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Sense-able process innovation in digital health infrastructures

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

Terje Aksel Sanner
University of Oslo, terjeasa@ifi.uio.no

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

Terje Sanner
University of Oslo,
terjesa@ifi.uio.no

Abstract. In this paper, we examine the role of IT in enabling and supporting process innovation at a general hospital in Norway. The motivation for our study is that fragmented and heterogeneous components of digital infrastructure in complex organisational settings hamper the ability to monitor and improve organisational performance through process innovation. Prior research indicates that loose couplings between traditional 'heavyweight IT' (resilient, secure, and stable) and 'lightweight IT' (consumer-oriented, context-aware and flexible) can support innovation. These principles have not been applied to process innovation. Our research question is, how can lightweight IT extend digital infrastructure to support process innovation, in hospital coordinative practices? We use the sense and respond framework from Overby et al. (2006) to analyze our case findings and derive a model for sense-able process innovation with lightweight IT. The model outlines how lightweight IT extends digital (health) infrastructure and affords an organisational ability to continuously sense and respond to the effects of process innovation.

Keywords: Process innovation, Digital infrastructure, lightweight IT and heavyweight IT, sense and respond

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1 Introduction

A persistent theme in IS research is the role of IT in enabling organisations to quickly respond to incoming requests from various types of clients or recipients (Abernathy and Utterback 1978). This applies to all types of organisations, also hospitals. The activity of optimising processes using IT is often referred to as process innovation (Davenport 1993). While several sectors such as finance, industry, and retail have been transformed through radical process innovation, complex professional organisations such as general hospitals have struggled to realize the potentials of process innovation.

In this paper, we investigate how one hospital in Norway use IT to improve the performance of its horisontal processes[1]. This implies investigating how IT was used to make coordination between hospital departments and functions more efficient, which in turn has a bearing on patient flow, patient satisfaction, and patient safety. Hospitals are professional bureaucracies where different types of specialisations, procedures, and knowledge interact but are challenging to coordinate (Mintzberg 1983).

Hospitals have historically been concerned with patient records and the knowledge and documentation requirements associated with each specialised practice in the hospitals. As each professional discipline has detailed requirements (Hall 2005), a range of dedicated systems has emerged. This tendency can explain the fact that health sector IT infrastructures are often very fragmented, with several monolithic systems geared towards stability and security and often aligned through best-of-breed strategies (Bygstad and Hanseth 2016). Best-of-breed strategies require that different IT systems are integrated through standardised interfaces, but the long-standing efforts to investigate, develop, test, implement, and integrate stand-alone IT systems lead to long-lasting and demanding processes. The integration of IT silos (Bannister 2001; Bygstad and Hanseth 2018; Miller and Tucker 2013) through best-of-breed strategies results in at least two major challenges.

First, the "handoff between functions is frequently uncoordinated" (Davenport 1993, p. 8), something that leads to severe challenges in supporting information flow across and within functions; e.g.; health care units and departments (Øvrelid and Halvorsen 2018). 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" (Ministry of Health 2016).

Second, for clinicians and hospital staff tasked with patient flow and information sharing between departments, the development of clinical systems like digital patient records is a mixed blessing. It can take years from the time new requirements emerge until they are implemented, and when finally implemented in an IT system, the re-

quirement may be obsolete. The long duration of requirements handling and implementation, make user participation less effective since it is difficult to detect the exact consequence of a new requirement until it is implemented in practice.

These two challenges are related. Long-term IT projects make innovation difficult, expensive, and slow. This lowers the quality of IT services received by both patients and clinicians (Kelly and Young 2017; Piening 2011). Improved IT services are important within hospital settings as reduced time spent on logistics and coordination may free up time for patient treatment (France et al. 2005; Hertzum and Simonsen 2013; SINTEF 2016).

In this paper, we are mainly interested in hospital IT users responsible for horisontal coordination of patient flow, and how their information needs can be met. By horisontal coordination of patient flow, we refer to the processes of transferring hospital patients from admission to discharge, and the work that supports this flow, including the use of IT systems and ad hoc human coordination. We are interested in how process innovation in complex organisational settings, such as general hospitals, can be done faster and with more active engagement from users.

We ask:

How can lightweight IT extend digital infrastructure to support process innovation, in hospital coordinative practices?

To improve the services provided by health IT portfolios we suggest that the old digital infrastructure referred to as heavyweight IT needs to be *complemented* with lightweight IT that is more oriented towards process innovation and improved user services.

By heavyweight IT, we refer to the robust hospital information silos and the IT engineering tradition that envelops them (Bygstad 2017). The digital infrastructure of most general hospitals predominantly constitutes a portfolio of best-of-breed heavyweight IT systems. In contrast, we refer to lightweight IT as solutions characterised by rapid implementation cycles, and ubiquitous access to tailored information through user-friendly interfaces (ibid). Examples of lightweight IT are apps developed and deployed swiftly on mobile equipment, as well as Robot Process Automation where non-IT specialists can implement service automation tools (Bygstad 2017; Lacity and Willcocx 2015).

Previous studies have looked at how the interplay between heavyweight IT and lightweight IT can facilitate innovation (Bygstad 2017). However, how this interplay support process innovation across departments and functions in a complex organisational setting has not been studied. We approach this knowledge gap through a case study at the newly opened Kalnes general hospital in Norway. In tandem with the construction of Kalnes, the hospital conducted a comprehensive digitalisation and innovation initiative.

We draw on Overby et al.'s, (2006) concept of *sense and respond*, and refer to process innovation with lightweight IT as *sense-able*, because it enables faster and more dynamic implementation processes whereby user needs can be taken more profoundly into account.

We proceed by reviewing related research on process innovation (2.1) and the interplay between digital infrastructures and lightweight IT (section 2.2) before we describe our sense and respond framing on process innovation (section 3). In section 4 we outline our approach to data collection and analysis. In section 5, three case vignettes are used to describe and analyse our findings. In section 6 we discuss the implications of our findings, present our model for *sense-able process innovation,* and specify the contributions of the study.

2 Related research: Process innovation in digital infrastructures

In this paper, we address IT-supported process innovation that introduces changes to hospital practices, primarily coordinative practices of patient flow. Hospitals are particularly challenging venues for process innovation since they are organised as professional bureaucracies (Mintzberg 1983) where different types of competencies, practices, and knowledge are interacting but challenging to coordinate. Both the process innovation literature and digital infrastructure literature deal with the role of IT in supporting work processes. However, while the process innovation literature emphasises (top-down) systematic improvement of business processes (Hammer and Champy 1993; Schmiedel and Vom Brocke 2015; vom Brocke and Rosemann 2015); the digital infrastructure literature addresses the (bottom-up) emergence of socio-technical arrangements and how this shape work practices (Aanestad et al. 2017; Hanseth and Lyytinen 2010). We seek to understand, how these two perspectives can interact to support process innovation in a complex organizational setting. Before we deal with this issue, we will describe relevant characteristics attributed to the two streams.

2.1 Process innovation

Business Process Reengineering's (BPR) main message was that organisations must remove manual work and use information technology to radically innovate horisontal processes (that cut across organisational functions and departments) (Hammer and Champy 1993; Hammer 1990).

Hammer (1990) outlined six principles for implementing horisontal 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 integrating 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 novel technology's ability to overcome barriers to organisational change, but BPRs lack of social dimensions and the tendency of top-down managerial sidedness to its implementation was a significant shortcoming (Davenport 1996; Melao and Pidd 2000). As organisational processes are complex phenomena that involve collaboration between people attached to different parts of the organisation, a nuanced view is needed (Melao and Pidd 2000).

Business Process Management (BPM) (vom Brocke and Schmiedel 2015; vom Brocke and Mendling 2018) emerged as a response to the shortcomings of BPR. In BPM both people and organisational culture are recognized as important; people in the sense that BPM "needs to consider the employees' qualifications in the discipline of business process management as well as expertise with relevant business processes" (vom Brocke and Rosemann 2015, p. 6), and organisational culture in that "BPM needs a common value system supportive of process improvement and innovation" (vom Brocke and Rosemann 2015, p. 7).

A key focus of BPM is to investigate the role of IT in establishing more effective processes. Schmiedel and vom Brocke (2015, p. 10) claims that "new technologies of the digital age represent a key source of numerous affordances for process innovations". These are emergent process innovation technologies that change the way people work and enable more dynamic processes, or more dynamic configuration of processes (Kemsley 2015).

While BPR and BPM have a long tradition in industry and retail, horisontal process thinking has proven to be more challenging in the health sector. This is due to the dynamic, complex, ad hoc, and multi-disciplinary nature of healthcare processes (Rebuge and Ferreira 2011) as well as the underdeveloped (or fragmented) digital infrastructure (Helfert 2009). Also, organisations with knowledge-intensive processes encounter certain challenges when streamlining their workflow (Seidel et al. 2010; Tarafdar and Gordon 2007). Indeed, more than a decade ago Lenz and Reichelt (2005) wrote that "realizing process-oriented IT architectures in healthcare is a great challenge for the business process management community—if not even the 'killer application' for this type of technology".

In summary, BPM introduces a business process perspective where, although people are included, optimising processes is the prioritised activity. Recent BPM research has, however, also focused on solutions that can complement and run on top of established functionally-oriented IT systems to leverage and improve patient flow. Next, we reflect on how this can be done in digital infrastructures.

2.2 Process innovation with lightweight IT in digital infrastructures

Digital infrastructures

By digital infrastructure, we refer to socio-technical ensembles of systems that operate in networks rather than standalone (Hanseth and Lyytinen 2010; Henfridsson and Bygstad 2013). The digital infrastructure literature has provided a conceptual basis for understanding and describing the heterogeneity and multiplicity of digital arrangements as well as the organisational structures, human agency, and IT capabilities that operate in relation to these elements. The digital infrastructure's heterogenous arrangements are referred to as an installed base. All change and innovation efforts in digital infrastructures must relate to the extant installed base, something that makes process innovation challenging, and slow, i.e the installed base has a strong conservative influence (Aanestad et al. 2017; Grisot et al. 2014).

While the process innovation literature is concerned with processes of deliberate optimization and change, digital infrastructure research is concerned with how extant socio-technical arrangements inhibit or constrain planned change. For example, research on digital infrastructure highlight how different groups or functions within organizations tend to obtain their own specialized IT systems from a variety of vendors, which results in IT silos (Bannister 2001; Bowman et al. 2011). This makes information exchange between functions and departments difficult, even within the same hospital, and makes strategic goals such as efficiency, flexibility, and competitiveness partly unfulfilled (Miller and Tucker 2013). Moreover, digital infrastructures accumulate complexity, which necessitates slow and incremental change based on cultivation of the installed base (Aanestad and Jensen 2011). Process innovation initiatives that target relatively fast results (Davenport 1993) will have to look for new ways of avoiding or changing the existing IT regime.

Lightweight IT and heavyweight IT

In a fruitful attempt to distinguish between forms of innovation in digital infrastructures, Bygstad (2017) identify heavyweight IT and lightweight IT as two complementary knowledge regimes. 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." (ibid, p. 181) The digital infrastructures in the health sector have been dominated by heavyweight IT (Bygstad and Hanseth 2018; Øvrelid and Bygstad 2019), which has made innovation challenging.

Recently, we have seen a growth in digital services in tandem with individuals and organisations rapid uptake of commercially available devices such as tablets, smartphones, wearable sensors, and electronic whiteboards. Bygstad (2017) refers to this as lightweight IT. Examples of lightweight IT are apps developed and deployed rapidly on mobile equipment and applied as welfare technology to monitor elderly citizens living at home (Bygstad 2017). Another example is Robot Process Automation where non-IT specialists can implement service automation tools (Lacity and Willcocx 2015). Since the knowledge of the context is just as important as the tool, lightweight IT is defined as "a socio-technical knowledge regime, driven by competent users' need for solutions, enabled by the consumerization of digital technology, and realized through innovation processes" (Bygstad 2017, p. 2).

Hence, the distinction between heavyweight IT and lightweight IT is based on the recognition of different types of knowledge regimes informing the development of digital infrastructures and the need for these regimes to interact (Howard-Greenville and Carlile 2006). We employ the notion of lightweight IT based on three characteristics relevant to the innovation of *user services*.

First, we are interested in the role of lightweight IT as a front-end-oriented knowledge regime driven by new information needs and innovations. This includes the ability to rapidly identify new business opportunities and implement IT solutions to address the opportunities (Bygstad 2017). Lightweight IT solutions typically employ resources already available in the consumer market which supports rapid purchase and customization (Gregory et al. 2018).

Second, we are concerned with the role of whiteboards and mobile technology in sharing, visualizing, distributing, and highlighting information in complex settings (Hertzum and Simonsen 2015; Torkilsheyggi and Hertzum 2017). This contributes to transparency and improved overview in a way that may enable bottom-up and locally relevant process innovation. Lightweight IT may also contribute to improving the mediation between work practices and IT in shaping and making more effective processes (Jonsson et al. 2018; Sanner and Øvrelid 2019). At hospitals, the constant

flow of patients makes efficient use of resources challenging. Hence, IT systems that are configurable and flexible for different user groups can strengthen the cross-functional transparency and overview of information.

Third, we emphasize the modular structure of lightweight IT. Modularity both strengthens the configurability and the redesign flexibility of IT (Henfridsson et al. 2018; Yoo 2010; Yoo et al. 2010), it makes IT easier to change, and easier to connect to other IT systems through standardised interfaces.

Process innovation through interaction between lightweight IT and digital infrastructure

Above we have outlined two different modes of innovation that both are oriented towards IT-enabled change. Figure 1 describes how process innovation and digital infrastructure may interact with support from a particular knowledge regime called lightweight IT. As we have seen. lightweight IT solutions are typically geared towards innovation, usability, and flexibility (Torkilsheyggi and Hertzum 2017). Three prominent characteristics of lightweight IT are *process-oriented, informative, and modular.* Process oriented connects to process innovation, that is, knowledge on how user services can be defined and made available to better adapt to horisontal processes (Hertzum and Simonsen 2019). Informative relates to how IT equipment can be used to highlight and visualise processes, resources, and needs related to these matters (ibid). Modular refers to the more separated and agile interaction with the digital infrastructure (i.e., heav-

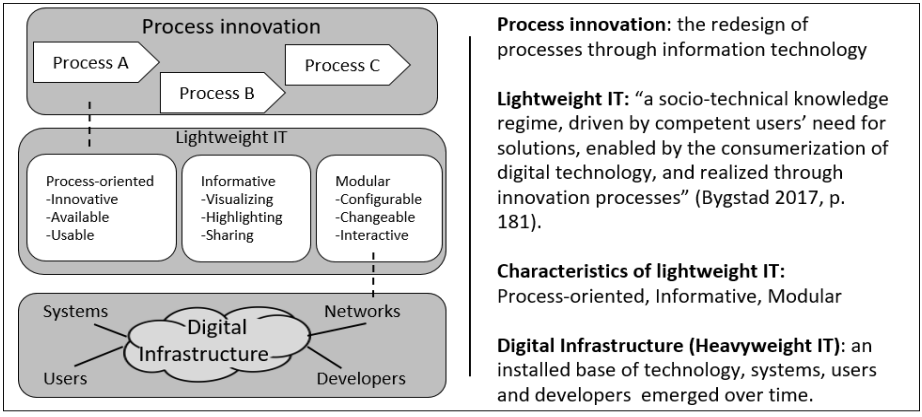

Figure 1. Process innovation, lightweight IT and Digital Infrastructure

yweight IT). A modular structure, we propose, (see also figure 3 in section 5) makes the interaction configurable, changeable, and interactive. Lightweight IT solutions are typically configurable by the user organisation without assistance from the vendor and thus easier to adapt for process innovation.

Given these characteristics, lightweight IT may act as a bridge between process innovation and extant digital infrastructure (Bygstad and Øvrelid 2020). Practitioners gain access to a deep repository of information, but also the flexibility to configure the sharing and visualisation of this information to fit with horizontal coordinative processes.

In this paper, we draw on the sense and respond lens from Overby et al. (2006) to investigate a general hospital's use of lightweight IT (in combination with heavyweight IT) to facilitate process innovation in relation to workflow coordination. We refer to the improved processes as *sense-able*, to signify rapid and iterative implementation cycles addressing the changing needs of different users, often triggered by the process innovation itself, are sensed and responded to.

3 Sense and respond in process innovation

Enterprise agility concerns the ability of firms to sense and respond to environmental changes (Overby et al. 2006). Enterprise agility requires both the ability to *sense* a change and how changes affect the operations as well as the ability to readily *respond* to these changes. The ability to *sense* requires insight into the actions of others, such as consumer preferences and economic, regulatory, or technological change or advancements. The ability to *respond* can entail a simple move, such as adjusting an existing venture, or a complex move, such as embarking on a new venture (Overby et al. 2006). Furthermore, Overby et al. distinguish between process-oriented IT and knowledge-oriented IT. Process-oriented IT concerns the interaction (internally and externally) with customers, suppliers, and partners. Knowledge-oriented IT is concerned with knowledge reach—which refers to "the comprehensiveness and accessibility of codified knowledge that is available to a firm" (ibid, p. 126). These distinctions are important, since "knowledge-oriented IT is more directly supportive of a firm's sensing capability…while… process-oriented IT is more directly supportive of a firm's responding ability" (ibid, p. 127).

While Overby et al. primarily focus on organisations operating in competitive markets, we apply their sense and respond lens to the study of a hospital's digital infrastructure.

Following Overby et al. we understand hospital sector infrastructures as primarily consisting of knowledge-oriented IT, and to a less degree process-oriented IT. The installed base of specialist systems has created a fragmented digital infrastructure of knowledge-oriented IT (Aanestad et al. 2017, Bygstad and Hanseth 2018) with poor integration between systems and manual routines to support patient flow. This is inefficient from a horisontal process innovation perspective (Davenport 1993; Hammer 1990). Hence, even though hospitals may sense the need for change, their ability to respond is generally limited.

In the context of digital infrastructure in complex organisational settings, we define sensing *as the organisational ability to use IT in a way that reduces the time it takes from a change introduced by process innovation (negative or positive) is detected until the organisation can respond to it. By responding we refer to the organisational ability to use IT to either revert or modify (in case of negative effects) or amplify (in case of positive effects) the effect.*

In the following, we will describe our methodological approach (section 4) before we apply the sense and respond lens to analyse our case.

4 Method

Figure 2. Kalnes Hospital

The setting for our empirical case study is Kalnes general hospital in Østfold County in Norway. The hospital opened in November 2015 and replaced 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 Fredrikstad hospital, 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 one building with four floors that provide health services. The building was designed to allow different departments to dynamically expand and retract to adapt to changes, such as seasonal flu.

The construction of Kalnes hospital has created opportunities for hospital-wide process innovation. Mobile technology and electronic whiteboards are deployed throughout the hospital. The electronic whiteboards provide up to date information for patients, their families, professionals assigned to patients, and hospital support staff, such as housekeepers and porters. The hospital management has high ambitions regarding its process-oriented use of IT (Bygstad et al. 2017). Kalnes Hospital serves as an extreme case of our area of concern (Gerring 2006), because of the ambitious efforts to integrate and align clinical work processes and patient records keeping with novel IT solutions to support horisontal process innovation and improve coordination.

Our research approach is based on engaged scholarship (Bygstad and Munkvold 2011; Mathiassen and Nielsen 2008) where practitioners are not only sources of empirical data, but also helpful in constructing narratives and discuss theoretical and practical implications. To structure our data analysis we used temporal bracketing (Langley 1999).

4.1 Data collection

From July 2016 to June 2018, we performed three rounds of data collection and follow-up (see table 1). We started with in-depth and open-ended interviews where management and project managers presented the main goals as well as how they planned and organized the IT-oriented process innovation initiative. To understand how the process innovation efforts were received by hospital staff, we conducted observations at the emergency unit and health wards. We focused on how coordinators, clinicians, and service personnel were able (or not) to use IT to perform their coordinative tasks. We continued with further conversations with observed personnel to avoid misunderstandings.

Subsequently, we examined Kalnes' role in the health region through meetings, workshops, and seminars. We were in particular interested in how Kalnes have addressed and solved some of the challenges other hospital struggled to solve. We also participated in a seminar with more than 100 e-health professionals.

Finally, as a third data collection exercise, we revisited Kalnes during 2018 and attended meetings to investigate how the process innovation efforts had evolved and how the hospital had responded to emergent issues.

In all, we have conducted 35 interviews, with managers, project and process managers, clinicians, technical experts, and housekeepers as well as IT system suppliers. We have inspected documents on patient treatment regulations, requirements from the regional health authorities, and documentation regarding IT solutions.

Collection	*Activity*	*Data*
Interviews	35 interviews with CEO, CIO, Process manager, Project managers, clinicians, and staff.	Goals, purpose, and results of the project, strategic, and organisational development.
Observation	More than 60 hrs. of observation.	Results of the implementation, the relation between information and decisions.
Workshops	Workshops and seminars	Strategies, ambitions, and consequences of digital innovation at Kalnes, and the role of Kalnes in the bigger regional initiative.
Documentation	Documentation of process design, system design, and technical issues.	More than 500 pages on system design, process descriptions, and work descriptions.

Table 1. Data Collection

4.2 Data analysis

The data analysis was conducted in four steps (table 2). We first established a chronology of key events, challenges, and aims related to the process innovation efforts at Kalnes. In parallel, we identified key entities (i.e., actors, organisation, and artefacts) involved in the process innovation activities. We observed that the combination of IT solutions enabled the organisation to improve particular horizontal processes, and our goal was to explain why.

In the second step we observed coordinative actors and their challenges regarding horisontal flow, we identified key technology for supporting horisontal flow including situations where digitalisation initiatives improve or challenge the existing order. This included identifying core processes and resources as well as the initiatives to digitalise

them. By using Langley (1999) to structure our approach, we identified three key activities conceptualised as *digitalise, visualise, and manage* to describe the incremental process of process innovation in our case.

In the third step, we raised questions such as, when sharing the status of resources across wards and to relevant decision-makers, what challenges arise? How are the new possibilities and challenges dealt with? How does the interplay between technological components enable or constrain work performance of coordinative actors? During our investigation, we found that there was an urge amongst the coordinators and ward managers to use the opportunity given by the process innovation approach and the lightweight IT to optimise horisontal performance. We used the conceptual model from Overby et al. (2006) to analyse how the actors sensed emerging challenges and how they tried to respond to them. We saw that responses became the subject of collective evaluation and sometimes re-evaluation.

Step	*Activity*	*Output*
1	Identify key events and key, IT solutions and coordinative actors and how their roles unfold over time.	Section 4.3: The new hospital, upstart, and development.
2	Observe coordinative actors and identify challenges regarding patient flow, and key technology for supporting patient flow.	Section 5.1-5.3. Three vignettes describing three incremental activities in process innovation initiatives
3	Structure the approach in "temporal brackets" (Langley 1999). Analyze the process innovation challenges using the conceptual model from Overby et al., (2006) to generalize the findings.	Section 5: Analyses of process innovation as performed in three activities, and where each becomes the subject of a sense and respond reflection and decision
4	Theorizing the challenges and outcomes when using lightweight technology in process innovation.	Section 6: A process model to describe the role of lightweight IT in sense-able process innovation

Table 2. Data Analysis

During our involvement, we saw that process innovation initiatives building on heavyweight IT and facilitated by lightweight IT, led to *sense-able process innovation* also because it was easier to rapidly trace the consequences of changes. This led us to establish a process model of process innovation leveraging lightweight IT to sense and respond to the effects of process changes.

4.3 Case background: Process innovation at Kalnes

1999-2012: Process innovation in a new hospital

In 1999, the Norwegian Parliament decided to build a new hospital in Østfold County. The CEO of the new hospital, Just Ebbesen, was both a medical doctor and experienced 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." Pursuing the aim of a hospital built on process thinking and advanced digital solutions, Ebbesen expanded the management team with a CIO with experience from production and retail in 2011 and a Process Director in 2012.

2013-2015: User participation in process modeling

Process modeling and redesign started in 2013 at the old hospital, in Fredrikstad. Around 25 clinicians, other hospital staff, and external consultants worked full time in the modeling project. The workgroup together with IT personnel and architects, as well as development experts, modeled 63 work processes in detail. They mapped the processes (sub-processes of 38 clinical pathways) and identified the IT requirements needed to support each step. The Health South-East region did not have a system that supported patient flow and hospital logistics. Kalnes contracted a system supplier called Imatis. Their whiteboard and mobile solution supports patient flow. The Imatis solution was based on lightweight IT principles and knowledge (see figure 3).

2016-2018: User services to support process innovation

The project was able to implement the most necessary systems and integrate them with the Imatis solution before the hospital opened in November 2015. A very important reference site for Kalnes was Køge hospital in Denmark, where Imatis had been

implemented through a cooperative project between the hospital staff, the vendor of the whiteboards, and the University of Roskilde (Hertzum and Simonsen 2015). 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 to all hospital personnel, and a message broker for distribution of messages to mobile phones and whiteboards (and other systems). The solution was extensive and supported information flow between major clinical systems, mobile, whiteboard terminals, logistics, and emergency communication. Access and security were role-based (as was the access to the health wards and other sections within the hospital).

The initiative was modeled on top of the extant portfolio of heavyweight IT, including Electronic Patient Record (EPR), chart, radiology and lab systems, etc. This enabled the hospital to monitor and improve workflow performance. Examples of emergent process innovation efforts included:

- Division of routine processes into well-defined steps;
- Making hospital resources available across departments and wards;
- Exchanging patient information during transfers between departments; and
- Establishment of arenas where patient flow challenges could be discussed and dealt with regularly.

For instance, the interplay between the emergency unit and the hospital wards was supported by the whiteboard solution that enabled a visual overview of all available hospital beds. "It is a completely new work situation for me," a coordinator stated, "because the whiteboard enables me to have full overview and control of the process."

A key patient flow indicator is the average time used from a patient is admitted until the patient is discharged. This had increased from 3.2 days in the old hospital to 3.6 days at Kalnes hospital. The cause was assumed to be a non-optimal discharge process, as the status of the patients was not changed immediately. Consequently, available rooms were not cleaned on time. Both problems were rooted in the fact that tight logistics requires disciplined updating of information systems by multiple coordinative actors, and several initiatives were taken to improve this.

These issues also led to tighter synchronisation between support services like housekeeping, dietary services, hospital porters, and clinical processes. In turn, the increased transparency of patient flow processes led to the establishment of collaborative arenas to identify solutions to coordination and workflow issues. In the following, we provide detailed insights into the efforts to enable and support process innovation at Kalnes through three case vignettes. The vignettes illustrate a gradual emergence of hospital

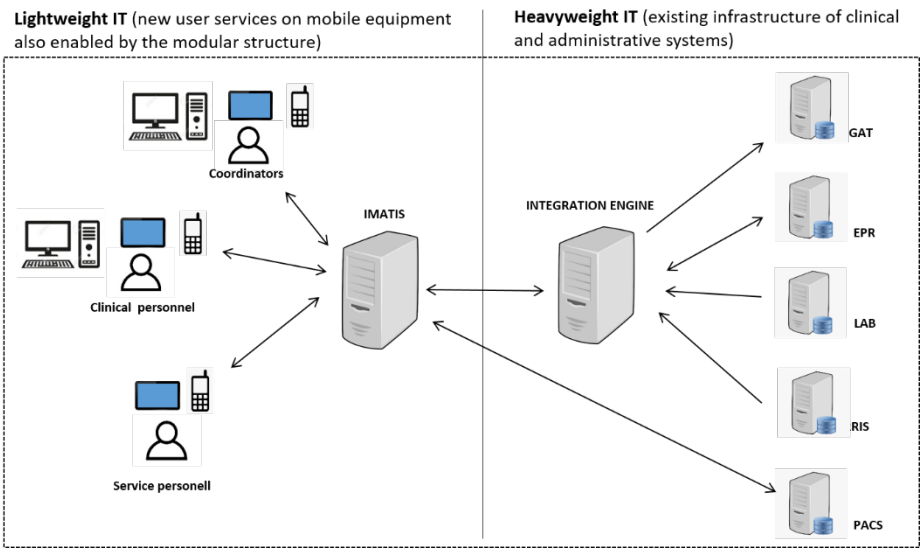

Figure 3. Imatis, users and integration engine

sense and respond capabilities through efforts to *digitalise*, *visualise* and *manage* hospital process information. First, we provide a brief introduction to the three vignettes.

5 Findings: Sense-able process innovation at Kalnes

Kalnes emergency unit receives between 90 and 120 patients every day. Most patients drop-in after having been referred by their general practitioners or primary health care units. Kalnes Hospital's efficiency goal for patient stays at the emergency unit is two hours, but the average time of stay is 4.5 hours.

Kalnes hospital has several departments (e.g., neurology, heart, and lung) 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 acquired electronic whiteboards and mobile devices with Imatis software installed as a part of their process innovation strategy. There is functionality in Imatis to display all available rooms in all wards and reserve them for patients. Hospital staff (e.g., nurse, clinician, or housekeeper) can access custom Imatis information views on mobile clients (tablets and smartphones) based on their role and location within the hospital.

A large portion of the information displayed through Imatis on mobile devices and whiteboards are harvested from the main EPR systems at Kalnes. Through an integration engine (see figure 3), Imatis is also integrated with the personnel administration

system, called GAT, lab, radiological information system (RIS) and picture archiving and communication system (PACS). The interplay between the extant hospital information systems and Imatis undergirds information transparency about the availability of hospital resources and supports hospital-wide coordination. We refer to the existing digital infrastructure as heavyweight IT, and the new process-oriented IT as lightweight IT (see figure 3)

We present three case vignettes that illustrate how the interplay between lightweight IT and heavyweight IT supports the development of sense-able process innovation at Kalnes hospital. The first vignette resent some of the preconditions for digitalisation of hospital processes and resources using lightweight IT. Then, we describe the effects of improved information sharing and visualisation on particular coordinative processes and shared resources. The third and last vignette, describe efforts to continuously assess and manage process innovations through interdepartmental meetings and seminars and by individual hospital staff.

5.1 Digitalise processes and resources

An important initial activity related to the transition from manual to digital processes is to divide manual processes into subprocesses measured and recorded separately. An example is triage. The purpose of triage is to ensure that patients with immediate needs for health care receive it first. It is critical but challenging 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 (project manager)

Sometimes, clinicians can quickly decide who needs treatment (tacit decision-making) and then complete the treatment. This may cause the department not to treat the most important cases first. The separation of triage and treatment based on general principles (explicit decision-making) is an example of breaking more or less coherent working processes into sub-processes measured separately. Due to the importance in terms of patient safety of isolating triage from subsequent treatment, the Kalnes hospital management decided to prioritise this activity despite apparent difficulties. When the triage information about the patient is captured and shared, it can be used by different

hospital departments to prepare for the patient that is likely to be transferred from the emergency unit. This speeds up patient transfers and aligns with the hospital's goal to shorten patient's stay at the often crowded emergency unit.

At Kalnes hospital, admitted patients stay in single bedrooms, each with a small bathroom. Housekeepers clean the room upon every patient transfer or discharge. The cleaning routine takes between 18 and 25 minutes. This was not the case at the old hospital in Fredrikstad, where rooms with two or four patient beds were cleaned once a day, irrespective of patient transfers or discharges. At Kalnes the housekeepers use Imatis to register, respond to, and manage their activities. For some housekeepers, work is both physically harder, more stressful, and more challenging, partly because of IT use for all the activities. One housekeeper who transferred from Fredrikstad hospital noted that:

> We run from room to room. The list [worklist on mobile phone] is never empty. When I sign out at the end of my shift the list still has tasks that are not complete. It feels like I did not do enough.

At the old hospital, the coordinative process of identifying available beds and treatment resources was manual. Nurses would walk around, ask personnel, and make notes on the availability of resources. At Kalnes, key hospital resources have been digitalised. The transition from manual to digital access enables the organisation to improve the sharing of resources between departments. The movement of a patient from the emergency unit to one of the hospital wards should involve several communication steps and quality checks as the quote illustrates.

> First, the doctor assigned to the patient gives 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 identifies a room for the patient and sends 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).

In practice, the swift coordination of patient transfers from the emergency unit at Kalnes to other departments is sometimes hampered by clinician's delayed entry of information about patients and some hospital ward coordinators' practice of main-

taining a buffer of unused beds at their ward to safeguard against local overcrowding. This caused needless delays in patient transfers and sometimes led to patients being transferred to a different ward than the one most appropriate for their condition (e.g, patients' place in the lung ward instead of the heart ward).

The hospital management deemed the digitalisation of the workflow coordination pertaining to patent transfers of strategic importance. Consequently, the hospital process director established a weekly patient flow seminar for different departments and professional groups to negotiate its implementation. The activity of making manual routines and resources digital, changes and sometimes transforms activities related to horisontal processes and their coordination.

Analysis

Process innovation aimed at digitalisation of both resources and activities may lead to certain challenges. We described some of the difficulties by which physicians struggled to split holistic processes into sub-processes. The response to this critical issue was to proceed. Another challenge was how global access to local resources challenged the local autonomy of each ward. In some cases, this led the hospital to reverse the global accessibility of particular resources. We refer to the response as re-evaluation which is the process by which management decides to reverse a step in the digital process innovation. Furthermore, digital handover had to follow requirements for safety and quality. This led digital handover to be implemented gradually instead of as a big bang. All three examples demonstrate that the organisation *senses* the difficulty experienced by hospital employees in the process innovation activities, but also how hospital management and departments collectively *respond* to these difficulties if necessary.

5.2 Visualise processes and resources

The main admission point at the emergency unit is conditioned by the hectic activity of busy physicians, coordinators, patients, relatives, porters, and housekeepers. Ambulance personnel who have just delivered a patient need a document to be signed by a responsible physician. The phone chimes constantly. The main goal is to take care of patients, this includes maintaining their patient record, looking for available rooms, and making sure that each patient is allocated to a physician.

Whiteboards help the emergency unit coordinator to gain an overview. In figure 4 we see that the coordinator is equipped with big screens displaying information. The

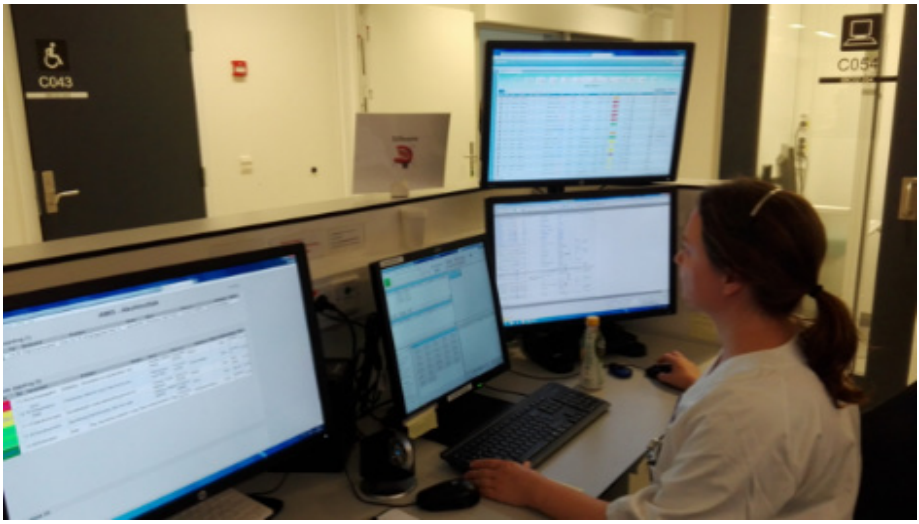

Figure 4. Emergency unit coordinator

left screen indicates arriving ambulances with patients. This facilitates proactive identification of rooms and available physicians.

The Imatis whiteboard (upper right) gives an overview of available hospital resources. It also gives an 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-rays as well as the responsible nurse and doctor. Further, it enables active participation in preparing patient treatment like registering a patient, attaching necessary resources, and switching care personnel when needed. The whiteboard keeps the clinical and logistical personnel informed about the status and enables swift modification.

"Oh, they have to start discharging patients from the wards". The emergency coordinator utters after looking at one part of the screens with an indication that the emergency unit is filled up. The coordinator then inspects if patients are marked for discharge from the health wards. This overview allows them to be proactive in releasing resources from the emergency unit.

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). Also, communication with the cleaning personnel and the booking of beds is much easier. One nurse said, "It is much easier to get an overview when we have the information both in our heads and on the screens". 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 catering and housekeeping. Also, it provides a good overview of patients admitted to the department and the department to which they belong.

The digitalisation of the housekeeping routines has replaced a lot of the earlier ad-hoc communication that had to take place. The availability of resources through the mobile system enables the clinicians to notify when a room has to be cleaned and to indicate airborne or body fluid contamination. Housekeepers make direct data entry into Imatis by indicating that they have 'started cleaning', 'cleaning in progress' and 'finished cleaning'.

> The cleaning routines take approximately 30 minutes but sometimes it takes three hours from a room cleaning is booked to the cleaning is performed. This is especially in the peak hours. The housekeepers have rescheduled the way they work 4 times since the hospital was opened (nurse).

Analysis

Lightweight IT solutions (Bygstad 2017) utilize mobile smartphones and electronic whiteboards and support process innovation through information sharing and visualisation. The utilization do, however, require interaction with heavyweight IT (see figure 3). Information visualisation helps the various hospital coordinators, the nurses and managers in the wards and the housekeepers to coordinate their work. This improved overview increases their ability to sense important changes that have a bearing on their activities. Lightweight IT (supported by heavyweight IT) can be seen as a process technology that improves an organisations sense-ability (Overby et al. 2006). Organisational *responsiveness* relates to how this visualisation helps individuals, teams, and departments adjust their working schedules to address the needs of their surroundings.

5.3 Manage processes and resources

Process innovation with lightweight IT complementing heavyweight IT may improve transparency and provide a basis for collective decision-making. First, digitalisation provides easier access to process information. Information can be displayed as custom views, which provides a basis for department or individual self-management. At Kalnes, the housekeeping department re-organized its activities several times based on an emer-

gent understandig of actual hospital needs. For example, ward managers organize their units based on analyses of the daily patterns of referral, treatment, and discharge, while coordinators identify available resources and map them onto patient trajectories.

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 brings together logics pertaining both to patient flow (efficiency) and patient treatment. This strengthens the collective appreciation for local challenges and their cross-departmental interdependencies.

> In the patient visit, we use Imatis to identify who needs to be treated first, based on the level of urgency. Then we try to prioritize 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 have to be cleaned so that they can do this right away.(ward manager)

The visibility of the information enables management to establish common arenas to address flow challenges. The electronic whiteboard is at the center of several arenas for discussing the patient flow. An example is 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 has availability in the mid-day when the emergency unit is full.

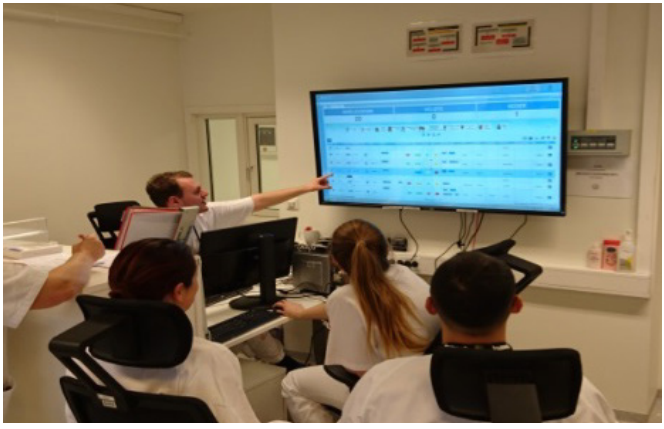

Figure 5. Whiteboard meeting

> The whiteboard meeting starts at 0850 and lasts for ten minutes. In this meeting, all the admitted patients are discussed as participants 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 optimise the patient flow, the whiteboard meeting is an important arena for process innovation.

Process innovation through digitalisation may create unintended effects or bring to life hidden challenges. For instance, seamless integration between lightweight IT solutions and heavyweight IT give rise to challenges in terms of keeping users informed about where data 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 can assess what system they are making data capture against or retrieving information from—as everything is 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 flow back into the EPR where the status of the patient has not yet been updated by the clinician in charge of the patient.(housekeeper)

In sum, the whiteboards make it easier to gain information about processes and resources and have also motivated the establishment of arenas where patient flow is discussed and prioritized. However, the immediate sharing of information also calls for a new level of awareness about when information needs to be entered and how it will be acted upon by other hospital staff.

Analysis

Lightweight IT integrated with heavyweight IT affords new possibilities for managing innovation (Bygstad et al. 2017). These improved conditions for management of process innovation efforts, can be seen as a part of a hospital sense and respond capability. In our case, sense relates to how the IT potential is used actively to identify available resources, but also what it takes to define something as a (digital) resource. Hospital-wide access to resources allows staff to be proactive and check for the availability of resources

before they are needed. The decentralized autonomy, discussions, and negotiations are giving the departments increased understanding of the importance of patient flow, and what it takes to improve it. Improved visibility gives improved management of resources and more flexible use of the workforce by assigning human resources to different units and tasks depending on demand. In addition, this leads to the swift identification of problematic and risky processes, and consequently a more agile and faster response.

In summary, establishing mechanisms to discuss the result of digitalisation allows early identification of challenges and outcomes that requires response. We refer to this as an ability to sense and respond to emergent challenges in coordination practices. A digital infrastructure extended with lightweight IT, we propose, may shorten the loop between identified challenges and the implementation of improvements and inform continuous monitoring and response. It is also important in strengthening the worker's sense of control and efficiency.

6 Discussion: Sense-able process innovation and responsive digital infrastructure

In this paper, we address IT supported process innovation in hospital coordinative practices. Our case focuses primarily on coordinative practices that have a bearing on patient flow, as this was a key priority at Kalnes general hospital. General hospitals are particularly challenging venues for process innovation since they are organized as professional bureaucracies (Mintzberg 1983) where different types of competencies, practices, and knowledge interplay, but are challenging to coordinate.

While BPM addresses the design of optimal processes with the help of IT (Hammer and Champy 1993; Schmiedel and Vom Brocke 2015), digital infrastructures are not designed but evolve bottom-up through local adaptation, cultivation, and drift (Aanestad et al. 2017; Ciborra et al. 2000). How can these two different perspectives be aligned to improve coordinative practices in complex organisational settings? Further, how can we establish faster and more sense-able process innovation to support coordinative actors at the hospital? Based on this foundational interest, we asked:

How can lightweight IT extend digital infrastructure to support process innovation, in hospital coordinative practices?

In addressing the research question we derive two contributions: we provide rich empirical insights into a complex process innovation project, and in 6.1 we build on this insight to establish three propositions for process innovation in digital infrastructures. Then, in 6.2 we build a process model for sense-able process innovation.

6.1 Supporting process innovation in digital infrastructures

In this section, we describe how lightweight IT and heavyweight IT supports process innovation in a complex organisational setting through three principles: *user services that facilitate redesign of processes to support patient flow coordination; leverage of the installed base and users, and facilitation of rapid innovation cycles.*

Connect process innovation and lightweight IT: Improved user services facilitates redesign of processes to support patient flow coordination

First, it is important to improve user services to facilitate a user oriented way of redesigning horisontal processes when needed. The BPR and BPM literature identifies principles for improved support for patient flow using IT. The early BPR literature highlighted the importance of reducing the amount of paper and manual activities to enable more efficient business process reengineering based on information captured directly at the source. Further, human action and decision-making should be mediated (by IT) (Jonsson et al. 2018; Sanner and Øvrelid 2019) in the most efficient way possible, while security must be built into the process (Hammer 1990; Hammer and Champy 1993). In later BPM literature (Schmiedel and vom Brocke 2015; vom Brocke and Schmiedel 2015; vom Brocke and Mendling 2018) this insight is maintained but reoriented towards people, emphasising the need to take the qualifications and experiences of the employees seriously.

The process innovation with lightweight IT and heavyweight IT at Kalnes aligns with the principles of the later BPM literature, but contribute to this literature by adding empirical insight (Recker and Mendling 2016). Kalnes established teams with clinicians, support staff, and external consultants, that worked full time in the process modeling project. The workgroups together with IT personnel and architects and software development experts, modeled 63 work processes in detail. They mapped the processes and identified the IT requirements needed to support each step. The hospital management was concerned with drawing on professionals and experiences from the private sector when organising the project.

Connect lightweight IT and heavyweight IT to leverage the installed base and the users

Second, process innovation in the hospital must take the installed base of extant digital infrastructure into account (Aanestad et al. 2017). In contrast to the early BPR philosophy of "don't automate, obliterate" (Hammer 1990; Hammer and Champy 1993) the

extant organisational resources must be actively leveraged when doing process innovation in highly professionalized and complex organisational settings.

In digital infrastructures, development is closely tied to specialised work practices and IT systems, and consequently demanding to change, especially if the logic of change is different from the dominant one. The users are important resources in validating and further developing their systems. This means that the users must participate and that the existing resources and technologies must be envisioned as part of future arrangements. This is not trivial since the existing systems are oriented towards particular professional specialization rather than horisontal flow across disciplines and departments.

At Kalnes human resources were included in the project from the very beginning, and their insights and knowledge were important when designing the processes in the new organisation. Thus, instead of acquiring and implementing new EPR's, the management decided to appropriate the existing digital infrastructure to fit the new workflow-oriented requirements.

Also, lightweight IT enabled a more configurable IT portfolio which was easier to change when needed. This modularity through integration interfaces (see figure 3) enabled powerful reuse of information across systems.

The result: facilitation of rapid implementation cycles with lightweight IT supported by heavyweight IT

Health care institutions often lack the required technology to strengthen the focus on horisontal processes. According to Overby et al. (2006) both process-oriented technology and knowledge-based technology is needed to reach a level of control where an organisation can sense and respond to changes. At Kalnes the digital infrastructure was complemented with Imatis to support process innovation by adding configurable user services. We consider this process-oriented technology as lightweight IT, which often involves configurable software that supports new innovative paths (Øvrelid et al. 2018).

With lightweight IT, the effects of iterative experimentation with process innovation can be monitored and sensed rapidly. This allows decision-makers to decide if there is a need to reverse the process innovation or proceed (see section 6.2). In 2013 the management team at Kalnes decided to acquire a new process technology to complement the installed base of already existing IT systems. They also built on the decision made by the regional management to optimise the installed base through a best-of-breed strategy. Through the Kalnes project, a process innovation initiative evolved where people participated and heavy engineering was avoided.

Moreover, modularized IT with distinct functionality often makes the division of responsibilities between systems or modules in the digital infrastructure easier to identify, which makes errors easier to rectify. User-oriented lightweight IT makes it easier to visualise patterns of performance and hence increase the ability to detect bottlenecks or shortcomings that lead to an inefficient performance in the organisation. The inter-departmental awareness of uneven performance, made visible through lightweight IT, supported collective efforts to detect causes of organisational inefficiency. At Kalnes, transparency of information across departments gradually facilitated a collective insight into end-to-end processes and the causes for non-optimal processes that lie outside the local control of any single department. Improved visualisation of challenges to workflow coordination led to the establishment of collaborative arenas that unified the search for proactive responses to common or shared challenges. Our work extends what Bygstad (2017) proposed, that the process innovation capacity of lightweight IT (interplaying with heavyweight IT) in sharing, visualizing, and redistributing information enables horisontal process improvement also across departments.

6.2 A process model for describing sense-able process innovation

In 6.1 we identified and described three important principles for sense-able process innovation. In this section, we use these principles to develop a process model. Figure 6 illustrates the sequence of sense-able process innovation, which we define as *a gradual*

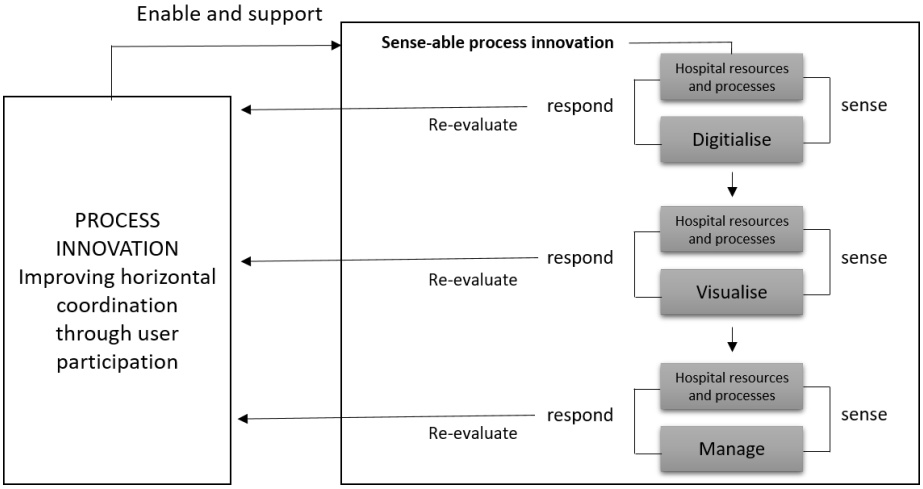

Figure 6. Sense-able process innovation in responsive digital infrastructures.

and open innovation process where challenges are dealt with incrementally and addressed through digitalisation, visualisation, and managing process innovation efforts. Table 3 outlines the definitions of the various concepts in the model.

Concept	*Definition*
Process innovation	Process innovation is the activity by which processes (structured sets of events) are significantly improved by the use of IT.
Sense-able process innovation	A gradual and open innovation process where challenges are dealt with incrementally and addressed through digitalization, visualisation, and managing process innovation efforts.
Digitialise	The process by which manual or analog processes and business logics are replaced by digital ones
Visualise	Digital processes and resources are made accessible through whiteboards or mobile devices.
Manage	The improved conditions for management achieved through interaction between heavyweight and lightweight IT
Re-evaluate	The process by which management decides to reverse the process innovation e.g. by reducing the digital accessibility to a shared resource
Improved horisontal coordination	The outcome of process innovation that includes digitalisation, visualisation, and management, leading to an improved and more efficient process.

Table 3. Definitions

The model describes a way of performing process innovation with lightweight IT. Process innovation is about identifying and digitalising processes (Hammer and Champy

1993). We define digitalised as *the process by which manual or observe, analog resources or processes are made digital*. Increased visualisation, we observe, is one of several outcomes of digitalised processes (Zuboff 1988). Whiteboard technology contributes to improve the visuality (Hertzum and Simonsen 2015). We consequently define visualise as *the effect of digital processes or resources when displayed on and made access to through whiteboards or mobile equipment.* As we saw in the last section, (and in section 5.2) lightweight IT has a strong visualisation ability that makes information more powerful, shareable, and easier to distribute. It does also, we propose, improve the conditions for management. By manage, we refer to *the improved conditions for management achieved through digitalisation and visualisation.* Management in this setting includes core service personnel and how they can manage their work tasks. Each of these three activities, digitalise, visualise, and manage, goes through a sense and respond cycle, where the outcome of implementation is responded to. A change addressing process innovation challenges may, as described in section 5, be re-evaluated or implemented. By re-evaluate, we refer to *the process by which management decides to reverse the use of or reduce the accessibility to a resource due to special challenges*. Improved horisontal coordination is a result of a completed process innovation cycle that includes digitalisation, visualisation, and management.

Examples from our case are the triage processes that had to be implemented even though it was complicated for the clinicians. Other examples are the global access to rooms that had to be reversed as some rooms should only be accessible to special departments. Examples of sense and respond when it comes to visualizing and managing are how whiteboards and meetings are facilitated by lightweight IT in interaction with digital infrastructure, and how whiteboards and meetings are used to benefit from this improved foundation.

The process model (figure 6) emphasizes the connection between sense-able process innovation and responsive infrastructures during the activity of process innovation at a general hospital. The process of digitalise-visualise-manage is incremental, for each step the changes must be evaluated. By using existing technological arrangements and complement it with lightweight IT, we may obtain a technological foundation that is more manageable and easier to change at the top layer (Bygstad 2017).

In summary, lightweight IT is, we propose, more configurable to human action, and may, in interplay with digital infrastructure improve the support of horisontal processes in hospitals. This may also improve mediation (Jonsson et al. 2018). A central improvement is that the sense-able monitoring ability of lightweight IT helps the organisation detect non-optimal flow faster, and make it easier for the organisation to respond. Sense-able process innovation is about identifying needed functional require-

ments fast, and then decide how to proceed. Responsive digital infrastructure is the result of a digital framework that makes it easier and faster to configure the software locally. Through this, the organisation increases its ability to innovate faster and to use experiments in the activity of innovation.

6.3 Limitations and further work

Our process model is derived from a single in-depth case study, and further research is needed to verify its applicability. Our research may also be extended by using quantitative studies to verify the suitability of our framework. We thus encourage future research to apply different methods and analytical frameworks to validate and extend our research.

7 Conclusion

In conclusion, digitalisation is challenging, cumbersome, and laborious, but necessary to improve organisational performance and capacity utilization. Digitalisation of manual processes and routines lay the foundation for two important improvements. The public sector organisation may adapt faster to ever-changing societal requirements. Moreover, the organisation is better equipped to sense its performance. If hasty changes have been implemented, the detection of the unwanted consequences of these changes can be identified and the organisation may re-evaluate the process innovation.

Our main contribution is three propositions to describe the incremental structure in digital process innovation, and a model to describe the sense-ability of process innovation. We depict this incremental process through three stages: *digitalise,* visualise*, and manage* which together forms what we call *sense-able process innovation*, where organisational workers for each step participate in deciding if a change should be implemented or re-evaluated. We also describe the configuration of lightweight and heavyweight IT that allows for this form of sense and respond in process innovation efforts in complex organisational settings. Our case describes how existing technology can be complemented with process technology, thus favoring an approach that avoids heavy engineering while including the workers.

Notes

1. By horisontal processes we relate to the overarching processes at business level, while we use coordinative processes and patient flow to refer to the specific processes at the general hospital.

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