Information Infrastructures and the Challenge of the Installed Base

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3.1 Introduction

In this chapter we present the core theoretical concepts underlying the research included in the book. The empirical cases concern inter-organizational information systems, specifically e-prescription and governmental patient-oriented eHealth platforms. These systems span organizational boundaries and comprise multiple local systems as well as shared system components. Such interconnected networks of systems can be conceptualized in different ways. In software engineering, notions like "system-of-systems" (Maier 1998), "ultra-large scale systems" (Feiler et al. 2006) or "coalitions of systems" (Sommerville et al. 2012) are employed to draw attention to the specific characteristics and challenges that such systems pose.

We employ a perspective that denotes these interconnected, distributed collections of systems as "information infrastructures". This perspective emerges from a different, disciplinary diverse background. It stems from Information Systems studies, Science Technology and Society studies, and Innovation studies; i.e. disciplinary domains that have a dual focus that covers both technology and human/societal aspects (Monteiro and Hanseth 1995). In the next section we present this overall perspective. We then zoom in on one of the core notions of the information

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infrastructure perspective – the installed base. This notion helps us examine the trajectories of evolution for the e-prescription solutions and patient platforms.

3.2 Information Infrastructures

Some informatics researchers seek to understand technologies from a socio-technical perspective, i.e. to include the organizational and social context of its design and use. The fields of Information Systems (IS) research, Computer-Supported Collaborative Work (CSCW) and Human Computer Interaction (HCI) have this orientation to actual use situations and real users. Here it has emerged a body of research based on ethnographic studies of how people work with technologies. The recognition of how technology is intimately intertwined with organizational structure, procedures and work practices is a fundamental insight from this stream. For instance, Winthereik and Berg (2003) describe the historical evolution of the patient record over the last century as related to the organizational development of hospitals and the professional development of the medical and other health professions. Technologies for documentation and coordination of work have co-evolved together with the organizational structure, the personnel's skills and the work routines. The resulting collection of paper-based tools (forms, records, binders, tables, shelves etc.) and organizational routines comprise a complex information infrastructure that supports medical work (Berg 1999; Berg and Goorman 1999). This is often taken for granted, and its crucial role is often only realized when disturbances occur, e.g. when a digitization project is initiated (Vikkelsø 2005). For instance, the consequences of replacing a paper form with a digital version may not be fully realized unless one sees the paper form as not just being an information carrier but also a 'signalling device' for the coordination of work. The underlying, supporting and often invisible role of this set of technological components and organizational routines is one reason to call this an "information infrastructure". An organization-wide information infrastructure that is deeply embedded into work routines across several departments will be difficult to change, however, careful analysis of all its aspects can inform change strategies (Hanseth and Lundberg 2001; Ellingsen and Monteiro 2003; Silsand and Ellingsen 2014; Petrakaki et al. 2016).

This underlying and invisible role caused by technology's embeddedness within a work and organizational context is not the only reason to use the label of "information infrastructure". The IT systems implemented in healthcare are usually intended to connect multiple sites, either within an organization or beyond it. An information infrastructure that is non-local and distributed will encompass multiple actors that may have different needs and interests that may not be aligned. For an information infrastructure to work, some working resolution between the multiple local interests and the over-arching or "global" interests of the network as a whole, needs to be found (Star and Ruhleder 1996).

Understanding the complexities and mechanisms involved is a core ambition of information infrastructure studies. Earlier studies on the historical evolution of large-scale technical systems, for instance the emergence of electric power grids

(Hughes 1987), have drawn attention to the contests among the actors and their strategies for promoting their own solutions or interests. From such studies comes a set of concepts that help us understand the role of network effects, which are the mechanisms at play in interconnected setting with a large number of actors with different agendas and interests (Arthur 1989, 1990; David 1985). For instance, recognising that value is generated by the network, not the parts in isolation, and that initial moves in a particular direction encourage further moves along the same path, is crucial. While in early stages in the evolution of systems the path is relatively open, at later stages it becomes more bounded or may create lock-in situations.

Earlier research has illuminated what we may call on the one hand socio-technical complexity (caused by technologies being deeply embedded into organizations, and organizations being deeply embedded into technologies, see e.g. Leonardi 2011) and on the other hand network-related complexity (caused by the unpredictable dynamics between a large number of connected actors without central control, see e.g. Williams 2016). Based on these insights, IS researchers have attempted to formulate different ways to think about and deal with large-scale, complex and interconnected information infrastructures – approaches that are sensitive to the presence of complexity. Based on a number of in-depth case studies in global organizations, Ciborra et al. (2000) challenge traditional management approaches based on a control paradigm and advocates more humble, iterative and incremental managerial strategies. "Cultivation" is a metaphor that serves to characterize this alternative approach, in contrast to the prevalent "construction" mode based on detailed preplanning and tight control. A cultivation approach would prefer monitoring and intervention activities over strict control and ongoing adjustments over rigid preplanning. The evolution of the Internet is a paradigmatic example of technology development that has not followed the traditional managerial top-down approach. Hanseth and Lyytinen (2010) uses this case to derive design principles that are sensitive to (and exploit) the network effects that are a core defining feature of information infrastructures.

To build (or grow) infrastructures is a challenging endeavour for several reasons: information infrastructures expand through integrating previously separate systems, however, integration is not only a technical concern of achieving interoperability, rather a process embedding political and institutional interests. For instance, in the context of national or regional e-health infrastructures, a large number of heterogeneous actors, including developers and users' organizations, are involved with diverging interests, which requires ongoing political negotiations (Sahay et al. 2009). In addition, large-scale infrastructural projects require adequate coordination mechanisms. Infrastructure development is characterized by uncertainty. It is basically an open process due to the many interdependencies that need to be dealt with. Furthermore, unintended side effects and the participating actors' reflexivity can add to the complexity (Hanseth and Ciborra 2007; Hanseth et al. 2006). Moreover, infrastructure development is a visionary and political process with a moving target. It deals with an extended time span, as infrastructures are designed today to address future and unknown needs of users.

With this book we aim to contribute to the emerging body of literature that apply the information infrastructure perspective to study eHealth infrastructures.[1] Specifically, this book focuses on the process of evolution of various cases of information infrastructures in the health sector. The information infrastructure perspective encourages such a temporally extended process view, and the "installed base" concept is central in such analyses.

3.3 Installed Base

One of the core messages of the information infrastructure body of research has been to draw the attention to the role of the pre-existing, built environment, which is often overlooked by other conceptualizations of large, complex systems. Studies of information infrastructures emphasize the durability and central role of existing practices, conventions, tools and systems, and this "installed base" is seen to fundamentally impact the evolution of information infrastructures. This perspective emphasizes that "infrastructure does not grow de novo: it wrestles with the "inertia of the installed base" and inherits strengths and limitations from that base." (Star and Ruhleder 1996, p. 113).

Among practitioners the challenges posed by the installed base are well known. For instance, a corporations' huge and messy portfolio of IT systems from different technical generations that have accumulated throughout the years may significantly impacts the corporation's freedom to improve and innovate, for both technical and financial reasons. The metaphors of 'greenfield' versus 'brownfield' projects, imported to systems development discourse from the building industry, signify the same practical recognition of the power of the installed base. While a greenfield site has no prior installations, in a brownfield site there may be existing installations, other buildings, pipes and cables in the ground, or contaminated soil. Changes and innovations happen in that constrained space between what is already there and what can become realized in an already populated landscape.

The notion of installed base refers in general to the number of installations or products sold. The size of the installed base and existence of complementary products may, through self-reinforcing growth mechanisms, determine success or failure in the market (see e.g. Farrell and Saloner 1986; Schilling 1999). However, in Information Infrastructure studies the notion of installed base has a broader meaning. It was initially used in the context of a discussion on standardization and communication protocols, where it was commented that "a fundamental problem with OSI is that it is "installed base hostile" (Hanseth and Monteiro 1998b). The notion was later used in an extended way to encompass "all that is there", including the existing work practices with their tools and established

[1] See e.g.: Aanestad and Jensen 2011; Jensen 2013; Schellhammer et al. 2013; Grisot and Vassilakopoulou 2013; Rodon and Chekanov 2014; Grisot et al. 2014; Johnson et al. 2014; Rodon and Silva 2015; Thorseng and Jensen 2015; Hanseth and Bygstad 2015; Vassilakopoulou et al. 2016; Williams 2016.

division of labour, the legal and professional regulations in place, and so on (see e.g. Hanseth and Monteiro 1998a). The main argument is that information infrastructures are never designed from scratch, but they develop through the evolution of an installed base. Hanseth and Lyytinen (2010) define an installed base as the existing "set of ICT capabilities and their users, operations and design communities", and it also encompasses existing institutional and organizational components (Lanzara 2014). In the health sector for example an installed base may encompass patient record systems, medical departments, various groups of professionals as users (nurses, clinicians), dispensing practices, regulations etc. Accordingly, the main argument put forward in this book is that projects for the creation of large-scale health information infrastructures are shaped by the existing installed base: the organizational, institutional, regulatory, sociotechnical arrangements that are already in place.

We should keep in mind that an installed base is not a given 'thing', it is rather a conceptual tool. This conceptual tool can help us to capture the continuities and discontinuities in infrastructure evolution. It becomes observable and visible when analyzing plans and interventions acting upon the existing infrastructural arrangements. Rather than asking "what is the installed base" we should ask "when is an installed base"? In other words, rather than pointing to specific elements, we need to ask when and how some element of an existing reality becomes significant, for whom, with what effects? In what way do the different elements become significant, are they working as triggers, as resources, as competitors, as alternatives? For instance, will a particular feature of the organizational culture serve to facilitate or hinder change? The concept of installed base is a sense-making tool to examine and reflect on the challenges faced in the development of infrastructures. It implies a process-oriented understanding where it becomes crucial to trace and analyse the historical sequence of events and decisions that shape the forming of infrastructures.

The generic change strategy of the information infrastructure perspective – "cultivation of the installed base" – denotes a strategy that starts from what already exists (the installed base). This implies a re-conceptualization of the very notion of design of information infrastructure. Rather than design in the conventional sense, dealing with the evolution of infrastructures requires strategies to intervene and influence ongoing processes. The Information Infrastructure evolution process is best captured by the notion of 'growing' (instead of e.g. 'building' or 'constructing') since it gives a "sense of an organic unfolding within an existing (and changing) environment" where there is a "recurring issue of adjustment in which infrastructures adapt to, reshape, or even internalize elements of their environment in the process of growth and entrenchment" (Edwards et al. 2007, p. 369). These processes of infrastructure evolution happen along multiple temporal scales (Edwards et al. 2009; Ribes and Finholt 2009; Karasti et al. 2010). In this perspective, we approach the cases by paying attention to the strategies enacted in order to deal with the installed base, and examine how developing infrastructures entails engagement in processes of extension, recombination, substitution of parts and arrangements that already exist. In this view, new information technologies should never be seen

as isolated and univocal, but embedded in an intricate web of technologies, practices, routines to which they relate in specific ways. The pre-existing systems may serve as a foundation for a new system, components from the previous information infrastructure may be reused in the new, and other components me be redefined or removed. The challenges associated with this is the topic of the next section.

3.4 Challenges of Installed Base Cultivation

Infrastructures are never built "de novo" – they develop amidst a stream of technical antecedents, social conventions and professional rules and have to be adaptive to the developments of work practice. As these elements are changing, the information infrastructures are continuously evolving. At the same time, they have to be stable enough to reliably support activities that make use of them: "only a stable installed base allows new connections to be created" (Tilson et al. 2010). Taking an infrastructural perspective reorients our attention to interconnections and relationships as well as to issues of durability and permanence. The challenge is then to devise strategies for effectively managing future evolution (Ribes and Finholt 2009; Karasti et al. 2010). The installed base is both enabling and constraining infrastructure evolution (Hanseth et al. 1996; Hanseth and Aanestad 2003), it can be "a resource for creative design and innovation or a trap from which it is difficult to escape" (Lanzara 2014 p. 19). To manage the further evolution of the installed base is challenging, as it entails building on the installed base and transforming it at the same time. This creates a paradox: new developments need to fit and make use of existing arrangements and at the same time transform them. Overfitting on the existing installed base may strengthen its irreversibility and hinder change, disregarding it may limit the initial utility of any initiative and impede growth (Henningsson and Hanseth 2011). The paradoxical relationship between the installed base and infrastructural development initiatives cannot be resolved with simplistic approaches e.g. the old obliteration dogma of Business Process Reengineering or naive digitization ("putting electricity on paper"). Rather our argument is that the installed base matters in each case in a specific and contingent way.

This book aims to bring empirically based and theoretically informed insights into how the installed base matters. The book's empirical analyses investigate the various strategies in which infrastructure "builders" engage with (or disregard) the installed base. The stories describe how initiatives are shaped and paced by decisions on how to relate with the installed base, or alternatively, how they are shaped by the insensitivity to what is already in place. The two categories of cases, e-prescription infrastructures and governmental patient-oriented eHealth platforms are differently positioned with respect to the installed base. E-prescription initiatives are typically oriented to digitize an already present paper-based and analogue information infrastructure. The governmental patient-oriented web platforms are typically expected to allow more radical innovation, including new interaction patterns, roles and responsibilities for both patients and healthcare personnel. Overall, e-prescription initiatives are usually aiming to improve healthcare delivery by

systematic change, building in an orderly way upon the existing arrangements, while initiatives for patient-oriented eHealth platforms are usually seen as opportunities to pursue wider and more radical innovation (dramatic change) (Huy and Mintzberg 2003). Nevertheless, in any of the two types, pre-existing arrangements need to be taken into account, after all, these pre-existing arrangements are providing the contextual meaning of change. Hence, change has to be managed with a profound appreciation of the installed base.

The book chapters go beyond the initial design and development of each case and include experiences of reworking and reconfiguration during and after deployment as this has proved to be pivotal for systems' evolution. The narratives of each case bring forwards the paradoxical relationship between new eHealth initiatives that need to fit and make use of existing arrangements and at the same time transform them. The accounts of actual trajectories may not necessarily be neat "roll-outs"; detours and plan changes are part of the stories. Nevertheless, all cases are about large-scale planned and professionally managed initiatives with specific goals. The book is about this type of initiatives and aims to provide insights on how strategies can be specific to each context. Going beyond universal best practices that can be deadening and unresponsive to the actual challenges requires developing an awareness of the installed base. This awareness means being able to discern what is relevant and needs to be foregrounded and acted upon from what can be handled as mere background. In other words, the aim with the book is to help create an "installed base sensitivity" in decision-making both at the policy/strategic level and at the concrete e-health design level.

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