budgets, active and inspired management and participation from all levels of the organization.

Object: The central object(ive) for Kalnes was process innovation, and they established comprehensive plans where 25 clinicians and staff as well as external consultants participated for enabling this. From 2013, a work group modelled and redesigned all the processes in the emergency unit and the wards. Overall around 60 processes were modelled in considerate details with swim-lanes for respectively process change and needed IT-support. Even though the process innovation initiative dominated the project, the autonomy given from the regional authorities for Kalnes to establish their own particular configuration, enabled Kalnes to incrementally tailor their solution to the different departments need.

Enunciative modalities: As the Kalnes project was grounded in national, regional and local plans the project had extensive support both strategically and in economic terms from early on. The regional IT-unit Hospital Partner as well as the Health South-East management, together with central IT-suppliers of core patient records participated to enable a safe foundation. The process innovation initiative managed by the CIO and CEO at Kalnes identified an additional technological solution (Imatis) for resolving the process challenges.

Concepts: A central focus in the Kalnes project was process innovation, strengthened by concepts like logistics, transparency and flow. While logistics concerns process automation, i.e. improving efficiency through "smarter ways" of performing processes, transparency addresses a desired mode of improved overview of resources and personnel. Improved logistics and transparency enables more efficient flow, which is a central goal in process innovation initiatives.

Strategies: Although national and regional authorities strongly supported the Kalnes project, a central premise for the project initiative was local freedom. This allowed the project to address process innovation challenges with lightweight IT, and freedom to configure the interaction with the existing infrastructure in a way that primarily solved the local requirements.

Mechanisms: In the Kalnes case three mechanisms, and a possible fourth were identified. The *connection* mechanism was activated to link the *discursive formation* to the infrastructure, and to link the lightweight infrastructure to the underlying heavyweight infrastructure. The *transformation* mechanism was activated by the extensive process innovation effort supported by the digital infrastructure. This changed both the work processes and communication of patient flow information between work groups. Concretely, this mechanism was triggered when a layer of lightweight IT was implemented on top of the clinical core systems (heavyweight IT) in order to enable an improved use of information. This also gave the organization a better basis for monitoring performance and production. An additional requirement for triggering the transformation mechanism is that the project has to be organizationally anchored. This will be discussed more profoundly in section 6.2.2. The fourth mechanism, *scaling*, was not triggered, but presented as a real opportunity.

Outcome: Ultimately, Kalnes, by providing a configured package of process innovation and standard infrastructure, also stood forward as a possible solution to the difficulties experienced in the Digital Renewal program. They advance from being an example of more or less successful process innovation, to being a possible example of regional and national eHealth innovation.

Identified mechanisms

In the case analyses four mechanisms, *discursive formations, connection, transformation and scaling* was identified, guided by the specific role of technology in mechanisms (Bygstad et al. 2016). See Table 8 for definitions, and figure 6 and 7 for illustrations.

Discursive formation is a mechanism with distinct abilities to *first,* identify areas where struggling programs exists, and *second* to establish strategies to enter into arenas where debates regarding the struggling program is performed. *Third,* discursive formations propose solutions to the acknowledge shortcoming in the program, and fourth they may (or may not) demonstrate that among its content are a technological solution. *Discursive formations*, then, is a *system of dispersion* that denotes the object, enunciative modalities, concepts and strategies included in the external discourse that competes on changing an existing infrastructure. A *discursive formation* that claims rather than demonstrates its connection to a technological solution may experience loss of confidence and gradually evaporate and therefore rejected by the respective infrastructure.

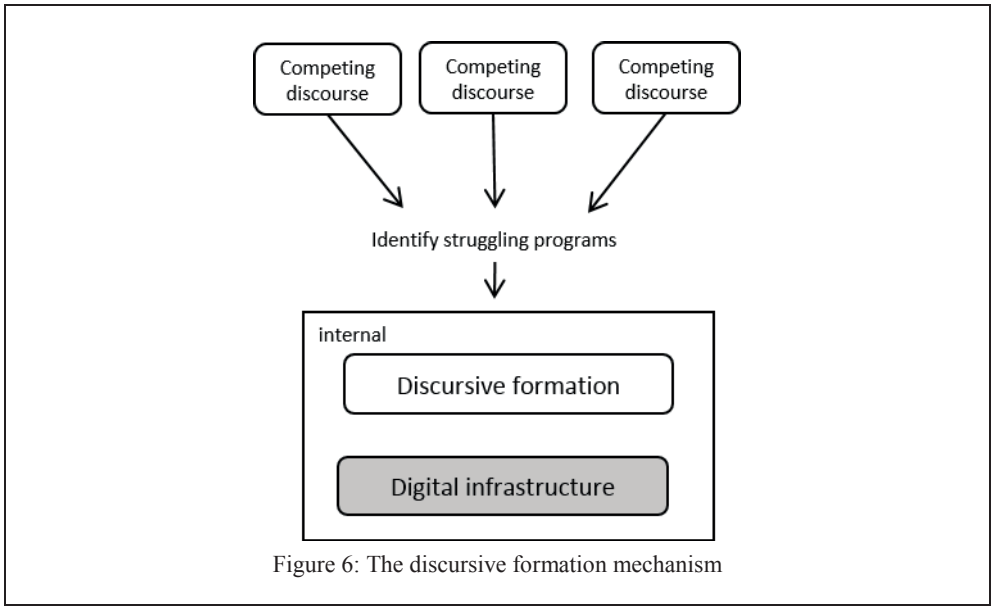


Figure 6: The discursive formation mechanism

The *connection* mechanism changes the infrastructure by introducing a new form of materiality that connects discourse and infrastructure. The mechanism is triggered when a *discursive formation* becomes a part of the infrastructure, i.e. it attaches itself to the existing infrastructure. The discursive formation relates itself to what Foucault call its *associated domain*. The connection between discursive formation and infrastructure gives us a new way of understanding materiality; it describes how the discursive formation gains strength through putting infrastructure into production.

The *transformation* mechanism enables an organization to obtain specific changes in accordance with acknowledged shortcomings. It can be defined as the result of the connection between discourse and infrastructure when a large part of the infrastructure is changed through this interaction. Transformation has a greater impact than connection, and may become the dominating form of production within the organization.

Scaling denotes "a self-reinforcing process by which an infrastructure expands its reach as it attracts new partners by creating incentives for collaboration" (Henfridsson and Bygstad 2013, 918). In this case, it implies that the infrastructural solution is applied to a larger regional or national setting, i.e. that it enters into and improves a larger eHealth program by providing solutions that address acknowledged shortcomings.

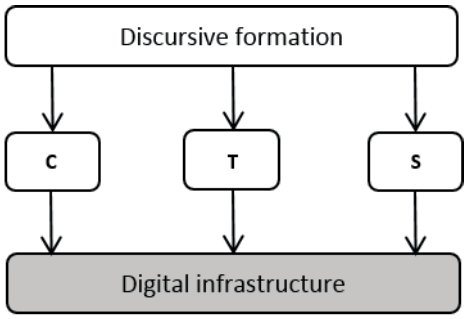


Figure 7: Interaction between discursive formation and digital infrastructure through three mechanisms, connection, transformation and scaling.

Table 8 provides a definition of the four mechanisms.

Mechanism	Definition
Discursive formation	A system of dispersion that identify and enter into arenas where struggling programs reside, and that may contain the power to change an infrastructure in crisis.
Connection	A process whereby one discursive formation associates with a material structure.
Transformation	A process whereby a discursive formation are materialized through a deeply anchored technological solution supported by both strategic management and other organizational actors.
Scaling	A self-reinforcing process by which an infrastructure expands by proposing a configured solution to common challenges.

Table 8: Definitions of mechanisms

RQ 2: What characterizes a technological solution that is suitable for supporting strategic shifts within eHealth?

In this section, findings related to the second research question will be described. The content is derived from papers 3,4 and 5, but inspired by findings from paper 2 and analyses in paper 6.

Paper 3 concerns the modern and prestigious Kalnes hospital in Østfold, which received a relatively high degree of freedom to configure their own IT strategy. Led by an innovative CEO and an energetic CIO they strived to build a hospital based on process thinking and advanced IT solutions. The key events in this case were: Process modelling and IT piloting at the old hospital (2013-2015), Start up at new hospital (November 2015), and stabilizing solutions (2016-2017).

The process challenges included:

- Receiving emergency patients arriving with ambulances or by taxi, registering them, conducting triage and medical diagnoses, and requiring additional services such as lab tests or radiology.
- Allocating new hospitalised patient to wards and beds, and providing the necessary information to the staff, and to patient's family.

- Setting up a clinical pathway for each patient, and allocating various resources and services in calendars
- Ensuring that each patient received exactly the medicines that the doctor(s) had prescribed (closed loop medication).
- Co-ordinating the discharge of patients with municipalities. For instance, the municipal care institutions required that information on an incoming patient should be sent before noon.
- Providing the kitchen with exact information on how many meals, dietary requirements, room numbers etc.
- Providing the cleaning department with timely information on which rooms to clean, and when.

The planning and implementation went through three phases. From 2013-2015 preparations at the old hospital in Fredrikstad included modelling of existing processes and the acquisition of a new IT solution from Imatis. The Imatis solution included three main services:

- A solution for patient self check-in and dealing with queues
- A system for visualisation of patient flow and logistics, with whiteboards
- A message broker for distribution of messages to mobile phones and other units

Kalnes main challenge was, however, to align the process innovation part (newly modelled processes and the configured Imatis solution) with the underlying digital infrastructure. The digital infrastructure was a "regional package" of more than 300 applications maintained by the regional IT Centre. The core applications were the electronic patient record (EPR) system, lab system, radiology system and chart and medication system. These applications were part of the regions e-health mega-program, Digital Renewal, which aimed at integrating the most important systems. As the integrated package was not ready, and progress was slow, the responsibility for parts of the start-up package was in 2013 transferred from the Digital Renewal program to the Kalnes Hospital Project, because of the tight deadline in 2015 (when the hospital opened). An IT architecture team was established at Kalnes, particularly to deal with the complex integration issues.

The CEO comments, "If the responsibility for the IT solution had not been transferred to us in 2013, we would never have kept the deadline. Regionally, there were simply too many cooks. We had to simplify things to get the solutions running."

Four main challenges or tensions were gradually solved. First, the IT Centre in Oslo accomplished the demanding interplay between the Imatis lightweight solution and the regional infrastructure. Second, the possible tension between the medical regime (using core clinical applications) and logistics (using Imatis) was not actively opposed, and arenas for exchanging insights were established. Third, Kalnes had some freedom to configure the solutions according to their own requirements, and this was prioritized at the expense of complex regional issues like scaling and flexibility. Fourth, Kalnes established, together with the regional IT Centre, an entirely new configuration of lightweight IT and heavyweight IT. The Imatis solution demonstrated how lightweight IT could mediate effectively between the processes and the existing digital infrastructure; in fact, most of the redesigned processed were informed by the solution.

While the practical contribution related to the way lightweight IT serves as a mediating technology between the process innovation initiative and the core clinical systems in the installed base, the theoretical contribution of the paper regarded how to deal with conflicting forces within the process innovation initiative, and the package of existing systems from the installed based. While the process innovation initiative was initiated and strongly sought by from the management; the package of existing systems from the installed based, was adapted to clinical and administrative work. It was necessary to find a way of aligning these two forces. The *governance mechanisms*[11] of process orientation and an integrated project allowed the managers to (i) design key processes for better patient flow and (ii) implement the new processes and technical solutions as mutually supporting elements. The *architecture mechanisms* of systems integration and lightweight IT allowed the managers to (i) connect to the existing digital infrastructure and (ii) to connect processes and infrastructure loosely, by innovative deployment of lightweight IT. By doing this, the paper theoretically contributes to the digital infrastructure literature

[11] The governance mechanism and the architecture mechanism are not elaborated further in this thesis.

by proposing a configuration for successful process innovation, in a complex e-health context. The configuration (El Sawy et al. 2010) shows a causal pathway for extending infrastructure theory by a context of loose coupling, but with sufficient governance and architectural links to the larger infrastructure.

Paper 3 is both practically and theoretically occupied with architectural and governance related issues for enabling cooperation between lightweight IT and heavyweight IT. This is framed as a prerequisite for changing the digital infrastructure, and improving logistics. Paper 4 investigates a process innovation case where these preconditions where difficult to obtain. The case in Paper 4 is an innovation initiative at an emergency unit in Oslo, where municipality authorities and technology vendors either behaved conservatively or refused to cooperate with the project owners. The project owners consequently had to apply for funding and technological solutions on the outside of the existing governance regime. This also meant that the parallel sequence of aligning lightweight IT and heavyweight IT was abandoned. The key events in this case were:

- Pre-planning: The most important activities was related to identify collaborators, and prepare and apply for funding from the research council
- Later in 2014 the most important activities was to acquire whiteboard technology and analyse existing processes. Samkad did also established a collaboration with Sintef, an expert organization in industrial processes.
- The implementation of mobile and whiteboard technology was done in 2015 and 2016. It was first used to improve internal processes, and then it was expanded to improve the message interaction between Health units.
- In 2016-2017 the Oslo Municipality worked to integrate the innovation initiative with core clinical systems. Because the heavyweight IT vendors resisted, Oslo Municipality established a solution for "low-scale" integration through a newly established interface.

The Samkad project (interaction at the emergency unit) established in 2014 received initial funding from the research council, and used the funding to analyse their own activities and performances. The project manager emphasizes the importance of participation: "We have a high degree of employee involvement. This is tremendously challenging, but it raises the quality of our services."

The Samkad management contacted a system vendor Imatis, to acquire mobile and whiteboard solutions designed to be particularly strong on logistics (Imatis had installations in both Australia, Denmark as well as several hospitals in Norway). The project manager says, "The collaboration with Imatis gave benefits quickly." In fact, Imatis was installed after only three months.

The project also addresses the new requirements from the national coordination reform (Helsedirektoratet 2016) focusing on improved digitalization of interaction within and between health units. A doctor says, "Static systems are not suitable in an efficient production." The Samkad project, consequently, addressed the following challenges:

- Improving the routines for patient admission, and discharge.
- Improving the overview so that the physician on duty can find and book available rooms.
- Providing kitchen and cleaning personnel with information on meals, dietary requirements and room numbers.
- Improving communication during shifts of clinical personnel.
- Improving the interaction with the city districts to reduce amount of time used for message writing and phone conversation afterwards.

The Samkad project had (initially) two central goals. First, to improve internal processes i.e. use digital technology to streamline internal logistics. The second goal was to improve the interaction with city districts. This consisted of creating a message standard that enabled Aker and the receiving unit to communicate faster and more efficiently about the patient condition. Addressing these challenges, the lightweight IT solution from Imatis helped the project and the organization to relatively fast obtain a more dynamic organizational performance. The emergency unit is satisfied with the new solution, and a doctor says, "This is a considerable improvement, especially the registering and notification that a patient is arriving."

The second goal, the improvement of the interaction with city districts was managed by implementing a new message standard. ADL (Activities in Daily Life) has a simpler and more distinct decision-making structure where patient health is defined by numbers and colours. This makes it easier for the receiving unit to immediately identify who needs particular treatment (see paper 4 for details). The new message interaction with city districts was seen as an improvement by most of the users. "The standardization of ADL gives us a more systematic description, and less deviation," a nurse said. "It is easier to use", said another and "it is much easier to immediately identify the important information", according to a third.

The theoretical contribution in the paper emerges using the lens of business process innovation to the literature on digital infrastructures. Through this lens, it was observed that the value of the installed base was retained, while the implementation project at the same time was done faster. In addition, the role of lightweight technology in improving logistics and message interaction within and between health units was demonstrated. The lightweight technologies availability on the commercial market makes acquisition and implementation faster. Based on the findings, a "bypassing strategy" where a new layer of technology is built separately from the existing infrastructure in order to effectively address process innovation efforts, was suggested. This means that lightweight IT can be built separately from heavyweight IT when conditions for collaboration are not present. In some cases, this could be fruitful in order to add speed to innovation projects. In addition, late in the project Oslo municipality initiated an effort to integrate the lightweight infrastructure with clinical core systems. Through this, we can also see that lightweight IT may operate separately and that success in process innovation may open up for possibilities for further integration later.

The configuration of lightweight IT and heavyweight IT in order to enable process innovation is also the focus of Paper 5, which is primarily occupied with two things. First, the innovative capacity of lightweight IT as a flexible, dynamic and distributed technology for process innovation is investigated. In practice, we followed the clinicians and administrators working at the emergency unit and the health wards as well as the coordinators operating in between, in order to understand the role of technology when moving the patient from admission to discharge. The unit of analysis was chosen in order to complement the managerial challenges from Paper 3 with "everyday challenges" related to process innovation within and between hospital departments. In the activity to establish what is called *coordinative paths*, three central issues were identified: *challenges related to digitalization*, the *informating ability of innovative technology*, and the *self-management possibilities* digitalization gives.

Challenges with digitalization: The use of IT to improve processes, remove manual work and digitalize relations may give improved performance. Digital booking of ward resources done by the emergency unit may eventually enable "silent reports" where manual routines are removed. Some challenges may also be introduced. An example is the difficulties of dividing a process like triage in two steps: the identification of the level of seriousness, and then the treatment. Sometimes these steps are intertwined. Another issue regards the sharing of resources across wards. This may open up for the booking of rooms and equipment meant for special use (infection rooms, x-ray equipment etc.).

Informating ability of innovative technology: Communication through mobile phones and electronic whiteboards has given the units and wards more overview of production and performance. A nurse at the emergency unit says, "It's an important device in the administration of the unit… Earlier we had to call for every detail, now we have a much better overview." A ward manager says, "Imatis gives a good overview, also when family members call, it is easy to answer. It provides good communication with food makers and cleaners. In addition, it gives a good overview of patients admitted to the department and the department to which they belong."

Self-management: Kalnes have made good use of process innovation improvements and visualization mechanisms to establish several collaborative arenas where patterns of performance and production are discussed. Examples are the "tavlemøte" (department whiteboard meeting). In this meeting, they agree on who needs to be treated first, based on level of urgency. Then they work on the patients that most likely can be discharged the same day. This practice also enables the cleaning personnel to get a good insight into rooms that has to be cleaned so that they can do this right away. The digital integration of work tasks requires an increased synchronization between departments and working units. On one hand, this may create more demanding work tasks, but may also give work groups more prestige. An example is housekeeping that have become an integrated part of the collaborative arenas where flow issues are discussed.

At Kalnes coordinators and cleaners ability to perform self-management have improved because they have gained better tools for reflecting on production and performance. Further, it was observed that although some of the doctors are critical towards the whiteboard system, they actively participate in some of the arenas where horizontal flow coordination is addressed. Improved process flow may be in their interest. The "flow-arenas" also release motivation to improve capacity utilization. The transparency of organizational performance seems to give an improved understanding of cross-sectional challenges and triggers activities and solutions to address them. Kalnes is designed to enable process flow also in that the health wards are designed equally. This enables flexibility and universal availability of resources.

The technological portfolio is partly modularized. Imatis' integration interface gives a looser coupling between the outside and the inside of the organization, protecting its internal logic. It may operate independently of the regional infrastructure if needed. The increased informating ability also makes it easier to provide counter-strategies when needed, in that side effects are identified relatively early.

In the core of these three papers lies the focus on process innovation, and digitalization as a way of improving an organizations informating ability. In addition to this, we investigate and suggest an architectural configuration of lightweight IT and heavyweight IT, which contributes to the understanding of what it takes to enable innovation and improve logistics. In section 6.2, the contribution related to the second research question will be explained in more detail.

6 CONTRIBUTIONS

In this chapter, the contributions in this thesis will be described and discussed by drawing on the literature on digital innovation in digital infrastructures (6.1, 6.2 and 6.3). The practical contributions will be described in section 6.4.

The research questions in this thesis are:

RQ 1: How does discourse affect strategic shifts in digital infrastructures? (Addressed in 6.1)
RQ 2: What characterizes a technological solution that is suitable for supporting strategic shifts within eHealth? (Addressed in 6.2)

In answering these two questions, two contributions are given. *First*, the role of discourse in strategic shifts in digital infrastructures is investigated. This includes acquire an improved understanding of how discourse connects to the digital infrastructure thus contributing to strategic shift. This will be done by first, in 6.1, establishing a framework to understand the role of discursive formations in strategic shifts. Then a set of configurations to explain how contextual conditions and mechanisms contingently lead to strategic shifts are proposed. *Second*, in 6.2, the characteristics of technology that makes it easier and more efficient to connect discursive formations and the digital infrastructure are identified and discussed. In 6.3, a summary of the general contribution to the field of digital innovation in digital infrastructures is given, and in 6.4, the practical contributions in this thesis are described.

6.1 The role of discourse in strategic shifts

6.1.1 The dynamics of strategic shifts

Analysing the three cases (section 5.2) I find that two forces are important for a potential strategic shift of an established digital infrastructure to happen. First, in line with Lakatos (1970), I find that the degree of acknowledgement of the problem is important; it makes management more vulnerable for critique. Second, as shown in the cases, the strength of the discursive formation is critical for the external discourse to disrupt the existing order of things.

In the case of Medicloud, the problem was widely acknowledged, and the discursive formation was well organised. However, the lack of a working prototype gradually reduced the strength of the discursive formation, and Medicloud never became more than a vision. In the case of Aker, the problem of poor logistics was acknowledged, and the discursive formation established a lightweight infrastructure that made the formation strong enough to disrupt the local patient flow solution. However, the discursive formation did not include the top managers, and was not able to disrupt the lower levels of the infrastructure. The Kalnes case was different; the top management clearly voiced the problem, and the discursive formation gradually became strong enough for a strategic shift.

At a more general level, a framework to understand these processes is suggested, illustrated in Figure 8, with a time axis.

Time 1 shows a digital infrastructure in a normal state. Changes are taken care of by cultivation of the installed base and by adaptation to changes in the environment (Hanseth and Lyytinen 2010). The discourse is an internal part of the infrastructural arrangements, and reproduces the infrastructure.

Time 2 illustrates the case when the digital infrastructure is experiencing a crisis, with external pressures, and managers are searching for remedies to their problems. In this situation, externally driven and often competing discourses may enter the scene, claiming that they have solutions to the program challenges. Sometimes, managers will deal with the situation assuring that the setbacks are temporal, and continue the program as planned. However, sometimes discourses are growing into a discursive formation, with the potential to trigger a larger shift.

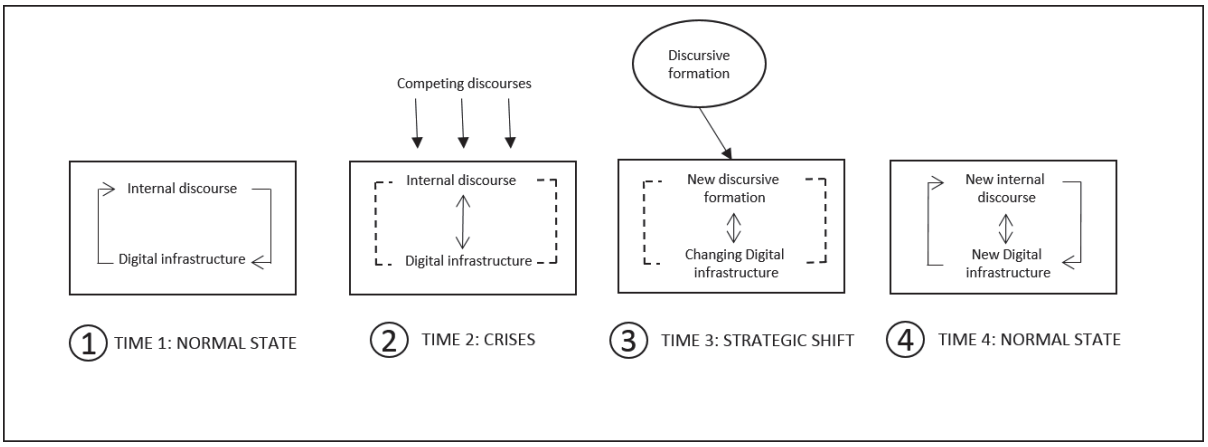


Figure 8: Discourse and Infrastructure in strategic shifts

Time 3 illustrates the discursive formation and the strategic shift. This will be a turbulent period. When a distinct discursive formation emerges several things may happen, and I focus on three. First, the discursive formation may be more or less left on the outside of the infrastructure and gradually evaporate. Second, the discursive formation may lead to a minor shift of the existing infrastructure, maybe as a separate digital arrangement as a possible candidate solution. Third, the discursive formation may be powerful enough to trigger a real strategic shift of the digital infrastructure. In section 6.1.2 these alternative trajectories are discussed.

Time 4 illustrates that after the shift, the new internal discourse becomes aligned with the new digital infrastructure, returning gradually to a normal state where the discourse and infrastructure are well aligned and supporting each other. This is called the *internalization* of discourse.

The framework deals, at a high level, with the interplay of discourse and infrastructure. Earlier studies on the use of discourse in IS looks at the difference between discourse and reality. This is done by either describing the role of discourse in imagining what technology can achieve (Swanson and Ramiller 1997), the role of discourse as an element in hiding management's actual intentions (Ellingsen and Monteiro 2008), or as an 'existential' aid for the individual to handle change (Edenius 2002, Wastell 2002). Within the literature on information infrastructures discourse is treated as an implicit part of the case dynamics. Growth (Edwards et al. 2009, Star and Ruhleder 1996), cultivation (Ciborra et al. 2000, Hanseth and Lyytinen 2010), bootstrapping (Hanseth and Lyytingen 2010) and generativity (Bygstad 2016, Henfridsson and Bygstad 2013) are all seen as fundamental although implicit providers of infrastructural evolution.

The framework contributes by demonstrating the distinct role of external discourse when eHealth programs encounter crisis, and the process of internalizing this discourse into the program. What the framework does not explain is how the discourse actually intervenes and changes the infrastructure, i.e. the causal mechanisms that are activated. How this process unfolds will be discussed in section 6.1.2.

6.1.2 Connecting discourse and infrastructure

In section 5.2, three cases was analysed using Foucault's (1972) archaeological framework for discourse analysis, and the CMO-scheme from Pawson and Tilley (1997) for investigating the relationship between context, mechanisms and outcome. Inspired by Elder-Vass (2010) who raised the question: *how can discursive formations have causal power,* discursive formations are regarded as mechanisms that need interaction with other mechanisms in order to persist. By saying this, I also propose that a discursive formation *matters*[12] primarily when other mechanisms are triggered.

Building on the configuration framework (figure 3) and the case analysis, I am now in a position to specify the configurations. In the configuration framework, building on Lakatos (1970) and inspired by El Sawy et al. (2010), three core contingencies are identified; *perceived problems*, *availability of technical solutions, and organizational anchorin*g. Perceived problems relate to the shortcomings of the

[12] This does not mean that a discursive formation have significance only based on its causal force. However, in this thesis, the causal power of discursive formations is the main issue.

existing program or situation. Availability of technical solutions refers to the actual solution that may change the physical part of the infrastructure. Organizational anchoring denotes the degree to which key actors in the related organisation or infrastructure support a strategic shift initiative.

The case analysis revealed three mechanisms, *connection, transformation* and *scaling*, connecting the fourth, *discursive formation*, to the infrastructure. The mechanisms are defined in table 8 and illustrated in figure 6 and 7 above. The three mechanisms may be seen as sequential, with increasing impact on the infrastructure. The resulting set of configurations (Figure 9) can briefly be summarized as follows: The discursive formation may interact with the three mechanisms in the infrastructure, resulting in an outcome. Whether the mechanisms are activated is contingent on the three contextual conditions, leading to different configurations.

Three such configurations are identified, *evaporation, inspiration, organizational transformation, and scaling* (The first three are illustrated in the figure below, while the fourth configuration, *large-scale transformation*, is described in text). They reflect how a discursive formation affects the digital infrastructure, i.e. the degree of strategic change: the first configuration leads to nothing while the fourth leads to an extensive strategic shift. In more theoretic terms, the configurations show how contextual conditions and mechanisms are conditioning the outcome of the program.

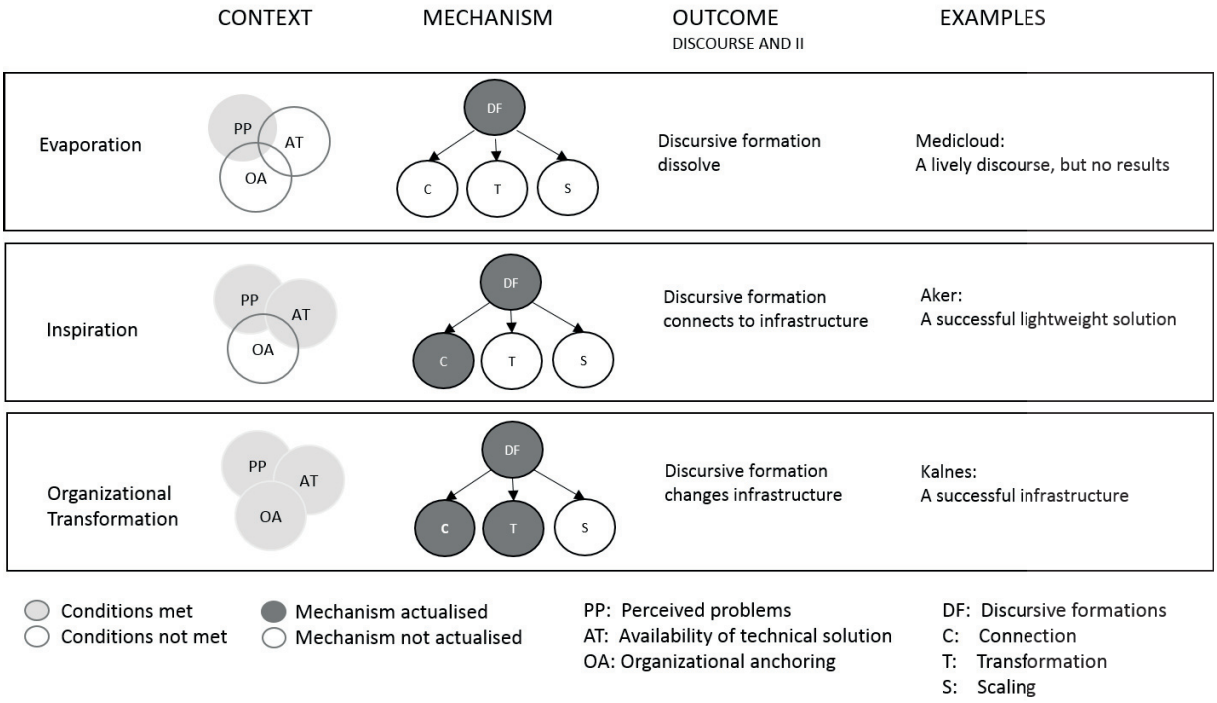


Figure 9: Context-Mechanisms-Outcome

Evaporation: This configuration is characterised by an established discursive formation, but with little or no impact on the digital infrastructure. It was exemplified by the Medicloud case, where the project was not able to trigger the necessary mechanisms for infrastructure change, and the project thus gradually halted. The reason for this outcome was first that only one of the three contextual conditions is met. Although a project distinctly aims to solve the perceived problems based on deep insight into strategic terrain inside the eHealth environment, a trustworthy technological solution must be available, and the initiative must have some organizational anchoring. In addition, the change strategy has to be aligned with or integrated into existing organizational routines, and the technological portfolio has to be extended to cover the new challenges. Discursive formations will encounter difficulties when they mainly rely on the power of the discourse itself.

The evaporation configuration is congruent with Ellingsen and Monteiro's (2008) point that the flexibility in discourse around organizing visions of technology can conceal the fact that discursive and actual strategies are operating at two different levels, and where one of them – operating in the 'hidden' – wins, while the other have no real impact in the end.

Inspiration: In this configuration, the discursive formation connects to the infrastructure through the connection mechanism. The fact that discursive formation connects to the infrastructure enables a deeper organizational impact in that it also addresses two contextual conditions: perceived problems and availability of a technological solution. When these two contextual conditions are met, new mechanisms may be triggered.

The example is the Samkad project at Aker, where the main goals were to improve the internal logistics, and the interaction between emergency units and the city districts. Despite several challenges, Aker implemented a lightweight infrastructure separate from the existing infrastructure, and this enabled them to implement mobile technology and electronic whiteboards in three KAD units. Through this solution, they were able to stand forward as an *inspiration* for other hospitals dealing with similar challenges. Aker was visited and inspected by several national and international agencies. However, a challenge for the Aker initiative was that while core knowledge personnel participated, management remained partly uninvolved and the existing techno-structure was not willing to co-operate. The lack of profound anchoring affected the project in that strategic plans, budgets and economical predictability were absent, and the project management had to apply for external funding for each project. This threatened the project's continuity, and may have led to exhaustion of core personnel including project managers.

The *inspiration configuration* is similar to Swanson and Ramiller's (1997) *organizing vision* in that technological development rests on the collective ability of the community to establish, maintain and negotiate discourse. Although the authors claim, "the product of talk or discourse, is effectively linked to material processes" (ibid, p. 468) it is not clear how this takes place. In my framing, the projects proceed or gain extended organizational impact when discourse and materiality are connected.

Organizational transformation: This configuration is characterized by a truly strategic shift, i.e. that the main components and relationships of the digital infrastructure are changed. As illustrated in figure 9, it is caused by a strong discursive formation and triggered by the three contextual conditions. The outcome of the interconnectedness between discursive formations addressing a perceived problem, aligned with a relatively homogenous organizational approach and with a technological strategy to implement and support the organizational strategies, is a *transformed organization.*

The example is the Kalnes case, where a completely new layer of lightweight technology, which is interacting systematically with the heavyweight core, changed the digital infrastructure (see also Figure 10 and 11). While both the Medicloud and the Aker case lacked or had limited support to put discursive strategies into action, the Kalnes case had managerial support from early on. The *transformation* mechanism was partly triggered using a technological strategy that enabled interaction between process innovation initiative and existing infrastructure, and partly by the fact that all levels of the organization participated including active and inspired management that provided predictable budgets. A third aspect of this transformation mechanism is that Kalnes through using innovative technology on top of a robust information infrastructure aligned themselves with modern market economic strategies, and fore-fronted themselves as a possible "innovation model" for the bigger regional program.

Yoo et al. (2010), outlines the potentially transformative power of IT when software products are organised in modules. Although very important, IT-enabled organizational transformation has at least two other aspects that have to be taken into account; the existing system portfolio, and the existing organizational practices. The inclusion of these factors into shift-programmes is labelled organizational anchoring, which is a premise to obtain organizational transformation. The findings indicate that to obtain transformation, the whole organization have to be involved in the change strategy. This is maybe not surprising given that earlier studies have demonstrated the involvement of executives in IT management (Jarvenpaa and Ives 1991) and that the entire organization must be involved in order to cultivate change (Sia et al. 2016). In the health sector, this picture is a bit more challenging, and later studies have pointed to the difficulties of transformation with the use of IT within the health sector (Agarwal et al. 2010). Transformation, i suggest, is obtained when innovative leaderships is combined with organizational anchoring materialized through budgets, plans and collective participation at all levels. In the same vein, the problems encountered by early business process reengineering initiatives (Hammer 1990, Hammer and Champy 1993) can be explained by their very limited focus on organizational anchoring.

Large-scale transformation: Our data indicates the presence of a fourth mechanism leading to a fourth configuration, labelled large-scale transformation. The key mechanism in the configuration is *scaling*. Scaling is by Henfridsson and Bygstad (2013, p. 918) defined as a "self-reinforcing process by which an infrastructure expands its reach as it attracts new partners by creating incentives for collaboration." I deviate to some extent from this in order to shed light on particular challenges when moving the focus from the private market to the public health sector. Scaling is consequently defined as "A self-reinforcing process by which an infrastructure expands by proposing a configured solution to common challenges." In my framing, this means the ability of a project to expand the scope of its strategic shift, and become part of a regional or national digital infrastructure.

The example is again the Kalnes case. As noted above the competitiveness of the Kalnes approach may bring them forward as a solution to the innovation requirements within eHealth programs. If so, the *scaling* effect will be that the Kalnes-model may be used in other regional hospitals as an integrated part of the Digital Renewal program. Another aspect of the scaling mechanism is its ability to attract users and new partners. This may also include enabling access for external collaborators like other hospitals, health units and general practitioners, but also patients and relatives through a platform strategy or similar.

In this part, I have discussed the role of discursive formations in bringing about strategic shifts when programs encounter crises. I see discursive formations as a strong but insufficient mechanism that has to connect to other mechanisms in order to change or transform the digital infrastructure. In 6.2, the particular characteristics of lightweight IT that makes it easier to change the infrastructure is investigated and discussed.

6.2 What characterizes a technological solution that is suitable for supporting strategic shifts within eHealth?

In 6.1, I demonstrated that a discursive formation make impact on eHealth programs in crisis, particularly when it connects to a technology belonging to a project that is profoundly anchored in important parts of the receiving organization. In 6.2, I will investigate the particular characteristics needed of a technology to support this strategic shift.

In section 2.3, it emphasized that lightweight IT is a knowledge regime with at least three central characteristics. *One* is the nature of the artefact, its usability, its occupation with improving processes and its easiness in implementation. According to Bygstad (2016), this includes the ability to bypass the existing infrastructure (if needed) when it is implemented. The *second* characteristic is the providers' ability to quickly follow up pilots, and implementations, so that users and organizations may experiment on and test new functionality. This also relate to the acquisition opportunity, the availability of the product on the commercial market (Bygstad 2016). A *third* important characteristic of lightweight IT is its modular, layered architecture. This arrangement facilitates loose coupling between systems components, and makes change easier.

From the research findings, three central aspects (from Paper 3, 4 and 5, see section 5.2) of lightweight IT in digital innovation are highlighted. First, lightweight IT is a process innovation knowledge regime, which is especially suited to support rapid change in order to improve logistics and other horizontal workflow processes. Further, lightweight IT has characteristics that provide better visual overview of organizational processes and performance. Finally, modular layered architecture enable loose coupling between software modules and make it easier and faster to implement changes in one module without affecting other system modules. These aspects will be discussed in 6.2.1

6.2.1 Three characteristics of lightweight IT

In Paper 3 (see section 5.2) it was demonstrated how a (re)configuration of the regional infrastructure into a looser coupling between central and local governance and architecture gave some autonomy from the installed base. The looser coupling between system modules enabled Kalnes to focus on the particular patient flow challenges addressed by the process innovation initiative both from a managerial, an organizational and from a technological point of view. The technological configuration consists of a process innovation initiative materialised in the Imatis lightweight solution, and an installed base of

clinical core heavyweight systems feeding the Imatis solution with clinical and administrative data (see Figure 10).

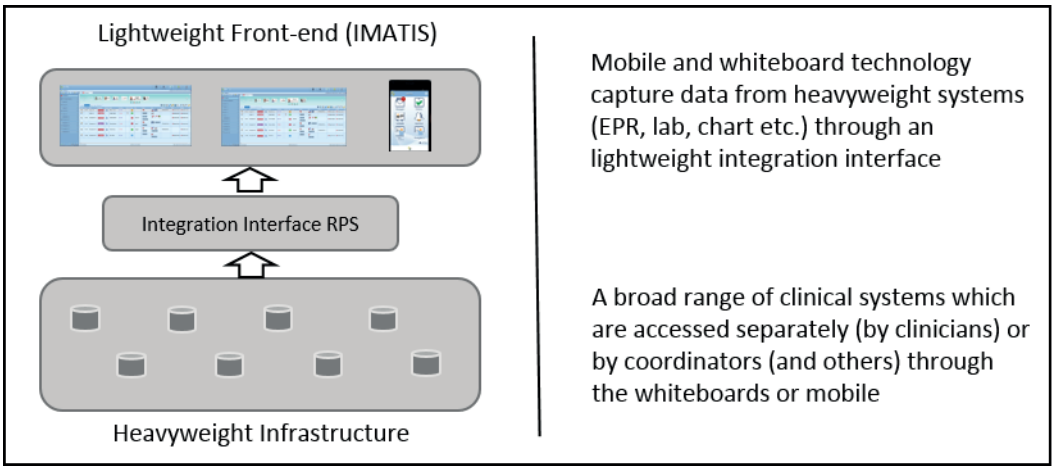


Figure 10: Lightweight IT and Heavyweight IT configuration

The configuration organizes the existing digital infrastructure, or heavyweight systems, as a back-end knowledge regime serving lightweight IT with information from core clinical systems. This may in some cases improve logistics considerably. Consequently, I concur with the insight that it is through interplay between lightweight and heavyweight that the most favourable results are likely to be obtained (Bygstad 2016). In short, interplay increases the possibility for obtaining organisational transformation considerably.

This entails the understanding of the installed base as an important part of hospital system processes. The two knowledge regimes (lightweight IT and heavyweight IT) should be loosely coupled technically, regarding standards and organisationally (Bygstad 2016), as loose coupling increases the redesign flexibility (Henfridsson et al. 2014). This also means that lightweight IT under certain contextual conditions may for a shorter or longer time operate separately from the digital infrastructure. The Aker case in Paper 4 (see section 5.2) demonstrates this. Loose coupling may liberate several strengths of digital technology (Henfridsson et al. 2014, Tilson et al. 2010, Yoo et al. 2010), and the current investigation highlight some of them.

First, lightweight IT is conceptualized as a front-end knowledge regime facilitating process innovation (see Figure 11). I call it a process innovation regime in order to highlight its ability to improve logistics, to increase redesign flexibility, and enable distributed autonomy as well as its powerful informating ability. I will further elaborate on each of these issues.

#Digitalized interaction may improve logistics and make it easier to identify bottlenecks.

Process innovation is about improving horizontal performance across functional silos in order to reduce or remove bottlenecks and trigger unused capacities. Digital technology provides the ability to establish new digital relationships (Tilson et al. 2010), but this presuppose better coordination and management of functional interdependencies (Davenport 1993).

In paper 4 and particularly in paper 5 it is demonstrated how lightweight IT supports the activity of digitalizing coordinative paths. Coordinative paths are the trajectories along which a patient have to be moved from admission at the emergency unit (or the wards), through the wards until discharge. We have *digital* coordinative paths when horizontal performance is supported by technology. This is seen as a part of the process innovation regime because it contains some of the premises from Hammer and Champy's groundbreaking work. According to Hammer (1990) there are (at least) six principles for implementing end-to-end processes using the power of IT. *First*, organize around outcomes instead of tasks. *Second*, those who use the output should perform the process. *Third*, make sure that real information producing work replaces information-processing work. *Fourth*, link instead of integrate parallel activities. *Fifth*, connect performance and decisions, and build control into the process. *Sixth*, capture information once, and at the source. Hammer and Champy saw the existing sociotechnical arrangements as an obstacle for innovation, but my empirical work bring forth the installed base as an important part of hospital system processes, and thus of innovation and change. This applies in particular

to the knowledge of existing processes and the basic premises they contain (Melao and Pidd 2000). Nonetheless, Hammer and Champy had some penetrating insights regarding the need to understand the services delivered to the customer in their totality, and modern technology's ability to exceed existing barriers in enabling organizational change. Although Kalnes (and Aker) are not fully there yet, their aims and movement certainly goes in that direction. At Kalnes interaction between emergency unit and wards has been digitalized in that patient transfers between units are done based on universal access to resources like rooms, equipment and personnel. At Aker logistics was improved relatively fast when lightweight IT was implemented to support it.

#Redesign flexibility makes it easier to innovate

Redesign flexibility obtained through loosely coupled modular components, produces differences in kind, rather than differences in degree (Yoo et al. 2010). Differences in kind mean that the level of re-programmability is high (ibid). An example is that loosely coupled architectures may enable use of information on different equipment, and that different equipment may use several types of files. The separation between lightweight and heavyweight IT, connected through a common interface, enabled Kalnes to not being fully dependent on long-term regional processes. The local configuration of architecture and governance, gave them the possibility to exploit the abilities of lightweight IT to support horizontal process innovation. The "bypassing strategy" enabled Aker to improve logistics and innovate the organization through the redesign flexibility in the Imatis solution. The contextual conditions (see section 6.1.2 and Figure 9) apply here. Kalnes was part of a prestigious project supported by national as well as local authorities. This secured the budgets and the maintenance of cash flow. Aker, on the other hand, had to rely on short-term funding, and had only a limited degree of anchoring at the management level. At the same time, while Kalnes is part of a larger regional initiative, and required to be more or less disciplined in how the digital infrastructure is arranged; Akers smaller context gave them more space for innovation. Nonetheless, in both cases lightweight IT, through its redesign flexibility, contains the capabilities needed to meet some of the contextual requirements.

#Distributed autonomy enables problem solving at the local level

The redesign flexibility is helpful in both establishing new digital relationships, and in providing distributed autonomy. The locally relevant distribution of corporate information provide changed control paradigms (Tilson et al 2010), through a more distributed organization (Yoo et al. 2010) where local challenges are dealt with at the appropriate level. Both at Kalnes and at Aker the internal participation in process innovation was improved through the implementation of lightweight IT. This also motivates the establishment of collaborative arenas where clinical and administrative personnel can discuss flow challenges. In addition, there are indications that working with horizontal processes, enables organizational actors to gain an improved understanding of the significance of the wider environment in solving local challenges. Both at Aker and at Kalnes organizational actors are active in proposing solutions to improve the interaction between internal wards and between hospital units. Examples from the cases are improved and more effective message standards between Aker and City districts, as well as the urge to use technology for improving and make a more predictable patient flow.

#Lightweight IT enables a powerful informating ability

Lightweight IT has, given the appropriate contextual conditions, the characteristics to improve the transparency and insight into horizontal processes. Drawing on Zuboffs (1988) notion *informate,* I denote the process of leveraging IT to make information about work visible and actionable across organizational functions and departments. Zuboffs informating framework indicates the need for management to be active in recognizing the potential of IT to generate information about the underlying productive and administrative processes that were previously opaque. The ability of lightweight technology to revitalize and visualize core system information also reconfigures the role of heavyweight systems to be an important fundament in a platformization strategy (Bygstad and Hanseth 2018).

The increasing redesign flexibility enables hospitals (like Kalnes) to continually monitor and improve the innovation initiatives. Organizational actors (like the coordination nurses) are engaged in technological development and become key players in process innovation in that they participate and monitor directly the outcome of the interventions. Further, even though I strongly acknowledge the important role of heavyweight IT in feeding lightweight IT with information, I was particularly

investigating the role of lightweight IT in sharing, visualizing, and redistributing the information. This informating ability (Zuboff 1988) is contributing to transparency and improved overview in a way that may enable and motivate bottom-up and locally relevant process innovation.

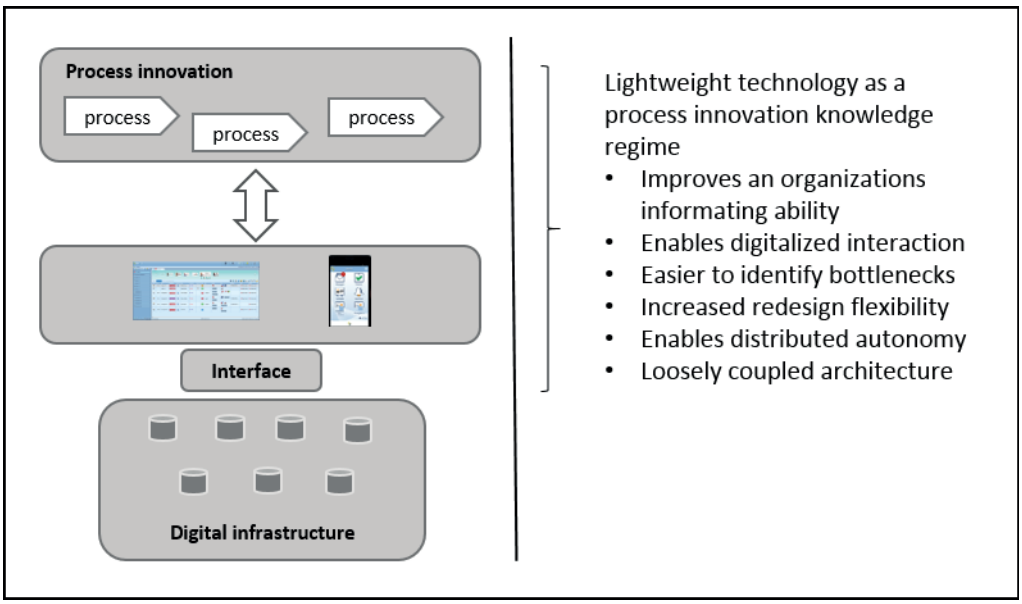


Figure 11: Lightweight IT as a process innovation knowledge regime

The informating ability also gives insight into efforts related to digitalization of processes, and the effect of these. In my framing, informate concerns the systematization and digitalization of underlying processes in order to more easily give insight into patterns of performance and production. Improved efficiency and transparency may facilitate further digital innovation. Digitalization of this kind does, however, intervene in organizational inertia and triggers organizational tension. Silo systems, clinical regimes, work processes, routines and regulations which have been more or less aligned is re-enacted, brought into life, and has to be aligned once again. Accordingly, the functional and the horizontal efforts must be balanced (Garud and Kumaraswamy 2005). This may also shed light on some of the challenges and the risks when creating digital coordinative paths. Even in cases where innovation threatens important stability, digitalization helps the organization in identifying the consequences of negative effects. This can makes it easier to reverse the change.

Second, I also add to the literature on digital innovation by giving empirical examples of architectural redesign flexibility through loosely coupled architecture, and the distributed autonomy this may facilitate. Loosely coupled architecture concerns the modularization of systems and modules into layers with more autonomy. Tight coupling between software and hardware or between system components in functional silos makes change difficult. Loosely coupled architecture means that changes in one system can be done without affecting other systems. It enables independent development in respectively lightweight and heavyweight IT systems. The architectural flexibility resulting from this may strengthen process innovation initiatives in that changes may be implemented without calling upon the whole heavyweight infrastructure of roadmaps, vendors, and technicians in order to bring about the desired change. While new digital relations in products may entail new apps, new social medias or new sensors, new digital relations in process innovation efforts, concerns the way organizational actors are digitally interlinked in performing sequential and step-wise patient flow. This includes the way bottlenecks are identified and dealt with.

In summary, process innovation is facilitated by using mobile technology and whiteboard technology, that is, lightweight IT characterized by rapid implementation cycles and ubiquitous access to tailored information through user-friendly interfaces. The whiteboards also facilitates the inspection of the result of process innovation in that information is displayed in common arenas where patient flow is discussed. I agree with the literature on digital innovation and digital infrastructures (Yoo et al. 2010, Tilson et al. 2010, Henfridsson et al. 2014) but adds to this literature on two grounds (see Figure 11).

First, I focus on process innovation rather than product innovation. There are similarities in the preconditions in that loosely coupled architecture removes some of the physical constraints and systemic entanglements in functional silos. There are, however, also differences in that "deep" process innovation are dependent on information from core systems. The architectural re-configuration of lightweight and heavyweight into front-end and backend systems are thus a bit different from the challenges in product innovation.

Second, I inspect the hospital setting, which has additional challenges compared with the consumer industry and the machine bureaucracy (Mintzberg 1993). Health IT system portfolios often consist of a wide range of clinical and administrative systems, with the tendency to become functional silos. Integration between systems is a way to enable interaction. However, since these systems are usually programmed in proprietary languages and often lack standardized interfaces, each element must be given special attention in integration projects. By re-configuring the role of these systems in the way outlined in Figure 11 and 12, where core systems feed the lightweight frontend with clinical information through a standardized interface, several things may be improved. First, it enables change in one system without necessarily affecting the whole system portfolio. Second, it enables distributed autonomy where users can both monitor performance and adjust performance based on the feedback. Third, it gives a better division of labour between innovation efforts and core clinical systems.

6.2.2 Lightweight IT as a change regime in digital infrastructure

In figure 8, Time 2 indicates a crisis in the digital infrastructure following from acknowledged shortcoming in the existing program. The shortcomings may be caused by lack of innovation and lack of decentralised autonomy. A discursive formation (see 6.1) backed up by a digital strategy may solve the challenges and lead to a strategic shift. The empirical evidence is the Aker case and the Kalnes case. The strategic shift in the Aker case is more modest. Lightweight technology is used to improve logistics but separately from the existing digital infrastructure. Since it operates as a separate digital arrangement, it is insufficiently anchored in the existing organisation. The findings indicate that it is difficult to transform the digital infrastructure with this model. In the Kalnes case a strategic shift occurs.

The configuration of lightweight IT frontend fed by a heavyweight IT backend enables at least two significant improvements. First, it turns lightweight IT into a very powerful process innovation technology that may improve logistics. Lightweight IT also displays and visualizes information in ways that strengthens Kalnes use and re-use of information. Trough improving horizontal processes by using electronic whiteboards in sharing, visualizing and redistributing information *across* departments the organization may obtain improved insight into its own performance. This may help the organization to both sense and respond (Overby et al. 2005); i.e. to establish an improved insight into the organizational performance and gradually establish means to deal with them. Second, this configuration makes it easier to change part of the digital infrastructure without changing everything. This orientation is also facilitated by the specific features of digital technology to break away from established innovation paths (Svahn et al. 2017), in order to enable rapid scaling (Huang et al 2017). According to Yoo et al. (2010, p. 725) "digital innovation … requires a firm to revisit its organizing logic and its use of corporate IT infrastructures." In the Kalnes case the process innovation effort was supported by the reconfiguration of the digital arrangements, governed by the management and re-organization of horizontal processes. As described in 6.1.1, the deep transformation rested on the strength of the organizational anchoring. A digital strategy relying on shortsighted projects and budgets only partly supported by management may lose the momentum and experience loss of strength.

6.3 General contribution to digital infrastructure theory

The *main* interest in this thesis is the role of discourse in strategic shifts in digital infrastructures, particularly in situations where the digital infrastructure is in some sort of crisis. This includes efforts to establish an improved understanding of how discourse connects to materiality - the digital infrastructure. The *second* interest concerns the investigation of the characteristics of technology that make this connection easier and more efficient, and that finally may solve the crises in the infrastructure.

An investigation into the relationship between the acknowledged shortcoming in the existing program, and the search for possible solutions was performed. I was *first* occupied with the role of discourse in

this process, and particularly discourses that are emerging in collectives or *formations*, as Foucault frame them. Foucault's framework was used to analyse the content of these *discursive formations*, framed as a central mechanism in change processes leading to strategic shifts. A more close inspection of the role of lightweight IT in bringing about this shift was then initiated.

Earlier empirical research on digital infrastructures indicates that more than one mechanism is needed to enable digital innovation and a strategic shift (Henfridsson and Bygstad 2013), and what is unclear in Foucault's discursive formations is the causal relation between discourse and objects. That is, what other mechanisms are needed to generate a positive outcome. This relationship was investigated by applying critical realism to the empirical material. Particularly I used the CMO scheme (Pawson and Tilly 1997) to study the relation between three contextual conditions - perceived problems, available technological solution and organizational anchoring (the social, managerial or technical links to the main organization) - and a particular outcome was identified in the three cases. I propose that the relation between context and outcome is caused by mechanisms internal to the digital infrastructure and which are triggered through specific interaction between discursive formations and digital arrangements. Two contributions are highlighted.

First, I reconceptualise the relationship between discourse and infrastructure, and offer an alternative model for understanding strategic shifts.

After showing that previous research does not address this in sufficient depth, I demonstrate empirically and theoretically how Foucault's (1972) concept of discursive formation allow me to separate the concerns of discourse and digital infrastructure. In addressing this issue the starting point was Elder-Vass' (2010) proposal that discursive formations have causal power, which led me to conceptualise discursive formations as mechanisms. This allowed a detailed analysis of the relationship between discourse and digital infrastructure, which is mainly lacking in previous infrastructure research (Hanseth and Lyytinen, 2010) and in the social constructionism research (Doolin et al. 2013) like ANT (Callon 1986, Latour and Woolgar 1986), or socio-materiality (Scott and Orlikowski 2013). I explain how a discursive formation *disperses* into an infrastructure, and possibly changes it. It also extends the contribution of Constantinides (2013) in showing that although discourse and technology are entangled, a careful analysis of the interplay between discourse and infrastructure *over time* (illustrated in Figure 8 and 9), may reveal that they can be analytically "disentangled".

The digital infrastructure literature has offered various perspectives on strategic shifts, with slightly different emphasis on stability and cultivation (Aanestad et al. 2017, Hanseth and Lyytinen 2010) and path creation, path-changing innovation, value paths and rapid change (Henfridsson et al. 2014, Henfridsson and Yoo 2014, Henfridsson et al. 2018, Huang et al. 2017). Innovation initiatives are strengthened by digital technology with more rapid implementation cycles and better user interfaces that displays organizational performance. The detailed analysis of the interplay between discourse and infrastructure (illustrated in Figure 8 and 9), building on a critical realist approach (Elder-Vass 2010, Pawson and Tilley 1997) propose that strategic shift may be explained by various configurations of a set of mechanisms and three contextual conditions. Doing this a more fine granulated analysis of the content of discursive formations is produced, and the relationship between discourse and other mechanisms leading to a certain outcome, is demonstrated. This is important, I propose, in order to understand the role of discourse in processes of digitalization. The methodological approach demonstrates that bridging Foucault's concept of discursive formation with critical realism (initially suggested by Elder-Vass, 2010), can be a promising avenue for research in the digital infrastructure field, in which discourse is a prominent phenomenon.

Second, I offer an explanation for how and why lightweight IT makes it easier to change the digital infrastructure

In section 6.1 I describe and discuss how discursive formation and other mechanisms propose a solution that may change the digital infrastructure. In section 6.2, I describe and discuss some of the characteristics of lightweight IT that makes it easier to achieve this change.

Lightweight IT can be seen as a sociotechnical *knowledge regime* with both independent and collaborative abilities. While the regime of lightweight IT are formed by the generative relationship between knowledgeable end-user groups and entrepreneurs, the heavyweight IT regime is dealing with core systems and the activities related to stabilizing, securing and scaling them (Bygstad 2016, Bygstad

and Iden 2017). The regimes of lightweight IT and heavyweight IT have independent strengths. Examples of strengths with lightweight IT are mobile apps that enables swift purchase of metro tickets, apps to improve service work or white collar work as well as improved welfare technology solutions (Bygstad and Iden 2017). Heavyweight IT, on the other hand, gives secure access to comprehensive information repositories. Consequently, both are needed in order to enable profound business innovation (Bygstad 2016).

In the studies, I were interested in the practical implications of lightweight technology operating either separately or in correspondence with heavyweight IT, in order to improved workflow coordination across organizational departments and functions. In Time 3 in Figure 8, the process innovation knowledge regime of lightweight IT address a shortcoming in the heavyweight IT programs, the lack of innovation and lack of speed in IT implementation and adoption strategies. The result is a strategic shift. The loosely coupled lightweight IT frontend, and heavyweight IT backend, is the contingent configuration that enables this change. This solution may also scale to other hospitals. Finally, a sequential explanation for the evolution of digital infrastructures (from Time 1 to Time 4) in crisis is provided.

6.4 Practical contributions

Research question one - *how does discourse affect strategic shifts in digital infrastructures?* is primarily theoretical, but the role of discourse may, from a practitioner point of view, give a better understanding of how objects, concepts and strategies make impact on technological innovation in digital infrastructures. The issue may inform and help politicians, managers and strategists who seek to manage the dynamic role of discourse in organizational and technological innovation. This applies particularly for public sector strategists and policy makers who often rely on reports and documents that outline necessary change and circulate these within the existing network. In short, earlier outcomes of recent programs may inform policy makers on what works and not (Pawson and Tilley 1997). Discourse should be included as an important factor in such evaluations.

Public sector strategists need to, and do to a certain extent, integrate themselves into debates and discourses in the wider marketplace in order to sense new trends, and to learn how to deal with them. As expenses grow and the patience of both public sector bureaucrats and citizens drops, public sector programmes must be configured to provide both a faster change frequency while at the same time provide good services to the citizens.

In general, technological discourses are not only fads or trends, but also often more or less reasonable solutions to complex real-world challenges. Insight into dynamics of digital ecosystems may give a better understanding of how other sectors have addressed similar challenges. Expertise on governance and architecture are out there in the market, and although the health sector is burdened with additional challenges, existing solutions can sometimes be reconfigured to fit particular requirements. Big eHealth programs like Digital Renewal are expensive, complex and long lasting, with slow development. They may deteriorate if they are not able to dynamically adapt to emergent situations.

The practical contributions related to the second research question, *what characterizes a technological solution that is suitable for supporting strategic shifts within eHealth*, are the following.

Paper 3 is addressing these challenges from a governance and architecture perspective. In order to obtain success, process innovation initiatives have to be connected to the digital infrastructure. As the Kalnes case demonstrate, a careful configuration of governance and architectural mechanisms may enable beneficial solutions. The particular configuration of lightweight and heavyweight IT may show a way forward to more platform-oriented solutions (Tiwana 2013) in e-health, in the sense that lightweight interfaces are loosely coupled to the main applications. Lightweight IT have a very important role in this configuration, both as an intermediate technology, but mainly as a flexible process innovation knowledge regime which supports, and speeds up digital innovation initiatives. The configuration at Kalnes is demonstrating a balanced approach between agility and flexibility on one hand, and stability and security on the other. It may be relevant for CEOs, CIOs, as well as other managers and architects both on a local and regional level.

Finally, at Kalnes there was a fortunate mix of competences; a visionary CEO, a process oriented director of development, and a hands-on CIO, who worked equally enthusiastic with architectural issues

as with mobile phone configurations. In addition, the technical teams both at the hospital and at the Data Centre worked hard to solve problems, and gradually acquired the necessary competence.

The Aker case described in paper 4 shed light on particular challenges in small but intensive emergency units, and how some of the challenges can be solved by innovative technology. First, the value of the existing knowledge and processes in creating a "map" of shortcomings and common challenges is identified. Then the role of lightweight technology in improving logistics and message interaction within health wards and between hospitals is demonstrated. The lightweight technologies availability on the commercial market makes acquisition and implementation faster. Based on this, a "bypassing strategy" where a new layer of technology is built separately from the existing infrastructure in order to effectively address process innovation efforts is suggested.

Paper 5 discusses the particular configuration of innovative technology and core clinical systems that address challenges related to workflow coordination within and across organizational departments and functions. The electronic whiteboard with its big screens gives a powerful overview of status and performance, and motivate the establishment of collaborative arenas like meetings, workshops and seminars to discuss challenges. The interconnectedness of digital systems further challenges stability of status quo and may tempt managers and others to digitalize fragile processes and resources. This may create beneficial but also negative outcomes. The monitoring of these outcomes does, however, make it possible to reverse decisions relatively fast.

The practical insight from paper 4 and 5, although relevant also for managers and strategists, is mainly inspected from the perspective of project managers, team managers, ward managers, as well as actors participating in horizontal coordination of patient flow. For these actors there may be several possibilities addressing challenges of practical work. First, improvement in logistics does not necessarily threaten existing processes, but may make them easier. Second, electronic whiteboards may motivate establishment of collaborative arenas where patient issues is discussed and where decisions may be taken and implemented right away. The feedback from the whiteboard may be important in the planning of patient treatment as well as logistics in that key actors agrees on a treatment sequence based on principles of logistics (the patients that are close to discharge are visited first). Even though the electronic whiteboards described in paper 4 are implemented separately from the clinical core systems in the existing infrastructure, they may enable some quick benefits (but also some new challenges, like redundancy). It is however when the whiteboards and mobile are operating in interaction with clinical core systems that the more profound benefits will be obtained (see Figure 11 above). To integrate lightweight IT and heavyweight IT may be difficult when parts of the infrastructure and organization are not willing to cooperate. This also means that organizational anchoring (see 6.2.1) is important. In some cases, it may be beneficial to first establish a separate infrastructure. The more fundamental success may come later when the potential strengths of the separate infrastructure have been acknowledged.

In addition, innovation projects may enhance learning processes and lead to increased competency. The cases described in paper 4 and paper 5 provide examples of how the organization starts with analyses of existing processes, and where this activity gives a deep and broad insight into their own performance within a closer or wider network of interaction.

The learning processes may also require that system vendors should work in close cooperation with the organization in order to address challenges and expectations raised through the innovation project. The learning process consists of addressing shortcomings and improved tools to address them. Findings from the cases suggest that lightweight IT as a knowledge regime enables faster implementation, and are more focused on usability. Everything does not have to be done up-front (as in waterfall processes), but evolve as a gradual learning process throughout implementation, maintenance and improvement.

7 CONCLUSION

7.1 Summary

Strategic shifts in digital infrastructures are sometimes necessary in order to solve programs in crisis. In the Norwegian health sector, the billions of Norwegian Kroner (NOK) used on "heavyweight" infrastructures have only solved some of the challenges, and eventually led to some dissatisfied and

frustrated users, managers and entrepreneurs. The overall ICT portfolio within the hospital sector has remained fragmented and information exchange between applications and organizations problematic.

This situation is caused by the fact that while some applications were standardized within the regions, new ones were continuously introduced to support various new specialist practices, as a part of new digital instruments, etc. Moreover, while an increasing number of hospitals were running the same software packages, these packages were configured differently at each hospital making information exchange between hospitals very challenging. In order to solve this problem, extensive and expensive integration and consolidation efforts have been initiated. Due to the tight integration that these strategies imply, the difficulties of achieving change and innovation have survived. But since the health sector is both seen as one of the most difficult sectors to change, and as one of the most attractive for digital innovation in the years to come, actors with sophisticated strategical and technological solutions gathers around eHealth programs in crises. Because of the important public role of eHealth programs, media, citizen and professional experts, or "Greek choruses" as Sauer and Willcocks (2007) label them, surround these programs.

Discourse has an important role in this turbulent environment, but its explicit role is not investigated sufficiently. In this study, both the context for, the content and the evolution of such discourses is investigated by using Foucault's archaeological framework. By relating this framework to a critical realist approach, discursive formation are framed as a mechanism that have to connect to other mechanisms in order to bring about the needed change. Moreover, in order to change the infrastructure, a discursive formation must connect to something useful. The connection mechanism is triggered when an app, a mobile, or an electronic whiteboard is solving a particular problem and is integrated into the organization either as a part of the existing digital infrastructure or as a separate digital arrangement.

The second interest of this thesis is consequently an investigation into characteristics needed of a technological solution to support a strategic shift. Three characteristics are identified and described. First, lightweight IT makes it easier to change the existing arrangements because it solves fundamental challenges related to logistics, horizontal processes and other forms of process innovation. Second, it enables an improved informating ability regarding organizational performance and production. Third, lightweight IT makes it easier to change the digital infrastructure, also because it consist of a modular arrangement solving particular challenges the digital infrastructure struggles with. Loose coupling between system modules makes it easier to establish an interaction with the existing digital infrastructure.

The main theoretical contribution in this thesis relates to the improved understanding of the role of discourse in strategic shifts in digital infrastructures. Strategic shifts can be explained by the support enabled by the technology in order to trigger mechanisms. In order to trigger mechanisms, one or more contextual conditions must be fulfilled. To obtain transformation three contextual condition must be met: perceived problems, technological solution and organizational anchoring. The digital infrastructure and the processes supported by it are transformed when a new layer of lightweight IT is implemented above the heavyweight IT systems. This also gives the organization a better basis for improving their processes and for monitoring performance and production. Table 9 briefly summarize research questions, findings and contributions.

Research question	Research contributions	Relationship to research and practice
How does discourse affect strategic shifts in digital infrastructures?	The role of discourse in strategic shifts of digital infrastructures is investigated. By using a critical realist approach, discursive formations are framed as a mechanism that needs other mechanisms to change the infrastructure. Three other mechanisms, connection, transformation and scaling, that explains strategic shifts given particular contextual conditions are outlined.	The study investigates the role of discourse in strategic shifts in digital infrastructures. In the literature on information infrastructures or digital infrastructures, the role of discourse has not been explicitly investigated. In the field of information systems, the discourse has earlier not been investigated as a causal force.
What characterizes a technological solution that is suitable for supporting strategic shifts within eHealth?	The role of lightweight IT in changing the digital infrastructure is investigated, and particularly what characteristics lightweight IT holds that makes this change possible. • Process innovation knowledge regime • Facilitates deeper insight into performance • Loosely coupled architecture enables distributed governance	Add to the literature on digital innovation in digital infrastructure by providing a process innovation view. By establishing a layer of lightweight IT above heavyweight IT, and reconfiguring the role of heavyweight IT, an organizations informating ability is improved. The modular structure of lightweight IT makes change and innovation easier and faster.

Table 9: Contributions

7.2 Limitations

The first contribution is experimental in at least two ways. First, it aims to disentangle discourse from infrastructure and theorize their relation differently from what have been done in earlier II literature. Second, its relatively novel use of Foucault framed within the methodological field of critical realism might challenge the general understanding of how Foucault might be used within the field of IS. On a more concrete level, the CMO configurations are not exhaustive and that there might be others.

The mechanisms and the configurations identified in this thesis have been exposed to internal validation, but less assessed with other cases (see section 4.4 for internal and external validation). In addition, the approach is not configured to address all types of discourse, but mainly the discourse on technology. That being said, also actors within the wider sphere (media, interest groups, professionals), participates in framing and pushing the discourse in certain directions.

There are also limitations related to the second research question. Process innovation is particularly occupied with horizontal logistics, or "business processes". The complexity may hence be lower than in cases that also address complex clinical challenges. In the case of health this relates to the horizontal process moving the patient from admission at the emergency unit or health wards (refereed by primary care or arrived with ambulatory vehicles like ambulance or helicopter), throughout the health wards until discharged. Although important, as hospitals struggles with both external (between health units) and internal (between units) interaction, this study have not inspected more complex processes like emergency operations, planned operations and other clinical processes.

The second research question is answered by using the empirical insight gained from emergency unit coordinators, ward coordinators, and ward managers, in addition to project managers, team managers and other logistics personnel. This means that clinical actors' view and difficulties related to logistics are less inspected and patients point of view (from home care/primary sector care, through hospital wards and home again) have not been investigated explicitly.

7.3 Further research

Finally, i will briefly suggest further research. Foucault's archaeological framework can be extended and used as a concrete and distinct tool for discourse analyses. It can both be used to identify the role of

discourse in recent historical events (as we did in Paper 2, Øvrelid et al 2017), but also in more contemporary case studies as demonstrated in this thesis.

Further, in this thesis it is shown that lightweight IT, or/and a specific configuration of lightweight and heavyweight IT, is particularly suitable to improve horizontal processes, to enable a better informating ability, and to lay the foundation for faster innovation. This could be further applied to clinical processes and clinical logistics like operational planning, while maintaining the overarching focus on improving horizontal performance.

Another investigation that could be done regards the role of outsourcing of the technical infrastructure. Does outsourcing, which means that services and/or technology to provide these services are more or less in its entirety outsourced to an external supplier, make it more difficult to establish a configuration of lightweight IT and heavyweight IT?

In addition, what implications does the necessity of enabling both fast and slow implementation of IT systems have on the software engineering methodologies? How can classic software engineering approaches and more agile software development methods be aligned in order to address interaction between lightweight IT and heavyweight IT?

8 REFERENCES

Aanestad, M., Grisot, M., Hanseth, O. and Vassilakopoulou, P. (2017) *Information Infrastructures and the Challenge of the Installed Base*. Springer.

Aanestad, M. and Jensen, T., B. (2011) "Building nation-wide information infrastructures in healthcare through modular implementation strategies," Journal of Strategic Information Systems, 161-176

Aanestad, M., Hanseth, O. (2000) "Implementing Open Network Technologies in Complex Work Practices: A Case from Telemedicine," in Organizational and Social Perspectives on Information Technology, R. Baskerville, J. Stage, and J. I. DeGross (eds.), Kluwer Academic Publishers, Boston, 2000, pp. 355-369

Abbate, J. (2000) *Inventing the Internet*, MIT Press.

Agarwal, R., Gao, G., Des Roches, C., Jha., A., K. (2010) "Research Commentary—The Digital Transformation of Healthcare: Current Status and the Road Ahead," Information Systems Research 21(4):796-809

Alvesson, M., Karreman, D. (2000) "Varieties of discourse: On the study of organizations through discourse analysis", Human Relations Vol 53 (9), pp 1125-1149.

Anderson, G. F., Frogner, B. K., Reinhardt, U. E. (2007) "Health spending in OECD countries in 2004 an update", Health Aff. 26(5), 1481–1489, 2007

Archer, M. (1995) *Realist Social Theory: the Morphogenetic Approach*, Cambridge University Press.

Ash, J., S., Berg, M., Coiera E. (2004) "Some Unintended Consequences of Information Technology in Health Care: The Nature of Patient Care Information Systems-related Errors". *J Am Med Inform Assoc*.11:104-123

Bannister, F. (2001) "Dismantling the silos: extracting new value from IT investments in public administration". Information Systems Journal 11(**1**):65-84.

Barad, K. (2007) *Meeting the universe halfway: Quantum physics and the entanglement of matter and meaning.* Durham: Duke University Press

Baskerville, R. L., Myers. M. D. (2009) "Fashion waves in Information Systems Research and Practice," MIS Quarterly, Vol 33, No 4, pp. 647-662.

Berg M. (1999) "Patient care information systems and health care work: A socio-technical approach". International Journal of Medical Informatics 55, 87-101.

Best, A., Greenhalgh, T., Lewis, S., Saul, J. E., Carroll, S., Bitz, J. (2012) "Large-scale transformation in health care: A realist view," The Milbank Quarterly, 90 (3), 421–456.

Bhaskar, R.A. (1998) "General introduction," in M. S. Archer, R. Bhaskar, A. Collier, T. Lawson, and Norrie, eds., *Critical realism: essential readings*. London: Routledge, pp. ix-xxiv.

Bhaskar, R.A. (1998B) "Philosophy and scientific realism," in M. S. Archer, R. Bhaskar, A. Collier, T. Lawson, and Norrie, eds., *Critical realism: essential readings*. London: Routledge, pp. 16-47.

Bhaskar, R.A., Lawson, T. (1998) "Introduction," in M. S. Archer, R. Bhaskar, A. Collier, T. Lawson, and Norrie, eds., *Critical realism: essential readings*. London: Routledge, pp. 3-16

Bissett, A. (2002) "Surgical Strikes: Ideological Weaponry," In: Alvarez, Isabel et al. (eds.) (2002): *The Transformation of Organisations in the Information Age: Social and Ethical Implications*. Proceedings of the sixth ETHICOMP Conference, 13 - 15 November 2002, Lisbon, Portugal. Lisbon: Universidade Lusiada: 747 - 756

Boland, R., Lyytinen, K., Yoo, Y. (2017) "Wakes of innovation in Project Networks", Organization Science, 18(4), p. 631-647

Bouwman, H.; van Houtum, H.; Janssen, M; and Versteeg, G. (2011) "Business Architectures in the Public Sector: Experiences from Practice," Communications of the Association for Information Systems: Vol. 29, Article 23.

Braa, J., Hanseth, O., Heywood, A., Mohammed, W., Shaw, V. (2007) "Developing Health Information Systems in Developing Countries: The Flexible Standards Strategy," *MIS Quarterly* (31:2), pp. 381-402.

Bygstad, B. (2016) "Generative innovation: a comparison of lightweight and heavyweight IT," Journal of Information Technology, 24. May 2016, pp 1-14.

Bygstad, B. (2015) "The Coming of Lightweight IT," ECIS 2015. ISBN 978-3-00-050284-2 http://aisel.aisnet.org/ecis2015_cr/22

Bygstad, B. Hanseth, O. (2018) "Transforming Digital infrastructures through Platformization", Twenty-Sixth European Conference on Information Systems (ECIS 2018), Portsmouth, UK, 2018

Bygstad, B., Munkvold, B., E., Volkoff, O. (2016) "Identifying Generative Mechanisms through affordances: A framework for critical realist data analysis," Journal of Information Technology, Vol. 31, p. 83-96

Bygstad, B, Iden, J. (2017) "A Governance Model for Managing Lightweight IT", World Conference on Information Systems and Technologies, Recent Advances in Information Systems and Technologies pp 384-393

Bygstad, B. (2008) "Information Infrastructure as Organization: A Critical Realist View," Twenty Ninth International Conference on Information Systems, Paris 2008

Böhl, D., Hoffmann, D. and Ahlemann, F. (2016) "The structural anchoring of IS/IT innovation management: Toward an Organizational design theory," *Twenty-Fourth European Conference on Information Systems* (ECIS), İstanbul,Turkey, 2016

Callon, M. (1986) "Some elements of a sociology of translation: domestication of the scallops and the fishermen of St Brieuc Bay. In: Law, J. (ed.) Power, Action and Belief: A New Sociology of Knowledge, pp. 196–233. Routledge & Kegan Paul, London (1986)

Cash, J. I., Earl, M. J., Morison, R. (2008). "Teaming Up to Crack Innovation and Enterprise Integration," *Harvard Business Review*, 86(11), 90–100.

Ciborra, et al. (2000) *From control to drift – The Dynamics of Corporate Information Infrastructures.* Oxford: Oxford University Press

Ciborra, C., Hanseth, O. (1998) "From tool to Gestell: Agendas for managing the information Infrastructure", Information Technology & People, Vol. 11 Issue: 4, pp.305-327,

Ciborra, C. (2002) *The labyrinths of information: Challenging the wisdom of systems*, Oxford University Press

Ciborra, C. (2005) "Interpreting e-government and development: Efficiency, transparency or governance at a distance?" Information Technology & People, Vol 18, Issue 3, pp 260-279

Constantinidis, P. (2013) "The communicative constitution of IT innovation," *Information and organization* 23 (2013) 215-232

Christensen, C., Grossman, J., Hwang, J. (2009) *The innovator's prescription – A disruptive solution for Health Care,* McGraw Hill

Danermark, B., Ekstrom, M., Jakobsen, L. and Karlsson, J.C. (2002). *Explaining Society. Critical Realism in the Social Sciences*, London: Routledge.

Davenport, T. (1993) *Process Innovation*. Cambridge, MA: Harvard Business School Press

Davidson, A., I. (1986) "Archaeology, Genealogy, Ethics" in Hoy, D., C. (ed) "Foucault: A critical reader" Blackwell, p 221-233

Devaraj, S., Ow, T. T., Kohli, R. (2013) "Examining the Impact of Information Technology and Patient Flow on Healthcare Performance: A Theory of Swift and Even Flow (TSEF) Perspective." *Journal of Operations Management* 31, no. 4 (May 2013): 181–92. doi:10.1016/j.jom.2013.03.001.

De Vries, J., Huijsman, R. (2011) "Supply chain management in health services: an overview", *Supply* Chain Management: An International Journal, Vol. 16 Iss: 3, pp.159 – 165.

Dobrzykowski, D. D. (2012) "Examining Heterogeneous Patterns of Electronic Health Records Use: A Contingency Perspective and Assessment", International Journal of Healthcare Info Systems and Informatics, 7(2), 2012

Doolin, B., Grant, D., Thomas, R. (2013) "Translating translation and change: Discourse-based approaches," Journal of Change Management 13(3): 251-265.

Edenius M. (2002) "Discourse on E-Mail in Use," IFIP TC8/WG8.2 Working Conference on Global and Organizational Discourse about Information Technology December 12-14, 2002, Barcelona, Spain

Edwards, P. N., Jackson, S. J., Bowker, G. C., and Williams, R. (2009). Introduction: An Agenda for Infrastructure Studies, *Journal of the Association for Information Systems* (10:5), pp. 364-374.

Elder-Vass, D. (2015) "Disassembling Actor-network Theory," Philosophy of the Social Sciences, Vol 45 (1), pp 100-121.

Elder-Vass, D. (2010) "The causal power of discourse," Journal for the Theory of Social Behaviour 41:2. 0021-8308 p 143-160.

Eliassen, K., O. (2016) *Foucaults begreper*, Scandinavian Academic Press, Oslo 2016

Ellingsen, G., Monteiro E. (2008) "The organizing vision of integrated health information systems," Health Informatics Journal, vol 14, No 3, 223-236

Ellingsen, G., Monteiro, G. (2005) "Slight surprise of integration", In Carsten Sørensen (ed), *Designing ubiquitous information environments: socio-technical issues and challenges*. Springer Publishing Company. ISBN 0387275606. 20. p. 261 – 274

El Sawy, O. A., Malhotra, A., Park, Y., Pavlou, P.A. (2010) "Seeking the Configurations of Digital Ecodynamics: It Takes Three to Tango," Information Systems Research (21:4), pp. 835-848.

Fairclough, N. (2005) "Discourse analysis in organization studies: The case for critical realism", Organization studies 26(6), p 915-939

Fairclough, N. (2003) "Political correctness: The politics of culture and language", Discourse and Society, Vol 14, issue 1, 2003

Faulkner, P., Runde, J. (2012) "On sociomateriality" In P. Leornardi, B. Nardi, & J. Kallinikos (Eds.), *Materiality and organizing* (pp. 49–66). Oxford: Oxford University Press.

Fichman, R. G., Dos Santos, B. L., Zheng, Z. (2014) "Digital innovation as a fundamental and powerful concept in the information systems curriculum," MIS Quarterly, Vol 38, No.2 pp 329-353.

FIGI (2014) "From IT Silos to Generative Infrastructures", short description available from http://www.mn.uio.no/ifi/forskning/prosjekter/figi/ Accessed 21. February 2018

Foucault, M. (1972) *The archaeology of Knowledge* Routledge Classics London and New York

Foucault, M. (1981) "The order of discourse," in *Untying the Text: A Post-Structuralist Reader*, Young R., (ed), Routledge & Kegan and Henley, 1981.

France, D. J., Levin, S., Hemphill, R., Chen, K., Rikard, D., Rickard, D, Makowski, R., Jones, I, Aronsky, D. (2005) "Emergency physicians' behaviors and workload in the presence of an electronic whiteboard", International Journal of Medical Informatics 74, 827—837, 2005

Gal, U., Lyytinen, K., Yoo, Y. (2008) "The dynamics of IT boundary objects, information infrastructures, and organisational identities: the introduction of 3D modelling technologies into the

architecture, engineering, and construction industry." European Journal of Information Systems 17 (3), 290–304.

Gamma, E., Helm, R., Johnson, R., Vlissides, J. (1995) *Design Patterns: Elements of reusable object-oriented software,* Reading, MA: Addison-Wesley, Reading.

Garud, R., Kumaraswamy, A., Karnøe, P. (2009) "Path Dependence or Path Creation?" *Journal of Management Studies,* Volume 47, Issue 4, pp 760-774.

Garud, R., Kumaraswamy, A. (2005) "Vicious and virtuous circles in the management of knowledge: The case of Infosys Technologies." *MIS Quarterly* 29 (1), 9-33.

Garud, R., Karnøe, P. (2001) "Path Creation as a Process of Mindful Deviation," in Garud, Raghu Karnøe, Peter (ed.). *Path Dependence and Creation*. Mahwah, N.J.: Lawrence Erlbaum Associates, Incorporated. 2001. 1-40.

George, A. L., Bennett, A. (2005) *Case Studies and Theory Development in the Social Sciences*, Cambridge, MA: MIT Press.

Gidlund, K. (2015) "Three Governments Living Happily Ever After: Discursive Tensions and Conflicting Epistemic Cultures in the Development of Public E-Services," *International Journal of Electronic Government Research*, 11 (3), 43-56, July-September 2015

Greenhalq, T., Wherton, J., Papoutsi., C., Lynch., J., Hughes., G., A'Court., C., Hinder., S., Fahy., N., Proctor, R., Shaw., S. (2017) "Beyond adoption: A new Framework for Theorizing and Evaluating Nonadoption, Abandonment, and Challenges to the scale-up, Spread and Sustainability of health and Care Technologies," Journal of Medical Internet research, vol., 19 (11), p 1-21.

Greenhalgh, T. Stramer K, Bratan T, Byrne E, Russell J, Hinder S., Potts, H. (2010) "The Devil's in the Detail: Final report of the independent evaluation of the Summary Care Record and HealthSpace programmes." London: University College London; 2010.

Grisot, M., Hanseth, O., Thorseng, A. (2014) "Innovation Of, In, On Infrastructures: Articulating the role of architecture In Information Infrastructure," Journal of the Association of Information Systems, volume 15, 197-219

Gutting, G (1989) "Michel Foucault's archaeology of scientific reason: Science and the history of reason," Cambridge University Press.

Gutting, G. (2013) "Michel Foucault," available from https://plato.stanford.edu/entries/foucault/#4.3 Accessed 27/2/2018

Hacking, I. (1986) "The Archaeology of Foucault" in Hoy, D., C. (ed) "Foucault: A critical reader" Blackwell, p 27-40

Hall, S., Gieben, B. (1992) *Formations of modernity*, Blackwell, Cambridge 1992

Hammer, M. (1990). "Reengineering work: don't automate, Obliterate," Harvard Business Review.

Hammer, M., Champy, J. (1993). *Reengineering the corporations*, Harper NYC.

Hanseth, O., Lyytinen, K. (2010). "Design theory for dynamic complexity in information infrastructures: the case of building internet," Journal of Information Technology, 25(1), pp.1-19.

Hanseth, O. (2002) "From systems and tools to networks and infrastructures. Toward a theory of ICT solutions and its design methodology implications," http://heim.ifi.uio.no/~oleha/Publications/ib_ISR_3rd_resubm2.html

Hanseth, O., Aanestad, M. (2003) "Design as Bootstrapping: On the Evolution of ICT Networks in Health Care," *Methods of Information in Medicine* (42), pp. 385-391.

Hanseth, O., Ciborra, C. U. (2007). *Risk, complexity and ICT*. Edward Elgar Publishing.

Hanseth, O., Monteiro, E. (1997) "Inscribing Behaviour in Information Infrastructure Standards," Accounting, Management & Information Technology (7:4), pp. 183-211.

Hardy, N. (2010) “Foucault, Genealogy, Emergence: Re-examining the extra-discursive,” Journal for the theory of social behaviour, p 68-90.

Helsedirektoratet (2016) https://helsedirektoratet.no/samhandlingsreformen

Henfridsson, O., Nandhakumar, J., Scarbrough, H., Panourgias, N. (2018) “Recombination in the open-ended value landscape of digital innovation,” Information and Organization 28(2018), 89-100

Henfridsson, O., Yoo, Y., Svahn, F. (2009) “Path creation in digital innovation: A multi-layered dialectics perspective,” Sprouts Working papers.

Henfridsson, O., Mathiassen, L., Svahn, F. (2014) “Managing technological change in the digital age: the role of Architectural frames,” Journal of Information Technology, (2014), 29, 27-43.

Henfridsson, O., Bygstad, B. (2013) “The Generative Mechanisms of Digital Infrastructure Evolution,” Management Information Systems Quarterly, 37(3), s 907- 931

Henfridsson, O., Yoo, Y. (2014) “The Liminality of Trajectory Shifts in Institutional Entrepreneurship,” Organization Science (25:3), pp. 932-950.

Henningsson, S., Hanseth, O. (2011) “The Essential Dynamics of Information Infrastructures” (2011). ICIS 2011 Proceedings. 14. https://aisel.aisnet.org/icis2011/proceedings/projmanagement/14

Hertzum, M., Simonsen, J. (2013) “Work-practice changes associated with an electronic emergency department whiteboard,” Health Informatics Journal, 19, 46-60, 2013

Huang, J., Henfridsson, O., Liu, M. J., Newell, S. (2017) “Growing on Steroids: Rapidly scaling the user base of digital ventures through digital innovation,” MIS Quarterly Vol. 41 No. 1, pp. 301-314

Iden, J. (2013) *Prosessledelse*, Fagbokforlaget Vigmostad & Bjørke, (2013)

Jarvenpaa, S., Ives., B (1991) “Executive involvement and participation in the Management of Information Technology”, MISQ Vol. 15, No 2, pp 205-227.

Kallinikos, J. (2004) “Farewell to constructivism: technology and context-embedded action” In: Avgerou, Chrisanthi and Ciborra, Claudio and Land, Frank, (eds.) *The Social Study of Information and Communication Technology: Innovation, Actors and Contexts*. Oxford University Press, Oxford, 140-161. ISBN 0199253560

Klecun, E. (2016) “Transforming healthcare: policy discourses of IT and patient-centred care,” European Journal of Information Systems, 25, pp 64-76.

Klein, S., Schellhammer, S. (2017) “Medication Infrastructure Development in Germany,” in Aanestad et al *Information Infrastructures within European Health Care*, Springer 2017, p 151-170.

Kelly, C., Young, A. (2017) “Promoting innovation in Healthcare”, Future Healthcare Journal Vol 4, 121-5, 2017

Lacouture, A., Breton, E., Guichard, A., Ridde, V. (2015) “The concept of mechanism from a realist approach: a scoping review to facilitate its operationalization in public health program evaluation,” Implementation Science, 10: 153, 2015, 1-10.

Larman, C. (2004) “Applying UML and Patterns: An Introduction to Object-Oriented Analysis and Design and Iterative Development,” Third Edition Addison Wesley Professional (2004)

Lakatos, I. (1970) “Falsification and the Methodology of Scientific Research Programmes,” in Lakatos, I., Musgrave, A. (eds) *Criticism and the growth of knowledge*, pp 91-196, Cambridge University Press 1970.

Lakatos, I. (1978) “Introduction,” in Lakatos I., Worral, J., and Currie, G. (eds) *The methodology of Scientific research programmes, Philosophical Papers vol. 1*, Cambridge University Press,1978 p.1-8.

Latour, B., Woolgar, S. (1986) *Laboratory Life: The Construction of Scientific Facts*, Princeton University Press, Princeton

Latour, B. (1993) *We have never been modern*, Harvard University Press.

Lee, C., Schmidt, K. (2018) "A bridge too far? - Critical remarks on the concept of "infrastructure" in CSCW and IS", inV. Wulf, et al. (eds): Socio-Informatics: A Practice-based Perspective on the Design and Use of IT Artifacts. Oxford: Oxford University Press, pp. 177-217.

Lopez, J. (2001) "Metaphors of social complexity," in J. Lopez *and G. Potter (eds),* After Postmodernism*:* An Introduction to Critical Realism*.* New York*:* Athlone Press, pp 86-93

Lyytinen, K., Newman, M. (2008) "Explaining Information Systems Change: A Punctuated Socio-Technical Change Model," European Journal of Information Systems (17:6), pp. 589-613.

Melao, N., Pidd, M. (2000) "A conceptual framework for understanding business processes and business modelling," Information Systems Journal 10(2), 105-129, 2000

Mingers, J. (2014) "Systems Thinking, Critical Realism and Philosophy: A Confluence of Ideas," Routledge 2014.

Mingers, J., Mutch, A.,Willcocks, L. (2013) "Critical Realism in Information Systems Research," *MIS Quarterly* 37(3): 795–802.

Mingers, J. (2004) "Re-Establishing the Real: Critical Realism and Information Systems Research," in *Social Theory and Philosophy for Information Systems,* J. Mingers and L. Willcocks (eds.), Chichester, UK: Wiley, pp. 372-406.

Mintzberg, H. (1993) *Structure in Fives: Designing Effective Organizations*. Prentice-Hall, Inc.

Monteiro, E., Pollock, N., Hanseth, O., Williams, R. (2013) "From artefacts to infrastructures," Computer Supported Cooperative Work, Vol 22, Issue 4-6, pp 575-607, August 2013

Monteiro, E. (2000) "Actor-Network Theory and Information Infrastructures" in Ciborra et al (2000) *From Control to Drift – The Dynamics of Corporate Information Infrastructures*, Oxford: Oxford University Press pp. 71-87

Monteiro, E. (1998) "Scaling Information Infrastructure: The Case of Next-Generation IP in the Internet," The Information Society, 14:3, 229-245.

Monteiro, E., Hanseth, O. (1995) "Social shaping of information infrastructure: on being specific about the technology." In: Orlikowski, W.J., Walsham, G., Jones, M.R., DeGross, J.I. (eds.) Information Technology and Changes in Organizational Work, pp. 325–343. Chapman & Hall, Boca Raton (1995)

Mutch, A (2013) "Sociomateriality – taking the wrong turning?" Information and organization 23 (2013) 28-40

Nambisan, S., Lyytinen, K., Majchrzak, A., Song, M. (2017) "Digital innovation management: Reinventing innovation management research in a digital world", MIS Quarterly Vol. 41 No. 1, pp. 223-238/March 2017

Norwegian Ministry of Health, Preposition 125. 2015
https://www.regjeringen.no/contentassets/b218612046c84ad89bec57fa537ea57f/nn-no/pdfs/prp201420150125000dddpdfs.pdf
Accessed 1. March 2018

Norwegian Directorate of Health (2017), available from
https://ehelse.no/Documents/Nasjonal%20ehelsestrategi%20og%20handlingsplan/Nasjonal%20handlingsplan%20for%20e-helse%202017-2022%20%28PDF%29.pdf
Accessed 8. March 2018

Nielsen, P., Aanestad, M. (2006) "Control Devolution as Information Infrastructure Design Strategy: A Case Study of a Content Service Platform for Mobile Phones in Norway," Journal of Information Technology (21), pp. 185-194

Nyberg, D. (2009) "Computers, customer service operatives and cyborgs: Intra-actions in call centres," Organization Studies, 30(11), 1181–1199.

Overby, E., Bharadwaj, A., Sambamurthy, V. (2006) "Enterprise Agility and the Enabling Role of Information Technology," European Journal of Information Systems (15), pp. 120-131

Parker, G., Van Alstyne, M., Choudary, S. P. (2016) *Platform Revolution: How networked firms are transforming the economy and how to make them work for you*, New York: W. W. Norton & Company

Parker, G., Van Alstyne, M., Jiang, X. (2017) "Platform ecosystems: How developers invert the firm", MIS Quarterly Vol. 41 No. 1, pp. 255-266/March 2017

Parnas, D.L. (1972) "On the Criteria to be Used in Decomposing Systems into Modules," Communications of the ACM 15(12), 1053-1058. (1972)

Pawson, R., Tilley, N. (1997) *Realistic Evaluation*, London: Sage Publications.

Peppard, J., Ward, J. (2016) *The Strategic Management of Information Systems, Building a Digital Strategy*, 4th Edition, John Wiley & sons Ltd

Pearce, F., Woodiwiss, A. (2001) "Reading Foucault as a Realist." In Realism after *Postmodernism*: An Introduction to Critical *Realism*, ed. J. Lopez and G. Potter, 51-62. *New York*: *Athlone Press*. Purvis, *T*., and A. Hunt.

Piening, E. P. (2011) "Insights into the process dynamics of innovation implementation", Public Management Review, vol 13, issue 1, p 127-157, 2011

Potter, G., Lopez, J. (2001) "After postmodernism*:* The new millennium", in J. Lopez *and G. Potter (eds),* After Postmodernism*:* An Introduction to Critical Realism*.* New York*:* Athlone Press

Rotter T., Kinsman L., James E.L., Machotta A., Gothe H., Willis J., Snow P., Kugler J. (2010). "Clinical pathways: effects on professional practice, patient outcomes, length of stay and hospital costs (Review)". *Cochrane Database of Systematic Reviews.*

Salazar, A., Ortiga, B., Escarrabill, J., Corbella, X. (2004) "Emergency department complaints: A 12 year study in a University hospital." *Annals of Emergency Medicine*, 44 (4).

Sauer, C., Willcocks, L.P. (2007) "Unreasonable expectations – NHS IT, Greek choruses and the games Institutions play around mega-programmes". *Journal of Information Technology*, 2007. 22: p. 195-201.

Sayer, A. (1992) *Method in Social Science. A Realist Approach*, New York: Routledge.

Schaanning, E. (2000) *Fortiden i våre hender: Foucault som vitenshåndtør. Bind 1: Teoretisk praksis*, Unipub Forlag.

Schaanning, E. (2000B) *Fortiden i våre hender: Foucault som vitenshåndtør. Bind 2: Historisk praksis*, Unipub Forlag.

Scott, S., Orlikowski, W. (2013) "Entanglements in practice: Performing Anonymity through Social Media," *MIS Quarterly* Vol. 38, No. 3, pp 873-893

Sia, Soh Weill (2016) "How DBS Bank Pursued a Digital Business Strategy." *MISQ Exective*, 15(2):105-121.

Snow, C., P. (2001) [1959] *The Two Cultures*. London: Cambridge University Press

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

Stahl, B. C. (2004) "Whose discourse? A comparison of the Foucauldian and Habermasian concepts of discourse in critical IS research," In Proceedings of the Tenth Americas Conference on Information Systems, New York, 06 to 08 August 2004, 4329 - 4336

Smith, S., Johnston, R., B. (2014) "How critical realism clarifies validity issues in information systems theory Theory-Testing Research," Scandinavian Journal of Information Systems Vol 26(1), p 5-28.

Svahn, F., Mathiassen, L., Lindgren, R. (2017) "Embracing digital innovation in incumbent firms: How Volvo cars managed competing concerns", MIS Quarterly Vol. 41 No. 1, pp. 239-253/March 2017

Swanson, E. B. (2002) "Talking the IS Innovation Walk," IFIP TC8/WG8.2 Working Conference on Global and Organizational Discourse about Information Technology December 12-14, 2002, Barcelona, Spain

Swanson, E., Ramiller, N. C. (1997) "The organizing vision in Information systems innovation," Organization Science Vol 8, no 5, pp. 458-474

Sørensen, C. (2013) "Digital Platform and Infrastructure Innovation", In Mobile Strategy Challenges (In Japanese), ed. H. Higashikuni. Tokyo: Nikkan Kogyo Shimbun Ltd.

Tilson, D., Lyytinen, K., Sorensen, C. (2010) "Digital Infrastructures: The Missing IS Research Agenda," Information Systems Research (21:4), pp. 748-759.

Tiwana, A. (2013) *Platform Ecosystems: Aligning Architecture, Governance, and Strategy*, Morgan Kaufmann, Waltham, MA.

Utaker, A. (2009) "Foucault og Kant," AGORA NR. 2–3, 09 pp. 81-103

Van Lent, W.A.M., Sanders, E.M., Van Harten, W.H. (2012) "Exploring improvements in patient logistics in Dutch hospitals with a survey." BMC Health Services Research, 12, 232–240.

Yoo, Y., Henfridsson, O., Lyytinen, K. (2010) "The New Organizing Logic of Digital Innovation: An Agenda for Information Systems Research," Information Systems Research (21:4), pp. 724-735.

Yoo, Y., Boland, R. J., Lyytinen, K., Majchrzak, A. (2012) "Organizing for innovation in the Digitized World», Organization Science, Vol 23, No 5, pp 1398-1408

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

Wastell D. G. (2002) "Organizational Discourse as a Social Defense: Taming the Tiger of Electronic Government," IFIP TC8/WG8.2 Working Conference on Global and Organizational Discourse about Information Technology December 12-14, 2002, Barcelona, Spain

Willcocks, L. (2004) "Foucault, Power/Knowledge and Information Systems: Reconstructing the present," in Mingers, J., Willcocks, L., P. (eds) *Social theory and Philosophy for Information Systems*, Wiley Series in Information Systems

Willcocks, L. (2006) "Michel Foucault in the Social Study of ICTs: Critique and Reappraisal," Social Science Computer Review (24:3), 2006, pp. 274-295

Wynn, D., Williams, C. K. (2012) "Principles for Conducting Critical Realist Case Study Research in Information Systems," *MIS Quarterly* (36:3), pp. 787-810.

Zuboff, S. (1988) *In the Age of the Smart Machine*, Basic Books, New York.

Østerberg, D. (1988) "Metasociology: An inquiry into the Origins and Validity of Social Thought," Norwegian University Press, Oslo.

Øvrelid, E., Bygstad, B., Hanseth, O. (2017) Discursive formations and shifting strategies in e-health programmes*, Twenty-Fifth European Conference on Information Systems (ECIS), Guimarães, Portugal, 2017*

Øvrelid, E., Bygstad, B. (2016) "Exploring loose coupling in system interaction," Issue Nr 7 (2016). 5. http://aisel.aisnet.org/iris2016/5

APPENDIX A

RESEARCH PAPERS

Nr.	Title	Published at
1	Øvrelid, E., Bygstad, B. (2016) "Extending e-Health Infrastructures with Lightweight IT"	Scandinavian Conference on Information Systems SCIS 2016: Nordic Contributions in IS Research pp 43-56
2	Øvrelid, E., Bygstad, B., Hanseth, O. (2017) "Discursive formations and shifting strategies in e-Health programmes"	Proceedings of the 25th European Conference on Information Systems (ECIS), Guimarães, Portugal, June 5-10, 2017 (pp. 873-886).
3	Bygstad, B., Hanseth, O., Siebenherz, A., Øvrelid, E. (2017) "Process innovation meets digital infrastructure in a high-tech hospital."	Proceedings of the 25th European Conference on Information Systems (ECIS), Guimarães, Portugal, June 5-10, 2017 (pp. 801-814).
4	Øvrelid, E., Halvorsen, M., (2018) "Process innovation with lightweight IT at an emergency unit"	Proceedings of the 51st Hawaiian Conference on System Sciences (HICSS 2018)
5	Øvrelid, E., Sanner, T., Siebenherz, A., (2018) "Creating Coordinative Paths from admission to discharge: The role of lightweight IT in hospital digital process innovation"	Proceedings of the 51st Hawaiian Conference on System Sciences (HICSS 2018)
6	Øvrelid, E., Bygstad, B. (2017) "Strategic shifts in Digital Infrastructures - The role of Discursive Formations"	In review in International Journal (submitted 2. November 2017)

Extending e-Health Infrastructures with Lightweight IT

Egil Øvrelid(✉) and Bendik Bygstad

Department of Informatics, University of Oslo,
Gaustadalléen 23 B, Oslo, Norway
{egilov, bendikby}@ifi.uio.no

Abstract. Our interest in this paper is to understand the interplay between large technological programs and smaller innovation projects, i.e. how a small project may enter and change the larger structure. In our e-health context we conceptualise this as the interplay between heavyweight and lightweight IT. Our research questions are, how does an innovation initiative develop within an established information infrastructure, and how can we overcome the barriers for interplay between heavyweight and lightweight technologies? Our empirical evidence is a case study in the health care sector in Norway, where we investigated a mega-program called Digital Renewal, and a small lightweight initiative called Medicloud. The theoretical lens was actor-network theory and we offer two insights. First, we identify a set of barriers for fruitful interplay between heavyweight and lightweight IT. Second, we show that these barriers may be overcome by a careful combination of technical and organisational solutions, in order to stabilise a new network as a part of the larger information infrastructure.

Keywords: Heavyweight and lightweight IT · Information infrastructures · eHealth innovation

1 Introduction

Our interest in this paper is to understand the interplay between large technological programs and smaller innovation projects, and how it develops over time.

Public sector IT mega-programs with political and societal prestige are usually a response to perceived problems, such as poor services or high costs. Much attention is given to the coordination and control of these programs, because they are high-risk initiatives. In spite of several spectacular failures [1–3] many programs are relatively successful in building large information infrastructures. When successful, they tend to gain momentum, focus on consolidation and become irreversible just by size. Over time this often becomes a barrier to innovation, because (i) large-scale programs do not satisfy all user and organisational needs and (ii) new technologies continuously challenge the established thinking of the programs.

What does it take to change the trajectory of large programs? In his work on scientific programs and paradigms, Lakatos [4] argued that programs tend to continue in spite of experienced problems, as long as there are no clear alternatives present. Such

M. Gellerstedt et al. (Eds.): SCIS 2016, LNBIP 259, pp. 43–56, 2016.
DOI: 10.1007/978-3-319-43597-8_4

alternatives, in our context, usually emerge through a public discourse on information technologies, where a new *organizing vision* [5, 6] is presented.

In this research we investigate the relationship between a large e-health program and a small innovation initiative. The health sector is currently the target of large expectations to the contribution of IT solutions for better health care, and mega-programs are in work in most rich (and many poor) countries. Most of them include complex integration of various systems, and focus heavily on security and privacy.

In parallel, we have witnessed the arrival of new technologies, such as Internet-of-Things, and new ways of use, such as *consumerisation* and *bring-your-own-device* [7]. This development challenges the dominant knowledge regime of mega-programs in two ways; first, it allows professional users, together with vendors, to develop and implement IT solutions for special clinical needs, bypassing the programs and IT departments. Second, it has opened a new discourse on the relationship between *heavyweight* and *lightweight IT* [8, 9]. Heavyweight IT is defined as the established paradigm of software engineering, while lightweight IT is conceived a socio-technical knowledge regime driven by competent users' need for IT services, enabled by the consumerisation of digital technologies [8].

There are many unresolved issues regarding the interplay of lightweight and heavyweight IT. What we wish to investigate in this research is how a lightweight initiative unfolds and interacts with the mega-program and the established information infrastructure. The interplay between lightweight technologies and Enterprise IT, have some significant challenges [7, 9]. The extended digitalisation of organisational life gives what Tilson et al. [10] calls new paradoxical regimes of control that goes beyond the idea of hierarchical control [10]. This gives challenges theoretically as well as for IT governance and affects all levels of analysis [10]. Our research questions are:

- How does an innovation initiative develop within an established information infrastructure?
- How can we overcome the barriers for interplay between heavyweight and lightweight technologies?

We proceed by discussing heavyweight and lightweight IT, within the field of information infrastructures. To develop our argument we build on Actor-Network Theory to analyse two cases, one light- and one heavyweight initiative. The differences are highlighted during the negotiations; barriers against interplay arise and give new challenges to the participants and their respective organisations.

2 Related Research

2.1 Heavyweight and Lightweight IT

Developments of infrastructures in the health sector are often part of large programs, large-scale IT systems delivered by big and experienced vendors with complex and sophisticated organisation. These systems, usually IT silos of legacy systems, are often a major hindrance to organisational change and innovation [11]. The complexity of these systems increases as the number of interconnected links increases, making the

Table 1. Heavyweight and lightweight IT [8].

	Heavyweight IT	Lightweight IT
Profile	Back-end: supporting documentation of work	Front-end: supporting work processes
Systems	Transaction systems	Process support, apps, BI
Technology	Servers, databases, enterprise bus technology	Tablets, electronic whiteboards, mobile phones
IT architecture	Centralised or distributed	Meshworks
Owner	IT department	Users and vendors
Development culture	Systematics, quality, security	Innovation, experimentation
Problems	Increasing complexity, rising costs	Isolated gadgets, security
Discourse	Software engineering	Business, practice innovation

risk for unexpected incidents higher [12]. Integrations effort may mitigate some of these problems, but are also increasing complexity and costs.

The inherent inertia of these infrastructures is currently being challenged by a new type of technological regime called lightweight IT [8]. Lightweight IT is the new paradigm of mobile apps, sensors and bring-your-own-device, also called consumerisation or Internet-of-Things. It is typically cheap and easy to use technology, it can often be deployed without IT specialists and it tends to be mobile technology.

As illustrated in Table 1 the key aspect of lightweight IT is not only the cheap and available technology as such, but the fact that its deployment is frequently done by users or vendors, bypassing the IT departments. Bygstad claims that "Lightweight IT may be seen as complementary to heavyweight; it is well suited for the tasks that heavyweight IT has often failed to support, i.e. the simple and immediate needs of a user" [8: 3].

We believe it is fruitful to see this as two different knowledge regimes: heavyweight and lightweight IT. Heavyweight IT is becoming increasingly complex and specialised, while lightweight IT emerges as a new innovation arena, allowing non-specialist to experiment with cheap technology. Lightweight IT is defined as a socio-technical knowledge regime driven by competent users' need for IT services, enabled by the consumerisation of digital technologies [8]. While heavyweight IT is challenged by increasing complexity and rising costs, lightweight IT suffers from problems with security and governance [9]. There is currently no shared discourse between the two communities, as heavyweight IT is discussed in the software engineering community, while lightweight IT is an innovation discourse.

Several researchers have looked into the challenge of dealing with the new situation. Harris et al. [7] looks at the benefits and challenges related to IT Consumerisation tools brought into the workplace. Bygstad [8] identifies the generative potentials of interplay between heavy and light, while Willcocks et al. [9] suggest how interplay between lightweight and heavyweight should be designed. We aim to extend these insights by an in-depth investigation of the interplay between the two knowledge regimes.

2.2 Information Infrastructures

Infrastructure is used as a term to conceptualise interconnected system collectives. The past 20 years have witnessed research on digital infrastructures covering different settings such as health, telecom, finance, government, and manufacturing. Hanseth and Lyytinen [15] defined an information infrastructure as "a shared, open (and unbounded), heterogeneous and evolving socio-technical system (which we call installed base) consisting of a set of IT capabilities and their users, operations and design" [15: 4]. The heterogeneous mix of people and technologies are built on the installed base [13, 14]. As the installed base grows its development and growth become self-reinforcing, through cultivation [13]. Gateways, devices for enabling communication between parts of the infrastructure, are important tools to be used in such cultivation processes.

Infrastructures as emerging sociotechnical networks with a broad growth base with a multitude of actors on several levels have a certain dynamic which also create tensions. Tensions are over time "inscribed" into the networks and have obtained a certain closure, but new tensions may continually arise, and take the form of conflict.

The managing of infrastructural development then is about "the careful nurturance of infrastructural change, and attending to the tensions that emerge from it" [16: 28]. Tensions, can be seen as both barriers and resources to infrastructural development, and should be engaged constructively. Barriers can be both cultural or institutional dependencies which prevent adoption, as well as power relations which prevent action.

Resources can be equipment or personnel, or international organisational units, as well as financial and human capital. Both of them may be seen as constructive elements in the development. They are of particular importance to obtain "long-term properties of infrastructural fit, equity, and sustainability" [16: 29]. In our analysis we build on this duality of barriers and resources.

3 Theoretical and Methodical Lens

3.1 Actor Networks and Translation

Actor-network theory is known for the tight interplay between social and technical means. Human and non-humans are linked together in networks conditioned by actors pursuing interests. The stabilisation of interests is about alignment through negotiations [17]. ANT provides a language for describing how this translation takes place on a quite specific level, and looks at the role of discourse in establishing scientific facts [18]; technological systems [19]; and how discourse is used in order to seduce and displace actors into ones program [18].

The technology-in-the-making is conditioned by socio-technical negotiation between a whole range of actors, and outlines the "open-ended character of this process – the stumbling, the compromises, the way non-technical interests get dressed up in technical disguise…" [17: 71] This is in opposition to management processes dominated by top-down, rational, decision making. The alignment is not necessarily obtained through facts, solution or beliefs alone, "order is an effect of an achievement – it is not given a priori" [17: 72].

In his path-breaking paper on the domestication of the scallops and the fishermen of St. Brieuc Bay, Callon [20] looks at the "role played by science and technology in structuring power relationships", to understand "the emergence, development, and eventual closure of controversies" in the study of science and technology [20: 197]. Callons contribution to ANT is first that he demonstrates "the abandonment of all a-priori distinctions between the natural and the social" [20: 196], that is, he describes the interplay between technical and social actors in "equal" terms. Second he describes some of the challenges in obtaining network alignment through this interplay.

Callon demonstrates the establishment of networks through four moments of translation. The first, *problematisation*, has a double significance in that someone raises a problem, which involves a whole series of actors, while they at the same time have a way of framing the problem which positions them in the centre of the debate as an obligatory passage point: "we can help you; we have a solution to the problem." They are both trying to define the network and the links between the actors in the network by framing and addressing a common problem, but at the same time concrete enough to maintain the position in the centre. In addition, the problem is often so big that it cannot be solved by one or two individuals. It is a collective challenge. This leads us to the moment of *interessement*, which is about determining the solidity of the problematisation, or to redefine it in order to strengthen and stabilise the identity of the other actors. The rhetoric here is more like: "we have the same interest as you", and is about attaching the stakeholder's directly to the centre.

The moment of *enrolment* concerns the transformation of a question into a series of statements, which are more certain. Enrolment is achieved if interessement is successful. To describe enrolment is thus to describe the group of multilateral negotiations, trials of strength and tricks. This means that enrolment could turn into a battle between alternative stakeholders and where actors which threatens to cut the link between the central actors and the other actors has to be removed. The enrolment is also depending on some of the actors waiting to accept whatever conclusion drawn by the specialists.

The moment of *mobilisation* depends on the representatives being successful in their attempts to attract the actors, "will the masses follow their representatives"? [20: 214] This moment, thus, is about demonstrating the validity of the spokesmen's observations and the devices effectivity. The "mobilisation…has a definite physical reality which is materialised through a series of displacements" [20: 217]. The credibility of the earlier work is at stake.

In *Dissidence*, the fifth moment, the representatives are questioned, discussed, negotiated, rejected, etc., which again opens the network for intruders from competitive forces.

We use Callons framework in order to (1) describe the interaction between technological regimes of heavy and light through several moments in order to identify when and how tensions arise, and (2) use the moments in order to identify actual tensions, how, when and where they occur. After we have described our data collection and analysis, we look at two cases that can shed light on our interests.

4 Method

Our approach was a case study, conducted in the Health South-East Region in Norway. It covers 2.8 million people, representing more than 50 % of the Norwegian population. It consists of 11 hospitals, and is taken care of by a workforce of 77.000 employees, working on a total budget of over 8 billion euro [21].

We investigated a large e-health program called Digital Renewal and one lightweight initiative, Medicloud, and their interaction. Digital Renewal was a mega-program of around 1 bn. Euro that aimed at standardising work processes and technologies in the Health South-East Region, running from 2013–18. Medicloud was a small initiative from within HospitalPartner (the IT department of the South-East Region) that emerged in 2014, aiming at supporting lightweight application, and connecting them to the established infrastructures of clinical systems.

We chose the two cases because they offered an opportunity to study in detail the emergence of a lightweight initiative, and its interaction with a large program. Information was gathered as a research activity with interviews and observations.

4.1 Data Collection

We interviewed top executives and IT managers, developers and architects, in Digital Renewal in the period 2013–16. In parallel we followed the evolution of Medicloud 2014–16 as well as conducting interviews, participating in conferences, seminars and workshops where both big vendors and smaller initiatives participated (Table 2).

Table 2. Data collection

Year	Activity	Participants
2013–2016	Interviews	Executives, directors, developers and architects in the Digital Renewal program
2014–2016	Meetings	Medicloud, HospitalPartner, HealthSouthEast, Sunnaas hospital
2015–2016	Interviews	Medicloud live, or on email
2015	Conference	2 whole days, 4 sessions, discussions, conversations
2015	Workshops	Participants from 20 of the biggest health-IT vendors in Norway
2015–2016	Analysing documents	Written by Medicloud, HospitalPartner, HealthSouthEast authorities

4.2 Data Analysis

We conducted the following steps. First we established a chronology based on the evolution of Medicloud from 2013, as well as the emergent program of Digital Renewal from 2013. In step 2 we looked at the evolution of Medicloud and identified three periods where Medicloud moved from attracting interest to be an actor within the health conferences, and a possible actor in the innovation programs within the health sector. The findings were discussed with the informants. See Table 3.

Table 3. Data analysis

Step	Description	Output
1	Establishing a chronology 2013–16	Case description
2	Analyses of Medicloud evolution	Table 4
3	Analysing tensions between lightweight and heavyweight IT, and identifying barriers	Three barriers, Sect. 6.1
4	Proposing possible solution for overcoming barriers	Sect. 6.2

In step 3 we analysed the patterns of interaction between lightweight and heavyweight, and identified three barriers for interaction. In step 4 we proposed some possible solutions to overcoming the barriers.

5 The Case: Interplay Between Medicloud and Health South-East

We first present Digital Renewal, then the Medicloud initiative.

5.1 The Digital Renewal Program

Digital Renewal is an ambitious e-health program in Health South-East that aims at standardising the IT portfolio for all hospitals in the region, and integrating a large number of IT silo systems, including electronic medical records, patient administrative system, laboratory data and radiology [22]. It was established with a top-down governance regime, with four sub-programs, each with many projects. It has a time span of 7–8 years and a budget of around 1 bn. Euro.

Digital Renewals long-term work for consolidation of hospital IT systems, in order to enable communication between hospitals, systems and users, has been quite successful. The need to have long term and rational plans - giving both suppliers and the regional management predictability - and the demands to cope with the requirements of new systems, features and artefacts has, however, created some tensions. Clinical systems may take years to be implemented, because they need verification in accordance with a range of heavyweight principles like security, efficiency, economy, as well as planning, displacement of resources, etc. As a response to this, in 2014 some clinicians raised critical voices, claiming that the program was not paying enough attention to local clinical needs. In 2015 the Program Board decided that Digital Renewal had to take local needs into account. During 2015 an increasing interplay between the big program and smaller initiatives occurred, particularly thanks to Medicloud.

5.2 The Coming of Medicloud

The Digital Renewal strategy focused on standardisation and consolidation, not innovation. However, both within and outside the health region alternative initiatives

Table 4. Medicloud phases

Phase	Process moment (Callon 1986)	Description	Number of projects	Technology	Relation to digital renewal
P1 2013–14: Establishment and marketing	Problematisation and interessement	Attracting stakeholders, establish a common vision for innovation	0	None	Ignored
P2 early-mid 2015: Arena for innovation	Enrolment	Medicloud as a tool for innovative technology	9	None	Observed
P3 late 2015: Lightweight infrastructure	Mobilisation	Start of interplay, revealing tensions between knowledge regimes	10+	IBM Bluemix	Dialogue established

started to appear. Medicloud was established in 2013 as a small initiative within HospitalPartner, with one full time employee and people working in it part-time through projects.

Deploying the lens of ANT we describe the evolution of Medicloud in three periods. See Table 4. Phase 1 is about the establishment of an internal innovation project using workshops and seminars to attract stakeholders within health innovation. The goal in this period was to establish an arena for attracting vendors and clinicians working on innovation and technology, and to make available a technological environment. Through several workshops, relations towards smaller initiatives and big vendors were established, but no concrete pilot projects.

In the *second phase,* HospitalPartner funded the project, hired one more fulltime employee and gave access to 3–4 additional resources part time. The second phase saw a tighter collaboration between Health Sector innovations and Medicloud, as an arena for innovation and through the planning of a technological infrastructure to enable access to health information. Nine innovation initiatives within the Health Sector were collaborating with Medicloud, while Digital Renewal did not see the project as interesting in the first period; they gave it increasing attention in the second period when the debate within the South-East region included Medicloud as an innovation initiative.

In the *third phase* Medicloud was receiving increasing attention as an innovation arena. Before 2014 discourses around innovation was almost non-existent at the biggest Health-IT conference in Norway, Hels-IT. In 2015, innovation became the hottest issue in the same conference. Medicloud also arranged a popular two-day seminar at the conference with a lot of attendance, and entered later into strategic discussions on Medicloud's role as an innovation alibi in the Health South-East region. A group for light and heavyweight strategies was established in 2016 within Health South-East where the IT director and several other directors participate. Internal discussions on Medicloud's role in a new organisation model are ongoing. In this phase, several tensions that shed light on our challenges were emerging. Interplay is very important for Medicloud in that the innovation initiatives relying on them have to be provided with a range of heavyweight resources like access to valid information and security.

6 Analyses and Discussion

We return to our research questions:

- How does an innovation initiative develop within an established information infrastructure, as discourse and solution?
- How can we overcome the barriers for interplay between heavyweight and lightweight technologies?

To develop our argument we build on the insight that tensions may be seen as dualities; they are both barriers to solutions, but also reveal possibilities to overcome the barriers [16]. As shown in the case, the Medicloud initiative, with remarkably small resources, succeeded in setting innovation on the agenda, attracting the most important stakeholders in the Norwegian health sector, and enabled a possible establishment of a lightweight infrastructure within the regional system.

The first phases were characterised by using the innovation momentum to establish activities to attract as many stakeholders as possible, to make Medicloud known, and to be a specific arena for discourse around innovation. In the second phase (enrolment), which is about strengthening the ties by maintaining the interest and fight competition, nine initiatives collaborated with Medicloud. These initiatives gave Medicloud a respectable standing, demonstrating progress and increasing maturity.

However, during mobilisation tensions arose because of shortcomings in the lightweight infrastructure, and in the plan to expand it. The heavyweight actors raised critique towards Medicloud, requiring plans for how the development should take place, and a technological framework that enabled collaboration between Medicloud and Heavyweight technologies. The mobilisation thus rested on the ability to solve a set of barriers; otherwise the network will not be stabilised.

Tensions are as described in the literature part as both barriers and resources, and Table 5 below gives an overview of the findings related to tensions as barriers and resources.

Table 5. Tensions, barriers and resources

Tensions between heavyweight and lightweight IT	#1: Knowledge regime	#2: Scaling	#3: Security, privacy
Barriers to interplay	HW: Lightweight lacks Software Engineering professionality LW: Heavyweight is conservative and a hinder for innovation	Lightweight solutions difficult to industrialise	Lightweight communities prioritises usability before security/privacy
Resources for overcoming barriers	Opportunity - Innovation - Division of labour	New actors: (Such as Medicloud) Broker Middleware	Input to improve security/privacy solutions

6.1 Identifying Tensions and Barriers

As shown in Table 5 we identified three types of tensions relevant for our context; on knowledge regimes, scaling, and security/privacy.

Tension #1: Knowledge Regimes. Tensions between the two knowledge regimes were latent in the beginning, but surfaced in phase 3, when interactions became more direct. For example, in a large meeting in late 2015 between Medicloud and several heavyweight companies, (Microsoft, Apple, DIPS, Tieto and several others) Medicloud was presented as an arena for innovation, outside the heavyweight system of tenders, ordering, development and implementation. Medicloud was profiled as providing a technological platform, a playground, where the users can perform trial and error on medical data. The heavyweight vendors were not impressed:

> HW1: "who is going to buy the Medicloud platform?"
> HW2: "how are you going to industrialise innovation? What is the strategy besides teasing people?"
> HW3: "what happens if all the pilot initiatives collapse because of the lack of a suitable technical environment"?
> HW4: "What is Medicloud doing in order to move the attention from long-term order regime to a lighter which facilitates innovation and lightweight…"?

These tensions were also visible internally, in HospitalPartner and Digital Renewal. The Medicloud manager was at various occasions campaigning to "phase out the old model of production and replace it with a new one", where the clinicians and usability are in centre. He also expressed the desire to participate within a "bi-modal strategy" where heavy- and lightweight are separated into two platforms running independently of each other.

We interpret these tensions as a barrier between the two knowledge regimes, who found it hard to respect each other; the heavyweight community felt that the lightweight people lacked the required software engineering professionalism, while the lightweight proponents thought that the heavyweights were a hindrance for innovation. *Digital Renewal* consisted of long-term projects going on for years and where planning, ordering, implementation and training had to follow requirements of security and control. The Medicloud people said: "We would not like to be a part of Digital Renewal…the reason for this is the slow progress - we can do in two weeks what Digital Renewal need 4 years to do".

The heavyweight providers tend to see lightweight solutions as competition, and Medicloud's strategy to raise a new discourse on innovation that bypasses the heavyweight requirements was constantly countered by the heavyweight actors displacing the discourse back into heavyweight terrain.

Tension #2: Scaling. In the interactions between Medicloud and the lightweight projects we observed that the lightweight project managers went from enthusiasm over the potential of their solutions to frustrations over the obstacles of setting the solutions into production. One project manager said in a meeting with Medicloud:

> "We have developed, in close co-operation with the clinicians, an excellent app solution for supporting an emergency unit. We were expecting that Medicloud could help us in setting it into production. But now you are telling us that we have to wait for a solution some time in the future, or going through the established bureaucracy?"

Medicloud acknowledged the problem, but could not promise a solution. "It takes time to provide a modern industrial production platform, and we need more money." While cloud solutions are readily available, they become easily stand-alone applications, without the necessary integration with basic medical registers.

We interpret this as a barrier for lightweight innovation. Lightweight project tend to make prototypes, aiming at getting feedback on the usability, and the continual modification of the prototype based on the interaction. The challenge is that projects may evaporate through the inability to provide long-term planning for the continuation of projects, including how the product finally will be industrialised. This shortcoming may also threaten some of the motivations within the spirit of innovation these initiatives rely on. The test and production routines of heavyweight IT are established to maintain stability for clinical solutions, and do not go well with lightweight entrepreneurship.

Tension #3: Security and Privacy. In large e-health infrastructures security and privacy are based on law and detailed regulations, and implemented with a number of technical and organisational mechanisms. For instance, in all applications that access patient information includes a filter for user identification and fine-granulated access and update rights.

The HospitalPartner managers and developers expressed concerns that these requirements were not treated sufficiently by the more entrepreneurial lightweight vendors. Also heavyweight actors like Microsoft, Apple, DIPS, and Cerner were challenging Medicloud's strategy for security and privacy. For instance, they argued, if they were to make APIs available for lightweight applications, they are required by law to ensure that access and information is compliant with regulations. Even more problematic, if lightweight app is designed to update clinical systems, the security requirements are heavy indeed.

There is no doubt that this constitutes a barrier for lightweight IT, because on the one hand the lightweight focus is on usability and feedback in interaction with the clinicians, making security a second priority. On the other hand, some of the success rests on the lightweight ability to provide trust amongst the users as they are dealing with very important privacy issues.

6.2 Overcoming Barriers

Our empirical evidence does not provide outright solutions for these barriers, but we use two sources to describe possible solutions. First, tensions are also resources; they give information, direction and suggestions. Second, we build on the existing literature [7–9] on communication and collaboration between heavy and light to carve out possible solutions.

#1. Overcoming Knowledge Regime Barriers. We observed that heavyweight concerns were sometimes mixed with acknowledgements of the limitations of the current heavyweight regime. A director within Health South-East Region commented:

> "In the Digital Renewal program there is a lot of central governance, and little freedom. There is a need to clean up the infrastructures, create order. There is a lot to do but not much time. These challenges are forcing us to rethink. We cannot own everything, command everything, and control everything. Medicloud is very good at teasing us, telling us to rethink our strategies".

This attitude may not be shared by the whole heavyweight community, but it opens up for some reflections on how the barriers may be overcome. First, the lightweight agenda of user-oriented innovation should be accepted as legitimate by the heavyweight community. It is a fact that many of the heavyweight systems do not support clinical processes sufficiently well [23, 24]. The opportunities offered by lightweight IT might help to improve this, not only by better usability of solutions, but also by establishing a culture for local innovation. Second, the increasing costs and complexity of heavyweight solutions are hardly sustainable over time, and there is a need to discuss the division of labour between heavyweight and lightweight IT [9]. A possible way forward is to think in terms of basic registers and their integration by heavyweight IT, and a user-oriented layer of lightweight non-intrusive systems on top, with local variations.

#2. Overcoming Barriers Related to Scaling. These barriers, as described above, relates to setting lightweight solution into production, and also enabling diffusion to a broader set of users.

Setting lightweight solutions into production, without invoking the heavyweight regime of SLAs, test regimes and toll-gates, requires new thinking. One possible solution is the "app store"; modelled on Apple`s platform for apps. An app store for the health sector is conceivable and easy to establish, and would be appreciated by the lightweight community and users. However, this does not solve the needs for integration with clinical systems. One way to solve these needs is to establish brokers (such as Medicloud) and necessary middleware between the inside and the outside of the heavyweight infrastructure. This would enable users on the outside to access the lightweight infrastructure, while the coupling between the infrastructures would secure that the two regimes interoperate in a loose manner. Obviously, there are many unsolved questions on how this can be implemented.

#3. Overcoming Barriers Related to Security and Privacy. Everyone working in or close to the health sector is informed about the sensitivity of information and thus the control regime needed for taking care of personality issues. There is no way that lightweight IT can take this lightly. While heavyweight IT has created extensive algorithms driven by distant servers, lightweight IT should look for simpler solutions.

One inspiration can be current mobile solutions, where vendors have innovated more pragmatic security solutions using fingerprints, chips or pins; this approach takes advantage of the cheap and available commercial solutions from the key innovation arenas. These are solutions that the users are comfortable with, and trust. The limitation of these solutions, however, is that many issues on security and privacy remain unresolved.

7 Conclusion

In this paper we investigated how information infrastructures are extended. Building on a case from e-health our aim was to understand the interaction of a heavyweight IT infrastructure and lightweight IT initiative, and the tensions of the interplay. We add to the existing literature with two contributions.

First, we extend information infrastructure theory by identifying three types of tensions relevant for the interplay with a larger structure, knowledge regime, scaling and security/privacy. These tensions are creating specific barriers for the integration of lightweight IT:

- *Knowledge regimes:* The heavyweight regime resists acknowledging the legitimacy of the rival regime.
- *Scaling*: Lightweight solutions are difficult to industrialise.
- *Security/privacy:* Lightweight communities prioritise usability before security/privacy.

Second, we discuss how these barriers may be overcome. There is a danger in that lightweight programs may be sucked into the bigger system, that they may become colonised by heavyweight regimes. Knowledge regime barriers can be overcome by accepting first the user orientation in lightweight initiatives, and second the need for division of labour between the two sides. Scaling barriers can be overcome by enabling use of digital diffusion of apps through app-stores and similar, and by establishing lightweight initiatives as brokers or middleware on the outside of the infrastructure.

Barriers related to security and privacy issues can be overcome by enabling the use of cheap and available commercial solutions, although these may have some limitations when used in the health sector.

References

1. Priemus, H., Flyvbjerg, B., van Wee, B. (eds.): Decision-Making on Mega-Projects: Cost-Benefit Analysis Planning and Innovation. Edward Elgar Publishing, Cheltenham (2008)
2. Currie, W.: Translating health IT policy into practice in the UK national health service. Scand. J. Inf. Syst. **26**(2), 1–24 (2014)
3. Sauer, C., Willcocks, L.P.: Unreasonable expectations – NHS IT, Greek choruses and the games institutions play around mega-programmes. J. Inf. Technol. **22**, 195–201 (2007)
4. Lakatos, I.: Criticism and the methodology of scientific research programmes. In: Proceedings of the Aristotelian Society, New Series, vol. 69, no. 1968–1969, pp. 149–186 (1969)
5. Swanson, E., Ramiller, N.C.: The organizing vision in information systems innovation. Organ. Sci. **8**(5), 458–474 (1997)
6. Ellingsen, G., Monteiro, E.: The organizing vision of integrated health information systems. Health Inform. J. **14**(3), 223–236 (2008)
7. Harris, J., Ives, B., Junglas, I.: IT consumerization: when gadgets turn into enterprise IT tools. MIS Q. Exec. **11**(3), 99–112 (2012)

8. Bygstad, B.: The coming of lightweight IT. In: Proceedings of European Conference of Information Systems (ECIS), Münster, Germany (2015)
9. Willcocks, L., Lacity, M., Craig, A.: The IT function and robotic process automation. In: The outsourcing Unit Working Research Paper Series, October 2015. http://eprints.lse.ac.uk/64519/1/OUWRPS_15_05_published.pdf
10. Tilson, D., Lyytinen, K., Sorensen, C.: Digital infrastructures: the missing IS research agenda. Inf. Syst. Res. **21**(4), 748–759 (2010)
11. Bannister, F.: Dismantling the silos: extracting new value from IT investments in public administration. Inf. Syst. J. **11**(1), 65–84 (2001)
12. Perrow, C.: Normal Accidents: Living with High Risk Technologies. Princeton University Press (1999)
13. Hanseth, O.: From system and tools to network and Infrastructure - towards a theory of ICT solutions and its design methodology implications (2002). http://heim.ifi.uio.no/~oleha/Publications/ib_ISR_3rd_resubm2.html
14. Hanseth, O., Monteiro, E.: Understanding information infrastructures, unpublished manuscript (2010). http://heim.ifi.uio.no/~oleha/Publications/bok.html
15. Hanseth, O., Lyytinen, K.: Design theory for dynamic complexity in information infrastructures: the case of building internet. J. Inf. Technol. **25**(1), 1–19 (2010)
16. Edwards, P., Jackson, S., Bowker, G., Knobel, C.: Understanding infrastructure: dynamics, tensions and design. In: Report on a Workshop History and Theory of Infrastructure: Scientific Cyberinfrastructures (2007). http://deepblue.lib.umich.edu/bitstream/handle/2027.42/49353/UnderstandingInfrastructure2007.pdf?sequence=3&isAllowed=y
17. Monteiro, E.: Actor-network theory and information infrastructures. In: Ciborra, C., et al. (eds.) From Control to Drift – The Dynamics of Corporate Information Infrastructures, pp. 71–87. Oxford University Press, Oxford (2000)
18. Latour, B., Woolgar, S.: Laboratory Life: The Construction of Scientific Facts. Princeton University Press, Princeton (1986)
19. Monteiro, E., Hanseth, O.: Social shaping of information infrastructure: on being specific about the technology. In: Orlikowski, W.J., Walsham, G., Jones, M.R., DeGross, J.I. (eds.) Information Technology and Changes in Organizational Work, pp. 325–343. Chapman & Hall, Boca Raton (1995)
20. Callon, M.: Some elements of a sociology of translation: domestication of the scallops and the fishermen of St Brieuc Bay. In: Law, J. (ed.) Power, Action and Belief: A New Sociology of Knowledge, pp. 196–233. Routledge & Kegan Paul, London (1986)
21. Helse Sør Øst: Helse SørØst RHF – det regionale helseforetaket (2015). http://www.helse-sorost.no/om-oss/om-helseforetaket
22. Helse Sør Øst: Regional klinisk løsning (2015). http://www.helse-sorost.no/aktuelt_/digitalfornying_/tre-programmer_/Sider/regional-klinisk-dokumentasjon.aspx
23. Ash, J.S., Berg, M., Coiera, E.: Some unintended consequences of information technology in health care: the nature of patient care information systems-related errors. J. Am. Med. Inform. Assoc. **11**, 104–1123 (2004)
24. Berg, M.: Patient care information systems and health care work: a sociotechnical approach. Int. J. Med. Inform. **55**, 87–101 (1999)

Spring 6-10-2017

DISCURSIVE FORMATIONS AND SHIFTING STRATEGIES IN E-HEALTH PROGRAMMES

Egil Øvrelid
Dept. of Informatics, University of Oslo, Norway, egilov@ifi.uio.no

Bendik Bygstad
Dept. of Informatics, University of Oslo, Norway, bendikby@ifi.uio.no

Ole Hanseth
Dept. of Informatics, University of Oslo, Norway, oleha@ifi.uio.no

DISCURSIVE FORMATIONS AND SHIFTING STRATEGIES IN E-HEALTH PROGRAMMES

Research paper

Egil Øvrelid, Dept. of Informatics, University of Oslo, Norway, egilov@ifi.uio.no

Bendik Bygstad, Dept. of Informatics, University of Oslo, Norway, bendikby@ifi.uio.no

Ole Hanseth, Dept. of Informatics, University of Oslo, Norway, oleha@ifi.uio.no

Abstract

Research has shown that large IT programmes in e-government and e-health are challenging not only in terms of project failures and in terms of high costs, but also that the public and sectorial discourses greatly influences the trajectories and outcomes of mega-programmes. However, few IS studies have investigated this phenomenon in much depth, and the aim of this contribution is to shed more light on the relationship of discourse and mega-programmes. We use Foucault's discourse concept to analyse discursive formations aiming to promote and establish solutions in e-health programs, but frame our investigation in information infrastructure theory. Our empirical evidence is a 15-year study of the growth of the national e-health infrastructure in Nor-way, where we analyse the interplay of the national eHealth discourse and the various programme ini-tiatives. Our study offers two contributions. First, we demonstrate how the concept of discursive for-mation allows for an in-depth analysis of the role of discourse in large eHealth programs. Second, we show how shifts of discourse, combined with experienced problems in on-going programs, may disrupt the trajectories of large information infrastructures.

Keywords: Discourse, discursive formations, eHealth, Information infrastructures

1 Introduction

Our interest in this paper is to understand how large IT initiatives are being influenced and formed by discourses, and - reversely - how the discourses are affected by the practical experiences from these programmes.

Public sector IT mega-projects with political and societal prestige are usually initiated as a response to perceived problems, such as poor services or high costs. There are considerable risks related to this type of projects (Priemus et al 2008, Currie, 2014), both economical and organizational costs are high, and often these projects will attract considerable attention with possible negative publicity.

In a seminal article by Sauer and Willcocks (2007) *Unreasonable expectations – NHS IT, Greek choruses and the games institutions play around mega-programmes*, the authors describe the turbulent discourse of the failed NHS e-health programme. The main reasons for failure are that these structures are (i) much larger than single organization systems, (ii) technically more heterogeneous and (iii) organizationally more complex because of many stakeholders. Often, no single actor is in control, leading to long processes of power struggles, compromises and complex co-ordination. In addition, they are particularly exposed (as they should be) to public discourse, which Sauer and Willcocks analyse as three "Greek choruses"; the public officials who defend the programme, the internal institutions and medical professions that are "sympathetic critics" and the media, consultants and academics that constitute the "professional critics".

Research on discourse is associated to Foucault's archaeological research. The most cited contribution on the role of discourse in IS research is the *organizing vision* (Swanson and Ramiller 1997), which denotes how technology is viewed in the light of what it can do for organizations, how discourses about

technology is opening up further discourses about societal and organizational implications, and possibilities enabled through technological change.

Public mega-programs, however, are different from the private company context that Swanson and Ramiller researched, in the sense that the decisions are more complex, often involving hundreds of organisations, several technologies, public discourse and political pressures. One way to frame these issues is the *information infrastructure* research (Hanseth and Lyytinen, 2010), which has successfully investigated the nature and dynamics of large interconnected systems. According to this theory information infrastructures are not designed and implemented, but grow organically and adaptive from an open installed base.

Few studies have, however, dealt with the role of discourse. Therefore, we know less about the role of discourse in the evolution of public information infrastructures such as e-health. What are the more specific dynamics of discourse and large IT initiatives, for instance: how is discourse translated into action? What is the trajectory from political and public suggestions, ideas and choices to implementation? In short, how can we understand the dynamics of interaction between discourse and infrastructure when a program is encountering difficulties and alternative solutions emerge as problem solving? Our interest in this led us to ask the following research questions:

- What is the role of discourse in disruptive shifts in information infrastructures?
- Which patterns of interaction between discourse and infrastructure events can we identify?

In his work on scientific programmes and paradigms, Lakatos (1969) argued that "programmes" tend to continue in spite of experienced problems, as long as there are no clear alternatives present. This resonates well with documented management practices and the "garbage can" theory (Cohen, March and Olsen, 1972); when alternatives emerge, new decisions may be taken. We take this insight as our starting point, and analyse the interplay of discourse and reality of an e-health mega-programme, where we identify and analyse three strategy shifts. To develop our argument, we use Foucault's term discursive formation as our analytical lens, and we offer a model of discourse dynamics.

2 Information Infrastructures and Discourse

The literature on information infrastructures (Ciborra et al. 2000, Hanseth and Lyytinen 2010), describes them as open, heterogeneous, performative and emergent, and its central interest is patterns of growth. Examples of information infrastructures are the Internet, interconnected supply chains, financial systems, e-government solutions and e-health.

Infrastructures may grow in different ways, sometimes through decentralized autonomy (Ciborra 2000) i.e. through drift instead of control (Ciborra et al 2000), sometimes through centralized governance (Broadbent and Weill 1999). They can grow through bootstrapping, i.e. prototypes attracting a range of stakeholders and leading to a self-reinforcing or self-organizing installed base (Hanseth and Lyytinen 2010), or they can grow through enabling interaction between heavyweight and lightweight technologies (Bygstad 2016). Further, the information infrastructure research often focused on how inscription and translation is obtained. Inscription is about "the way technological artefacts embody patterns of use"; while translation is about shaping the infrastructure according to one's own needs (Monteiro 2000, 76, 77). In both cases, the infrastructure is seen as already existing, and the users either customize it to their own needs, or bend the use of it in a direction that suits them. The literature is much less clear when it comes to the role of discourse in infrastructural growth.

Earlier work using discourse analyses within the IS field has concentrated on the use of narratives and buzzword in management practices (Swanson 2002, Monod et al 2002, Westrup 2002); or on the relation between discourse and practice during implementation of technology or technological routines in organizations (Rose and Kræmmergaard 2002, Oliver and Oliver 2002, Gidlund 2015, Ellingsen and Monteiro 2008). A third group looks at how discourse is used as an existential tool downgrading the overwhelming amount of data and information in modern organizations (Wastell 2002, Edenius 2002).

The research on "organizing vision" (Swanson and Ramiller 1997, Ellingsen and Monteiro 2008) has given good insights into the role of discourse in technological strategies and implementation. They

show that the success of organizing visions depends on the flexibility enabled through the discourse, and how reciprocal transformations over time maintain the vision among the stakeholders. The ambiguity and flexibility is necessary then, for both the efficiency and the legitimation of the vision. This is necessary in order to mobilize participation in realization of the vision amongst the multitude of actors performing within the health sector. However, Swanson and Ramiller do not outline a distinct method for investigating the wider political implications of large programmes, but are more interested in the technology's role in the discourse. In addition, public mega-programs are different from the private company context that Swanson and Ramiller researched, in the sense that the decisions are more com-plex, involving hundreds of organisations, several technologies, public discourse and political pres-sures.

In our framing, *information infrastructure* is the existing socio-technical arrangements of digital artefacts and networks as well as the organizational rules and regulations which structures these arrangements. We use *discourse analysis* to identify and describe the existing as well as intervening challenges and solutions which seeks to improve or change the infrastructure in order to address an emergent shortcoming. The most important discourses emerges in groups or formations. We are inter-ested in the content of these formations and their relations to infrastructural change. In order to elabo-rate on this perspective we use Foucault's term *discursive formation*, in order to shed light on the rela-tionship between discourse and infrastructure evolution.

3 Discourse and Information Infrastructures

3.1 Discourses and discursive formations

The French philosopher and historian of ideas Michel Foucault's core of investigation is centred around the modern episteme which emerged in the early modern age, their patterns of growth and their content. His main point was that they emerged not only in the light of their own reason, but also as a result of gathering of discourses from several fields, both inside and outside the political and scientific institutions. His book "The archaeology of knowledge" from 1972 outlines his method for performing these investigations. In his historical research he investigates the emerging discourses, and identified something he called *discursive formations*. What is this?

In his archaeological research into history of thought Foucault tried to identify who said what, why this was said, what it meant, and what it led to. If a single person or a small organization stated something, the statement had little power. It was when a rising number of statements emerged that something became a discourse. Finally, when the discourse increased, the number of statements around a particular argument increased and maybe reached the books or in our days the media, discursive formations could be established. These discursive formations created through discourse their own "space of interplay" (Foucault 1972). This way of looking at the emergence of knowledge by investigating the role of the broader "popular" discourse, was radical, but not unreasonable.

Foucault was particularly interested in two aspects of the discourses. First he was occupied with how discourses was established through a statement's referentiality to a whole set of existing statements, utilities, practices and institutions (Schaanning 1996). We can see that this has to do with order, patterns or systems which establish themselves through practices, but also that it is something processual which is brought into play. The "space on interplay" (Foucault 1972, 204) opens up for emerging perspectives which doesn't necessarily subordinate itself to a single authoritarian logic (ibid).

In addition, a central issue is that the living conditions of the discourse are dependent on the object the discourse is connected to, and whether discursive formations agree on this object. "The object does not …pre-exist itself…It exists under the positive conditions of a complex group of relations" (Foucault 1972, 49). The object emerges under relational conditions and "juxtapose itself with other objects" (ibid, 50). This means that the discourse is defined by the external relations not by its own "nature", and that discursive relations establish the possibility for statements about a given object. The discourse is normalized through discursive formations that have the necessary power to institutionalize rules and regulations making them routine (Clegg 1998).

In order to understand the discursive formations, one has to individualize them in order to find how they relate on a deeper level. Things are not always as they seem, strategies may be the outcome of un-foreseen and not always "rational" alliances, and this is why it is necessary to analyze the actors and their programs individually. An historical investigation into shifting trends means that we have to un-pack the alliances in order to understand the individual parts, where they come from and how they are gradually established. What brought them together? What rules or patterns of interaction can be de-duced from the gradual formation of alliances?

The Archaeology, then, is the Foucauldian twist of using historical inquiries to inspect and examine, not physical objects, but the statements and discourses of the human sciences, "in order to uncover the discursive practices that constitute the field of knowledge" (Willcocks 2004, 250). Archaeology is the mapping of the enabling conditions for the production of truth and knowledge (Willcocks 2004) a "reordering of events…not perceived before" in order to lay bare the empirical conditions under which (expert) statements come to be counted as true (Hacking 1986).

3.2 The anatomy of discursive formations

Michel Foucault suggests four analytical strategies or ways or techniques to identify these gradually established chains of interactions named discursive formations. See Table 1.

First a discursive formation can be identified by its *area of interest*; what it is about, the object of its occupation. In Foucault's own work these entities are Madness, Sexuality or The Clinic, but the main point is that these objects are constituted by the virtue of the different discourses on the object. What is the central challenge that is addressed? What is it one is talking about within this area of challenge? The identification of the object is done through investigating the areas (surface of emergence and surface of appearances) where these challenges are talked about, and identify how and from whom the forming of the object is done (authorities of delimitation). This might be done by analysing and relating the different ways actors talk about the object to one another (grids of specification).

Second, the identification of enunciative modalities is about analysing the different actors. Who is speaking, with what right and qualification? From what institutional site, and with relation to which possible networks? The actor's utterance is of special importance if we understand the actors enunciative modality, that is, the mode of the actor, where, when, from whom and why the utterance is made. Foucault is particularly interested in the relation between the speaker and his or her position in relation to the actual debate.

The third way of identifying and defining discursive formations could be to inspect the formation of concepts – how concepts are established and used. This might be done through investigating the relation between concepts (types of dependence); by investigating their coexistence, or by looking at the procedures of intervention between concepts. Coexistence may be done by looking at how discourses travels between disciplines or by how old discourses is given new life. Intervention is how concepts from other fields are brought in and radically changing the way the object is understood.

	OBJECT	**ENUNCIATIVE MODALITIES**	**CONCEPTS**	**STRATEGIES**
Example:	Madness	Doctors, Judges, Experts	Older: genus, species Newer: Organism	Language conventions or economical discourse
Identified through investigating:	Where are the challenges addressed? Who is forming the object and how? How does the object of discourse relate?	Who is speaking, with what right and qualification? From what institutional site? What are the actor's possible networks?	Relations between concepts Coexistence between concepts Use of radical new concepts from other fields	Points of diffraction economy of the discursive constellations (why something lives on and something disappears) Decimation (who decides what strategies that count and why and what is the result)

Result:	Identification of the object of discourse	How the relations between discourse and actors are established	Concepts in the discourse and the "logics" of their relations	Understanding of contents and reasons for strategic shifts

Table 1: Elements in Discursive formations

Finally, the fourth way, the *formation of strategies*, is occupied with three different aspects. The first is about how the discourse is "spread" between fields. The second regards the "economy of the discursive constellations" which is about identifying the rules that leads to decimation of the discourse, why something lives on and something disappears. The third, decimation, is a part of a strategy to conserve social or scientific cultures. This is about who decides what strategies that count, why and what is the result of these decisions. In both cases however the main goal is to identify where the dis-course is coming from and the central rules for its unification. Table 1 gives a summary of the content of discursive formations.

3.3 The Role of Discourse in Shifts of Information Infrastructures

We have described the framework Foucault outlined for identifying discursive formations. Foucault was concerned with the contextual logic of the systems that challenged the existing programs. However, while discursive formations provide us with a lens to understand the anatomy of discourses, we need an additional theoretical framing. What makes shifts actually happen?

For Kuhn "normal science" was the step-by-step everyday work of scientists. Normal science was performed and elaborated until they were challenged by a new scientific paradigm that changed the whole area. Institutions, practices, intellectual and technological resources were lifted onto a new track (Kuhn 1996). Imre Lakatos was also concerned with the logic of system shifts, but he related them to the needs of the dominant programs had to (i) understand their own deficiencies, and (ii) open up to anyone on the outside who could complement the program (Lakatos 1970). This implies we use Laka-tos insight that "programmes" tend to continue in spite of experienced problems, as long as there are no clear alternatives present, and that disruptive shifts will only happen when discourse has identified and converged around an alternative strategy.

Summing-up, we are interested in the role of discourse in disruptive shifts of information infrastructures, and we suggested that Foucault's rich concept of discursive formations provide us with a powerful lens to investigate this. To understand why and when these shifts occur, we supplemented this with Lakatos' insight that shifts in programs will not take place until there is a viable alternative, brought to the scene by discourse. We investigated our case with this theoretical lens.

4 Case and Method

We chose a multilevel case study approach (Greenhalq et al., 2010) in order to investigate the inter-play of policies, programs and projects. Norway is a Scandinavian country with 5.2 million inhabitants who enjoy a high standard of living and public health services. The sector is governed by the Ministry of Health and Care, while the Directorate of Health is an implementing agency and health advisory. Primary care is supplied by private GPs and municipal services.

Our starting point was the national policies for e-health, which was a continuous public debate issue during these years (with links to the broader discourse on New Public Management), and presented some high-level IT governance and architecture issues. In order to identify the interactions of discourse and the growing e-health infrastructure our approach was to conduct a systematic analysis of (i) the documented discourses, (ii) the documented events and (iii) the interactions between them.

4.1 Data Collection

We studied the governance and development of a national e-health infrastructure in Norway over a period of fifteen years (2000-2015), at three levels:

- *The national level*: we interviewed top executives and IT managers at the Ministry of Health and Directorate of Health, analysed plans and initiatives, and we analysed the topics of the national e-health conference from 2001-15.
- *Regional level*: we investigated the development of a regional information infrastructure in the Health South-East from 2000 to 2015, through a sequence of programmes.
- *Project level*: we followed two large projects, the Portal project at Rikshospitalet in 2009 to 2011, and; the DIPS project at Oslo University Hospital 2013-2015. We also followed a smaller initiative, the Medicloud project in 2014-15.

In total, more than a hundred interviews lasting from between 1 and 4 hrs were conducted. We interviewed both strategic managers, project managers, IT directors as well as innovators and users. The notes taken during the interviews were transcribed directly afterwards, and shared amongst the researchers. Follow up interviews were taken when needed. In addition, more than fifty strategical documents as well as tender or competition proposals and documents or presentations from EHealth confer-ences was analysed. We also spent many hours observing meetings and seminars, and observing clini-cians use the various solutions.

4.2 Data Analysis

We conducted the following steps:

Step	Description	Output
1	Establishing a chronology 2000-2015, and identifying shifts in the discourse and infrastructure	Figure 1
2	Identifying and investigating the content of discursive formations	Section 5.2
3	Analysing patterns of interaction between discourse and infrastructure events	Section 5.2
4	Theorizing shift patterns	Section 6, Discussion

Table 2. Data analysis

In the first step, we conducted a temporal analysis of all our materials, identifying important events, both in the evolution of the e-health infrastructure, and the accompanying discourse. We identified three large *shifts* in the 15-year period. The result of this analysis is documented in Figure 1.

Then we identified three discursive formations, and analysed them in detail, using Foucault's framework, as described in the review section. In doing so we drew on our rich empirical materials, including a discourse analysis of the content of the annual national e-health conference. This relates to the Foucauldian strategy of identifying the object of discourse, and the actors gathering around the dis-course; their position as well as the "conceptual architecture" and the diffusion into a new strategy. Further, we analysed the shifts, i.e. patterns of interaction between discourse and infrastructure events that eventually led to disruptive shifts in the e-health strategy. Through this analyses we identified, not only the moments' relation between acknowledged shortcoming of the existing program, and the shift; we did also carefully analyse the content of the different trends thereby giving a deeper understanding of the content of discursive formations. Finally, drawing on Lakatos, we proposed answers to our re-searched questions, and theorized the shifts, connecting more explicitly with information infrastructure research.

5 Findings and Analyses

We first give an overview of the growth of a national and regional e-health infrastructure the past 15 years, and the on-going discourse, in order to establish a chronological baseline. Then we analyse in more detail the interactions between the discourse and the events.

5.1 Background: Growth of national and regional e-health infrastructures 2001-15

Until 2002 all public hospitals were owned by the 19 Norwegian counties. 1st of January 2002, the central government took over the ownership and organized the hospitals in five health corporations called Regional Health Authorities (RHA) given the names Health North, Mid, West South and East respectively. In 2007 South and East were merged into the South East Regional Health Authority ("Health South-East"). In total there are currently 39 legal public hospitals organizations, each of consisting of up to 10 individual hospitals.

Before the reform in 2002, ICT strategies and decisions were attached to the individual hospital. The motivation behind the reform was a commonly felt need for more and better coordination and collaboration among the hospitals. Moreover, it was a broad consensus about the importance of exchange of information electronically for achieving this. So immediately after the reform, each region established a central organization representing the regional health authorities and an ICT unit as a part of this. In all regions, it was decided to focus on standardizing ICT. The most important was to standardize the most important applications, i.e. that all hospitals should run the same EPR, radiology, lab and chart and medication systems etc. All regions also established a governance model based on Gartner's so-called Y-model[1] which organize the overall ICT activities and responsibilities into three roles control and strategizing (regional board and management), customer (hospital) and vendor (regional ICT vendor). All regions transferred most of the ITC staff in the hospitals into a regional ICT organization. The strategy for standardizing applications was based on tendering processes where the regional au-thority signs a "framework contract" with one vendor for each application running for 5-10 years. The hospitals decide on their own when they need a new solution, but compliant with the contracts. In 2003 an organization called "*National* ICT" was established on the Ministry of Health's initiative in order to achieve better coordination of ICT activities and solutions among the RHAs. Specifying a common ICT architecture for all regions based on a service-oriented architecture, and standardizing archetypes for core data elements have been among the highest prioritized activities.

In spite of these and other initiatives, the overall ICT portfolio within the hospital sector has remained fragmented and information exchange between applications and organizations problematic. Around 2005 the fragmented eHealth solutions were brought to the attention of national media, through histories of poor patient treatment because of non-integrated IT solutions, and ridiculed the practice of transporting x-ray images by taxi between hospitals. The political pressure on the sector increased, and the answer from the top health executives to the challenge was to establish a new governance regime. One reason for this disappointing situation is the fact that while some applications where standardized within the regions, new ones were continuously introduced to support various new specialist practices, as a part of new digital instruments, etc. And while an increasing number of hospi-tals were running the same software packages, these packages were configured differently among the hospital making information exchange almost as difficult as if they were using applications from dif-ferent vendors.

[1]Helsedirektoratet (2014). Utredning av «én innbygger – én journal» Komparativ analyse av de regionale helseforetakene på IKT-området. September 2014. https://www.regjeringen.no/contentassets/355890dd2872413b838066702dcdad88/komparativ_analyse_rhf_ikt.pdf

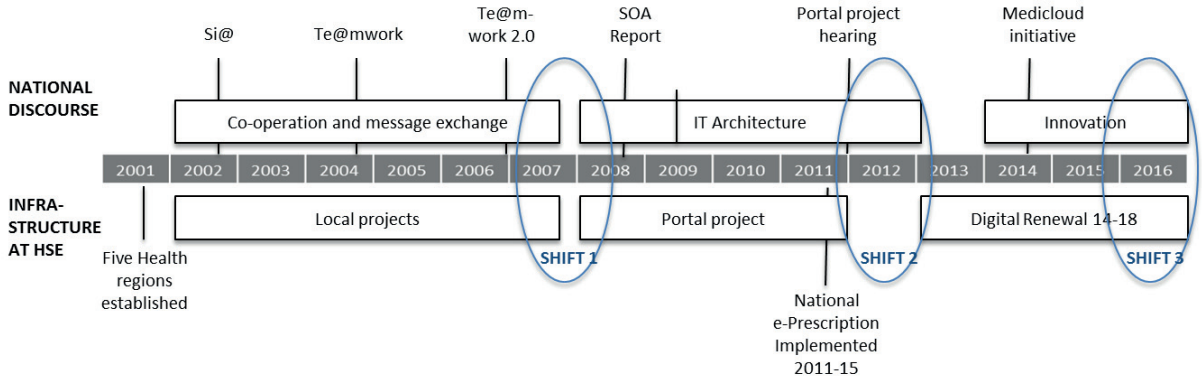


Figure 1. Timeline

5.2 Patterns of interaction and shifts

Figure 1 show three phases of discourse and three phases of programmes. The discourses were held at a national level, while we analyse the programmes that were conducted within the largest (South-East) health region. We identified three large *shifts* in the 15-year period. A shift is here understood as a significant change in both discourse and actual programs. The shifts are illustrated in the timeline.

We identified three different national discursive formations aiming at providing solutions to the acknowledge challenge in the e-health program; growing an integrated infrastructure. The discursive formations were conceived from of a common discourse on modernization of technological health infrastructures, but differ in the way they position themselves within those discourses.

We will analyse the findings in four sections separated by the three shifts. The theoretical lens gives us a vocabulary to understand the discursive formations and their content that gives them power to enable change. We will also discuss them in relation to each other, identifying the scale of change by looking at the regularity. See Table 3.

DISCURSIVE FORMATION	SHORT-COMING	OBJECT	ENUNCITIVE MODALITIES	CONCEPTS	STRATEGIES
Co-operation and message exchange	Paper-based records and lack of cooperation	Digitalization	National, regional and local authorities. Gartner group.	Cooperation	Centralized Strategy, Decentralized Autonomy, Combination top-down and bottom-up
IT Architecture 1	Slow progress, fragmentation	Fragmentation	National authorities, International agencies, and consultants	Modularization	Modular architecture, Top-down Governance
IT Architecture 2	Collapse of Portal project	Consolidation	National authorities and politicians. Norwegian parliament. The control committee	Integration	Integrated architecture, Top-down Governance
Innovation	Lack of innovation and decentralized autonomy	Flexibility	National and international agencies, local hospitals. Commodity suppliers	Innovation	Cloud-based Architecture Agile strategies Mixed governance

Table 3. Discursive formations analysis

5.2.1 Cooperation and message exchange

We call the first discursive formation we identified "Co-operation and message exchange", and it first addresses the challenge of paper-based records. The most important object of the government takeover of the hospitals was the need for standardization through *digitalization* of the central application core: The medical records, the lab solutions, and the pacs systems. The increased possibility to obtain *digitalization* had been an important issue of all the political and technological debates on Health-IT evolution for several years. The strategic report "Health for every Bit" from 1997 emphasized digitalization, and Gartners Y-model was seen as a strategic tool to facilitate the diffusion of this strategy.

Historically each hospital, and even each department, had been working on digitalization acquiring or developing their own IT systems, reflecting functional specialization. In addition to shared systems, such as patient record, chart and medication, lab, and imaging, most units had acquired their own systems for births, cancer, diabetes and so on. In the period 2001-2007 most hospitals in the country conducted their own projects, many of them addressing the increasing need for integration of various "silo" solutions. The strategy was intended to facilitate centralized standardization, but it lead to more fragmentation. Why?

After the establishing of the five health regions in 2001, there was an on-going debate on *co-operation* at many levels. The political inspirations are observable in strategic reports like "Say@" from 2001 and "Te@mwork" from 2004. Inside each hospital it was increasingly acknowledged that clinicians needed access to medical information produced by other units; likewise, inside each region there was a need to exchange data, particularly between hospitals and primary care GPs. Finally, at a national level, there was a need to exchange patient information between regions. How should this be done, given the variety of solutions? The answer, according to the Directorate of Health, was to exchange standardized messages, and a long-lasting campaign, *Message Exchange*, run for several years.

We can thus say that the first of the four periods are conditioned by discourse on the object of *digitalization* – the move from paper to digital medical records – through the concept of *cooperation* - the enabling of cross-units' interaction. The discursive formations are important drivers for system change, but also for the level of scale the change causes. In the first period after the change of authority from the counties and the university hospitals to the State, there was still a significant power in the decentralized model, and the state had to take this into account by enabling local freedom. This lead to a decentralized governing model with distributed freedom for local projects to build on their installed bases, using messages based on standards which were agreed upon, to communicate between health units. Even though the object of discourse – digitalization - is the central goal, the combination of centralized strategy and decentralized autonomy gives the ambivalent result of enforcing other aspects, like the concept of cooperation.

Progress was slow, and both the internal and national discourse started to show signs of impatience. We interviewed a key player in policy development, and asked for his assessment of the current situa-tion and the road ahead. He commented:

> "The main problem is the fragmentation of solutions, which has a historical explanation. Each hospi-tal, each clinic – and even each clinician – has had the freedom to choose any solution that was available, during that past 30 years. These choices have often been made arbitrarily, dependent on which vendors were knocking on the door, or other local conditions. The result is hundreds of different solutions, which cannot exchange data, because of the lack of standards, and cannot communicate, because of the lack of integration. Today, this is a hindrance for patient oriented care, and for evidence based medicine. It is also expensive. There is only one solution, which is an overall consolidation to shared systems, and a standardization of data and processes. This requires the courage to establish a top-down governance, an integrated architecture and well-financed programmes to implement the strategy".

The message exchange initiative inherited the decentralized structure from the preceding programs. The more profound problem of fragmentation was not sufficiently dealt with, and the increasing tendencies of centralization lead to a shift in the discourse.

5.2.2 Shift 1: From message-based cooperation to SOA

Programs continue despite failures until new solutions are provided. The slow progress and fragmentation of the message exchange initiatives led the authorities to tighten the control and look for a standardized model which could solve their problems. The discursive formation of IT architecture emerges, and with it the strong concept of modularization. Several architectural solutions were suggested. Once they found the SOA (Service oriented architecture), they thought they had found the remedy. SOA had been introduced in the software engineering community in the early 2000s (Erl 2009). In 2004, the national e-health group "National ICT" initiated a project for a National IT-Architecture, resulting in a large report in 2008, which recommended a completely new approach for e-health solutions, based on SOA. The aims were quite ambitious, and emphasized patient-centred care, a process perspective (instead of IT silos) and role-based services. A national architecture based on a shared information model and service bus technology was recommended.

In line with these principles, a possible pilot was available. At the most prestigious national hospital (Rikshospitalet) the IT department had developed a portal solution, based on SOA. The portal solution was built on the idea of a new layer over the silo applications that gave clinicians role-based access to various services. The solution required some re-engineering of the applications, from GUIs to services, and also dealing with a complex set of security and privacy issues.

Rikshospitalet, SOA, Gartner, National ICT were not the only actors for-fronting this strategy. The discourse on architecture gradually resulted in an internationalization of the scope, bringing foreign suppliers into the setting. A tender for a full solution was won by a New Zealand software company in 2010, and expectations were high, both in the local and national e-health communities. However, the company was not very experienced in e-health solutions, and large problems emerged during implementation.

We can see that the problem of fragmentation and slow progress leads to a discourse on IT architecture and modularization. Modularization presupposes not only a central organization of architectural decisions, but also a very mature service layer where components are related through loose coupling. The discursive formation of IT architecture thus brings with it a stronger focus on centralization and top-down governance, and a modularized solution. After one year of intensive preparations and works, the project collapsed. Why?

The change can be understood by its radical strategic shift of modular architecture. But how can the object of the discourse – fragmentation – be solved by modular architecture, instead of the more con-tiguous solution of integrated architecture? Modularity seemed as a solution by providing both top-down government as well as decentralized distribution of authority. The radical transformation is that this is difficult when the premises for modularization is not present, that is, the pre given conditions was more located in the strategies than in the reality. This lead to the second shift.

5.2.3 Shift 2: From SOA to integration

Changes are not always voluntarily, and in 2011 the Portal project was stopped after having spent around 20 million Euros. The event became a national scandal in the media, and an inquiry was conducted at the Norwegian Parliament where the leader of the Control- and Constitution Committee claimed that the project suffered mismanagement of highest order. One result of the negative press was that the term *portal* was scandalized. The e-health community embarked on a discourse on *best-of breed* (choosing different applications, and integrating them later) of *suite strategy* (choosing one, integrated solution, such as EPIC). There was now an urgent need for a new solution. The discursive for-mation of IT architecture remains, but changes first to hybrid architecture, which later turns into inte-grated architecture.

The solution consisted of choosing the EPR solution most widely used in Norway (DIPS) as the central application, and to integrate it with other systems with a service bus middleware, and "bundle" this strategy into a large architectural program called *Digital Renewal.* The program was given around 1 bn. Euro, and was initiated to standardise and implement this architecture for the 70 hospitals in the region. A separate unit, the Integration Factory (specializing on Microsoft BizTalk) (Bygstad 2016, Bygstad and Hanseth 2016), was established to program the numerous physical integrations between

the central EPR and the other clinical and administrative systems. The key project, implementing DIPS with the needed integrations, ran successfully in 2013-14. The other health regions, with one ex-ception, ran similar projects. The discourse on e-health architecture continued in the sector, but on a more sober tone; the SOA ideal models were largely put to rest, and the discussion centred on *suite* or *best-of-breed* solutions, actualised by the Copenhagen and Helsinki health authorities' decisions to ac-quire EPIC.

Even if the portal project collapses, the discursive formation of IT architecture and top-down governance remains, but shifts to a focus on consolidation. There is then continuity in discourse on IT architecture and centralization, but a change in strategy from modular to integrated architecture and sys-tems. The regional authorities reshuffled their strategies into a more realistic approach were Consoli-dation became the central concept. The fragmentation was addressed by an orderly "bottom-up" ap-proach taking the existing 4000 systems into account, but by "cleaning up the mess", removing some of them, rationalize some of them and integrate the rest.

5.2.4 Shift 3: From integration to innovation

A new discourse was entering the field in 2014, when it became clear that although Digital Renewal approach was successful, it was quite expensive, and it provided few new services, since most of the resources went to integration and consolidation. Many clinicians worried that all other IT initiatives were stopped for the lack of money, which was considered very unfortunate, because of a stream of innovations in the medical field, based on lightweight IT such as sensors, tablets and mobile technology. In addition, upstart companies complained that the heavyweight IT communities blocked access to innovations (Bygstad, 2016). This echoed an international discourse in e-health, where a *platform* strategy (Baldwin and Woodard 2008), with ecologies with large vendors and third party innovators, was becoming popular. For instance, Epic and Apple signed a co-operation agreement in 2014.

Because of the increasing discourse on innovation, HSØ established a new unit, *Medicloud*, with a mandate to explore possible solutions to connect heavyweight and lightweight IT. Medicloud, which was part of the IT Service Centre (HospitalPartner), quickly established relationships with various clinicians and upstart IT companies, and in 2015 a number of pilot projects were initiated (Øvrelid and Bygstad 2016). At the annual e-health conference, the shift in discourse was evident. Medicloud held a separate event to accommodate lightweight innovations, and the large EPR vendors assured the public that they were quite open to offer APIs to app providers.

The clinical part of the "digital renewal" program had three main goals: reduce the amount of systems; standardize remaining systems; enable integration between them through standardized messages. This orderly approach to "clean up the mess" became very expensive and very slow, and lacked inno-vation. Innovation may however challenge the existing regime. Innovation may be driven with what Bygstad (2016) calls "lightweight IT" knowledge regime which is in contrast to "Heavyweight IT" re-gime. Even though the huge project of Digital Renewal admits shortcomings and opens up for innova-tion, it is still not clear how to do it and at what cost.

The new discursive formation of innovation supported and strengthened by national and international agencies, local hospitals as well as suppliers of commodity software gathered around the object of increased flexibility through strategies of cloud-based architecture and mixed governance. The discursive formation of Innovation is thus a heterogeneous undertaking that relates to both making new products, speed up the production process as well as enabling decentralised autonomy, and there are several challenges related to how to embed it into the program. The balance between order and innovation needs to be worked out, and this is in itself a sort of transformation between existing and pre-existing paradigms of both software development and program governance.

6 Discussion

In this section, we return to our research questions. Our general contribution is that we extend infor-mation infrastructure theory by including discourse as a key factor in infrastructure evolution.

We are interested in the relationship between existing infrastructure, the emergent discourses that arises when weaknesses are identified in the existing infrastructure, and how these emergent discourses influence and change the infrastructures. Within the frame of this contribution we add to the existing literature on the role of discourse in IS in our two contributions:

- We propose an analytical framework for discourse analysis
- We use the framework to analyse the dynamics of discourse and infrastructure in strategy shifts in national e-health programmes

We used an analytical framework when analysing our data, and identified a repeating pattern of interaction of discourse and growing infrastructure. The analytical framework is an adaption of Foucault's archaeological method for identifying discursive formations, appropriated to the IS context. As Foucault is mainly interested in the content of discursive formations rather than the cause of the change from one formation to another, we have added Lakatos' insight that program shifts are caused by shortcomings or failure in the existing program. Unpacking strategic shifts understanding the object, modalities, concepts and strategies give insight into the anatomy of discursive formations presenting themselves as solutions to the acknowledged shortcoming or failure. The content of discursive formations; the object, modalities, concepts and strategies may have varying strength and impact. The insight into the different elements in the formations and their content thus enables us to gain deep knowledge on the role of discursive formations in Infrastructure evolution, as well as their varying strengths.

Our second contribution follows from the insight given by our framework. Strategic shifts are explained by the dynamic interaction between infrastructural programs and technology discourse. The discourse is conditioned by actors positioning themselves in the struggle for power of definition through defining the object, concept or strategies. Technology discourse is broad enough to make sense also for managers, strategists and politicians creating a powerful coalition providing solutions to common problems. The shifts may address challenges of varying difficulties. While challenges of minor or medium difficulty may be solved by choosing existing available options; challenges of high difficulty may require an entirely new conceptualization of the whole strategic approach. As an example there is a difference between the relatively drastic shift from local projects with decentralized authority, to a portal solution which requires an entirely new IT architectural foundation (Shift 1); and a continuation of IT architecture shifting from modularization to consolidation (shift 2). There is also a difference in the challenges related to Shift 2 and Shift 3, in that Shift 2 is a continuation while Shift 3 challenges the whole regime, introducing new challenges to governance. This detailed insight may be further investigated using the same framework. Nevertheless, the same basic rule applies to all of them: The proposed solution to an acknowledged shortcoming has to be strong enough to convince the existing programme management (politicians or strategists) that it will fit their purpose.

Generally, we contribute to information infrastructure theory (Hanseth and Lyytinen, 2010), which has not dealt much with discourses, with the exception of Ellingen and Monteiro (2008). This stream of research has emphasised that infrastructures evolve as a growth of an open installed base, adapting to changes in the environment. Our position is that discursive formations should be included in the installed base, and often play an important role in this evolution. In particular, as our case vividly illustrates, discourse plays a key role in strategy shifts. While Ellingsen and Monteiro highlighted the flexi-ble character of organising visions (allowing actors with different interests to converge), our findings document a more detailed trajectory of the cyclical nature between infrastructure and discourses.

7 Conclusions

In this study, we investigated the discourse dynamics in large e-health initiatives, through a longitu-dinal case study. We offer three new insights. First, we propose an analytical framework for investi-gating the role of discourse in infrastructural evolution. Then we use this framework to explain the shifts of the infrastructural programs and the reason for this. In general, we extend information infra-structure theory by including the discourse term into the installed base. The study was exploratory, and further research should validate our model.

References

Baldwin, C. and C. Woodward (2008). "The Architecture of Platforms: A Unified View" Working Paper 09-034, Harvard Business School

Broadbent, M., Weill P. and D. St. Clair (1999). "The implications of information technology infrastructure for Business process redesign" *MIS Quarterly* Vol. 23 No. 2, 159--182

Bygstad, B. (2008). "Information As Organization: A Critical Realist View" *ICIS 2008 Proceeding*

Bygstad, B. (2016). "Generative innovation: a comparison of lightweight and heavyweight IT." *Journal of Information Technology*, 24. May 2016, pp 1-14.

Bygstad, B. and O. Hanseth (2016). "Governing e-Health Infrastructures: Dealing with Tensions." *Thirty Seventh International Conference on Information Systems, Dublin 2016*

Ciborra, C. (2000). "From Alignment to Loose Coupling: From MedNet to www.roche.com" in Ciborra et al *From control to drift - The Dynamics of Corporate Information Infrastructures*. Oxford: Oxford University Press, 193—211

Ciborra, C., Braa, K., Cordella. A., Dahlbom. B., Failla, A., Hanseth, O., Hepsø. V., Ljungberg, J., Monteiro, E. and Simon, K.A. (2000). *From control to drift – The Dynamics of Corporate Information Infrastructures.* Oxford: Oxford University Press

Clegg, S. (1998). "Foucault, power and organizations" in McKinlay A, Starkey K (eds) *Foucault, management and organization theory: From panoptic on to technologies of Self* SAGE, London

Cohen, M., March, J.G. and J.P. Olsen (1972). "A Garbage Can Model of Organizational Choice" *Administrative Science Quarterly* 17(1), 1-25

Currie, W. L. and M. W. Guah (2007). "Conflicting institutional logics: a national programme for IT in the organisational field of healthcare" *Journal of Information Technology* (2007) 22, 235-247

Currie, W. (2014). "Translating Health IT Policy into Practice in the UK National Health Service" *Scandinavian Journal of Information Systems*, Vol. 26, Issue 2, p. 1-24

Edenius, M. (2002). "Discourse on E-Mail in Use" *IFIP TC8/WG8.2 Working Conference on Global and Organizational Discourse about Information Technology* December, 2002, Barcelona, Spain

Ellingsen, G. and E. Monteiro (2008). "The organizing vision of integrated health information systems" *Health Informatics Journal*, September 2008, vol 14, No 3, 223-236

Erl, T. (2009). *Service-Oriented Architecture -Concepts, Technology and Design* Prentice Hall, Boston

Foucault, M. (1972). *The archaeology of Knowledge* Routledge Classics London and New York

Gidlund, K. (2015). "Three Governments Living Happily Ever After: Discursive Tensions and Conflicting Epistemic Cultures in the Development of Public E-Services" *International Journal of Electronic Government Research*, 11 (3), 43-56, July-September 2015

Greenhalgh, T. Stramer K, Bratan T, Byrne E, Russell J, Hinder S. and H. Potts (2010). *The Devil's in the Detail: Final report of the independent evaluation of the Summary Care Record and HealthSpace programmes.* London: University College London; 2010.

Hacking, I. (1986). "The Archaelogy of Foucault", in Hoy, D. (ed), *Foucault: A critical Reader* Oxford, Blackwell.

Hanseth, O. and K. Lyytinen (2010). "Design theory for dynamic complexity in information infrastructures: the case of building internet." *Journal of Information Technology*, 25(1), pp.1-19.

Kuhn, T. (1996). *The Structure of Scientific Revolutions* 3rd edition University of Chicago Press

Lakatos, I. (1970). "Falsification and the Methodology of Scientific Research Programmes". in Lakatos, I., Musgrave, A. (eds) *Criticism and the growth of knowledge*, pp 91-196, Cambridge University Press 1970.

Monod, E., Truex, D. and R. Baskerville (2002). "The Discourse of a Large Organizational Transformation: The reengineering of IBM, 1989-1994" *IFIP TC8/WG8.2 Working Conference on Global and Organizational Discourse about Information Technology* December 12-14, 2002, Barcelona, Spain

Monteiro, E. (2000). "Actor-Network Theory and Information Infrastructures" in Ciborra et al (2000) *From Control to Drift – The Dynamics of Corporate Information Infrastructures*, Oxford: Oxford University Press pp. 71-87

Oliver, D., Oliver, L. (2002) "ERP Adoption: Selling the System" *IFIP TC8/WG8.2 Working Conference on Global and Organizational Discourse about Information Technology* December 12-14, 2002, Barcelona, Spain

Priemus, H., Flyvbjerg, B. and B. van Wee (Eds.). (2008). *Decision-making on mega-projects: cost-benefit analysis, planning and innovation*. Edward Elgar Publishing.

Rose, J. and P. Kræmmergaard (2002). "Dominant Technological Discourses in Action: Paradigmatic Shift in Sense Making in the Implementation of an ERP System" *IFIP TC8/WG8.2 Working Conference on Global and Organizational Discourse about Information Technology* December 12-14, 2002, Barcelona, Spain

Sauer, C. and L. P. Willcocks (2007). "Unreasonable expectations - NHS IT, Greek choruses and the games Institutions play around mega-programmes". *Journal of Information Technology*, 2007. 22: p. 195-201.

Schaanning, E. (1996). "Diskursens materialitet del 1: Foucault." in *Arr, Idèhistorisk Tidsskift*, Oslo, Norway

Swanson, E. B. (2002). "Talking the IS Innovation Walk" *IFIP TC8/WG8.2 Working Conference on Global and Organizational Discourse about Information Technology* December 12-14, 2002, Barcelona, Spain

Swanson, E. and N. C. Ramiller (1997). "The organizing vision in Information systems innovation" *Organization Science* Vol 8, no 5, pp. 458-474

Wastell, D. G (2002). "Organizational Discourse as a Social Defense: Taming the Tiger of Electronic Government". *IFIP TC8/WG8.2 Working Conference on Global and Organizational Discourse about Information Technology December* 12-14, 2002, Barcelona, Spain

Westrup, C (2002). "Discourse, Management Fashions, and ERP Systems" *IFIP TC8/WG8.2 Working Conference on Global and Organizational Discourse about Information Technology* December 12-14, 2002, Barcelona, Spain

Willcocks, L. (2004). "Foucault, Power/Knowledge and Information Systems: Reconstructing the present" in Mingers, J., Willcocks, L., P. (eds) *Social theory and Philosophy for Information Systems*, Wiley Series in Information Systems

Øvrelid, E. and B. Bygstad (2016). "Extending e-health infrastructures with lightweight IT." In *Lecture Notes in Business Information Processing*. ISSN 1865-1348. *259*, s 43- 56 . doi: 10.1007/978-3-319-43597-8_4

Spring 6-10-2017

PROCESS INNOVATION MEETS DIGITAL INFRASTRUCTURE IN A HIGH-TECH HOSPITAL

Bendik Bygstad
Dept. of Informatics, University of Oslo, Norway, bendikby@ifi.uio.no

Ole Hanseth
Dept. of Informatics, University of Oslo, Norway, oleha@ifi.uio.no

Anette Siebenherz
Østfold Hospital, Norway, Anette.Siebenherz@so-hf.no

Egil Øvrelid
Dept. of Informatics, University of Oslo,Norway, egilov@ifi.uio.no

PROCESS INNOVATION MEETS DIGITAL INFRASTRUCTURE IN A HIGH-TECH HOSPITAL

Research paper

Bendik Bygstad, Dept. of Informatics, University of Oslo, Norway, bendikby@ifi.uio.no

Ole Hanseth, Dept. of Informatics, University of Oslo, Norway, oleha@ifi.uio.no

Anette Siebenherz, Østfold Hospital, Norway, Anette.Siebenherz@so-hf.no

Egil Øvrelid, Dept. of Informatics, University of Oslo, Norway, egilov@ifi.uio.no

Abstract

Digitalisation is usually about process innovation with the use of IT, i.e. automating or informating organisational processes. However, redesigned processes are often misaligned with the underlying digital infrastructure. For instance, improving patient logistics with the help of IT is a key aim for current e-health initiatives, but has proven to be quite challenging in practice, and is sparsely dealt with in the literature. Our research question is, how can a process innovation initiative successfully interact with an underlying digital infrastructure? Our empirical evidence is an in-depth case study at a new high-tech hospital in Norway. Building on a proposed framework of interaction between process innovation and digital infrastructure, we identify and analyse two governance and two architectural mechanisms. Theoretically, we contribute to the digital infrastructure research by proposing a configuration for successful process innovation, in a complex e-health context. For practitioners, we show that lightweight IT can serve as a mediating technology in the configuration.

Keywords: Process innovation, e-health, digital infrastructure, case study

1 Introduction

Digitalisation denotes a complex transformation, where the physical and the digital are entwined and configured in new ways. Digitalisation usually includes two key elements; the redesign (or automation) of a work process or service, and some innovative use of IT. For instance, Amazon redesigned the way we buy books, and a traffic *app* in a smart phone tells us when the next bus arrives. However, in many cases the process redesign and the underlying digital infrastructure are misaligned; i.e. they do not support each other. An example from e-health illustrates this.

A common complaint from hospital patient patients is that while the medical treatment was excellent, the co-ordination between different units was poor, and the information on schedule, waiting time and further actions was often lacking (Salazar et al, 2004; Norwegian Ministry of Health, 2015). For instance, a patient may consult a doctor on a disease and is asked to take a blood test or an x-ray. The doctor (or nurse) usually cannot book this, but has to send a requisition, which is treated by the lab or radiology department, and then a reply eventually arrives. Another example: A patient is offered medical treatment on a specific date in the morning. However, when arriving at 8, the patient is told that "you will be summoned", and then sits down to wait for many hours.

There are several reasons for these practices, but the two most important are that (i) patient flow has had a lower priority than medical treatment in the functional organisation of hospitals, and (ii) therefore the organisational processes and IT solutions were designed to support medical treatment, not logistics. From the patient and societal points of view, the costs are certainly high in terms of wasted time and goodwill, and both politicians and hospital managers have launched many initiatives to meet the challenge of poor patient flow.

Two main approaches has been:

- *A process initiative*, implemented under different names such as patient logistics or flow, patient careers, or clinical pathways. They cover somewhat different aspects, but the core idea is to adopt a process perspective (initially developed in industry), that focuses on redesigning and institutionalising a sequence of work tasks.
- *An IT initiative*, which focuses on integrating the many silo systems of hospitals, in order to support a more holistic patient flow.

Ideally, the two approaches complement each other; the process innovation approach presupposes that information from different systems is available when needed, and the IT approach assumes that if the information is available, it will satisfy the need of the process. However, the experiences of the past two decades show that this is more difficult than expected, and patient logistics is still one of the most challenging tasks in modern hospitals (Van Lent et al., 2012). While process redesign is challenging in itself, a particular problem is that the installed base of IT solutions represents a considerable challenge for redesigning processes. This is not only because the IT solutions are "poor" (which is actually true in some cases), but also because silo IT solutions support organisational silos. Breaking these up is therefore a double challenge, which is easily underestimated.

Our research question is:

- *How can a process innovation initiative successfully interact with an underlying digital infrastructure?*

In this study we investigate these issues in a high-tech hospital in Norway. High-tech hospitals are characterised by *digitalisation*, i.e. in addition to advanced IT support such as clinical systems and a host of medical-technical apparatuses, they are based on a digital infrastructure, which connects the various organisational and technical parts into one integrated whole. At least, that is the ambition. To develop our argument we propose a framework to understand how the two forces interact.

2 Two Theoretical Approaches and a Framework

We first discuss research on process innovation and digital infrastructures; then present our framework. Our context is large health care solutions.

2.1 Process innovation

"All work is process work", wrote Michael Hammer (2015), and defined a business process as "a collection of activities that takes one or more kinds of input and creates an output that is of value to the customer". Process innovation is admittedly a complex and non-linear phenomenon, but we can also understand it more concretely as "the reengineering of work through information technology" (Davenport, 1994). In practice, building on Zuboff's (1988) terms, this means usually to *automate* the whole or parts of a process to make it more efficient, or to *informate* it to help users solving problems. The process innovation literature has identified several innovation-enabling IS activities, such as infrastructure flexibility, collaboration with suppliers and distributors, project management and process analysis (Tarafdar and Gordon, 2007).

While business process redesign and business process management have a long tradition in industry and retail, process thinking has proven to be more challenging in the health care sector. However, process thinking has been introduced under several labels:

- *Patient careers;* the sequential steps of logistics and treatment, has been discussed since the 1960s (McKinlay, 1967).
- *Patient logistics,* the flow of patients through the health services (Van Lent et al., 2012)
- *Clinical pathways*, denoting the steps of treatment, seen from a medical perspective (Rotter et al., 2010).
- *Hospital supply chain management,* a more systemic view of the flow of all types of resources (De Vries and Huisman, 2011).
- *Patient oriented care,* focusing on the needs of the patient, rather than the clinicians (Meijboom et al, 2011).

These terms all address a "horizontal" view of the health care services or the hospital, complementing the "vertical" view of the highly specialized medical treatment. The key aim of these approaches is to support the flow of the patient through the various services and units.

In the larger picture of inter-organisational supply chains, previous research has shown that supply chain management in a health care setting is different from the industrial sector, but that existing concepts, models and supply chain practices can be extended to supply chain management in health services (De Vries and Huisman, 2011). The process e-health literature, however, address only sparsely the role of the underlying digital infrastructure.

2.2 Digital infrastructures

Digital infrastructure research offers a quite different perspective; it regards the interconnected networks of organisations, people and technologies as the key object. Hanseth and Lyytinen defined an information infrastructure as "a shared, open (and unbounded), heterogeneous and evolving socio-technical system (which we call installed base) consisting of a set of IT capabilities and their users, operations and design." (Hanseth and Lyytinen, 2010) The heterogeneous mix of people and technologies are built on the installed base. As the installed base grows its development and growth become self-reinforcing, through cultivation.

Evolution of digital infrastructures is different than process innovation; infrastructures are not "designed", but evolve through the combined actions of many stakeholders. Some researchers have identified generative mechanisms for this evolution, such as innovation, adoption and scaling (Henfridsson and Bygstad, 2013), denoting socio-technical networks of actions. For instance, the digital infrastructure of the South-East Health region of Norway (including our case hospital) had been growing for 20 years, and included around 4.000 different applications, each with a specific user group. Scandinavian research has identified *complexity* (organisational, technical and practices) as the key challenge of e-health infrastructures Ellingsen and Bjørn, 2014). In addition, a central theme has been the tensions between local needs and global standardisation (Bjørn and Kensing, 2013, Bygstad and Hanseth, 2016).

2.3 A Framework to Deal With Conflicting Forces

Research has shown that there are some inherent conflicts between process redesign and digital infrastructures (Beverungen, 2014; Rahimi et al., 2014). From a theoretical point of view these conflicts originate in the complexities of both structures. Process complexity originates from the number and dependencies of processes, but even more importantly from the instability; innovation and improvement usually means change of processes. Digital infrastructure complexity grows with the number of elements over time, where the installed base (Hanseth and Lyytinen, 2010) of interconnected systems and established routines becomes a force in itself, which is difficult to change.

From a more practical view we observe the conflicting forces in change initiatives that include IT solutions. First, the knowledge regimes are different; the process design community is business (or organisation) oriented, while the digital infrastructure community is mainly technology oriented. Second, the plasticity is different; while processes can relatively easily be redesigned, the inertia and path dependency of the installed base of infrastructures is well documented (Hanseth and Lyytinen, 2010). Third, the time perspective differs; process redesign is usually focused on innovation and time-to-market, while the digital infrastructure people are concerned about the need for a long-term and holistic architectural perspective.

How do the two forces interact? The common approach is *projects*, where representatives for the two communities co-operate in planning and executing joint activities. Focal artifacts for co-operation are boundary objects, i.e. objects that inhabit different, but intersecting social worlds, and satisfy the informational requirements of both (Star and Griesemer, 1989). Typical boundary objects in our context are user interfaces, which mediate the interaction of a person in a process, and the underlying digital infrastructure. Thus, when process models are (re)modelled the need for information or IT services are included in the process steps. In order to accomplish this, boundary-spanning competence is critical. Tarafdar and Gordon (2007) found that IS competencies in Knowledge Management, Collaboration, Project Management, Ambidexterity, IT/Innovation Governance and Business-IS Linkages affected process innovations positively. Rahimi et al (2014) investigated the alignment between business process and IT governance, and found that the presence of mutual adjustment between business process and IT management functions was critical to support strategic and operational process and IT decision making.

At a more theoretical level Tiwana (2013) argued that two key mechanisms are available to deal with complexity in digital ecosystems; *architecture* and *governance*. Architecture denotes how the main elements are organised and interact, while governance deals with decision rights, who decides what. We build on these insights, and suggest a conceptual framework to understand the interaction between process innovation and digital infrastructure.

As Figure 1 shows we envision to different structures; on the upper part of the figure we show the redesigned processes, while the lower part shows the underlying digital infrastructure. Between them are two mediating mechanisms, governance and architecture. At a general level we can define the role of the mechanism in these terms:

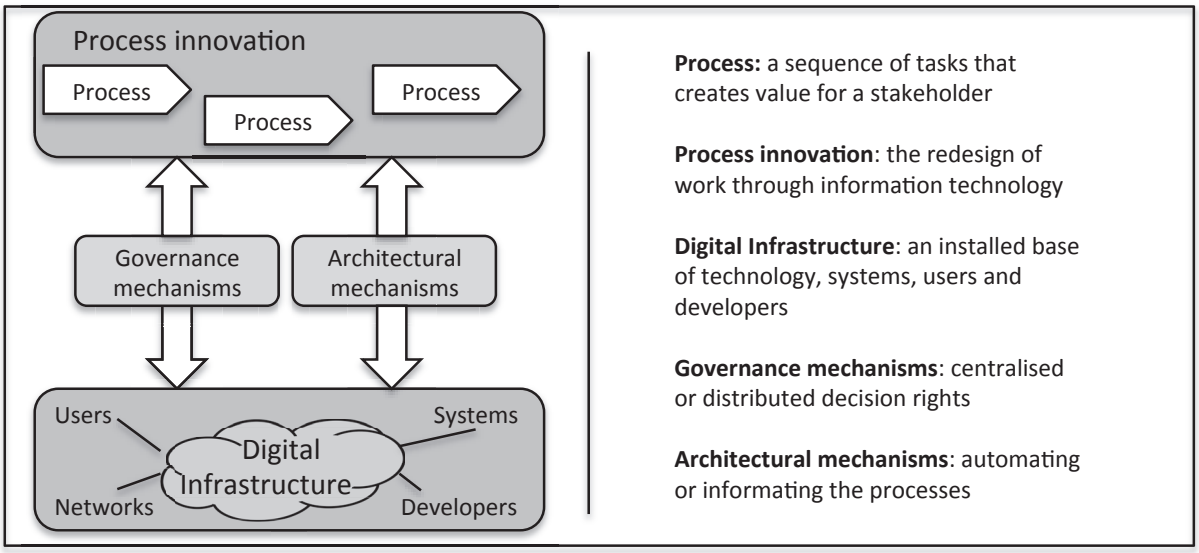


Figure 1. Framework

- G*overnance* mechanisms regulate who decides what, for instance whether the redesigned process should lead to changes in the digital infrastructure, or (the other way) whether new technologies in the infrastructure should lead to process changes. Governance mechanisms can be centralised or distributed.
- A*rchitecture* mechanisms deal with designing and implementing the technical solutions that support the processes. The nature of support can be automating (strongly structuring) or informating (providing more information for the user) the processes (Zuboff, 1988).

These definitions are our theoretical foundation, but in practice there are many unsolved questions. What is less known is under which conditions they will work, and how they actually cause outcomes. A more fine-grained investigation was needed.

3 Method

3.1 Method Approach

We chose an in-depth case study to investigate these issues, because the research question asked for a detailed investigation of a phenomenon in its real context (Yin, 2013). In selecting the case we followed Gerring's (2007) typology, and chose an *extreme case*, which is prototypical or paradigmatic of some phenomenon of interest.

Our selected case was a brand new hospital in Norway, the Østfold Hospital. It opened in the autumn 2015, and was presented as the most modern hospital in Europe, in its use of information technology and process orientation. Thus, it satisfied our key criteria; it was quite ambitious in both our objects of interest, and offered a unique opportunity to study the interplay of process design with digital infrastructure.

3.2 Data Collection and Analysis

We conducted an intensive study over one year, with interviews, observations and documents as our data sources. In line with our dual perspective we had a dual data collection strategy:

- To understand the patient logistics strategy we interviewed top managers in the health region and at the hospital, the CIO, line managers and clinicians. We also observed "whiteboard meetings" and the practical work at the emergency unit.
- To map the digital infrastructure we interviewed IT personnel at the Østfold hospital and the South-East Regional Authority and the IT Centre. We also interviewed vendors and consultants, and collected strategy plans, project plans, requirements specifications and status reports.

In order to develop *converging lines of inquiry* in a complex case (Yin, 2013*)*, we built - iteratively, as trends and topics emerged - on multiple sources. In total, we conducted 29 interviews, observed 6 sessions and collected 6 key documents. Se Table 1.

Type	**Managers**	**Clinicians**	**IT personnel and vendors**
Interviews	6	15	8
Observations	1	4	1
Documents	3		3

Table 1. Data collection

Data analysis was conducted in three steps, following a critical realist approach; from events we identified mechanisms, defined as a causal structure that causes an outcome (Bhaskar, 1998), and then

tried to understand the context under which the mechanisms were actualised (Pawson and Tilley, 1997). See Figure 2.

Figure 2. The CMO scheme

First we established a baseline of the process innovation initiative, and the digital infrastructure. Then we identified a large number of interaction episodes, and from these we identified four mechanisms; two governance and two architectural mechanisms (see Table 2). Finally, we used the Context-Mechanism-Outcome scheme to analyse the context, the interaction of mechanisms and the outcome. This allowed for a *configurational view* (El Sawy et al., 2010) on causality, which treats outcomes as a result of specific configurations, based on careful analysis of contingencies and mechanisms.

3.3 The Case

In 1999 the Norwegian Parliament decided to build a new hospital in Østfold County. Østfold Hospital is part of the South-East Regional Health Authority, which covers around half of the Norwegian population, and has 80.000 employees. The construction at the new site started in 2010, and the hospital opened in November 2015, with both somatic and psychiatric services, and 4800 employees (Fig 3).

The CEO of the hospital, Just Ebbesen, was a doctor and a pioneer in using IT to innovate and support clinical processes. He commented:

> "I had been engaged with the relationship of process innovation and IT the past 15 years, both theoretically and practically, and I knew what I wanted to achieve: hospital processes should be well defined and supported by information. The overall thinking was inspired by the theory of *value configurations* (Stabell and Fjellstad, 1999), so the Moss hospital[1] was designed as the *value chain* (dealing with the standardised high volume cases), the Østfold (Kalnes) hospital as the *value workshop* (dealing with complex diagnoses and treatment) we needed a comprehensive communication solution for the *value network* (including clinicians, staff, patients and municipalities)".

In 2011 he hired an energetic CIO with experience from production and retail, in 2012 a Process Director, and established a top management team aiming to build a hospital built on process thinking and advanced IT solutions. The process challenges included for example:

- Receiving emergency patients arriving with ambulances or by taxi, registering them, conducting triage and medical diagnoses, and requiring additional services such as lab tests or radiology.
- Allocating new hospitalised patient to wards and beds, and providing the necessary information to the staff, and to patient's family.
- Setting up a clinical pathway for each patient, and allocating various resources and services in calendars
- Ensuring that each patient received exactly the medicines that the doctor(s) had prescribed ("closed loop medication").
- Co-ordinating the discharge of patients with municipalities. For instance, the municipal care institutions required that information on an incoming patient should be sent before noon.
- Providing the kitchen with exact information on how many meals, dietary requirements, room numbers etc.
- Providing the cleaning department with timely information on which rooms to clean, and when.

[1] The Moss Hospital was part of the Østfold Hospital, situated around 30 kilometers away.

- Creating a real-time (graphical) logistics overview for management, to ensure an optimal flow of patient and use of resources

While these needs may sound straightforward, the reality is that each of them required a very careful design of the process, and that almost every step of the process was dependent on reliable information from various IT systems.

Figure 3: Østfold Hospital (Photo: HSØ)

Phase 1: Process modelling and IT piloting in old hospital 2013-15

The modelling and redesign of processes started in 2013, first in the emergency unit; later in ward. Around 25 clinicians and staff were allocated full-time to then project, plus a number of external consultants. A work group, consisting of clinicians, IT personnel, organisation development specialists and IT architects modelled 63 work processes, each of them in considerate detail, with "swim lanes" (for roles) and the need for IT support in each step. (Most of these work processes were sub-processes of 38 different clinical pathways). A separate group worked with the details of the Imatis solution, first working with process steps; later configuring the different views of the whiteboard.

The IT part was more challenging. The "regional package" consisted of more than 300 applications, maintained and run by the regional IT Centre. The key applications were the electronic patient record (EPR) system, lab system, radiology system and chart and medication system. The region was at the time running an e-health mega-program, Digital Renewal, aiming at integrating the most important (silo) systems[2] However, the integrated package was not ready, and progress was slow. After some heated discussions in 2012 the responsibility for parts of the start-up package was transferred in 2013 from the Digital Renewal program to the Østfold Hospital Project, because of the tight deadline in 2015. Both the lab system and the chart and medication system were new, and had to be integrated into the regional package at tight deadlines. An IT architecture team was established in Østfold, particularly to deal with the complex integration issues.

In addition, a new, more lightweight IT solution was specified to support logistics and communication; a system from Imatis. This was organised as a sub-project, with an external consultant as project manager, working with a group of clinicians who had modelled and redesigned many processes. The Ima-

[2] The large Digital Renewal program of the Health South-East had established a regional IT architecture with an integration framework built on Microsoft BizTalk, enabling a large number of systems to exchange data within and outside the region (see Bygstad and Hanseth, 2016). The 2010 and 2012 IT plans of Østfold Hospital included this package, with some local additions. Initially, the IT solution at Østfold Hospital was also governed by the program.

tis environment was strongly supported by top management, but the doctors, the IT departments, and the vendors were more sceptical. The CIO commented:

> "The link between processes and IT solutions were excellent, and the process modelling was very useful. But the solution was new to the regional IT Department, and integration with the clinical systems was demanding. I spent my days co-ordinating various vendors, the IT Operations and the doctors. A number of unresolved issues and questions popped up: who has the responsibility for technical integration (Vendors? The IT Centre? We?) The enormous amounts of clinical information from sensors and medical equipment – should everything be stored? And so on…"

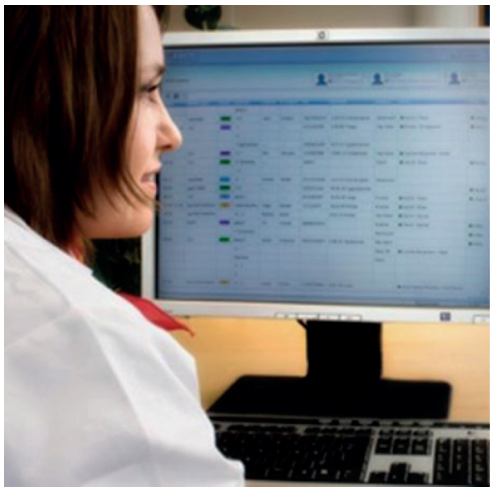
The Imatis solution was based on lightweight IT[3], and used self check-in automats, mobile phones, tablets and electronic whiteboards, which were modelled in the processes.

Phase 2: Start-up at new hospital, Nov 2015

The start-up was successful, but narrowly so. The integration solution between the major clinical systems was complex, and some improvisation and shortcuts were done, and the lab solution was a pioneer installation, with an inexperienced vendor. The hospital was also a world test-case for implementing the chart- and medication system to be used not only at surgery units, but also in wards.

The Imatis solution included three main services:

- A solution for patient self check-in and dealing with queues
- A system for visualisation of patient flow and logistics, with whiteboards (see Figure 4)
- A message broker for distribution of messages to mobile phones and other units



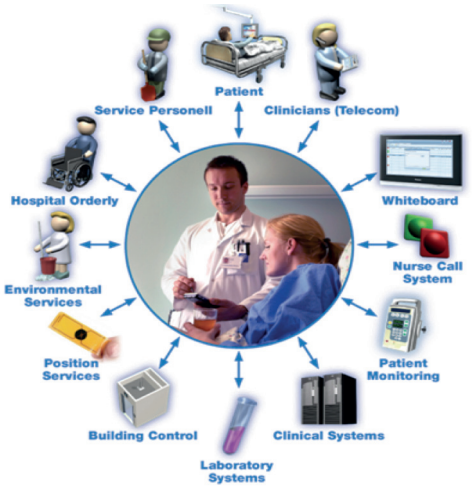


Figure 4. Nurse using whiteboard, and Imatis services (Photo: HSØ)

As seen in Figure 4 the solution was extensive, and supported the flow of information between the major clinical systems, medical surveillance instruments, ambulance systems and the mobile terminals of both clinicians and patients. Access and security were role-based, enabling flexible use of equipment. Some of the whiteboards views were too rich, and were adjusted as personnel experienced daily use.

[3] We define lightweight IT as a knowledge regime, driven by competent users' need for solutions, enabled by the consumerisation of digital technology and realized through innovation processes (Bygstad, 2016).

Phase 3: Stabilising solutions (Jan 2016-August 2016)

Several challenges were addressed in the months following the start-up. Local champions were active in motivating users in the new environment. For instance, the interplay between the emergency unit and the wards had been unsatisfactory, where the emergency co-ordinator used to call all wards to find an available bed. With the whiteboard solution she had now a visual overview of all available beds – provided that the wards had updated the situation. When this was routinized, the whole atmosphere in the wards improved a lot, because the telephones stopped ringing. "It is a completely new work situation for me", said the co-ordinator, "because the whiteboard enables me to have full overview and control of the process".

A key process indicator at a hospital is the average time of patients staying, which had increased from 3.2 in the old hospital to 3.6 days. The reason was assumed to be that the discharge process was not optimal, because the status of the patients was not changed immediately. As a consequence, available rooms were not cleaned in time. Both problems were rooted in the fact that tight logistics require a very disciplined updating of systems, and several initiatives were taken to improve on this.

A number of other issues emerged, but overall the situation in the autumn 2016 was satisfactory; a very innovative hospital had been established, for the benefit of both patients and clinicians. However, the ride had been pretty bumpy. Our key research interest was to identify the mechanisms explaining both the bumps and the success.

4 Findings

Building on our proposed framework we analysed the case in terms of governance and architectural mechanisms. Findings are summarised in Table 2. We deal with each mechanism by analysing the conflicting forces.

Type	Mechanism	Conflicting forces	Solutions
Governance mechanisms	Integrated project	Process design initiative vs. IT centre	Integrated approach: both processes and IT
	Process innovation	Process innovation vs. user habits	Soft implementation
Architectural mechanisms	System integration	Short-term hospital needs vs. regional architecture	System integration conducted at Østfold
	Lightweight IT	Lightweight IT vs. heavy-weight IT	Extensive solution (but not complete) with loose coupling to heavyweight

Table 2. Findings overview

4.1 Process design initiative vs. IT centre

The Østfold project was organised as one integrated initiative, including both physical structures, organisation and IT services. This meant that the physical architecture, the process redesign, and the supporting IT solution were all integrated in one project. The arrangement was unusual, but it gave the top management a strong negotiating position. The CEO commented:

> "If the responsibility for the IT solution had not been transferred to us in 2013, we would never have kept the deadline. Regionally, there were simply too many cooks. We had to simplify things to get the solutions running."

Through the project Østfold Hospital mobilised a large number of clinicians, administrative personnel, external consultants and local IT staff to work together to support the logistic and clinical processes with IT services. The extensive Imatis solution had to be detailed to give sufficient support, and workshops were regularly held to connect technology and tasks. Then, practical solutions with electronic whiteboards, mobile phones and tablets had to be found, dealing with many vendors.

During the project there were tensions between the project team in Østfold and the IT Operations Centre in Oslo. For the Østfold team the IT Centre was slow in responding to requests and changes, and also lacked the necessary competence with the lightweight Imatis solutions. Seen from the IT Centre the Østfold project was one of many on-going initiatives, and their expectations were often perceived as unreasonable. Tensions were gradually resolved, and the Integration Factory at the IT Centre in Oslo accomplished the demanding interplay between the Imatis lightweight solution and the regional infrastructure.

4.2 Process innovation vs. user habits

The process modelling was a fruitful joint learning arena for the clinicians and IT personnel. It resulted in an overall logistics view of the hospital, including the reception of patient from ambulances or municipalities, the flow between the medical and ward units, and the discharge of patients. It also resulted in careful redesign of many processes, supported by the new IT solutions. For instance, a new routine was the *whiteboard meeting*, a short stand-up daily meeting of doctors and nurses. The whiteboard shows a list of the current patients at the ward; the medical condition of each one is discussed, and it is decided who shall be discharged and who needs further treatment. The decisions are recorded immediately by touching the screen and changing status.

In practice, however, these process innovations were met with resistance from many clinicians. One sub-project manager commented:

> "People are emotionally connected to applications, i.e. they are used to the GUIs, the logics and the routines supported by the systems. In contrast, people feel much less loyalty to a process, which in many cases is imposed from the outside, and makes them feel insecure in conducting their habitual work".

This applied for instance to the doctor's use of solutions; they were used to using the Electronic Patient Record system, and preferred to use it also for tasks where the Imatis solution required input. This was not actively opposed.

4.3 Short-term hospital needs vs. regional architecture

The high priority and fixed deadline of the Østfold hospital had led to a situation where the responsibility for systems integration was transferred from regional level to the local project. This meant that the core clinical systems, such as the EPR, lab, radiology and chart- and medication systems were configured and tested by the project. The definite deadline required fast decisions and action, and many of the more complex regional issues, such as scaling and flexibility, were postponed. The result, as shown in the "big-bang" start-up in November 2015, was relatively successful. But the CIO reflected:

> "We have to acknowledge that while lean processes are beneficial for the clinicians, one consequence is increased complexity in the IT solutions. This leads to challenges in keeping up stability in IT operations and maintainability in our systems. But so far the solution works".

The IT Centre did not appreciate the many technical shortcuts conducted by the Østfold team, which would cause technical debt and might create problems at a later stage. For instance, after the Østfold implementation doubts were raised whether the lab solution was scalable to a regional level.

4.4 Lightweight IT vs. heavyweight IT

The most innovative and prestigious solution in Østfold was the Imatis solution, partly illustrated in Figure 4. The Imatis solution was an example of what has been called lightweight IT (Lacity and Willcocks, 2015; Bygstad, 2016); i.e. commercially available IT components, relatively easy to implement, and loosely coupled to the heavyweight systems. The Imatis solution showed how lightweight IT could mediate effectively between the processes and the existing digital infrastructure; in fact, most of the redesigned processed were informated by the solution. However, the interaction between lightweight IT and heavyweight infrastructure was demanding, and the most ambitious process aim failed for this reason.

The planned *multi-booking* solution aimed at solving one of the key process issues, namely to book the necessary resources for a clinical pathway based on a specific diagnosis. For instance, if a patient is diagnosed with breast cancer, a multi-booking system would (automatically) generate a detailed schedule for the patient, including oncologist consultations, x-ray, surgery, and other activities. The benefits would be considerable, both for the patient and for internal logistics. Unfortunately, the solution failed; although satisfactory software was tested, integration with the EPR systems proved too difficult, partly because of conflicting vendor interests.

5 Discussion

In many ways the Østfold Hospital was an impressive innovation project on a large scale, showing that process innovation can be excellently supported by the digital infrastructure, while also extending the infrastructure. It also shows how Stabell and Fjeldstad's (1998) concept of *value network* can be effectively utilised in an e-health context. Connecting the large number of actors (clinicians in various departments, hospital staff, patients and their families, municipal institutions, ambulances) into a network built on whiteboards and mobile equipment, can greatly improve logistics. This was achieved through *visualisation*, rather than automation; various actors (such as the emergency unit co-ordinator wanting to allocate patients to ward; the kitchen preparing meals; the patient waiting in a queue; the municipal care home planning reception of patients) were supplied with the necessary information at the right time, and could act rationally on it.

The solution was not just "implemented" top-down, rather it was the result of on-going innovation and negotiation. The character of these processes is the key to our theoretical contribution.

5.1 Contribution to Digital Infrastructure Theory

In accordance with critical realism (Pawson and Tilley, 1997) we theorise our finding through the CMO scheme; in a specific context, some mechanisms may cause certain outcomes. This implies that both context and mechanisms are necessary factors in explaining the outcome.

The basic governance and architecture mechanisms of ecosystems (Tiwana, 2013) and digital infrastructures (Hanseth) are well documented in research. Considering our findings we think that a reasonable interpretation of the Østfold case is that large-scale IT-enabled process innovation in a hospital was successful by a specific *configuration* (El Sawy et al, 2010) of context and mechanisms:

- The context of a brand new hospital, with some autonomy from the installed base of the regional infrastructure, offered an opportunity of innovation for an ambitious and able top management group to leverage the available mechanisms:

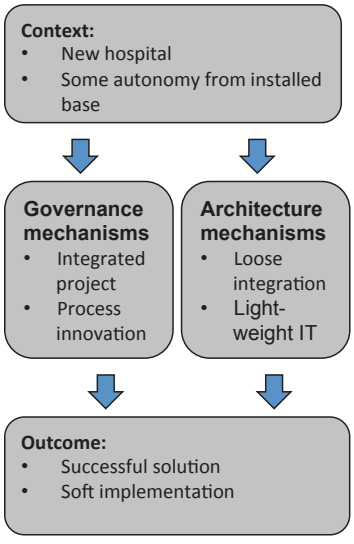


Figure 5: Configuration

- The governance mechanisms of process orientation and an integrated project allowed the managers to (i) design key processes for better patient flow and (ii) implement the new processes and technical solutions as mutually supporting elements.
- The architecture mechanisms of systems integration and lightweight IT allowed the managers to (i) connect to the existing digital infrastructure and (ii) to connect processes and infrastructure loosely, by innovative deployment of lightweight IT (Figure 5).

The attributes of lightweight IT were important, in the sense that the processes were not *automated*, i.e. strongly structured by IT, but rather *informated* (Zuboff, 1988*)*. This meant that clinical personnel were equipped with relatively flexible IT tools, such as mobile phones and electronic whiteboards, to support their tasks, but in a problem-solving way. The lightweight tools could also be reconfigured by local IT staff if needed. Therefore, lightweight IT is a part of our suggested configuration, enabling incremental design and implementation.

An important aspect is how the governance and architectural mechanisms interact, and may reinforce each other. For instance, in the Østfold case an obvious success factor was that the integrated project supported the technical solutions much better than a regional project would have done, and vice versa, the success of the lightweight architecture increased the legitimacy of the project.

Would the same have been feasible in another context, for instance in an established hospital? It is possible, but evidence from many failed similar initiatives (Ellingsen et al, 2013; Bjørn and Kensing, 2013) suggests that it would have been much more challenging. Our contribution to digital infrastructure theory (Hanseth and Lyytinen, 2010) is therefore *configurational* (El Sawy et al., 2010): it shows a causal pathway for extending infrastructure theory by a context of loose coupling, but with sufficient governance and architectural links to the larger infrastructure. We also extend the Scandinavian e-health research by proposing an alternative approach for dealing with the complexity issues.

5.2 Contribution to Practice

The practical contribution can be summarised in the following.

First, connecting process innovation and digital infrastructure is necessary for the success of such initiatives, but the case illustrates that large digital infrastructures cannot be "designed" top down, but evolve through governance and architectural growth. As illustrated in the Østfold case a careful use of the governance and architectural mechanisms may enable beneficial solutions.

Second, the role of lightweight IT shows how an intermediating technology, relatively loosely coupled to the digital infrastructure, offers the agility and flexibility to support process innovation. It also shows a way forward, to more platform-oriented solutions (Tiwana, 2013) in e-health, in the sense that it decouples lightweight interfaces from the main applications.

Finally, competence is critical. In the Østfold there was a fortunate mix of competences; a visionary CEO, a process oriented director of development, and a hands-on CIO, who worked equally enthusiastic with architectural issues as with mobile phone configurations. Also, the technical teams both at the hospital and at the Data Centre worked hard to solve problems, and gradually acquired the necessary competence.

6 Conclusion

Digitalisation is a convenient term, but denotes an extremely complex transformation, where the physical and the digital are entwined and configured in new ways. It includes usually both process innovation and a changing digital infrastructure. In this paper we investigated the interaction of these two forces in a high-tech hospital.

Our main contribution is a new *configuration* of how process innovation in e-health can successfully interact with a large existing digital infrastructure; the key is an integrated project with relatively loose

coupling to the digital infrastructure, but still allowed to draw on its resources. This configuration is not smooth; it requires on-going negotiation between conflicting forces, and it requires the courage to accept a less streamlined development. This, however, is perhaps the characteristic of digital innovation?

References

Beverungen, D. (2014). "Exploring the Interplay of the Design and Emergence of Business Processes as Organizational Routines", *Business & Information Systems Engineering*, 6 (2014), pp. 191-202.

Bhaskar, R. (1998). "General Introduction", in M.S. Archer, R. Bhaskar, A. Collier, T. Lawson and A. Norrie (eds.) *Critical Realism: Essential readings*, London: Routledge, pp. ix–xxiv.

Bjørn, P., and Kensing, F., (2013). Special Issue on Information Infrastructures for Healthcare: The Global and Local Relation. *International journal of Medical Informatics*, (82:5):281- 282.

Bygstad, B. (2016). Generative innovation: a comparison of lightweight and heavyweight IT. *Journal of Information Technology*, doi: 10.1057/jit.2016.15.

Bygstad, B. and Hanseth, O. (2016). "Governing e-Health Infrastructures: Dealing with Tensions". *Proceedings of the 37rd International Conference of Information Systems (ICIS),* Dublin, Ireland.

Davenport, T. (1994) *Process Innovation*. Cambridge, MA: Harvard Business School Press.

De Vries, J., Huijsman, R. (2011) "Supply chain management in health services: an overview", *Supply Chain Management: An International Journal*, Vol. 16 Iss: 3, pp.159 – 165.

Ellingsen, G. and Bjorn, P. (2014) "Special Issue Editorial. Information Infrastructures in Healthcare. Action Research, Interventions, and Participatory Design," *Scandinavian Journal of Information Systems*, 26(2), article 2.

Ellingsen, G., Monteiro, E., and Røed, K., (2013). "Integration as interdependent workaround". *International Journal of Medical Informatics*, (82): 161-169.

El Sawy, O. A., Malhotra, A., Park, Y., and Pavlou, P.A. 2010. "Seeking the Configurations of Digital Ecodynamics: It Takes Three to Tango," *Information Systems Research* (21:4), pp.835-848.

Gerring, J. 2007. *Case Study Research: Principles and Practices*, New York: Cambridge University Press.

Hanseth, O., and Lyytinen, K. 2010. "Design Theory for Dynamic Complexity in Information Infrastructures: The Case of Building Internet," *Journal of Information Technology* (25), pp. 1-19.

Henfridsson, O. and Bygstad, B. (2013). "The Generative Mechanisms of Digital Infrastructure Evolution". *MIS Quarterly*, 37(3):907-931.

Hammer, M. (2015). What is business process management? In vom Brocke, J., Roseman, M. (eds) *Handbook on business process management* 1: Introduction, methods and information systems. (2nd Edition, pp. 3–16). New York: Springer.

Lacity, M. and Willcocks, L. (2015). "Robotic Process Automation at Telefonica O2". *MIS Quarterly Executive* 15(1): 21–35.

Norwegian Ministry of Health. (2015). Prop. 125.

McKinlay,J.B. (1967). "The concept "patient career" as a heuristic device for making medical sociology relevant to medical students." *Social Science & Medicine,* 5(5):441-460.

Meijboom, B., Schmidt-Bakx, S., Westert, G. (2011). "Supply chain management practices for improving patient oriented care", *Supply Chain Management: An International Journal*, (2011) Vol. 16 Iss: 3, pp.166 - 175

Pawson, R., and Tilley, N. 1997. *Realistic Evaluation*, London: Sage Publications.

Rahimi, F., Møller, C., & Hvam, L. (2014). "Alignment between business process governance and IT governance". In *Proceedings of Twentieth Americas Conference on Information Systems*.

Rotter T, Kinsman L, James EL, Machotta A, Gothe H, Willis J, Snow P, Kugler J. (2010). "Clinical pathways: effects on professional practice, patient outcomes, length of stay and hospital costs (Review)". *Cochrane Database of Systematic Reviews*

Salazar, A., Ortiga, B., Escarrabill, J., Corbella, X. (2004). "Emergency department complaints: A 12 year study in a University hospital". *Annals of Emergency Medicine*, 44 (4) (2004), p. 520

Stabell C.B. and Fjeldstad O.D. 1998. "Configuring value for competitive advantage: on chains, shops, and networks". *Strategic Management Journal,* 19(5):413-437.

Star, S.L., and Griesemer, J. (1989). ''Institutional Ecology, 'Translations' and Boundary Objects: Amateurs and Professionals in Berkeley's Museum of Vertebrate Zoology, 1907-39.'' *Social Studies of Science* 19 (3): 387-420.

Tarafdar, M. and Gordon, S. (2007). 'Understanding the influence of information systems competencies on process innovation: a resource-based view'. *Journal of Strategic Information Systems*, 16, 353–92.

Tiwana, A. (2013), *Platform Ecosystems : Aligning Architecture, Governance, and Strategy*, Morgan Kaufmann, Waltham, MA.

Van Lent, W.A.M., Sanders, E.M., & Van Harten, W.H. (2012). "Exploring improvements in patient logistics in Dutch hospitals with a survey". *BMC Health Services Research*, 12, 232–240.

Yin, R. (2013). *Case Study Research*. Sage Publications.

Zuboff, S. (1988). *In the Age of the Smart Machine*, Basic Books, New York.

Process innovation with lightweight IT at an emergency unit

Egil Øvrelid
University of Oslo
egilov@ifi.uio.no

Marit Røed Halvorsen
Oslo Municipality, Health Section
marit.roed.halvorsen@hel.oslo.kommune.no

Abstract

In this paper, we are studying the role of lightweight IT in process innovation. Our research question is how can lightweight IT support process innovation within an established e-health information infrastructure? Our empirical evidence is a qualitative case study at a primary care emergency service in Oslo. We provide two contributions. First, applying the lens of business process innovation to the literature on information infrastructures, we retain the value of the installed base, while we at the same time ad speed to the implementation project. Second, we demonstrate the role of lightweight technology in improving logistics and message interaction within and between health units. The lightweight technologies availability on the commercial market makes acquisition and implementation faster. Based on this, we briefly suggest a "bypassing strategy" where a new layer of technology is built separately from the existing infrastructure in order to effectively address process innovation efforts.

1. Introduction

The modern society of today where the population is increasingly concerned about health, add an extra burden to the organization of health services, their accessibility, as well as the cost for providing these services [1, 2, 19, 31, 32]. The Healthcare System has traditionally been praiseworthy occupied with qualitative patient care, and the IT systems that surround clinical practice has primarily concentrated on clinical processes with the mission of securing practice. A drawback of this orientation is that hospitals are struggling with logistics both internally and externally, as clinical systems focus on optimization of clinical practice, not on horizontal process support [6]. A usual complaint from patients is thus that while the treatment was excellent, the coordination between units was slow, the waiting time long, and feedback almost nonexistent [3, 4]. This is partly caused by the significant difficulties in streamlining the supply chain [5]. One of the main consequences of these challenges is that innovation efforts in the health sector once initiated tend to lose steam, and slow down [19, 31].

Addressing these challenges requires the optimization through redesign of processes and digitalization of IT, and modern innovative "lightweight" IT have shown promising tendencies in establishing process improvement [10, 27, 28]. We will follow-up on these promising studies by looking into the role of lightweight technologies in process innovation. Accordingly, this research attempt to answer the following research questions: How can lightweight IT support process innovation within an established e-health information infrastructure? This perspective includes looking into the role of the organizational installed base and the role of innovative technology in process innovation.

We proceed by related research from the field of information infrastructure [7]. Incremental and path dependent change has been more central than process innovation in this literature. We then move on to describe Hammer and Champys [29, 30] important and original insight in how to use IT to transform modern organizations business processes, but balance it with a more 'nuanced' approach provided by Melao and Pidd [34]. We adopt the term "installed base" [7] from information infrastructure literature in order to frame and understand the importance of retaining some aspects of the pre-existing sociotechnical layers of rules, regulations, and technological tools in process innovation initiatives in the healthcare system.

2. Information infrastructures and lightweight IT

We see information systems as information infrastructures and are interested in how they evolve. Information infrastructures are sociotechnical layers of technology, people, regulations, policies, tools and facilities formed over time [7, 8, 13, 33]. The historically accumulated installed base, which is a central aspect of the infrastructures nature, have a strong conservative influence [8]. This means that all

URI: http://hdl.handle.net/10125/50280
ISBN: 978-0-9981331-1-9

change and innovation has to consider the installed base. Information infrastructures have to be carefully cultivated [18, 33]. Bootstrapping is a particular form of cultivation in that it focus on usefulness, and that change has to be carefully performed step-by-step [7, 33]. A prerequisite for change is thus that the existing conditions are understood and taken into account. This can make process innovation challenging and slow. Information infrastructures may turn into path dependent silo structures which resists external innovation [8, 13, 33]. This resistance is also conditioned by power in that it is "driven by IT professionals, enabled by systematic specification and proven digital technology, and realized through software engineering" [10:2]. Bygstad [10] label this regime "heavyweight IT".

Process innovation initiatives interested in relatively fast results [15] will have to look for new ways of avoiding or changing the existing regime, and an emerging stream within IS research is the field on Internet-of-things, tablets, smartphones and whiteboards. Bygstad [10] conceptualize this as "lightweight IT". Important features with lightweight IT is its mobile and remote characteristics enabling system access through apps implemented on handheld devices, or automation of white-collar work through interfaces for enabling easier implementation of service automation tools [10, 11, 12].

Lightweight IT is not only a technology but also a knowledge regime with at least three central characteristics. *One* is the nature of the artefact, its usability, its occupation with improving processes and its easiness in implementation. This technology have according to [10] the ability to bypass the existing infrastructure when it is implemented. The *second* characteristic is the providers' ability to quickly follow up pilots, and implementations, so that users and organizations may experiment on and test new functionality. Finally, the *third*, which is the acquisition opportunity, the availability of the product on the commercial market [10].

In this paper, we look at a particular case of lightweight IT, electronic whiteboards, and its impact on change processes. This has been done before. The literature on computer supported cooperative work, human-computer interaction, medical informatics and health informatics, demonstrates the mediating ability of electronic whiteboards across practices [16, 17]. Through improving the visual overview [20], whiteboards serves a coordinative function [21, 26]. The findings from these studies highlights the whiteboards adaptability to a complex practice [20, 22, 23, 24], more than cross-sectional information flow. These findings also address technical solutions developed in-house and thus not made available on the commercial market. We are interested in two other aspects of lightweight technology in process innovation initiatives. First we shed light on the role of commercially available innovative technology and its impact on process innovation initiatives. Second we investigate the electronic whiteboards role in improving horizontal processes within or across departments. To inform our empirical case we use the process innovation literature, which helps us identify central business processes and their characteristics

3. Process innovation

Business Process Reengineering's (BPR) main message was that organizations have to remove manual work, and use information technology to radically innovate end-to-end (horizontal) processes [29, 30]. Hammer [30] outlines six principles for implementing end-to-end processes using the power of IT. *First*, organize around outcomes instead of tasks. *Second*, those who use the output should perform the process. *Third*, make sure that real work that produces the information replaces information-processing work. *Fourth*, link instead of integrate parallel activities. *Fifth*, connect performance and decisions, and build control into the process. *Sixth*, capture information once, and at the source.

Hammer and Champy emphasized the need to understand the services delivered to the customer in their totality, and modern technology's ability to exceed existing barriers in enabling organizational change. BPRs lack of organizational dimensions and the tendency of top down managerial sidedness was, however, a significant shortcoming. As processes are complex organizational phenomena where workers attached to different parts of the organizations are collaborating, a more nuanced view of processes, and a systematic approach to understand them, was needed [34]. A weakness in the BPR approach is the way they ignore the importance of historical learning and adaptation as well as the existence of rules, regulations, and technological components that has gradually accumulated. In the literature on information infrastructures, this "installed base" [7] is an important point of departure, and acknowledges the step-by-step emergence of collaborative networks in organizations [33, 34].

Melao and Pidds [34] four perspectives on end-to-end processes, combine a top-down management perspective with a heterogeneous bottom-up understanding of organizational change. In every organization there will be processes which can be streamlined and improved pretty fast, while other more complex processes will take longer time.

Their first perspective **business processes as deterministic machines** concerns breaking tasks into well-defined operations performed rigorously without deviations. This requires well-understood processes where intervention based on human knowledge is minimized. The *second* perspective, **business processes as complex dynamic systems,** regards the dynamics and interactive features of processes. Neither in this perspective is human characteristics and human communication seen as important feedback mechanisms when adjusting system performance. It is thus most appropriate on well-defined processes and tasks that require limited adjustment. The *third* perspective, **business processes as interacting feedback loops** includes interactions with the wider environment. Decision-making based on feedback gives a more bureaucratic approach where human actors must intervene in particular situations to ensure that processes go ahead according to policies and other criteria. This perspective fits well to foster learning through the identification of information flow and critical decision points, as well as the activities that go along with it. The *fourth* perspective, **business processes as social constructs** emphasize processes as made and enacted by actors with special knowledge, different values, expectations and (possible hidden) agendas. The knowledge related activities requires wider value-related frames of interpretation. Although some standardization is necessary, the autonomy of work is important to enhance learning and improved understanding.

In summary, the early BPR literature is still very relevant as a source for process innovation, and important when innovating sociotechnical information infrastructures. As changes in health care settings and educational institutions should result from negotiations and compromises, the installed base has to be taken into account [7, 13, 33, 34]. In Melao and Pidds approach, this perspective is included but it is not clear in what way the installed base influence the process modeling. Nor do they elaborate on activities associated with digitalizing business processes.

In section 5 and 6 we describe and analyze the consequences of process innovation in a health care setting where the installed base has to be taken into account, but also how process innovation may improve business processes using digital technology. First we describe our methodological approach.

4. Method

In 2010, the Health South East region in Norway decided to shut down Aker Hospital as a part of the Oslo University Hospital merging. Protests from the citizens kept the hospital open, and in 2016 Health South East announced that Aker is a part of their future plans. The SAMKAD project (Interaction at KAD) established in 2014 started as a project for improving internal capacity utilization, and then became a part of a bigger initiative to improve interaction between health units. SAMKAD address a challenge outlined in the national coordination reform, which says that it is "particularly important to ensure good coordination when the responsibility for the patient moves between hospitals and municipalities, and between departments and units within hospitals and municipalities. Good cooperation and relocation to local medical centers can help it" [35]. Nevertheless, several reports are pointing at difficulties in the current interaction between primary and secondary sector [25], difficulties caused by poor communication [14, 39].

SAMKAD has gradually turned into a complex project where AKER collaborate with 4 hospitals, 60 nursing homes in 15 neighborhoods and in total 660 general practitioners.

4.1. Data Collection

Our research approach is a qualitative case study [9] inspired by engaged scholarship [36, 37]. In this type of research, the informant's role is not only about verification of factual data, but also in constructing the narrative and in some cases to be a qualified participant in discussing theoretical and practical implications [37]. In this framing research becomes a collaborative approach between knowledgeable researchers and practitioners that together secures and improves the research findings [36, 37]. One of the authors of this paper was central in the process of acquiring the technology as well as the preparation and implementation of organizational changes. We used data from the longitudinal implementation project that lasted two years to reconstruct planning and implementation of the technology.

From November 2015 to January 2017, we collected data using qualitative methods and performed in total 20 interviews; 9 with clinicians, 7 with project leader, and 4 with technical expertise. In order to investigate the technological impact on the organization we had three rounds of observations (around 25 hrs.) over a period of one month. We followed up with new interviews as well as analyzes of around 20 documents on workshop results, treatment regulations, political requirements as well as technical descriptions.

4.2. Data analyzes

The studies core interest relates to the ongoing debate

on differences between the classical EPR systems, their change difficulties, and the innovative technology to improve this [10, 12]. We started by asking project managers about the acquisition process and the performance of the supplier during the implementation and follow-up. We also asked how they used existing resources like role descriptions, regulations and technological tools when they planned and implemented the technology. During the study the role of SINTEF, an expert organization on industrial processes, was emphasized. SINTEF and SAMKAD created a "24 hrs. at KAD" visual map which gave KAD a way of expressing and understanding their existing processes and to identify significant challenges in the way they worked. We asked project management and section managers how they organized the planning and implementation phase, and the role of the clinicians in this activity. During the fieldwork we asked doctors and nurses questions like: have the whiteboards changed your practice in any way? Have you gained anything from this change? Based on this we established a chronology of the projects development (step 1 in table 1).

Table 1: Data analyses

Step	Description	Output
1	Establishing a chronology 2014-17	Section 5
2	Identified five challenges and three development phases	Section 5
3	Analyzing SAMKAD we identified 4 aspects of process innovation	Section 6
4	Two contributions	Section 7

We identified five challenges addressed in three phases (step 2 in table 1). Using Melao and Pidd [34] we identified 4 aspects of process innovation (step 3). Combining [34], [7] and [10] we provide two contributions (step 4). Our data show that Hammer and Champys [29] original scope is still very relevant, and that Melao and Pidds [34] four perspectives on business processes extends Hammer and Champy in taking the impact of organizational and technological legacy into account. We proceed by describing our case study, before we analyze the case using the lens of process theory.

5. Process innovation at Aker

Following Hammer and Champy [29] process innovation is about removing bottlenecks, manual work, and double work in order to facilitate horizontal performance. Aker had several practical challenges they wanted to solve in order to improve their internal performance and consequently enable process innovation. Their process innovation list derived from our data collection and analyzes included:

- Improving the routines for patient admission, and discharge.
- Improving the overview so that the physician on duty can find and book available rooms.
- Providing kitchen and cleaning personnel with information on meals, dietary requirements and room numbers.
- Improving communication during shifts of clinical personnel.
- Improving the interaction with the city neighborhoods to reduce amount of time used for message writing and phone conversation afterwards.

This may seem straightforward but SAMKAD needed to carefully design all the new processes and how ICT systems should be used to support them. They divided the project into two parts: (1) Improving internal logistics, and (2) improving interaction with city neighborhoods through more effective message exchange. In phase 1 and 2 we briefly portray the process of acquiring the technology, and the way SAMKAD worked to improve internal processes. Then in phase 3 we describe SAMKADs solution to improve the interaction with city neighborhoods.

Phase 1: Acquiring whiteboard technology and analyze the existing processes

At Aker emergency unit (KAD), they had difficulties in keeping up with the pace of arriving patients and treatment requirements. Their process innovation initiative started with a parallel process of defining software requirements, and analyzing existing processes. The project of SAMKAD was established to address this. The project managers at SAMKAD were disappointed with the lack of interest from the existing EPR vendors to participate in the change process. The existing systems needed a lot of modification to enable a more efficient process support, as "static systems are not suitable in an efficient production," (clinician). Accordingly, SAMKAD had to apply for external funding, both for acquiring technology and for establishing and implementing the project. One of the project managers had worked with a whiteboard and mobile supplier called Imatis in an earlier project, and initiated a cooperation with them. SAMKAD implemented Imatis technology after only three months, first

separated from the existing information infrastructure. Usually changing the digital infrastructure takes months sometimes years. To fulfill health security regulations and to enable cooperation between KAD, Imatis technology and Oslo Municipality, Imatis moved their cloud from Amsterdam and into the technological regime of Oslo Municipality. Oslo Municipality then granted access to Imatis installations between city districts of Stovner, Østensjø and KAD so that information could be exchanged using similar formats.

SAMKAD and SINTEF, an expert organization on industrial processes, developed a detailed analyzes of the existing treatment processes and called it "24 hrs at KAD". The map was divided into two parts, separated by a horizontal timeline in the middle. The upper parts dealt with requirements expressed by the patients, while the lower parts of the map described clinical activities and concerns. The map displays in detail both important and more regular concerns. Through the visualization SAMKAD was able to identify 'the peak', a certain point during the day when patients are admitted while the discharge of the patients lags behind, making a congestions of patient concerns and clinical activities. The result was that potentially seriously ill patients had to wait.

The work on designing the map was a collective effort where approximately 25 workers from several departments participated. The collaboration enabled a better understanding of the reasons for the occurrence of 'the peak'. Through the workshops, SAMKAD identified several areas of improvements. The project leader emphasize the collective effort: "We have a high degree of employee involvement. This is tremendously challenging, but it raises the quality of our services." The work and the analyzes leading to the visual map enabled SAMKAD to look for processes which could be digitalized relatively fast and identified the ones related to patient admission, discharged patients, challenges related to work shifts, and exchanging effective information between KAD and other health units.

Phase 2: Using Whiteboard technology to improve internal processes

After the comprehensive analyzes of activities during 24 hours at KAD, SAMKAD wanted to improve selected processes. Imatis Whiteboard was installed after three months. It is an agile contrast to the classic record systems. "The classic systems are very slow"…"very difficult to use to improve efficiency" (doctor)…"they don't harmonize with the way we are working", and "are best to use when working with one patient at a time" (nurse). The doctor sums it up by saying, "our challenges have different requirements", and "the collaboration with Imatis gave benefits quickly". Patients arrive at KAD from several sources (left squares of figure 1). The physician on duty decides the patient admission to Aker, and select KAD ward. Two examples (2A and 2B) describe areas where whiteboard technology has influenced the process, and the result of this.

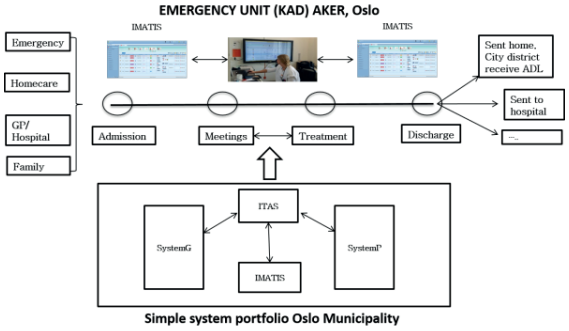


Figure 1: Patient flow and technical regime

2A. Admission and discharge

The physician on duty is writing record notes in SystemP when her phone rings. She receives a request for admission to KAD. The doctor looks up the patient in SystemP, asks some questions about the general condition of the patient, and chooses a unit for the patient admission. She registers the information in SystemP and in Imatis. In Imatis the field "Registered" is marked. The nurses at the receiving unit reads the information, clarifies the room, and make sure that the necessary resources are booked. "This is a considerable improvement, especially the registering and notification that a patient is arriving," the doctor says. Earlier they had to write paper notes and give it to the caretaking nurse by hand. If the physician on duty was positioned in another unit, this activity could take time. Now everyone in the department can immediately see the information displayed on the whiteboards. The same applies to discharge of patients. Since KAD is an emergency unit, with short-term admissions, it is very important to have overview of the internal resources. The whiteboard technology visualizes the availability of rooms and other resources. Cleaning and kitchen personnel have access to their own 'view', enabling a more efficient planning of basic services. Nurses and clinicians including the physician on duty can now answer incoming requests right away.

2B. Morning department meetings

Since the whiteboards display patient information, including responsible clinician and treatment status, they are a central resource in the morning department

meetings. Management uses the meeting to repeat general focus on treatment areas. The night nurses use whiteboards to update the day shift on patient statuses. It is as an example very easy to update the patient lists by using drag and drop functionality, when assigning a new responsible nurse to a patient. When family members are visiting the patients, the nurses instantly identifies the room where the patient is located.

Phase 3: Message interaction between Health units

The second challenge for the SAMKAD project was to improve the interaction between KAD and city neighborhoods. Patients arriving at KAD are often senior citizens that receive homecare from the city district they live in. The city districts and KAD exchange information, but KAD also exchange patients and documentation with other health units.

As the city districts have the caretaking responsibility for the citizen, KAD send care messages through the record system after the treatment. These messages are comprehensive, partly unstructured and it is sometimes difficult for the receiver to "grasp" the most important issues regarding the condition of the patient. The city districts called KAD by phone several times in order to understand what the message content really meant. There was a need for improving the interaction through more effective and distinct messages. In cooperation with two city districts Stovner and Østensjø, SAMKAD created a message structure in Imatis using ADL-standard and are currently performing a pilot-project on these messages. The ADL structure is simpler than the care messages and easier to standardize using a numeric system to describe the condition of the patient.

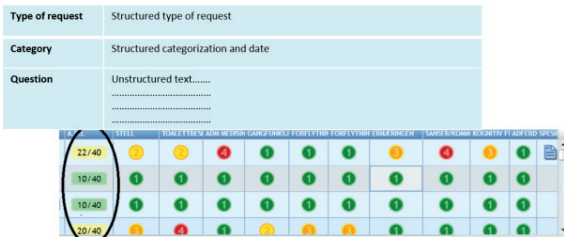


Figure 2: Difference between care messages and ADL [1]

Several informants' expresses positive views on the change: "The standardization of ADL gives us a more systematic description, and less deviation," a nurse said. "It is easier to use", said another and "it is much easier to immediately identify the important information", according to a third.

In this section we described SAMKADs collective organizational approach where the work processes was analyzed, and improvement areas was identified. The improvements concerned important patient flow processes both within and across hospital units. In section 6 we will elaborate on these issues.

A possible shortcoming in the current installation is the lack of integration between the record system(s) SystemG (city districts) and SystemP (General practitioners) and Imatis. Main suppliers (of SystemG and SystemP) have refused to give access to their interfaces. The ongoing work to enable integration between the record systems and Imatis is done by the municipality, not the suppliers (see lower parts of figure 1). Oslo Municipality has currently initiated a new strategy for "welfare technology", and the SAMKAD innovation project is a part of this, enabling further improvements in the interaction between different Health units and KAD. In 6.4 we address this issue.

6. Analyzes

In this section, we will analyze the case using Melao and Pidds [34] four perspectives of business processes. 6.1 is related to findings in Phase 1 in Section 5 in the way that SAMKAD made important use of their existing practices, rules and regulations when they innovated their processes. Through the participation from organizational actors' processes that was relatively easy to improve was identified. 6.2 is based on findings from Phase 2 where the processes identified in Phase 1 is digitalized. Also in complex hospital settings processes that are relatively straightforward exists, and digitalization may in some cases give improvements relatively fast. 6.3 is based on Phase 3 where SAMKAD improved their message exchange with city neighborhoods, and relates to Melao and Pidds connection between internal and external units through interacting feedback loops. 6.4 is derived from the analyzes of the project events, and is particularly based on Phase 2 and 3 where the role of lightweight technology came forward as of significant importance in making the project successful.

[1] Activities in Daily Life (ADL), structured into distinct categories like walking ability, medication, cognitive ability, danger of falling, nutrition, etc.

6.1. Using installed base in process innovation

At KAD emergency unit, they had significant challenges with the patient flow, and in getting overview of available resources like clinicians, rooms and equipment. They used paper notes to communicate, and walked long distance to deliver them. The improvement process started establishing a detailed overview of all process related aspects. The result was a comprehensive map that became a fundamental and collective entity to identify areas of improvement in at least two ways. *First* as noted by Melao and Pidd [34], business processes may be social constructs i.e. processes partly made by people with different values, expectations and agendas and special knowledge. In health and educational institutions, autonomy of work is of particular importance, the "installed base" [7] has to be taken into account, as change often happens through a collective analytical process conditioned by negotiations and compromises [13, 33, 34].

Second, complex "enmeshed" processes may consist of simpler elements that may be improved relatively fast. Melao and Pidds second perspective puts faith in the dynamics and interactive features of processes, where feedback mechanisms are standardized, systematized, and automatized. It is thus most appropriate on well-defined processes that require little adjustment. At KAD the collective approach on the complex map, helped them identifying areas of adjustment, while the electronic whiteboard enabled implementation of required changes.

Table 2: Analyzes Phase 1

Melao and Pidd	SAMKAD Phase 1
Business processes as social constructs i.e processes as made and enacted by people with different values, expectations and agendas as well as special knowledge.	"24 hrs at KAD" is made based on input from workers, existing rules and regulations. Peoples values and expectations are used as a central resource for process innovation.
Business processes as complex dynamic systems i.e the dynamics and interactive features of processes.	KAD identified processes that could be improved, and extended the understanding of their own organization.

6.2. Lightweight IT in process innovation

At KAD, the implementation of electronic whiteboards led to improvements on several areas. *First*, using the whiteboard for processes of admission and discharge of patients made communication more effective. *Second* the use of the same technology for cleaning and kitchen personnel to dynamically gain information on what to do and when, improved the preparation of rooms and food. In addition, the visualization of the information on the electronic whiteboards gave a better overview of the patients and the treatment status and consequently improved communication during meetings. Relating to Melao and Pidds perspectives we see that whiteboards has the ability to improve logistics in relatively static operations by sending electronic messages to key actors when something has to be done. Cleaning and foodservices operate relatively independent of patient treatment processes, and can be planned separately. Following Hammers [30] six principles for improvement, KAD is now occupied with the relation between tasks and outcomes; they have partly automated communication so that there is a more effective relation between the process performer and the information receiver. Decisions are immediately displayed on the whiteboard, improved messages have reduced double work, and there is less manual communication on logistics. Integration between systems may further reduce double work.

Table 3: Analyzes Phase 2

Melao and Pidd	SAMKAD Phase 2
Business processes as deterministic machines: breaking tasks into well-defined operations that can be performed without deviations.	Improve logistics: the admission and discharge of patients, as well as the cleaning of rooms and preparation of food.

6.3. Improving message exchange

Efficient communication may improve treatment quality. KADs communication with city districts was inefficient. The care messages were comprehensive, and thorough, but the city districts nevertheless needed clarifications. The improved messages, which took the requirements in the interacting feedback loops seriously, led to fewer phone calls, a more standardized and distinct message format, which clarified status when the patient was sent home from KAD. These improvements may lead to releasement of important resources. *Second*, on a more general level, the SAMKAD project is about improving horizontal processes across hospital units. The complex map "24 hrs. at KAD" enabled the clinicians to see their role as an actor in a bigger system where patients move between health units. KADs collaboration with fifteen city districts and four

hospitals requires a deep insight into internal and external conditions for dynamic interaction, and lightweight IT has a promising ability in facilitating this.

Table 4: Analyzes Phase 3

Melao and Pidd	SAMKAD Phase 3
Business processes as interacting feedback loops performance and a wider set of interactions, according to policies and other parts of the wider environment which may affect the processes.	Improve interaction through collaborations on standardization.

In summary, KADs combination of a collective approach to understand their challenges (Melao and Pidds second and fourth perspective) was a prerequisite to identify logistical and interactive improvements (perspective one and three)

6.4. Using lightweight IT in a "bypassing strategy."

We describe the process at KAD in three steps. *First,* process innovation, and the technology needed to innovate, challenged the existing regimes, and the resistance from several stakeholders made the implementation of the solution a challenging task. *Second*, the SAMKAD project decided to establish a lightweight infrastructure, and then *third* gradually implement a foundation for interaction between lightweight and heavyweight IT. This stepwise interaction is made necessary through the resistance from the existing regime of heavyweight vendors, juridical, economic and political protectors of status quo. The digital infrastructure consisted of a technological portfolio where vendors had long-term contracts, governed by an established regime for maintaining and developing this technology. Although EPR vendors still resist, the success of the installation has made the technological managers in Oslo Municipality more positive towards the integration.

Table 5: Stepwise integration of lightweight infrastructure

Phase	Activity and challenge	Solution
P1:2014	Establish a process innovation plan, and identify relevant technology. Resistance from existing regime.	Technological solution identified and apply for funding from research councils
P2: 2015-2016	Prototyping and implementation of mobile and whiteboard technology.	Establish a separate lightweight infrastructure and enable interaction between KAD and municipality.
P3: Late 2016-2017	Integrating heavyweight and lightweight infrastructure. Heavyweight vendors resist.	Oslo Municipality establish a solution (ITAS in figure 1) for "low-scale" integration between heavyweight and lightweight IT.

7. Discussion

In this study, we build on a case from an emergency unit in Oslo to investigate the role of lightweight IT in supporting process innovation within an established e-health information infrastructure. We frame our study within the field of information infrastructures, but use insights from business process innovation to develop our argument.

Despite Hammer and Champys [29, 30] lack of differentiation between different types of organizational configurations and processes, they have basic innovation advices that are still very valid. Melao and Pidds [34] perspective enable us to identify different types of business processes conditioned by the respective differences in organizational purposes. They provide guidance for identifying internal and external processes that can be improved quite quickly while they at the same time retain the awareness of horizontal flow and capacity utilization. An additional difference between early BPR literature and the later literature from Melao and Pidd is that organizational culture, which consists of 'processes shaped by beliefs, values, expectations and previous experience' [34:120] has to be recognized as valuable. The literature on Information infrastructure [7] have framed and conceptualized these pre-existing resources, rules, regulations, processes, and systems as installed base. The installed base should as far as possible be used as a resource not as a threat to the process innovation initiatives.

We add to the existing literature on information infrastructures by providing *two* contributions.

First, our findings show that broad organizational participation in the analytical phase in process innovation initiatives gives collective energy and inspiration to identify areas of improvement. In Section 5, Phase 1 and Section 6.1 we described how existing processes and regulations was used as a point of departure. In contrast with Hammer [30] which talks about "obliterate" and to "start from scratch", we claim that the installed base can be a rich source for process innovation, i.e. it enables creative use and re-use of existing structures and knowledge in the efforts to establish and improve horizontal processes. This will reduce the resistance towards change as the organizational actors find that certain aspects of their work may be improved. The literature on information infrastructures [7, 13, 33] carries this insight, but frame it as incremental and path dependent development. To keep the steam and motivation up among the organizational actors, innovation sometimes requires development to be performed a bit faster [15]. This leads us to the second contribution.

Second, we find that lightweight IT have certain strengths which is important for process innovation. Lightweight IT improves logistics within an organization, and interaction between organizations. In addition, the long term and slow development progress of heavyweight projects where it sometimes takes years from analyzes to implementation may cause collective and individual energy to dissolve and disappear [19, 31]. In section 5, phase 2 and 3 we described the relatively fast acquisition, implementation and adoption of innovative technology in improving distinct logistical processes, processes related to communication between clinical personnel, and interaction between health units. The lightweight supplier provided a prototype very fast and extended the energy into the actual implementation project. In section 6.2, we also described how principles from the early BPR literature [29, 30] might be helpful in identifying slow and time-consuming manual processes.

We can understand the strength of lightweight IT through three aspects, which facilitates process innovation. *First* through the "artefact" which enables improved information overview through an aggregated visualization of patient status and position in relation to the horizontal flow. *Second* the ability of lightweight IT suppliers to quickly provide assistance in the efforts to plan, implement and further develop the solution, as well as providing a technology which can bypass the existing arrangements if necessary. *Third*, the ability to commercialize and make the technology universally accessible gives hospital organizations the possibility to acquire and re-use successful configurations established elsewhere.

Based on this we also shed light on the technical modelling aspects of process innovation. We humbly suggest a step-by-step evolution through three phases of implementation of lightweight IT at an emergency unit. In section 5, Phase 1-3 we described the acquisition process, and figure 1 gives an overview of the outcome. In section 6.4 we suggest that lightweight technology may be implemented separately and that integration with the existing digital infrastructure may be done afterwards. The ability of lightweight IT to operate independently or loosely coupled to the patient record systems may contribute to the realization of parts or all of the process innovation ambitions. A separate acquisition process may speed up the innovation initiative and enable the organization to improve their flow processes faster.

Through these two contributions we extend information infrastructure theory by providing a process innovation lens governed by the knowledge regime of lightweight IT, and consequently provide a faster and more adaptable view of innovation in information infrastructures. Second we also add to the literature on information infrastructure [7, 18, 33] and electronic whiteboards [16, 17, 20, 24] in that we not only focus on improvements within particular clinical departments, but on cross-sectional information flow and the added requirements this entails.

In conclusion reflecting on our findings, we do not claim that lightweight technologies solve all organizational and technological challenges in the health systems. There is a broad range of health treatment trajectories that requires a broader, more elaborate and more secure approach. There is however a tendency that lightweight IT may solve some of the challenges, in our case the logistical processes and interaction between health units. In addition, our findings origin is an emergency unit in Oslo, Norway, and may not fit complex emergency units in bigger cities. This may particularly apply to our suggested implementation strategy. Further studies should shed light on this issue.

8. References

[1] Norwegian Directorate of Health: https://ehelse.no/Documents/Nasjonale%20prosjekter/Nasjonal%20handlingsplan%20for%20e-helse.pdf, 2016

[2] G. F. Anderson, B. K. Frogner, and U. E. Reinhardt: "Health spending in OECD countries in 2004 an update", Health Aff. 26(5), 1481–1489, 2007

[3] A. Salazar, B. Ortiga, J. Escarrabill, and X. Corbella, "Emergency department complaints: A 12 year study in a University hospital" Annals of Emergency Medicine, 44(4) 2004

[4] Norwegian Ministry of Health. Prep 125. https://www.regjeringen.no/contentassets/b218612046c84d89bec57fa537ea57f/nnno/pdfs/prp201420150125000dddpdfs.pdf, 2015
[5] J. De Vries, and Huijsman, R., "Supply chain management in health services: an overview," Supply Chain Management: An International Journal, Vol. 16, 159 -165, 2011
[6] W.A.M. Van Lent, E. M. Sanders, and W. H. Van Harten, "Exploring improvements in patient logistics in Dutch hospitals with a survey". BMC Health Services Research, 12, 232–240, 2012
[7] O. Hanseth and K. Lyytinen, "Design theory for Dynamic complexity in Information infrastructures: the case of building internet." JIT, 25(1), 1-19, 2010
[8] E. Monteiro, "Scaling Information Infrastructure: The Case of Next-Generation IP in the Internet, The Information Society", 14:3, 229-245, 1998
[9] George, A.L., and Bennett, A., Case Studies and Theory Development in the Social Sciences, MIT Press, 2005
[10] B. Bygstad, "Generative innovation: A Comparison of lightweight and heavyweight IT", JIT, 1-14, 2016
[11] M. Lacity, and L. Willcocks, Robotic Process Automation at Telefonica O2, MIS Quarterly Executive 15(1): 21–35, 2015
[12] L. Willcocks, M. Lacity, and A. Craig, The IT function and Robotic Process Automation. http://eprints.lse.ac.uk/64519/1/OUWRPS_15_05_published.pdf
[13] M. Grisot, O. Hanseth, and A. Thorseng, "Innovation Of, In, On Infrastructures: Articulating the role of Architecture In Information Infrastructure", Journal of the AIS, vol.15, 197-219, 2014
[14] Norwegian Board of Health Supervision: https://www.helsetilsynet.no/upload/Publikasjoner/rapportr2016/helsetilsynetrapport1_2016.pdf , 2016
[15] Davenport, T., Process innovation: reengineering work through information technology, Harvard Business School press, 1993
[16] G. Fitzpatrick, and G. Ellingsen, "A Review of 25 Years of CSCW Research in Healthcare: Contributions, Challenges and Future Agendas." Computer Supported Cooperative Work 22:609–665, 2013
[17] D. Aronsky, I. Jones, K. Lanaghan, and C. M Slovis,"Supporting patient care in the emergency department with a computerized whiteboard system". J.Am.Med. Inf. Assoc.15(**2**),184–194, 2008
[18] Ciborra C. et al, "From Control to Drift – The Dynamics of Corporate Information Infrastructures," Oxford University Press, 2000
[19] E. P. Piening, "Insights into the process dynamics of innovation implementation", Public Management Review, vol 13, issue 1, p 127-157, 2011
[20] M. Hertzum, and J. Simonsen, J, "Visual overview Oral detail: The use of an emergency-department Whiteboard", Int. J. Human-Computer Studies 82, 21–30, 2015
[21] A. Tang, J. Lanir, S. Greenberg, and S. Fels, "Supporting transitions in work: informing large display Application design by understanding whiteboard use", Proceedings of the Conference on Supporting Group Work. ACMPress, NYC ,149–158, 2009
[22] P. Bjørn, and M. Hertzum, "Artefactual multiplicity: a study of emergency- department whiteboards", Comput.Support.Coop.Work 20, 93–121, 2011
[23] H. J. Wong, M. Caesar, S. Bandali, J. Agnew, and H. Abrams, "Electronic inpatient whiteboards: improving multidisciplinary communication and coordination of care", Int.J.Med.Inf. 78 (**4**), 239–247, 2009
[24] M. Hertzum, "Electronic emergency-department whiteboards: A study of clinicians' expectations and experiences", International journal of medical informatics 80, 618–630, 2011
[25] Office of the Auditor General of Norway.: https://www.riksrevisjonen.no/rapporter/Documents/20152016/Samhandlingsreformen.pdf, 2015
[26] P.F. Hu, Y. Xiao, D. Ho, C. F. Mackenzie, H. Hu, R, Voigt, and D. Martz, "Advanced visualization platform for Surgical operating room coordination: distributed video Boardsystem", Surg.Innov.13(2), 129–133, 2006
[27] M. Hertzum, and J, Simonsen, "Work-practice Changes associated with an electronic emergency Department whiteboard," Health Informatics Journal, 19, 46-60, 2013
[28] D. J. France, S. Levin, R. Hemphill, K. Chen, D. Rickard, R. Makowski, I. Jones, and D. Aronsky, "Emergency physicians' behaviors and workload in the presence of an electronic whiteboard", International Journal of Medical Informatics 74, 827—837, 2005
[29] Hammer, M. and Champy, J., Reengineering the corporations, Harper NYC, 1993
[30] M. Hammer, "Reengineering work: don't automate, Obliterate", Harvard Business Review, 1990
[31] C. Kelly, and A. Young, "Promoting innovation in Healtcare", Future Healthcare Journal Vol 4, 121-5, 2017
[32] D. D. Dobrzykowski, "Examining Heterogeneous Patterns of Electronic Health Records Use: A Contingency Perspective and Assessment", International Journal of Healthcare Info Systems and Informatics, 7(2), 2012
[33] M. Aanestad, and T. B. Jensen, "Building nation-wide information infrastructures in healthcare through modular implementation strategies", Journal of Strategic Information Systems, 161-176, 2011
[34] N. Melao, and M. Pidd, "A conceptual framework for understanding business processes and business modelling". Information Systems Journal 10(2), 105-129, 2000
[35] Helsedirektoratet: https://helsedirektoratet.no/samhandlingsreformen, 2016
[36] L. Mathiassen, "Designing Engaged Scholarship:From Real-World Problems to Research Publications," Engaged Management Review, Vol. 1, 2017
[37] B. Bygstad, and B. E. Munkvold, "Exploring the role of informants in Interpretive Case Studies Research in IS", Journal of Information Technology, 1–14, 2010
[39] M. Romøren, R. Pedersen, R. Førde, "En pasient, to verdener – samhandling mellom sykehjemsleger og sykehusleger", Tidskr Nr Legeforen nr. 3; 137-193, 2017

Creating Coordinative Paths from admission to discharge: The role of lightweight IT in hospital digital process innovation

Egil Øvrelid
University of Oslo
egilov@ifi.uio.no

Terje Aksel Sanner
University of Oslo
tsanner@gmail.com

Anette Siebenherz
Østfold Hospital
Anette.Siebenherz@so-hf.no

Abstract

In this paper, we examine the role of IT in process innovations related to patient flow from emergency care admission, through subsequent patient transfers, and discharge. In particular, we explore how digital technology helps create and improve coordinative paths. We find that the interplay between traditional "heavyweight IT" (resilient, secure and stable) and "lightweight IT" (mobile, context-aware and flexible) enable process innovation in complex health care settings. Drawing on Zuboffs "informate" perspective, we highlight the strength of digital information technology as a process innovation enabler. We provide two contributions. First, we shed light on the innovative capacity of lightweight IT as a flexible, dynamic and distributed technology for process innovation. Second, using Garud and Kumaraswamys framework of vicious and virtuous circles, we identify and discuss potential positive and negative outcomes of process innovation.

1. Introduction

General hospitals are structured to optimize specialists and departments vertical work processes, while horizontal coordination have received less priority. This clinical orientation is mainly caused by interdependencies related to specialization [2]. A challenge with this form of organization is that patients who suffer from ill-defined or interrelated health issues are referred back and forth between seemingly uncoordinated professionals and departments for diagnosis and treatment. A common complaint from patients is thus that while the actual treatment was excellent, the coordination between units was slow, the waiting time long, and feedback almost nonexistent [3, 4]. In Norway, these challenges have informed the establishment of national coordination reforms, as it is "particularly important to ensure good coordination when the responsibility for the patient moves between hospitals and municipalities and between departments and units within hospitals and municipalities" [5].

Davenport [6:8] claims that "in functionally oriented organizations, handoff between functions are frequently uncoordinated." Process innovation improve coordination and management of functional interdependencies [6]. Nevertheless, initiatives striving for improved horizontal processes through better clinical pathways or other ways of appropriating the patient trajectory using IT, have had limited success [7]. Substantial improvements may require optimization through digitalization and process redesign. This is important within hospital settings as reduction of time spent on logistics may release time for patient treatment [9, 10, 11].

In accordance with [8] we refer to robust hospital information "silos" and the IT engineering and support tradition that envelops them as "heavyweight IT". However, to be able to leverage rapid developments in todays' IT industry and meet citizens growing expectations towards digitalized health care services, hospitals and other health care institutions strive to implement "lightweight IT" solutions, characterized by rapid implementation cycles, and ubiquitous access to tailored information through user-friendly interfaces [8].

In this paper, our goal is an improved understanding of process innovation and digitalization challenges in a hospital setting. We investigate efforts in digitalization of horizontal processes, our research question is *what are the challenges and the outcomes of using lightweight technology in process innovation initiatives at a general hospital?*

We proceed by discussing related research (2.1), before we describe our theoretical lens (2.2).

2. Theory

2.1 Digital infrastructures and lightweight IT

Public sector IT systems may be characterized as "IT silos", where data and functions are organized in a way

URI: http://hdl.handle.net/10125/50287
ISBN: 978-0-9981331-1-9

that hampers innovation [12, 13]. In addition, heterogeneous IT solutions deep embeddedness in clinical practices makes change challenging. In essence, the inertia of extant solutions and practices "resists" external intervention, and changes need to be introduced in small and incremental steps [14].

Hospital IT portfolios typically constitute fragmented and clinically oriented IT acquisitions. A long tradition of clinical orientation in the development of hospital IT portfolios have led to fragmented systems, support functions and regulations, which makes information exchange across departments difficult, even within the same hospital. This is of concern to hospital administrators as workflows that are more efficient can save costs, enhance efficient use of scarce hospital resources (e.g., radiology), lead to more effective diagnosis and treatment of patients, and reduce patient waiting time [15].

The conservative influence of extant hospital IT portfolios have for some time been challenged by process innovation initiatives seeking to create coordinative paths in order to improve horizontal performance. Examples are patient logistics [7], clinical pathways [17], and hospital supply chain management which is a systemic view of the flow of all types of resources [18]. These initiatives typically address "horizontal" workflow processes, but often fail to interact with and leverage existing databases and functions.

Digital process innovation is about using IT to improve business processes [6]. In the health sector, process innovation may refer to reducing the time spent between diagnoses, to treatment and followed up. In hospitals, this may be achieved by reducing waiting time and shortening the time from admission to discharge. Recently, we have seen a growth in digital services in tandem with individuals and organizations rapid uptake of commercially available devices such as tablets, smartphones, wearable sensors and electronic whiteboards. [8] refer to this as "lightweight IT". Lightweight IT is not only a tool, but also "a socio-technical knowledge regime, driven by competent users' need for solutions, enabled by the consumerization of digital technology, and realized through innovation processes" [8: 2].

We employ the notion of lightweight IT based on three characteristics. *First,* we are particularly interested in the role of lightweight IT as a front-end knowledge regime driven by practice-oriented innovation. We primarily study practices related to coordinative activities and the innovation of coordinative processes. We are also interested in the role of heavyweight IT in supporting lightweight IT, especially because it is through interplay between lightweight and heavyweight that favorable results are likely to be obtained [8]. The two knowledge regimes should be loosely coupled both technically, regarding standards and organizationally [8]. *Second,* even though we strongly acknowledges the important role of heavyweight IT in feeding lightweight IT with information, we particularly investigate the role of whiteboards and mobile technology in sharing, visualize, and redistribute information. This informating ability is contributing to transparency and improved overview in a way that may enable bottom-up and locally relevant process innovation. *Third,* we are interested in lightweight IT as an example of digital innovation. This includes investigating the innovative potential including the increasing redesign flexibility [23]; their ability to establish digital links and provide changed control paradigms [20], through distributed organization [21].

In summary, the innovation of coordinative processes is facilitated by using mobile technology and whiteboard technology, that is, lightweight IT, characterized by rapid implementation cycles, and ubiquitous access to tailored information through user-friendly interfaces. The whiteboards also facilitates the inspection of the result of process innovation in that information is displayed in common arenas where patient flow is discussed. The redesign flexibility, we claim, is both helpful in establishing digital links, but also in providing distributed autonomy.

For instance, [25] have studied the interplay between lightweight and heavyweight IT in process innovation, but mainly from a strategical perspective. Our study, on the other hand relates to the practical implications of this interplay, how lightweight and heavyweight IT interaction supports "everyday" coordination within and across organizational departments and functions.

Lightweight IT solutions have recently shown promising in supporting cross-functional processes in complex settings, for instance by improving organizational visibility of treatment statuses [9, 26, 28] as well as patient coordination care [29]. These studies primary focus, however, is improved coordination *within* a particular department. In this paper, we rather focus on initiatives related to improving horizontal workflows across departments as well as the challenges related to these innovation activities.

2.2 Process innovation and its challenges

Process innovation is about translating information into action by removing manual work between the source and the registration [30]. This can be done through better coordination and management of functional interdependencies [6]. Drawing on Zuboffs [31] notion *informate,* we denote the process of leveraging IT to make information about work visible and actionable across organizational functions and departments. Zuboffs informating framework indicates the need for

management to be active in recognizing IT's potential to generate information about the underlying productive and administrative processes that were previously opaque. Zuboff documents how the explicit representation of tasks, gathered from monitoring agent behavior and/or outcomes, sets in motion a series of dynamics that will ultimately (re)configure the nature of work and social relationships that organize productive activity. In essence, Zuboff observes that informating will improve performance and the quality and autonomy of working life, when employees are obligated, and accept, the use of feedback from IT to adjust their work behavior.

Informate, then, is a condition enabled through digitalization and automation of manual processes or through compiling digital processes or information earlier displayed separately. Digitalization of processes, what Garud and Karnøe [32] calls path creation, may entail struggling against existing social rules and taken for granted techniques and tools. In a way, entrepreneurial activity is about disembedding oneself from existing structures and mobilize support, rather than resistance from an inertia of work practices and systems. Hence, process innovation "is a collective effort where paths are continually and progressively modified as new technological fields emerge" [32:2].

Informate can both be a result of complex interacting processes i.e. integrated modules, and local resources made universal through enabling access across organizational units. Digital interconnectedness enables improvement of horizontal performance but it also threatens stabilized local processes and departments [23]. The increasingly sophisticated insight into patterns of organizational processes and information may tempt managers to disturb complex and interdependent processes [33]. Furthermore, the use of the information potential enables a better overview of the positive and negative effects of process innovation. In turn, this may inspire strategies to reinforce and sustain virtuous circles [1]. However, the coupling of different organizational processes can give rise to unanticipated negative consequences that may degenerate into vicious circles [34]. Two principles are suggested by [32, 34] to avoid vicious circles. *First*, avoid tight coupling between system components as it may cause feedback generated at another level or in another system to amplify across the entire system and generate unintended negative consequences [34, 1]. A *second* example is the negative result of increased bureaucracy and centralization of decision making [34].

The information system and its dynamics can thus be outlined in three properties. First, the effects of initiatives taken at one level of the system can be felt across the levels. Second, these effects may lead back to the mutually causal nature of processes unfolding at and across levels, and third, the effects of specific initiatives are not immediately obvious because of time lags between causes and consequences. There is therefore an inherent ambivalence in the dynamics. If you leave the information system alone virtuous circles may never materialize. If you intervene and connect or couple processes within and across levels and functions vicious circles may emerge [1].

In order to steer out of vicious circles one should identify and decouple system processes that may have triggered the vicious circle, or establish a deviation counteracting tool. This could be middleware or other forms of automated tools which counteract the negative impact of process innovation [1]. This careful navigation enabled by organizations informating ability is interesting on two grounds. *First,* we investigate the role of lightweight technology in process innovation. *Second* we investigate how process innovation initiatives leads to vicious or virtuous circles, and how lightweight IT supported by heavyweight IT is used to identify, disseminate and adjust outcomes.

3. Method

Figure 1: Kalnes Hospital

The setting for our empirical research is Kalnes general hospital in Østfold County (near Oslo) in Norway. Østfold has about 300.000 inhabitants. The 85.500 square meter high-tech hospital opened in November 2015 and replaced the old Fredrikstad hospital. Kalnes has one of Norway's largest emergency units in addition to general hospital functions such as delivery wards, clinical and surgical departments and psychiatry. At the old hospital in Fredrikstad, departments were distributed across different buildings with up to nine floors based on functional separation. At Kalnes the hospital design is markedly different. The hospital has four floors that provide health services and the building was designed to allow different departments to dynamically expand and retract. The construction of Kalnes hospital has created opportunities for hospital-wide process innovation. Mobile technology and electronic whiteboards are deployed all over the hospital. The electronic whiteboards provide up to date information for patients, their families, professionals assigned to patients and hospital support staff. The hospital management has

high ambitions regarding its process-oriented use of IT [25]. Kalnes Hospital serves as an extreme case of our area of concern [35], because of the ambitious efforts to integrate and align clinical work processes and patient records keeping with novel innovative technology to support horizontal process innovation and coordination.

Our case study research approach is based on engaged scholarship [16, 19] inspired by an "insiders ontology" [22] where informants are not only sources of empirical data, but also helpful in constructing narratives and discuss theoretical and practical implications [16]. One of the authors of this paper was central in the process of planning and implementing the IT solutions at Kalnes. The planning included redesign of the old workflow processes at Fredrikstad, as well as organizational restructuring.

3.1. Data collection

From July 2016 to April 2017, we conducted 22 interviews, with clinicians, project leaders, technical experts and cleaning personnel as well as system suppliers. We started with interviews where Kalnes management and project leaders presented the main goals as well as the organizing of the IT oriented process innovation initiative. We proceeded by performing observations within the emergency unit and the health wards, where challenges related to process flow were addressed. We followed up with new interviews as well as analyses of documents on patient treatment regulations, political requirements from the regional health authorities and descriptions of the technical solutions. We also participated in local and regional meetings and workshops where findings, including ours, were discussed. Through this "bottom-up-investigation", we identified coordinative actors, actors whose central role is to plan and coordinate the movement of patients and information across hospital departments, and were particularly interested in how they use IT to perform and coordinate their work.

3.2. Data Analyses

Our initial data analysis was informed by two themes: the identification of opportunities and challenges for assisting process oriented re-design of hospital patient flows with digital ICTs and the role of ICTs in mitigating emergent process bottlenecks. For instance, mobile and whiteboard technology availed information about the status of patients and resources such as rooms and beds across hospital functions in real time. However, this seamless information transparency could sometimes introduce new coordination challenges.

We analyzed the case in the light of how interplay between technological components enable or constrain work performance of coordinative actors, and were particularly interested in the challenges and possibilities that arise and how they were dealt with. We then used the conceptual model from [1] to analyze respectively the challenges and outcomes of innovate-informate interaction, before we discussed the implication for our findings on the field of research, and identified some contributions. Table 1 provides details of our analysis.

Table 1: Data analysis

Questions-Description	Output
Identify key coordinative actors and their challenges regarding process flow, as well as the key technology for supporting process flow	Case description, three steps of digitalization to obtain process innovation.
Follow key actors, key meetings and clinical encounters in order to identify situations where digitalization initiatives improves or challenges existing order and the outcome of this.	
Identify core processes and resources, the initiatives to digitalize them, and the outcome. For instance, when sharing the status of resources faster and to more relevant decision makers, what challenges arise? How are the possibilities and challenges dealt with?	
Analyze the process innovation challenges using the conceptual model from [1] in order to generalize our findings.	Analyses, digitalization in the light of challenges and outcomes
Theorizing the challenges and outcomes when using lightweight technology in process innovation	Two contributions, discussion.

4. Case

Kalnes emergency unit receive between 90 and 120 patients every day. Some arrive by helicopter or ambulance, but most patients "drop in" having been referred by their general practitioners or primary health care units. Kalnes hospitals efficiency goal for patient stay at the emergency unit is two hours, but the average time of stay is 4.5 hrs.

Kalnes hospital has several departments (e.g., neurology, heart and lung wards) positioned in close proximity to the emergency unit, where patients can stay for up to three nights. Each department has a coordinative nurse tasked with facilitating patient flow. Kalnes hospital fall under the jurisdiction of region Health South-East (HSØ), one of four semi-autonomous

health regions in Norway with their own IT strategies and framework agreements. Kalnes hospital acquired standard electronic whiteboards and mobile devices with Imatis software installed as a part of their workflow-oriented design strategy. Imatis was previously implemented in the emergency unit at Køge hospital in Denmark through a cooperative project between the hospital staff, the vendor of the whiteboards and the University of Roskilde [26]. There is functionality in Imatis to display all available rooms in all departments and reserve them for patients. Hospital staff, regardless of function (e.g., nurse, clinician or housekeeper), can access custom Imatis views on mobile clients (tablets and smartphones) based on their role and location within the hospital. The Imatis vendor have had a close cooperation with Kalnes hospital both during implementation and in the activities related to improving and tailoring the solution according to Kalnes' needs. A project manager emphasize this: "It is very interesting to work with them…they are very active and interested in how we are doing." The EPR (Electronic Patient Records) provider does not ignore the creativity from Kalnes, but often respond with, "yes, this is a good idea, but you have to wait for our next upgrade." The internal project manager says, "Imatis recognizes that the development is happening here and now, not in 2 or 3 years."

A large portion of the information displayed through Imatis on mobile devices and whiteboards are harvested from the main EPR system at Kalnes. Imatis is also integrated with the personal administration system GAT. The interplay between the EPR, GAT and Imatis is central in enabling transparent information on the availability of hospital resources.

We investigated the role of electronic whiteboards and mobile technology and the clinical systems in patient flow coordination, following the coordinative actors, how they dealt with bottlenecks and flow challenges, and the role of IT as an important enabler in these endeavors.

We proceed by looking at the activities of digitalizing manual routines (4.1). Then we describe the improved transparency this gives (4.2) and how this overview may highlight solutions to challenges (4.3). Finally, we look at some particular challenges with digitalization efforts (4.4).

4.1. Digitalizing processes and resources

ICT has the ability to enable digital links and a more flexible interaction between organizational actors. An important activity related to digitalization is to divide entangled processes into sub processes measured separately. An example is triage. The purpose of triage is to ensure that patients with immediate needs for health care will receive it first. It is therefore important to separate the process of triage from the following treatment.

"Dividing processes and resources is a challenge. When clinicians are asked to measure the process of triage they perform and measure the entire treatment, not only the identification of what treatment is needed. While the process of triage takes around 2 minutes the treatment takes a long time, sometimes up to an hour."

The clinicians have the ability to quickly decide who needs treatment (tacit decision-making), and then complete the treatment. This could however lead to the most serious cases not be taken care of first. The logical separation of triage and treatment based on general principles (explicit decision-making) is an example of breaking more or less coherent vertical working processes into sub-processes measured separately.

Further, at the old hospital the coordination process of identifying available rooms and treatment resources was done manually, by walking around asking key personnel, and then make notes on the availability. At the new hospital, they have digitalized some of these resources. The digitalization enables the organization to share resources across local units and according to a universal standard. However, this may sometimes conflict with local autonomy and local rules for accessing and using the resources.

The digitalization of some of the cleaning routines have replaced a lot of the earlier ad-hoc communication that had to take place in order to secure good routines. The availability of resources through the mobile technology system enable the clinicians to notify when a room have to be cleaned and in what way by indicating airborne or body fluid contamination. Cleaners also make direct data entry into Imatis by indicating that they have "started cleaning" and "finished cleaning".

The most important aspect of patient treatment processes is to secure the quality and safety of care. The movement of a patient from the emergency unit to the health wards includes several quality checks performed and communicated between the receiver and the deliverer. An example demonstrates this.

First, the doctor assigned to the patient give the emergency unit coordinator the task of finding a room for the patient. The coordinator then registers in Imatis that the patient is "ready for ward". The receiving ward considers this request and responds. The status of the patient is updated to "reported to post". The coordinative nurse in the receiving ward identify a room for the patient and send a message to the hospital porter who makes sure that a bed is in place. Finally, a report about the patient transfer is sent from the emergency unit to the ward. "Our goal is a silent report, but some of these steps are still done manually by phone" (doctor).

Fragmented healthcare portfolios require users to log in to a variety of systems. Also at Kalnes they have non-integrated systems where information is registered separately. By having these elements available in Imatis or the EPR further optimization of hospital performance and human and material resource utilization could be obtained. Kalnes have in collaboration with the major system providers of EPR and Imatis technology established an interface, which grants access to major information systems. This interface facilitates innovation, in that it gives access to information, which can be recombined across system domains.

4.2. Informating: Transparency, visibility and collaborative arenas

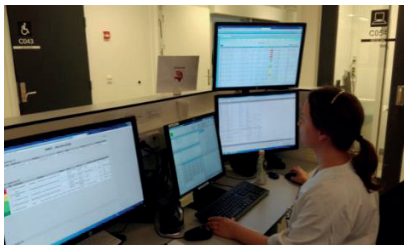


Figure 2: Emergency unit control board

The main admission point at Kalnes is well equipped with big screens displaying information from all the important systems (Figure 2). The whiteboard (upper right) *first* enables an overview of available resources, *second* it gives a fast and neat overview of the medical condition of the patient, the reason for the admission, the level of emergency (triage), the result of blood tests and x-ray results as well as the responsible nurse and doctor. *Third,* it enables an active participation in the dynamics of patient treatment information like registering patient, attaching necessary resources and switching care personnel when needed. The whiteboard keeps the clinical and logistical personnel informed about the status and enables a swift modification when needed. This functionality relies largely on the integration between whiteboards and the EPR systems.

The whiteboard system has introduced some improvements. "It's an important device in the administration of the unit… Earlier we had to call for every detail, now we have a much better overview" (nurse). In addition, communication with the cleaning personnel and the booking of beds is much easier thanks to Imatis. One nurse said, "It is much easier to get an overview when we have the information both in our heads and on the screens" (nurse). The health ward clinicians also emphasize the visual abilities of Imatis: *"Imatis gives a good overview, also when family members call, it is easy to answer. It provides good communication with food makers and cleaners. In addition, it provides a good overview of patients admitted to the department and the department to which they belong*."

The electronic whiteboard have enabled the creation of arenas for discussing the patient flow. Examples are the whiteboard morning meeting where the overarching focus is coordination and logistics. A central challenge at Kalnes is the peak at mid-day when both the emergency unit and the health wards are full. A solution to this challenge is to discharge patients from the ward in the morning so that the ward have availability in the mid-day when the emergency unit is full. The morning department meetings at the old hospital used manual whiteboards. Now they use electronic whiteboards.

"The whiteboard meeting starts at 0850, and lasts for ten minutes. In this meeting, all the admitted patients are discussed as they try to identify who can be discharged. The unit manager is managing the whiteboard registrations, while the doctors and nurses give feedback. The patients are divided into three categories: 1. immediate help, 2. Patients who can be discharged, 3. Patients who have to stay another day."

By enabling transparent information and use this information to optimize the process flow, whiteboard meetings is an important arena for process innovation. By touching the screen and changing status, decisions are registered immediately.

Through digitalization, making information visible and transparent, the cleaning personnel have the possibility to plan their daily performance. This is a non-trivial challenge made easier through enabling access to needed information for decision-making.

"Cleaners change the status of the resource; Cleaning in progress, Cleanliness finished." "The cleaning routines take approximately 30 minutes but sometimes it takes three hrs. from a room cleaning is booked to the cleaning is performed. This is especially in the "peak hours". The cleaners have rescheduled the way they work 4 times since the hospital was opened" (nurse).

The transparency and visibility provided by the digitalization of processes enables a local autonomy for the cleaning department to address and solve their main challenges themselves. More on this in 4.3.

4.3. Self-management

Process innovation obtained through digitalization gives improved transparency and provides an improved basis for decision-making on several grounds. *First*, digitalization provides easier access to information. Digitalization allows the information to be displayed in customized view, and this provides a basis for department/units self-management. Examples are the cleaners that can organize and re-organize their activities based on the actual hospital need. Another example are the ward managers who can organize their

units based on analyzes of the daily patterns of referral, treatment and discharge. A third example are the coordinators that can identify the available and necessary resources and map them onto the patient trajectory.

Second, the whiteboards are both displaying information related to flow processes (when can the patient be discharged?), and information on specialized diagnostics and treatment. The whiteboard consequently bring together actors where some think about the flow while others think about clinical treatment. This strengthens the common insight into local challenges.

"In the patient visit, they use Imatis to identify who needs to be treated first, based on level of urgency. Then they work on the patients that most likely can be discharged the same day. This practice also enables the cleaning personnel to get a good insight into rooms which has to be cleaned so that they can do this right away."

The information visibility enables them to establish common arenas to address flow challenges. The whiteboard meetings are standardized ways of discussing patient flow, and recently a new type of meeting, "Patient flow seminars", was established by the process director to address more general challenges related to resource availability and process innovation.

The ICT potential is used actively to identify available resources, but also what it takes to define something as a (digital) resource. The access to cross-sectional resources enables a proactive process where nurses and coordinators are checking availability when needed. The decentralized autonomy, discussions and negotiations is giving the departments increased understanding of the importance of process flow, and what it takes to optimize it. The visibility enables improved management based on the movement of resources across different wards, and a more flexible use of the workforce by assigning human resources to different units and tasks depending on demand.

4.4. Process innovation challenges

Process innovation through digitalization may create unintended effects or bring to life hidden challenges. An example is when universal resource transparency creates tension between local and global resource management:

"..The emergency unit applies to transfer a patient to the heart ward. The coordinator finds that the heart ward is full, but that they have two patients that can be transferred to the lung ward. The heart ward coordinator calls the lung ward which responds by saying that they have no available beds, but they do not report this back to the emergency. Patient is still marked "grey" in Imatis. 5 hrs after the first referral, the emergency calls back to the Heart Ward, only receiving the response that neither them nor lung has available beds. The patient coordinator nevertheless knows that the lung ward have space in the corridor. The emergency unit continues by enforcing the move of patients from heart to lung and then transferring the emergency unit patient to the heart ward 6 hrs. after the first inquiry."

The tight integration also gives challenges in terms of keeping users informed about where data actually resides and how information is shared and updated between systems. This may be particularly problematic when systems are so well integrated that end users no longer are able to assess what system they are making data capture against or retrieving information from – as everything is seamlessly "at their fingertips" in one user interface. For instance, as indicated by one housekeeper:

"Some coordinative nurses delay the booking of room cleaning for patients who are targeted for transfer or discharge as they are worried information registered in Imatis will feed back into the EPR where the status of the patient has not yet been updated by the clinician in charge of the patient".

In addition, tight integration between EPR systems, mobile technology and whiteboard systems may create situations and ripple effects where a system error in one place causes unexpected results in other connected systems. When the EPR stop working, the whiteboards and mobiles stops working too. Kalnes have established back-up routines with manual follow up when this happens. The problem is that this creates double registration routines for as long as the system is unavailable, and that information has to be registered back into the respective systems when the error is corrected. Tight coupling may be partly reduced by having an RPM (resource and process management) interface between mobile and whiteboard technology system and the EPR system. This interface enables the access to a separate database when the EPR system fails and consequently gives a looser coupling between the process technology and the EPR system.

5. Analyzes: Challenges and outcomes of process innovation

Digitalization of manual processes and resources provides opportunities for a better overview of organizational behavior. Establishing arenas to discuss the result of digitalization allows early identification of the positive and negative consequences of digitalization, and making decisions that can strengthen or mitigate these consequences.

Process innovation is challenging in that it favors the horizontal and deemphasize the functional perspective. Understanding the concrete consequences of

digitalizing coordinative paths is thus important in order to balance and control innovation efforts. In order to analyze our case we use insights from [1]. They categorize their findings into negative outcomes, which (may) turn into vicious circles, and positive outcomes that turns into increasing returns and virtuous circles (figure 3). Table 2 outlines our findings.

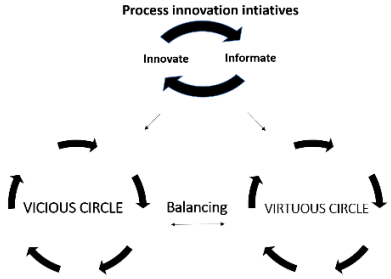


Figure 3: Possible outcome of process innovation

Table 2: Vicious and virtuous effects

INNOVATE	INFORMATE
Identify bottlenecks and streamline manual processes with IT. Implement cross-sectional coordinative IT. Integrate modules through a common interface.	Make information visible and actionable. Distributed information access. Sets in motion a series of re-configuration and redesign possibilities.
MAY LEAD TO	
VICIOUS	**VIRTUOUS**
Tight coupling between systems creates challenges when one of the systems collapse Unclear relations between where data is registered and where they are stored Universal resource management creates competing priorities between wards and may reduce local autonomy over resources	Coordinators and cleaners can analyze the result of and improve their work. Improved interplay between coordinators and clinicians Common "flow arenas" for addressing workflow challenges Common access to cross-sectional resources improves capacity utilization Increased insights in end-to-end processes and a process-oriented organization

Innovate, is about digitalizing manual processes or make singular processes earlier digitalized interact. Digitalization may improve efficiency by removing bottlenecks and streamline manual processes. This use of ICTs potential to enable cross-sectional coordination is also enabled by interfaces and modules positioned in the technical architecture which gives access to information across system domains. The integration of the two systems with the personal administration system GAT, gives a rich repository of information available for making and extending functionality.

Informate is the effect of digitalization when certain conditions are met. Information is made visible and actionable when whiteboard and mobile technology is implemented in a way that is aligned with horizontal coordinative processes. Information made visible and actionable across hospital departments and wards activates a set of re-configuration possibilities. By actionable we mean that the information can be acted upon digitally, by clicking, drag-and-drop and similar, based on decisions taken. The innovate - informate interaction gives possibility to re-configure processes and to investigate the effect this re-configuration have on horizontal and functional processes. It shortens the loop between acknowledged shortcoming and improvement, but it thereby also threatens the stability of existing ways of doing things. It may both lead to vicious and virtuous outcomes.

Vicious circles may emerge during digitalization and creation of coordinative paths. Tight coupling between heavyweight and lightweight IT can cause vicious circles. When the coupling causes all systems to go down when one system goes down, manual follow-up routines is needed as a backup. The organizational information acquired during system collapse later has to be registered back into the respective systems, introducing possible challenges related to accuracy and precision. A second challenge may arise when users used to relate to one particular system must relate to several systems governed by other clinical domains. This may lead to hesitation and delayed registration of important information. A third vicious effect leading to negative circular spirals may be caused by the universal availability of resources. Some resources like special rooms, equipment or humans may be better utilized locally.

Virtuous circles on the other hand may arise when changes have positive outcome. At Kalnes coordinators and cleaners ability to perform self-management have improved because they have gained better tools for reflecting on performance. Further, we observed that although some of the doctors are critical towards the whiteboard system, they actively participate in some of the arenas where horizontal flow coordination is addressed. Improved process flow may be in their interest. The "flow-arenas" also create a certain motivation in improving capacity utilization. The transparency of organizational performance seems to give an improved understanding of cross-sectional challenges and triggers activities and solutions to address them. Kalnes is designed to enable process flow also in that the health wards are designed equally. This

enables flexibility and universal availability of resources. The technological portfolio is partly modularized. The RPS engine gives a looser coupling between the outside and the inside of the organizational system, protecting its internal logic. It may operate independently of the regional infrastructure if needed. The increased informating ability also makes it easier to provide counter-strategies when needed, in that side effects are identified relatively early.

6. Discussion

We return to our research question: *What are the challenges and the outcomes of using lightweight IT in process innovation initiatives at a general hospital?* Digitalization is a key factor in process innovation, which is about translating information into action by removing manual work and bottlenecks between the source and the registration [30]. Informate is the effect of the digitization of manual processes or the linking of already digital processes causing a common outcome. The interaction between innovation and informating leads to outcomes which can be referred to as either virtuous or vicious. While [1] are interested in knowledge management strategies and the outcome of continuous efforts to digitalize knowledge, we are looking at the relation between coordination practices and accessibility to cross-sectional information in process innovation initiatives. A central premise for the universal access to process flow information we find, is the interplay between heavy and lightweight technologies. This interplay does also enable optimization of vertical and horizontal processes. The shared division of labor [27] allow organizational actors and workgroups with different epistemologies to collaborate through "rich connections" [1]. The premise for this is however that the mapping between technology and practice is carefully balanced and that side effects are taken care of.

We give two contributions. *First*, we draw on literature on digital innovation [8, 20, 21, 23, 25] to investigate how lightweight technology strengthens path creation initiatives dealing with optimization of horizontal flow. Lightweight technology and the knowledge regimes attached to it are concerned with continuous improvement, and this requires dynamic and flexible follow-up from the supplier. "Imatis have understood that the development is happening here and now, not in 2 or 3 years" as one internal project leader makes clear. A central aspect of lightweight technology is its informating ability. Huge whiteboards displaying patient information are used by a knowledge regime that operates around patient flow processes. The actors are equipped with mobile technology to improve communication across wards. It is earlier claimed that whiteboards strengthens communication and commitment [26] and optimize information management [28]. These studies investigate processes *within* isolated departments. Our work demonstrates the process innovation capacity of lightweight technology in sharing, visualizing and redistributing information enabling horizontal process improvement *across* departments. This informating potential enables changed control paradigms [20], through distributed organization [21] in that the procedural distance between action and the effect of this action is reduced. This gives local actors improved insight into horizontal processes. The increasing redesign flexibility enables Kalnes to continually monitor and improve the innovation initiatives. The coordinative actors are engaged in technological development and become key players in process innovation in that they participate and monitor directly the outcome of the interventions.

The *second* contribution is insight into efforts related to digitalization of processes, and the effect of these. Digitalization processes intervene in organizational inertia and triggers organizational tension. Silo systems, clinical regimes, work processes, routines and regulations which have been more or less aligned is re-enacted, brought into life, and has to be aligned once again. Accordingly, the functional and the horizontal efforts must be balanced. By using the framework of vicious and virtuous cycle [1] we explicitly look at how innovation initiatives with lightweight technologies, backed by heavyweight technology, informate organizational processes and enables efficiency improvements. By doing this we also shed light on some of the challenges and the risks of creating coordinative paths.

In **conclusion**, digitalization is challenging, cumbersome and laborious, but necessary in order to improve organizational performance and capacity utilization. Digitalization of manual processes and routines prepares the fundament for two important improvements. The organization may faster adapt to ever-changing societal requirements. Moreover, the organization are better able to monitor their own performance. If hasty changes have been implemented, the detection of the negative outcomes of these changes can be done relatively fast, the organization may adjust the intervention and try again. If the change is successful, a new horizontal path has been created and might be further improved.

7. References

[1] R. Garud, and A. Kumaraswamy, "Vicious and Virtuous Circles in the Management of Knowledge: The Case of INFOSYS Technologies." MIS Quarterly, vol. 29, p. 9-33, 2005.

[2] Mintzberg, H, Structure in fives*:* Designing effective

organizations. Englewood Cliffs, N.J: Prentice-Hall, 1983
[3] Salazar, A., Ortiga, B., Escarrabill, J., and Corbella, X, "Emergency department complaints: A 12-year study in a University hospital." Annals of Emergency Medicine, 2004
[4] Norwegian Ministry of Health. Prep 125. 2015
[5] Helsedirektoratet 2016 Coordination reform https://helsedirektoratet.no/samhandlingsreformen
[6] Davenport, T, Process innovation: reengineering work through information technology, Harvard Business Press, 1993
[7] W.A.M, Van Lent, E. M. Sanders, and W. H. Van Harten, "Exploring improvements in patient logistics in Dutch hospitals with a survey." BMC Health Services Research, 12, 232–240, 2012.
[8] B. Bygstad, "Generative innovation: A Comparison of Lightweight and Heavyweight IT," Journal of Information Technology, 1-14, 2016
[9] M. Hertzum, and Simonsen J, "Work-practice changes associated with an electronic emergency department whiteboard," Health Informatics Journal, 19 (**1**) 46-60, 2013
[10] D. J. France, S. Levin, R. Hemphill, K. Chen, D. Rickard, R. Makowski, I. Jones, and D. Aronsky, "Emergency physicians' behaviors and workload in the presence of an electronic whiteboard," International Journal of Medical Informatics 74, 827—837, 2005
[11] SINTEF, Gevinstanalyse av IMATIS i Bærum kommune, https://www.sintef.no/publikasjoner/publikasjon/pubid=SINTEF+A27754 2016
[12] F. Bannister, "Dismantling the silos: extracting new value from IT investments in public administration." Information Systems Journal, 11(1):65-84, 2001
[13] H. Bowman, H. van Houtum, M. Janssen, and G. Versteeg, "Business Architectures in the Public Sector Experiences from Practice." Communications of the Association for Information Systems, Vol. 29, 2011.
[14] E. Monteiro, "Scaling Information Infrastructure: The Case of Next-Generation IP in the Internet", The Information Society, 14:3, 229-245, 1998.
[15] S. Devaraj, T. T. Ow, and R. Kohli, "Examining the Impact of Information Technology and Patient Flow on Healthcare Performance: A Theory of Swift and Even Flow (TSEF) Perspective". Journal of Operations Management 31, 4, 2013
[16] B. Bygstad, and B. E. Munkvold, "Exploring the role of informants in Interpretive Case Studies Research in IS", Journal of Information Technology, p. 32-45, 2011
[17] T. Rotter, L. Kinsman, E. L. James, A. Machotta, H. Gothe, J. Willis, P. Snow, and J. Kugler, "Clinical pathways: effects on professional practice, patient outcomes, length of stay and hospital costs," Cochrane Database, 2010
[18] J. De Vries, and R. Huijsman, "Supply chain management in health services: an overview", Supply Chain Management: An International Journal, Vol. 16 Iss: 3, pp.159 – 165, 2011.
[19] L. Mathiassen, and P. A. Nielsen, "Engaged Scholarship in IS Research- The Scandinavian Case," Scandinavian Journal of Information Systems, Vol. 20, No. 2, 3-20, 2008.
[20] D. Tilson, K. Lyytinen, and C. Sørensen, "Research Commentary, digital infrastructures: the missing IS research agenda." Information Systems Research, 21, 748-759, 2010.
[21] Y. Yoo, O. Henfridsson, and K. Lyytinen, "Research Commentary-The New Organizing Logic of Digital Innovation: An Agenda for Information Systems Research." Information Systems Research, 21(4):724-735, 2010.
[22] R. Garud, A. Kumaraswamy, and P. Karnøe, "Path dependence or path creation," Journal of Management Studies, Volume 47, Issue 4 June 2010 p. 760–774.
[23] O. Henfridsson, L. Mathiassen, and F. Svahn, "Managing technological change in the digital age: the role Of architectural frames. Journal of Information Technology, 29, 27-43, 2014.
[24] E. Øvrelid, and B. Bygstad, "Extending e-health infrastructures with lightweight IT." In Lecture Notes in Business Information Processing. 1865-1348. 2016, 43-56.
[25] B. Bygstad, O. Hanseth, A. Siebenherz, and E. Øvrelid, "Process innovation meets digital infrastructure in a high tech hospital," 25th European Conference on Information Systems (ECIS) Guimarães, Portugal, 2017
[26] M. Hertzum, and J. Simonsen, "Visual overview, oral detail: The use of an emergency-department whiteboard," Int. J. Human-Computer Studies, 2015, 82, 21–30.
[27] I. Nonaka, and H. Takeuchi, The Knowledge-Creating Company, Oxford University Press, New York, 1995
[28] D. Aronsky, I. Jones, K. Lanaghan, and C. Slovis, "Supporting patient care in the emergency department with a computerized whiteboard system." J.Am.Med. Inf. Assoc.15(**2**),184–194. 2008.
[29] H. J. Wong, M. Caesar, S. Bandali, J. Agnew, and H. Abrams, "Electronic inpatient whiteboards: improving multidisciplinary communication and coordination of care." Int.J.Med.Inf, 78 (4), 239–247, 2009.
[30] M. Hammer, "Reengineering work: don't automate, obliterate." Harvard Business review, 1990
[31] S. Zuboff, In the age of the smart machine, Basic Books, 1988, New York
[32] R. Garud and P. Karnøe, "Path Creation as a process of Mindful Deviation," in Path Dependence or Path Creation?, Erlbaum, New Jersey, p. 1-40, 2001.
[33] G. Ellingsen, and E. Monteiro, "The slight surprise of Integration," In: Sørensen C., Yoo Y., Lyytinen K., DeGross J.I. (eds) Designing Ubiquitous Information Environments: Socio-Technical Issues and Challenges, vol 185. Springer, Boston, MA, 261-274, 2005.
[34] M. Masuch, "Vicious Circles in Organizations," Administrative Science Quarterly (30:1), pp. 14-33, 1985.
[35] Gerring, J., Case Study Research: Principles and Practices, Cambridge University Press, 2006