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FROM RECOMBINATION TO RECONFIGURATION: AFFORDING PROCESS INNOVATION IN DIGITAL INFRASTRUCTURES

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FROM RECOMBINATION TO RECONFIGURATION: AFFORDING PROCESS INNOVATION IN DIGITAL INFRASTRUCTURES

Research paper

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Abstract

A central challenge for public sector institutions is to improve their innovative capability. However, they must also ensure stability by managing a vast amount of systems and procedures. In this context, improving horizontal processes across functional boundaries can be particularly challenging. Process innovation, the goal-directed restructuring of processes, can create more efficient and innovative organizations, but it requires innovative digital infrastructures. We therefore ask: how can a digital infrastructure afford process innovation? In our framing, this implies identifying affordances as process innovation outcomes, but also describing a particular infrastructural configuration that enables these affordances. Our analysis builds on an in-depth case study at a Norwegian hospital, which has recently gone through a large-scale digitalization and innovation project. Health sector cases are pertinent to our research question, as the sector has experienced several difficulties in its initiatives to innovate and digitalize their infrastructures. We contribute to the literature on digital innovation and digital infrastructures in two ways. First, we identify a set of affordances and how they are configured together to innovate processes in a hospital. Second, we provide a framework for understanding the transition from siloed infrastructures to a more innovative digital infrastructure. By this, we provide a distinct approach to how the relation between digital innovation and process innovation can be theorized in the digital infrastructure innovation literature.

Keywords: Reconfiguration, Process innovation, Affordances, Digital infrastructure
1 Introduction

In this paper we describe and discuss efforts to accomplish process innovation in the public sector. By doing this, we address two limitations in the existing literature on innovation in digital infrastructures. First, researchers have shown an interest in how large-scale and interconnected digital infrastructures provide opportunities for innovation (Tilson et al., 2010). Their findings offer a range of valuable insights on how the architectures of such infrastructures allow near endless recombination to produce novel value (Henfridsson et al., 2018). However, this literature has to a lesser extent focused on how digital innovation can restructure processes. Processes, structured sets of activities, are central to all organizations, and process innovation, the goal-directed restructuring of them, can make organizations more efficient and innovative. Second, while recombination is at the core of innovation (Henfridsson et al., 2018), not all digital infrastructures enable such activity. Even though digitalization raises expectations towards transformation of the public sector (Janowski, 2015), studies have shown that reaching this goal is difficult (Holgersson et al., 2017). In reality, digital innovation in the public sector tends to focus on digitizing existing services without changing related activities (Holgersson et al., 2017). This does not mean that digital innovation is not possible within a public service context, “but rather that public sector innovation may follow a different path than in the private sector” (Bertot et al., 2016, p. 212). Since the public sector, and especially the hospital sector, poses different challenges for innovation from those in sectors studied in the digital innovation literature, additional activities are required (Bygstad and Hanseth, 2018).

In the hospital sector, there are hundreds of clinical silo systems operating in vertical layers. Efforts to integrate such systems through standardized and centralized interfaces entail complex interactions between them, leading to expensive and slow process innovation efforts (Bason, 2018). Although recombination is widely used in hospitals and can be effective, it typically contains a number of manual and tacit activities that remain hidden for people other than the actor (Mønstad et al., 2018). This condition is not sufficient to achieve process innovation, since several of the activities are not systematically linked, and information is stored in separate silo systems. Given the increased pressure for digitalization of the public sector, these challenges must be dealt with (Fishenden and Thompson, 2013; Janssen et al., 2012), but it’s not entirely clear how.

There are several ways to solve these challenges, for example by introducing platform technologies (Tiwanana, 2014) or by implementing suite systems (Williams and Pollock, 2012) to create a foundation for standardized interaction. These are measures that assume a radical transformation ‘up-front’, which will be costly, long-term and slow (Greenhalgh et al., 2010). A third solution could be to complement the silo systems by adding a new layer of components to enable faster change, in order to get out of old conditions (Skog et al., 2018). By adding a new layer that is more suited to process innovation (through its more flexible, tailorable and adjustable functionality) the role of the silo systems given their rich data content, can be reassigned to primarily function as an information source. We frame this reassignment using Normann’s concept of reconfiguration. Reconfiguration is defined as the possibility to bring together, for a given time/space/actor, a more ‘dense’ accumulation of assets, human activities, and knowledge, than before. Density denotes that “the best combination of resources is mobilized for a particular situation” (Normann, 2001, p. 27).

In this context, it is important from both a practical and a theoretical perspective to study how digital health infrastructures can enable process innovation. Our research question is therefore: How can a digital infrastructure afford process innovation? In our framing, this implies identifying affordances as process innovation outcomes, but it also denotes gaining knowledge on what is required of a particular infrastructural configuration to obtain these affordances. Our analysis of how digital infrastructures afford process innovation builds on an in-depth case study at a Norwegian hospital, which has recently

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1The installed base of the hospital sector’s systems, user environments, knowledge, and activities can lead to inertia towards change (Hanseth and Lytyinen, 2010; Monteiro, 1998). The installed base is, however, also in possession of invaluable treatment documentation that can become a rich resource for digital process innovation, if aligned with horizontal processes (see Bygstad et al., 2018)
gone through a large-scale digitalization and innovation project. We proceed by investigating related research on digital innovation in digital infrastructures.

2 Related research: digital innovation through reconfiguring digital infrastructures

Through the last decades’ large-scale diffusion of digital networks and the growth of innovative products, services, and processes that have come with them, the Information Systems field has produced an increasing amount of literature on digital infrastructures and the mechanisms of how such phenomena afford innovation. This research has provided insight into a wide array of domains, like product innovation (Henfridsson et al., 2014; Svahn et al., 2017), platform ecosystems and their implications on the economy (Parker et al., 2016; Tiwana, 2014), distributed autonomy (Tilson et al., 2010), rapid scaling of user bases (Huang et al., 2017), and organizational consequences of innovation in a digitized world (Yoo et al., 2012).

Digital innovation is both “a process and an outcome and is about combining digital technology in new ways or with physical components that enables socio-technical changes and creates new value for adopters” (Osmundsen et al., 2018). To understand how digital innovation can be enabled in a specific context, public sector health care, for a specific purpose, process innovation, we ground our research in literature on how digital infrastructures, networks of digital systems, in general can enable digital innovation. While literature on this topic can be categorized in multiple ways (Eaton et al., 2015), we identify three streams as prominent for understanding innovation in digital infrastructures. We label the first stream information infrastructure literature. This stream takes as its starting point the complexity that emerges in the intersection between organizations and their technical infrastructures. Based on a large variety of empirical studies, it has provided insights into the strategies available to evolve and create novelty in such environments that are not controllable as wholes (Aanestad et al., 2017; Hanseth and Lyytinen, 2010). In this literature, the installed base is the focal object (Aanestad et al., 2017) something that emphasizes the continuity of large structures and motivates cultivation strategies rather than controlled planning (Ciborra et al., 2000). The difficulty with this point of departure is that the inertia of the installed base (Monteiro, 1998) may limit the freedom and the flexibility needed for innovation. These difficulties have been addressed by a new stream of research focused on the digital infrastructure (Henfridsson and Bygstad, 2013; Tilson et al., 2010), which investigates more closely the mechanisms from which infrastructures evolve, and the conditions for enabling digital innovation.

We characterize the second stream of research as the combinatorial perspective. Combinations and recombinations have been key concepts in the study of innovation since Schumpeter (Henfridsson et al., 2018), but the modular layered architecture of the digital has provided a radical shift in the possibilities for novelty through recombinations (Nambisan et al., 2017). Digital artefacts as discrete objects have properties affording combinatorial innovation, as digitization, re-programmability and the self-referential nature that characterize them entails an integral potential for flexibility (Kallinikos et al., 2013; Yoo et al., 2010). When digital artefacts are organized in networks with other digital artefacts, these properties have shown themselves to create an unprecedented potential for scaling, diffusion and recombinability of digital services and information (Huang et al., 2017; Lyytinen et al., 2017). Digital innovation in digital infrastructures is in this stream occupied with how the potential for open-ended connections between digital artefacts afford the construction of novel value (Henfridsson et al., 2018). The third stream of research is constituted by the literature on how digital infrastructures afford service innovation. It is closely related to the combinatorial innovation perspective but is more oriented towards the enabling conditions for service innovation. While the former stream focuses on the generative properties of digital artefacts and infrastructures, the service innovation literature has mainly investigated how networks of actors utilize digital infrastructures to exchange information and co-create value through combining resources (Barrett et al., 2015). This stream thus leans more towards explaining innovation as emanating from the agency of actors than from the properties of artefacts (Nambisan, 2018). Central to the service innovation literature is the notion of liquefaction, which refers to the ability to separate information from the physical world through technology (Lusch and Nambisan, 2015; Normann, 2001).
As Normann argues, the liquidity that comes with digital infrastructures provides the opportunity to unbundle activities that formerly had to be physically collocated, and rebundle these activities through new digital relations (Normann, 2001).

The information infrastructure literature, thus, is occupied with preserving important resources (both digital and analogue) embedded in the installed base of legacy systems, expertise in the user environments and knowledge of particular institutional arrangements (Hanseth and Lytyinen, 2010). The combinatorial literature and the service innovation literature, on the other hand, study how the characteristics of digital infrastructures afford innovation. Digital infrastructures, modular layered architectures providing flexibility and re-use, is seen as having a potential for innovation unprecedented in analogue phenomena (Tilson et al., 2010; Yoo et al., 2010). The health sector, however, struggles to reach this level of maturity.

To capture the particular strength of the digital for reconfiguring existing resources with new resources, we use the concepts dematerialisation, modularisation and connection as enabling activities for process innovation. These concepts derive from Normann’s (2001) concepts of liquefaction, unbundling and rebundling. We use them in their derived forms to describe how the physical becomes digital through decoupling of information from physical forms and activities, and how the digital infrastructure allows actors to combine liquefied information and processes into new (digital) information and new (physical and digital) processes. The derived forms also allow us to point out the conceptual similarities between Normann and other literature on digital innovation.

According to Normann, liquefaction signifies that “what has been dematerialised can easily be moved about” (Normann, 2001, p. 33). We hence use the term dematerialisation to denote the activity of separating and dividing the physical and the analogue from the digital. This is related to Kallinikos et al.’s, (2013) insight that digital artefacts are more easily moved around, and a way of enabling a more flexible re-materialisation in different types of artefacts. It is also congruent with Zuboff’s (1988) description of a transition from a manual to a digital work practice, and with Lusch and Nambisan’s (2015) focus on “resource liquification”, that is a driver for service innovation. Second, we use the term modularisation to denote the unbundling activity of separating and decoupling. This activity is described by Tiwana (2014) as packetization, how digital data can be divided into small coherent packets (Parnas, 1972) to enable transmission across digital infrastructures. Third, we use the term connection to denote the activities that reassemble new bundles and create new dependencies between those bundles. This is also addressed by Yoo et al., (2010) as new digital relations and by Henfridsson et al., (2018) as value connections. The three concepts of dematerialisation, modularisation and connection capture both the combinatorial stream’s focus on the potential of the digital and the recombination that it affords, as well as the service innovation stream’s perspective on the agency in digital infrastructures. Collectively these concepts address the activity of reconfiguration, that is, the activities related to secure that “the best combination of resources is mobilized for a particular situation” (Normann, 2001, p. 27). Table 1 gives an overview of the definitions and literature related to these concepts.

<table>
<thead>
<tr>
<th>Activity</th>
<th>Derived from</th>
<th>Definition</th>
<th>Literature</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dematerialisation</td>
<td>Liquefaction</td>
<td>Decoupling of information from physical forms and activities in order to enable re-materialisation in different types of artifacts and to different types of users.</td>
<td>Normann, 2001; Zuboff, 1988; Kallinikos et al., 2013; Lusch and Nambisan, 2015</td>
</tr>
<tr>
<td>Modularisation</td>
<td>Unbundling</td>
<td>Packaging information into small, coherent and transmittable modules or services.</td>
<td>Normann, 2001; Tiwana, 2014</td>
</tr>
<tr>
<td>Connection</td>
<td>Rebundleing</td>
<td>Connecting modules or services, enabling new processes and new dependencies between them.</td>
<td>Normann, 2001; Henfridsson et al., 2018; Nambisan et al., 2017; Yoo et al., 2010</td>
</tr>
</tbody>
</table>

Table 1. Key concepts from the literature
The combination of dematerialisation, modularisation and connection provide us with a conceptual apparatus that describe the fundamental activities of how digital infrastructures can be reconfigured to enable process innovation. To investigate the result of these activities, we turn to process innovation and affordances.

3 Analytic lens: Affordances as relations between infrastructure and organization

There is a vast amount of literature on the mechanisms on how digital infrastructure affords innovation. Less is written about how such infrastructures afford process innovation. The focus has rather been on digital products or on how innovation is accomplished across networks of organizations (Lusch and Nambisan, 2015; Nambisan et al., 2017). In contrast, the study of process innovation concerns how the coordination of functional interdependencies of an organization can be improved, to effectively produce specific outcomes for its users, customers, and markets (Davenport, 1993). Process innovation is thus about the ordering of work, but with a focus on the horizontal rather than the vertical structures of organizations.

Process innovation holds the promise that by using the potential of IT important organizational processes can be significantly improved (Davenport, 1993). Process innovation can be realized when the characteristics of digital infrastructures are utilized to construct new and more flexible relations and distributed autonomy (Yoo et al., 2010). In turn, this can enable efficient business processes. How, then, can we understand the mechanisms taking place as these new relations are created?

Affordance has become an increasingly popular concept within Information Systems (Anderson and Robey, 2017; Volkoff and Strong, 2017), as it can be utilized to capture how behaviour is caused in the relation between users and artefacts at all levels of an organization. An affordance is defined as “the potential for behaviours associated with achieving an immediate concrete outcome and arising from the relation between an artefact and a goal-oriented actor or actors” (Strong et al., 2014, p. 69). In other words, the affordance belongs not only to the actor or the artefact, but also to the relationship between them. It is a potential for action, not the actualization of the action itself. If person A wants to talk to person B at a distance, A’s phone affords her to place a call to B. This relation between A and her phone exist regardless of her actually taking the phone call.

If we go into depth in the phone calling affordance, we see that it exists as a group of sub-affordances. Such lower level affordances are all the potentials for behaviour that make up a higher-level affordance (Volkoff and Strong, 2017). To place a call, A is afforded to actions like holding the phone in her hand, dialing a set of numbers, clicking on an existing contact, and speaking into the phone’s microphone. In this framing, affordances exist in layers, each building on the affordances on the level below. This entails that individual and organizational affordances on different levels, are depending on each other.

Strong et al. (2014) exemplify this with the affordances of a hospital system. The configuration of the system offered a set of affordances between individual nurses and the system, for example, to capture standardized data about patients and to access information regardless of physical locality within the hospital. These two affordances provided the base of a higher-level affordance, where the system afforded a pool of healthcare professional to take responsibility of specific tasks, in contrast to previous structures where specific tasks were delegated to specific personnel (Strong et al., 2014).

When we study how digital infrastructures afford new processes, we are interested in how the configuration of an organization’s digital infrastructure afford new activities in the organization, and how these affordances and their related activities are grouped in ways that lead to effective processes across organizational boundaries. This means that we study both how a digital infrastructure is configured to afford new activities, and how these affordances are put together to allow the continual development of new processes.
4 Method and case

The setting for our research is Kalnes hospital in Østfold County in Norway, about 80 kilometers south of the Norwegian capital of Oslo. The county is part of the South-East Regional Health Authority, which covers around 60% of the Norwegian population. Kalnes, an 85,500 square meters high-tech hospital, opened in November 2015, replacing the old Fredrikstad hospital. It has one of Norway’s largest emergency units in addition to general hospital functions such as delivery wards, clinical and surgical departments, and psychiatry.

Kalnes was the first hospital in Norway to obtain a HIMSS\(^2\) classification of level 6. It served 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 innovative technology to support horizontal process innovation and coordination. The extreme-case method selects a case because of its “extreme value on an independent or dependent variable of interest” (Gerring 2006 p. 101). Such extreme cases are useful for developing practical insight into the accomplishment of process innovation and well suited to develop new theory (Gerring, 2006). Our research approach is based on engaged scholarship (Van de Ven, 2007). The approach requires a longitudinal perspective (Langley 1999) where we study the phenomenon over time and obtain strong and trustful relationships between researchers and practitioners. Our unit of analysis is the whole hospital, i.e. how the digital infrastructure of the hospital affords process innovation. Our case fundamentally deals with process innovation challenges in the health sector, which are made difficult by fragmented and silo-oriented system portfolios. The Kalnes case provides an opportunity to inspect these challenges from an “optimistic” viewpoint since the hospital had the opportunity to configure its system portfolio in a way that enabled process innovation.

4.1 Data collection

From July 2016 to June 2018, data were collected through 35 interviews, several observations, and document analyses. We also participated in workshops and seminars. We interviewed CEO, CTO, process managers, analytic experts, clinicians, project managers, technical experts as well as system suppliers. The interviews and interactions were performed in two rounds. The first round started with interviews where Kalnes’ management and project leaders presented their goals as well as how they organized their 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 continued 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 investigation, we identified coordinative actors, whose role is to plan and coordinate the movement of patients and information across hospital departments. We were particularly interested in how they use IT to perform and coordinate their work. In the second round, we observed meetings at all levels, particularly the ones related to process flow challenges. Data was used extensively to inform decisions and to solve concrete challenges.

4.2 Data analysis

The data analysis was conducted in three steps (table 2), inspired by Bygstad et al.’s (2016) critical realist analysis framework for identifying affordances (Bygstad et al., 2016). We first established a chronology of key events, challenges, and aims related to the process innovation efforts at Kalnes, before we identified key entities (i.e. actors, organization, and artefacts) involved in the process innovation activities. We observed that the configuration enabled the organization to improve particular processes, and we were occupied with explaining why. This led us to identify how the IT portfolio was configured to enable process innovation. The first task, then, was to analyze the reconfiguration process. In the

second step, we analysed distinct processes that emerged through process innovation by using the affordance lens. We identified a set of affordances that could explain innovative processes and saw that although the process innovation affordances were valuable to describe the outcome of the innovation initiatives, it did not explain the particular IT configuration that enabled these process affordances. In the third step, we analysed the case using the concept of reconfiguration (Normann, 2001) to describe how process innovation at Kalnes was achieved.

<table>
<thead>
<tr>
<th>Step</th>
<th>Description</th>
<th>Output</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Identify efforts related to process innovation and the role of technology in this.</td>
<td>Section 4.3</td>
</tr>
<tr>
<td>2</td>
<td>Identifying, analyzing and categorizing affordances</td>
<td>Section 5, figure 1 and table 3</td>
</tr>
<tr>
<td>3</td>
<td>Identify and describe reconfiguration, and the contribution it entails</td>
<td>Section 6</td>
</tr>
</tbody>
</table>

Table 2: Data analysis

4.3 Process innovation through reconfiguration at Kalnes

Preparing for process innovation

In 1999, the Norwegian Parliament decided to build a new hospital in Østfold County. The construction started in 2010-2011. 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 digital innovation, Ebbesen expanded the management team with a CIO with experience from production and retail in 2011 and a process director in 2012. Some of the process challenges at the hospital included:

- Receiving emergency patients arriving with ambulances or by taxi, registering them, conducting triage and medical diagnoses, using lab tests or radiology if necessary.
- Allocating newly hospitalized patient to hospital wards and beds, and providing the necessary information to the staff, and to the patient’s family.
- 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 cleaning department and dietary services with timely information on which rooms to clean and when and what to serve regarding food.

Process modeling and redesign started in 2013 at the old hospital. Around 25 clinicians, staff and external consultants, worked full time in the 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. Health South-East lacked a system solution to support patient flow and other logistics. Kalnes signed a contract with a system supplier called Imatis, which has a solution that supports patient flow.

Reconfiguring the infrastructure

The Kalnes project had to take into account the installed base of the health region when they started their innovation project, which had three main implications: First, Kalnes had to use the existing IT portfolio as a point of departure, but they had to reconfigure it to support process innovation. Second, they had to acquire technology that specifically enabled process innovation. Third, they had to make sure that the existing package of technology and the new process technology interacted to generate the best possible result. The existing system portfolio of more than 300 applications was run by the regional IT centre called Hospital Partner. The portfolio consisting of electronic patient record (EPR), lab system, radiology system and chart and medication system, had to be reconfigured to interact with the patient...
flow system from Imatis. An IT architecture team was established to deal with integration issues. In parallel, the Imatis solution was configured to support logistics and communication. The Imatis environment was strongly supported by top management, but the doctors, the IT departments, and the vendors were more skeptical. The Imatis solution was based on lightweight IT principles, meaning that they are user-centered, enabled by the consumerization of digital technology and non-invasive in existing architectures (Bygstad, 2017; Øvrelid and Bygstad, 2016). The technologies included self-check-in automatiks, as well as information access through mobile phones, tablets, and electronic whiteboards. Lightweight IT was thus a central part of the more dynamic hospital.

The new digital infrastructure at Kalnes, thus, consisted of two major layers: A layer of lightweight IT that provide easy-to-use interfaces and touch screens for logging-in, drag-and-drop, as well as registering and changing the information, in addition to neat visualized graphics and information that affords discussion and collaboration on distinct process issues. And a layer of heavyweight IT, consisting of the regional package of core clinical systems like EPR, Lab, Medical chart, and emergency systems. The integration was done through an RPS (resource and process management system) integration interface. The main effect coming out of the integration between clinical core systems (and other existing systems or heavyweight IT) and the process solution (lightweight IT) was a reconfiguration where core clinical systems work as the main information backbone, while the process solution from Imatis operates as an information communicator to handheld devices as well as electronic whiteboards. The whiteboards were important given their ability to display information in a visual format that makes it easier to discuss and easier to modify.

**Implementing and customizing process innovation**

The project was able to integrate the most important systems with the Imatis solution before the hospital opened in November 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, 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, important 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 mobile and whiteboard user interfaces were adjusted to fit daily use.

The project team and particularly the project managers were important in motivating users. Kalnes was the first hospital in Norway that to this extent combined lightweight IT with the heavyweight package of Electronic Patient Record (EPR), chart and lab systems etc. to support process innovation. The combination of these two system regimes enabled the organization to both improve the performance and the communication of the performance. This inspired the organization to strive for continual improvement.

Examples of process innovation challenges and solutions were:

- Dividing processes into more detailed steps, for example dividing and specifying the triage-activity into several subprocesses.
- Make global resources available across sections and wards
- Identify the steps needed to successfully enable the communication and exchange of important patient information when transferred from one unit to another
- Establish arenas where challenges can be discussed and dealt with on a regular basis

For instance, the interplay between the emergency unit and the wards had been unsatisfactory, where the emergency coordinator needed to call all wards to find an available bed. The whiteboard solution provided a visual overview of all empty beds. The result was an improved atmosphere in the wards, because the telephones stopped ringing. “It is a completely new work situation for me,” a coordinator

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[3]Bygstad (2017) use the concepts of Heavyweight IT and Lightweight IT to distinguish between the well-established knowledge regime of large systems, driven by a software engineering approach developing ever more sophisticated solutions through advanced integration (heavyweight IT), and the knowledge regime of mobile apps, sensors and bring-your-own-device, also called consumerisation and Internet-of-Things (lightweight IT) (Bygstad, 2017).
stated, “because the whiteboard enables me to have full overview and control of the process.” A key process indicator for the process flow 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. 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 in time. Both problems were rooted in the fact that tight logistics requires disciplined updating of systems, and several initiatives were taken to improve this. These issues also led to tighter synchronization between support services like housekeeping, dietary services, and clinical processes. Rooms had to be cleaned more quickly and more dynamically according to various clinical needs. The improved transparency of patient flow processes led to the establishment of collaborative arenas to discuss and find solutions to flow issues. A common aspect of these meetings is that they are short, around 10-15 minutes, and targeted. The meetings have become arenas for both identifying challenges and make decisions to deal with them. In 2017 Kalnes established an analytics department and used the new configuration to enable a deep insight into matters of analytics and to deal with bottlenecks and other flow challenges.

5 Findings: Process innovation affordances

The events and how they were supported by IT were analysed over time to abstract the nature of the phenomenon. Our approach was centred on investigating the digital infrastructure and its role in improving patient flow logistics and communication. We saw the importance of the digital infrastructure (Henfridsson and Bygstad, 2013), but also how the collaboration between lightweight IT and heavyweight IT (Bygstad, 2017) strengthened certain conditions for process oriented work. This made us reconceptualise the study by looking at the particular affordances that made process innovation efforts possible.

![Figure 2. Processes, coordinators, affordances and digital infrastructure at Kalnes Hospital](image)

Through our analyses of key events and key entities, we found several candidate affordances. By comparing the results with the existing literature on affordances (e.g. Strong et al., 2014), we labeled these as resource integrating affordances, visibility affordances, and process flow affordances. This grouping entails that the affordances have similar enabling conditions, are of the same type, and have relatively similar functional outcomes (Bygstad et al., 2016).
<table>
<thead>
<tr>
<th>Groups</th>
<th>Affordances</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Resource integrating affordances</td>
<td>Accessing</td>
<td>Potential to act on digital access to global resources</td>
</tr>
<tr>
<td></td>
<td>Booking</td>
<td>Functionality for digital booking of global resources</td>
</tr>
<tr>
<td></td>
<td>Silent reporting</td>
<td>Functionality for digital hand-over of patient related information</td>
</tr>
<tr>
<td>Visibility affordances</td>
<td>Monitoring</td>
<td>Observing and make decisions regarding admitted patients</td>
</tr>
<tr>
<td></td>
<td>Individualizing</td>
<td>Visualize and make decisions based on the patient’s particular situation</td>
</tr>
<tr>
<td>Process flow affordances</td>
<td>Progressing</td>
<td>Making sure that patient flow is improving</td>
</tr>
<tr>
<td></td>
<td>Synchronizing</td>
<td>Exercising control over organizational operations</td>
</tr>
</tbody>
</table>

Table 3. Process innovation affordances

5.1 Resource Integrating Affordances

The layers of affordances identified as resource integrating affordances concern how the digital infrastructure enables efficient digital interaction between organizational actors through informational integration. In our case, the relevant actors are coordinators positioned in different sections and wards who strive to move patient efficiently from admission to discharge (see figure 1). The enabling condition of these affordances is that the infrastructural configuration of heavyweight and lightweight allowed information produced in one functional area to be accessed from other areas. The affordances are of the same type, as they are affordances for processes where actors from one ward utilize the resources from another ward. Their functional outcomes are also similar, as they ensure a more efficient access to resources across wards.

**Accessing.** Hospitals consist of several separated functional areas, which a patient must move between from admission to discharge. This entails that resources (people, rooms, objects, equipment) are scattered throughout the organization and must be accessed through passage points controlled by each functional area. The process innovation project at Kalnes enabled easier access to these resources across functions using digital technology. This digital access to cross-functional resources became fundamental to workflow coordinators. It meant that they could identify available resources across the wards. However, this was not achieved as easy or seamless as one might think. As the functional expertise need to reserve rooms with special equipment for particular diseases (like infections) or within close proximity to the physician (like severe intensive cases), some of the rooms must be kept outside global accessibility. At Kalnes these tensions were treated pragmatically by keeping particular rooms unavailable (based on authority or diseases).

**Booking.** The accessing affordance provides an enabling condition for the booking affordance, in that digital resources allows for digital booking of these resources. However, it also requires a cultural shift where resources earlier seen as primarily local become global. At Kalnes, the booking affordance enables emergency unit coordinators to book a room for a patient in one of the seven wards. The booking affordance also enables emergency unit coordinators in need of a particular ward (e.g. the lung ward) to suggest that patients admitted to the lung ward can be moved to available rooms at the heart ward if convenient. This “juggle” with available resources gives a more efficient and flexible use of resources across wards.

**Silent reporting.** The silent reporting affordance can be defined as the ability to move a patient from one section to another as well as all the documentation attached to the patient, without exchanging paper, phone calls or other verbal disclosure of information. At Kalnes, the silent report affordance is enabled by the system configuration, but it still needs to be followed by agreements and handovers in order to be legitimate. This can be seen as a step-wise transition needed in order to secure that trust becomes embedded in the digital communication and that the affordance will be further developed over time.

5.2 Visibility affordances

For Volkoff and Strong, visibility affordances refer to “the potential for users to monitor organizational operations across boundaries and to make decisions using global data” (2013, p. 831). Visibility is thus
about making information more visible and actionable to enable improved monitoring of organizational operations. In the Kalnes case, information literally became more visualized through lightweight technologies like digital whiteboards. The enabling condition of these affordances is the infrastructural configuration of heavyweight and lightweight IT, since it enabled technology with a stronger emphasis on the visual aspects of information, to display information from clinical core systems. The visibility affordances are affordances for processes where actors can organize and visualize information tailored to specific tasks. Moreover, they ensure a more efficient use of available information.

**Monitoring.** At Kalnes, several types of cross-sectional and interdisciplinary meetings have been established to sort out tensions and deal with challenges both within and across wards. These meetings are informed by information from the big whiteboards. As one informant told us,

> “The whiteboard meeting starts at 08:50 and lasts for ten minutes. The head of unit manage the whiteboard registrations, while the doctors and nurses give feedback. The patients are divided into three categories: those who need immediate help, patients who can be discharged, and patients who should stay another day. The morning meetings enable the cleaning personnel to get a good insight into which rooms have to be cleaned during the day.”

The monitoring affordance strengthens the organizational ability to get a better overview of actual and possible status of resources and patients as well as the performance of services. This gives increased insight into contextual conditions and relationships between resources and processes, and establishes an improved fundament for decision-making.

**Individualizing.** Kalnes hospital has implemented patient self-check-in machines. Kalnes have also a one-room policy that gives the patient privacy both when interacting with the physician during patient visits when meeting family or friends in visiting hours, but also after and between these visits for rest and reflection. Lightweight IT supports these two innovations by informing the trajectory from patient admission, or self-check-in, through treatment in individual rooms, before the patient is discharged. The improved overview and communication about the particular trajectory of the patient, give better insight into the patient’s particular history of disease. This makes it possible to separate the past from the present and enable a more mindful and precise patient treatment.

### 5.3 Process flow affordances

The process flow affordances depend on the resource integrating affordances and the visibility affordances. The lower level affordances thus constitute the enabling conditions of the higher-level ones. The process flow affordances are potentials for action on the organizational level for horizontal processes to be effectively carried out.

**Progressing.** The progressing affordance is the organizations’ potential to ensure that the patient flow is improving over time. Although the process innovation initiative at Kalnes was quite successful, in that the qualitative aspects of treatment was improved, and re-admission was reduced, there was still significant potential for improvement regarding bedtime per patient. Kalnes established an analytics team to identify and address these challenges more distinctly. The task of this analytics team was to inspect and investigate the organizational performance related to patient flow, to enable faster and more precise decision making. To obtain this goal, Kalnes established cross-sectional meetings. The main task of the analytics team was to identify complex cross-functional relations and deal with them. The progressing affordance depends on the resource integrating affordance of accessing and the visibility affordance of monitoring as enabling conditions in that the conditions for decision-making is improved. E.g. when cross-sectional department meetings are performed, and the challenges are displayed visually through graphs or statistics. As both clinicians and other decision makers are present, decisions can be made right away enabling “sense and responding” (Overby et al., 2006).

**Synchronizing.** The output of the synchronizing affordance is that earlier separate functions are brought in tighter relation. Coordinators were given the right to book services directly from service personnel like housekeeping and dietary services. The service personnel needed to respond more directly to these bookings and organize their workflow accordingly. This meant that functions that were dependent be-
came related and synchronized. Synchronizing is enabled by the resource integrating and visibility affordances. Synchronizing also depends on the visibility affordances in that personnel can discuss the general patient flow in each ward (and that the emergency unit or others can follow the patient flow in each ward), and that each patient is given more individualized attention. The digital whiteboards have both the capability to visualize groups of patients, as well as each individual patient. This also leads to more collective participation and improved overview of all the admitted patients.

6 Discussion: Reconfiguring digital infrastructures

In this study, we attempt to answer the following research question: how can a digital infrastructure afford process innovation? Our point of departure is the hospital sector, where typically hundreds of clinical silo systems operate in vertical layers. This is not adequate for effective horizontal processes. Moreover, efforts to integrate such systems through standardized and centralized interfaces entail complex interactions between them, leading to expensive and slow process innovation efforts.

Inspired by Normann’s concept of reconfiguration and the theory of affordances, our main contribution is a framework for describing the transition from a silo-oriented situation, through reconfiguration to a situation where process innovation is easier to obtain. Through this transition, we demonstrate how innovative reuse of system modules can solve challenges within eHealth, and how process innovation efforts can be fulfilled.

The first situation (left in figure 2) demonstrates the preceding condition of siloed heavyweight systems, not connected with the process technology, and where each of the systems is accessed separately. In clinical work, this can be satisfactory as clinical personnel manually combine resources from different digital systems in their decision making (Mønstad et al., 2018). This condition is, however, not sufficient to achieve process innovation, since several of the activities are not systematically linked and large parts of the information are tacit and not accessible.

The second situation (middle part of figure 2) demonstrates the main activity of reconfiguration, which contains three sub-activities: dematerialisation, modularisation and connection.

Figure 2. Reconfiguration to afford process innovation

By dematerialisation we refer to the activity of releasing information from its physical constraints to obtain a situation where digital resources are made available across settings (Kallinkos et al., 2013, Normann, 2001). This may also include the digitising of paper documents and the readjustment of services. In addition, it includes making available information from silos-systems across technological and organizational boundaries. Examples are the detachment of particular information from core clinical systems in order for the information to be used by the process technology. By modularisation we refer to how dematerialised content is organized into “discrete information packages” (Tiwana, 2014), with specific, defined and distinct information content (Parnas, 1972). The modularisation activity makes it
possible for any actor to make use of dematerialised content. Examples include making a bed or a room (or other resources) digitally available across wards and units. We use the term connection to denote the activities that reassemble new modules and create new dependencies between those modules, that is, when possibilities enabled through dematerialisation and modularisation are acted upon and made use of. This is referred to by Yoo et al (2010) as new digital relations and by Henfridsson et al. (2018) as value connections. The dematerialised and modularized objects or services are brought together and establish new digital relations between actors, resources and processes.

Reconfiguration, then, enables novel use of process oriented lightweight IT and core clinical heavy-weight IT. As described in section 4.3, the introduction of digital whiteboards made it possible to visualise available beds for coordinators working at the emergency unit. This provides an example of reconfiguration. The specific actors, belonging to different wards, previously kept information about available beds. This led emergency coordinators to call each ward by telephone to find beds for patients being transferred from the emergency unit, a highly inefficient practice. By adding the lightweight IT to the infrastructure, information about available beds could be separated from the ward where it originated and used by the coordinators when they performed their activities.

The third situation (right part of figure 2) demonstrates that the use of heavyweight infrastructure and lightweight IT to innovate processes, triggers affordances. We follow Bygstad et al., (2016) in conceptualizing digital innovation as emanating from affordances. Affordances are by definition relational, they exist in the interplay between technology and human agents. We have identified three categories of affordances: resource integrating affordances, visibility affordances and process flow affordances. These affordances release and actualise process innovation. For example, the enabling condition of the resource integrating affordances is that the infrastructural configuration allowed information produced in one functional area to be accessed from other areas. In other words, the configuration affords the use of information produced in separated wards in the activities in other wards. The enabling condition of the visibility affordances is that information stored in clinical core systems could be accessed by technologies with a stronger emphasis on the visual aspects of information. The new infrastructural configuration allowed integral configuration of information, as evident in the individualising affordance. The process flow affordances are the potentials for action on the organizational level for horizontal processes to be effectively carried out. While the progressing affordance is the organizations potential to ensure that the patient flow is improving over time, the synchronising affordance brings earlier separate functions in tighter relation. The reconfigured infrastructure at Kalnes provided a novel use of IT to afford process innovation. Since IT architectures in the public sector tend to be silo-oriented and confined by functional boundaries, reconfiguration through dematerialisation, modularisation and connection to afford process innovation are a challenging task. In addition, innovation in the public sector often is about digitizing existing services without changing the activities they are related to (Holgersson et al., 2017). Our case shows how an infrastructural configuration allows digital innovation where also processes are significantly improved and give new values to the users.

7 Conclusion

This study deals with the practical and theoretical challenge of enabling process innovation in public sector infrastructures. A key obstacle for process innovation in the public sector is siloed infrastructures that make horizontal performance across specialized functions challenging. We answer our research questions, by proposing that digital infrastructures can afford process innovation through adding a process layer that covers horizontal processes and at the same time reconfigure the digital infrastructure in order for clinical core systems (heavyweight IT) and process technology (lightweight IT) to interact. To this end, we contribute to the literature on digital innovation and digital infrastructures in two ways. First, we identify a set of affordances and how they are configured together to innovate processes in a hospital. Second, we provide a framework for understanding the transition from siloed infrastructures to a more innovative digital infrastructure. With these contributions, we provide a distinct approach to how the relation between digital innovation and process innovation can be theorized in the digital infrastructure innovation literature.
8 References


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