



# Building nation-wide information infrastructures in healthcare through modular implementation strategies

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## ABSTRACT

Initiatives that seek to realize the vision of nation-wide information infrastructures (II) in healthcare have often failed to achieve their goals. In this paper, we focus on approaches used to plan, conduct, and manage the realization of such visions. Our empirical material describes two Danish initiatives, where a national project failed to deliver interoperable Electronic Patient Record (EPR) systems while a small, local solution grew and now offers a nation-wide solution for sharing patient record information. We apply II theory, specifically the five design principles proposed by Hanseth and Lyytinen, to contrast the organization and implementation strategies of the two projects. Our findings highlight how implementation strategies differ with respect to how stakeholders are mobilized. We argue that the realization of nation-wide IIs for healthcare not only requires a gradual transition of the installed base, which current II theory advocates. Here we articulate and exemplify a modular implementation strategy as an approach that also addresses the challenges related to mobilization and organization of multiple stakeholders.

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## 1. Introduction

This paper addresses implementation strategies for large-scale information infrastructures (II) in healthcare. The issue is highly relevant as both governments and healthcare providers direct a considerable amount of resources towards achieving nation-wide, fully integrated healthcare information infrastructures, where interconnected and interoperable Electronic Patient Record (EPR) systems are central. However, although the visions of national health II based on interoperable EPR systems have been long-standing, they have proven difficult to realize on a nation-wide scale (Middleton et al., 2005). Studies show that both the process of implementing EPR systems on a wide scale, and that of achieving interoperability between the systems, has been challenging both in the US (Ash and Bates, 2005; Berner et al., 2005; Kohn et al., 2000) and in Europe (Currie and Guah, 2007; Greenhalgh et al., 2008, 2010; Jones, 2004).

In this paper we focus on approaches used to plan, conduct, and manage the realization of national healthcare information infrastructures; i.e., “how to get there from here” (Middleton et al., 2005). This focus is based on the observation that in addition to national initiatives with long timeframes, other initiatives exist, often with a smaller scale. As Jones (2004) observed, there seems to be an “apparent success of technologically rather unsophisticated EPR systems” (ibid., p. 262), often implemented in a context of local problem-solving and short-term initiatives. We believe that important insights can be gained from how these successful projects plan, conduct, and manage the realization of their visions. However, we do not intend merely to advocate small-scale, pragmatic, bottom-up implementation approaches in favor of centralized, top-down

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ones. Rather, both approaches seem to pose a number of challenges in the context of national healthcare IIs. For example, top-down initiatives face challenges related to the transition from existing IT systems to new ones. They may also result in complex systems that are challenging to realize in practice and that may be too expensive to change in future adaptations. While bottom-up approaches more easily accommodate the existing IT systems and are more resilient to future change, they will normally lead to a less integrated national system (Coiera, 2009). The purpose of this study is to examine implementation challenges and strategies for achieving IIs in healthcare, and to contribute with a more nuanced conceptualization of such infrastructures.

We examine the implementation process of two different projects directed at achieving interoperability between EPR systems in the Danish healthcare sector. The first project, “Basic Structure for EPR Systems” (B-EPR), aimed to develop a novel and comprehensive standard for interoperable EPR systems across the entire health sector. While this initiative was well-funded and supported by the national health authorities, it was eventually abandoned without having delivered a working prototype. The second initiative, the “Standardized Extraction of Patient Information” (SEP), was instigated as a problem-solving local solution to help hospitals exchange data from their existing EPR systems. It was based on an existing national standard for patient information and easily integrated with the existing EPR systems. This application was replicated in other locations, and was later supported by additional infrastructure and is currently the *de facto* solution for sharing patient record information in Denmark. Theoretically, we draw on resources from information infrastructure (II) literature, which offers advice on how to design and change IIs. In particular, II theory conceives of design and implementation of large-scale IIs as ongoing and interrelated activities, as “cultivation of the installed base”. In our analysis we ask: to which degree did the initial visions of the two projects allow them to pursue an implementation strategy according to the recommendations in the II literature? In addressing this question, we zoom in on the relation between the initial formulation of goals, their consequences in terms of design, and the subsequent implementation strategy. Practically, this focus allows us to discuss how the implementation strategies recommended by the II theory can be facilitated. Moreover, it allows us to critically examine the notion of “installed base cultivation” as an implementation strategy. Based on our empirical study we contribute to the II literature by formulating an extension of this approach. In the context of nation-wide healthcare information infrastructures, core challenges are related to the mobilization and coordination of multiple stakeholders during the implementation process. These are the challenges on which we focus this paper, and which our proposed notion of modular implementation strategies addresses.

Following next section’s review of the II literature and the five design principles proposed by Hanseth and Lyytinen (2010), we describe the research setting and our research approach. Subsequently, we present the empirical material which is organized as chronological summaries of the two projects’ trajectories. We then examine the implementation strategy of each of the initiatives and conclude by offering theoretical and practical implications of our findings.

## 2. Information infrastructures

One stream of research that has addressed the challenges of realizing large-scale technological systems is the II literature (Hanseth and Lyytinen, 2010; Monteiro and Hanseth, 1995; Star and Ruhleder, 1996; Edwards et al., 2007, 2009). Here, large-scale information systems are understood to not be standalone entities, but integrated with other information systems and communication technologies, as well as with other technical and non-technical elements. Thus, this approach is relevant for analyzing the domain of nation-wide, integrated healthcare infrastructures. In the following review, we present II literature’s recommendations for change strategies and design principles for building IIs.

### 2.1. Changing IIs: cultivation of installed base

Much of the II literature offers post hoc accounts of troubled or failed II projects at the corporate level, emphasizing their complexity, uncontrollability, and unintended consequences (see e.g. Ciborra et al., 2000; Hanseth and Ciborra, 2007). These studies tend to claim that traditional models of rational, managerial decision-making are of limited practical relevance in the context of II management. In general, the II literature advocates iterative and adaptive development approaches along with ongoing alertness, monitoring, and interventions. This is illustrated by the metaphor of “cultivation”, which contrasts the predominant, techno-rational approach of a planning-based “construction” approach (Ciborra et al., 2000). The installed base notion is central to the cultivation approach, as large-scale and long-lived assemblages are rarely designed and implemented from scratch but rather “designed as extensions to or improvements of existing ones in contrast to green field design. The installed base of the existing infrastructure and its scope and complexity influences how the new infrastructure can be designed” (Hanseth and Lyytinen, 2004, p. 207). IIs are gradually growing; they “wrestle with the inertia of the installed base [...] and are fixed in modular increments, not all at once or globally” (Star, 1999, p. 382). The notion of installed base in the II literature is sociotechnical and practice-oriented, it includes the physical and social context of work, existing technologies and routines, and the worker’s skills and beliefs. For instance, in a study of the introduction of EPR systems in hospitals, Hanseth and Monteiro (1998) discuss the highly entrenched and even institutionalized nature of work practice into which EPR systems have to fit. They conceptualize this context as aligned (i.e. stable) sociotechnical actor-networks and discuss how appropriate change strategies need to take this existing sociotechnical “installed base” as its starting point. Approaches

that neglect to deal with the installed base are often called “installed base hostile” (Hanseth et al., 1996; Hanseth and Monteiro, 1998; Jakobs, 2006).

On these assumptions, the II literature claims that there will not merely be a “jump” or switch between the old and the new II, but a gradual and step-wise transition. Designing and specifying the transition process becomes important, perhaps even more important than specifying the goal (Monteiro, 1998; Hanseth and Aanestad, 2003). A successful transition process in the context of IS implementation is illustrated by Hanseth and Lundberg (2001) in their account of the introduction of Picture Archiving and Communication Systems (PACS) in Swedish hospitals. The authors describe how the tools being utilized before digitization (e.g. paper forms and analog films) were linked with the clinical practices and established communication patterns into sociotechnical, standardized, and institutionalized actor-networks (ibid. p. 359). All aspects of such an II cannot be changed instantly but have to be implemented in a gradual fashion and proceed through changing elements or sub-networks. The challenge is thus that “the new must match the old during the transition period. (...) A successful transition will then require links and some kind of interoperability across these inconsistencies” (ibid. p. 361). In their study, a careful transition strategy was designed to ensure that certain elements (e.g. specific paper forms) and sub-networks (i.e. work routines) were changed without disruption of services. The initially digitized sub-network, which was relatively self-contained with clearly defined interfaces to the other sub-networks, was interrelated with the remainder of the analog II through temporary ‘gateways’ such as scanners and printers. By allowing for a decoupling of sub-networks, the gateways facilitated a gradual transition process. Such decoupling is made possible by modular solutions, and “modularity” has thus been emphasized as a key design principle for IIs (Hanseth and Monteiro, 1998; Hanseth and Lyytinen, 2004, 2010). Hanseth et al. (1996) argued that IIs “consists of a highly complex and extensive physical network of interconnected modules of communication technology. The only feasible way to cope with such a network is by modularization; that is, by decomposition or black-boxing” (ibid., p. 416). We will pursue this line of thought by looking more closely into the modularization of the two healthcare IIs, i.e. the B-EPR and the SEP solutions.

## 2.2. Design principles for IIs

While most of the II literature presents descriptive case studies, Hanseth and Lyytinen (2010) have synthesized these studies’ insights into a normative design theory for IIs. They distinguish between two generic challenges when designing IIs. The first challenge, called the “bootstrap problem”, addresses the establishment of a novel II. Since an II gains much of its value from its large and diverse user base and components, the fact that initially the user community is non-existent or small precludes the fact that the infrastructure can offer these benefits. Secondly, the “adaptability problem” relates to the further growth and expansion of an II where unforeseen demands, opportunities, and barriers may arise.

In order to address the “bootstrap problem”, the first design principle proposed by Hanseth and Lyytinen is “design initially for direct usefulness”. When a large user base cannot be expected, the solution must persuade the initial users by itself, through targeting their needs and solving their problems in a way that does not assume a complete solution or a large user base. Their advice is to prioritize immediate use value and to let the scalability, extension, and completeness of the solution come later. Secondly, Hanseth and Lyytinen advise the designer to “build upon existing installed base”, for instance, exploiting existing infrastructures, platforms or communication formats (technical or non-technical) that are already in use. In this way, the initial costs of developing the solution will not only be lower, but more importantly, the adoption barrier for the user will be smaller. The third principle recommends “expanding the installed base by persuasive tactics to gain momentum”. Thus, the slogan “users before functionality” captures the advice to generate positive network effects from extending the user base. Before new functionality is added, the user base should have grown enough to sustain the added cost of development and learning that this addition entails.

For the “adaptability problem”, where the aim is to build flexible and adaptable IIs, Hanseth and Lyytinen advise the pursuit of “making the IT capability as simple as possible” as the fourth principle and “modularize the information infrastructure” as the fifth principle. The purpose of these principles is to separate the layers of infrastructures from each other (e.g.

**Table 1**  
Design problems and principles (Hanseth and Lyytinen, 2010).

Design problem	Explanation	
Bootstrap problem	Design initially for direct usefulness	The solution must persuade the initial users through targeting their needs and solving their problems; easy to use and implement; useful without a larger user base
	Build upon existing installed base	Exploit existing infrastructures, platforms or communication formats already in use; no need for new support infrastructures
	Expand installed base by persuasive tactics to gain momentum	Generate positive network effects from extending the user base; before adding new technology, ensure that the user base has grown to sustain the added cost of development and learning
Adaptability problem	Make the IT capability as simple as possible	Make the information infrastructure as simple as possible (both technically and socially); promote overlapping IT capabilities
	Modularize the information infrastructure	Separate the layers of infrastructures from each other and exploit gateways to connect different layers

service layers from transport layers), to exploit gateways to connect different layers or regions, and to maintain loose couplings between the connected IIs. We have summarized the five principles related to the bootstrap problem and adaptability problem in Table 1.

### 2.3. Beyond installed base cultivation to deal with stakeholder mobilization

We find the principles by Hanseth and Lyytinen (2010) useful to pursue when investigating healthcare IIs. However, in doing so we need to keep in mind that the example provided by Hanseth and Lyytinen (2010), i.e. the history of the Internet, describes a special case of an II that developed in initially unforeseen ways. The authors' account foregrounds the designers' role and emphasizes how design decisions were made in the face of dynamic complexity stemming from the unpredictability of future growth and demands. In this paper we address a somewhat different situation; namely the challenges of developing an II with a clear goal of achieving interoperability among different EPR systems. Such initiatives are based on collectively formulated visions and goal, and a core issue for healthcare II implementation is thus to deal with larger collectives of already involved actors in reaching these goals. This is not trivial, as the healthcare domain is highly complex and politicized in nature (Ballantine and Cunningham, 1999; Pettigrew et al., 1992), and implementation of IIs involve stakeholders who may already have invested a great deal in different technologies. Hanseth and Lyytinen acknowledge that "the theory is limited in scope. It says nothing about the politics during II design and how a designer can cope with the power" (ibid., p.15). While not aiming to explicitly analyze politics and power issues, we believe that that the II theory will benefit from a discussion also of the challenges of organizing, mobilizing and coordinating multiple independent stakeholders.

Hanseth and Lyytinen's principle no. 3, the recommendation to use persuasive tactics in order to expand the installed base, goes somewhat in this direction. However, their account is centered on the II designer and casts other actors in a relatively passive adopter/non-adopter role, thus this principle mainly translates to giving users incentives to adopt and use the II, and the concern is to increase the number of users in order to create a momentum of the II. The persuasion of users first happens by offering immediate and direct usefulness, and then by exploiting the potential of the existing user base to create network effects (e.g. user communities) that may offer additional incentives to continue to participate and to further innovate. We question whether this conceptualization adequately represents the actual challenge of stakeholder mobilization in a context of goal-directed, national initiatives to establish healthcare IIs. By examining how stakeholders in such a context can be mobilized and coordinated, we contribute to the existing II literature on a topic that has general relevance. Previous research on inter-organizational systems (IOS), such as Electronic Data Interchange (EDI), also reported discrepancies of "control, consensus and cooperation" (Williams, 1997, p. 232) between different stakeholders (Webster, 1995; Spinardi et al., 1997). In general, II development seems to happen in contexts where agency is distributed, and where emergent and planned changes are mixed in "a complex and multi-determined system" (Edwards et al., 2007, p. i).

With this particular ambition in mind, we will focus on how the two healthcare projects, the B-EPR and the SEP projects, dealt with goals, design decisions and subsequent implementation strategies. The objective is to examine how gradual transitions of the installed base was (or was not) pursued, and how mobilization and organization of multiple stakeholders was (or was not) achieved.

## 3. Research methodology

### 3.1. Research setting

The empirical data stem from two case studies conducted in Denmark. Denmark potentially offers optimal conditions for national authorities to build a healthcare II consisting of interoperable EPR systems for several reasons. Denmark provides free public healthcare services to its relatively small population (5.5 million in 2009). Unlike the situation in the US, for example, where healthcare services are provisioned by multiple independent and private providers, the healthcare system in Denmark is predominantly public and government-controlled through comprehensive legislation, annual budgetary allocations, and governmental institutions. The Ministry of Health and Prevention directs healthcare services, and the responsibility for everyday operation of public healthcare services is divided between regions<sup>2</sup> and municipalities. The regions are responsible for running hospitals and for the general practitioners (GPs). The municipalities are in charge of public health, homecare nursing, school health service, rehabilitation, and the majority of social services. Government healthcare expenditures are higher than the per capita expenditure in other European countries, and well above the OECD average (Ministry of Health and Prevention, 2008). In 2006, the total expenditures on healthcare services amounted to 9.5% of the GDP, or an average of 3362 USD per capita (OECD, 2008). Over the last decade, the Danish government has initiated and sponsored significant initiatives to increase the digitization of its healthcare services. National healthcare digitization strategies have been published since 1996, and development and implementation of EPR systems has been high on the agenda.

Our study describes two Danish healthcare initiatives. The first case describes how, in 2000, the health authorities started to develop a national EPR standard called the "Basic Structure for EPR Systems", or the B-EPR model. The aim was to build a common standard that would facilitate information sharing between the different EPR systems used by Danish healthcare

<sup>2</sup> In 2007, a government reform was passed in Denmark which replaced 14 counties with 5 regions and reduced the number of municipalities from 275 to 98.

**Table 2**  
Data sources.

Data sources	Document titles
National digitization strategies	<ul style="list-style-type: none"> <li>– “Plan of Action for Electronic Patient Records”, Danish Ministry of Health 1996</li> <li>– “National Strategy for IT in Healthcare 2000–2002”, Ministry of the Interior and Health 1999</li> <li>– “National IT Strategy 2003–2007 for the Danish Healthcare Service”, Ministry of the Interior and Health 2003</li> <li>– “National Strategy for IT in healthcare 2008–2012”, <i>Digital Health 2007</i></li> </ul>
Regulations (legislation, financial arrangements, standards, etc.)	<ul style="list-style-type: none"> <li>– “The Economy of Counties 2005”, Economy Agreement between the Government and the Association of County Councils 2004</li> <li>– “Principles for Standardization and Diffusion of EPRs”, Ministry of Health, National Board of Health, County Council, and H:S 2002</li> </ul>
Evaluation studies	<ul style="list-style-type: none"> <li>– EPR Observatory status reports from 2000–2006</li> <li>– Evaluation reports of B-EPR implementations</li> <li>– Evaluation reports from SEP pilot projects</li> <li>– Evaluation of SEP solution (EPR Observatory)</li> <li>– Deloitte report 2007</li> </ul>
Public debate	<ul style="list-style-type: none"> <li>– Radio broadcast July 2008</li> <li>– Debates in: The Journal of the Danish Medical Association, Daily Medicine, Danish Nurses' Organization, Computer World</li> <li>– Websites: Digital Health, Ministry of Health and Prevention, Danish Nurses' Organization</li> </ul>
Conferences, seminars, workshops, meetings	<ul style="list-style-type: none"> <li>– “Electronic Health Record Observatory” conferences (attended in 2003, 2005, and 2006)</li> <li>– Workshop on Reform, Management and Organizational Processes in Healthcare, 2004</li> <li>– Scandinavian Conference on Health Informatics, 2005, 2009</li> </ul>
Interviews	<ul style="list-style-type: none"> <li>– A member of the EPR Observatory</li> <li>– A consultant who was involved in defining and developing the SEP model</li> </ul>

See Appendix 1 for complete references.

providers. However, while EPR systems today are widely used both in primary healthcare (approximately 100%) and in hospitals (around 60%), the B-EPR standardization did not succeed and the standard was in practice abandoned in 2005–2006. The B-EPR standard was initially presented as a communication standard, but drifted into a comprehensive information model requiring changes in the execution of documentation practices, replacement of existing EPR systems, and development of several new surrounding services and applications. Apart from small and partial pilot installations, no working software implementation was realized before the project was terminated.

The second case describes a small local project, also initiated in 2000, between a few county hospitals that wanted to share patient information. The initiative was called the “Standardized Extraction of Patient Information” (SEP) and was a pragmatic solution to exchange information between different EPR systems. A software module extracted a standardized dataset (according to the SEP standard) from the various hospitals' EPR and Patient Administrative Systems (PAS). A copy of this information was stored in an SEP database, and the information was accessible via a browser window. Today, SEP is included as ‘the e-record service’ in the national healthcare portal, *Sundhed.dk*, and provides a majority of hospitals, general practitioners, and citizens across Denmark with the possibility of accessing electronic health records.

In terms of our research interests, we describe the goals for the two projects, how the solutions were designed and how the projects were organized and managed. Our focus is to provide a factual background description, emphasizing the consequences and effects of each project's goals on its design and execution. We do not aim to offer a complete account of either project's progress; rather, the purpose of the case description is to contrast the two very different implementation strategies, with respect to how they dealt with installed base and with the need to mobilize and coordinate multiple stakeholders.

### 3.2. Sources of empirical material

Publicly available documents, most of which can be found on the Internet, and interviews have formed the basis for our reconstruction of the history of the Danish EPR standardization initiatives (see Table 2). First, we gathered governmental documents such as national digitization strategies, and descriptions of standards and regulations related to healthcare. In these documents, we mainly searched for the way standardization initiatives and interoperability issues were discussed, and what strategies were proposed. Second, we assembled and reviewed reports and evaluation studies on these standardization initiatives. These evaluations, which were mainly comprised by the EPR Observatory's annual status report, helped us in understanding the challenges encountered and results achieved. Third, we followed the public debate for a number of years, where politicians and other key stakeholders have commented on healthcare and IT-related issues in newspapers, radio, TV, and on the Internet. The public contributions served as a way of gaining an understanding of both the political issues as well as the organizational and technological challenges that were and are at stake with respect to EPR systems. Fourth, we attended conferences, seminars, and workshops on healthcare related issues over a number of years (since 1999), which exposed us to ongoing debates. Fifth, we interviewed two persons who had been involved in the projects.

One of them had been a member of the Danish EPR Observatory, and the other had played an active role as the architect of the SEP model. The purpose of the interviews was to get our case description verified, and ask additional questions about facts that we could not access from the other sources of information. Each interview lasted for an hour, was taped-recorded, and subsequently transcribed verbatim.

### 3.3. Analysis of empirical material

Our analysis of the data sources was guided by the research objective of studying the implementation strategies and the approaches to mobilization of multiple stakeholders. The analysis happened in consecutive stages, and through an iterative process of working with the material along with the theoretical resources to tease out insights. The first stage involved getting an overview of the large amount of written data material. In the second stage, we looked for answers to how the projects were handled and how the tasks were decomposed, sequenced, and prioritized. By continuously posing questions to our empirical material, we were able to re-construct the storyline, and add sufficient detail to the two cases. Our research objective was to examine the goals and the design consequences, and then to investigate how this had an impact on the implementation strategy, both with respect to installed base cultivation and stakeholder mobilization. The third stage involved a detailed write-up of the two projects, which is presented in the next section.

## 4. Towards a healthcare II in Denmark

The two projects both addressed the problems of non-integrated EPR systems in Denmark. However, each project approached it in radically different ways and experienced different outcomes.

### 4.1. Case study 1: the B-EPR project

#### 4.1.1. Strategic initiatives to build a national healthcare infrastructure in Denmark

In 1996, the Danish Ministry of Health published the *Action Plan for Electronic Patient Records* (Sundhedsministeriet, 1996), where the development of EPR systems was promoted through the Ministry's provision of financial as well as other support to local EPR implementation projects. As a result, several hospitals adopted EPR systems (Vingtoft et al., 2000). The subsequent national strategic document, *the National IT Strategy in Healthcare 2000–2002* (Sundhedsministeriet, 1999), went a step further in centralizing the coordination of the IT efforts by presenting a standardization of the content and structure of patient data in the EPR systems. The aim was to achieve standards that allowed for a transfer of data across systems, where interoperability between EPR systems became a core goal. In doing so, the Ministry of the Interior and Health laid out the groundwork for a basic structure of EPR systems, i.e. the B-EPR project. The National Board of Health was assigned a leading role in the development work, which was based on the conviction that a standardized data model was required to achieve a uniform structuring of content (Sundhedsministeriet, 1999, p. 6).

In 1999, a working group composed of healthcare personnel and computer scientists initiated the design of the B-EPR standard, and version 1.0 of the B-EPR standard was released in December 2001. In a joint declaration, signed in 2001, between the Ministry of the Interior and Health, the National Board of Health, the counties, and the Capital Area Health Organization, it was agreed that B-EPR should serve as a generic information model for clinical IS and constitute the national standard for EPR systems. According to a member of the EPR Observatory, there was strong political support for the strategic goals connected to B-EPR and it “became the flagship for the National Board of Health”. He also claimed that the goals of the initiative were expanded: “Initially B-EPR was sold as a communication standard, which means that you have different EPR systems that are aligned by a communication standard to exchange data. In the National Board of Health they became very ambitious and they considered requirements of data structure and data consistency to be important . . . so the communication standard turned into a system model.”

This orientation was partly dictated by another aim that had been an integral part of the B-EPR plans. The health authorities wanted to replace the existing national patient register, which since 1977 had collected data on patients' diagnoses (Sundhedsministeriet, 1999), with a new, process-oriented national patient register. This would allow for a better overview of results and performance by facilitating a longitudinal linking of events and encounters to standardized care pathways. Such a register would require more structured data in the EPR systems, including the standardization of clinical terminology and datasets, as well as a coupling of the information to the ongoing clinical process. This required a different type of EPR system than the existing so-called “1st generation” systems, where doctors and nurses wrote out documentation in separate parts of the system and the notes were organized chronologically in a document repository.

The B-EPR standard comprised a new data model based on a process view of clinical work. More precisely, the authorities pursued a problem-oriented structure that allowed for a grouping of information related to specific clinical events (i.e. diagnose, plan, implement, evaluate) and a process-orientation that allowed for a linking of information to longitudinal episodes of care, the clinical pathways (Vikkelsø, 2007). Other key objectives were to support cross-disciplinary documentation and cross-sector information sharing, as well as increase the structure of information in order to facilitate the re-use of information for clinical, statistical, planning, and research purposes. To comply with this data model, it required development from scratch of new EPR systems that would live up to the B-EPR standard. Most emphasis was directed towards the overall data

model, but by November 2002, UML specifications for the medication and imaging modules of the B-EPR had been defined. Further updates to version 1.0 of the standard were published both in 2003 and 2004. In *the National IT strategy 2003–2007 for the Danish healthcare service* (Ministry of the Interior and Health, 2003), the B-EPR was presented as a national project, and there was a requirement that all standard-compliant products (i.e., actual EPR systems) should be able to exchange patient record information. Both the counties and the health authorities agreed that a full scale implementation of the B-EPR standard across Denmark should be achieved by January 1, 2006.

#### 4.1.2. Testing and evaluating the B-EPR model

In 2004, pilot projects were conducted to test the B-EPR in three areas: an evaluation of the B-EPR prototypes, clinical validation of the basic model, and an information exchange test. Two companies had developed prototypes that were tested for their adherence to the standard in 41 use case scenarios. Both prototypes were found to show satisfactory adherence to the B-EPR standard (Nøhr et al., 2004), which was a pre-condition for the next step, the clinical validation. However, during the clinical validation, the prototypes were deemed too immature to be properly evaluated. Since no working prototype could be tested, the validation was conducted mainly as an assessment of change readiness in the hospitals, a comparison of the clinical staffs' opinions both before and after the trial in two departments at one hospital, combined with a questionnaire on usability (Vingtoft et al., 2005). In the third step, the exchange test, the standard's ability to facilitate interoperability was tested. However, even in the design of this test, the original goal of interoperability between systems was downplayed. Instead, the emphasis was on testing whether the B-EPR prototypes generated correct reports for the new national patient register (Bernstein et al., 2004; Bernstein and Bruun-Rasmussen, 2004).

The evaluation reports highlighted the clinicians' perceptions of and reactions to the new standard. While the clinicians voiced positive attitudes towards the idea of a standardized EPR system and its problem-oriented structure, they found the B-EPR model to be somewhat technically complex and stated that this way of working was not easily transferable to clinical practice. In one hospital, where B-EPR was tested, the conclusion by one of the doctors was: "We are still using the electronic record but the problem oriented documentation structure has been abandoned. We are happy about EPR ... but I cannot understand why they want us to continue using a conceptual model (B-EPR) which has been tested and which is problematic ... there is no enthusiasm for B-EPR" (clinician quoted in Olsen 2004, p. 59).

Certain skepticism toward B-EPR also seemed to emerge on a broader scale. The drift from a communication standard towards a comprehensive and radically new system model implied quite significant ramifications. This generated concerns, both in the counties and among the vendors; however, the climate did not favor open discussion about the desirability of the B-EPR. The SEP architect, who collaborated closely with the vendors in developing SEP, stated that "the vendors were very skeptical towards the B-EPR, but no one dared to say so."

During the development of the standard, it became evident that a new terminology was needed. It was argued that the International Statistical Classification of Diseases and Related Health Problems (ICD) and other national classification schemes were not sufficient for the requirements of B-EPR, and, in 2004, the HealthTerm project was initiated with the aim of translating the international Systematized Nomenclature of Medicine, Clinical Terms (SNOMED CT), to Danish.<sup>3</sup> The initial expectation was that the translation of SNOMED would be available within 2 years.

B-EPR version 2.1 was released by the end of 2004 and had been enhanced with respect to the insight gained from testing. The Ministry of Health invited a hearing, where vendors argued that the B-EPR model would place great demands on the systems developers, and that all of the new releases of the B-EPR standard were considered a challenge. The Board of Health was criticized for abandoning the original vision of interoperability, since the initial aim of securing an exchange of information between EPR systems seemed to have been replaced by an orientation on clinical documentation for the national patient register to facilitate the national health authority's overview of patient trajectories (Olsen, 2004). This critique was downplayed by the health authorities (Larsen, 2004), who argued that the purpose of giving the right person access to information at the right time was still maintained as the purpose of the B-EPR; what had changed was merely the technical approach to realizing it.

At the same time, the milestone originally specified in the national IT strategy for 2003–2007, which stated that "before the end of 2005, EPRs based on common standards must be implemented in all hospitals" (Ministry of the Interior and Health, 2003, p. 33), seemed impossible to achieve. It was modified by the County Council Union to be achieved "... as soon as possible after this date" (Amtsrådsforeningen, 2004, p. 11). The standardization work within the National Board of Health continued, and version 2.2 was released for a public hearing in May 2005, and accepted by the National EPR Standard Group on August 17, 2005. However, further development of the standard was frozen, allegedly to allow proposals from vendors and to initiate projects that could test version 2.2. The testing of this version never commenced and further development of the B-EPR standard stopped after this point. The work so far had consisted of specification of the standard decoupled from any technical realization, and according to the member of the EPR Observatory "it was not until 2004 that they realized that B-EPR was not something you throw to the vendors and then get a B-EPR compliant system". The actual B-EPR prototypes

<sup>3</sup> SNOMED is an electronic collection of medical terminology, which covers clinical information such as diseases, procedures, microorganisms, findings, and pharmaceuticals. It ensures a consistent way of indexing, storing, retrieving, and aggregating clinical data across specialties and sites of care. In being relevant to the B-EPR system, it helps organize the content of medical records, and thereby ensures consistency in the way data is captured, encoded, and used for the clinical care of patients and research.

that had been used in the pilot tests had been removed from the hospitals immediately after the tests, since “the prototypes were not solid enough to be used in the clinical settings” (member of the EPR Observatory).

In 2006 the EPR Observatory acknowledged that the development and implementation challenges were far greater than expected (Bernstein et al., 2006, p. 6). They concluded that technically the B-EPR prototypes could not live up to the requirements in practice and that the economic and clinical consequences were not taken into consideration (Rasmussen, 2007). They also criticized the “big bang approach” and the fact that the B-EPR standard was not compliant with existing systems. Consequently, the observatory recommended that the basic structure be put on hold until a new and better version was available. Similar conclusions were published in a report by the consulting company Deloitte (2007), which argued that a full-scale implementation of a B-EPR based system was not imminent in any of the pilot sites and that development work was not ongoing (p. 36). The current version had not yet been tested, and the development of a Danish healthcare terminology (HealthTerm) was not expected to be finished until 2010 (p. 40). Moreover, the municipalities were not interested in implementing B-EPR (p. 34), and the costs of pursuing this strategy were uncertain (p. 38). Deloitte recommended that the authorities consider alternatives to B-EPR based on international standards. The report questioned whether the B-EPR model was realizable at all. In the most recent national IT strategy (Digital Health, 2007), B-EPR was only mentioned in an appendix where the conclusion from the Deloitte report was repeated.

The standardization has had little effect on securing interoperability. Deloitte’s review uncovered 23 different and non-interoperable “EPR landscapes” across Denmark, i.e., combinations of core elements (modules) that comprised core clinical systems such as PAS and EPR. As a consequence, the Minister of Health decided to put the B-EPR development on hold. He approached the critics of B-EPR by arguing that “not even the international market can deliver a common solution” (Bang, 2007). The debate then shifted towards discussing a sector-wide, common architecture as an alternative approach.

#### 4.2. Case study 2: the SEP project

##### 4.2.1. The standardized extraction of patient information (SEP) project

A different initiative for addressing the interoperability challenges started in 2000, when the “Standardized Extraction of Patient Data” (SEP) solution was drafted and tested by two counties and three IT vendors. The idea behind the project was sketched by a consultant physician and former employee in the Danish National Board of Health. The purpose was to make electronically registered patient data available between hospitals within counties and across county boundaries in Denmark. The philosophy behind SEP was that, as hospital owners, it should be possible to make patient data registered in EPR systems, Patient Administrative Systems (PAS), and other hospital systems on currently and previously admitted patients available to other hospitals in the county.

In practice, predefined elements of patient data were extracted from existing PAS and EPR systems and structured according to a format defined by the SEP standard. The data elements were transferred using an XML standard to a SEP database that was shared between the cooperating hospitals. Through secure Internet access, an Internet browser made it possible for healthcare professionals to view selected patient information by searching on the patient’s civil registry number, and to record data. The database contained only textual information such as diagnoses, contacts, doctors’ notes, observations, requisitions, test results, medicine prescriptions, procedures, medicine administration, and personal information. Nursing notes, non-textual form information, and imaging information were not included. The SEP solution also allowed data extraction for analysis purposes.

The development of the SEP solution was based on an analysis of existing health information systems. The architect of the model made the following argument: “The counties had spent a lot of money to be in a leading position in the EPR area, and so had the three IT vendors. They were not interested in scrapping all existing systems that did not cohere with the B-EPR standard set up by the National Board of Health. They were interested in relying on what existed and then gradually working towards something in common. This is why I analyzed the existing systems to find common types of events that could represent all data. And I was able to come up with only 18–20 types . . . so even though there were big differences between the systems, there was a significant common core.” Thanks to the existence of the national patient register since 1977, central aspects of the information structure were quite similar across the different PAS and EPR systems. The SEP architect described how during a seminar in one of the counties where the SEP model was presented: “one supplier after the other stood up and said that this was a real practical solution which could be realized with a limited amount of resources and which would solve a big problem.” In a presentation of SEP at the EPR Observatory’s 2001 meeting, the graphical description of the combined conceptual model could be represented on one (readable) PowerPoint slide (Olsen, 2001).

##### 4.2.2. Testing and evaluating the SEP solution

One of the first pilot hospitals to test the SEP solution did not have a pediatric ward and consequently had to transfer some of its patients to the pediatric department (newborn children) and to the gynecological/obstetric department (pregnant women and new mothers) at another hospital. These were frequently emergency transfers, which meant that the paper documents sent with the patient were often incomplete. When the SEP solution was developed and a pilot version had been installed in the hospital, the receiving hospital was able to access data for the transferred patients from the EPR system at the hospital of origin in the SEP database. The pilot lasted for about a month and the prototype was kept in use after the pilot phase at the users’ request (SEP Evaluation report, 2002). Another pilot project involved two counties with information access requirements regarding concrete patient transfers between a thoracic surgery department at one hospital and an organ



surgery department and a medical/coronary department at two other hospitals. The pilot project ensured that all three hospitals had reading access to the patient record systems through the SEP database although they worked with different EPR systems. Apart from an update of the SEP database made by the secretary, the project did not require any changes in data registration and only few changes in work procedures. The users' evaluations were positive and also here the SEP solution continued to be used after the pilot period at the users' request (SEP Evaluation report, 2003, p. 23).

The users who were involved in the pilots emphasized that SEP was significant because it “makes it immediately possible to have an operational access to viewing and comparing data across the various information systems, including EPR systems, and thus it largely contributes to solving one of the most significant healthcare information problems [in terms of information sharing and data access]” (SEP Evaluation report 2003, p. 4). Few technical issues were mentioned in the assessment of the solution, and the evaluation group stated that “the data structure appears simple, logical and in accordance with common clinical practice” (SEP Evaluation report, 2002, p. 14).

The two counties financed the work with the SEP standard and the IT vendors were in charge of developing the software. The objective was not to develop an advanced model but rather a practical and simple solution to the perceived need of providing access to data in electronic record systems. It had been realized early that the immediate need was to access data and not to move data from one system to another. The conclusion by the member of the EPR Observatory was: “SEP is a practical, improvised solution in a situation where you have different systems that cannot communicate. It is not an ideal solution but it is a practical solution if the alternative is that you are not able to see the data.”

#### 4.2.3. Establishing the foundation for a national SEP project

The SEP model was not imposed on the counties, and there were no deadlines like in the B-EPR project; rather, it was offered to those hospitals that wanted to share and access patient data. Based on the successful pilot projects, the organization MedCom decided to establish a national SEP project to coordinate various aspects relating to SEP's further deployment. This included, e.g. rules for address allocation, distribution of the SEP XML standards, regulations for user and security administration, and the coordination of purchase processes (MedCom, 2003, p. 11). The objective of MedCom was to facilitate an expansion of the SEP solution as a potentially nation-wide solution. Despite this, the project was careful not to present itself as an alternative to the B-EPR. Instead, it was presented as a supplement, and a temporary transition solution for achieving the same thing during the transition period, and for those hospitals that had not yet procured any B-EPR system (Bruun-Rasmussen et al., 2003, p. 116; MedCom, 2003, p. 3).

During the spring of 2003, MedCom established a nation-wide secure healthcare intranet where county-wide intra networks were connected via a VPN connection to a national hub. This was meant for MedCom's core activity, i.e., electronic message exchange, but it also allowed the SEP users secure internet access to data on SEP servers. The implementation of SEP grew gradually and MedCom defined and refined a number of SEP specifications and guidelines on e.g. data content, communication requirements between SEP databases within and across counties, technical maintenance of SEP solutions, and classifications used when registering data. During 2004 another county had joined the two initial pilot counties, two other counties were close to joining and negotiations started with the remaining counties. In October 2004, MedCom stated in a newsletter that the SEP solution was technical reliable in several counties but that the process of educating users, establishing support organizations in each county, assigning user certification, and integrating the practical usage of SEP in the hospital's daily work routines still had to be settled (MedCom, 2004). By February 6, 2006, more than 1.25 million patients' records were uploaded, and on April 24, 2006 the two million records milestone was passed. In addition, not only hospitals could benefit from using SEP. In January 2007, a large number of general practitioners were given access, and at the same time, citizens of one county could access their patient information in what was called the e-record. Finally, in December 2008, the capital region (Copenhagen) as the last region adopted the SEP solution. By April 1st, 2009, an e-record existed for 4.3 million Danes. The actual degree of usage greatly varied, and was low in some places. In four out of five regions the coverage across both GPs and citizens was almost fully established, only some hospitals still were left to join. The technical infrastructure for a sector-wide sharing of patient record information had been established across Denmark.

## 5. Analysis

If we compare the goals of the two projects, we see an important difference in the level of ambition and scope. Table 3 provides an overview of the goals, rationale and implications of the two projects.

The B-EPR project was ambitious and broad in scope. It was supposed to deliver the specifications for a radically different EPR system for all actors in the Danish healthcare sector. The aim was broader than mere interoperability; the wishes of the National Board of Health on pathway-oriented structure and automated reporting to the government also greatly shaped the project. By comparison, the goals set up in the SEP project were more limited with the aim to solve a specific problem: the healthcare professionals' lack of access to patient information when patients were transferred between hospitals. Consequently, there was no ambition to address any needs beyond those of the current stakeholders of the project. The different ambitions and scope of the two projects naturally led to different approaches towards implementation. Next we analyze the implementation approach against the II design principles offered by Hanseth and Lytinen (2010) before we zoom in on stakeholder mobilization.

**Table 3**

Goals, rationale, and implications in the two projects.

Goals	Rationale	Implications
<i>B-EPR</i>		
Nation-wide interoperable EPR infrastructure	Allow information sharing for everyone	Involve all healthcare actors as stakeholders in the project
Second generation EPR systems, cross-disciplinary and problem-oriented	Improved tool for clinicians and improved quality of patient treatment	Replace all existing EPR systems; develop new applications according to standard
Pathway-oriented EPR	To feed structured data to the national patient register	Replace existing register with new; replace existing EPR systems
Replace free text with structured documentation	Facilitate reuse of data and reporting	Extend existing terminology with SNOMED; start translation project
Automated reporting to government	Efficiency	Reporting mechanisms to be defined and implemented
<i>SEP</i>		
Address lack on information sharing for patient transfers	Solve a significant practical problem by allowing clinicians reading access to patient information	Necessary to define the data elements that can be extracted from existing EPR systems and other systems and create a solution
Facilitate data analysis	Possibility to analyze all clinical data across systems; quality improvement; research purposes	Solution should allow e.g. the import of data into Excel

### 5.1. The design principles of the B-EPR project

If we compare the B-EPR project's approach to the design principles offered by the II theory, we see that the B-EPR standard failed to offer usefulness to its first users (design principle no. 1). No early wins of the B-EPR solution were obtained. While a single B-EPR module (e.g. the medication module) could have offered local use value, it would not have allowed full interoperability between EPR systems. With respect to design principle no. 2, we see that the B-EPR standard did not build upon and extend the installed base. Rather, it sought to introduce a new standard, and it was requested that existing systems that did not cohere to this standard be abandoned. The B-EPR project envisioned a radical change, not only of EPR systems, but also of the existing documentation practices. However, the project did not focus on designing a strategy to deal with this change, but expected an un-problematized "jump" to the new solution when it was finished. This amounts to a strategy that must be classified as "installed base hostile". In terms of persuasive tactics (principle no. 3), the B-EPR initiative had strong support from top managers and politicians, where national strategies and formal agreements were core mechanisms in the mobilization of actors. While tests of the B-EPR model were conducted, no actual solution was offered to the prospective users as part of the mobilization strategy.

The design principles no. 4 and 5 specify simple and modular solutions, so that the II is able to grow flexibly. In the case of B-EPR, rather than minimal and simple solutions, a comprehensive solution addressing multiple goals was specified. The B-EPR data model was comprehensive, and was decomposed into multiple functional components (modules). However, these were interdependent and tightly coupled with the generic data model and with each other. The B-EPR standard also did not build interfaces to existing IIs, but depended on additional components that had to be developed from scratch and to be compatible with the B-EPR, such as new EPR systems, new terminology, and a new patient register.

### 5.2. The design principles of the SEP project

Contrary to the B-EPR project, the SEP project seemed to have followed an approach compatible with the advice of [Hanseth and Lyytinen \(2010\)](#). The SEP solution was developed to address an urgent problem of data exchange between systems, which is in accordance with principle no. 1 of designing for direct usefulness. Furthermore, the SEP solution was designed so that it built upon existing installed bases (principle no. 2); it did not require the design and implementation of large, new support infrastructures. The SEP solution was designed to work with, rather than replace, the already existing data format standards and EPR systems. A communication infrastructure, representing a common core of data elements, which had been in use for two decades to generate reports to the national patient register, formed the point of departure for the SEP solution. This information was extracted from an EPR system using an export module that did not impact the EPR system itself. Thus, the solution did not require changes in the existing documentation practices, but rather offered the possibility of reading patient information from other hospitals through a web browser.

According to principle no. 3, the solution was designed with the aim of providing a direct use value combined with relatively low implementation costs. This facilitated persuasion and enrollment of the stakeholders, since it balanced their costs to a degree that was sufficient for engagement and investment. The SEP solution represented a small, add-on functionality, which constituted a low-cost development task for the vendors and a low-risk investment for the hospitals. In this way, the SEP solution lived up to the design principle no. 4 on making the IT capability as simple as possible. Principle no. 5 recommends modularization through layering and gateways. SEP was a limited solution, which later was encompassed as one out

**Table 4**

Comparison of the two projects based on II design principles.

Design principles	B-EPR	SEP
Design initially for direct usefulness	No, initially only some modules were defined, not support for the complete clinical process	Yes, a central aim was to solve immediate problem of information access
Build upon existing installed bases	No, radical redefinition of information model, documentation practices, and EPR applications	Yes, SEP built on existing “ <i>de facto</i> ” information model, existing practices, and existing PAS/EPR systems
Expand installed base by persuasive tactics to gain momentum	No, rather successive revisions of (incomplete) standard. Enrollment of actors primarily by formal means (national strategy formulation and formal agreements with counties) based on power and legitimacy	Yes, results from pilots convinced the participants for further adoption across counties. Same solution could be implemented in multiple sites
Make the IT capability as simple as possible	No, not a major goal. Comprehensive and new EPR standard was the goal; the technical elements were complex	Yes, the design of SEP was simple; a need for a extraction program and a shared SEP database
Modularize the II	No, integral solution despite design with decomposition into functional software modules. Required additions that were coupled to and interdependent with B-EPR (terminology, register)	Yes, the infrastructure is decomposed into separate local application, transport and service sub-infrastructures; loose couplings; gateways to connect local applications to SEP internet server

of several other technologies into the national healthcare portal, sundhed.dk (health.dk). Its design was centered on only one perceived problem, i.e. to exchange relevant information for specific patients. SEP was also modular in the sense that it did not require new service or transport infrastructures but was interfaced with the existing infrastructures.

Table 4 sums up the main differences between B-EPR and SEP with respect to the design principles.

### 5.3. The B-EPR project's approach to stakeholder mobilization

Table 5 provides an overview of the B-EPR initiative in terms of its activities, the actors involved, the organization of the work, and the approaches taken to move forward.

Most of the standard specification work was conducted solely by the team at the National Board of Health (NBoH), and the B-EPR standardization work mainly remained a “desk activity” until it was terminated. Moreover, the main focus was on specifying the overall, formal data model with its structures, concepts and relationships between data elements. This model defined how information in an EPR system should be organized, but did not specify how an EPR system should be constructed. This model-centered approach precluded actual mobilization of the other stakeholders as the process unfolded. The end users (hospitals) were not mobilized because any actual benefits for them depended on the vendors actually developing EPR systems that incorporated the standard. The vendors did not develop any complete B-EPR-based system, since the successive revisions of the standard made technical development risky. If the vendors should have followed the approach planned by the NBoH, they would have to put in development costs all along, without any guarantee of producing a commercially viable product. For them, the rational decision would be to wait for the final, complete version of the standard before they started to implement it. Similarly, the users did not want to scrap their working non-B-EPR systems before any alternatives were available on the market.

We are interested in examining what role modularity may play in solving these dilemmas. An evaluation report stated that “a core experience from the work on Electronic Patient Records thus far is that in practice it is difficult to realize large and ambitious goals in a few giant leaps” (Deloitte, 2007, p. 13). However, how should such a project be decomposed and modularized? The B-EPR project decomposed the big task into smaller tasks and developed specifications for domain-oriented software modules, starting with the medication module and the imaging module. These domains were practically significant, perceived to be more structured than many other clinical work tasks, and thus they constituted a good starting point. Still, a single module was not a standalone and self-contained entity; it was supposed to work with many other modules (most of which were unspecified and remained unimplemented) that together comprised the whole solution. Also all of

**Table 5**

The organization of work and approaches in the B-EPR project.

Activities	Actors involved	Organization of work	Approach
Definition of standard	Working group at the National Board of Health (NBoH)	Definition of information model and specification of functional modules	New, comprehensive information model
“Anchoring” standard	NBoH, broad group of stakeholders	NBoH inviting comments on successive versions of standards	Comments from public hearings incorporated in revised standard
Validating/testing standard	NBoH, vendors, seven pilot hospitals	Multiple pilots with partial implementations of information model	Assessment of partial solutions, pilots discontinued
Mobilizing actors	NBoH, counties	Publishing national strategies and formal agreements	Agreement to implement within short timeframes
Realization (planned)	Vendors, counties	(Planned) multiple independent implementations	Dropped by vendors and counties (no attempts to implement after pilots)

the models depended on the overall, generic data model. Moreover, even the entire envisioned B-EPR standard would not be self-contained, but required both a new national patient register and a new terminology, neither of which were trivial undertakings. While the single modules might have been usable within their domain, they would not have provided complete digitization of patient information within a ward, not to mention the desired general interoperability between different EPR systems. While exchanging only medicine information with another hospital may be useful, it may also be considered as a too small a benefit to warrant the scrapping of existing EPR systems with a broader functionality and larger use value locally. In fact, the full benefits of the new B-EPR infrastructure would be realized only when the standard had been implemented in actual software applications, all of the actors had implemented these new EPR systems, and the additional components of this whole II were fully functional (i.e., including the new terminology and the pathway-oriented patient register). In this perspective the design of B-EPR produced an “all-or-nothing” approach, which again necessitated a problematic degree of stakeholder mobilization. As no quick wins could be offered, the project relied on generating commitment to its future vision, both via stipulating future benefits, and by exerting political and managerial pressure through national strategies and formal agreements. Thus, the type of modularity pursued by the B-EPR project did not offer immediate use value and problem-solving capability, and it did not balance costs and benefits. The intermediate results and deliverables in the B-EPR project did not reward the stakeholders for their efforts and costs. Rather, its intermediate steps were of the sort that merely demanded more belief and additional investments from the involved stakeholders.

#### 5.4. The SEP project's approach to stakeholder mobilization

The SEP project's approach was pragmatic, smaller in scope and proved easier to implement. In Table 6, we provide an overview of the project.

The SEP system was an addition to the existing procedures and tools, and as such, the project could approach stakeholder mobilization differently from the B-EPR initiative. First, it did not require the same number of actors involved, as it initially included only the immediately concerned user departments, involved vendors and the consultant. Secondly, the approach did not require that the stakeholders took large risks. Since the SEP solution required that vendors developed only a small, add-on functionality to extract data from existing EPR systems, their development costs were small. Also for the hospitals, this was a low-risk investment, as the hospitals did not need to replace any of their existing systems, or change the users' clinical practices and documentation practices. The prototype tests provided proof that the SEP solution actually worked and offered immediate use value, which strengthened stakeholders' commitment. SEP structured the way the extracted data was stored in the database, but it did not impose any novel structure onto the pre-existing EPR systems, or the documentation practices, since it was based on the existing data structure. These systems already had to generate standardized reports to the national patient register, which had existed since the 1970s, and one effect of this was a quite comparable data structure across the various systems. Thus all EPR vendors were able to adapt to and utilize SEP with minor investments.

The way modularity was achieved in the SEP project was different from the B-EPR project, where the overall solution was decomposed into functional domain modules. The SEP solution was in itself a self-contained solution to one perceived core problem, i.e., lack of access to existing information about patients being transferred between hospitals. This problem was essentially similar in structure for any collaborating healthcare institution across the entire country, so that the SEP solution was generic and not specific to any discipline or type of work. Thus, the SEP solution could be replicated in just about any hospital department, which lowered the costs, risks and adoption barriers. Subsequently it could be used to provide access to patient record information also for general practitioners as well as citizens. We argue that this generic and self-contained nature of this solution facilitated both its initial realization, and also its further adoption and diffusion process. The adoption of the SEP solution was not an obligation, but rather an offer to the hospitals. It delivered immediate rather than future benefits, and as such, was an attractive investment for hospital owners. Moreover, a given actor's level of investment in the solution would be directly related to its use value, as perceived by that same actor; there was not the asymmetry between costs and benefits that is often seen in large-scale, infrastructural projects. Thus, no central mandate or pressure was required to fuel the process, and the process did not have to be strongly coordinated and managed. While the pilot trials were conducted within a given timeframe, the project seemed to subsequently have been managed by adjusting plans and actions to the pro-

**Table 6**

The organization of work and approaches in the SEP project.

Activities	Actors involved	Organization of work	Approach
Definition of standard	Consultant, two counties, three vendors	Consultant analyzed different vendors' EPR and PAS systems	Identify a common core of data elements, defining the SEP model
“Anchoring” standard	Consultant, vendors	Consultant specified, vendors commented	Adjustments to practical, technical and financial realities
Validating/testing standard	Consultant, two counties, vendors	County's EPR vendor implemented SEP solution in hospitals	Small, additional modules to existing EPR/PAS systems
Mobilizing actors	Vendors, counties	County-vendor collaboration	Voluntary decision to implement by county, purchase of solution from vendor
Realization	Vendors, counties, consultant	Vendors build prototypes	Prototypes in continued use, solution refined and later sold to other counties

gress in the field, rather than defining milestones and achievement goals up front. The growth was one of replication across multiple use sites, before the extension or addition to the solution. When the solution was taken further by MedCom on a national scale, other issues were resolved such as maintaining standards and databases, sharing of contract information, coordinating vendors, etc. The national extension of the SEP solution mobilized even more actors as GPs and Danish citizens could access their health data. Stakeholder mobilization around SEP could thus happen in a “self-driven” manner that did not require exercise of power.

## 6. Discussion

### 6.1. The initial approach shapes the implementation strategies

In the two case studies we examined the initial approach to realization of visions and how it shaped the subsequent implementation strategy. We examined two different cases with different approaches and implementation strategies. The B-EPR and the SEP initiatives were not equivalent, and they may not be directly comparable. However, with our focus on the mobilization of actors, they serve to illustrate crucial diversity in implementation strategies. The B-EPR followed an approach that required wide and long-term commitment from the stakeholders; however, it did not manage to achieve and maintain wide enough stakeholder mobilization over a sufficiently long period of time. The project was geared towards some collectively experienced (rather than specific and local) benefits in the future, and offered few tangible outputs along the way. Thus the choices made in the B-EPR project in themselves introduced considerable challenges related to stakeholder mobilization, which made the project vulnerable. SEP, on the other hand, worked with significantly reduced demands on stakeholder mobilization in its initial phase. This was partly due to the lower ambitions and smaller scope compared with the B-EPR project. Moreover, we argue, it was due to the kind of modularity of the SEP solution (a standalone, generic problem-solving component with standardized interfaces), which differed from that of the B-EPR project (functional modules within an integrated solution). The SEP solution delivered use value when it was implemented rather than merely promising future benefits in return for current investments. Moreover, it delivered use value to the implementers rather than to someone else; thus the challenges related to the asymmetry between investments and benefits could be avoided, and the benefits justified the investments made by the involved actors. In this way, SEP's modular design allowed an implementation strategy which did not require every potential stakeholder's participation, investment and commitment up front. This meant that the implementation and adoption of SEP could happen in a decoupled and independent manner, thereby exemplifying what we call a modular implementation strategy, which represents a way of organizing projects that seek to minimize the challenges related to stakeholder mobilization.

### 6.2. Modular implementation strategies

Previous research has emphasized how II development tends to happen as gradual transitions of the installed base (Monteiro, 1998). In this paper we argue that “cultivation of installed base” is vital, but that we in addition need to deal with the challenges of organizing, mobilizing and coordinating multiple independent stakeholders. When we propose the notion of “modular implementation strategies”, we seek to indicate the possibility to deliberately design implementation strategies with the aim of minimizing the challenges related to stakeholder mobilization. Within II research, the bootstrapping strategy (Hanseth and Aanestad, 2003) deals with this issue to some degree, as the strategy suggests how to organize the growth of IIs, how to select a starting point, design step-wise expansions, and define a suitable sequence of progress. The argument revolves around the strategic utilization of the self-reinforcing growth mechanisms of network technologies. We seek to formulate a similar, complementary logic here, with an orientation towards the challenges of enrolling and involving multiple stakeholders.

Our notion of modular implementation strategies implies extensions of the II design principles offered by Hanseth and Lyytinen (2010). On first view, the recommendation of modularity shares some similarities with that proposed by Hanseth and Lyytinen; however, we argue that the justification and the rationale are different. While Hanseth and Lyytinen recommend us to “modularize the II” (design principle no. 5), the role of modularity is limited to “accommodate the growing need for openness and heterogeneity in [the] future” (Ibid., p. 6), i.e. as a precautionary principle in order to avoid future lock-in into sub-optimal solutions or standards. Thus modularization is seen as a design principle that helps to address the “adaptability problem” of an II, related to growth, change or development of an II. We have here demonstrated its relevance also to the “bootstrap problem”. We argue that modular solutions, allowing modular implementation strategies may be crucial for an II to be realizable at all. Modular implementation strategies can bypass, or at least significantly reduce the challenges to stakeholder mobilization, such as the ones encountered by the B-EPR project, and can allow a decoupling of implementation activities, so that actors can adopt partial solutions relatively independently. While modularity is important for keeping an evolving II flexible and adaptable, we have shown that it is equally important when designing the initial solution in a “realizable” way. Thus we could argue that in order to adequately deal with “the bootstrap” challenge in a context of multiple stakeholders, the first three design principles could be complemented by a fourth: “seek appropriate modularity to ensure easy stakeholder mobilization”.

### 6.3. What is an appropriate modularity?

We see a connection between appropriate modularity and Hanseth and Lyytinen's first design principle: "design for direct usefulness". There is no doubt that ambitious and comprehensive solutions (like the B-EPR) can offer significant benefits to the users. The problem is often that these benefits are not immediately available and thus cannot be utilized in the process of stakeholder mobilization. We take "direct usefulness" to mean that benefits must be realizable within a short timeframe, and the benefits achieved must balance costs and investments to an acceptable degree for each stakeholder. The direct usefulness of the SEP solution was related to its ability to meet a specific need: it facilitated access to information about patients transferred between hospitals. The solution was centered on a perceived problem and offered a solution to this problem, and this motivated the participants sufficiently to realize the solution. We see a similar problem-centeredness if we look to the successful introduction of the Emergency Care Summary (ECS) records in Scotland. An evaluation of the ECS project emphasized its non-strategic origin, and concluded that the momentum in creating ECS came as an "opportunistic response to a change in the provision of OOH [Out-Of-Hours] primary care in Scotland" (Edwards, 2007, p. 2), rather than as a conscious, strategic effort to overcome the inefficiencies of information exchange.

If such a problem-centric approach addresses a generic problem, the solution can then be reused by many actors, which lowers costs and risks of realization. This would allow spread and growth through "persuasive tactics" (design principle no. 3). Moreover, with generic and reusable solutions, the actual adoption could happen in a decoupled and independent manner, as preferred by each stakeholder, instead of through a scheduled and coordinated process, which is more demanding. We argue that such qualities should be recognized as important when designing nation-wide health IIs. However, such a problem-centric solution would most often be partial, while a nation-wide II would require a comprehensive solution that addresses several problems and many stakeholders' needs. The individual solutions should then be able to interface with other partial solutions, like the SEP today is one element in the larger health portal.

In sum, we see these aspects of a modular solution having parallels to how modularization is utilized within software engineering. Software designers seek to create modules with a high degree of internal cohesiveness (highly integrated modules) and a low degree of external interdependencies or couplings (high autonomy of modules). Transposed from software engineering to IS project management, internal cohesiveness may parallel the problem-and-solution-centeredness and the tight coupling of costs and acquired benefits. Similarly, the principle of low degree of external dependencies may parallel the choice that a solution should work with the existing information infrastructure and to utilize standardized interfaces towards it, rather than require specially adapted solutions.

We argue that modular solutions allow modular implementation strategies, where the "persuasive tactics" (design principle no. 3) may be easier to deploy than for comprehensive, integrated solutions. A similar point is presented by Sahay et al. (2009), who argued that configurable technologies allow flexibility in an unstable implementation context. Hanseth and Lyytinen also indicate that IT capabilities differ, and that some may have lower adoption barriers than others (ibid., p. 10). We believe this is crucial, and we have here focused on the way a solution's modularity poses larger or smaller demands to the stakeholder mobilization. Some approaches and solution designs require the coordination of a large set of stakeholders, while other approaches and solution designs can work with a reduced set of stakeholders, and thus avoid a large part of these challenges. Consequently, the issue here may not be as much about a top-down or a bottom-up approach for building national healthcare IIs but rather a question about modularity vis-à-vis stakeholder mobilization.

In this view the concept of *stable intermediary form* introduced by Simon (1962) may be useful in the pursuit of such aspects and qualities. Simon argued that a naturally occurring complex system would exhibit a certain hierarchy, in the sense that there is a subdivision of its entities into several layers. He linked this observation to the claim that a system that exhibits hierarchy will evolve faster than a system that does not: "Complex systems will evolve from simple systems much more rapidly if there are stable intermediate forms than if there are not" (Simon 1962, p. 473). We are particularly interested in his observation that "a partial result that represents recognizable progress toward the goal, plays the role of a stable subassembly" and "the existence of stable intermediate forms exercise a powerful effect on the evolution of complex form" (ibid., p. 472). In the context of national healthcare IIs, an approach and a solution that offers some kind of "stable intermediary forms" may enable realization and implementation through stepwise growth, where stakeholders' costs and benefits are sufficiently balanced. We argue that it may be worthwhile to explore the notions of stable intermediary forms further along with the concept of modularity in an attempt to critically rethink implementation strategies.

Our study has been conducted within the Danish healthcare sector, but we argue that the findings have general validity and are relevant where IIs are developed in contexts without a clear line of command and with multiple independent stakeholders. We would like to encourage further research to investigate initiatives also in other national contexts, which differ in the way healthcare is organized and managed. Researchers may also seek to enhance, refine or challenge our findings in other sectors within as well as beyond the public domain.

## 7. Concluding remarks

In this paper, we have addressed the challenges of realizing nation-wide IIs for healthcare, where large-scale and long-term stakeholder mobilization is a core challenge. We believe that while a vision "can successfully kickstart an ambitious transformation [process] [...] realizing the vision, however, is likely to be an incremental and iterative process that unfolds

over many years" (Robertson et al., 2010, p. 11). We have presented two empirical case studies with different approaches to realizing these visions, and we have drawn on II theory to analyze implementation strategies. II theory advocates gradual transition strategies that start with the installed base. In addition, we have argued that the implementation strategy must deal with the multiple stakeholders and be able to mobilize and coordinate them. Based on our empirical analysis of the two case studies we propose the notion of a *modular implementation strategy*. Such a strategy, made possible by appropriate modularity of the solution, allows the implementation to be organized in a way that does not require wide-spread and long-term commitment from stakeholders initially. Solutions that provide immediate use value by offering generic solutions to perceived practical problems, balance the stakeholders' costs and benefits, and solve a problem with minimal external dependencies, can avoid some of the dilemmas often associated with large-scale IIs. The case studies illustrate the dangers of introducing too high requirements to stakeholder mobilization, and the notions of stable intermediary forms and modular transition strategies may help decision-makers to pursue other avenues when planning large-scale implementation projects.

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### Danish websites

- Centre for Health-telematics: <<http://www.cfst.dk/wm142478>>.
- Danish Institute for Health Services Research: <[http://www.dsi.dk/frz\\_about.htm](http://www.dsi.dk/frz_about.htm)>.
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- Digital Health: <<http://www.sdsd.dk/Default.aspx>>.
- Electronic Healthcare Record Observatory: <<http://www.epj-observatoriet.dk>>.
- MedCom: <<http://www.medcom.dk/wm109991>>.
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