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# NATIONAL INITIATIVES TO BUILD HEALTHCARE INFORMATION INFRASTRUCTURES

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# NATIONAL INITIATIVES TO BUILD HEALTHCARE INFORMATION INFRASTRUCTURES

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## Abstract

*Significant sums of money are invested in information systems (IS) initiatives in the healthcare sector all over the world. Most countries have implemented Electronic Patient Record (EPR) systems, which are clinical IS that support documentation of examination, treatment, and care of patients. EPR systems are expected to raise the quality of care, reduce medical errors, cut waiting time and render the operation of healthcare more effective. Many of the expected benefits from EPR systems hinge on their ability to facilitate information sharing between healthcare providers. Consequently, many governments and healthcare providers have formulated national strategies to achieve a fully integrated information infrastructure building on interoperable EPR systems. In this paper we describe how the health authorities in Denmark have attempted to achieve interoperability through standardization of EPR systems in the so-called B-EPR initiative (i.e. Basic Structure for EPR). The initiative eventually failed and we argue that the main reason for this was too high ambitions along three dimensions: the geographical reach, the functional scope, and the temporal span. We argue that a critical look at the ambition level and associated strategies may contribute to formulating more modest targets. It is worthwhile to focus on defining strategies that specify how small and manageable initiatives can be extended and built on.*

*Keywords: Electronic Patient Records, healthcare, information infrastructures, standardization, interoperability*

## **1 INTRODUCTION**

The significant sums of money invested in information systems (IS) initiatives in the healthcare sector all over the world are indicative of their perceived potential to improve healthcare services (Currie and Guah 2007; LeRouge et al. 2007). For instance, most countries attempt to replace paper-based patient records with electronic patient record (EPR) systems, which are clinical IS that support documentation of examination, treatment, and care of individual patients. EPR systems are expected to raise the quality of care, reduce medical errors, cut waiting time, and render the operation of healthcare providers more effective (Dick and Steen 1991).

Many of the expected benefits from EPR systems depend on their ability to facilitate information sharing between healthcare providers. Consequently many governments and healthcare providers have formulated national strategies to achieve a fully integrated healthcare infrastructure building on interoperable EPR systems. However, when EPR development and implementation extend beyond a local setting and when the use of EPR exceeds typical support for daily clinical work, additional concerns arise; most of them related to standardization (Bjørn et al. 2009). For example, the implementation of coding schemes to achieve structured data entry represents interests of actors beyond the immediate context of use and creates tensions that need to be negotiated in the local clinical work practices (Winthereik 2003). Achieving collaboration between diverse actors requires striking a balance between producing meaningful information for the other party and not producing additional work (Winthereik and Vikkelsø 2005). It is crucial, but challenging to establish standards that succeed in striking a pragmatic balance between these diverse interests (Rolland and Monteiro 2002).

In this paper we focus on the challenges that emerge when attempts are made to implement, standardize, and govern EPR systems across multiple healthcare organizations. We present a case study of the quest for interoperable EPR systems in Denmark. Here the health authorities attempted to implement national EPR standards to facilitate information sharing between the different EPR systems used by healthcare providers on a national scale. As Denmark is relatively small and has a publicly managed and centralized healthcare sector, the conditions for achieving these aims appeared to be favorable. However, our findings show that the Danish health authorities did not achieve their initial goals and finally had to abandon the project. While EPR systems are widely used both in primary healthcare (approximately 100%) and in hospitals (60%) in Denmark, the standardization objectives were not achieved as planned, neither were the original visions of interoperable EPR systems realized. Our investigation highlights the challenges that characterized the standardization process. Based on the findings we propose a framework that identifies the challenges for standardization which stem from three different sources: the geographic reach of the standardization effort, its functional scope and its temporal span. This framework is useful as a conceptual tool for analyzing standardization approaches with respect to their ambition levels.

In the next section, we review relevant literature that offers conceptualizations of EPR systems and which emphasizes how technology is embedded in its context of use and the multiplicity of its interconnected components. We then describe the research methodology and present the case study of the Danish B-EPR initiative. Based on the empirical findings and existing literature we formulate a framework for discussing the complexity of EPR information infrastructures along three dimensions: geographical reach, functional scope and temporal span. Finally we present the implications for IS in healthcare.

## **2 THEORETICAL PERSPECTIVE ON INTEROPERABILITY**

In this section we draw on the information infrastructure perspective (Hanseth and Lyytinen 2004; Star and Ruhleder 1996) to address the challenges that arise when achieving interoperable EPR systems. This perspective allows us to address the challenges associated with systems that extend beyond a local context and serves multiple communities with different interests simultaneously.

## **2.1 The concept of information infrastructures**

The term infrastructure refers to any substructure or underlying system. It denotes the “basic physical and organizational structures (e.g. buildings, roads, power supplies) needed for the operation of a society or enterprise” (Oxford dictionary). According to Star and Ruhleder (1996) an infrastructure signifies “something upon which something else runs or operates” (p. 112).

In the IS field, information infrastructures have received considerable attention in the context of large-scale enterprise systems (Ciborra 2000), networks, and databases (Bowker 2005). In some IS literature, infrastructures are conceived primarily as large conglomerations of technological components and human skills that combine to serve the corporate needs of an organization (Broadbent et al. 1999). This concept emphasizes the standardization of systems and platforms and focuses on the material features of technologies such as connectivity and interoperability (Duncan 1995). Alternatively, some researchers have argued that information infrastructures extend beyond materiality and human skills to encompass social, organizational, and moral elements (Ciborra 2000; Hanseth and Lyytinen 2004, Star and Ruhleder 1996). We build on these studies and conceptualize information infrastructure as a system of standardized practices and modes of communication that emerge in relation to a particular set of IT artifacts within a community (Gal 2007).

Observing EPR systems from an information infrastructure perspective illuminates the intricate ties of EPR systems to a diverse set of socio-technical components such as other information systems, paper forms, medical equipment, organizational practices, personal skills, professional norms, and legal and industry regulations (Berg 1999). For instance, an EPR system may draw on patient demographic data from the Patient Administrative System and laboratory results from the laboratories' internal production systems. An EPR system in-use is entwined with the daily working processes in a hospital ward and constitutes a salient element in the standardized practices and modes of communication related to clinical work (Svenningsen 2002).

The development of work practices and communication modes in relation to an EPR system may differ across various departments and different groups of clinical and non-clinical personnel such as physicians, managers and researchers (Østerlund 2002). These groups will interact differently with the system, use it for different purposes, and process different information with it. This diversity brings to the fore the inherent tension in the development and operation of large-scale information infrastructures: the need to accommodate multiple local use patterns while maintaining inter-site functionality, operability, and standardization (Bjørn et al. 2009).

## **2.2 Standardization issues in the healthcare sector**

As noted, an information infrastructure is not restricted to a single local context and is used by more than one community. When attempting to make EPR systems interoperable across the healthcare sector a crucial challenge is to facilitate information sharing and collaboration across heterogeneous professional communities (Bjørn et al. 2009). This makes standardization a critical issue. The various standards that are defined by professional, managerial and legal authorities impact local work practices and communication modes but nevertheless need to be integrated in order for wide-scale collaboration and exchange of information to take place. For instance, classification systems that are defined by professional societies on a national or even international scale are often incorporated into EPR systems. These classification systems are expected to inform the activities of diverse user communities whose established practices and categorization system may differ significantly. This often creates tensions that need to be managed and balanced both when standards are developed (Markus et al. 2006) and when they are implemented (Rolland and Monteiro 2002; Timmermans and Berg 1997). Therefore standardization requires balancing the tensions between central uniformity of categories, information structure, and practices on the one hand, and local autonomy on the other.

The tension between global and local issues (Vaast and Walsham 2009) vividly plays out in the context of the implementation and use of EPR systems. For instance, one may think of multiple local EPR applications which properly serve the needs of multiple communities. The diversity of applications, work routines and usage patterns across sites does not constitute a problem in itself but

becomes a problem only when the sites are requested to interoperate and exchange information. The vision of interoperable EPR systems thus spurs the need for the standardization of data formats and information models. Moreover, as the use of interoperable EPR systems extend beyond a single local context, it will require the establishment of additional information infrastructure resources such as address registers, technical infrastructures (networks, message servers, etc.), adequate security mechanisms, and financial incentive mechanisms. Thus the attempt to realize this is far more complex than decoupled hospital-internal EPR systems. On the other hand, a network of interoperable EPR systems is also more attractive and useful than just a collection of isolated local EPR systems. In this case it is thus relevant to conceptualize standardization as revolving around the need to strike a balance between increased risks of failure and benefits that comes with increased ambitions or scope of the initiative.

Increased complexity of an ambition does not imply that it is impossible to realize in practice. A well-working global standard that has proved robust enough to survive for over 100 years and to serve a host of different interests across the globe is the WHO's classification scheme ICD – The International Classification of Diseases and Related Health Problems. Bowker and Leigh Star have studied the emergence of the classification scheme and emphasize how it since its inception has dealt with multiple tensions which have not always been resolved but contained through various pragmatic means (Bowker and Star 1994; 1999). A sensible amount of granularity has been defined based on experience along the way, and appropriate “garbage categories” have been included. The ICD is partly a nomenclature (i.e. merely a list giving no causal explanations) and partly a classification (built on a model of linking causes and effects). A mixture of organizing principles is employed, e.g. topological, aetiological, and operational (Bowker and Star 1994, p. 200). Modifications and production of different parallel lists (e.g. within a country) are allowed in a regulated way. The study of the ICD suggests that in order to achieve solutions to standardization of complex problem domains we may have to focus on formulating such pragmatic, composite, and modular approaches; processes that by necessity will take time – the ICD was developed over a period of more than 100 years. These points should also be relevant to the standardization of EPR systems, which are even more complex artifacts than a classification scheme. The question then is how to deal with complexity in information infrastructures such as EPR systems.

Interoperable EPR systems imply the inclusion of multiple usages and actors. When the number of actors or usages increases, the associated complexity of the standardization process is also likely to increase. This comes with increased risks of failure, but also with increased potential for benefits if success is achieved. The large-scale standardization, that establishing interoperable EPR systems entails, requires dealing with challenges such as diversity in local usages, variety between different types of usage, and gradual evolution of information infrastructures (Monteiro and Hanseth 1995). As presented later, we use the terms *geographical reach*, *functional scope* and *temporal span* to discuss these challenges. There are inherent tensions associated with these challenges, where the associated risks of failure and rewards need to be balanced.

In the following sections we present data from a longitudinal case study that describes how health authorities in Denmark have approached the standardization of EPR systems in order to achieve interoperability.

### **3 RESEARCH DESIGN**

#### **3.1 Research setting**

Denmark can be considered as a “critical case” (Flyvbjerg 2006) to investigate the conditions for national authorities to build a healthcare information infrastructure consisting of interoperable EPR systems. Denmark provides free public healthcare services to its relatively small population (5.5 million in 2009). Unlike the situation in e.g. the US 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 the public healthcare services is divided between regions<sup>1</sup> and municipalities. The regions are responsible for the running of hospitals and for the general practitioners (GPs). The municipalities are in charge of public health, homecare nursing, school health service, rehabilitation as well as the majority of social services.

The governmental healthcare expenditure in Denmark per capita is well above the OECD average (Ministry of Health and Prevention 2008). In 2006 the total expenditure 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 introduced significant initiatives to increase the digitization of its healthcare services.

The case study describes how the health authorities in 2000 started to develop a national EPR standard called the “Basic Structure for EPR systems” (i.e. the B-EPR model). The aim was to build a common standard that would facilitate information sharing between the different EPR systems used by the Danish healthcare providers. However, it turned out that the B-EPR standardization did not succeed and the standard was, in practice, abandoned in 2006.

In the case description, we describe the goals and strategies set up for the project, we look at how it was organized and managed, and we give an account of the main actions. With respect to our research interests, our focus is to provide a factual background description, emphasizing the consequences and effects of the project design and execution.

### **3.2 Data sources**

We have mainly used publicly available documents (most of them available on the Internet) to form the basis for our reconstruction of the Danish B-EPR initiative. In addition, we have interviewed relevant stakeholders who were able to clarify certain aspects and to verify our initial case description.

*First*, we gathered governmental documents such as national digitization strategies, descriptions of the standards, and regulations related to healthcare. In these documents, we primarily searched for the way standardization initiatives and interoperability issues were discussed and which strategies were proposed.

*Second*, we reviewed reports and evaluation studies on these standardization initiatives. Especially the Danish EPR Observatory’s annual status reports were valuable in understanding challenges encountered and results achieved over the years.

*Third*, we followed the public debate 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 to get an understanding of the political issues as well as 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 (from 1999 to present date), which gave a good understanding of the ongoing debates.

*Fifth*, we interviewed two persons who had been involved in the project. One of them had been member of the EPR Observatory, and the other had played an active role as consultant in the development of an alternative model. The purpose of the interviews was to get our case description verified and to 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 transcribed verbatim.

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<sup>1</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.

## **4 CASE DESCRIPTION: TOWARDS A DANISH HEALTHCARE INFORMATION INFRASTRUCTURE**

The first strategic attempts to organize EPR systems implementation in the Danish healthcare sector were outlined in an Action Plan for Electronic Patient Records published by the Danish Ministry of Health in 1996 (Sundhedsministeriet 1996). The strategy was to promote, stimulate, and coordinate the development of EPR systems in Danish hospitals. The action plan also aimed at establishing coherence and interoperability between the EPR systems and the multiple local systems that had been in use in the Danish healthcare sector since the 1970s (e.g., patient administrative systems, laboratory systems, and picture archiving and communication systems) through a gradual process of standardization. Based on this initiative, 13 Danish hospitals started to implement EPR systems. Many of the systems were “1st generation EPR systems” (Vingtoft et al. 2000), which were labelled and characterized by a mono-disciplinary documentation of patient data where doctors and nurses would document in separate parts of the system and where the notes would be organized chronologically.

In 1999 the National IT Strategy in Healthcare for 2000-2002 was published (Sundhedsministeriet 1999). This strategy outlined a number of standardization initiatives with respect to the content and structure of patient data in the EPR systems, and introduced communication standards to transfer data across systems. In this strategy the health authorities suggested to introduce a pathway-based national patient register to obtain a better overview. Such a register would require more structured data in the EPR systems, including standardization of clinical terminology and data sets as well as different clinical pathways. With a strong conviction that a standardized data model was required to achieve uniform structuring of content (Sundhedsministeriet 1999, p.6), the Ministry of the Interior and Health laid the ground for a basic structure for EPR systems – i.e. the B-EPR project – and the National Board of Health was assigned a leading role in the development work.

In 1999 a working group initiated the design of the B-EPR standard. Version 0.1 was released for a public hearing in April 2000 among representatives from the counties, vendors, professional organizations, and staff at hospitals. This version was updated to 0.2 and was tested at a Danish hospital during 2001. There was strong political support and in 2001 it was agreed that B-EPR should serve as a generic information model for clinical IS and constitute the national standard for EPR systems.

The visions of the B-EPR added up to a quite radically different type of EPR system than the existing “1st generation” systems. An important goal was to obtain more well-structured data by pursuing a problem-oriented structure that allowed grouping of information related to specific clinical events rather than the existing chronologically oriented, non-structured document repository (Vikkelsø 2007). The problem-oriented structure centered on four fundamental steps of the clinical process: diagnostic consideration, planning, execution, and evaluation. Other objectives were to support cross-disciplinary documentation, cross-sector information sharing, to link information to longitudinal episodes of care, and to facilitate re-use of data for clinical, statistical, planning, and research purposes.

A larger revision of the B-EPR system resulted in version 1.0 to be tested in December 2001. By November 2002, UML specification for the medication and imaging modules of the B-EPR had been defined. Further updates to version 1.0 were published and in June 2003 clinical trial projects were initiated in seven counties in order to provide input to further development (Hvidberg and Tvede 2003). At the same time, the National IT strategy 2003-2007 for the Danish healthcare service (Ministry of the Interior and Health 2003) was published. In this document, the B-EPR was presented as a national project. The counties and the health authorities agreed that a full scale implementation of the B-EPR standard across Denmark should be achieved by January 1st 2006. The national project should work along three lines: a) develop a prototype (in practice XML schemas for exchange and functional prototype with database, i.e. a test system with user interface), b) perform clinical testing, and c) provide implementation support.

In 2004, pilot projects were conducted to test the B-EPR in seven hospitals on three areas: evaluation of the B-EPR prototypes, exchange test, and clinical validation. Two of the prototypes were tested for

their adherence to the standard in a “desk test” and both were found to show satisfactory adherence to the B-EPR standard. The clinical validation was then performed as an assessment of change readiness before and after the trial in two departments at one hospital, combined with a questionnaire on usability (Vingtoft et al. 2005). The report concluded that the clinical usability had been unsatisfactory due to the premature stage of the development, and consequently found that the basic model’s feasibility could not really be assessed. In the third test, the standard’s ability to facilitate interoperability was tested. Initially the plan was to test whether a complete EPR record, as well as parts of it, could be exchanged between two B-EPR prototypes. However, in the evaluation report it was stated that: “After starting the B-EPR project it was agreed that the evaluation of exchange should only comprise explicit and implicit reporting of data from the prototypes in the main projects (Amager Hospital and Aarhus Amt) to F-LPR” (Bernstein et al. 2004, p. 5). The F-LPR (Forløbs-baseret LandsPatientRegister) refers to the pathway-oriented national patient register as mentioned above. The report stated that the test was considerably more difficult than expected and the Ministry of Health asked for a more in-depth evaluation report (Bernstein and Bruun-Rasmussen 2004).

The evaluation reports also highlighted the clinicians’ perceptions of and reactions to the new standard. They found the B-EPR model to be technical complex and that the standard was not easily transferable to a clinical practice. A former doctor argued: “We are still using the electronic record but the problem oriented documentation structure is 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.” Certain scepticism against B-EPR also appeared on a broader scale. A member of the EPR Observatory mentioned: “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 was a change with quite significant ramifications, and it generated some opposition, both in the counties and with the vendors.

In parallel with the clinical trials, the development of the standard itself continued. A consolidated version 2.0 was published in March 2004, with the same core as before but with more extended functionality. Simultaneously with the progression of the standardization, the necessity of a new terminology had become evident. It was argued that the current ICD and other national classification schemes were not sufficient for the needs of B-EPR, and in 2004 the HealthTerm project was initiated with the aim to translate the international Systematized Nomenclature of Medicine – Clinical Terms (SNOMED CT) to Danish<sup>2</sup>. The initial expectations were that the translation of SNOMED would be available within two years.

B-EPR version 2.1 was released by the end of 2004 and had been enhanced with respect to the insight gained from the testing, especially in facilitating reporting to the national pathway-oriented patient register. Early in December 2004, the Ministry of Health invited a hearing about version 2.1 and the resulting comments as well as the test results were used to further develop of the standard. Version 2.2 from 2005 incorporated many of the change suggestions both from the experiences in the pilot projects and the hearings, including a certain simplification of the standard. Version 2.2 was released for a public hearing in May 2005 and accepted by the National EPR Standard Group. Further development of the standard was frozen to allow requests for proposals from vendors to be issued and to initiate projects that could test version 2.2. However, testing of this version never commenced and further development of the B-EPR standard stopped after this point. The B-EPR applications that had been used in the pilot tests had already been removed from the hospitals, since “the prototypes were not solid enough to be used in the clinical settings” (member of the EPR Observatory).

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<sup>2</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 to index, store, retrieve, and aggregate clinical data across specialties and sites of care. Relevant to the B-EPR system, it helps organizing the content of medical records and thereby ensures consistency in the way data is captured, encoded and used for clinical care of patients and research.



In a hearing about the B-EPR version 2.1 in 2004, some challenges were mentioned, particularly from vendors who argued that the B-EPR model would put too large demands on the systems developers. Also a report published by a doctor (Olsen 2004) was explicitly critical towards the standard, arguing that the common structure in B-EPR was not easily transferable to clinical work practices, as it would require substantial changes of the registration of data and the structure of the records. Healthcare professionals would be subject to more structured registration practices with an increased use of standard texts and codes. They could see no immediate benefits. It was also criticized that healthcare professionals as such were not consulted when developing the B-EPR standard.

The National Board of Health was criticized for being too ambitious: “With the B-EPR, the National Board of Health has chosen to implement a problem-oriented approach in a very complex, rigid, and dogmatic way where every department has to register everything in its detail from day one without considering local needs and practical solutions” (Olsen 2004, p. 18). Moreover, the Board of Health was criticized for abandoning the original vision of interoperability. One concrete point of critique was that the initial aim and output of securing exchange of information between EPR systems seemed to have been downplayed and replaced by an orientation on clinical documentation to the national patient register to facilitate national authorities’ overview over patient trajectories (ibid. pp. 41-42).

The goal set out in the national IT strategy for 2003-2007 stating 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 “... or as soon as possible after this date” (Amtsrådsforeningen 2004, p. 11). Also the EPR Observatory acknowledged that the development and implementation challenges were far larger than expected (Bernstein et al. 2006, p. 6). They concluded that the B-EPR was technically immature 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 was put on hold until a new and better version was available.

In 2007 the consulting company Deloitte (2007) published a report which concluded that a full-scale implementation of any 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 was not yet 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 should consider alternatives to B-EPR based on international standards. The report questioned whether the B-EPR model was realizable at all and stated that the costs were uncertain. In the most recent national IT strategy (Digital Health 2007) the B-EPR was only mentioned in an appendix.

The standardization had had little effect on securing interoperability. Across Denmark the review uncovered 23 different and non-interoperable “EPR landscapes”, i.e. combinations of core elements (modules) that comprised core clinical systems. As a consequence the Minister for Health decided to put the B-EPR development on hold.

## **5 LEARNING FROM THE B-EPR INITIATIVE**

The above account describes how the Danish health authorities attempted to develop and implement the B-EPR model and how they eventually had to give up the initiative. In hindsight it appears appropriate to say that the visions were too ambitious and unrealisable. The Deloitte report stated that “a central experience from the former work with electronic patient record systems is that it in practice it is difficult to realize large and ambitious goals in a few big steps” (Deloitte 2007, p.13). This statement was repeated in the current Danish national strategy from 2007. We argue that this is a core issue and that being able to learn from such experiences is crucial for healthcare IT. Thus we present a framework that can help to disentangle the aspects of the story along three dimensions: geographical reach, functional scope, and temporal span.

## 5.1 Geographical reach, functional scope, and temporal span

We propose that in general the challenges associated with large-scale information infrastructures are related to the ambitions of the initiative with respect to at least three dimensions: *the geographical reach* of the initiative, *the functional scope* as well as *the temporal span*.

The number of actors involved and thus the *geographical reach* of the information infrastructure: the larger an information infrastructure, the larger are the potential benefits (economies of scale, market size, etc.). However, the diversity between the actors augments as a growing number of “local” practices are brought into play and need to adapt the infrastructure (Vaast and Walsham 2009).

The coverage of different use areas and thus the *functional scope* of the information infrastructure: a wide and generic application that serves many usages has a higher value/potential market than an application specifically targeted for a smaller user group and a defined set of usages. However, with increased scope of functionality the complexity of the application also increases, related to the potential for interdependencies between modules and “internal conflicts and tensions”.

The gradual and incremental development and thus the *temporal span* of the information infrastructure: radical breaks with the past may be more appealing, but also more difficult than small extensions of the existing. A radically novel vision may be what is wanted; however, due to the composite nature of information infrastructures many interconnected elements may have to change (technologies, legislations, markets etc.). Changes in information infrastructures are therefore often slow and incremental, consisting of ad-hoc additions and improvements to the existing installed base (Ciborra 2000; Hanseth and Lyytinen 2004). Thus a vision that implies a radical change may not be realizable at the required point in time, since it is beyond the reach of the single actor/initiator. In contrast, for small and incremental changes, the required functionality, additional components, skills etc. may be more easily achieved or already available within the context. The timeframe for infrastructural change processes is thus usually longer than that for many conventional and delimited IS projects. Nevertheless, attempts are typically made to set specific time limits for any change process to curb the expenditure of organizational and financial resources.

When the number of actors involved (the geographical reach) increases, usually the diversity that needs to be accommodated also increases. Similarly, if the initiative is to cover many different use areas (i.e. increase the functional scope) the complexity of the resulting application (which serves many usages) also increases, for instance related to the potential for interdependencies or mismatches between modules. The concept of temporal span relates to the timeframe of the initiatives as well as their degree of radical (as opposed to incremental) change. Radical breaks with the past and quick changes are more difficult than small and/or slow changes of the existing information infrastructure.

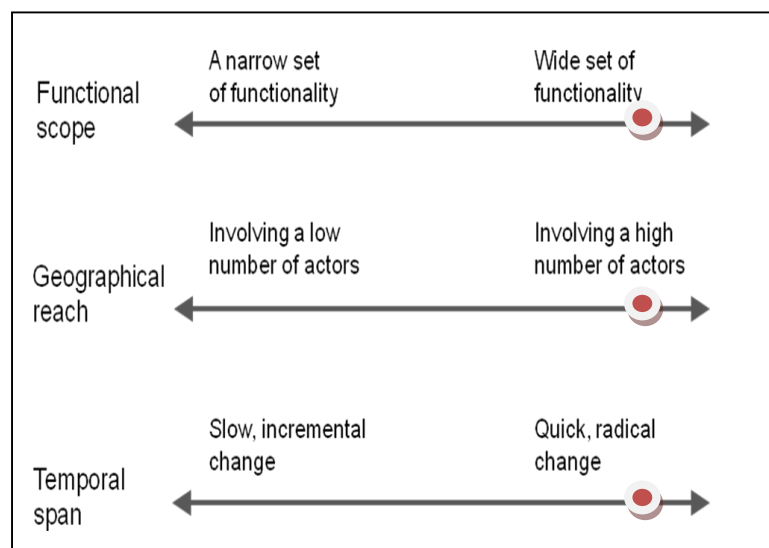


Figure 1. Three dimensions of complexity

As illustrated in figure 1, we argue that when the types of usage (functional scope) and the number of actors (geographical reach) increase along with far-reaching visions for change (temporal span), the associated complexity of the undertaking also increases.

## 5.2 An analysis of the Danish B-EPR initiative along the three dimensions

The ambitions in the B-EPR project were high along all three dimensions (as we have illustrated in figure 1 above). The *functional scope* of the initiative was broad as it sought to address many aspects simultaneously. The commitment to a process-oriented and problem-based organization of patient records entailed changes along two lines. Firstly, clinical staff was required to change their work practices with respect to documentation, i.e. from a free-text to a structured mode of data entry. The increased work load in the clinical practice was a major issue in the critique against B-EPR (although this aspect has not been specifically emphasised in this paper). The healthcare professionals experienced that they had to document much more in the system and that it required an increased administrative burden on them. The core problem with the B-EPR was that it did not produce any partial results that gave the stakeholders immediate rewards for their efforts and costs.

Secondly, the technology had to be developed to support this new mode of information organization and presentation, and defining a generic architectural model was only part of the required task. For instance the need for a structured clinical terminology became apparent, and the current terminology was deemed inadequate – thus the SNOMED project was initiated. Moreover, legitimating the F-LPR project was also closely linked to the B-EPR project, where the process-oriented record systems would generate process data.

Another consequence of the ambitious coverage was the need to decompose the actual design and development into smaller sub-projects that should focus on separate parts. However, this introduced additional complexity related to handling the interdependencies between these different modules.

Also the project's *geographical reach* in terms of future users was rather wide as it aimed to define the patient record for both primary healthcare and the hospital sector across the whole country. This meant that a large number and a diversity of local practices were supposed to be covered by the solution. The actual development has shown that the municipalities did not want to implement a B-EPR system, and also that other hospitals' EPR implementation projects have occurred somewhat decoupled from the authorities' strategic focus on B-EPR. Particularly after the regional reform in 2007 other rationalities have been seen to influence the processes of EPR procurement.

With respect to the *temporal span* of the initiative, the attempt was also highly optimistic. Radical changes were expected within a short timeframe, without much attention towards specifying the intermediate steps. For instance, when the SNOMED project was initiated in May 2005 the expected timeframe was one of 2-2.5 years; however, by 2008 it is not expected to be finished before 2010. The ambitions that all Danish hospitals should have EPR systems before 2006 were also modified.

## 6 DISCUSSION AND CONCLUSION

In this paper we have addressed the challenges of standardization for interoperability when engaging in information infrastructure initiatives. We argue that a critical look at the ambition level and associated complexity of strategies may contribute to formulating more modest targets, both with respect to geographical reach, functional scope, and temporal span. Moreover, we believe it is worthwhile to focus on defining strategies that specify how small and manageable initiatives can be extended and built on.

When building or changing large-scale information infrastructures, the transition process from the existing to the future state is of crucial importance (Monteiro 1998). It is not enough to define the goal and start the requirement specification. The goal description needs to be connected to the existing information infrastructure, and a realistic growth strategy that aims at increasing complexity only in manageable "chunks" at a time must be formulated. Minimizing complexity necessitates that changes are realized in small steps. Hanseth and Lyytinen (2010) argue that design principles for information

infrastructures should build on usefulness for the users and rely upon existing installed bases. The B-EPR case shows that the initiative failed on these dimensions as it was too ambitious and radical.

Perhaps an initiative should only move along one of the dimensions at a time, e.g. either extend the functional scope within the existing user base, or to implement the existing and available functionality in a wider user community before extending the functionality. Which of these choices are optimal we believe is an empirical question. Too high ambitions and aiming for geographical reach, functional scope, and radical changes at once will only imply too much complexity and will run a higher risk of failing. It is important to distinguish between what is realizable in the short and long term and to separate and select the orientation of the initiatives in order to reduce complexity as much as possible.

In the context of information infrastructures, standards are usually not simply mandated by a central body of authority, but emerge over time through a less centrally controlled and less efficient process. In our understanding, the necessity to deal with emerging complexity is the major reason for this character of the process. A growing number of healthcare IS (such as EPR systems) have infrastructural characteristics and this requires a more sophisticated understanding of how complexity emerges and can be dealt with. We hope that our framework has the potential to help decision makers address the complexity in advance or during an ongoing process, and that it can assist in defining an effective transition strategy that is specific enough to actually guide action.

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