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Innovation Of, In, On Infrastructures: Articulating the Role of Architecture in Information Infrastructure Evolution

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Abstract

In this paper, we address the question: "which conditions enable successful information infrastructure innovation?". Information infrastructures are characterized by nonlinear evolutionary dynamics. Based on a case study that examines the design, development, and initial use of a web-based solution for patient-hospital communication at a Norwegian hospital over a ten-year period, we trace the evolution of a new II. This longitudinal analysis takes installed base cultivation as its conceptual basis. Specifically, we draw on three aspects of a cultivation strategy: growth process, user mobilization, and learning to cultivate. The analysis shows how the solution started as a bottom-up initiative of a small and motivated team at the hospital IT department, and how it grew gradually in a flexible and evolutionary way. Our findings support the argument that successful infrastructure innovations are based on a cultivation strategy addressing specific users' needs, usefulness, and evolutionary growth. We make three key contributions to information infrastructure research. First, we expose the role architecture plays in the growth of IIs. Second, we provide insights about cultivating IIs, especially in their bootstrap phase. Third, we identify three different but interrelated types of innovation—in, of, on infrastructure—that articulate the critical role of IIs architecture in enabling successful innovation.

***Keywords**: Information Infrastructure, Innovation, Patient-Centred, Strategy, Evolution, Installed Base, Cultivation, Architecture.*

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1. Introduction

There is considerable research interest in understanding processes of IT innovation in the healthcare context, the associated challenges and conditions for successful outcomes. Introducing IS in healthcare is a complex process due to the differing needs of healthcare providers (with diverse professional roles, training, and experience), patients (with diverse conditions, personal characteristics, and medical trajectories), and medical treatments (with diverse procedures and approaches) (Finchman, Kohli, & Krishnan, 2011). A system that may work well in one setting may fail in another, or result in different reorganizations (Barley, 1986). In addition, the shift from paper-based to system-based documents disrupts the effectiveness of daily routines of document handling (Goh, Gao, & Agarwal, 2011). These alterations are difficult to predict and manage because documents, along with other artefacts in general that are used for organizational coordination, do not work in isolation but are part of a multiplicity of artefacts and technologies that defy easy standardization and integration (Ellingsen & Monteiro, 2003, 2006; Hartswood, Procter, Rouncefield, & Slack, 2003). ICT implementations also transform communication practices between health professionals and patients (e.g., Piras & Zanutto, 2010; Vikkelsø, 2005; Winthereik, Van Der Ploeg, & Berg, 2007). Patients, professionals, and health ICTs co-constitute each other in complex ways, and changing such an entanglement of social, organizational, and technical elements is a politically textured negotiation process with uncertain outcomes (Berg, 1999; Vikkelsø, 2010). Moreover, managing such change processes is highly challenging (e.g., Constantinides & Barrett, 2006; Currie & Guah, 2006; Greenhalgh et al., 2010; Hanseth, Jacucci, Grisot, & Aanestad, 2006; Jones, 2004).

Acknowledging this complexity, prior research has tried to identify conditions for successful IS innovation processes in healthcare. For instance, research shows how IS compatibility with existing workflow tends to have direct impact on the success of adoption and the performance that results (Goh et al., 2011), how technologies affecting providers' decision making tend to have a bigger impact on performance (DesRoches et al., 2010), and how organizational factors, each facilitating and hindering IS implementation at various points, have complex roles (Scott, Rundall, Vogt, & Hsu, 2005). In this paper, we contribute to this research by analyzing a case of information infrastructure (II) innovation in a hospital where a new patient portal is introduced. We want to understand which conditions enable successful innovation in a case where technology is an II. To do this, we discuss the role architecture plays in the innovation process in our case, and argue how the shifting architectural arrangement supports a cultivation strategy and positively shapes the resulting infrastructural innovation. From the case analysis, we identify three types of innovation related to II evolution, which we name innovation **of**, **in**, and **on** infrastructures. While innovation of infrastructures corresponds to the conceptualizations and implementation of a new infrastructure, including re-conceptualizing and re-engineering existing infrastructures, innovation in infrastructures denotes replacing or modifying existing components of an infrastructure without changing the constituting architecture. Finally, innovation on infrastructures signifies the extending of existing infrastructures by adding new modules on top of (or in addition to) what exists. Our research articulates the role architecture play in the innovation of IIs, and brings attention to architectural innovations as the most critical element of infrastructural innovations.

IIs are open and heterogeneous technologies to which the classical model of IT organizational change and decision making does not generally apply (Orlikowski & Hofman, 1997). Further, II design, development, and implementation processes are characterized by nonlinear evolutionary dynamics such as unintended effects and drift (Ciborra et al., 2000; Hanseth et al., 2006), duality of risk (Hanseth & Ciborra, 2007), and multiple interdependencies (Aanestad, Jensen, & Grisot, 2009). In this evolutionary process, an II always "wrestles with the inertia of the installed base and inherits strengths and limitations from that base" (Star & Ruhleder, 1996, p. 113). Inertia to change may come from technical elements, human habits, and social norms (Edwards, Bowker, Jackson, & Williams, 2009), and they may create lock-in and unanticipated effects (Monteiro, 1998; Hanseth & Ciborra, 2007). Moreover, effective infrastructures take on distinctive inertial qualities, which makes reversals costly and difficult (Jackson, Edwards, Bowker, & Knobel, 2007).

Against this backdrop, the infrastructure literature views the planning and management of IIs as an ongoing effort where technology is “cultivated” rather than built; therefore, it counteracts designers' assumptions that they have control over the design space in a traditional sense (Ciborra & Hanseth, 1998; Edwards, Jackson, Bowker, & Knobel, 2007; Freeman, 2007; Kallinikos, 2011; Monteiro & Hanseth, 1996). In this paper, installed base cultivation is taken as conceptual basis. This view acknowledges the open-ended processes of sociotechnical negotiations that characterize IIs evolution and the possibility to influence their direction (Monteiro, 1998; Hanseth & Aanestad, 2003; Hanseth and Lyytinen, 2010).

In this paper, we build on this line of work by investigating the cultivation process of a novel II. More specifically, we study the process of II innovation in the context of a project that developed a patient-oriented web-based solution called MyRec. MyRec provides patients with access to information and services at a large Norwegian hospital (named hospital N), and it was designed on the initiative of a small team at the hospital IT department. The initiative remained a rather small project with a limited user base for several years. MyRec was originally conceptualized as being tightly coupled to the existing hospital infrastructure, but instead resulted in a flexible and incrementally growing solution loosely coupled to the hospital infrastructure. At the time of writing, after about 7 years from its formal initiation, MyRec had matured and much of its functionality was adopted into routine use for hospital-patient communication. However, MyRec was not a finished solution. Rather, it continues to evolve and incrementally broaden its services to a growing user base in hospital N and recently in other hospitals throughout the country. For these reasons, and because MyRec is an open, evolving, enabling, gradually growing solution, we consider it to be a successful case of II innovation that has followed a cultivation strategy. Moreover, while MyRec is not yet a large infrastructure, its creators seek to involve it into an all-inclusive platform supporting a large number of patient-oriented services. In Norway, recent policy documents strongly advocate ICT-based patient-centered care. To this end, several initiatives both at the national and local level (including the one reported in this study) are in the process of implementing web-based patient services.

In this paper, we describe and analyze the evolution of the MyRec initiative over a period of ten years (2002-2012). In the analysis, we focus on three aspects of MyRec's cultivation process: process orientation, user mobilization and learning. By exposing the team's activities, we point to the role of MyRec architecture: how it changed over the years and how it enabled the cultivation strategy.

This paper progresses as follows: in Section 2, we review relevant literature in II studies dealing with strategies for innovation, and we argue that keeping complexity manageable and having an experimental approach are critical factors for successful II innovation. In Section 3, we introduce installed base cultivation as our conceptual basis. We explain our research methodology in Section 4, and introduce our case study on MyRec evolution in Section 5. The case description covers a ten-year period of MyRec evolution organized into three main phases: conceptual design, initial experiences, and maturation. Afterwards, in Section 6, we analyze the cultivation strategy. Finally, in Section 7, we discuss the role of architecture in the innovation process (identified as innovation of, in, and on infrastructures) and present our contribution to the literature on innovation processes in IIs.

2. Approaches to Information Infrastructure Innovation

In this section, we review existing research on information infrastructures innovation by focusing on two set of strategies for achieving innovation: top-down specification-driven and bottom-up emerging strategy. The top-down specification driven strategy reflects the traditional approach to infrastructure innovation and development where the innovation process starts with a strong emphasis on stakeholders' agreement on standards and their specification. Often, a formal standardization body organized in committees carries out the specification work. These committees then agree on the infrastructure's functional requirements, architecture, and overall design. Finally, the interfaces between the modules are specified in terms of technical standards. Only at this point do technology providers implement the standards into their products and the infrastructure is built without reiterations of the defined specifications. In the top-down specification-driven approach, functional requirements are assumed to be specified beforehand for the whole lifetime of the infrastructures together with all its components. After its implementation, the infrastructure is, implicitly at least, assumed to be stable without further innovation processes taking place. A typical example of this approach is the development of 2G and 3G mobile telecommunication infrastructures. A similar top-down specification-driven approach used in software engineering has been adopted for developing IIs in many sectors (Ciborra et al., 2000).

However, research has shown how the top-down specification-driven approach has limitations when it comes to successfully innovating information infrastructures (Ciborra et al., 2000; Greenhalgh et al., 2008; Hanseth & Ciborra, 2007; Lyytinen & Fomin, 2002). The approach does not take into account the openness of IIs, their sociotechnical complexity, or their evolutionary growing dynamics. Thus, infrastructural innovation processes fail or are prematurely terminated. An example is the failure of the Connecting-for-Health initiative in UK. This project (created to develop a national health II) has shown the difficulty of accurately planning large-scale IT-driven innovation programs (Greenhalgh et al., 2008; House of Commons, 2011; Sauer & Willcocks, 2007). Hanseth, Bygstad, Ellingsen, Johannesen, and Larsen (2012) have analyzed a number of large infrastructural innovation initiatives in the Norwegian health sector. They found that many projects adopted a top-down specification-driven strategy. These projects delivered a number of standard specifications that ultimately proved to be unattractive for vendors and user organizations (Hanseth et al., 2012). Other studies have critically analyzed how top-down specification-driven strategies are widely adopted in the development of national and pan-European eGovernment solutions (Contini & Lanzara, 2009, 2013), and in the development of corporate infrastructures in many large business organizations in sectors such as manufacturing, chemical, pharmaceutical, and oil (Ciborra et al., 2000). Research has also exposed the emergence of reflexivity and side effects triggered by such top-down approaches in sectors such as healthcare, banking, mobile telecom, and the ship industry (Hanseth & Ciborra, 2007).

This body of empirical research has demonstrated that infrastructures are constantly evolving and "always an unfinished work in progress" (Edwards et al., 2009, p. 365). In cases of successful infrastructure evolution, research has pointed out to the gradual growth of users and functionality as a critical dynamic, and has suggested bottom-up strategies as successful approaches to IIs innovation (Hanseth & Aanestad, 2003; Hanseth & Lyytinen, 2004). In such bottom-up approaches, standards are not specified and agreed on up front—they are emergent, flexible, and dynamic (Brunsson, Rasche & Seidl, 2012). However, according to Hanseth and Lyytinen (2010), bottom-up approaches face two main challenges: bootstrapping and adaptability. Bootstrapping is the challenge of how to attract and motivate users to start using a new technology, while adaptability is the challenge of how to avoid lock-in effects. In Section 3, we present installed base cultivation as a strategy for bottom-up innovation of II.

3. Theoretical Approach: Installed Base Cultivation

In theorizing II evolution, Monteiro and Hanseth (1996) have conceptualized an II as an open, shared, evolving, standardized, and heterogeneous installed base. In this understanding, "installed base" is considered to be "what is already there"; for example, existing work practices, human resources, standards, technological artefacts, organizational commitment (Bowker & Star, 1999; Ciborra & Hanseth, 1998; Hanseth & Lyytinen, 2010; Monteiro & Hanseth, 1996). A cultivation approach acknowledges the existence of the installed base, and it seeks to address change in an incremental and gradual manner. Cultivation entails a natural process that demands support and monitoring activities that are directed toward a material that is itself dynamic and posses its own logic of growth (Ciborra, 1997; Dahlbom & Mathiassen, 1993). Ciborra (1997) emphasizes the unpredictability of cultivation processes and argues that an organization "accumulates various unutilized resources often unintentionally as it grows and these resources represent potential for further growth though new, usually unplanned, recombinations" (Ciborra, 1997, p. 75). Overall, three main aspects can be said to characterize a cultivation strategy: process-orientation, user mobilization, and learning.

The first aspect, process-orientation, requires ongoing and careful step-by-step engagement with technology and existing institutionalized practices. It implies a process of incremental changes of the infrastructure over time. The second aspect, user mobilization, relates to the distributed control implied in a cultivation strategy. Designers do not have full control over the design space and the authority to formally mandate use. Instead, users need to be mobilized and motivated to use the new technology. This aspect is illustrated by Hanseth and Aanestad (2003), who argue that, in order to bootstrap an infrastructure, one should enroll the most motivated users first by offering them immediate benefits and targeting the least critical and simplest practices (Hanseth & Aanestad, 2003). The third aspect, learning, concerns the selection process that is implicated during cultivation. Cultivation is a learning-driven strategy, where designers judge which parts are functioning well and which parts are not. For instance, in analyzing the introduction of telemedicine infrastructure into surgical theaters, Aanestad and Hanseth (2002) argue how “stunts” (singular transmission events) provided moments of core learning in the adoption of the new infrastructure. Stunts enabled participants to seize interesting and relevant opportunities. We take this conceptual basis to analyze MyRec evolution with attention to the activities of the project team and to the role of the shifting architectural arrangement.

4. Research Setting and Methodology

4.1. Site

Hospital N is a large hospital located in Oslo. It is part, and under the authority, of a regional health authority called the South East Health Region. Beside serving patients in the area, it has extensive functions at the cross-regional and national level. It is a hospital with several highly specialized functions, such as organ transplantation, bone marrow transplantation, specialized heart surgery for children, and specialized neurosurgery. It is also a university hospital and has responsability for researching and developing new treatment methods. In 2002, at the time MyRec project started, hospital N had approximately 4000 employees and 7,000 rooms. In addition, approximately 28,000 patients were admitted as inpatients, 17,000 patients were given day-treatment, and 130,000 outpatient consultations were performed each year. In January 1, 2009, hospital N was merged with two other hospitals to form one large health trust of 20,000 employees working in 40 different facilities in the Oslo area.

4.2. Data Collection and Analysis

We document a case study concerning MyRec’s design, development, and implementation. This case study is part of our longitudinal research conducted since 2001 on the change processes of hospital N’s information infrastructure, where we have previously studied the electronic patient record (EPR) implementation process (Hanseth et al., 2006), and a scanning project (Aanestad et al., 2009). In the study documented in this paper, we collected our data in two phases. Phase I took place between September 2010 and September 2011, and phase II between March 2012 and November 2012. We used semi-structured interviews, observations, and document reviews in both phases. We conducted twenty-two interviews of sixty to ninety minutes across the two phases. We recorded and fully transcribed all interviews. In phase I, we conducted interviews with MyRec team members periodically over time. The interview guide covered several topics. We asked managers to describe (among other topics): 1) the historical origins of the MyRec concept, 2) the technical challenges and implemented solutions, 3) the organization of the users’ workshops, and 4) the consultations with the hospital managers and the privacy ombudsman. During phase 1, we also obtained data by observing design workshops with users, and we asked health workers to describe their actions in order to understand the existing practices of patient-hospital communication in clinics. The documents we reviewed included internal project reports, design session’s reports, team members’ PowerPoint presentations to various audiences, policy documents, laws, and articles from specialized Norwegian journals. In phase II, we conducted interviews with both MyRec team members and key people not directly involved in the project but who were in close proximity to it, such as participants in the Clinical Portal project at the hospital’s IT department. In this round of interviews, we expanded our understanding of the project’s evolution. In addition, one of the authors closely followed the design and development process on MyRec’s module for diabetes management.

We paid particular attention to the contextualization of our case and took into account our experiences with past IT projects in the same setting. We also studied IT strategy documents for the healthcare sector in Norway, and collected information on other health ICT projects in Norway. Finally, we shared the preliminary findings of this study with the project team. In response, team members provided helpful comments, which mainly confirmed and elaborated further identified issues and themes.

We conducted this research using an interpretive approach (Eisenhardt, 1989; Klein & Myers, 1999; Walsham, 1993). We read interview transcripts to identify interviewees' understanding of the main steps in the project history, the main challenges in the process, the activities they undertook in order to handle them, and the resulting consequences of such activities. While the timing and precise order of the events was sometimes difficult to establish, the interviewees estimated them. We have conceptualized II innovation as installed base cultivation in order to analyze the case. The concept of installed base cultivation draws attention to the longitudinal evolution of technology. It stresses how evolution is shaped by initial choices and how "what is already in place" (i.e., existing technologies, work practices, routines, assumptions, organizational structures) enables or constrains possibilites of adapting, interconnecting, or creating new components. Specifically, we analyze the cultivation strategy with attention to process-orientation, user mobilization, and learning. We have taken an historical approach to expose the iterative evolution of the installed base. The analysis explains the emerging and experimental character of the innovation process and the role played by the solution's architecture in enabling a successful innovation.

5. Case Description

5.1. Background to the Case Study

MyRec is intended to be the primary IT point of contact between patients and the hospital. In this way, it provides a secure and trusted communication environment. MyRec uses two security solutions—implemented at different times—for secure identification and secure electronic message exchange: one (called BankID) is used in Norway for Internet banking, and the other (called BuyPass) is extensively adopted in the Norwegian public sector. National regulations stipulate a number of strict requirements for handling personal health information and demand the highest level of security (defined as level 4) for information systems containing personal health data. After user authentication, patients access the services in MyRec offered by their clinical unit. Clinicians can access MyRec with their regular username and password. The portal is built on an Oracle database server and a content management system. The communication with other systems is mainly based on web services. In Winter 2012, (at the end of the period covered in the study), MyRec offered several generic services such as booking and rescheduling appointments, secure messaging, ordering home-tests andequipment, a prescription record, and online forms for various purposes. It also offered several specialized services targeting specific user groups. For instance, patients with Hemophilia could register their usage of drugs. More-specialized services were also under development or running in a test environment.

5.2. Detailed Case Description

We provide a description of the historical evolution of MyRec over a period of ten years (2002-2012). We identified three main phases (see Table 1): the first phase (2002-2005) covers the conceptual design of MyRec, the second phase (2006-2008) describes the initial experiences of implementation and use of MyRec and the third phase (2009-2012) describes a maturation period where MyRec's functionality extended and user adoption scaled to the whole hospital. Taken together, we consider these phases to be MyRec's start-up period. In our description, we tried to expose the reasons behind early decisions and events, constraints and opportunities, and how they shaped MyRec's evolution.

Table 1. Main Events in MyRec's Evolution by Phase

2002-2004	2005-2008	2009-2012
Phase I **Conceptual Design**	**Phase II** **Initial Experiences**	**Phase III** **Consolidation**
-2002: Design of MyRec as component in the Clinical Portal. -Clinical Portal prioritize hospital fragmentation problem, MyRec no further included. -2003: First initial sketches of MyRec as independent solution. -2004: First mock-ups with suggested functionalities. -2004: Conceptualization of secure messaging functionality to address the problematic use of email in patient communication.	-2005: Creation of an IT unit for "research and patient services" with a new manager. -2005: First functional version of MyRec implemented. -2005: Secure messaging implemented. -Design of the rescheduling appointment functionality and diversification in open and closed services. -Some functionalities are disabled. -2008: Change of security solution.	-2009: MyRec project starts to be contacted by clinical departments and patient organizations. -2009: Development of a number of modules addressing problems of patient-hospital communication in various clinical departments. - Development of a number of generic modules. -2012: Scaling implementation of general functionality. -2012: Participation of MYRec project in a EU project. -2012: Other hospitals implement MyRec.

5.2.1. First Phase 2002-2004: Conceptual Design

At hospital N, over the years, a consensus grew concerning the need to improve patient-hospital communication. However, it was only realized in early 2000 during the conceptualization of an IT solution called Clinical Portal. The Clinical Portal was an internal portal designed by hospital N's IT department. The portal was intended to be an integration layer that would provide a unified view of clinical information, which, at that time, was scattered across more than 100 information systems in the hospital. One of the initial design sketches from 2002 shows the portal having five different use areas concerning clinical information: the first two for clinical internal use, the third for administrative purposes, the fourth for supporting cooperation with other health institutions, and the fifth representing patient access to information and documents. Accordingly, one of the first conceptual views of the Clinical Portal (see Figure 1) shows a patient interface (green box on the right) named "My Journal". A manager recalls: "The point[with this conceptual view] was that we should be able to serve several types of user group, from patients to clinicians, via the same architecture". He further explained:

> *We had a range of specialist applications for different areas that run on a relatively heterogeneous hardware and infrastructure. On the top of that we added a layer mainly from (IT provider quoted) on which we wanted to build services to support various groups. Tight together with a meta directory with role-controlled access, that was the whole idea*.

In this view, the patient interface would give patients access to information provided by underlying source systems (e.g., EPR, patient administrative system, laboratory systems).

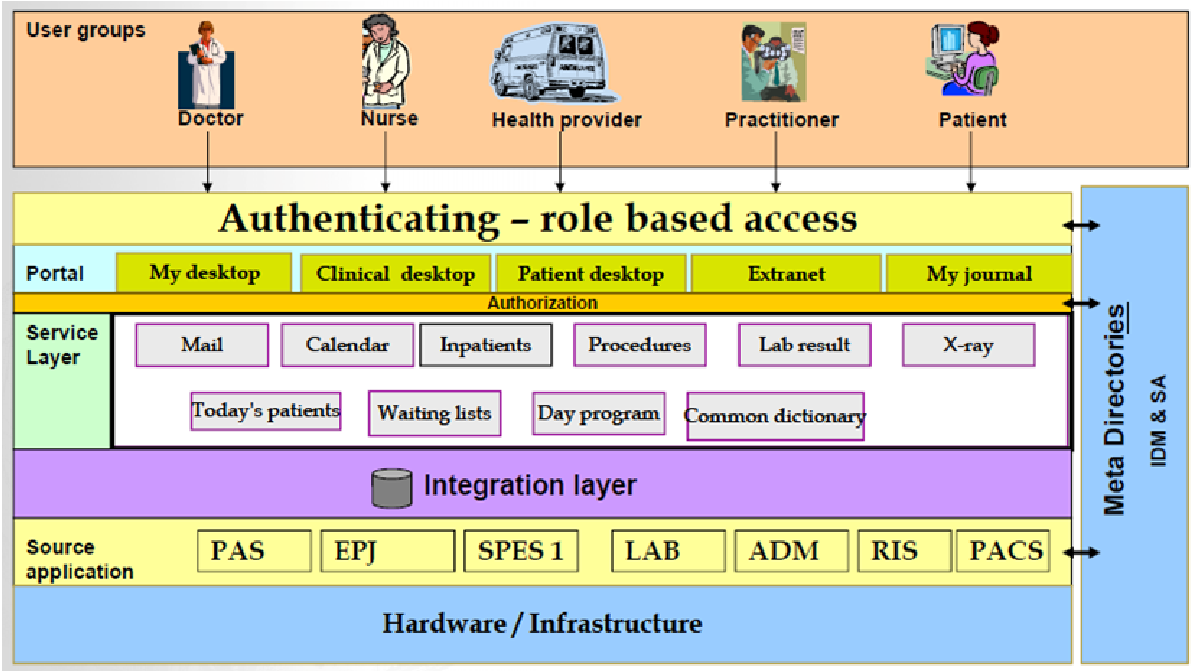

Figure 1. Conceptual View of Clinical Portal

From Autumn 2002 to Summer 2003, Clinical Portal's design was further specified and development was started. Despite the initial sketches, "My Journal" was not developed. It soon became clear that the fragmentation of existing information systems was the most urgent problem to address. A manager recollects how patient interface and patient services were not considered a priority at this point in the Clinical Portal project, but rather as an activity to do "on the side".

During the Summer of 2003, two IT department members, one with a background in nursing and work experience in one of the hospital departments, and the other an experienced interface designer, started on their own initiative to design a solution for patient communication. The manager with nursing experience recognized patients' information needs from his own previous practice and was motivated to work with a solution for hospital-patient communication. His main argument was that informed patients feel more involved in their own treatment, which tended to result in a better prognosis. Their initial intent with the patient interface was to provide hospital patients with trusted quality health information on diseases and prevention. Moreover, information was to be in Norwegian and consistent with treatment specifications offered in hospital N.

The two initiators started by sketching screen layouts and information content for patient services. While they were not actively and financially supported by the IT department's management, they were not stopped in their work. Further, because patient communication was left out of the Clinical Portal project, there were no conditions that the patient communication solution should be part of the portal. They named the solution "MyRec" and, by 2004, they had designed screen mock-ups (the home page is shown in Figure 2). In their initial discussions, they produced a list of services that they believed would be useful to patients (see Table 2).

Table 2. MyRec Functionalities in the First Version

Administrative	Patient oriented
Information about hospital treatments, diagnosis and procedure Provider details Appointment rescheduling Secure messaging Information on preparation for admission FAQ Access log	Patient information Patient representative Secure access MyDiary Discussion forum Personalized links Content search

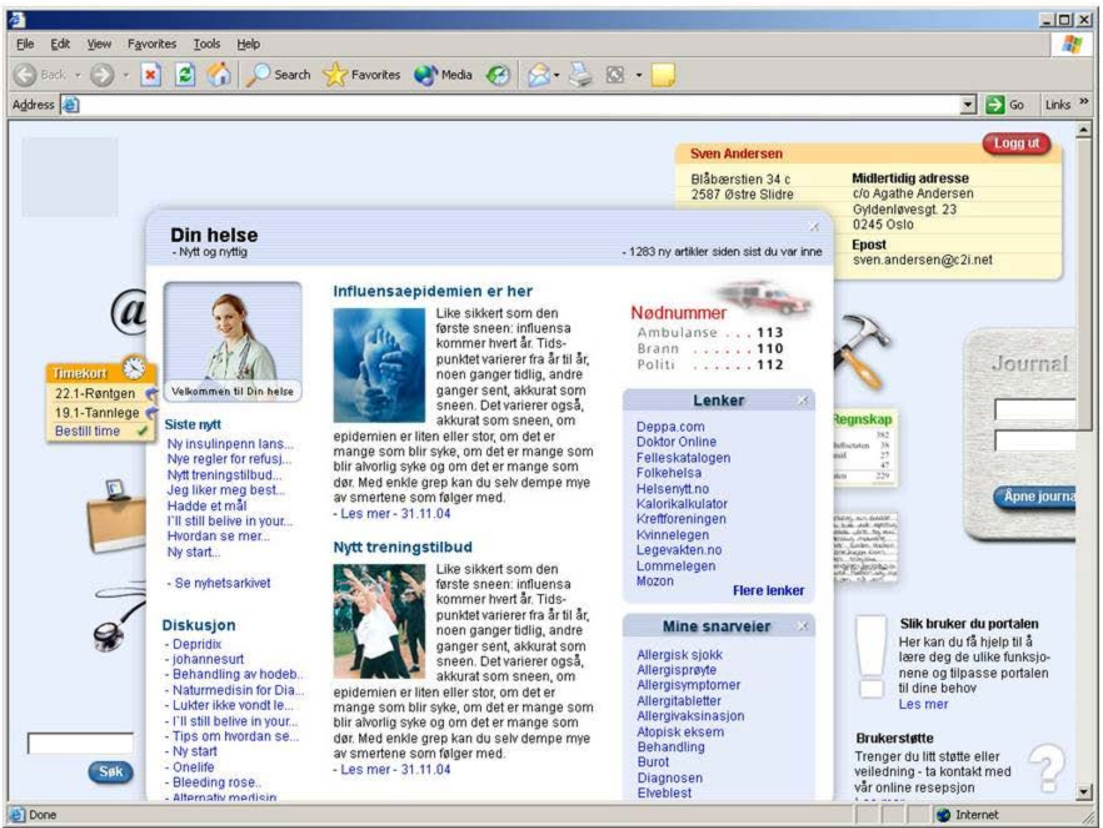

Figure 2. First Mockup (from 2004)

Three main decisions were taken in this phase that defined MyRec and shaped its evolution. First, patients were envisioned as owner (not just recipients) of their medical information and active communication partners with the hospital. For example, the functionality called MyDiary was intended to be a private place where patients could write their personal notes. Patients themselves would eventually decide whether to share text with doctors or nurses. The patient-centered vision of patients as users of a new infrastructure for hospital communication set MyRec apart from the existing hospital infrastructure for clinicians.

Second, based on their experience with a previous EPR project (where users where not involved in designing the solution), the initiators acknowledged that the design of MyRec had to be driven by concrete problems that users—patients and healthcare personnel—were experiencing in their current communication practices. For instance, a current problem was the use of email for patient-hospital communication. According to the Norwegian law on health information security, ordinary email cannot contain sensitive data. One informant defined the situation as “a ticking bomb”. To respond to this practical need, the initiators decided to design a secure messaging service.

Third, MyRec was conceived to be a flexible and stand-alone solution. One of the two MyRec initiators had been involved in the implementation project of hospital N's EPR. The EPR was a commercial off-the-shelf software product not easily adaptable to hospital N's work practices (see Hanseth et al., 2006). Thus, the initiator decided that, differently from the EPR, MyRec should have a modular architecture supporting adaptability and configurability. He also selected a flexible tool for content management (called iKnowbase) that would allow designers to easily publish and modify content according to users' needs. Moreover, because he was also informed about the difficulties in the ongoing Clinical Portal project, he wanted to design MyRec's functionality with minimal integration with the hospital systems (now integrated via the Clinical Portal). He recalls how this was a strategic choice to avoid being dependent on decisions taken in the portal project.

5.2.2. Second Phase 2005-2009: Initial Experiences

In the second phase, MyRec project gained support from the IT department, the hospital management, and the Norwegian Data Protection Authority. The leader of the IT department recognized "that patient services over [the] Internet would be something that would come, it was not a question of 'if' but 'when and how' this would come". Thus, in 2005, he reorganized the IT department and created a new unit named "research and patient services" and appointed a unit manager. The new unit worked formally as team on MyRec project. At the same time, the hospital management recognized that MyRec was an innovative "showpiece" to present to the regional health authority, which was not supportive of the Portal project. The Clinical Portal project faced serious challenges because it turned out to be technically much more demanding than expected, and it was beset with problems of performance and stability. An informant says: "We started to work on something [MyRec] that was completely different, and the managers were very keen that it was a way to show what we could do". Support came also from the Norwegian Data Protection Authority, which approved of the secure messaging service.

With this support, MyRec was now envisioned as the main patient system separated from the Clinical Portal. However, because MyRec was not part of the Clinical Portal, hospital departments were not mandated to use it. MyRec team had to inform the hospital users that a solution for patient communication existed and that MyRec functionality could be tailored to each department's own communication needs. The team actively worked on recruiting users, as one of the team members recalls:

> *We started looking for patient groups with long lasting and high intensity relationships to the hospital, like chronic diseases, we asked the rheumatologists who have patients who have been through 30 or 40 surgeries, so we thought that they might be interested ... Then based on previous knowledge, we looked at those that have high volume emails*.

During 2005-2006, the first set of MyRec functionality was developed and implemented. Each functionality was built in a self-standing module. The first two were secure messaging and appointment rescheduling. The secure message service works by notifying patients via email that there is a message to be read in MyRec. In this way, no sensitive information is actually sent. Once notified, patients can log in MyRec to read messages. One of the first departments using secure messaging was the children and youth rheumatology department, which used to have an ordinary email address for communicating (often sensitive material) with patients. Many other departments had the same security concern and they were pleased to put such functionality into use. In addition to the general problem of email use in the hospital, however, MyRec's secure messaging system also solved specific needs. For instance, the audiology department had wanted an analogous solution for many years because patients with hearing disabilities (many of whom had cochlear implants) could not use the phone to ask the department for assistance (such as in requesting spare parts or batteries). In another instance, the use of secure messaging solved the slow transmission of the previous communication system. In this case, ordinary emails were sent by patients to the hospital centralized mailbox with the request to cancel appointments for day surgery. These emails were then printed out on paper and sent via ordinary mail to the surgical department (because it was a department located outside the hospital, the communication could not be sent via email). This procedure took a couple of days, and requests for cancelling operation were often received too late to use the same timeslot for other surgeries. As a result, many patients did not show up for their scheduled surgeries, and the hospital could not be refunded because the cancelling requests were not sent in time. The use of MyRec's secure messaging system made this communication more effective and lowered the number of patients not attending appointments.

The second functionality, which concerned rescheduling appointments, was initially developed in response to a children's department requirement. The department had problems with their procedures for booking and changing appointments, which often resulted in patients not showing up at scheduled times. Patients' parents were notified of appointments at the department via ordinary letters. Parents could call the department if they needed to reschedule. However, they often did not manage to notify their request via phone. The functionality in MyRec allowed them to request another appointment online. After these initial experiences and users' feedback, MyRec was adjusted. For instance, users complained that the security solution for user authentication was too cumbersome and time-consuming. It required patients to install a card reader on their computer together with software. For support, patients would often call the hospital when they were supposed to contact the security solution provider instead. In response MyRec was reconfigured to allow some services to be openly available before log-in services, and later another security solution was implemented. The idea was for patients to enter "just enough information" into MyRec to be identified by the receiver on the hospital side. Rescheduling appointment was moved to the open environment. The overall architecture of MyRec was flexible enough to allow these reconfiguration with little effort.

The redesign of rescheduling appointment had a very positive response from the department and their patients, and was then adopted by many other departments. A positive consequence was that patients changed their appointments much earlier than what they used to, and appointments were scheduled and rescheduled in a more efficient way. In addition, departments that adopted the functionality could tailor it to their specific needs. For instance, in a case where appointments were booked by the day (and not by day and hour), patients could see available days in MyRec. In another case, the same functionality allowed patients to order home self-tests (for Chlamydia) that were sent to them via mail in an anonymous package.

Learning from the positive experience with secure messaging and rescheduling appointment, the team realized the validity of addressing real problems in communication practices, and the importance of adhering to security and legal requirements. This understanding was also confirmed by the lack of user adoption of other functionality originally part of MyRec. For instance, the discussion forum was disabled. It was not needed by patients—who were already using other established social networks—and it did not attract users. MyDiary was also disabled. Legally, one cannot store within a hospital system patient information not accessible to clinicians. Also, in this case, the modularized architecture enabled an easy reconfiguration. The team came to recognize the importance of keeping a close dialogue with the hospital departments and their patients and of recognizing their specific communication needs. Finally, in this second phase, an important change took place when a new security solution called BankID was implemented. BankID was developed by a cooperation of Norwegian banks for costumers' authentication in online banking services, and it is a solution with which most Norwegian are familiar. It required the combined use of a secure PKI based code generator, social security number, and password. The familiarity of BankID to patients made MyRec easier to use.

5.2.3. Third Phase 2009-2012: Maturation

The initial experience, user involvement, and architecture decisions had important implications for MyRec's evolution. The initial user experience with the first implemented functionality was positive and resulted in more efficient appointment scheduling and the establishment of online communication between departments and their patients. The generic character of the first functionality—rescheduling appointment and secure messaging—made it attractive to most hospital departments. Thus, instead of having to promote MyRec in the hospital, the team started to be directly contacted by potential users, from the hospital departments but also from the patients' associations. At the beginning the user workshops focused on existing modules, but eventually they became forums for generating ideas for new functionality. Throughout, the team prioritized patients' communication needs over those of clinicians. One of the team members said:

We are asked a lot of time by the wards at the hospital to make technologies for them and then we usually say no because that is not patient centered, [MyRec] is about patient centered computing, and making technologies to make their life easier is sort of stepping on a lot of toes.

At the same time, MyRec team kept brainstorming ideas for generic services to make information more accessible to patients and innovate patient services. For instance, the team envisioned a service to track the status of referral letters to the hospital, explained by one member as similar to “tracking a package that you have ordered over the Internet”. With this service, a patient referred to the hospital would know if his letter had, for instance, been received and read by a doctor or not. Another generic functionality aimed to give patients access to their discharge letters. Discharge letters were stored in the hospital EPR, and, while a copy was usually sent to GPs at the time of a patient’s discharge from the hospital, it was not given to the patient. This functionality was the first one requiring integration with the EPR system The realization process took longer than expected because development was put on hold due to ongoing discussions about replacing the EPR in the hospital to comply with regional health authority’s directives (design started in 2007, the module was developed in 2009, and working in a test environment but not implemented as 2012).

The design and development of other modules illustrate the adaptability of the solution. For instance, the form to collect information on patients’ diet was originally developed for the lipid clinic and later adapted for other departments needing periodical reporting of patients’ diets. Another example is the web shop module for ordering equipment for patients (e.g., insulin pumps) (a screenshot of the module is shown in Figure 4 for illustrative purposes). This module supported a more transparent process where patients could check their current and past orders. It was later adopted by the hospital archive department for ordering standardized packages of documents. For instance, patients could order a “change GP package” or a “second opinion package”.

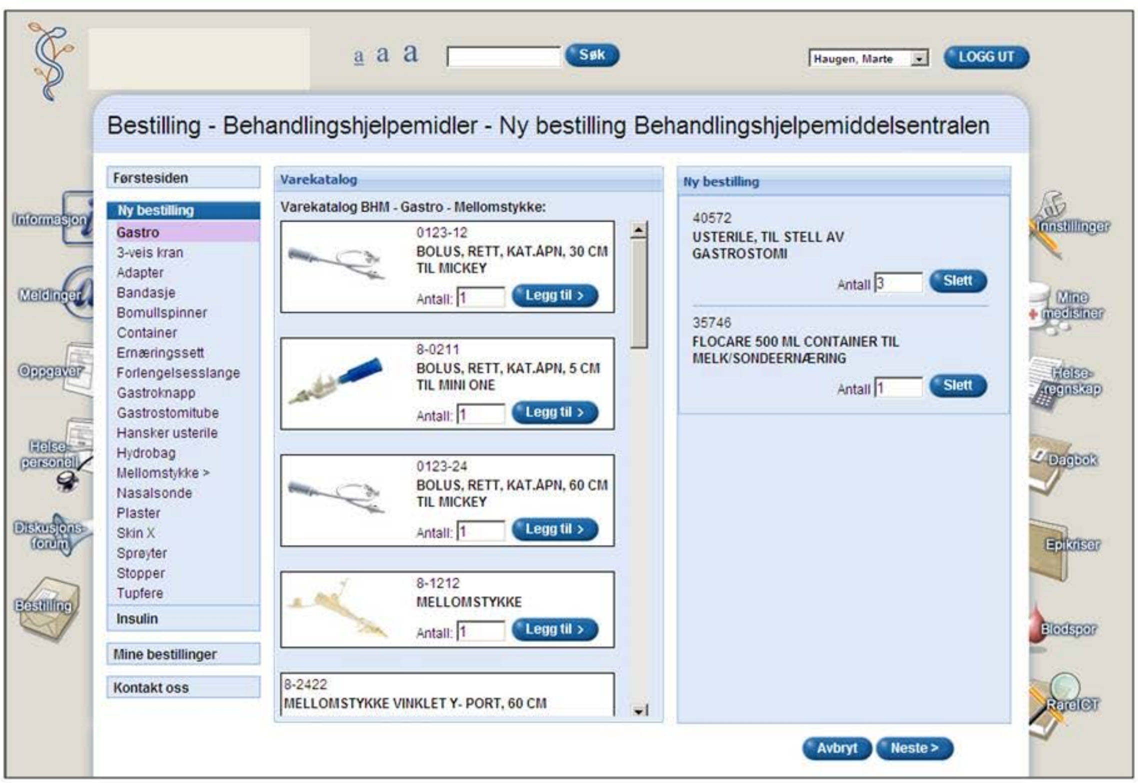

Figure 4. View of the Web Shop for Medical Equipment

MyRec's growth process was slow. Even when MyRec started attracting a wider and diversified user base with the new modules, the hospital never solidly financed it. In 2009, three large hospitals in Olso, including hospital N, were merged into one health trust. The new hospital trust, located in four main sites across the city, was meant to offer one-door access to specialized services on a national level, and local hospital services for the people of Oslo. The merger entailed a complex reshuffle of the services offered and a reorganization of clinical and service units previously belonging to different hospitals. At the same time the Clinical Portal project was stopped, and a new costly and resource-demanding project started in order to develop a new hospital portal solution (called Clinical Workflow). As result, many IT projects in the hospital and the development of modules in MyRec were delayed.

A new opportunity came in 2010 when MyRec team entered a collaboration with the Diabetes Association. They started a new project to develop interactive services for diabetic patients. The project was further supported by an EU project in 2012 that investigated patient empowerment through IT-enabled patient self-management. In this context, MyRec team became part of a consortium of European hospitals and private IT companies involved in piloting and evaluating solutions to support chronic disease management.

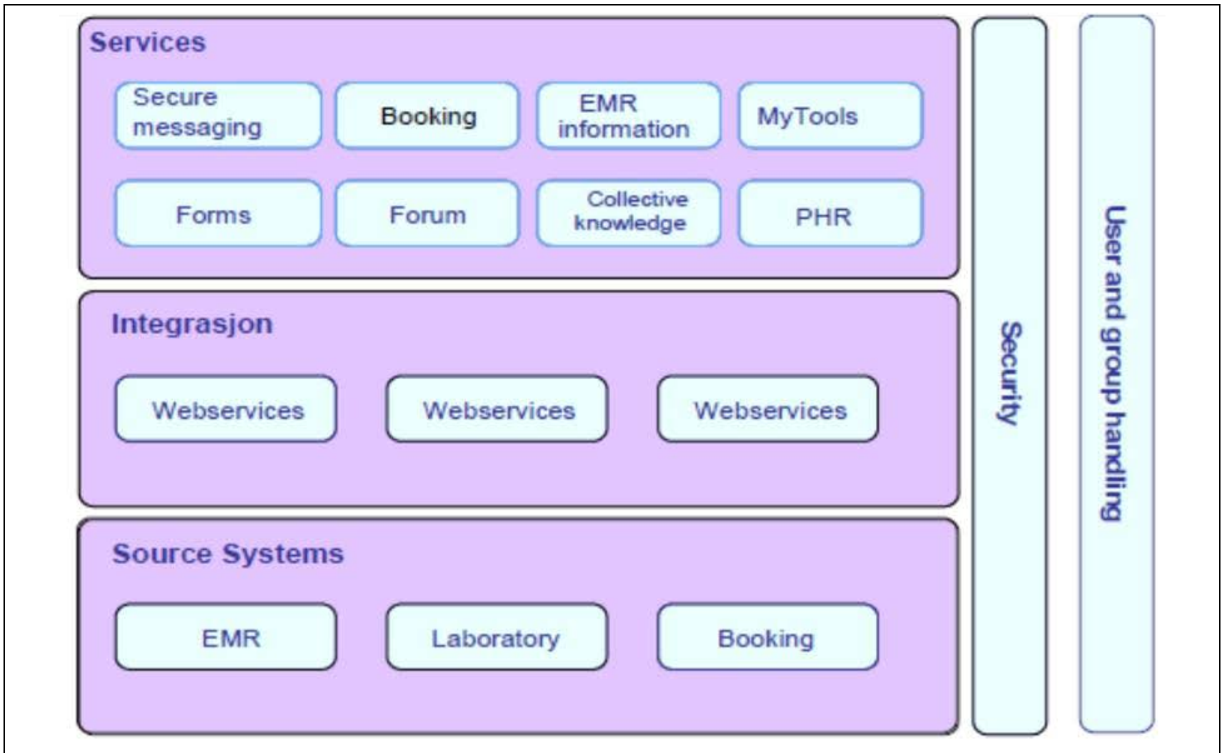

Figure 5. MyRec architecture as appears in the EU project application

As part of the project, MyRec team developed a module that included a form and a digital tool. The form was intended for diabetic patients to self-report information in preparation for consultations (such as medication list, blood sugar levels, need of new prescriptions). The digital tool (DiaClock) was originally a physical artifact similar to a 24-hour clock with which patients could visualize the relation between food intake, insulin level, amount of exercise, and blood sugar levels. Both the online forms and the digital DiaClock screens could be saved by the patient in MyRec, and the patient could decide if and when to share them with clinicians. In addition, it was possible to enter and save comments about each single DiaClock picture, and to to print information from the application. This module for diabetic patients was not developed using the content management tool, but by an external company.

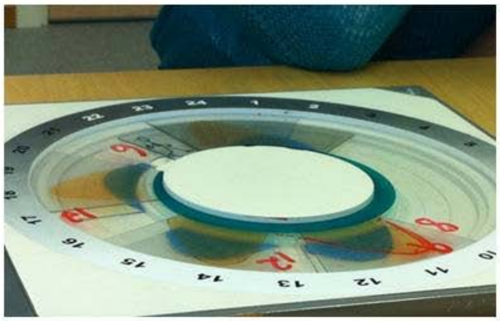
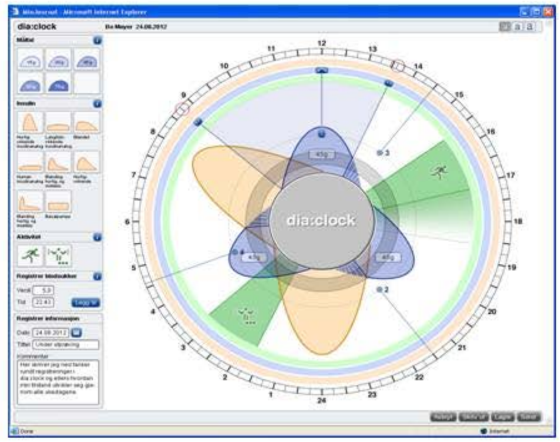

Figure 6. The DiaClock as Physical Artifact on the Left, and Digital Version on the Right

Finally, during 2011-2012, the rescheduling appointments functionality became very popular in the hospital and a major attractor for new users to uptake the software in other departments. In addition, the hospital trust decided to offer this functionality to all patients in the outpatient clinics (they expected it to be in operation by the end of 2013). Thus, in the last period covered in our study, MyRec use scaled up to the whole hospital trust.

6. Analysis

In this section, we interpret MyRec evolution asa process of cultivating the installed base. As Section 5.2.1 describes, the team started working on MyRec with a strong vision of the kind of solution they wanted to create: an infrastructure for patient services that was flexible and adaptable. They were faced both with a bootstrap problem and an adaptability problem of setting up a new II. We analyze how they dealt with these problems according to the three main aspects of cultivation identified in Section 3; namely, process-orientation, user mobilization, and learning. In each aspect, we focus on the role of MyRec architecture. Table 2 summarizes our analysis.

Table 2. MyRec Evolution as Installed Base Cultivation

	Installed base	Cultivation activity
Process-orientation	-Existing work practices in the clinical units and artefacts in use -Personal experiences of MyRec team in the hospital -Existing information practices of hospital-patient communication	-MyRec team was highly involved in design activities (e.g. design workshops, presentations) and follow-ups (e.g., responding to user feedback) -Involvement of clinical teams and patient representatives
User mobilization	-Illegal use of email -Patients difficulties in changing or cancelling appointments	-Proposing simple and easy to use solutions -Showing immediate users' benefits -Easily adaptable solution
Learning	-Personal experiences of MyRec team in the hospital -Responses from early adopters of functionality in the first implementation -Legal requirements for security and handling of health information	-Brainstorming for services of generic use -Actively searching for communication "difficulties" in patient-hospital communication. -Creating generic modules -Users' able to select from a range of functionality

6.1. Process orientation

Cultivation processes require a step-by-step engagement with the existing installed base over time. The installed base in our case is represented by the existing hospital practices and hospital information infrastructure. MyRec team's sensitivity to the installed base of clinical practices developed from their engagement with the users. This included activities such as organizing and participating in design workshops, keeping contact with clinics, and receiving and responding to users' feedback. These activities (workshops, presentations, meetings) were not targeted at specific user groups (e.g., physicians or nurses), but were targeted at teams taking care of a specific patient group (e.g., the clinical team caring for patients with eating disorders). A clinical team included physicians, secretaries, nurses, and other health workers (e.g., nutritionists, physiotherapists, and social workers). At the workshops, the clinical team was asked to describe the information practices of patient-hospital communication in their unit, and discuss and brainstorm possible uses of MyRec in their daily practices of communication with patients. These activities helped to map the existing installed base of practices, roles, routines, and responsibilities in the clinical teams. In addition, patient organizations were usually involved in the process: the decision to use MyRec in each clinical unit was intended by MyRec team to be a collective decision involving patients' representatives and clinical workers. Often, more than one year was needed to design and develop a new module. For example in some cases the clinical team realized, by mapping their communication practices, the need to improve them before being able to use MyRec. MyRec team recognized a need of maturation on the part of the departments, and waited for them to initiate the process without pushing for an uptake of the solution.

Considering the hospital infrastructure as installed base, the team strategically kept the relation of MyRec to the portal to the minimum, both organizationally and technically. The initial idea of developing an interface that gave patients access to information in the Clinical Portal and other source systems would require an overall architecture tightly coupled with MyRec. However, MyRec remained loosely coupled to the hospital infrastructure and as self-contained as possible. Had the solution begun by giving access to information from other systems, such as the Clinical Portal, then the resulting technical integration would have led to an overall increase in technological complexity. This would have further increased the organizational complexity and required tight collaboration and coordination across projects. The complex process of giving patients access to their discharge letters exemplifies this challenge. In this instance, the MyRec team negotiated with the EPR vendor a targeted integration specific to the discharge letter. In another case, integration was targeted at one of the laboratory systems to allow patients with a genetic condition to directly access their test results. These examples demonstrate how the architectural arrangement facilitated a process orientation of incremental steps.

6.2. User Mobilization

In a cultivation process, user mobilization is critical. In the initial phase, the IT managers decided that the Clinical Portal should also include an interface for patients. They decided that a patient-oriented solution was needed, that it should be realized as component of the Clinical Portal, and that it should constitute a way to access data from the infrastructure source systems such as the hospital EPR and the radiology information system. This decision would have meant mandated use of the patient services for the hospital users.

However, MyRec was not integrated into the Clinical Portal. Instead, it formed a new II that needed to be bootstrapped. Hospital users were not informed and involved in the initial conceptualization, and they could not relate to MyRec. In addition, MyRec's initial direction was for information content and not services, which at first did not attract interest. As Section 5.2.2.describes, the first two parts of functionality to be implemented were rescheduling appointment, and secure messages. The urgency of the problems they addressed, and the simplicity of the solution (e.g., the fact that it did not require a new system or training) made it attractive for users. Moreover, early adopters were satisfied with the solution and talked about it with their colleagues from other units. Patients were also very positive. New clinical units took the initiate to contact MyRec team and ask for a presentation. Another aspect that reinforced the positive response was the adaptability of the solutions: while the functionality was simple, they could also be made specific (for instance, by adding text fields according to the needs of the clinical units).

MyRec team mobilized users by showing how MyRec could address their current problems of information management and communication between hospital and patients. For instance, MyRec provided easy ways to report information, to order home tests, and to report medication use. These functionalities were simple solutions to concrete problems of small user groups that would have immediate benefits. Again the modular and flexible architecture allowed MyRec to evolve into a collection of modules of different character, some general (e.g., changing of appointments) and some specialized (e.g., the web shop).

6.3. Learning

A cultivation strategy implies a learning process where designers learn "to sort what works from what does not". In the case of MyRec, the first identified set of functionality was driven by the team, not the users (Section 5.2.1). Some of these functionalities were not used (e.g., Forum), and some were controversial (e.g., MyDiary). However, others were successful because they responded to generic problems common to all departments (e.g., secure messaging). From these initial experiences (see Section 5.2.2), the team learned how to select functionality most likely to be taken into use. They brainstormed for services of generic use based on their own experience with hospital work, and they actively asked departments to report to them problems related to patient-hospital communication that MyRec could address. However, even when working on designing specialized services, they adopted a generification strategy so that modules could be reused with other content. This was the case of the web-shop (see Section 5.2.3).

The modular architecture allowed the team to take away the functionality that was not used (MyDiary), and to change the security solution without impacting on the overall system. It also allowed moving some of the functionality out of the secure environment. For instance, rescheduling appointment does not require log in (see Section 5.2.2). MyRec was first developed as an infrastructure with few main building blocks such as a security solution for the required level-four, a site, and a content management tool. Gradually, individual modules were developed. MyRec thus became a toolbox from where new users such as departments and units could select and appropriate existing services in addition to requiring new ones.

7. Discussion

In this study, we have investigated the cultivation process of a novel II. The analysis explains how the overall strategy was experimental and opportunistic. Over the course of the MyRec's evolution, the team learnt to be pragmatic and flexible. They did not design a full solution at the start, but designed services responding to real needs, and they operated with a flexible technology that allowed them to experiment with modules without changing the overall infrastructure. In Section 7.1, we discuss the role of architecture in II innovation, and discuss the implications of our study for research on II innovation in Section 7.2.

7.1. The Role of Architecture in II Innovation

MyRec's concept and technical architecture have considerably evolved over the ten-year period we have covered. We can see from our analysis of MyRec's cultivation period that different types of innovations related to the infrastructure's architecture emerged. Initially, MyRec's team intended to create an innovation **of** the hospital infrastructure in order to support patient-services. While the team intended to support patient communication within the Clinical Portal, they abandoned this idea for a rather autonomous infrastructure with loose coupling to other hospital systems. This infrastructure included a set of basic services (secure authentication, site and content management tool) on which more specific services could be built. This first type of innovation was directed toward establishing a new infrastructure different from the existing hospital infrastructure.

A second type of innovation was directed towards creating innovation **in** the infrastructure. Once the conceptual development of MyRec was stabilized, the team worked on the design and implementation for the modules of MyRec's first version, and later added or disabled modules. Thus, innovation was not directed to the overall concept and architecture anymore, but toward the specific functionality for patient services in the existing MyRec infrastructure. For example, an important innovation in this infrastructure was the inclusion of BankID as a security solution. It also included services for changing-requesting appointments, web-shop, access to lab reports and discharge letters, services for ordering test kits, specialized services for patients with hemophilia, and so on.

A third type of innovation took place when MyRec's established infrastructure enabled a series of innovations **on** top of it. DiaClock is a good example of such an innovation. It has been developed as a new functionality that goes beyond content management while building upon a number of MyRec's established modules. Building on MyRec, DiaClock exploits the security, accessibility and reliability arrangements that are already in place.

Finally, the content management tool chosen for developing MyRec has proved to have significant generativity (Zittrain, 2006). In this way, it enabled the capacity for innovation that we saw in MyRec's development as an infrastructure. The content management system has been a powerful platform (Gawer, 2009) on which MyRec's various components could be developed easily. The more recent development of MyRec towards disease management, also demonstrates the importance of a generative platform that enables and stimulates the future growth of MyRec's infrastructure by enabling actors outside the team to combine existing modules and develop new ones in order to support more patient groups with powerful services.

7.2. Implications

In this paper, we ask which conditions lead to a successful information infrastructure innovation in the case of MyRec. Our findings confirm previous research concluding that successful IIs are based on a bottom-up, evolutionary approach. This approach emphasizes the importance of experimental development and simple and flexible solutions (Hanseth & Aanestad, 2003; Hanseth et al., 2006; Aanestad & Jensen, 2011). More generally, our findings support the argument that successful infrastructure innovations are based on a bootstrapping strategy that focuses on addressing real users' specific problems and providing immediate usefulness. Such strategies help create network effects, which help bringing more users on board and create the momentum to drive further adoption. Our findings also emphasize that the success was also due to the self-contained nature of the development organization. This was important in order for the team to be able to adopt an experimental approach in the beginning of the MyRec II's development and to be able to modify the II as the range of users grew and the II scaled. In addition, our analysis exposes the important role played by the II's architecture.

Recent literature has addressed the role played by architectures in II evolution and found that architectures shape the way IIs evolution is organized and managed (Aanestad & Jensen, 2011, Hanseth et al., 2012). Solutions that are based on architectures, which require all functionality to be in place from the very start, tend to create complex systems that are challenging to realize in practice, require a high degree of stakeholders' coordination, and may be too expensive to change in future adaptations (Aanestad & Jensen, 2011). On the contrary, solutions that are based on architectures that allow gradual scaling and growth tend to be more flexible in seizing opportunities and facing uncertainties (Sahay, Monteiro & Aanestad, 2009). These studies show how both the complexity of the solution (e.g., limited functionality vs full functionality) and the organizing of project activities (e.g., few stakeholders vs many stakeholders) have an impact on the success of innovation processes. Furthermore, in the context of digital technologies, architectures shape II innovation. Yoo, Henfridsson, and Lyytinen (2010) discuss how layered modular architectures enable innovation that is doubly distributed (not only among firms of the same ilk but also across firms of different kinds) (Yoo et al., 2010). Other research has pointed out the important role of platforms and platform centric architectures in enabling and stimulating the growth of "digital ecologies" (e.g., related to the mobile phone platforms iPhone/iOS and Android) (Eaton, Elaluf-Calderwood, & Sørensen, 2010; Gawer & Cusumano, 2008; Tilson, Lyytinen, & Sørensen, 2010).

Our contribution to this literature is to articulate the critical role of IIs architecture in enabling successful innovation. This role is constituted by the way the technological architecture is related to a variety of issues. First of all, as for all technological solutions, the architecture must represent the kind of modularization that satisfies the needs for flexibility to modify the solution as requirements change. Second, the architecture should mirror the structure of the organization developing the solution

(Colfer & Baldwin, 2010). Accordingly, if a development organization has to work independently in an experimental and entrepreneurial style, their IT solution needs to be equally independent from other solutions (Hanseth et al., 2012). A solution's technological architecture is also tightly connected to its functionality. Our findings also underscore the importance of a solution's architecture regarding speed and degree of innovation. Finally, our findings demonstrate different kinds of infrastructural innovation. We classify these as innovations of, in, and on infrastructures.

Innovations **of** infrastructures concern the conceptualizations and implementation of new infrastructures such as MyRec's initial visions and its first implementation. However, innovations of infrastructures also include re-conceptualizing and re-engineering existing infrastructures. In this way, innovations of infrastructure are closely related to an infrastructure's architecture. We may say that innovation of infrastructure means designing and implementing an architecture from scratch or changing an infrastructure's architecture. This type of innovation of infrastructure reflects a concern with the long term and involves complexities of sociotechnical and organizational considerations (Ribes & Finholt, 2009)

Innovations **in** infrastructures concern replacing or modifying an infrastructure's existing components without changing the architecture (Henderson & Clark, 1990). One important way in which existing components may be changed is through the generification processes (Pollock & Williams, 2008). In our case, this happened when modules where designed in a generic way.

Finally, an important way through which infrastructures grow is by adding new components **on** top of what exists. This is the kind of infrastructural innovation—on infrastructure—where infrastructures are expanded with complements (Baldwin & Woodard, 2009) and which is conceptually captured by generativity (Zittrain, 2006). We see then that infrastructural innovation includes both innovations of, in, and on infrastructures and, further, that these innovations are intertwined. Successful strategies for infrastructure innovations need to address all three. This expands Zittrain's (2006) concept of generativity, whichaddressesinnovations on (top of) existing infrastructures.

8. Conclusion

In this paper, we address what the conditions for successful infrastructural innovations are. We have, of course, not arrived at a complete answer to this question. However, we do believe that we identify important elements of such an answer. First of all, infrastructures need to be developed in a bottom-up and evolutionary manner where the experimental development of services that address the specific needs of specific user groups is a central element. Such an process places some requirements on both the infrastructure to be developed and on the organization developing it. Both need to be simple and flexible, which also means loosely coupled from other infrastructures and development organizations.

Second, successful infrastructural innovations need to address all three kinds of innovation: of, in, and on infrastructures. The latter two kinds of innovation depend on the first (i.e., the architecture of the overall infrastructure will constrain or enable innovations related to components in an existing infrastructure or on top of it). In addition, an infrastructure's architecture is related to a broad range of issues making it the most critical element of infrastructural innovations. An infrastructure's architecture must first enable the experimental activities required to learn what kind of services and infrastructure would be useful for its potential users. It must then bootstrap the infrastructure by getting the first users to start using it and to generate network effects that reinforce further adoption and give its diffusion greater momentum. As an infrastructure grows and its developers learn about user requirements, the architectural requirements change, too. The architecture must support a growing number of users and services, and stimulate and enable continuous growth of new services on top of an existing infrastructure.

We see in the MyRec case how simple technology and a small team are important conditions for experimental development in general, both for developing new architectural components and for (re-)designing the overall infrastructures. This is contrary to traditional approaches to infrastructural innovation based on a top-down specification that, as we review, have been dominant in telecom and healthcare fields.

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References

Aanestad, M., & Hanseth, O. (2002). Growing networks: Detours, stunts and spillovers. In *Proceedings from COOP 2002, Fifth International Conference on the Design of Cooperative Systems*, St. Raphael, France, 4.-6th June 2002.

Aanestad, M., & Jensen, T. (2011). Building nation-wide information infrastructures in healthcare through modular implementation strategies. *Journal of Strategic Information Systems*, *20*(2) 161-176.

Aanestad, M. Jensen, T., & Grisot, M. (2009). Dealing with tight couplings and multiple interactions in complex technological systems. Proceedings of *ECIS 2009,* Verona, Italy.

Baldwin, C., & Woodard, J. (2009). Platforms, markets and innovation. In A. Gawer, (Ed.). *The architecture of platforms: A unified view.edward elga*r, Cheltenham, UK, 19–44.

Barley, S. R. (1986). Technology as an occasion for structuring: Evidence from observations of CT scanners and the social order of radiology departments. *Administrative Science Quarterly*, *31*(1), 78-108.

Berg, M. (1999). Patient care information systems and health care work: a sociotechnical approach. *International Journal of Medical Informatics*, *55*, 87–101.

Bowker G. & Star S.L. (1999). *Sorting things out: Classification and its consequences*. Cambridge, MA: MIT Press.

Brunsson, N., Rasche, A., & Seidl, D. (2012). The dynamics of standardization: Three perspectives on standards in organization studies. *Organization Studies 33*(5-6), 613-632.

Ciborra, C. U. (1997). De profundis? Deconstructing the concept of strategic alignment. *Scandinavian Journal of Information Systems*, *9*(1), 67–82.

Ciborra, C. U., Braa, K., Cordella, A., Dahlbom, B., Failla, A., Hanseth, O., & Monteiro, E. (2000). *From control to drift: The dynamics of corporate information infrastructures*. Oxford University Press.

Ciborra, C. U., & Hanseth, O. (1998). From tool to: Agendas for managing the information infrastructure. *Information Technology & People*, *11*(4), 305-327.

Colfer, L., & Baldwin, C. (2010). The mirroring hypothesis: Theory, evidence and exceptions. *Harvard Business School Working Papers*, No 10-058.

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

Contini, F., & Lanzara, G.F. (2009). *ICT and innovation in the public sector*. Basingstoke, England: Palgrave Macmillan.

Contini, F., & Lanzara, G. F. (2013). *The circulation of agency in e-justice*. Law, Governance and Technology Series, Springer.

Currie, W. L., & Guah, M. W. (2006). IT-enabled healthcare delivery: The U.K. national health service. *Information Systems Management*, *23*(2), 7-22.

Dahlbom B., & Mathiassen L. (1993). *Computers in context: The philosophy and practice of systems design.* Oxford: Blackwell.

DesRoches C. M., Campbell E. G., Vogeli C., Zheng J., Rao S. R., Shields A. E., Donelan K., Rosenbaum S., Bristol S. J., & Jha A. K. (2010). Electronic health records' limited successes suggest more targeted uses. *Health Affairs, 20*(4), 639–646.

Eaton, B., Elaluf-Calderwood, S., & Sørensen, C. (2010). A Methodology for analysing business model dynamics for mobile services using control points and triggers. *Business Models for Mobile Platforms* (BMMP 2010).

Edwards, P., Jackson, S., Bowker, G., & Knobel, C. (2007). Report of a workshop on 'History and theory of infrastructures: Lessons for new scientific infrastructures', University of Michigan, School of Information.

Edwards, P. N., Bowker, G. C., Jackson, S. J., & Williams, R. (2009). Introduction: An agenda for infrastructure studies. *JAIS*, *10*(5), 364–374.

Eisenhardt, K. M. (1989). Building theories from case-study research, *Academy of Management Review*, *14*(4), 532-50.

Ellingsen, G., & Monteiro, E. (2003). A patchwork planet: Integration and cooperation in hospitals. *Computer Supported Cooperative Work*, *12*(1), 71-95.

Ellingsen, G., & Monteiro, E. (2006). Seamless integration: Standardization across multiple local settings. *Computer Supported Cooperative Work*, *15*(5-6), 443-466.

Finchman, R. G., Kohli, R., & Krishnan, R. (2011). Editorial overview—The role of IS in healthcare. *Information Systems Research*, *22*(3), 419-428.

Freeman, P. A. (2007). Is ‘designing’ cyberinfrastructure – or, even, defining it – possible? *First Monday*, *12*(6).
Gawer, A., & Cusumano, M. (2008). How companies become platform leaders. *MIT Sloan Management Review*, *49*(2) 28.
Gawer, A. (2009). *Platforms, markets and innovation.* Edward Elgar Publishing.
Goh, J. M., Gao, G., & Agarwal, R. (2011). Evolving work routines: Adaptive routinization of information technology in healthcare. *Information Systems Research*, *22*(3), 565-585.
Greenhalgh, T., Stramer, K., Bratan, T., Byrne, E., Mohammad, Y., & Russell, J. (2008). Introduction of shared electronic records: multi-site case study using diffusion of innovation theory. *British Medical Journal*, (Clinical research ed.).
Greenhalgh, T., Stramer, K., Bratan, T., Byrne, E., Russell, J., & Hinder, S. (2010). The devil's in the detail: Final report of the independent evaluation of the Summary Care Record and HealthSpace programmes. London: University College London.
Hanseth, O., & Aanestad, M. (2003). Bootstrapping networks, communities and infrastructures – On the evolution of ICT solutions in healthcare. *Methods of Information in Medicine, 42*(4), 385-391.
Hanseth, O., Bygstad, B., Ellingsen, G., Johannesen, L. K., & Larsen, E. (2012). ICT standardization strategies and service innovation in health care. *Thirty Third International Conference of Information Systems*, Orlando.
Hanseth, O., & Ciborra, C. U. (2007). *Risk, complexity and ICT*. Edward Elgar Publishing.
Hanseth, O., Jacucci, E., Grisot, M., & Aanestad, M. (2006). Reflexive standardization: Side effects and complexity in standard making. *MIS Quarterly, 30*, 563-581.
Hanseth, O., & Lyytinen, K. (2004). Theorizing about the design of information infrastructures: Design kernel theories and principles. *Sprouts: Working Papers*, *4*(4).
Hanseth, O., & Lyytinen, K. (2010). Design theory for dynamic complexity in information infrastructures: The case of building internet. *Journal of Information Technology*, *25*, 1-19.
Hartswood, M., Procter, R., Rouncefield, M. & Slack, R. (2003). Making a case in medical work: implications for the electronic medical record. *Computer Supported Cooperative Work*, 12 (3), 241-266.
Henderson, R. M., & Clark, K. B. (1990). Architectural innovation: The reconfiguration of existing product technologies and the failure of established firms. *Administrative Science Quarterly*, *35*, 9–30.
House of Commons (2011). The National Programme for IT in the NHS: An update on the delivery of detailed care records systems. National Audit Office, Department of Health, available at www.nao.org.uk/npfit-2011.
Jackson, S. J., Edwards, P. N., Bowker, G. C., & Knobel, C. P. (2007). Understanding infrastructure: History, heuristics, and cyberinfrastructure policy. *First Monday*, *12*(6).
Jones, M. (2004). Learning the lessons of history? Electronic records in the United Kingdom acute hospitals, 1988-2002. *Health Informatics Journal*, *10*(4), 253-63.
Kallinikos, J. (2011). *Governing through technology*. Palgrave Macmillan.
Klein, H. K., & Myers, M. D. (1999). A set of principles for conducting and evaluating interpretive field studies in information systems. *MIS Quarterly*, *23*(1), 67-93.
Lyytinen, K., & Fomin, V. V., (2002). Achieving high momentum in the evolution of wireless infrastructures: The battle over the 1G solutions. *Telecommunications Policy*, *26*(3–4), 149–170.
Monteiro, E. (1998). Scaling information infrastructure: The case of the next generation IP in the Internet. *The information Society*, *14*(3), 229-245.
Monteiro, E., & Hanseth, O. (1996). Social shaping of information infrastructure: On being specific about the technology. In W. J. Orlikowski, G. Walsham, M. R. Jones, & J. I. DeGross (Eds.). *Information Technology and Changes in Organizational Work*. London: Chapman & Hall.
Orlikowski, W. J., & Hofman, J. D. (1997). An improvisational model for change management: The case of groupware technologies. *Sloan Management Review*, *38*(2), 11-21.
Piras, E. M. & Zanutto, A. (2010). Prescriptions, x-rays and grocery lists. Designing a personal health record to support (the invisible work of) health information management in the household. *Computer Supported Cooperative Work, 19*(6), 585-613.
Pollock, N., & Williams, R. (2008). *Software and organisations: The biography of the enterprise-wide system or how SAP conquered the world*. Routledge.
Ribes, D., & Finholt T.A. (2009). The long now of technology infrastructure: Articulating tensions in development. *Journal of the Association for Information Systems, 10*(5), 375–398.
Sahay, S., Monteiro, E., & Aanestad, M. (2009). Configurable politics and asymmetric integration: Health e-Infrastructures in India. *JAIS*, Special Issue on e-Infrastructure, *10*(5), 399–414.

Sauer, C., & Willcoks, L. (2007). Unreasonable expectations – NHS IT, Greek choruses and the games institutions play around mega-programmes. *Journal of Information Technology*, *22*, 195–201.

Scott, J. T., Rundall, T. G., Vogt, T. M., & Hsu J. (2005). Kaiser Permanente's experience of implementing an electronic medical record. *British Medical Journal*, *331*, 1313-1316.

Star, L. S., & Ruhleder, K. (1996). Steps toward an ecology of infrastructure: Design and access of large information spaces. *Information Systems Research, 7*(1), 111–134.

Tilson, D., Lyytinen, K., & Sørensen, C. (2010). Research commentary: Digital infrastructures: The missing is research agenda. *Information Systems Research*, *21*(4), 748–759.

Vikkelsø, S. (2005). Subtle redistribution of work, attention and risks: electronic patient records and organisational consequences. *Scandinavian Journal of Information Systems*, *17*(1), 3–30.

Vikkelsø, S. (2010). Mobilizing information infrastructure, shaping patient-centred care. *International Journal of Public Sector Management*, *23*(4), 340-352.

Walsham, G. (1993). Interpreting information systems in organizations. John Wiley series in information systems; Chichester, West Sussex, England ; New York, NY: Wiley.

Winthereik, B. R., van der Ploeg, I., & Berg, M. (2007). The electronic patient record as a meaningful audit tool: accountability and autonomy in general practitioner work. *Science Technology Human Values*, *32*(1), 6-25.

Yoo, Y., Henfridsson, O., & Lyytinen, K. (2010). The new organizing logic of digital innovation: An agenda for information systems research. *Information Systems Research*, *21*(4), 724–735.

Zittrain, J. (2006). The generative internet. Harvard Law Review, *119*. 1974-2040.

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